Crane Conservation Strategy

Compiled and edited by
Claire M. Mirande and James T. Harris

IUCN
SSC Species Survival Commission
Crane Specialist Group

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Published by the International Crane Foundation, Baraboo, Wisconsin, USA

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This landmark volume provides a wealth of new information to guide conservation of the world's fifteen species of cranes and the ecosystems where they occur. It reflects the work and knowledge of dozens of devoted colleagues in the IUCN Crane Specialist Group. It updates and builds upon the group's first report, *The Cranes: Status Survey and Conservation Action Plan* (1996). As such it charts a comprehensive course forward for crane conservation, synthesizing information on the challenges and opportunities that face the world's cranes and all who care about them. The book is intended to serve crane researchers, conservationist practitioners, decision makers, and environmental educators.

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Front cover photo: Fifteen crane species of the world. Painting by David Rankin.
Back cover: Distribution map of 15 species of cranes of the world.

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In Dedication

James Thomas Harris

1950-2018

With grateful appreciation of Jim's 34 years of tireless service
to the cranes of the world
and his colleagues at the International Crane Foundation and abroad.

Jim's passionate commitment to safeguarding cranes and the places they live,
his overwhelming enthusiasm and eloquent words that inspired people,
his courage and perseverance in most difficult circumstances,
and his genuine interest in and care for those around him,
were admired and will always be remembered
by all who were fortunate to know him.

"The haunting calls of the world's cranes are sadder today because they have lost a devoted friend, and the conservation community has lost a true hero."
Kenneth Strom, National Audubon Society

On September19th, 2018 the Crane Specialist Group lost a dear friend and champion for the conservation of cranes and wetlands. Jim passed away peacefully surrounded by his family at his home in Baraboo, Wisconsin, USA after a valiant fight against liver and pancreatic cancer.

In 1984 Jim joined the International Crane Foundation (ICF) in Baraboo, Wisconsin as the Education Director. By the late 1980s, Jim served as Deputy Director expanding ICF's activities in Asia. In 2000, Dr. George Archibald stepped aside as ICF's President, and Jim succeeded him. Under Jim's leadership, ICF was directly involved in 45 projects in 22 countries around the world. In 2006, Jim decided to transition back to serve as director of ICF's East Asia program, while continuing as Vice President. From 2006, he also oversaw ICF's Africa program, a post he held until just before his retirement in early 2018.

Jim was a journalist by training and an eloquent and prolific writer. He wrote lovely pieces detailing his experiences with people and cranes in Asia, featuring evocative descriptions of landscapes and their inhabitants.

As Co-chair of the IUCN Crane Specialist Group with George Archibald (1988-2008), then Chair (2008-2017) and Co-chair with Kerryn Morrison (2018), Jim's vision for cranes and their landscapes has always been global in scale. He has adeptly integrated the expertise and passion of 350 members in over 50 countries. He led workshops, produced publications changing the course of how we address complex crane challenges such as agricultural land use and climate change, and brought diverse people together to find solutions to provide water for wetlands and cranes, whilst balancing human needs. His contributions are culminating this year with the publication of this much-anticipated Crane Conservation Strategy that engaged over 150 crane specialists in a review of the status and trends for all 15 crane species.

Jim's dedication, along with his wife Su Liying, to the cranes and wetlands of China, Russia, and beyond is well-known and greatly appreciated. He pioneered conservation work with a micro-lending program for farmers in return for crane habitat conservation in China, introduced improved water management techniques as part of reserve management plans in NE China, promoted sound science as a basis for improved management, initiated highly popular and effective international nature schools and camps in Russia and China, and established monitoring networks.

Jim's infectious reverberating laugh, gentle smile and good sense of humor radiated an energy, positivity and sense of hope to everyone around him. Jim's insights, critical thinking and recommendations were always constructive and valuable. His wise counsel was often sought by partners throughout the crane world, in part because Jim was always so supportive and giving of his time. As an incredible mentor, guide and confidant, Jim leaves behind many people, all

over the world, who have benefited, flourished, and been inspired by his example.

Thank you, Jim, for decades of dedication and the legacy you have left for us all to continue forward with for the conservation of the world's cranes. Thank you for your unfailing friendship to so many around the world.

"Up close, cranes make us feel we have escaped time, that nothing has changed – except the circling of sun, the sweep of seasons, the coming of ice millennia ago, the ice melting into shallow waters with deep, sucking mud, and where long beaks find tubers buried in darkness… Ancient cranes remind us of the eons of time where ten years is less than the blink of an eye, but looking forward, ten years can make possible the crane millennia ahead." Jim Harris, "Millennia," *ICF BUGLE*, vol. 45, No 3 (August 2016).

"*Those who witness the crane flocks … discover an ancient creature's response to a crowded and changing world. At most such sites, natural cycles are so disrupted that humans must take an active role for the cranes. Our challenge is to rediscover old balances, or create new balances, linking cranes, the land, and people.*" Jim Harris, "Cranes in a Crowded World," vol. 22, No 2 (May 1996).

Jim will be also remembered fondly for his passion for taking photos of the people, cranes and landscapes in the places he visited around the world. This photo, taken at Muraviovka Park in Far-eastern Russia captures his love for landscapes and the perfect shot.

Foreword

Cranes are one of many species of concern around the globe that are closely reliant on wetlands. Of the 15 species, 11 are listed as threatened under the IUCN 2019 Red List: one Critically Endangered (Siberian Crane), three Endangered (Grey Crowned, Red-crowned, and Whooping Cranes), and seven vulnerable (Black Crowned, Black-necked, Blue, Hooded, Sarus, Wattled, and White-naped Cranes); the other four are listed as Least Concern (Brolga, Demoiselle, Eurasian, and Sandhill Cranes). These crane species encompass diverse regions and landscapes, from the taiga to tropical broadleaf forest biomes. Cranes also are readily observable and charismatic because of their beauty, large size, unique calls, and behaviors. Moreover, cranes have a long heritage of cultural and spiritual values in many societies. These attributes—wide distribution, wetland affiliation, conservation status, and societal values at local to global scales—make cranes ideal models and ambassadors for conservation of healthy wetlands and grasslands across diverse landscapes. The relationship between cranes and people is remarkably complex, with cranes and people dependent on the same landscape across the world.

Cranes as a group also can serve a role as umbrella species at a broader ecosystem perspective. Societies around the globe have become increasingly aware of the value of biodiversity and healthy ecosystems, particularly related to wetlands. Conservationists forever strive to minimize the negative impacts to wildlife from the extraordinary transformations that humans have brought to landscapes around the world. Societies are facing growing challenges due to expanding human populations. A major concern is water security, including quality and availability of water during extreme events (e.g., drought), as well as food security. Wetlands provide us with critical ecosystem services at local to global scales: these habitats are essential in terms of water security, nutrient cycles, and human food production (e.g., water for irrigation, rice production).

This Strategy originated in the workshop *Cranes, Agriculture, and Climate Change* at Muraviovka Park for Sustainable Land Use, Russia, in 2010. Thirty participants from 14 countries, representing five continents, attended the workshop by invitation of the Crane Specialist Group. The participants debated the specifics on how crane specialists of the world respond to the challenges and opportunities afforded by the immense challenges happening around the world. The workshop participants identified the need to update the 1996 *Crane Conservation Action Plan*, drawing together and consolidating an update on cranes, their status and threats, and developing key conservation objectives and actions from around the world. Many of the workshop participants, as well as other conservationists from around the world, contributed sections, published and unpublished information, and provided reviews. Altogether, 31 section authors from the Crane Specialist Group and 191 others contributed to the development of this strategic plan with additional input or review.

In this Strategy, the Crane Specialist Group has gathered information on the status of cranes and the diverse threats affecting their conservation. Since cranes live in over 80 countries on five continents and adapted to an extraordinary range of conditions, this Strategy contains much, but not all, of the experience and lessons relevant to our objective—for cranes and people to live together and thrive across their global range. The Crane Specialist Group intends now to continue the quest for productive co-existence of cranes and people on the same landscape.

The charisma and cultural significance of cranes have inspired much attention in many countries to finding conservation solutions. Just as crane conservationists have learned from those working with other groups of animals, we hope these efforts will benefit the conservation of wetland and grassland species, as well as the human communities sharing the landscape.

Jon Paul Rodríguez
Chair, IUCN Species Survival Commission, Caracas, Venezuela

Acknowledgments

This publication was made possible by the valuable contributions of numerous individuals and organizations who have given their time and knowledge to write or review sections of this book, who shared photographs, unpublished information, and observations. The authors, contributors, and reviewers to crane species or threat assessments are listed below. We thank the Crane Specialist Group Steering Committee for providing the vision and focus for this publication, and Kerryn Morrison as Chair of the Crane Specialist Group for her oversight and guidance.

The inspiring words from George Archibald and Curt Meine in the Introduction provide a context for all that has happened since the first Crane Action Plan was published in 1996 and set the stage for the next five years. Cary Krajewski and Ken Jones were helpful in discussions regarding crane taxonomy. Staff at the International Crane Foundation contributed their expertise in many ways. We thank Dorn Moore and Dmitry Sarychev for producing the new range maps for all species; Jane Austin and Elena Smirenski for their extensive work with authors and contributors, editing, proofreading, and formatting the documents for this publication; and Betsy Didrickson and Sara Gavney Moore for selecting photographs.

This publication was made possible by the valuable contributions and expertise of numerous individuals and organizations who have given their time and knowledge to write or review sections of this book, and who shared photographs, unpublished information, and observations. The authors, contributors, and reviewers to crane species or threat assessments are listed below.

Support for the editors' time has come from the International Crane Foundation and the Endangered Wildlife Trust. Jane Austin's time was supported by U.S. Geological Survey Northern Prairie Wildlife Research Center. All recommendations put forward in this publication are those of the IUCN Crane Specialist Group. The International Crane Foundation supported publication of the book. Publication costs were generously supported by George Archibald and Hall Healy.

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Introduction

George W. Archibald[1] and Curt D. Meine[2]

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This landmark volume provides a wealth of new information to guide conservation of the world's fifteen species of cranes and the ecosystems where they occur. It reflects the work and knowledge of dozens of devoted colleagues in the IUCN Crane Specialist Group. It updates and builds upon the group's first report, *The Cranes: Status Survey and Conservation Action Plan* (1996). As such it charts a comprehensive course forward for crane conservation, synthesizing information on the challenges and opportunities that face the world's cranes and all who care about them.

This volume also reflects the vast experience and network of relationships of its dedicated editors, Jim Harris and Claire Mirande. Jim and Claire both began their careers at the International Crane Foundation (ICF) in 1984. In 1987 Jim spearheaded a landmark international crane workshop in China and subsequently guided ICF's efforts throughout northeast Asia and supervised ICF's Africa Program for a decade. Claire began her career in ICF's captive propagation program and soon became a vital link between in situ and ex situ crane conservation efforts globally. In 2000, Jim and Claire took on the administration of an unprecedented ten-million-dollar grant from the United Nations Environment Program's Global Environment Facility (GEF) to promote the conservation of Siberian Cranes. Jim retired in 2018 and, sadly for all those who knew and worked with him, passed away as this volume was being completed. Claire continues to lead and inspire through all her efforts at ICF and around the world.

Twenty-three years have passed since IUCN published the first *Conservation Action Plan* for cranes. We can look back over this period with both pride and concern. A new generation of talented crane conservation leaders has taken up this vital work around the world. We should be encouraged by the great progress, expanded capacity, and tangible results of our collective efforts. We should also be troubled by the array of continuing and emerging threats confronting the world's cranes. As we look backward and forward, we can also pause and consider just how much more information we now have about the ever-changing status of the cranes. The remarkable technological advances since 1996 now allow us to gather, share, and update information so much more efficiently and effectively. And yet information does not automatically translate into effective conservation. That still requires, and always will, the goodwill and great commitment of people. We are honored and humbled to be part of the global community of crane conservationists whose work is represented here.

This document offers impressively detailed accounts of the current status, threats, and conservation needs for each of the species of cranes. Here we provide a brief introductory overview. Of the fifteen species, eleven are listed as threatened under the IUCN Red List: one Critically Endangered (Siberian Crane), three Endangered (Whooping, Red-crowned, and Grey Crowned Cranes), and seven Vulnerable (White-naped, Wattled, Black-necked, Hooded, Sarus, Blue, and Black Crowned Cranes). The other four species are listed as Least Concern (Brolga, Demoiselle, Eurasian, and Sandhill Cranes).

North America has two species of cranes, including the rarest and the most abundant. Asia has eight species of cranes, two Endangered, three Vulnerable, and three with widespread distribution of Least Concern.

Europe has one species of Least Concern. The two species of southeast Asia/Australia include one Vulnerable and one of Least Concern. All four species of cranes resident in Africa are threatened (one Endangered and three Vulnerable).

The **Siberian Crane** (*Leucogeranus leucogeranus*) is considered the most endangered crane species. Three populations of Siberian Cranes have been recognized, all of which breed in northern Siberia, and winter in Iran, India, and China. Shooting likely caused the demise of the tiny Western Asian population (nine birds in 1996) that wintered on the Caspian lowlands of Iran. A lone male crane in this population has continued to appear there each winter. In 1996, only four Siberian Cranes in the Central Asian population arrived to winter at Keoladeo National Park in India. Poignantly, during the winter of 2002–03 only one pair remained. They did not return to Keoladeo the following winter. Although strictly protected on both their breeding grounds in western Siberia and their wintering grounds in India, illegal shooting along the migration route was likely the major factor behind the loss.

On a more encouraging note, the eastern population of Siberian Cranes that winters in China now numbers around 4,000 birds, a substantial increase from the 2,900–3,000 birds estimated there in 1996. This increase reflects improved counting methods, but also strict protection of the species throughout its expansive range, from the breeding grounds on the tundra of Yakutia in eastern Russia to its sole wintering site at Poyang Lake, China. Innovative water management at Momoge and Xianghai Nature Reserves—key migratory resting areas in northern China—have also contributed importantly to this success. The fate of the species will depend on securing a network of protected wetlands across its range in China as water is diverted for growing human populations; ensuring healthy wetland conditions sustained by normal water level fluctuations at its sole wintering grounds at Poyang Lake; understanding use of upland agricultural feeding sites during years when natural wetland foraging areas are not available (due to drought or flood); and responding to an increasing risk from ingestion of poisoned grains that farmers spread to catch ducks and geese.

The **Whooping Crane** (*Grus americana*) continues to be the rarest of cranes, with a total population of 689 birds in the wild in 2018, with an estimated 500 birds in the only self-sustaining wild population. In 1996, this population included just 150 birds. The population's breeding grounds in northern Canada in Wood Buffalo National Park are protected, but there are growing concerns that climate change and oil development will negatively impact the species. The coastal wetlands in Texas where these cranes winter are threatened by sea-level rise, reduced freshwater availability due to upstream diversions and drought, land development, and the expansion of black mangroves into salt-marsh habitat. The Aransas National Wildlife Refuge and other nearby important wintering areas also face the continuing possibility of catastrophe should there be spillage from the barges that carry millions of tons of toxic chemicals along the Intercoastal Waterway, or an offshore oil spill similar to the Deepwater Horizon disaster in 2010. More positively, there has been recent strong recruitment in the population. A recent population viability analysis indicate that this population is unlikely to go extinct over the next 100 years—a significant increase in viability since 1996. There are also strong efforts underway to secure additional wintering habitat in Texas to support recovery goals.

Over the last two decades conservationists have undertaken a great deal of experimental work on captive breeding and reintroduction of Whooping Cranes. Through both success and frustration, our understanding of effective methods has increased greatly. A captive population of 160 birds, held at twelve major captive breeding centers, serves as both a safeguard should something happen to the wild population and a source of young cranes for reintroduction programs in Wisconsin and Louisiana. As of April 2018, the Wisconsin population that migrates to the southeast United States numbered about 100, and the non-migratory Louisiana population numbered 67. Neither population is yet self-sustaining.

The island population of non-migratory **Red-crowned Cranes** (*Grus japonensis*) in Japan has increased significantly from 594 in 1996 to more than 1,600 in winter of 2017–18 due to strong protection and artificial feeding programs in winter. The gradual reduction of artificial feeding to encourage the cranes to disperse more widely has perhaps led to some decrease in the overall population, which is being monitored. The migratory population that winters in and near the Demilitarized Zone (DMZ) between the Democratic People's Republic of Korea (DPRK, North Korea) and the Republic of Korea (ROK, South Korea) has also increased from an estimated 500–650 in 1996 to 1,250 in winter 2017–18. It appears that the loss of winter habitat in DPRK and perhaps in China has caused the cranes to move to the DMZ. There are growing concerns that, as lowlands in and near the DMZ are developed, one-third of the world's Red-crowned Cranes will face great challenges to their survival.

On mainland Asia, we have seen a distressing decline in the migratory population that winters in China from about 1,200 in 1999–2000 to fewer than 600 as of winter 2017–18. There are several factors behind this decline: loss of breeding and migratory stopover sites as well as wintering habitat, extended drought, the collection of wild eggs, and poisoning. This population is the focus of increasing efforts to improve productivity and understand and mitigate sources of mortality, especially for breeding adults.

The population of the **Grey Crowned Crane** (*Balearica regulorum*) has recently been estimated at 26,500–33,500. Overall estimates suggest that the species' global population has declined substantially, from over 100,000 individuals in 1985 and 85,000–95,000 in 1996—a reduction of 64–80% in forty-five years. This decline is attributed primarily to habitat loss and fragmentation, disturbance around nesting sites, illegal removal of birds and eggs from the wild for food, use of feathers or parts in traditional practices, domestication, and international illegal trade. This sharp decline, and the fact that the causes of this decline have existed since the 1960s and show no signs of abating, led to the up-listing of Grey Crowned Cranes from Vulnerable to Endangered in the 2012 Red List update.

Other threats to the species include poisoning and collisions or electrocutions related to power lines. An African-Eurasian Migratory Waterbird Agreement (AEWA) Single Species Action Plan was completed in 2015 for Grey Crowned Cranes across their range, and an International Working Group has been established to ensure the plan's implementation. The African Crane Trade Project, a collaborative effort involving multiple stakeholders, is helping to address the serious issue of illegal trade of Grey Crowned Cranes and other African crane species. Efforts to reverse the loss of critical wetland habitat, strongly linked to rapid human population growth especially in East Africa, are focused on sustainable, conservation-friendly livelihoods and other community-based conservation initiatives.

Although the population of **White-naped Crane** (*Grus vipio*) appears to be increasing, its numbers are shifting significantly in different portions of its range in northeast Asia. Numbers have declined in the western part of the range in Mongolia and nearby areas in Russia and China, where prolonged drought has reduced available wetland breeding areas. The species' breeding success rate has also been compromised by overgrazing, trampling of nests by livestock, predation by dogs, and the loss of wetlands as permafrost melts. This western population that winters at Poyang Lake, China has declined from about 3,000 in 1996 to fewer than 1,000. Important stopover sites have been lost, newly identified sites like Duolun are unprotected, and there is increasing evidence that birds are being lost to poisoning.

The wintering population in the Korean peninsula and southern Japan has increased from 1,900–2,300 in 1996 to almost 8,000. However, the population lacks natural habitat where it winters along the Korean DMZ and at Izumi, Japan. The Izumi cranes roost on artificially flooded rice paddies and depend on grain and fish provided daily by the local government, exposing them to risk from disease due to their high concentrations. Collaborative research, planning, and conservation efforts have increased throughout the species' range. A White-naped and Hooded Crane Network was initiated in 2015, and the North-east Asian Subregional Programme for Environmental Cooperation (NEASPEC) selected the White-naped Crane and Hooded Crane as priority flagship species for surveys and studies. Research and advocacy are ongoing to sustain wetlands and grasslands important for cranes, particularly for the Poyang Lake ecosystem in China, Daurski State Nature Reserve and Muraviovka Park in Russia, and the Khurkh and Khuiten Valleys of Mongolia.

The **Wattled Crane** (*Bugeranus carunculatus*) is the largest, rarest, and most wetland dependent of the African cranes. The population was estimated at between 13,000 and 15,000 in 1996 and then at fewer than 8,000 in 2004. The current global Wattled Crane population is estimated at >9,600 individuals. Although it is evident that the species has declined since 1996, it is unclear whether the improved numbers since the early 2000s reflect a true population increase or improved accuracy of population estimates. Five enormous floodplains in Zambia, Botswana, and Mozambique support more than 80% of the total population. Further research is required to better understand inter-annual or season movements among these large floodplain systems in south-central Africa, and local movements between the floodplains and the more isolated wetland dambos where many Wattled Crane pairs likely breed. Two isolated populations also exist: one of 250–300 birds in Ethiopia and the other of about 400 in South Africa. While the numbers in the Ethiopian population are primarily known from dry season counts of flocks, many breeding areas there remain unknown and unprotected. In contrast, most breeding sites in South Africa are well known and benefit from protection by land owners. Consequently, the total South African population has slowly increased from 250–300 in 1996 to around 400 today.

Major threats to Wattled Cranes include dams and upstream water diversions, human encroachment on floodplains and wetlands, and the invasive *Mimosa pigra*, a thorny bush from South America that is rapidly spreading across wetlands and displacing cranes and other wildlife. On the Kafue Flats of Zambia, with >3,200 individuals the most important wetland for Wattled Cranes, the ICF/EWT Partnership is actively working to control *Mimosa pigra* in collaboration with several other organizations and local communities. The partnership also works to improve water conditions that are degraded by upstream and downstream dams and provide core management support in a collaborative agreement with the Zambian National Department of Parks and Wildlife. In addition, the ICF/EWT Partnership is monitoring threats and conditions on other large floodplains; working closely with landowners and local communities in South Africa to secure key crane sites and improve management practices for cranes and biodiversity in general; and conducting research to improve our understanding of their status, distribution and threats in Ethiopia.

Until quite recently we knew little about the status of the **Black-necked Crane** (*Grus nigicollis*) across its range on the Tibetan Plateau and neighboring areas. Winter counts in the early 1990s where the cranes gathered in flocks to feed revealed a population in 1996 of about 5,600–6,000. By 2007, the winter numbers had risen to about 10,000 cranes. The total population is currently estimated at

10,000–10,200. The largest flocks are along river valleys in southern Tibet, with smaller groups in Bhutan and on the Yunnan Guizhou Plateau. After taking into account the improved winter counting methods, it appears that the population has remained stable or perhaps increased slightly.

However, many changes threaten the welfare of these high-elevation cranes. Warmer summers are melting glaciers that feed into wetlands. This may temporarily create more breeding habitat for aquatic birds, but over the longer term will have complicated impacts. The warmer weather is melting permafrost upon which some of these wetlands are "perched." They are also increasingly subject to disrupted drainage. Because of the historically short growing season, farmers formerly planted fast-growing grains that produced leftover grain for cranes. Prolonged and warmer summers now allow for the growing of vegetables that provide little food for cranes. In some areas, solar farms and greenhouses now carpet former grain fields. Feral dogs kill flightless cranes, and tree planting in the wetlands threatens the integrity of crane breeding and roosting areas. Researchers in China, Bhutan, and India are monitoring these changes and taking steps to help assure a safe future for the Black-necked Cranes. Encouragingly, since 1996 the Chinese government has made a great commitment to establish protected areas for this species. More than 20 million hectares are now protected—more than for any other bird species in China, and a reflection of their important role as a flagship species.

The **Hooded Crane** (*Grus monacha*) breeds across an enormous range in the wildland taiga of eastern Siberia. Their population has increased from an estimated 9,400–9,600 in 1996 to approximately 15,000 during the winter of 2017–18. Poyang Lake in China hosts about 1,000–1,500 wintering birds, but the vast majority migrate down the Korean Peninsula. About 1,700 winter in the coastal wetlands of Suncheon Bay in the Republic of Korea–an increase from about 200 in 1996. The remaining 13,000 or so birds continue on to Izumi in Japan. There, artificial feeding and the resulting crowded concentrations of Hooded and White-naped Cranes create risky conditions in which disease or a weather-related disaster could prove devastating for both species. Efforts are in progress to encourage dispersal and thus reduce the risk of disease from avian cholera and influenza and other pathogens.

Since 1996 the **Sarus Crane** (*Grus antigone*) has benefitted from new research, restoration efforts, and collaboration. Four populations are now recognized in South Asia (India/Nepal), Myanmar, Southeast Asia (Vietnam/Cambodia/Thailand), and Australia. These populations have experienced different trajectories over the last two decades. The population in South Asia, estimated at 8,000–10,000 in 1996, appears to be increasing across India and Nepal, based on intensive nest monitoring across the region, but a comprehensive range-wide population estimate is lacking. Sarus Cranes appear to be thriving in traditional agricultural landscapes with diversified farming systems and are most threatened by intensified monocultural agriculture.

The population of Sarus Cranes in Southeast Asia was estimated at 500–1,500 in 1996. Annual counts in the lower Mekong Delta begun in 2001 indicate a substantial decline from about 900 cranes to about 400 in 2016, although the Sarus Crane has been reintroduced in eastern Thailand and is increasing. The population faces major challenges due to the loss of breeding habitat in northern Cambodia and high mortality in non-breeding areas due to environmental contaminants. Fortunately, many important new protected areas have been established in Vietnam and Cambodia since 1996, and the Phu My project has become a globally renowned model linking livelihoods to Sarus Crane conservation. Myanmar supports a small population of about 300–400 Sarus Cranes, primarily in the Ayeyardwady Delta region. This population was poorly understood in 1996. Field surveys conducted over the last twenty years have begun to provide more reliable estimates. The status of the Sarus population in Australia, estimated at somewhere under 5,000 in 1996, is uncertain. The population is now estimated at 5,000–10,000, with more reliable population data pending results of recent field surveys.

The **Blue Crane** (*Anthropoides paradisea*) of southern Africa has been making a steady recovery from the 21,000 birds estimated in 1996. The population was decimated in the 1980s and early 1990s, falling from an estimated high of 100,000 due to poisoning and habitat loss in eastern regions of South Africa. Its population has increased in the southern portion of its range, where the cranes breed amid fallow wheat and pasture fields. The South African National Crane Censuses, conducted over a 10-year period between 1996 and 2005, estimated the population at around 25,000. The current global population is estimated at 25,500–30,000 and is increasing. In the future, drier climate conditions in core areas for these cranes, along with associated changes in agriculture, may negatively affect crane numbers. Other threats to the population include collisions with power lines, illegal removal of chicks for trade, mining for energy resources, and the transformation of grasslands to agriculture. A tiny population in Namibia, the only population beyond the borders of South Africa, has declined from 70–100 cranes in 1996 to about twenty now. New programs to increase awareness and engage private landowners, such as South Africa's Biodiversity Stewardship Programme, have been developed to help landowners sustainably manage their land while sustaining viable populations of Blue Cranes.

The **Black Crowned Crane** (*Balearica pavonina*) has experienced a dramatic population decline over the last several decades. Although this likely began before 1996, we did not learn about this drop until it was revealed during a major Black Crowned Crane initiative carried out between 2000 and 2004. The western population is estimated to have declined from an estimated 15,000–20,000 individuals in 1985 to 11,500–17,500 in 1996, and to 15,000 individuals in 2004. Strong anecdotal evidence suggests that number could be lower at present. The eastern (Sudan) population may have undergone a comparable decline from an estimated 50,000–70,000 estimated in 1985 to 55,000–60,000 in 1996 and to 28,000–55,000 in 2004. The exact extent of the trend is unclear due to the population's distribution across many war-torn and inaccessible countries in the region, making accurate initial and current counts very difficult. Given the uncertainty around these estimates, we provisionally estimate a worst-case decline of 30–49% over forty-five years (three generations), though the true figure may be higher depending on the status of the eastern subpopulation.

The species, once widespread across its range, has undergone dramatic declines in certain countries, such as Mali, and may even have been extirpated in others, such as Nigeria. Black Crowned Cranes have declined primarily due to habitat loss and degradation, domestication and illegal trade, and human and livestock disturbance around nesting sites. On a positive note, the ICF/EWT Partnership is working on the African Crane Trade Project focusing on research and monitoring, awareness, and advocacy for policy changes and legislation. The species has been listed on Appendix II of the Convention on International Trade in Endangered Species (CITES). In 1999–2002, ICF and Wetlands International developed a Status Survey and Conservation Action Plan for the Black Crowned Crane. Recent surveys suggest that strongholds for the species exist in coastal west Africa (Senegal to Guinea Bissau), Chad, and Ethiopia. Partners are poised to conduct surveys to monitor the species as travel to politically unstable range states becomes more feasible.

The **Brolga** (*Grus rubicunda*) occurs in Australia and New Guinea (where very little is known about it). Brolgas are most abundant in northern Australia, with 50,000–100,000 individuals estimated in 1996 and over 50,000 surveyed in 2012, suggesting a stable population. The small population in southeastern Australia, estimated at less than 1,000, has been decreasing since the early 1900s. Throughout Australia, Brolgas are threatened by habitat loss and degradation from agriculture, water impoundments and irrigation, and invasive species (both plants and animal predators). Since 1996, conservation scientists and NGOs have emerged as champions for the Brolga. The Brolga has been protected as a migratory species under federal and state legislation. The majority of Brolga habitat is located on private lands, and some habitat protection programs on private land have been initiated, particularly in Victoria. Regular, systematic, and standardized surveys are needed to establish and track total population numbers, distribution, and trends across the entire species range. More information is also needed on basic ecology, population dynamics, and habitat threats to inform appropriate management actions. Protection of key breeding habitat should be promoted through legislation, landholder incentives, and cooperation with private landholders.

The total population of the **Demoiselle Crane** (*Anthropoides virgo*) is estimated at 170,000‑220,000, compared to the 1996 estimate of 200,000‑240,000, suggesting that the population may be decreasing. About 60,000–70,000 remain in the steppe region of Kazakhstan and central Asia, but numbers in Kazakhstan have fallen from about 100,000 to 50,000‑60,000, with the decline occurring in the south and east. Two small populations found historically in the Atlas Mountains in northwest Africa and in Eastern Turkey have not been reported in recent decades. The species has also declined somewhat in the European part of its breeding range, from more than 60,000 in the mid-1990s to 45,000–58,000 in the mid-2010s.

In its main breeding areas in the Asian part of Russia (Transbaikalia), Mongolia, and northeast China, population numbers have declined from more than 110,000 to an estimated 60,000–95,000. These changes are due to changes in livestock farming, drought, intensification of agriculture throughout its range, and rapid economic development in China. Advertisements on the internet for crane hunting have raised concerns about the status of birds that migrate across Pakistan and Afghanistan and winter in northeast Africa. Regional and local crane working groups in Eurasia, Ukraine, Uzbekistan, Kazakhstan, India, and Turkey coordinate conservation efforts (including monitoring, networking, research, and education activities) for Demoiselle Cranes across its range.

The **Eurasian Crane** (*Grus grus*) population has grown from an estimated 220,000–250,000 in 1996 to over 700,000 today. Its breeding range extends from the United Kingdom to East Asia, with wintering areas in north and northeastern Africa (especially Ethiopia), Turkey, Middle East, India and China. The Western European population has grown from about 60,000–70,000 in 1996 to 350,000 cranes, and the Eastern European and Russian populations have grown from about 95,000 to 230,000. In Western Europe, the increase in breeding crane numbers and expansion of breeding wetland areas reflects improved public awareness, effective legislation, and changes in agriculture that provide more food resources during migration and winter. In Great Britain, the "Great Crane Project" supports the recovery of the breeding population through reintroduction and has contributed to the restoration of wetlands with pairs fledging chicks since 2015. With half a million cranes in Europe, crop damage is an increasing concern. At the same time, these cranes have become an engine for increasing nature-based tourism in many rural areas.

In the eastern portion of the range, numbers are likely declining. The Transcaucasian (or Anatolian) Cranes number around 250–300 individuals and are critically endangered. The Eastern Tian-shan Cranes are vulnerable, with estimates remaining around 1,000 individuals. Research on Eurasian Crane distribution, biology, ecology, and conservation status has expanded significantly over the last four decades, as has international cooperation through conferences, training, and publications. Cooperation in marking and monitoring cranes among various countries through databases and websites has advanced our knowledge of the movements, habitat use, and status of the Eurasian Crane.

The **Sandhill Crane** (*Grus canadensis*) has increased from an estimated 520,000 birds in 1996 to around 827,000 birds today. This gain has been largely attributed to increased availability of agricultural grains on migration and wintering areas, but also represents long-term recovery aided by species and habitat protections. In some regions the growing numbers have led to concerns about crop depredation. Successful solutions to crop damage, such as the non-toxic seed treatment anthraquinone (Avipel®), have been developed and deployed at the landscape scale. Currently, Sandhill Cranes are legally hunted in eighteen states and provinces in the United States and Canada. Hunting is closely regulated and monitored to ensure sustainable populations.

Research and monitoring continue to improve our knowledge of population demographics, habitat needs, and harvest impacts. Numbers in the Mid-continent Population were relatively stable from 1982 to the early 2000s and have increased in the last decade. The combined Rocky Mountain, Lower Colorado River, and Central Valley populations of Greater Sandhill Cranes stands at about 32,500. The Eastern Population, at about 95,000, has shown the greatest increase and has been expanding its range eastward; it now occurs from Minnesota to Nova Scotia. Two of the three non-migratory subspecies are endangered. Improved field research has allowed our estimates of the Cuban Sandhill Crane population to increase from 300 in 1996 to 525. The Mississippi Sandhill Crane population has remained small and precarious at an estimated 120 birds in both 1996 and at present. The population of Florida Sandhill Cranes was estimated at 4,000–6,000 in 1996 and at about 4,650 in 2003. Provision of optimal breeding habitat for all the non-migratory subspecies is a major concern.

These brief summaries reflect the remarkable work of hundreds of field researchers, local conservation leaders, and citizen scientists, working in agencies, universities, non-governmental organizations, and communities, in all the places where cranes occur. We can look back over the last two decades with deep gratitude for the continued commitment that allows us to learn from our losses and celebrate our gains. We can appreciate the greater clarity with which we understand the challenges and opportunities before us as we work to secure a resilient future for cranes and the ecosystems they inhabit.

How will future crane conservationists look back upon the work in this strategy? How will they weigh our efforts to address a rapidly changing climate, altered hydrological regimes, intensifying human demands for land and water, and other pressures on the world's cranes? We cannot know, but we can be certain that they will benefit from and build upon from the information we compile and share here. They will have new and different tools to work with. They will develop new policies to attain refined conservation goals. And they will find new ways to further conservation education, work in local communities, and encourage collaboration across boundary lines and landscapes.

In the future the conservation of cranes and biodiversity in general will still ultimately depend on the care and commitment of people. We feel confident that the human heart that will always thrill to the sight and sound of cranes. In 1996 we prepared the Crane Specialist Group's first action plan with the great encouragement of our dear friend and IUCN Species Survival Commission chair, Dr. George Rabb. We bid Dr. Rabb a final farewell in 2017. But his words and his passion remain with us and continue to inspire biodiversity conservation efforts worldwide. In one of his last published statements, he wrote:

> *An ethic of care and caring—such as people manifest for one another, for companion animals and plants, and for favorite places—must be extended to all of nature. Extending the moral scope of care in this way is important because it has the potential to change human behavior on a large scale. The moral and emotional power of care can give new vigor and broaden horizons for conservation.*

With the publication of this Crane Conservation Strategy, the IUCN Crane Specialist Group carries forward the hopes of Dr. Rabb and of so many dedicated colleagues. And we pass along to the next generation of conservationists the tools and knowledge they will need to ensure the survival of cranes and their wetland and grassland homes—and thriving human communities that care for them.

ORIGINS OF THIS STRATEGY

This Strategy was first envisioned by Jim Harris when he took over as Chair of the Crane Specialist Group, and he drove the process until his passing in September 2018. This idea was fully supported in the workshop *Cranes, Agriculture, and Climate Change*, held at Muraviovka Park for Sustainable Land Use, Russia, in 2010. Thirty participants from 14 countries, representing five continents, attended the workshop by invitation of the Crane Specialist Group. The participants recognized the need to update the 1996 *Status Survey and Conservation Action Plan*, drawing together and consolidating an update on cranes, their status and threats, and developing key conservation objectives and actions from around the world.

A second workshop was held in Beijing and Yueyang, China, in December 2012, immediately following the *Crane Protection and Sustainable Agriculture Workshop*. Eighteen specialists continued the work on the Crane Conservation Strategy, reviewing draft actions and priorities for conservation of the world's crane species. They also drew input from the more than 50 crane specialists from 11 countries and four continents, and about 30 others, primarily from academic and research institutions in China, who also attended and participated in discussions in the *Crane Protection and Sustainable Agriculture Workshop*.

Further discussions on the draft Strategy were held in Walsrode, Germany, in November 2014, with 15 members of the Crane Specialist Group representing nine countries and four continents. They critiqued the species reviews and maps that had been drafted and further developed the threat matrix and the objectives and actions for each of the threats.

Throughout the writing process, many of the workshop participants, as well as Crane Specialist Group members and other conservationists from around the world, contributed to sections, provided published and unpublished information, and conducted reviews. Altogether, 31 section authors from the Crane Specialist Group and 191 others reviewed or contributed to the development of this strategic plan.

HOW TO USE THIS PUBLICATION

Reading the Strategy from the beginning to the end will provide the reader with a holistic understanding of cranes around the world. However, most readers will likely have specific interests in a species, region, or issue (threat). The introduction provides a broad overview of the status of and threats to each species. The main reference information is provided up front, designed for rapid assessment and understanding of the status and threats by species:

- A Summary Table of the 15 crane species: taxonomy, delineated populations, subspecies, numbers and trends, and key threats;
- A Threats Matrix Table that ranks the severity of threats for each species;
- Vision Statement for Cranes;
- Overall Goals of this Strategy;
- Objectives and Actions: Identifying actions to address each threat, lead organizations and major contributors, time frame, and relation to IUCN Actions; and
- Monitoring progress and updating the plan.

Two annexes—Threats to Cranes and Species Review— provide detailed accounts that provide information supporting the earlier sections. Nineteen direct (proximate) threats are identified and discussed; indirect (ultimate) threats are also examined. The Threat sections are cross-referenced to guide the reader to related information. The Species Reviews summarize the species distribution and status of key sites, ecology, numbers and trends, threats, conservation and research efforts underway, changes since 1996, and priorities for conservation actions (conservation actions, research and monitoring).

Annex 3 provides a list of acronyms used throughout this publication (see page 449).

VISION STATEMENT FOR CRANES

The Crane Specialist Group works toward a future when populations of all 15 species of cranes are stable or increasing, and each species is reproducing well on protected, ecologically healthy habitats with minimum conflicts with people. Stopover sites offer secure habitats along the flyways even in years of drought or flood, while each species winters (or spends the dry season) at multiple sites where the cranes disperse over extensive foraging areas. Cranes enrich the cultures and conservation awareness among peoples of five continents, leading to effective conservation commitments at local, national, and regional scales.

OVERALL GOALS FOR CRANES

1. Crane populations are viable in the wild with sufficient genetic and demographic variability.
2. Healthy wetlands, grasslands, and agricultural systems on which cranes depend are sufficient to meet the breeding, wintering, roosting, and staging requirements of the species.
3. Healthy watersheds provide the timing, quantity, and quality of water necessary to sustain the ecosystems on which cranes depend.
4. The flyways that cranes traverse provide safe passage between breeding, roosting, staging, and wintering grounds.
5. Knowledge important to the protection and management of cranes and crane landscapes is continuously acquired and translated into conservation action.
6. Conservation policies that safeguard cranes and/or crane landscapes are enacted, enforced, and supported by agencies, industries, or others involved in natural resources development.
7. Conservation leadership is engaged and communicates effectively with decision makers, other stakeholders, and the general public on behalf of cranes and/or crane landscapes.
8. Communities realize improved livelihoods and other benefits (including cultural and spiritual values) from the sustainable management of cranes and/or crane landscapes.
9. Diverse groups of people work together (including scientists, government, non-government, citizens, and other stakeholders) for conservation and management based on their appreciation of the inherent values of cranes and/or crane landscapes.
10. Strong public awareness supports the conservation of cranes and crane landscapes.

SUMMARY OF THE 15 SPECIES OF CRANES: THEIR POPULATIONS, SUBSPECIES, DISTRIBUTION, NUMBERS, AND KEY THREATS

Populations are mainly delineated by flyways. Estimated population size is the most recent numbers available, up through spring 2018. IUCN Red List categories: CR = Critically endangered, E = Endangered, V = Vulnerable, LC = Least Concern. NA = not applicable. To indicate regional area: n. = northern, e. = eastern, w. = western, s. = southern, ne. = northeastern, n.-central = north central, etc.

Taxonomy for cranes follows Krajewski et al. (2010); refer to individual species accounts for subspecies taxonomies. Following publication of the *HBW [Handbook of the Birds of the World] and BirdLife International Illustrated Checklist of the Birds of the World* (del Hoyo et al. 2014), BirdLife International proposed modification of the scientific and common names for several crane species as well as for many other waterbirds. Four species of cranes (Sarus Crane, Brolga, White-naped Crane, and Sandhill Crane) were moved from the genus *Grus* to a new genus *Antigone*. However, we endorse, and have used in this report, the conclusions in Krajewski et al. (2010), the latest published research on the phylogeny on all 15 crane species and will do so until there is supporting evidence for the reclassification.

IUCN Red List Status	Species	Population	Subspecies	Distribution	Estimated population size in the wild up to Spring 2018	Current Trend	Key threats
CR	**Siberian Crane** ***Leucogeranus leucogeranus***			Asia	3,600–4,000	Overall probably stable	Habitat loss, especially due to changing hydrology
		East Asia		NE Siberia to Lower Yangtze River Basin	3,600–4,000	Probably stable	Habitat loss, especially due to changing hydrology
		Western/ Central Asia[a]		Central and West Siberia to India or Caspian Sea	10–20	Almost extirpated	Hunting
EN	**Whooping Crane** ***Grus americana***			North America	689	Increasing	Hydrological changes to wintering habitat, sea-level rise, power line collisions, genetic issues (small population size)
	Whooping Crane ***Grus americana***	Aransas-Wood Buffalo[b]		Northwest Territories, Canada, to Texas, USA	505		Hydrological changes to wintering habitat, sea-level rise, power-line collisions, genetic issues (small population size)
		Eastern Migratory[c]		Eastern USA	103		Illegal take, low reproductive success
		Louisiana[c]		Louisiana, USA	67		Illegal take
		Florida[c]		Florida, USA	14		Low reproductive success, power-line collisions
EN	**Red-crowned Crane** ***Grus japonensis***			NE Asia	2,800–3,430	Increasing	Habitat loss, changes in hydrology and agriculture, poisoning
		Continental		NE China, far-eastern Russia to coastal China and Korean Peninsula	1,580–1,830	Stable to increasing, but declining in China	Habitat loss, disturbance, changes in agriculture, poisoning
		Island		Japanese Islands of Hokkaido and Kunashiri	1,600	Increasing	Habitat loss, power-line collisions
EN	**Grey Crowned Crane** ***Balearica regulorum***			East and South Africa	26,500–33,500	Decreasing	Habitat loss and degradation, disturbance illegal trade, poisoning, power-line collisions
		East Africa	*B. r. gibbericeps*	East Africa (Uganda to Zimbabwe)	19,500–26,000	Decreasing	Habitat loss and degradation, disturbance illegal trade, poisoning, power-line collisions

IUCN Red List Status	Species	Population	Subspecies	Distribution	Estimated population size in the wild	Current Trend	Key threats
	Grey Crowned Crane ***Balearica regulorum***	Southern Africa	*B. r. regulorum*	South Africa, Zimbabwe, Mozambique	7,000–7,500	Increasing in South Africa, declining some areas	Habitat loss and degradation, disturbance illegal trade, poisoning, power-line collisions
VUL	**White-naped Crane** ***Grus vipio***			NE Asia	7,000-7,800	(d)	Habitat loss, especially due to changing hydrology, poisoning; power-line collisions
		Eastern		Winter in Republic of Korea and Izumi, Japan	5,500–6,500	Increasing	Habitat loss, agricultural intensification, disease risks
		Western		Winter in mid-Yangtze Basin, China	>1,000	Decreasing	Drought, disturbance, habitat loss due to changing hydrology due to water diversions, poisoning
VUL	**Wattled Crane** ***Bugeranus carunculatus***			East and South Africa	>9,600	Probably decreasing	Habitat loss, especially due to changing hydrology; increasing human population and development
		South-central		Botswana, Zambia, and Mozambique	9,100	Likely stable	Habitat loss and changing hydrology due to dams and water diversions, invasive species, illegal take, increasing human population and development
		South African		South Africa	380	Increasing	Habitat loss and degradation, disturbance, power-line collisions
	Wattled Crane ***Bugeranus carunculatus***	Ethiopian		Ethiopia	250–300	Stable to increasing	Habitat loss and degradation, invasive species
VUL	**Black-necked Crane** ***Grus nigricollis***			Central Asia	10,000–10,200	Increasing	Habitat loss and degradation in part related to climate change, changing and intensification of agricultural practices; increasing human populations
		Eastern		NE Yunnan and NW Guizhou Provinces, China	3,700	Stable	Habitat loss and degradation, overgrazing, disturbance
		Central		NW Yunnan	230–300	Stable	Habitat loss and degradation, disturbance
		Western		South-central Tibet and Bhutan	6,000	Increasing	Habitat loss and degradation, overgrazing, tree plantations
VUL	**Hooded Crane** ***Grus monacha***			NE Asia	14,500–16,000	Increasing	Habitat loss, disease risk (high concentrations at remaining winter sites)
VUL	**Sarus Crane** ***Grus antigone***			South Asia and Australia	15,000–20,000[e]	Stable or decreasing	Habitat loss, changes in agricultural practices, changes in hydrology
		South Asia	*G. a. antigone*	India and Nepal	8,000–10,000	Uncertain	Habitat loss due to changing and intensification of agricultural practices, changes in hydrology, power-line collisions

IUCN Red List Status	Species	Population	Subspecies	Distribution	Estimated population size in the wild	Current Trend	Key threats
	Sarus Crane ***Grus antigone***	China-Myanmar	Gradation of characteristics between *G. a. antigone* and *G. a. sharpii*	China, Myanmar	300–400[e]	Stable	Habitat loss due to changing and intensification of agricultural practices wetland conversion
		Lower Mekong Basin	*G. a. sharpii*	Cambodia, Vietnam	250	Decreasing	Habitat loss due to changing and intensification of agricultural practices, wetland conversion, deforestation, contaminants
		Australia	*G. a. gillae*	NE Australia	5,000–10,000[e]	Uncertain	Changing and intensification of agricultural practices
VUL	**Blue Crane** ***Anthropoides paradiseus***			South Africa, Namibia	25,000 –30,000	Increasing	Changes in agricultural practices, power-line collisions, grassland conversion, illegal trade
		Western Cape		Western Cape Province, South Africa	(e)	Increasing	Changes in agricultural practices, power-line collisions, grassland conversion, illegal trade
		Karoo		Northern Cape, Southern Free State, and Eastern Cape Provinces of South Africa	(e)	Stable	Changes in agricultural practices, power-line collisions, grassland conversion, illegal trade, poisoning
	Blue Crane ***Anthropoides paradiseus***	Grasslands		KwaZulu-Natal, Mpumulanga and NE Free State Provinces of South Africa	(e)	Stable	Changes in agricultural practices, power-line collisions, grassland conversion, illegal trade
		Namibian		Namibia	23	Decreasing	Changes in agricultural practices, power-line collisions, grassland conversion, illegal trade
VUL	**Black Crowned Crane** ***Balearica pavonina***			West Africa, Sudan, Ethiopia	43,000–70,000[e]	Decreasing	Habitat loss, including desertification, illegal trade
		West African	*B. p. pavonina*	West Africa, Chad	15,000	Decreasing	Habitat loss, including desertification, illegal trade
		Sudan	*B. p. ceciliae*	Sudan, Ethiopia	28,000–55,000[e]	Decreasing	Habitat loss, including desertification, illegal trade
VUL	**Brolga** ***Grus rubicunda***			Australia, New Guinea	50,000–100,000[e]	Unknown; decreasing in parts of its range	Habitat loss and degradation due to changes in agricultural practices, changes in hydrology due to water diversions
		Northern Australia		Northern Australia	~51,800	Stable	Habitat loss and degradation due to changes in agricultural practices, changes in hydrology due to water diversions
		Southeastern Australia		SE Australia	(e)	Decreasing	Habitat loss and degradation due to changes in agricultural practices, changes in hydrology due to water diversions
		New Guinea		New Guinea	(e)	Unknown	Unknown
		Southeastern Australia		SE Australia	(e)	Decreasing	Habitat loss and degradation due to changes in agricultural practices, changes in hydrology due to water diversions
		New Guinea		New Guinea	(e)	Unknown	Unknown

IUCN Red List Status	Species	Population	Subspecies	Distribution	Estimated population size in the wild	Current Trend	Key threats
LC	**Demoiselle Crane** ***Anthropoides virgo***			Eurasia, some winter in Africa	170,000–220,000	Probably decreasing	Habitat loss including desertification, changes in agricultural practices, hunting, power-line collisions
		European		Ukraine, Crimea, western Russian provinces, some wintering in East Africa	45,00–58,000	Decreasing	Habitat loss including desertification, changes in agricultural practices, hunting
		Kazakhstan and Central Asian		Kazakhstan, central Russia, winter on Indian subcontinent	57,000–67,000	Decreasing	Habitat loss including desertification, changes in agricultural practices, hunting, power-line collisions
		East Asian		East Siberian provinces of Russia, Mongolia, Northern China; winter on Indian subcontinent	65,000–98,000	Decreasing	Habitat loss including desertification, changes in agricultural practices, power-line collisions
		Atlas Plateau of northern Africa		Morocco, Tunis, and Algeria	Likely extirpated	–	–
		Eastern Turkey		Eastern Turkey	Likely extirpated	–	–
LC	**Eurasian Crane** ***Grus grus***			Eurasia, some winter in Africa	>700,000	Increasing	Habitat loss and degradation due to changing and intensification of agriculture
		Western[f]	*G. g. grus*	Scandanavia, Europe, Western Russia	590,000	Increasing	Habitat loss and degradation due to changing and intensification of agriculture, poisoning
		Eastern	*G. g. lilfordi*		110,000–112,000	Mixed	Habitat loss, changing and intensification of agriculture, poisoning, power-line collisions
		Transcaucasian	*(G. g. archibaldi)*[g]	Central and Eastern Turkey, Northern Iran	250–300	Decreasing	Habitat loss, changing and intensification of agriculture, hunting
		Tibetan	*(G. g. korelovi)*[g]	Tibetan autonomous regions, Kazakhstan, Kyrgyzstan, and China	1,000	Decreasing	Habitat loss, changing and intensification of agriculture, poisoning
LC	**Sandhill Crane**[h] ***Grus canadensis***			North America, NE Siberia	827,000	Increasing	Habitat loss in some areas, conflicts with agricultural practices
		Eastern	*G. c. tabida*	Eastern USA and Canada	87,000	Increasing	Habitat loss in some areas, conflicts with agricultural practices
		Mid-continent	*G. c. canadensis, G. c. tabida*[i]	Mid-contintent Canada to Mexico	660,000	Stable or increasing	Conflicts with agricultural practices
		Pacific Coast	*G. c. canadensis*[i]	British Columbia, Canada and coastal Alaska, USA, to central Valley of California, USA	41,500	Stable or increasing	Habitat loss in some areas, conflicts with agricultural practices
		Central Valley	*G. c. tabida*	Coastal British Columbia, Canada, and Central Valley, California, SE Oregon	8,500	Increasing	Habitat loss, changes in agriculture
		Lower Colorado River Valley	*G. c. tabida*	Northern Nevada to Southern California	2,500	Stable to increasing	Habitat loss, changes in agriculture
		Rocky Mountain	*G. c. tabida*	Idaho and Montana to North-central Mexico	22,000	Stable or increasing	Habitat loss, changes in agriculture
		Mississippi	*G. c. pratensis*	Mississippi	5,000	Declining	Habitat loss
		Florida	*G. c. pulla*	Florida	120–130	Stable to perhaps increasing	Habitat loss
		Cuba	*G. c. nesiotes*	Cuba	526	Stable to decreasing	Habitat loss

Notes

[a] Population includes unknown number of captive-reared/released birds.

[b] Original wild migratory population.

[c] Reintroduction.

[d] Population trends uncertain and may be attributed to shifting numbers among regions.

[e] Insufficient information to determine status and trends.

[f] Western Population conditionally divided into three subpopulations on the basis of their ecological features and flyways.

[g] Proposed subspecies; not currently recognized (Ilyashenko et al. 2008, 2011).

[h] Geographic distributions of Sandhill Crane populations follow Collins et al. (2015).

[i] We recognize five subspecies (IOC Master list v 8.2): Lesser, Greater, Florida, Mississippi, and Cuban. The Canadian subspecies rowani, earlier identified as part of Mid-Continent and Pacific populations, was found in 2001 to have insignificant genetic differentiation and is included in the Greater subspecies (tabida) (Rhymer et al. 2001).

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ANALYSIS OF KEY THREATS

Most Important Threats to Cranes and Severity of Threat to Each Species

Scoring for severity of threats to each species:

3 = Critical threat (is, or has the potential to be, a major factor in the decline of the population size and/or restriction in the species range).

2 = Significant threat (is, or has the potential to be, an important though not leading factor in the decline of the population size and/or restriction in the species range).

1 = Lesser threat (is, or has the potential to be, a detrimental factor in some localities or for some populations, but not with a significant or critical impact on the species as a whole).

1. Direct (proximate) threats

IUCN Threat*	Rank	Most important direct threats to cranes	Resulting stresses on cranes	Black Crowned	Black -necked	Blue	Brolga	Demoiselle	Eurasian	Grey Crowned	Hooded	Red -crowned	Sandhill	Sarus	Siberian	Wattled	White -naped	Whooping	*Total score*
7.2	1	Dams and water diversions (changes in quantity, timing, quality of water)	Altered hydrology (change in time, magnitude, and periodicity of flooding) that affects nesting and roosting habitat and food resources; increased wildfires	2	1	1	1	2	1	2	2	3	1	3	3	3	3	3	*31*
2.1	2	Conversion of wetlands for agriculture and other land development	Render former crane habitats unsuitable for nesting, feeding, roosting, and migration stopovers	2	1	1	1	1	1	3	2	3	1	3	3	1	3	2	*28*
2.1 2.3	3	Unsustainable exploitation of wetlands, including grazing and harvest activities	Disturbance of cranes, reduced habitat quality, reduced food resources	2	1	1	1	1	1	3	1	2	1	3	3	2	2	1	*25*
6.1 6.3	4	Human interference/disturbance, especially at nest sites	Cranes unable to use otherwise suitable habitat, reproductive failure, chick mortality	2	1	2	1	2	1	3	1	2		2	1	2	2	2	*24*
11.4	5	Prolonged drought and desertification, especially related to climate change	Reduced food supplies, increased vulnerability of nests and chicks to predation	3	2	2	2	2	1	1		2		2	2	2	2	2	*24*
2.1	6	Changes in agricultural land use and practices	Interference with feeding/ breeding on agriculture lands; increased exposure to agriculture poisons; altered, reduced, or lost food resources due to cropping practices including monoculture	1	2	3	1	2	1	1	2	2	1	2		1	2	1	*22*
1.1 1.2	7	Urban expansion and land development including mining	Reduced nesting and foraging habitat (e.g. flightless young), increased human disturbance	2	1	2	1			2	2	2	1	2	1	1	2	2	*21*
4.2	8	Collisions and habitat loss associated with utility lines and wind turbines	Mortality, crippling, render former crane habitats unsuitable for nesting, feeding, roosting, and migration stopovers	1	1	3	1	1	1	2	2	2		1	1		2	2	*20*
5.1	9	Illegal take including hunting, trapping, and poisoning	Rare species and regional population impacts	1		1		2	1	1	2	3			2	1	3	2	*19*
5.1	10	Unintentional and intentional poisoning or harassment of cranes related to agriculture	Effects from human responses to crop losses, including shooting or poisoning, or intensive disturbance, that can also affect health of cranes	2		2	1	1	1	2	1	2	1	2			2		*17*
9.1 9.2 9.3	11	Pollution and environmental contamination, including oil development	Impacts on habitat quality (food sources), reduced reproductive fitness and health, mortality associated with chronic exposure, and spill-associated die-offs	1	2				1		2	2		1	2		2	2	*16*
2.1 2.2	12	Conversion of grasslands for agriculture, afforestation, and mining	Reduced breeding and foraging habitat	1	1	2		1	1	1		1	2	1	1	2	2		*16*
5.1	13	Live capture and egg collection for domestication and international commercial trade	Population impacts including mortality, reduced reproductive success, and risks of disease introduction to wild populations; welfare issues	3		2	1	1	1	3		2		1		1	1		*16*

1. Direct (proximate) threats *(continued)*

IUCN Threat*	Rank	Most important direct threats to cranes	Resulting stresses on cranes	Black Crowned	Black -necked	Blue	Brolga	Demoiselle	Eurasian	Grey Crowned	Hooded	Red -crowned	Sandhill	Sarus	Siberian	Wattled	White -naped	Whooping	*Total score*
7.1	14	Impacts of fire on cranes	Mortality of eggs, chicks, and adults; increased predation; nest abandonment	1			1	1	1	1	1	2	1	1		2	2		*14*
8.2 8.1	15	Invasive species	Decreased quality of important habitats including reduced food resources, security and availability of roost and nesting sites, increased risk of predation				1			1	1	2		2	1	2	1	2	*13*
8.1	16	Disease related to increasing densities and human contact	Mortality, reduced fitness, risks from farm regulatory disease control measures					1	1		3	2	1				2	1	*11*
11.1 11.2	17	Loss of coastal habitat due to sea level rise, associated with land subsidence and/or climate change	Cranes must use secondary or artificial habitat, salinity increase in coastal freshwater habitats affecting food resources and drinking water	1			1				1	2		1				3	*9*
8.1 8.2	18	Predation	Often associated with habitat changes-- reproductive failure, population impacts for rare species		1		1	1						1			1	1	*6*
**	19	Genetic and demographic problems of small populations	Reduced reproductive success, decreased resistance to disease									1			1			2	*4*

* IUCN – Conservation Measures Partnership classification of direct threat to biodiversity (Salafsky N, Salzer D, Stattersfield AJ, Hilton-Taylor C, Neugarten R, Butchart SHM, Collen BEN, Cox N, Master LL, O'Connor S, Wilkie D. 2008. A Standard Lexicon for Biodiversity Conservation: Unified Classifications of Threats and Actions. Conservation Biology 22:897–911)

** "Genetic and demographic problems of small populations" is not listed as a threat in IUCN-CMP Threat classification. It fits as a stress since it can result from other direct threats, and it can cause further loss of viability to the population.

2. Indirect (ultimate) threats

Rank	Most important indirect threats to cranes	Resulting stresses on cranes	Black Crowned	Black-necked	Blue	Brolga	Demoiselle	Eurasian	Grey Crowned	Hooded	Red-crowned	Sandhill	Sarus	Siberian	Wattled	White-naped	Whooping	*Total score*
20	Human population density and growth	Driving force for land development, habitat fragmentation, etc.	3	1	2	1	1		3	3	2		3	2	2	2	1	*26*
21	Demand for economic growth and development	Driving force behind dams, diversions, wetland and upland development, pesticide use, etc.	1	1	2		1		2	2	2	1	3	3	2	2	3	*25*
22	Lack of knowledge/ awareness/public support	Results in poor land-use and development choices by policy-makers and communities	2	1	2	1	1	1	2	1	2		1	2	2	2	2	*22*
23	Lack of local conservation leadership for cranes and wetlands	Common obstacle to stewardship of local crane populations and habitat resources	3	1	1	1	1		2	1	2		2	2	2	2		*20*
24	Warfare and political instability	Reduced enforcement of laws protecting habitats and cranes; habitat degradation, poaching	3	1			1	1	1	1	2		2	1	1	2		*17*
25	Poverty and lack of livelihood alternatives	Can result in over-exploitation of wetland and grassland resources, poaching, etc.	3		1				3		1		3	2	3	1		*17*
26	Lack of effective legislation, administration, and enforcement	Inadequate protection of cranes and critical habitats	2	1	1		1		2	1	2		1	2	1	2		*15*
27	Loss of traditional values and ties to land	Contributes to unsustainable land-use practices	2	2	1		1	1	2		2		2			1		*14*

OBJECTIVES AND ACTIONS TO ADDRESS DIRECT (PROXIMATE) THREATS

Actions are proposed to address threats for the upcoming five-year period. Lead organizations are indicated in bold. See Acronyms section for organizational names. A new list of actions will be developed at the beginning of the next five-year period. A number of the activities will require long-term interventions and will continue beyond five years.

Objectives are categorized as related primarily to water, grasslands or agriculture, human activities, and other. Types of actions are highlighted by color as research and monitoring, direct conservation actions, and education/awareness/workshops. Main actions are highlighted in bold.

Threat/Objective type	Action category
Related to water	Research, modeling, and monitoring
Related to grassland and agriculture	Direct conservation action
Related to other human activities	Policy, planning, and legislation
Other	Education, awareness, workshops, and publications

Threat 1. Dams and water diversions (changes in quantity, timing, quality of water)

Objective: Environmental flows and other solutions improve habitats for cranes and human livelihoods in some of the most important river basins in the world—the Amur, Yangtze, Lower Mekong, and Upper Ganges of Asia; the Zambezi and Upper Nile of Africa; and the Guadalupe and Platte in North America.

Threat 1. Dams and water diversions (changes in quantity, timing, quality of water)			
Action	**Time scale**	**Lead organizations and major contributors**	**IUCN Action**
1.1 Develop a handbook on water management for crane conservation, including case studies, and summarize lessons learned and best practices		**ICF** U.S. Geological Survey	9.2
1.2 Develop, implement and monitor environmental flows in at least three critical crane/wetland complexes whose hydrological health is threatened	Years 1–5		1.2 Also 1.1, 6.4, 8.1/8.2
1.2.1 Design and implement solution for environmental flows to meet the need of Whooping Cranes and other species in the Guadalupe-San Antonio River basin and bay	Year 3	**The Meadows Center for Water and the Environment** Harte Research Institute ICF Other partners	1.2

Threat 1. Dams and water diversions (changes in quantity, timing, quality of water)			
Action	**Time scale**	**Lead organizations and major contributors**	**IUCN Action**
1.2.2 Institutionalize environmental flows plan for Zambezi River basin, with emphasis on Kafue Flats (Zambia) phase one and Zambezi Delta (Mozambique) phase two	Years 3 (Kafue), Year 5 (Zambezi Delta)	**ICF** **WWF** Regional universities Other partners	7.1, 6.4
1.2.3 Develop water management plan and implement it (including recommended infrastructure) for wetlands in Momoge National Nature Reserve in China	Year 1 (develop); Years 2–5 (implement)	**RIFEEP** Momoge NNR	6.4, 1.1, 6.5
1.3 Develop and publish scenarios for the impact of climate change on water security for cranes and for adaptation to increase resilience of natural and human communities living at or near crane sites			8.1, 5.1
1.3.1 Publish Climate Change Adaptation Plans for Momoge and Tumuji NNRs in China	Year 2	**RIFEEP** ICF Momoge and Tumuji NNRs	8.1, 5.1
1.3.2 Publish Climate Change Adaptation Plans for Zambezi River basin in southern Africa	Years 3–5	**ICF** **WWF**	8.1, 5.1
1.3.3 Publish Climate Change Adaptation Plans for Mekong River basin in southeast Asia	By year 3	**ICF** Mekong University network	8.1, 5.1
1.3.4 Publish Climate Change Adaptation Plans for Environmental flows for coastal Whooping Crane wintering grounds	Years 3–5	**San Antonio Bay Partnership (SABP)** ICF Other partners	8.1, 5.1
1.4 Be ready to work with hydropower planners, as the opportunities arise, to design new dams that facilitate water releases and other measures to reduce downriver impacts on wetlands and cranes	Years 1–5 (ongoing)	**ICF** **WWF** (committed to act when the opportunity arises)	6.5 Also 10.3, 5.2, 1.2
1.5 Hold workshop on water management and cranes to evaluate past efforts and plan next steps	Year 5	**ICF** U.S. Geological Survey	8.2, 9.2
1.6 Work with protected area authorities at Momoge and Xianghai National Nature Reserves in northeast China to implement demonstration projects for managing water to provide roosting and foraging habitat for cranes. (See also action 5.3 below)	Years 2–5	**RIFEEP** Momoge NNR Xianghai NNR	1.2

Threat 2. Conversion of wetlands for agriculture and other land development
Objective: Wetlands significant to cranes are identified and protected while degraded wetlands formerly used by threatened species are restored, involving communities in the stewardship of key sites. Intensifying agricultural development renders former crane habitats unsuitable for nesting, feeding, roosting, or migration stopovers. This threat is critical for six species of threatened cranes: Grey Crowned, Red-crowned, Sarus, Siberian, Wattled, and White-naped cranes.

Threat 2. Conversion of wetlands for agriculture and other land development			
Action	**Time scale**	**Leading organization; contributors**	**IUCN Action**
2.1 Secure or enhance protection status to 2–3 of the most significant unprotected wetlands for each of the six most affected crane species or develop community-based conservation programs at these sites	Two additional sites per year during years 1–5		6.1 or 3.1, 5.2
2.1.1 Grey Crowned Crane		**ICF / Endangered Wildlife Trust (EWT) Partnership**	6.1 or 3.1, 5.2
2.1.2 Red-crowned Crane		**ICF and Red-crowned Crane Conservancy**	6.1 or 3.1, 5.2
2.1.3 Sarus Crane		**ICF/Nature Conservation Fund India (NCF) Partnership**	6.1 or 3.1, 5.2
2.1.4 Siberian Crane		**RIFEEP**	6.1 or 3.1, 5.2
2.1.5 Wattled Crane		ICF/EWT Partnership	6.1 or 3.1, 5.2
2.1.6 White-naped Crane		**BFU (China)** **Wildlife Science and Conservation Center of Mongolia (WSCC)** WWF-Mongolia; **Daursky State Nature Reserve** ICF (Russia)	6.1 or 3.1, 5.2
2.2 Water releases and other management efforts to restore locations significant for the crane species most affected by agricultural conversion			1.2
2.2.1 Compile a list of candidate sites for restoration	By year 2	**ICF/EWT Partnership** Red-crowned Crane Conservancy ICF/NCF Partnership WSCC and Daursky State Nature Reserve	1.2, 6.4

Threat 2. Conversion of wetlands for agriculture and other land development			
Action	**Time scale**	**Leading organization; contributors**	**IUCN Action**
2.2.2 Restoration initiated at three sites	By year 5	Partners to be identified in year 3	1.2
2.3 Advocate for national policies and enforcement protecting wetlands from agricultural development. With tangible achievements in seven countries	Year 1–5	**ICF/NCF Partnership (India)** **Crane Working Group of Eurasia (Russia)** **ICF/EWT Partnership** (with partners to be identified for Kenya, Uganda, South Africa, Zambia)	7.2, 4.3
2.4 Develop and disseminate practical handbook regarding agricultural issues for crane and wetland managers and conservation practitioners	Years 1	**ICF/EWT Partnership** U.S. Geological Survey	3.1, 9.2
2.5 Develop guidelines for Best Management Practices for wetland restoration and management to increase wetland habitat values for cranes and other waterbirds	Year 5	**RIFEEP**, ICF	5.2, 1.2, 7.2, 9.2

Threat 3. Unsustainable exploitation of wetlands, including grazing and harvest activities

Objective: Sites where exploitation affects significant numbers of threatened cranes are identified, and a holistic conservation response for a dozen sites are designed and implementation begun within five years, with measured benefits to crane reproduction and/or numbers within 10 years.

Seven threatened species of cranes are significantly affected, with Sarus and Siberian facing the highest threat from this factor. Given the widespread nature of this threat, demonstration projects will be developed for the most threatened species (at least two for each of the seven species), with results disseminated.

Threat 3. Unsustainable exploitation of wetlands, including grazing and harvest activities			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
3.1 Implement community-based wetland conservation and management projects at the ten most important breeding grounds for Grey Crowned Crane, targeting at least 30% of the East African subspecies, with crane numbers stabilized at the sites	One to two sites initiated per year, all 10 underway by year 10	**ICF/EWT Partnership** with national and local partners	5.2, 1.1
3.2 Identify through surveys the ten most important breeding grounds for Black Crowned Cranes	By year 4	**ICF/EWT Partnership** Wetlands International BirdLife International National partners	8.1
3.2.1 Initiate community-based wetland conservation and management projects at two of those sites	Year 5	**ICF/EWT Partnership**	5.2, 1.1
3.3 Improve winter habitat conditions for Siberian Cranes at sub lakes at Poyang Lake through community consultations and water management that balances fish harvests with maintaining suitable water conditions for waterbirds			1.2, 5.1 8.2, 3.1
3.3.1 Complete and then revise water management plan for Poyang Lake National Nature Reserve sub lakes	Year 1, Year 3	**ICF** Poyang Lake National Nature Reserve (PLNNR) Nanchang University	8.2
3.3.2 Begin implementation at one additional sub lake per year	Years 2–5	**PLNNR and Nanjishan NNRs** ICF Local governments	1.2

Threat 3. Unsustainable exploitation of wetlands, including grazing and harvest activities			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
3.4 Implement long-term landscape-scale program in south Asia to alleviate negative impacts different human uses at wetlands important for Sarus Crane foraging, roosting and breeding.		**ICF/NCF Partnership**	1.2, 6.4, 5.1, 5.2, 5.5
3.4.1 In two or more South Asian landscapes, develop descriptive and empirical understanding of impacts of specific human activities (e.g., fishing/ aquaculture; water chestnut cultivation) at wetlands important for cranes, and incorporate findings into state and federal wetland policy to facilitate best practices	Year 1 onwards	**ICF/NCF Partnership**	8.2, 7.2
3.4.2 Implement demonstration projects in landscapes in south Asia where understanding of impacts of human use is high to implement solutions where necessary	Year 1 (1st project), Year 4 (2nd project)	**ICF/NCF Partnership**	8.2, 1.1, 1.2
3.5 Initiate pilot project in Mongolia, to promote sustainable grazing and minimize livestock interference with nesting cranes through exclosures, alternate watering points, and education among herdsmen	Years 1–3	**Wildlife Science and Conservation Center** U.S. Forest Service	2.1, 5.2, 3.1
3.6 Implement demonstration project at Ruoergai, China that promotes health of humans and wildlife on agricultural lands through maintaining traditional land practices and values with a focus on Black-necked Cranes (See also 6.3)	Years 2–5	**ICF** Ruoergai NNR Sichuan University	1.1, 5.5, 5.2, 2.1

Threat 4. Human interference/disturbance, especially at nest sites

Objective: Breeding success will increase and the available habitats expand during migration, breeding, and winter through awareness programs and more effective patrolling at key locations to reduce disturbance for the most affected species.

While this threat affects all crane species, it has the most significant impact on six threatened species: Siberian, Red-crowned and White-naped Cranes in East Asia, Sarus Cranes in South Asia, and the two species of African crowned cranes.

Threat 4. Human interference/disturbance, especially at nest sites			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
4.1 Identify locations where high disturbance significantly affects distribution and/or breeding success, developing a list by species	By year 2	**ICF** and small team of species experts	8.1
4.2 Develop and implement model project for reducing disturbance at one of the listed sites for each of four species			8.2, 3.1
4.2.1 Action plans developed with indicators	By year 3	**WSCC** (White-naped Crane, Mongolia) **Beijing Forestry University** (BFU) (White-naped Crane, China) **Crane Protection Association** (White-naped Crane, ROK) **ICF/NCF Partnership** (Sarus Cranes, South Asia) ICF/EWT Partnership (African Crowned Cranes)	8.2
4.2.2 Implementation	Years 3–5	Same, with the addition of Red-crowned Crane (**Hui River NNR and ICF**)	8.2, 3.1, 4.3
4.2.3 Evaluation and revision of plan	Year 5	Same	8.2
4.3 Develop booklet or brochure drawn from demonstration sites describing best practice and lessons learned	Year 6	**ICF** and small team of species experts	3.1
4.4 Plan and implement habitat management for Cheorwon (by DMZ, Republic of Korea) and establish community business targeted on Crane eco-tourism	Years 1–2 (2015–2017)	**Korean Ecotourism Korea Society;** Ministry of Environment, Republic of Korea	6.4, 5.1
4.5 Develop visitor management program for two sub lakes at Poyang Lake, with active participation by local communities leading to reduce incidence of cranes in alert posture or flushed by tourists/photographers	Year 1–4	**ICF** PLNNR	5.1, 3.1

Threat 4. Human interference/disturbance, especially at nest sites			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
4.6 Advocate with three regional government agencies in (Zabaikalsky Krai, Amur Region, and Primorski Krai) for strengthened regulations, raise awareness of disturbance associated with legal spring hunting of other species to nesting Red-crowned, White-naped, and Hooded Cranes at five sites in Transbaikalia and Russian Far East, and develop additional deterrents (social pressure) (see also 8.4)	Years 3–5	**CWGE**	7.1, 3.1, 5.5, 4.3
4.7 Advocate for strengthened regulations and raise awareness of disturbance to migrating Red-crowned, White-naped, and Hooded Cranes at two stopover sites	Year 3–5	**MoLEP-DPRK**	7.1, 3.1, 5.5

Threat 5. Prolonged drought and desertification, especially related to climate change

Objective: An action plan for each species where this threat is rated critical or severe will mitigate impacts of drought, desertification, and climate variability/extremes to the extent that population declines are halted or populations remain stable.

Demonstration projects will be disseminated so approaches can be implemented in other areas, and to influence policy. Note that responses to impacts of climate change are addressed in this objective and several others.

Threat 5. Prolonged drought and desertification, especially related to climate change			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
5.1 Address impacts of desertification on Black Crowned Cranes			8.1
5.1.1 Develop holistic management plan based on desertification information, monitoring data of distribution, habitat use, and habitat quality	Year 4	**ICF/EWT Partnership** Wetlands International BirdLife International	6.4
5.2 Manage water for at least two sub lakes within Poyang Lake National Nature Reserve in China to ensure good foraging habitat for Siberian and White-naped Cranes (see Action 2.3), to be followed by two more sub lakes.	Years 1–3 (2 sub lakes) Years 4–5 (2 more sub-lakes)	**PLNNR** with help from ICF	1.1, 1.2
5.3 Implement pilot projects at Momoge and Xianghai NNRs in Songnen Plain of China, leading to water management that ensures foraging habitat in conditions ranging from drought to flood for breeding and migratory cranes (See also action 1.6 above)	Years 2–5 (Momoge) Years 3–5 (Xianghai)	**RIFEEP** Momoge and Xianghai NNRs ICF	1.1, 1.2
5.2.2 Disseminate results and best practice to other wetland reserves in the region	Years 4–5	**RIFEEP**, ICF	3.1, 5.2
5.2.3 Select two other sites in northeast China for replication after year 5	>Year 5	**RIFEEP**, ICF	8.2, 1.1/1.2
5.4 Document impacts of drought in north Africa with a focus on Algeria on wintering success of Eurasian Cranes	Years 1–5	**French Crane Working Group** in cooperation with Algerian universities	8.1
5.4 Locate and assess wetlands most important for Siberian and other migratory cranes in the Keerqin Desert of northeast China and recommend protection measures	Years 13	**ICF**	8.1, 6.1

Threat 6. Changes in agricultural land use and practices

Objective: Land-use practices conducive to persistence of cranes on agricultural landscapes are implemented in areas important to threatened cranes.

Most species of cranes benefit from finding extensive foraging habitat on farmlands but changing markets and farming practices can render these lands unsuitable for cranes. This threat is most significant to the Blue Crane, as the vast majority of its population depends on the mosaics of habitats in intensively farmed wheat-growing regions of South Africa

Threat 6. Changes in agricultural land use and practices			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
6.1 Develop handbook that summarizes key information and conservation best practices related to cranes on agricultural landscapes (same as 2.4)			3.1, 9.2
6.1.1 Assess the larger forces driving change on agricultural landscapes, such as global and local economic trends, social factors and climate change, and how these challenges might be addressed	Year 1	**U.S. Geological Survey** ICF/EWT Partnership	8.1
6.1.2 Summarize current knowledge on the effects of specific farming practices on cranes, including level of mechanization, pesticides, crop selection, and disturbance	Year 1	**EWT** U.S. Geological Survey ICF	8.1
6.1.3 Develop guidelines for farmers and ranchers encouraging holistic management that considers needs of cranes and other wildlife while acknowledging need for profitability	Years 1–2	**ICF/EWT Partnership** U.S. Geological Survey	3.1, 5.1
6.1.4 Publish and disseminate handbook	Year 2	**ICF**	3.1
6.1.5 Develop two brochures based on the handbook for farmers (one for commercial agriculture, the other for subsistence agriculture)	Year 2	**ICF** U.S. Geological Survey	3.1
6.2 Conduct long-term studies of habitat selection, foraging behavior, and local movements of cranes on farming landscapes and disseminate results and recommendations to improved land use practices or for conservation action	On-going		8.1, 3.1, 7.2
6.2.1 On breeding population of Sandhill Cranes, Wisconsin, USA, disseminate results through publication of three papers	Ongoing; by year 5 (publications)	**ICF**	8.1

Threat 6. Changes in agricultural land use and practices			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
6.2.2 On Eurasian Cranes (year round in W. Europe), publish one paper per year in local language articles in German, French, Spanish, and Estonian with English abstracts and provide reports to governments and members of the crane protection groups documenting impacts on cranes	Years 2–5	**European Crane Working Group** and national groups in Europe	8.1, 3.1
6.2.3 On Blue Cranes in Western Cape, South Africa, publish results	By Year 5	**EWT** Overberg Crane Group	8.1
6.3 Implement demonstration project that promotes health of humans and wildlife on agricultural lands through maintaining traditional land practices and values with a focus on Sarus Cranes in Ganges Plain, South Asia (See also 3.7.)		**ICF/NCF Partnership**	1.1, 5.2, 5.5
6.3.1 Assess and measure factors leading to changes in agricultural practices, particularly stressors on these landscapes (e.g., mercury accumulation), and determine impacts on vital population rates of Sarus Cranes (e.g., breeding success) (see also Objective 9 below)	Years 1–5	**ICF/NCF Partnership** South Asia Institute of Technology (Hyderabad)	8.1
6.3.2 Determine degree of change in agricultural practices over time in 8–10 landscapes in South Asia covering 700 Sarus Crane pairs, and measure impacts on population parameters of Sarus.	Years 1–5	**ICF/NCF Partnership**	8.1
6.3.3 Publish and disseminate results, and initiate process with governments to develop policy to incorporate agricultural landscapes with Sarus as areas important for wildlife conservation	Years 2–5	**ICF/NCF Partnership**	3.1
6.4 Conduct population and habitat assessment for Sarus Cranes in agricultural landscapes of Myanmar	Years 1–3	**ICF**, Yangon University, WCS	8.1
6.5 Send request to local governmental agencies with strong rationale to limit expansion of the greenhouse and ginseng fields in Cheorwon and Yeoncheon, Republic of Korea; follow up with additional communications	Years 1–2	**Korean Crane Network**	7.1
6.6 Communicate with local government and farm leaders to limit usage of agricultural chemicals including pesticides, DPRK at selected project site	Year 2–3	**MoLEP-DPRK**	3.1

Threat 7. Urban expansion and land development including mining

Objective: Integrated strategies at key sites address threats of land development for each of the five most sensitive species (East Asia: Red-crowned, White-naped and Hooded Cranes; North America: Whooping Crane; South Asia: Sarus Crane).

Threat 7. Urban expansion and land development including mining			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
7.1 Identify and evaluate crane habitat areas of current and potential habitat loss, and select for action one or more significant sites for each of the five target species	Years 2–3	**ICF** with regional partners (East Asia) **ICF** and USFWS (North America) **ICF/NCF Partnership** (South Asia)	8.1, 6.4
7.2 Develop or update awareness materials for each species or area highlighting: the values of wetlands at risk to people, cranes and other wildlife; the threats; and an array of conservation solutions	Year 3	**ICF** and local partners (East Asia) **ICF** and TPWD (North America) **ICF/NCF Partnership** (South Asia) **MoLEP** (DPRK)	3.1
7.3 Propose protected area status, or other means of protection—such as zoning, inclusion in water recharge zones, community-based reserves—for crane habitats in these locations	Year 4	Same as above and **Korean Crane Network** (for Republic of Korea)	6.4
7.3.1 Secure enhanced protection for 1–2 areas for each species	Year 6	Same as above	6.4
7.3.2 Recommend alternative feeding sites for White-naped Cranes in Gimpo and Imjin River estuary	Year 3	**Korean Crane Network**	6.4
7.4 Identify and implement alternative strategies for financing and protecting five key crane sites in Africa from development (conservation offsets, community reserves, eco-compensation)	Years 1–5 (initiate at least one each year)	**ICF/EWT** with local partners	6.4, 5, 6.1
7.5 Implement land acquisition program to secure coastal Texas habitat for Whooping Cranes to achieve recovery goals	Years 1–5	**USFWS** TPWD Coastal Bend and Bays Estuaries Program (CBBNEP) ICF and local partners	6.1

Threat 7. Urban expansion and land development including mining			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
7.6 Develop a land acquisition program to secure dry-season habitats for Sarus Cranes in the Mekong River Delta	Years 3–5	ICF Birdlife International, Waterfowl & Wetland Trust (WWT)	6.1-4

Threat 8. Collisions and habitat loss associated with utility lines and wind turbines

Objective: Research on impacts of the energy sector including (1) crane interactions with power lines and wind farms, (2) electrocutions and other causes of mortality, and (3) related habitat loss and disturbance will guide future activities and enhance strategic decision-making by both individuals and organizations, reducing impacts on cranes.

Affects 12 species with critical impacts on Blue and Whooping Cranes, and significant impacts on Grey Crowned, Hooded, Red-crowned, White-naped, and Sarus. The Blue Crane already experiences considerable mortality from power line collisions while future development of wind farms within its core range will be intense. Electrification of rural Africa will put African crane species increasingly at risk. For hydropower, see Objective 1.

Threat 8. Collisions and habitat loss associated with utility lines and wind turbines			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
8.1 Facilitate a network of 30 scientists, managers, and energy specialists to gather and disseminate information about power-line and wind farm impacts, monitoring results, and mitigation measures widely among conservation practitioners, utility managers, and relevant officials	Ongoing	**Power Line Network** coordinated by EWT Feathers Environmental Services	10.3, 8.1, 9.2
8.2 Conduct study to evaluate the effectiveness of different power-line marking devices to reduce crane mortality	Years 4–5	**EWT and ESKOM** (South African Electric Utility Company) Local crane working Groups in Spain, France, Germany NABU in Germany	8.1
8.3 Identify top hotspots for affected crane species due to crane/energy interactions	By Year 2	Power Line Network **EWT/ICF Partnership** ICF/NCF Partnership	8.1
8.4 Implement pro-active mitigation at top five hotspots for power-line collisions, reducing crane mortality by at least 10% at each site	Year 5	**EWT** with national partners Power Line Network	5.2, 2.1
8.5 Reduce Blue Crane mortality due to power line collisions by 20%	Years 1–5		2.1
8.5.1 Complete study on Blue Crane movements and habitat selection on the Western Cape landscape, as a basis for developing a proactive mitigation plan for Blue Cranes within 4 years	Years 1–4	**EWT**	8.2, 2.1
8.5.2 Identify and implement measures to reduce mortality due to power lines and wind farms at five key locations	Years 4–5	**EWT** ESKOM	8.2, 2.1, 5.2

Threat 8. Collisions and habitat loss associated with utility lines and wind turbines			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
8.6 Provide data to inform decisions on placement of new power lines or wind turbines to reduce Whooping Cranes mortality along the Central Flyway of the USA			8.1, 7.2, 7.3
8.6.1 Build and apply a habitat suitability model (in the Central Flyway of USA)	Year 2–5	**ICF**, USFWS, CWS, USGS	8.1, 7.2, 7.3
8.6.2 Distribute habitat suitability model data layer to decision makers	Year 5	**ICF**, WCRT ABC	8.1, 7.2, 7.3
8.7 Publish briefing document and action plan to understand and mitigate crane interactions with electrical infrastructure	Year 2	**EWT**, Feathers Environmental Services, ICF/NCF Partnership, Regional representatives for North America, Europe, and Asia	9.2, 6.4

Threat 9. Illegal take including hunting, trapping, and poisoning

Objective: Impacts of harvest on crane populations will be reduced by identifying and targeting hotspots of illegal hunting and poisoning and by increasing research, monitoring, and education to ensure sustainable harvest levels in areas where hunting is permitted.

Thirteen species are known to be affected, with significant impacts on Whooping, White-naped, Red-crowned, Siberian, Hooded, Black Crowned, Grey Crowned, and Demoiselle Cranes.

Threat 9. Illegal take including hunting, trapping, and poisoning			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
9.1 Establish Hunting & Poisoning Work Team and collaborate with other Hunting or Poisoning Work Groups	Year 1	**Hunting and Poisoning Work Team under Crane Working Group of Eurasia (CWGE),** in collaboration with International Union for Conservation of Nature (IUCN), Convention on Migratory Species of Wild Animals (CMS), and African-Eurasian Waterbird Agreement (AEWA)	10.3
9.2 Identify priority hotspots for illegal hunting of Whooping, White-naped, Red-crowned, and other cranes through literature review, consultation with experts, and tracking and monitoring efforts	Years 1–2	**Hunting and Poisoning Work Team**	8.1
9.3 Develop strong local crane hunting networks (crane working groups, legal hunting groups) in three priority areas and share and disseminate information	Years 1–2	**ICF** with state agencies (Whooping Crane) CWGE (in Central Asia and Russia Far East)	10.3, 3.1
9.4 Implement awareness programs to reduce illegal hunting and poisoning of cranes at five priority areas through hunter education, alliances with farmers addressing solutions to crop depredation, and media campaigns	Years 3–5	**ICF** (northeast China and central North America) **CWGE** (Central Asia and Russian Far East) ICF/EWT (East Africa)	3.1, 10.3
9.5 Develop guidelines for rehabilitating poisoned cranes and distribute to relevant agencies	Years 2–3	**ICF** with Chinese partners	2.1, 6.6

Threat 9. Illegal take including hunting, trapping, and poisoning			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
9.6 For four priority areas, advocate strengthening enforcement and raise awareness of existing laws and penalties (fines, jail time) for illegal hunting and develop additional deterrents (social pressure) (see also 4.5)	Years 1–3 (Whooping Crane and Hui River); Years 3–5 (CWGE)	**ICF** with state agencies (Whooping Crane) **CWGE** (Eurasian, Siberian, and Demoiselle Cranes-Central Asia) **CWGE** (Red-crowned, White-naped and Hooded Cranes-Russian Far East) **ICF** with Hui River NNR (Red-crowned and White-naped Cranes)	4.1, 4.2, 4.3, 3.1
9.7 Conduct study to estimate the impact of poisoning on threatened crane species and identify strategies using local actions on key sites and national laws and international treaties to minimize mortalities	Years 2–4	**ICF/EWT Partnership** (Blue Crane in South Africa; Grey Crowned Crane in Kenya)	8.1, 6.4, 7.1
9.8 Reduce indirect disturbance to cranes associated with hunting of other species, at five sites, especially during spring hunting in Asia, through collaboration with hunting agencies and hunter education		**CWGE**	10.3, 3,1
9.8.1 Develop a model management and monitoring strategy intended to initiate and guide efforts to reduce indirect impacts to cranes through regulation of a sustainable, well-managed hunt of legal species	Year 2	**CWGE**	6.4
9.8.2 Begin trial actions based on the strategy	Year 3	**CWGE**	8.1, 2,1
9.8.3 Closely monitor impacts on crane reproduction over a 10-year period (compared to baseline established in Years 2–3)	Years 4–13	**CWGE**	8.2
9.9 Conduct a test/demonstration project with one private game property that does not follow existing management regulations to redirect them from illegal hunting to cooperation	Years 2–5	**CWGE**	8.1, 5.2, 3.1

Threat 10. Unintentional and intentional poisoning or harassment of cranes related to agriculture
Objective: Crop deterrents and a variety of other preventive measures minimize shooting, poisoning, and harassment of cranes due to crop depredation. Cranes cause low levels of crop damage in many areas, but this strategy addresses damage hotspots and demonstration of effective ways to minimize or prevent crop damage, so that proven tools and strategies are available for use elsewhere.

Threat 10. Unintentional and intentional poisoning or harassment of cranes related to agriculture			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
10.1 Compile data or conduct research on damage to crops caused by cranes (i.e., type of crops and timing / growth phase of damage)			8.1
10.1.1 For Grey Crowned Cranes on subsistence agriculture in East Africa	Years 2–3	**ICF/EWT Partnership**	8.1
10.2 Demonstrate economic viability and procure government approval for commercial use of Anthraquinone as a crop deterrent for use on seeds			8.1, 7.2
10.2.1 United States [achieved in 2018]	Year 1	**ICF**	8.1, 7.2
10.2.2 South Africa (Grey Crowned and Blue Cranes)	Years 1–3	**ICF/EWT Partnership**	8.1, 7.2
10.2 Implement a pilot project in East Africa to develop and demonstrate effective preventive response to crop damage for subsistence farmers	Years 3–5	**ICF/EWT Partnership** and national partner	5.1, 5.2
10.3 Disseminate lessons and best practices for methods to reduce conflicts between cranes and farmers through handbook on cranes and agriculture (same also Actions 2.4 and 6.1)	Years 2–4,	**ICF/EWT Partnership** and U.S. Geological Survey	3.1
10.4 Prepare two short publications to disseminate findings and recommendations derived from the guide for cranes and agriculture	Years 3–5	**ICF/EWT Partnership** and U.S. Geological Survey	9.2

Threat 11. Pollution and environmental contamination, including oil development

Objective: The impacts on cranes and their habitats of both pollution events (e.g., oil spills) and chronic exposure to contaminants (e.g., agricultural pesticides, heavy metals) will be investigated; increased understanding of these risks will help awareness, advocacy, and conservation planning efforts to reduce the long term effects on crane populations.

Environmental contaminants can have both direct and indirect impacts on cranes. Degradation of water and habitat quality can impact food availability. Acute exposure to toxic chemicals can cause mortality events, and chronic exposure can result in reduced reproductive fitness, hormonal abnormalities, and immunologic compromise. Contaminants are considered an emerging threat for most crane species; currently there are particular concerns for Whooping Cranes at risk from oil industry activities near their wintering and breeding sites as well as for Asian and African cranes using landscapes where agricultural chemical use is increasing, and crane landscapes where mining development is increasing.

Threat 11. Pollution and environmental contamination, including oil development			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
11.1 Assess severity of environmental contaminant exposure and impact for threatened crane species and key crane habitats			8.1
11.1.1 Gather and compile reports on known cases of morbidity or mortality from contaminant exposure	Years 1–5	**Hunting and Poisoning Work Team**	8.1
11.1.2 Select four high risk sites and implement research projects to evaluate the environmental contamination (including mercury accumulation) and crane exposure (e.g., agricultural landscapes in East and South Asia, wetlands in Southeast Asia, areas of energy development in North America)	Years 2–5	**ICF** (Whooping) **ICF/NCF Partnership** (Sarus) **Wildlife Science and Conservation Center of Mongolia** ICF (White-naped) Muraviovka Park (White-naped and Red-crowned) U.S. Geological Survey Mekong University Network (Sarus)	8.1
11.1.3 Develop and share basic protocols for investigation and laboratory analysis of suspected crane poisoning cases	Year 3–5	**ICF**	8.1, 9.2
11.2 If environmental contaminants emerge as a significant threat, convene a workshop to share information, discuss, formulate mitigation strategies, and outline both the review and call to action		**ICF** Partner to be determined	10.3, 9,2, 6.4

Threat 11. Pollution and environmental contamination, including oil development			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
11.2.1 Produce a comprehensive review (white paper) on environmental contaminant issues for cranes, followed by an executive summary and call to action for conservation managers and decision-makers	Year 5	**ICF** Workshop participants	8.1, 7.1, 7.2
11.2.2 Identify a resource list of those working on crane contaminants issues and collaborating technical experts in relevant fields (water quality, agricultural chemical use, toxicology, etc.)	Years 1–5	**ICF** Workshop participants	10.3, 9.2

Threat 12. Conversion of grasslands for agriculture, afforestation, and other development

Objective: Highly important grassland areas for cranes will be protected in order to prevent negative impacts on crane populations.

In many regions, cranes have adapted to changes in grasslands to farmlands, but three species of threatened cranes—Blue, Wattled, and White-naped—have experienced declines through loss of foraging habitat or impacts of grassland conversion on adjacent wetland breeding locations. The still widespread Demoiselle Crane appears to be declining in significant parts of its range, in part due to loss of grassland habitat.

Threat 12. Conversion of grasslands for agriculture, afforestation, and other development			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
12.1 Assess and address conservation needs for grasslands important to the western subpopulation of White-naped Cranes			8.1, 6.4
12.1.1 Identify conservation needs for grassland habitats for breeding, migratory, and wintering habitats of the western subpopulation	Years 1–2	**ICF** **WSCC** **BFU** Chinese Academy of Science (CAS)	8.1
12.1.2 Advocate for and implement protection measures on the Daurian steppes for this subpopulation	Years 1–4	**WSCC** U.S. Forest Service ICF	7.2, 6.4, 6.1
12.1.3 Develop recommendations and advocate for protection measures on migratory stopovers at Duolin, Miyun and other key stopover sites	Years 2–5	**BFU** ICF CAS	6.4, 7.1/7.2
12.1.4 Advocate for and implement protection measures for grassland habitats at Poyang Lake	Years 2–5	**PLNNR** ICF BFU	7.2, 1
12.2 Assess and address conservation needs for grasslands important to the northeastern subpopulation of Blue Cranes	Years 2–3	**EWT**	8.1, 6.4, 1.1

Threat 12. Conversion of grasslands for agriculture, afforestation, and other development			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
12.2.1 Secure at least 150,000 ha of suitable grassland habitat under the Biodiversity Stewardship Programme in South Africa	Years 1–5	**EWT** ICF Mpumalanga Tourism and Parks Agency Ezemvelo KwaZulu-Natal Wildlife Eastern Cape Parks and Tourism	6.1
12.2.2 Secure at least 100,000 ha of important grassland sites from unsustainable development in South Africa under the Protected Area network, in collaboration with private and communal landowners	Years 1–5	**EWT** ICF Mpumalanga Tourism and Parks Agency Ezemvelo KwaZulu-Natal Wildlife Eastern Cape Parks and Tourism	6.1, 10.3
12.2.3 Identify and secure at least two important sites in the grassy Karoo	Years 3–5	**EWT**	8.1, 6.1
12.3 Monitor four subpopulations of Demoiselle Cranes as well as the grasslands and croplands they depend upon		**Crane Working Group of Eurasia** (CWGE)	8.1
12.3.1 Compile and disseminate results of monitoring	Annually	**CWGE**	8.1
12.3.2 Assemble specialists and evaluate status and trends for this species and its habitats	Year 5	**CWGE**	8.1
12.4 Monitor two subpopulations of Eurasian Cranes as well as the grasslands and croplands they depend upon			8.1
12.4.1 Assess and disseminate impacts of changing agriculture practices towards monoculture in industrial grasslands on food availability for staging cranes at Baltic Sea and effects on breeding success in Germany	Years 1–4	**German Crane Working Group**	8.1
12.4.2 Seek agreements with farmers using the Agri-Environmental Programme of the EU, in the process determining the number of farmers and number of hectares under current contracts	Years 1–5	**French Crane Working Group**	3.1, 5.2

Threat 13. Live capture and egg collection for domestication and international commercial trade

Objective: Impacts of captive crane trade on wild Grey and Black Crowned Cranes and other crane species are reduced to a sustainable level (no negative impact on the wild population).

Requires research, monitoring and mitigation measures that target local supply and demand, regional trade networks, and global demand; must work through CITES and national governments to strengthen and enforce trade laws.

Threat 13. Live capture and egg collection for domestication and international commercial trade			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
13.1 Ensure that legal trade in wild birds does not contribute to the decline of the population			2, 3, 4, 7, 8
13.1.1 Actively support maintaining suspension of legal trade until CITES conditions have been met	Annually for the CITES CoP or CITES Animal Committee meeting (whichever is relevant)	**ICF/EWT Partnership** National partners for Tanzania, Guinea, Sudan and South Sudan (range countries in Significant Trade Review) Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)	7.2
13.1.2 Where legal trade has reopened, introduce and advocate for a universal identification of traded birds	Develop a protocol within Year 1; Advocate for its implementation Years 2–5	**ICF/EWT Partnership** AEWA Signatories to AEWA	7.1, 3.1
13.1.3 Identify target groups, implement strategy to raise awareness of the detrimental impact of trade upon a declining population	Year 2	**ICF/EWT Partnership** National partners	8.1, 3.1
13.2 Reduce the illegal trade taking place			4.1, 4.3

Threat 13. Live capture and egg collection for domestication and international commercial trade			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
13.2.1 Implement studbooks and regional management plans for Grey Crowned and Black Crowned Cranes under managed zoo associations	Years 1–5 Years 1–5 Years 2–5 Years 2–5	**Association of Zoos and Aquariums** (AZA) **Chinese Association of Zoological Gardens** (CAZG) **European Association of Zoos and Aquaria** (EAZA) **Pan African Association of Zoos and Aquaria** (PAAZAB)	2.3
13.2.2 Conduct a review of legislation as it relates to crane trade in East Africa and provide the relevant government representatives responsible for wildlife trade with a report which clearly outlines gaps in the legislation or areas that need strengthening. This could include increased penalties for illegal trade of Grey Crowned Cranes	Years 2–3	**ICF/EWT Partnership** AEWA focal points in Kenya, Uganda, Rwanda. Tanzania	7.1, 8.1
13.2.3 Finalize a CITES Non-Detriment Finding Report for Grey Crowned Cranes in South Africa	Years 1– 2	**EWT** ICF/EWT Partnership South African National Biodiversity Institute Relevant South African provincial conservation authorities	7.2, 2.1
13.2.4 Understand the barriers to law enforcement in East Africa and develop and implement a plan to address these so that law enforcement of regulations on illegal trade is strengthened	Years 1–2 (develop plan); Years 2–4 (implement plan)	**ICF/EWT Partnership** AEWA Focal Points Relevant government conservation agencies responsible for managing wildlife trade	7.1, 7.2, 7.4

Threat 13. Live capture and egg collection for domestication and international commercial trade			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
13.2.5 Conduct training workshops in Kenya, Uganda, and Rwanda leading to improved enforcement of laws, successful prosecutions, and actions taken within the judicial systems, customs, and other enforcement agencies based on improved understanding of the illegal trade of cranes	Years 1–3	**ICF/EWT Partnership** working with Community Action for Nature Conservation and Kenya Wildlife Society Nature Uganda and Ministry of Tourism Wildlife and Rwanda Wildlife Conservation Association Rwandan Development Board	7.1-7.4
13.2.6 Raise awareness within at least three local communities in Kenya, Uganda, and Rwanda of the illegality of Grey Crowned Crane trade	Years 1–5 (tangible activities each year for each country)	**Kipsaina Crane Conservation Group** (Kenya) **Nature Uganda** (Uganda) Rwandan Development Board and **Kitabi College of Conservation and Environmental Management** (Rwanda) ICF/EWT Partnership	3.1
13.2.7 Develop and implement an effective system to manage and control birds already in captivity in Rwanda and Uganda	Years 1–5	**Rwanda Wildlife Conservation Association** Rwanda Development Board **Nature Uganda** Uganda Ministry of Tourism, Wildlife and Antiquities NGOs Zoo associations	2.3, 6.4
13.3 Conduct research on the market chain through the UAE for both Grey and Black Crowned Cranes	Years 1–3	**ICF/EWT Partnership**	8.2
13.3.1 Conduct investigation of sources of demand for wild caught crowned cranes including specifically private aviculturists and zoos and wildlife parks outside the formal zoo associations	Years 1–3	**ICF/EWT Partnership**	8.2, 2.3

Threat 13. Live capture and egg collection for domestication and international commercial trade			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
13.3.2 Based on results of the investigation, develop and implement action plan for reducing demand targeted at main sources of demand	Year 3 (develop plan) Years 4–5 (implement plan)	ICF/EWT Partnership	2.3

Threat 14. Impacts of fire on cranes

Objective: Impacts of fires on crane reproduction are significantly reduced by identifying hotspots, improved fire management methods, and public education.

This threat could become more significant with climate change. Species and locations most at risk include: Red-crowned and White-naped Cranes on their breeding grounds in the Amur-Heilong River Basin in Russia, Demoiselle in steppe and semi-desert areas of Russia and Kazakhstan, Sarus Crane in South-East Asia, and Wattled Crane in the flood plains of the Zambezi Delta in South-Central Africa and in South Africa.

Threat 14. Impacts of fire on cranes			
Action	**Time scale**	**Lead organization; major contributors**	**IUNC Action**
14.1 Develop brochure that summarizes fire impacts on cranes and management solutions, for use by specialists as they advise protected areas and other officials for each of the sites where cranes are affected by wild fires	Year 3	Muraviovka Park (in Russian) ICF/EWT Partnership (in English)	3.1
14.2 Conduct demonstration projects on fire management at three hotspots that are implemented by local management agencies. Crane Specialist Group members assist in monitoring and disseminating results			3.1, 8.1, 9.2
14.2.1 Red-crowned and White-naped Cranes in Amur-Heilong Basin Russia	Years 1–4	Muraviovka Park	3.1, 8.1, 9.2
14.2.2 Sarus Cranes in South Asia	Year 4	ICF/NCF Partnership	3.1, 8.1, 9.2
14.2.3 Wattled Cranes in Zambia	Year 4	ICF/EWT Partnership	3.1, 8.1, 9.2
14.3 Conduct a field study to evaluate the risks of wildfire on Sarus Crane nesting and reproductive success in northern Cambodia	Year 5	ICF Mekong University Network	8.2

Threat 15. Invasive species

Objective: Negative impacts from invasive species upon significant crane habitats are reduced through monitoring, testing and implementation of control measures, and dissemination of results through the Crane Specialist Group and other networks.

Recommended actions address invasive species currently significant to threatened crane species and set up a mechanism to proactively identify new and potential invasive species threats.

Threat 15. Invasive species			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
15.1 Develop and implement a long-term management plan to control *Mimosa pigra* and other emerging threats and monitor Wattled Crane recovery in Zambia		**ICF/EWT Partnership** Zambian Department of National Parks and Wildlife WWF-Zambia	1.1, 6.4
15.1.1 Revise 2007 plan for management of *Mimosa pigra* at Kafue Flats in Zambia incorporating lessons learned	Year 1	**ICF/EWT Partnership** Zambian Department of National Parks and Wildlife WWF-Zambia	6.4
15.1.2 Clear and maintain cleared areas of *Mimosa pigra* at Kafue Flats in Zambia, with 3000 additional hectares cleared	Years 2–5	**ICF Zambezi Program** Zambia Department of National Parks and Wildlife	1.1
15.1.3 Monitor acres that remain free of *Mimosa pigra* at Kafue Flats in Zambia	Years 3–5	**ICF Zambezi Program** Zambia Department of National Parks and Wildlife	8.1
15.2 Develop and implement a long-term management plan to control *Mimosa pigra* and monitor Wattled Crane population at Boyo Lake, Ethiopia	Years 1–5	**Addis Ababa University** ICF	1.1, 2.1
15.3 Areas of reduced *Mimosa pigra* at Tram Chim and other sites within the Mekong Delta are maintained	Year	**ICF Southeast Asia Program** Tram Chim National Park	1.1
15.4 Test solutions for controlling *Spartina alterniflora* at Yancheng NNR in China	Year 3	**Yancheng NNR**	1.1, 8.2
15.4.1 Apply to 400 ha of tidal marsh	Year 4	**Yancheng NNR**	1.1
15.5 Based on 15.1–15.3, apply control measures used to reduce invasive species threats at another key crane location	Years 5, etc.	**Yellow River Delta NNR**	1.1

Threat 16. Disease related to increasing densities and human contact

Objective: Large concentrations of cranes in close proximity to human communities and domestic animal populations may be at heightened risk of epizootic disease. These populations will be identified, and plans formulated and implemented to reduce that risk at the most critical locations.

Threatened species have shown increased densities due to artificial feeding or habitat management that may be associated with disease risks. Increased flock densities above historic levels in regions with endemic avian diseases of concern to cranes require development of effective strategies to reduce transmission risk and manage potential outbreaks.

Threat 16. Disease related to increasing densities and human contact			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
16.1 Reduce risk of disease at artificial feeding sites used by threatened species			2.1
16.1.1 Alter feeding locations and strategies using adaptive management approach to assist dispersion of more cranes throughout historic and current ranges	Years 1–5	**Red-crowned Crane Conservancy** (Hokkaido) **International Hooded and White-naped Cranes Network** (Japan) **Waterbird Network** (Republic of Korea)	2.1
16.1.2 Ensure that feed used meets quality standards to minimize exposure to biotic or abiotic contaminants (mycotoxins, pesticides, etc.)	Years 1–5	**Crane Park Izumi and** Kagoshima University (Japan) Waterbird Network (Republic of Korea)	2.1
16.1.3 Monitor health and research stress for cranes at high- and low-density sites to understand impacts on bird populations, including mortality, and individual immune status and fitness that may affect species reproduction	Years 2–3	**Crane Park Izumi** (with Kagoshima University) **European Crane Working Group** and university partners	2.1, 8.1
16.2 Reduce risk of epizootic disease by conducting high risk site evaluations following Scientific Task Force on Avian Influenza and Wild Birds recommendations	Years 1–3		2.1, 8.1
16.2.1 Conduct epidemiological investigations to identify risks of disease transmission among domestic and wild birds at sensitive sites	Years 1–3	**Crane Park Izumi** and Kagoshima University **Red-crowned Crane Conservancy** with Rakuno and Hokkaido Universities	2.1, 8.1
16.2.2 Create regional disease contingency plans that mitigate impacts of crane disease outbreaks	Years 2–3	**Crane Park Izumi**	2.1

Threat 17. Loss of coastal habitat due to sea level rise, associated with land subsidence and/or climate change

Objective: Effects of sea level rise on Whooping Cranes in coastal Texas and Red-crowned Cranes in coastal China and Japan are evaluated, with plans developed and implemented to mitigate these impacts.

Few cranes depend on tidal wetlands – Whooping Cranes in coastal Texas and Red-crowned Cranes in Japan, Korea, and China, Hooded Cranes to a limited extent in Korea and China. Increased salinity of habitat associated with climate change is listed as a potential threat for Brolga and Sarus Cranes (see species reviews).

Threat 17. Loss of coastal habitat due to sea level rise, associated with land subsidence and/or climate change			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
17.1 Delineate spatial extent and impact of coastal wetland changes from eustatic sea level rise and subsidence within the current and predicted wintering range of Whooping Cranes	Year 3	ICF and USFWS	8.1
17.1.1 Develop action plans for the wintering Whooping Crane population that address habitat protection, freshwater inflows, habitat restoration and monitoring, and illegal shooting	Year 4	ICF and USFWS	6.4, 2.1
17.1.2 Prioritize areas where current and potential remaining Whooping Crane habitats will provide the most contiguous and high quality wintering requirements	Year 5	ICF and USFWS	8.1, 6.4
17.2 Complete research comparing breeding success and behavioral differences between brackish and freshwater habitats used by breeding and foraging Red-crowned Cranes in Japan	Year 3	Red-crowned Crane Conservancy	8.1
17.2.1 Map and assess brackish and freshwater wetlands offering potential breeding habitat for Red-crowned Cranes under conditions of sea level rise	Year 4	Red-crowned Crane Conservancy	8.1
17.2.2 Develop action plan for sustaining current crane populations	Year 5	Red-crowned Crane Conservancy	6.4
17.3 Conduct habitat assessment for Sarus Cranes in the Mekong River Delta	Year 3–5	Mekong University Network, ICF	8.1

Threat 18. Predation

Objective: This threat is not currently significant for any of the crane species. Monitoring of crane populations provides a means to detect emerging threats caused by predators related to invasive species, changes in hydrology, and climate change.

Threat 18. Predation			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
18.1 Document levels of impact and species predating on Eurasian Crane eggs or chicks in Germany including development of techniques using camera traps and telemetry eggs. If successful, techniques will be shared with other crane researchers	Years 1–3	German Crane Working Group	8.1
18.2 Monitor levels of predation by domestic dogs on White-naped and Demoiselle Cranes (eggs and chicks) in the Khurkh River Valley of Mongolia. Predation levels should decline as herders restrict movements and provide more food to their domestic dogs	Years 1–3	WSCC Mongolia	8.1, 3.1, 5.5

Threat 19. Genetic and demographic problems of small populations

Objective: Genetic diversity of small populations of cranes is monitored and managed to maintain viability and fitness on a species level.

The Whooping Crane went through a severe bottleneck and is the only crane for which loss of genetic diversity and demographic problems are a concern on the species level. Populations of other species at risk of reduced fitness include the Western/Central population of Siberian Cranes, the Mississippi Sandhill Crane, Blue Crane in South Africa, and Wattled Crane in South Africa. Captive populations should be well managed to retain genetic and demographic diversity to minimize need to acquire additional birds from the wild.

Threat 19. Genetic and demographic problems of small populations			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
19.1 Maintain a genetically and demographically viable population of Whooping Cranes as a buffer against extinction in the wild and to provide birds to support restoration of wild population			2.1
19.1.1 Under AZA SSP Program approved in 2015, maintain current genetic diversity of >90% for captive breeding program for Whooping Cranes	By Year 5	**AZA** ICF AZA zoos	2.3
19.1.2 Apply results of RAD-TAG research to determine relatedness and refine pedigree analysis for Whooping Cranes	By Year 2	**University of Colorado at Denver** San Diego Zoo ICF	2.2, 2.3
19.1.3 Conduct a Population Viability Analysis (PVA) and then a Population and Habitat Viability Analysis (PHVA) for the wild, captive, and released populations of Whooping Cranes	Year 1 + Year 3 (PVA + PHVA)	**USFWS** Whooping Crane Recovery Team **Conservation Planning Specialist Group** (CPSG) ICF Patuxent Wildlife Research Center	8.1
19.2 Develop and implement regional collection plans for captive cranes identifying species to promote conservation through captive management, propagation, education, research, and engagement in in-situ support	Years 1–5	**Regional Zoo Associations** (AZA, EAZA, CAZG, PAAZAB) In cooperation with relevant local and international governments NGOs, specialist groups, and Gruiformes Taxon Advisory Groups in other regions	2.3, 6.4, 3.1, 8.1

Threat 19. Genetic and demographic problems of small populations			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
19.3 Develop studbooks and masterplans for maintaining viable populations of species targeted for captive management	By Year 1 (studbooks) By Year 5 (masterplans)	AZA EAZA CAZG PAAZAB	2.3, 6.4, 3.1, 8.1

INDIRECT (ULTIMATE) THREATS

Threat 20. Human population density and growth

Objective: The CSG believes that like education and nutrition, family planning is fundamental to human dignity and critical for human health and development. Increasing human pressures are among the many challenges facing planetary health. By harming ecosystems we undermine food and water security and human health, and we threaten habitats and species. Ensuring family planning is available to all who seek it is among the positive actions we must take to lessen these pressures. Integrating reproductive health improvements with sustainable natural resource management is a valuable development approach.

Threat 20. Human population density and growth			
Action	**Time Scale**	**Lead organization; major contributors**	**IUCN Action**
20.1 Integrate reproductive health, including family planning, and health services into conservation projects, partnering with specialists in this field, at sites where human population pressure is a key threat to cranes and wetlands			
20.1.1 Initiate at three key sites for Grey Crowned Cranes	By Year 3, then continuing	ICF/EWT Partnership with **Nature Uganda** (Uganda), **Kipsaina Crane Conservation Group** (Kenya), **Endangered Wildlife Trust** (South Africa)	

Threat 21. Demand for economic growth and development

These two threats, while highly significant for the future of cranes, are beyond the scope of this conservation strategy.

Threat 22. Lack of knowledge, awareness, and public support

Objective: Strategic communications and education activities are an integral part of species action programs; they increase shared understanding among stakeholders of threats and help develop support for effective solutions. Communications and education are effectively used to influence policy beneficial to cranes and their habitats

Threat 22. Lack of knowledge, awareness, and public support			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
22.1 Create a sense of pride/value through ongoing education activities within local communities relating to their natural resources, leading to participation in conservation of cranes and their habitats at three sites each for four species			3.1, 5.1, 5.5
22.1.1 Grey Crowned Cranes in Kenya, Uganda, Rwanda	By Year 3, then continuing	ICF/EWT Partnership with **Nature Uganda** (Uganda), with **Kipsaina Crane Conservation Group** (Kenya), with **Kitabi College of Conservation and Environmental Management** and **Rwanda Wildlife Conservation Association** (Rwanda)	3.1, 5.1, 5.5
22.1.2 Red-crowned Cranes in Japan, Korea	By Year 5	**Red-crowned Crane Conservancy** (Japan), **Korean Crane Network** (Republic of Korea)	3.1, 5.1, 5.5
22.1.3 Siberian Cranes in at Poyang Lake (China) and Yakutia (Russia)	By Year 5	**ICF**, PLNNR, Nanjishan NNRs (China), Sterkh Foundation (Russia)	3.1, 5.1, 5.5
22.1.4 Sarus Cranes in South Asia (Nepal and India)	By Year 5	**ICF/NCF Partnership**	3.1, 5.1, 5.5
22.1.5 Whooping Cranes in USA	By Year 2, then continuing	**ICF**, Auburn University, Wisconsin Department of Natural Resources, USFWS	3.1, 5.1, 5.5

Threat 22. Lack of knowledge, awareness, and public support			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
22.2 Provide education, training, and technical support to assist five local communities to adjust livelihood activities in East and South Africa, benefitting communities, wetlands and their catchments	Years 2–4	**Kipsaina Crane Conservation Group** (Kenya) **Nature Uganda** (Uganda) **Kitabi College of Conservation and Environmental Management** (Rwanda) **BirdLife International** (Zimbabwe) **EWT** (South Africa)	9.2, 5.1, 5.2
22.3 Collect CEPA materials developed under this strategy and make available on-line through the ICF website for the following crane species (Siberian, Red-crowned, White-naped, Black-necked, Whooping, and Grey Crowned)	Year 3	**ICF**	3.1
22.4 Collect information, education and communication materials and distribute to stakeholders and local governments at selected project site	Year 2	**MoLEP** (DPRK)	3.1

Threat 23. Warfare and political instability

This threat, while highly significant for the future of cranes, is beyond the scope of this conservation strategy. Currently, for example, conflict and instability are preventing crane research or conservation in South Sudan, the most important country for Black Crowned Cranes. There are also ongoing risks of loss of foraging and roosting habitat around the Korean Demilitarized Zone for Red-crowned, White-naped, and Hooded Cranes.

Threat 24. Poverty and lack of livelihood alternatives

Objective: Poverty alleviation and development of alternative livelihoods are integrated with other conservation strategies for at least one demonstration site in the following countries: China, Vietnam, Cambodia, India, Nepal, Kenya, Uganda, Rwanda, Zambia, and Zimbabwe

Threat 24. Poverty and lack of livelihood alternatives			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
24.1 Provide training, facilitation, and economic opportunities in combination with ecosystem conservation approaches, resulting in greater income and more diverse livelihoods among select local communities with reduced impact on natural resources			9.2, 5.1-2, 6.4
24.1.1 Initiate at four key sites for Grey Crowned Crane	By Year 3	**Nature Uganda** (Uganda) **Kipsaina Crane Conservation Group** (Kenya) **Kitabi College of Conservation and Environmental Management** (Rwanda)	9.2, 5.1-2, 6.4
24.1.2 Initiate at two key sites for Wattled Crane	By Year 3	**BirdLife International** (Zimbabwe) **ICF/EWT Partnership** Africa Parks (Zambia)	9.2, 5.1-2, 6.4
24.1.3 Initiate at two key sites for Sarus Crane in South Asia and one key site in northern Cambodia	By Year 3	**ICF/NCF Partnership** (India) **ICF/Cambodia Ministry of Environment Partnership**	9.2, 5.1-2, 6.4
24.1.4 Continue to work at Cao Hai for Black-necked Crane	Years 1–5	**Cao Hai Farmers Association** ICF	9.2, 5.1-2, 6.4
24.1.5 Assess each project	3 and 5 years after initiation	Same as above for each project	8.2

Threat 25. Lack of effective legislation, administration and enforcement

Objective: The Crane Specialist Group actively engages in achieving changes in legislation, administration, and enforcement at all levels of government, and through international conventions, to reduce threats and to benefit cranes and their habitats.

For direct threats such as hunting, crane trade, agriculture development, and dams/water diversions, see objectives and actions listed on those pages.

Threat 25. Lack of effective legislation, administration and enforcement			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
25.1 As part of institutional strategic plan review, ICF will consider how to strengthen policy work for cranes, including possibility of employing a part-time or full-time position	Years 1–2	**ICF**	10.1, 4.2, 4.3, 7.1, 7.2
25.1.1 Implement plans for strengthening capacity to influence policies relevant to priority crane conservation	Years 3–5	**ICF**	7.1, 7.2
25.2 Thirty Crane Specialist Group members attend a workshop on methods for affecting policy at local, national, and international scales (to be held in conjunction with a global Crane Specialist Group Workshop)	Year 5	**ICF**	9.2, 10.3
25.3 Crane Specialist Group polls members to evaluate results from the above measures and makes adjustments in its activities	Year 6	**ICF**	8.2
25.4 Develop Sarus Crane conservation action plan for Cambodia and Vietnam	Years1–3	**ICF** Birdlife International, WWT Wildlife Conservation Society (WCS)	6.6
25.5 Develop crane conservation action plan for Myanmar	Years 4–5	**ICF** Yangon University WCS	6.6

Threat 26. Loss of traditional values and ties to the land

This significant threat is addressed in part through other objectives.

Threat 27. Lack of local conservation leadership for cranes and wetlands

Objective: Identify, train, and mentor conservation leaders and networks to work effectively to identify, monitor and reduce threats to cranes and their landscapes.

To be effective crane conservation leaders need confidence, experience, guidance, and support. Networking helps them learn from, inspire, and encourage each other. Key skills may include but are not limited to: conservation planning, evaluation and adaptive management; habitat assessment and management; crane research and monitoring; conservation GIS; community involvement; conservation communications; NGO and community-based organization development and management; financial management; fundraising/grant writing, and in some cases captive management and conservation medicine.

Threat 27. Lack of local conservation leadership for cranes and wetlands			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
27.1 Identify and train conservation leaders for key regions or countries important to cranes			9.2
27.1.1 Mentor 6–8 Zambians as a follow-up to study visit to the USA for training on wetland ecology, conservation communications, conservation planning and evaluation, crane ecology and population monitoring	Years 1–5	**ICF/EWT Partnership**	9.2
27.1.2 Train and provide ongoing mentorship to at least eight East Africans in project management, wetland ecology, conservation planning and evaluation, crane ecology and population monitoring either in the USA, South Africa or on site	Years 2–5 (at least 2 per year)	**ICF/EWT Partnership**	9.2
27.1.3 Bring four Yakutian scientists and managers to Alaska for training in protected are management and applied research	Year 3	Ministry of Nature Protection of Sakha Republic (Yakutia), **Institute for Biological Problems of the Cryolithozone** (Yakutia), reserves in Alaska or China, ICF	9.2, 8.1
27.1.4 Two Ph.D. students and two Master students from Southeast Asia finish their study program under the SUMMERNET project	Year 2	**Mekong Wetland University Network**	9.1, 9.2
27.1.5 Train 4 managers from Poyang Lake NNR in nature reserve and wetland management in USA	Year 2	**ICF**, Poyang Lake NNR	9.2

Threat 27. Lack of local conservation leadership for cranes and wetlands			
Action	**Time scale**	**Lead organization; major contributors**	**IUCN Action**
27.1.6 Develop a cadre of well-trained youth in six localities with good Sarus Crane populations in South Asia (Nepal and India) towards improving long-term monitoring capabilities, identification of key conservation requirements, and implementation of conservation-related activities	Year 2	**ICF/NCF Partnership**	9.2
27.1.7 Train managers and rangers from crane stopover sites in nature reserve and wetland management at two sites	Year 2	**MoLEP**-DPRK (To be confirmed)	9.2
27.2 Develop capacity to train conservation leaders in research and management within regions			9.2
27.2.1 Hold annual workshop under Mekong University Network to train university professors in 8 SE Asian countries on wetland management	Years 1–5	**Mekong University Network** Universities in China, Malaysia, Lao People's Democratic Republic ICF Other partners	9.2, 10.3
27.2.2 Develop a similar wetland management course for natural resource and conservation managers and university faculty in east and southern Africa aimed at improving management of wetlands used by Grey Crowned Cranes throughout their range	Years 3–4	**ICF/EWT Partnership**	9.2
27.3 Develop networks to collaboratively build capacity to protect and manage species or address key threats			10.3
27.3.1 Hold one meeting within a range country every 12–18 months for Siberian, Red-crowned Cranes; every 1–2 years for White-naped, Hooded, Black-necked, and Whooping Cranes	Years 1–5	**CMS Siberian Crane MOU** **Red-crowned network** **Black-necked Crane network** **White-naped Crane network** **Hooded Crane network** **Whooping Crane Recovery Team**	10.3
27.3.2 Hold one meeting every three years for threat based working networks	Year 3	**Power Line Network** **Hunting & Poisoning Work Team** **Wildlife Heath Work Team**	10.3, 2.1

CONSERVATION TOOLS

There are a number of common strategies that are used across the world to conserve cranes. Reintroductions / supplementations, research and monitoring are three that are the most commonly used and considered. Supplementation is a strategy used to bolster small declining populations and reintroductions to establish populations for a species that is severely threatened and / or in a serious decline. Research provides us with an improved understanding of the species and their requirements, and monitoring provides us with information on trends in the populations and also the ability to measure our conservation impact.

Methodologies used for these conservation tools often differ across the regions, each with their own lessons learned and adapted practices. There is a great opportunity therefore for sharing information and lessons learned from each of these methodologies to increase engagement between regions that strengthens approaches and ultimately conservation impact.

Conservation Tool A: Reintroductions

Demonstrate whether or not crane reintroductions can be successful in developing new populations or supplementing small populations at risk

The Whooping Crane is the only threatened crane species for which reintroduction is considered central to its recovery. Other endangered cranes still live in sufficient numbers in the wild to recover through natural reproduction if threats are well managed. Reintroductions aimed at bolstering small subpopulations, or returning a species to portions of its former range, are therefore not listed as global priorities, but can yield valuable lessons.

Conservation Tool A. Reintroductions			
Action	**Time scale**	**Contributors**	**IUCN Action**
A.1 Augment and manage reintroduced populations of Whooping Cranes and achieve reproductive success leading to a sustainable population			2.2
A.1.1 Conduct releases and research, including monitoring released birds, to evaluate potential for sustainability of migratory eastern flyway population	Years 1–5	**Whooping Crane Eastern Partnership**	2.2, 8.2
A.1.2 Conduct releases and research, including monitoring released birds, to evaluate potential for sustainability of non-migratory Louisiana population	Years 1–5	**Louisiana Department of Wildlife and Fisheries** USGS-Louisiana Co-op Unit and Louisiana State University ICF	2.2, 8.2

Conservation Tool A. Reintroductions			
Action	**Time scale**	**Contributors**	**IUCN Action**
A.2 Maintain a captive breeding population of Whooping Cranes to support reintroductions while addressing demographic and genetic goals through a Population and Habitat Viability Analysis (PHVA) and the AZA Species Survival Plan	Years 1–5	**Whooping Crane Recovery Team** ICF Calgary Zoo Audubon Center for Research of Endangered Species, San Antonio Zoo Audubon Nature Institute White Oak Conservation Other zoos	2.3, 8.1, 6.4
A.3 Compile lessons learned, and track and assess conservation value of reintroduction experiments undertaken on national/regional levels to restore threatened sub-populations of cranes	Year 3	**Memorandum of Understanding Concerning Conservation Measures for the Siberian Crane** (**CMS MOU**) (Siberian Cranes in Central Asia) **Kwa-Zulu Natal Crane Foundation** (Wattled Cranes in South Africa) **USFWS** (Mississippi Sandhill Crane) in USA) **Zoological Park Organization** (Sarus Cranes in Thailand) **The Great Crane Project** (Eurasian Cranes in UK) **Beijing Zoo** (Red-crowned Cranes in China)	8.2
A.3.1 Host a global conference on reintroduction techniques for cranes to exchange knowledge, build capacity, and develop leadership, and publish a set of peer-reviewed articles	Year 3	**ICF** with North American Crane Working Group and other institutional supporters (e.g., PWRC, other organizations doing reintroductions)	10.3, 8.1-2

Conservation Tool B. Research and monitoring—All 15 crane species

Research and monitoring provide a solid basis and are applied to conservation planning and action for each of the 15 crane species, documenting changing status, species biology and ecology, emerging threats to cranes and their habitats, and effectiveness of conservation responses as they are implemented.

This objective applies to all 15 species. As the Crane Conservation Strategy seeks to ensure that all crane species are sustained in the wild, the most threatened species have priority. Yet what we learn about the more successful species has important applications for other crane species. Our aim is to strengthen the research capacity for cranes, and dissemination/application in order to solve conservation challenges. Note that numerous research and monitoring activities have been incorporated into the threat sections.

Conservation Tool B. Research and monitoring—All 15 crane species			
Action	**Time scale**	**Leading organization; contributors**	**IUCN Action**
B.1 Formulate and disseminate recommended guidelines for monitoring of cranes and their habitats	Year 2	**ICF**	2.1, 6.4, 9.2
B.2 Hold a workshop every four years to review research relevant to crane conservation and report to the Crane Specialist Group Members on ongoing high priority research needs (to be held in conjunction with a global Crane Specialist Group Workshop)	Year 5	**ICF** Partners to be determined	9.2, 8.1
B.3 Conduct simultaneous winter counts for threatened species of cranes in Asia (Red-crowned, White-naped, Siberian, Hooded, and Black-necked Cranes) and dry season (Sarus Cranes in Vietnam/Cambodia)	Every 1–3 years		8.1
B.3.1 Red-crowned Crane	Every year	**Red-crowned Crane Conservancy** (Hokkaido, Japan) **Korean Crane Network** (Republic of Korea) **Yancheng and Yellow River Delta NNRs** (China)	8.1
B.3.2 Siberian Crane	Every winter (2 counts)	**Poyang Lake NNR**	8.1
B.3.3 White-naped and Hooded Cranes	Every winter	**Izumi Crane Museum** (Japan) **Korean Crane Network** (Republic of Korea) **Poyang Lake NNR** (China)	8.1

Conservation Tool B. Research and monitoring—All 15 crane species			
Action	**Time scale**	**Leading organization; contributors**	**IUCN Action**
B.3.4 Black-necked Crane	Every five years	**RIFEEP** ICF Kunming Institute of Zoology	8.1
B.3.5 Sarus Crane in Vietnam and Cambodia	Every year	**ICF** and local partners	8.1

IMPLEMENTATION, MONITORING PROGRESS, AND UPDATING THE STRATEGY

A conservation strategy is only relevant and of value if it is implemented, reviewed, and revised on a timely basis. With over 350 members in the IUCN Crane Specialist Group (CSG), it is imperative that we provide the framework for implementation, monitoring progress, and adaptive management—and ensure that all members have access to tools and information.

The time frame of this Strategy is five years, starting when it has been finalized and circulated to all CSG members. The actions pertaining to each of the species and for each region will be extracted and sent to the current CSG Steering Committee for further distribution to others working on relevant species or within those regions. A Strategy Task Force will be established, including two representatives per region, to oversee and advocate for the implementation of the Strategy and to train future leaders.

The Crane Conservation Strategy and the specific Objectives and Actions will be available on the IUCN CSG Portal. The Strategy Task Force and all CSG members will be encouraged to provide annual updates on progress made and propose any changes to the Strategy that should be considered; these will be made available online for all CSG members. CSG members will also be encouraged to update the background information from the Strategy, specifically as it relates to the species or threat reviews. All updates will be captured online for all CSG members to contribute.

Every second year, a report on progress made towards the Strategy will be produced and made available online for all CSG members. The Strategy Task Force will be tasked with obtaining information on the progress made within the Task Force member's regions. This report will showcase progress made and will also highlight activities not yet in progress so that a more concerted effort on those areas can be made. Any necessary changes to the Strategy will be made at this time and will include for instance actions that are no longer relevant or possible, and the addition of new actions to address threats that have arisen or have escalated in intensity. A more popular version of the update will be produced and made publicly available within six months of each of the report. The reports in Year 4 will provide the information we require for the Year 4 meeting and help us prepare for the update of the Strategy.

We will bring the members of the Strategy Task Force and CSG Steering Committee to a workshop in the fourth year of the implementation of the Strategy. The aim of this workshop will be to critically evaluate and review progress made, challenges and lessons learned, and adapt the plans accordingly. The workshop will also be used to design the next phase of the strategic planning process, ensuring that the plan for the next five-year period is in place when this Strategic Plan ends.

ANNEX 1.
THREATS TO CRANES

THREAT:

DAMS AND WATER DIVERSIONS (CHANGES IN QUANTITY, TIMING, AND QUALITY OF WATER)

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(with inputs from Rich Beilfuss, Sammy King, Kerryn L. Morrison, Elizabeth Smith, Griffin Shanungu, K S Gopi Sundar, and Triet Tran)

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Over the last century, loss of wetland habitat due to changes in hydrology—whether from impoundment behind dams, reduction in water supply due to diversions, or changes in timing and amounts of seasonal flows—have affected all crane species. The loss of wetlands worldwide has been well documented (Dugan and Jones 1993, Finlayson and Spiers 1999, An et al. 2007), as has the recent re-examination of the benefits and costs that dams bring to river systems, biodiversity, and people living downriver (Constanza et al. 1997, World Commission on Dams 2000, Brander et al. 2006).

Many crane species are adapted to the complex hydrologic conditions of wetland systems to meet their breeding, feeding, and roosting requirements. When dams and water diversions alter the timing, quantity, and quality of water in wetland systems, these hydrological changes in turn impact the plant and animal foods available to the cranes, the availability of vegetation cover and nesting materials for cranes, and the safety of cranes, particularly nests and young, from predation and disturbance. Hydrological degradation, especially more persistent drying conditions, also frequently result in more intensive and widespread fires, destroying nest sites and killing flightless chicks. These problems are exacerbated by climate change in many key crane areas—see, for example, Beilfuss (2012a) for the Zambezi River system in southern Africa, and Beilfuss and Tran (2014) for the Mekong River system in southeast Asia.

The solution to these problems generally involves water releases timed to match natural hydrologic regimes or other measures to restore to the extent possible the natural ecological conditions of the wetlands. The Lower Zambezi River in Mozambique provides a good example of the impacts of a major dam, the Cahora Bassa, and the steps that have been taken to partially restore the ecosystem services threatened by dramatic changes in seasonal flows (Beilfuss and Brown 2006, 2010).

Bento et al. (2007) studied the ecology of the highly aquatic Wattled Cranes in the Zambezi Delta, formerly one of the most important habitats for this Vulnerable species. They found that breeding cranes were limited to a small area on the west side of the delta where rivers coming from the mountains still flooded and supported growth of *Eleocharis*, the main food for these cranes. *Eleocharis* had vanished from the rest of the delta because the Cahora Bassa Dam had greatly reduced the seasonal flooding that drove the ecology of the delta wetlands.

The negative impacts on the cranes would not alone inspire changes in dam management. Bento, Beilfuss, and colleagues also studied the many values of the delta for other important wildlife species, subsistence livelihoods linked to agriculture, grazing, and fisheries, and commercially

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†Deceased.

important industries such as wild-caught prawn production (compiled in Beilfuss and Brown 2006). Their research gave voice to communities that had lost fisheries and flood-dependent agriculture, and convinced government authorities at the national level that adjustments in management of Cahora Bassa could restore ecosystem services to the wildlife and humans while still providing for production of electricity. Two decades of work are aimed at institutionalizing water releases into national water resources management planning, with careful monitoring to demonstrate the resulting ecological and socio-economic benefit streams (Beilfuss 2010, 2012b). Recommendations have also been developed for future water releases that will be needed to mitigate impacts of climate change (Beilfuss 2012a). Comparable efforts are underway for other parts of the Zambezi River basin, including restoration of the vital Kafue Flats in Zambia, home of the largest concentration of Wattled Cranes.

The impact of dams and water diversions can be particularly intense in semi-arid regions, such as southern Texas in the USA or the Songnen Plain of northeast China, where rainfall is highly variable and droughts occur frequently. Innovative water management at the watershed scale is essential to securing important crane areas, even when they are formally protected.

In coastal Texas, USA, changes to freshwater flows in the Guadalupe River system are impacting the only self-sustaining wild population of the Whooping Crane, which winter in and around Aransas National Wildlife Refuge in the Guadalupe Estuary. The Whooping Cranes depend on coastal marshes fed by freshwater inflows from the Guadalupe River system, which mix with saltwater from the Gulf of Mexico to create conditions suited to blue crabs (*Callinectes sapidus*), the main winter food for the cranes. When freshwater inflows drop below certain thresholds, the salinity of these habitats rises so that the blue crabs retreat to deeper water where they are inaccessible to the cranes (Chavez-Ramirez and Wehtje 2012). Further research is also needed to evaluate how the northward expansion of black mangrove (*Avicennia germinans*) into coastal marshes in the Guadalupe River basin are further exacerbated by decreases in freshwater inflows, and how this affects habitat availability for endangered Whooping Cranes.

Historic water policy in Texas allows municipalities, farms, and businesses to take water from rivers, but does not ensure that sufficient water remains in the rivers to maintain habitat for cranes, crabs, oysters, and people who harvest food from the estuaries. Drought is frequent and severe in southern Texas, including the extreme droughts of 2009–2010 that resulted in the deaths of as many as 23 Whooping Cranes; at those times, rights

The single-purpose operation of Cahora Bassa Dam to generate hydropower (top) has greatly reduced the exchange of floodwaters between the Zambezi River and the Zambezi Delta floodplain, altering the timing, duration, and extent of water on the floodplain and resulting in the drying-up of many waterbodies (middle) (Photographer: Rich Beilfuss, International Crane Foundation)

(Bottom) Railways and roads also block water exchanges between rivers and the floodplains they nourish for cranes, other wildlife, and people--such as in the Zambezi Delta, Mozambique (Photographer: Rich Beilfuss, International Crane Foundation)

already granted for water from the Guadalupe River exceed in-stream flows. A diverse community of conservationists, local governments, and businesses dependent on water resources challenged the State of Texas to manage water to preserve the ecological character and ecosystem services of the river estuaries (Beilfuss 2013). Many innovative water solutions are now in exploration, including purchase of water rights and storage of floodwaters in groundwater aquifers for later recovery.

Drought, coupled with water diversions, in the early to mid-2000s, led to the drying out of the entire network of wetlands set aside in protected areas in Songnen Plain (Harris 2009). Through the United Nations Environment Programme/Global Environment Facility Siberian Crane Wetland Project, water management plans were developed in Songnen Plain for several reserves of global importance to cranes and other waterbirds. The largest of these sites, Zhalong, which includes 200,000 hectares of wetland, now receives annual water releases supported by a special fund set up by provincial and city governments. Wetland restoration, however, depends on effective monitoring of water releases and mechanisms to adjust and vary these releases to sustain ecosystem function that is vital for the cranes and other biodiversity.

Canals and roads constructed within Zhalong National Nature Reserve alter water flows in the core area, reducing and fragmenting breeding habitat (Photographer: Liying Su)

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Whooping Cranes on their wintering grounds in coastal Texas, USA, in and near Aransas National Wildlife Refuge in the Guadalupe Estuary;
- Red-crowned and White-naped Cranes on their breeding grounds in the Amur-Heilong River Basin;
- Siberian Cranes at their migratory stopovers in northeast China and their wintering grounds in the mid-Yangtze River Basin;
- Wattled Cranes on large floodplains of the Zambezi River Basin and other large river systems in south-central Africa;
- Sarus Cranes in the Lower Mekong River Basin;
- Black-crowned and Grey Crowned Cranes throughout their range;
- Demoiselle Cranes throughout their range; and
- Hooded Cranes on their breeding range in Yakutia, at migratory stopovers along the Amur-Heilong River Basin, and wintering areas in the Yangtze River Basin; with
- Lesser impacts for Black-necked, Blue, Brolga, Eurasian, and Sandhill Cranes.

KEY RESEARCH AND MONITORING NEEDS

- Ecological studies of the cranes that enable prediction of the effects of changes in hydrology on cranes at specific locations;
- Model projects that demonstrate the methods and benefits of maintaining or restoring ecological flows to important crane sites, including the process of adaptive management;
- For key sites including restored sites, long-term monitoring of wetlands, including water, vegetation and species indicators, so that ecosystem changes can be detected and evaluated, and values of wetlands can be in incorporated into decisions regarding water and land management; and
- Assessment of the impacts of climate change on hydrology and ecosystem function for selected sites, in the context of impacts from current human activities.

PRIORITY CONSERVATION ACTIONS

- Scientific information about cranes and wetlands functions and values incorporated into decisions regarding dams, diversions, and other actions that will change the hydrology of crane habitats — linked to long-term engagement of stakeholders and decision-makers influencing the design and operation of dams and water diversions;
- At locations already impacted, assessment and planning for restoration of ecosystem attributes vital to cranes, wetland function, and provision of ecosystem services;
- Implementation of water management plans that promote wetland restoration, address relevant actions across the watershed, and incorporate monitoring of results to guide adaptive management processes. In addition, demonstrations are needed that incorporate assessment of climate change vulnerability for key species or habitats and actions for climate change adaptation to increase resilience of natural and local human communities; and
- Dissemination of successful case examples and best practice within and among regions.

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THREAT:

CONVERSION OF WETLANDS FOR AGRICULTURE AND OTHER LAND DEVELOPMENT

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Most crane species rely on the vegetative cover, security, and aquatic foods provided by wetlands at some time during their annual cycle, usually during nesting and brood-rearing. Wetlands also are important for providing secure roosting habitat throughout the year. Hence, the availability and quality of wetlands are critical for cranes, influencing their distribution, migration, and reproductive success. Conversion of wetlands was considered the most significant factor affecting cranes around the world when the Crane Action Plan was published in 1996 (Meine and Archibald 1996) and is currently the second most important threat identified affecting cranes after the dams and water diversions. Loss and degradation of wetland habitat are considered a primary factor in population declines of many crane populations (Meine and Archibald 1996; He et al. 2009; Sundar 2009, 2011; Su and Zou 2012; this Strategy).

Conversion of wetlands to agriculture has been ongoing for thousands of years in Asia, Middle East, Africa, and Europe. However, the pace of wetland loss worldwide has accelerated over the last 50–75 years. Wetland losses are believed to be substantial in many regions, but data for systematic quantifications for some regions is very limited or have high levels of uncertainty. Analyses indicate that an estimated 26% of wetlands had been lost to agriculture worldwide by 1985, with greatest losses in Europe, North America, and Asia (Organisation for Economic Co-operation and Development 1995). More recent, regional assessments indicate that overall, long-term wetland losses are much higher: 56% in both Europe and North America, 43% in Africa, and 45% in Asia (Davidson 2014). Losses have been much higher in inland natural wetlands but rates of loss are accelerating for coastal wetlands. In the United States, freshwater wetlands declined by 79% between the 1950s and 2004; 75% of those losses were attributed to drainage for agriculture (Dahl 2005). Wetland conversions in eastern Asia, which supports the greatest diversity of crane species, have been particularly severe. For example, in the Sanjiang Plain of northeastern China, an area which supports eight crane species, the landscape has changed from one dominated by wetlands in the 1980s to one characterized as agricultural fields dissected by a network of canals and ditches with a mosaic of wetlands and grasslands (Zhang et al. 2010). Extensive wetland fragmentation and loss also have occurred along the Siberian Crane's migratory path between its breeding and wintering grounds, largely due to agricultural development (Kanai et al. 2002). For more detailed information on wetland loss and fragmentation, refer to Austin (2018).

Conversion of wetlands to agriculture or other land development entails draining and clearing of wetland vegetation through burning, mowing, or cultivation, eliminating habitat and native foods important for feeding, nesting, and brood-rearing for cranes and other associated fauna. The extent of conversion can vary from total drainage (eliminating hydrological function) and clearing to hydrological impacts alone (e.g., reduced flooding to improve forage and accessibility for livestock grazing). While some agricultural practices may maintain some wetland-like hydrological function or vegetative cover after conversion, the impact to cranes is often substantial. For example, subsistence farmers in parts of Africa convert seasonally flooded wetlands to vegetable gardens that are farmed in both wet and dry seasons, often using a ridge and furrow system. Increased use of drainage, irrigation, sequential cropping, and associated disturbances have resulted in effectively eliminating these wetlands for Black Crowned Cranes and Wattled Cranes and also for wintering Eurasian Cranes in parts of Ethiopia (Nowald et al. 2014, Aynalem et al. 2018).

In the Mekong River basin, Sarus Cranes breed in small natural wetlands located in the dry deciduous Dipterocarp forests in Northern Cambodia. Even though many of these wetlands are located within protected areas, they are highly vulnerable to conversion to farmlands. On the wintering grounds in the Mekong Delta, wetlands that cranes use are also subject to conversion to agricultural uses.

Wetlands converted to rice (*Oryza sativa*) paddy systems retain some characteristics of wetlands, as most rice is grown under flooded conditions, relying on managed water diversion, irrigation, or natural flooding regimes (Elphick 2010, Sundar and Subramanya 2010). Ecologically, flooded rice paddies have lower plant and animal diversity and habitat heterogeneity than natural wetlands, but they can provide wetland-like habitat for cranes and other waterbirds. Cranes and other waterbirds benefit from residual seeds and aquatic biota for foraging. Paddy systems are important to cranes for breeding, migration, wintering, and foraging habitat throughout Asia and Africa as well as in California, USA, where few unmodified wetlands remain. Breeding Sarus Cranes better coexist with agriculture where there is a matrix of natural wetlands and rice paddies (Sundar and Subramanya 2010). Although paddy systems may be a beneficial agricultural use of wetlands for cranes, they can be a "double-edged sword for waterbird conservation" (Elphick 2010). Creation of new paddy systems can contribute to further losses of natural wetlands, either direct loss by conversion or diversion of water away from wetlands into paddies (e.g., Yala Swamp in Kenya, an important breeding ground for crowned cranes; Abila 2002). Intensification of paddy cropping practices (e.g., multiple crops annually, greater use of fertilizers and pesticides, different flooding regimes) may substantially reduce or eliminate the value of those paddies to cranes through reduced flooding; reduce availability of seeds, animal foods, and plant cover; and increase disturbance (Elphick et al. 2010a, b; Sundar and Subramanya 2010). However, alternative rice-paddy management approaches have demonstrated practices that benefit both cranes and farmers. For example, in the Winter-flooded Rice Paddy project, in the Kabukuri-numa wetland in the Miyagi Prefecture, Japan, farmers were able to improve crop productivity by flooding paddies during winter while also creating new roosting sites, dispersing over-concentrated waterbird populations, and increasing biodiversity (Kurechi 2011).

Wetlands converted to aquaculture may retain some benefits to cranes if they are managed as shallow systems. Often, however, development for aquaculture has resulted in fragmentation, eutrophication, and pollution (Ottinger et al. 2016), resulting in declines in mollusks and crustaceans important to foraging cranes (Duning et al. 1996, Ma et al. 1999). Similarly, wetlands converted to fish ponds for pisciculture have reduced use by cranes due to deepening of the wetlands, removal of vegetation, and frequent disturbance by fisherfolk managing the ponds or guarding fish from waterbirds (Sundar et al. 2015). Wetlands altered for aquaculture, however, could be managed to provide productive foraging habitat during most of their working cycle and allow cranes and agricultural activities to co-exist (Duning et al. 1996). For example, in Hungary, staging Eurasian Cranes use large drained fishponds for roosting (Végvári and Tar 2002).

Freshwater floodplain, recessional wetland in the Mekong Delta near Hon Chong, Vietnam, in the early stages of conversion to a shrimp farm on February 28, 2002 (Photographer: Jeb Barzen, International Crane Foundation)

Same wetland on March 10, 2004. After this wetland, and another nearby wetland where cranes roosted, were converted to other uses, Sarus Cranes moved from Hon Chong to Phu My (Vietnam)/Anlung Pring (Cambodia) (Photographer: Jeb Barzen, International Crane Foundation)

As the second-most important threat to crane populations around the world, preventing the conversion of wetlands is critical for crane conservation. Long-term success will necessarily involve conservation at local, regional, and flyway scales. Keys to success are collaborations of avian scientists and conservationists across broad scales to develop population goals, better understanding of habitat conditions and dynamics, and integrated waterbird management across scales. Monitoring and remote sensing programs are tools that can provide critical information at national and global scales to help guide conservation strategies and programs (Jones et al. 2009). For example, a network of protected areas has been identified for the protection of Siberian Cranes across their flyway from Russia to India and Iran (Secretariat of the Convention on the Conservation of Migratory Species of Wild Animals 2011) and key sites in East and Southern Africa have been identified for the conservation of Grey Crowned Cranes (African-Eurasian Migratory Waterbird Agreement 2015). International and regional conventions, treaties, and agreements are important for identifying priority areas to protect, sharing data, collaborating at regional and flyway or international scales, and building capacities for large-scale bird and habitat conservation. Important to all such programs and policies is the ability to identify geographic extent, status, and use of habitat, where and how it is threatened by agricultural conversion or other land development, and where actions would best be implemented.

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Grey Crowned Cranes throughout their range, but particularly in East Africa;
- Red-crowned Cranes throughout their range, but critical concerns focus on breeding and wintering grounds in Sanjiang Plain and other parts of northeast China, elsewhere in the Amur River Basin, and near the Korean DMZ;
- Sarus Cranes in India, Nepal, Myanmar, Mekong Delta, and Australia;
- Siberian Cranes on staging areas in northeast China, and wintering areas, particularly Poyang and Dongting Lakes;
- White-naped Cranes breeding in the Amur River basin including the Sanjiang Plain, and other parts of northeastern China, migration areas in the Korean DMZ, and wintering areas on Poyang and Dongting Lakes;
- Black Crowned Cranes throughout their range, exacerbated by drought;
- Hooded Cranes on wintering areas, particularly in Republic of Korea (South Korea) and Japan;
- Wattled Cranes in South Africa, Ethiopia, and Zimbabwe;
- Eurasian Cranes wintering in Ethiopia; and
- Whooping Cranes throughout their migration and wintering range; with
- Lesser impacts to Black-necked, Blue, Demoiselle, Sandhill, and Wattled Cranes.

RESEARCH AND MONITORING NEEDS

- Support the development and sustainability of regional and global wetland monitoring programs to identify areas important to crane species that are most at risk for wetland conversion, with a focus on regions with threatened and endangered species;
- Identify critical wetlands used by cranes within their flyway and across their range, and understand

the factors driving wetland conversion in those areas to guide development and implementation of effective mitigation measures;

- Continue and expand cooperative research on the impact of agriculture and land use practices on wetland function and risk of conversion to identify or develop programs and practices that benefit both cranes and farmers;
- Study the impact of various practices used in rice paddy systems to identify and develop practices that benefit both cranes and farmers;
- For crane populations in Southeast Asia and Myanmar/China, complete basic research that inventories, maps, and better understands rainy and dry-season wetlands important to these crane populations; and
- Improve enforcement of existing laws and agreements protecting wetland habitats from conversion and fragmentation.

PRIORITY CONSERVATION ACTIONS

- Support efforts to develop and/or implement national-level wetland conservation plans. This is important in all countries, but especially in China, India, Nepal, Vietnam, Laos, Cambodia, Mongolia, and Russia;
- Support efforts to develop and implement wetland conservation strategies for Poyang and Dongting Lakes, Sanjiang Plain, Daurian basin, and other key wetlands in China;
- Support efforts to develop and implement local level wetland conservation and management plans that benefit both cranes and people in sub-Saharan Africa and Southeast Asia, while concurrently building local capacity and knowledge in wetland management;
- Improve understanding of wetland ecosystems, and develop and test approaches to wetland management for conservation and sustainable resource extraction, in partnership with local institutions in countries within the range of Sarus Cranes, particularly India, Nepal, Myanmar, Cambodia, Vietnam, and Australia, and support traditional practices that assist in retaining crane populations alongside human use of wetlands;
- Address the conservation needs of cranes under the East Asian-Australasian Flyway Partnership, an umbrella international agreement for the conservation of the migratory cranes of East Asia (Japan, Russia, China, Mongolia, Democratic People's Republic of Korea [North Korea], and Republic of Korea [South Korea]);
- Address wetland conservation needs of Grey Crowned Cranes, and potentially Black Crowned Cranes, under the African Eurasian Migratory Waterbird Agreement;
- Implement the World Wildlife Fund's Amur-Heilong Basin Program and support further international efforts to integrate conservation and development goals in the basin;
- Seek legal protection from conversion for wetlands on the Korean Peninsula including the Choelwon Basin, Democratic People's Republic of Korea; and
- Encourage implementation of paddy, pisciculture, and aquaculture management approaches that can benefit both cranes and farmers.

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THREAT:

UNSUSTAINABLE EXPLOITATION OF WETLANDS, INCLUDING GRAZING AND PLANT HARVESTING ACTIVITIES

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Cranes have thrived in landscapes containing wetlands over millennia (Meine and Archibald 1996). Low-intensity utilization of wetland resources, especially plants useful to human communities, often did not significantly alter the ecological and hydrological attributes of wetlands that are necessary for cranes to breed successfully. This helped maintain ecological and hydrological conditions that were conducive for the persistence of viable crane breeding and foraging habitats, contributing to the coexistence of humans and cranes (Harris 1994). However, the growing demand for food, water, and plant materials by the ever-increasing human population over the years resulted in increased utilization pressure on wetlands, leading to the alteration to degradation and loss of wetlands (Junk 2002, van Asselen et al. 2013). This is a global environmental challenge that continues to threaten the ecological integrity of wetlands in landscapes and regions that define the geographical range of cranes in Africa and Asia, much to the detriment of breeding habitats of cranes (Meine and Archibald 1996, Austin 2018).

Unsustainable exploitation of wetland resources results in excessive removal of natural plant cover by humans overgrazing their livestock (Davies and Froend 1999, Mekonnen and Aticho 2011) or reed harvesting and commonly leads to alteration of wetland vegetation structure and hydrological functions that in turn affects the breeding productivity of cranes (Morrison 2015, Olupot 2017). Unsustainable exploitation of wetlands, as is the case with most natural resources, occurs when plant resources are extracted in a way that hinders the natural recovery of the wetland biota or ecosystem functions (Peres 2010). This compromises the wetland system's capacity to provide habitats for wildlife and natural products and services that people require to sustain their livelihoods (Barbier 1993, Schyut 2005). This phenomenon, often driven by excessive harvesting of plants and poor grazing management systems, is increasingly becoming a major threat to crane habitats in areas where local communities depend on wetland plants for craft making, construction, and livestock grazing in East Africa (Olupot 2017, Mekonnen and Aticho 2011, Morrison 2015) and South East Asia (Triet 2010, Song et al. 2014).

INDICATORS OF UNSUSTAINABLE EXPLOITATION

The indicators of unsustainable exploitation of wetlands vary, depending on the wetland's biophysical characteristics. They include structural changes in biophysical characteristics (e.g., vegetation structure and composition) (Fennesy et al. 2007, Middleton et al. 2006), which in turn affects the natural functions of the wetland (Moreno-Mateos et al. 2012). Vegetation type and cover has an influence on both surface water and groundwater hydrology of wetlands (Stromberg and Richter 1996, Yu and Ehrenfeld 2010). This implies plant communities and water conditions provide the basis for developing indicators of unsustainable exploitation of wetlands (Fennesy et al. 2007). Changes

Unsustainable exploitation due to overgrazing by large livestock herds in restricted pastures in Khurkh Valley leads to compaction and hummocking. The right side of fence shows potential for recovery with managed grazing. (Photographer: Nyambayar Batbayar, Wildlife Science and Conservation Center of Mongolia)

in the natural functions can be conceptualized as secondary effects, which are often manifested by a reduction in capacity to provide ecosystem services such as the provision of wildlife habitats or flood attenuation (Zedler and Kercher 2004). These indicators can be in the form of visible and easily identifiable changes observable around the site or patches where the unsustainable exploitation is taking place. They can also be discerned from downstream impacts such as changes in water quality (e.g., increased turbidity) and siltation of rivers and dams emanating from accelerated erosion in catchments containing wetlands affected by unsustainable exploitation (Gleason and Euliss 1998). In cases where unsustainable exploitation is a direct result of extensive removal of particular species, which may be a result of selective harvesting by local communities and grazing of palatable grass by livestock from a wetland, it may ultimately lead to opportunistic colonization by non-native species (Rapport and Whitford 1999, Zedler and Kercher 2004). In addition to vegetation structural changes, unsustainable exploitation due to overgrazing due to large livestock herds grazing in restricted pastures, with limited or no rotation, may also result in temporary or long-term soil compaction (Kakuru et al. 2013, Morris and Reich 2013). This may inhibit or slow down the regeneration of native grass.

IMPACTS ON CRANES AND OTHER WETLAND-DEPENDENT SPECIES

Primarily, ecological and hydrological changes caused by unsustainable exploitation of wetlands have negative impacts on habitat size and quality. This, in turn, affects negatively the breeding productivity and foraging patterns for wetland-dependent species (Zhaoli 2005, Song et al. 2014). Hence, the ultimate result is a reduction in species diversity and abundance. Unsustainable exploitation of wetlands affects ecological requirements of wetland-dependent species from both spatial and temporal perspectives. Extensive removal of plants from sections of a wetland fragments habitats and may in the long run lead to reduction in overall areal extent of wetland habitats (Ma et al. 2010, Babu 2015).

Habitat suitability, in terms of availability of native vegetation required for nesting and rearing of chicks, can be compromised if the breeding habitat is colonized by invasive species (Rapport and Whitford 1999). In some densely populated areas where wetlands have shrunk drastically due to agricultural encroachment, local communities spend extended periods of time in the remnant wetland patches, thereby disturbing breeding birds. This has been observed in landscapes where cranes are found in East Africa, mostly Rwanda and Uganda (Morrison 2015; Osiman Mabhachi, personal observations 2010–2017). This exemplifies the temporal dimension of habitat loss whereby constant presence of humans in wetlands discourages birds and other wetland-dependent species from breeding and foraging even when the space and food are available. Another spatial dimension of habitat loss is exemplified by cases where the rate of plant harvesting or grazing exceeds the rate of plant regrowth, resulting in greatly reduced plant cover or, over the long term, changes from herbaceous to woody plant communities, much to the detriment of species that require grasses for breeding and foraging (Middleton et al. 2006). This is a common phenomenon in wetlands that support globally significant populations of Grey Crowned Cranes such as the Kabale Wetlands in Uganda (Jimmy Muheebwa, personal comm. 2016) and Kingwal Swamp in Kenya (Maurice Wanjala, personal comm. 2016).

Grazing pressures may be increasingly shifted into wetlands when the total area available for grazing in rural landscapes shrinks as upland pastures are converted to crop fields or overall demand for grazing lands increase with livestock numbers. Increased grazing pressure in wetlands during drought periods has been documented in Kenya (Masese et al. 2012) and Zimbabwe (Scoones 1991). In some cases, wetlands important to cranes may be overgrazed when farmers fence off their properties, thereby restricting livestock to smaller pastures that contain wetlands used by cranes for breeding. This is the case at Kingwal Swamp, a wetland system situated in western Kenya that supported 25 Grey Crowned Crane breeding pairs in 2013 (Maurice Wanjala, personal comm. 2016). Overgrazing is a major problem in and around wetlands in Mongolia, Russia, and northeast China where the numbers of livestock cause destruction of the organic soil layer, loss of soil moisture, hummocking of vegetation, loss of plant diversity, and potential damage to permafrost (Voorhis and Gurrieri 2015). However, sustainably managed grazing or other types of plant harvesting can be beneficial for sustaining wetland function, quality, and productivity, as these uses can serve as surrogates to natural defoliation events such as wildfire or grazing by wild ungulates. In particular, grazing and plant harvesting activities can prevent the encroachment of woody vegetation, and use for grazing can help prevent the wetland from being converted to crops or other uses while still providing income to the landowner or community.

UNDERSTANDING DRIVERS AS PRECURSOR TO DEVELOPING SOLUTIONS

Unsustainable exploitation of wetlands is driven by site-based factors and other phenomena and processes operating beyond the geographical boundaries of the affected wetlands. Wetlands are invaluable landscapes to livestock farmers as they provide abundant, palatable, or nutritious fodder compared to upland pastures, thereby providing invaluable ecosystem services. The quest to derive economic benefits by the livestock farmers is a primary driver of unsustainable exploitation of wetlands. As in most cases where natural resources are not utilized in a sustainable manner, unsustainable exploitation of wetlands occurs when the desire to derive economic benefit outweighs the need to maintain wetland ecological integrity and functions (Barbier 1993, Schyut 2005). This may be a result of lack of knowledge on the negative impacts of farming practices or excessive harvesting of plants on wetlands and how wetland degradation can translate into gradual reduction in ecosystem goods and services and ultimately loss of livelihoods (Kakuru et al. 2013). Limited technical skills on how to plan and implement sustainable wetland management systems has also been cited as a major underlying driver of wetland degradation through exploitative use (Shrestha 2011, Lamsal et al. 2015). Such management systems would include practical methods such as plant recovery, regulated spatial and temporal harvesting, and rotational grazing.

In Africa, wetlands provide alternate grazing areas when grass in the uplands is depleted during the dry season or when there is a drought (Scoones 1991, Adams 1992, Kakuru et al. 2013). Rainfall patterns are therefore a driver of unsustainable exploitation. The underlying drivers of unsustainable exploitation are also are rooted in land tenure systems and other institutional and policy factors operating (Finlayson et al. 2005, Masese et al. 2012). The tenurial dimension of the drivers can be exemplified by two examples. First, some wetland systems are managed as common lands that provide plant resources accessed freely by local communities. The risk of unsustainable exploitation in wetlands is high in such cases when access to plant resources is unregulated. In cases where patches of wetlands have been privatized, with households depending entirely on resources found on their small farms, as is the case in Kenya and Uganda, households may be forced to harvest plants at a rate that exceeds the regeneration process. When recommending solutions to mitigate unsustainable exploitation of wetlands, it is critical to consider the underlying drivers to ensure that the solutions do not only lead to threat reduction but are also aligned with local land-use plans, land utilization priorities, and the ecological requirements of wildlife. This is an approach increasingly being promoted as a solution to balance livelihoods (based on utilization of land and biological resources) and species and habitat conservation (Fisher et al. 2006, DeFries et al. 2007). This entails recognizing that landscapes can be designed and managed so that they continue to provide their natural ecological functions while at the same time generating goods and services for the benefit of people.

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Grey Crowned Cranes in densely human-populated landscapes in the Lake Victoria Basin, covering Kenya, Rwanda, and Uganda;
- Wattled Cranes that depend on wetlands used for agriculture by subsistence farming communities in the Ethiopian Highlands and the Driefontein Grasslands in Zimbabwe;
- Black Crowned Cranes in transformed wetlands impacted by climate change in Upper Niger Delta (Mali) and Lake Chad (Chad), and the Sudd Wetlands in Sudan and South Sudan;
- Sarus Cranes in India, Cambodia, and Laos in the inland freshwater wetlands in the Indo-Gangetic floodplains;
- White-naped and Red-crowned Cranes from overgrazing in northeast Mongolia, Transbaikalia, and Amur Basin in Russia, and northeast China; and
- Siberian Cranes in China; with
- Lesser threats to Black-necked, Blue, Brolga, Demoiselle, Eurasian, Hooded, Sandhill, and Whooping Cranes.

RESEARCH AND MONITORING NEEDS

- Assess the impacts of the main practices associated with unsustainable exploitation (e.g., overgrazing and unregulated harvesting of plants for use as fodder) on the viability of crane habitats around key sites known to support globally significant populations of cranes;
- Fine-scale (country- and site-level) mapping of threats to wetland ecosystems threatened by unsustainable exploitation to guide in the prioritization of wetlands targeted from conservation action;
- Assess the feasibility of wetland restoration techniques that target wetlands already affected by over-utilization and determine how restoration can contribute to improving habitats for cranes;

- Evaluate alternative livelihood options in terms of their effectiveness in reducing over-exploitation of wetlands and pressure on wetlands;

- Evaluate how local and larger-scale social and economic processes influence utilization of wetland resources; and

- Model land use and economic processes that influence wetland utilization to guide development of conservation actions.

PRIORITY CONSERVATION ACTIONS

- Facilitate wetland restoration projects at sites already affected by over-utilization, with input from local resource users and appropriate government agencies;

- Advocate for the enactment and effective implementation of wetland policies in crane range countries to provide a legislative framework for curbing over-exploitation of wetland resources;

- Develop models for site-level wetland protection measures, including community enforced regulations for limiting agricultural encroachment and regulation of harvesting of wetland products;

- Institute site protection mechanisms within the framework of national legislation and community support and aspirations, including development of site management plans; and

- Promote alternative livelihood projects linked to tangible conservation targets so as to reduce pressure on wetlands.

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THREAT:

HUMAN INTERFERENCE/DISTURBANCE, ESPECIALLY AT NEST SITES

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Across the globe, cranes are increasingly living in human-modified habitats. Growing human populations demand land for agriculture and development, resulting in the conversion of wetland and grassland habitats, which drive the expansion of commercial, livelihood, and recreational activities. Cranes are placed in frequent contact with human activities, especially in agricultural settings, and are forced to cope with a variety of human pressures. Although human interference is the fourth highest ranking threat to cranes, affecting 14 of the 15 species, there is limited scientific data validating assumptions about impacts of disturbance on the viability of crane populations (i.e., reproductive success, reduced energetics).

BREEDING AREAS

Human activities are of highest concern during the breeding period, when disturbances could result in reduced productivity. These disturbances include 1) human activities associated with farming practices (e.g., planting, weeding, harvesting) and tending of livestock; 2) management activities (e.g., burning reeds to improve plant density); 3) increased livestock numbers; and 4) the loss of plant cover and greater fragmentation of remaining habitat with plant harvesting, that result in greater exposure of cranes to disturbances or predators (see also *Unsustainable exploitation of wetlands*, including grazing and harvest activities). In areas of high human population densities, such as Uganda, Rwanda, and Kenya, Grey Crowned Cranes are threatened by increased agricultural activity around nest sites. A resulting increase in vigilant behavior reduces the amount of time cranes spend tending to eggs and chicks, likely reducing hatching and fledging success (Kerryn Morrison, personal comm. 2016). Such disturbance is thought to be a critical threat to Grey Crowned Cranes in East Africa (Morrison 2015). However, studies to quantify effects are required to understand if these human activities do cause reduced breeding success.

Negative effects of disturbance are augmented during dry periods, when wetland habitats are reduced and fragmented, or when wetlands have been degraded and are drier than in natural situations; nests and young chicks are more accessible to humans, dogs, and livestock. Due to their preference for deeper waters and sensitivity to disturbance, Red-crowned Cranes are particularly susceptible. Goroshko (2012) found that in the Daurian Steppe of Mongolia, China, and Russia, Red-crowned and White-naped Crane numbers fell sharply as water levels declined during a long drought in the early 2000s. Disturbances from people and livestock have become more severe due to fragmentation of breeding habitats in the eastern part of the range, where pressures to expand farmland are greater, and in more sparsely inhabited western parts of the range due to prolonged drought concentrating breeding birds, people, and livestock within the shrinking areas of available water. Similarly, along Inner Mongolia's Wuerxun and Hui Rivers, drought conditions from 2000 to 2010 caused water levels to drop significantly and forced cranes and herdsmen to share scarce water resources. From 2008–2010, Red-crowned Cranes disappeared from Wuerxun River, and in Hui River National Nature Reserve they were not able to raise sufficient chicks to sustain their population (Liying Su, personal comm. 2015). Rising water levels, herdsmen education initiatives, and students studying breeding behavior who served as incidental nest guards, preventing disturbance and improving breeding success, have all allowed the cranes along the Hui River to recover in recent years. There is also concern about disturbance to Black-necked Cranes from livestock on the breeding area in Ruoergai (Fengshan Li, personal comm. 2016). In Mongolia, disturbances from horse and cattle grazing and domestic dogs are correlated with the nesting success of White-naped Cranes (Batbayar and Mirande 2016). Camera traps used to monitor breeding pairs in the Khurkh River Valley in 2016 documented for the first time how nesting cranes are affected by horses; the cameras provided evidence that horses may have substantial impact on the nesting cranes because horses were regularly grazing in wetland areas. Spring hunting is another serious threat for Red-crowned and White-naped Cranes in Russia. Although cranes are not game species, legal spring hunting of other waterbirds creates intensive disturbance for breeding cranes (Smirenski and Smirenski 2010, Goroshko 2015).

Siberian Cranes breeding on the tundra in Yakutia (Sakha Republic) in northeastern Russia can be seriously disturbed by waterfowl hunters and mammoth bone collectors, who use tracked vehicles. Studies are in progress to assess possible impact on nesting success. Domestic reindeer (*Rangifer tarandus*) pastured on Siberian Crane breeding habitat have been observed eating crane eggs (Vladimirtseva 2000) or killing small chicks. Domestic reindeer breeding has declined since the 1990s

During a field trip for wetland nature reserve staff, everyone stayed in viewing area away from the lake to watch birds, but one person walked all the way to the lakeshore for better photographs and scared all birds away. We seek to prevent such disturbance by visitors through education and ecotourism programs (Photographer: Jim Harris, International Crane Foundation) on the Siberian Crane breeding grounds in the Allaikhovsky District but may be restored in the future (Nikolai Germogenov, personal comm. 2016). In this case, reindeer breeders should coordinate timing and location of their routes with nature protection agencies of Sakha Republic.

Nest guarding by local communities has also been undertaken to protect Sarus Cranes in one location in India where the cranes breed along irrigation canals. The accessibility of these sites facilitates the removal of crane eggs by people for food, and predation of chicks by feral dogs (see *Sarus Crane* species review in this publication: Triet Tran's personal observation in Northern Cambodia, October 2015). A project was formulated in the Indian state of Rajasthan in 2004–2005, in which 17 Rural Village Sarus Protection Groups were formed to physically guard Sarus Crane eggs and juveniles from poaching. That year, 19 chicks successfully fledged from 22 nests (Kaur et al. 2008). However, the project could not be sustained. The problem of egg and chick poaching, however, is not very widespread in south Asia, and Sarus Cranes have relatively high breeding success each year (K S Gopi Sundar, personal comm. 2016). At some crane sites, high numbers of visitors and poor tourism management caused much disturbance to cranes, and in some extreme cases forced cranes to abandon the sites (Triet Tran, personal observation in the Ha Tien Plain Vietnam, 2005).

STOPOVER AND STAGING AREAS

The effect of disturbance along migration routes is less understood. In far-eastern Russia, spring hunting of waterfowl causes Red-crowned Cranes to abandon stopover sites as well as breeding grounds. There is a need for buffer zones to protect roosting sites in major staging and stopover areas in Russia and neighboring countries (Ilyashenko and Mirande 2013). For some crane populations, migration to and from wintering grounds coincides with plowing and harvest seasons. In China, there have been reports of White-naped Cranes leaving or abandoning sites (such as at Miyun, Beijing) due to human activities (Yifei Jai, personal comm. 2015).

Siberian Crane migration between Yakutia's tundra in the north of far-eastern Russia and wintering ground in China coincides in time with hunting and fishing seasons and leads to undesirable crane-human interactions especially at transit stops. Not just disturbance but accidental shooting during poor visibility from snow or fog was documented at least four times by local people and nature inspection agencies during fall migrations from 2005–2014 along the Middle Aldan River in southeastern Yakutia.

Luo et al. (2012) explored the impact of human-caused disturbances on Hooded Cranes at stopover sites in northeastern China; they found that such disturbances interrupted foraging, increased flying time, and increased the duration of their vigilance by 200%. High-intensity sounds such as tractor noises during plowing and harvest periods, mooing sounds by grazing cattle, and especially whistles or shouts by farmers caused cranes to flush or otherwise changed their behavior.

WINTERING GROUNDS

Human disturbances are perhaps most frequent on wintering grounds, which tend to be less remote and in areas of higher human density. Li et al. (2015) investigated the foraging behavior of Hooded Cranes wintering in China's Shengjin Lake National Nature Reserve. They found that cranes foraging in the highly disturbed rice paddy fields of the reserve's buffer zone exhibited strikingly different behavior compared to those feeding in the natural wetlands of the relatively undisturbed core area. It has not been determined whether the change in activity budgets while foraging in rice fields leads to a change in breeding success. High vigilance also reduced the time available for locomotion and maintenance behaviors, including resting and preening.

For crane species that undertake annual migrations, physiological costs incurred during winter may be carried over to spring and have the potential to affect breeding outcomes. Whooping Cranes wintering in salt marshes along the Texas coast alter their behavior and may be displaced from preferred habitats in response to boat traffic, low-flying aircraft, vehicles, and people on foot (Lewis and Slack 2008). Fishing, hunting, crabbing, birdwatching, and other commercial and recreational activities are also known to disturb cranes if conducted in close proximity. Cumulative disruptions to their daily activity patterns can lead to reduced foraging time, increased stress, and impaired body condition upon arrival at breeding grounds (Elizabeth Smith, personal comm. 2015).

In Poyang Lake National Nature Reserve, wintering Siberian Cranes are threatened by unregulated nature tourism and consistent disturbance by visitors. Photographers and birdwatchers approaching too closely cause the cranes to fly, expending precious energy, and forcing them to abandon otherwise suitable habitat. A visitor management strategy is currently being developed and will include visitor education, regulations, and infrastructure for responsible bird watching such as platforms, optical equipment, and photography blinds. Local residents will serve as visitor management personnel, and communities will benefit from improved nature tourism (Jin 2017).

White-naped and Hooded Cranes are also affected by disturbance on their wintering grounds. Commercial development is increasing in the Civilian Control Zone (CCZ) buffer area, immediately adjacent to the Korean Demilitarized Zone; the CCZ is the primary location where cranes feed on rice gleanings. In recent years, the Republic of Korea's (South Korea) government has allowed expanding human activity in the CCZ, leading to increased disturbance from photographers and construction of greenhouses by farmers. The Republic of Korea's Ministry of National Defense removed about 504 ha of land from the CCZ near Yangjiri in 2013 and removal of more land is expected. On the wintering grounds in Izumi, Japan, daytime foraging areas on private lands outside the protected area are threatened by human disturbance, road development, and power lines.

Understanding and managing human disturbances to cranes will be essential as the need for peaceful coexistence continues to rise. A sound scientific basis for mitigating the negative effects of disturbance is key, including a better understanding of the effects on breeding productivity and subsequent impacts at the population or flyway level. One promising approach is to alter the timing or specific location of harmful human activities so that they do not coincide with breeding months or important breeding areas. This adjustment can be challenging since the crane breeding season also coincides with increased wetness on the landscape, which is when grazing and other agricultural activities are conducted. Similarly, temporarily mitigating human activities at key stopover sites and wintering areas can help ensure cranes are able to carry out their daily and annual cycles with success. Management actions that request local communities to alter livelihoods (e.g., asking herdsmen in Mongolia to reduce grazing around crane nests during the incubation period) need to be developed with strong stakeholder engagement to develop solutions that are viable and supported by local communities.

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Grey Crowned Cranes, especially in Kenya, Rwanda, and Uganda;
- Siberian Cranes on their wintering grounds and migratory stopovers in East Asia;
- Whooping Cranes on their Texas wintering grounds;
- Red-crowned Cranes on breeding areas in far-eastern Russia and northeastern China, and wintering areas in China and Republic of Korea;

- White-naped Cranes on breeding grounds in far-eastern Russia, Mongolia, and northeastern China; and on wintering areas in China, Republic of Korea, and Japan;
- Sarus Cranes in India and Southeast Asia;
- Black Crowned Cranes are potentially at risk across their range, but further studies are needed; and
- Hooded Cranes at stopover sites in northeastern China and wintering grounds in China, Republic of Korea, and Japan; with
- Lesser impacts to Black-necked, Brolga, Eurasian, and Hooded Cranes.

RESEARCH AND MONITORING NEEDS

- Identify priority areas where human disturbance is a major threat to crane populations;
- Undertake scientific studies to quantify the intensity, frequency, and duration of particular disturbances and their effects on breeding productivity, foraging, and other crane behaviors, and develop criteria to evaluate their relative importance;
- Undertake scientific studies of the physiological costs of human disturbances to cranes, and whether such impacts affect survival and reproduction;
- Investigate methods to reduce the impact of disturbance to cranes through management actions and/or policy measures (e.g., seasonal buffer zones); and
- Obtain an understanding of the factors that influence the population dynamics of the Grey Crowned Crane, including impact of disturbance on breeding productivity and adult and juvenile mortality.

PRIORITY CONSERVATION ACTIONS

- Identify people whose activities may reduce breeding success or crane energetics, and implement targeted education and awareness campaigns;
- Improve local communities' appreciation of and attachment to cranes through outreach programs and promotion of crane custodianship, targeting schools, farmers, and community groups;
- Test feasibility, at one to two sites, to involve communities in the monitoring and protection of nests, eggs, and chicks while carefully assessing whether these protection activities do not lead to greater disturbance;
- Continue education campaign aimed at reducing human disturbance to Red-crowned Crane nests at Hui River National Nature Reserve (NNR) in China;
- Reduce disturbance to Grey Crowned Cranes during the breeding season by increasing awareness, using local community champions to keep watch on breeding cranes, and regulating the use of key sites through management plans;
- Understand the impact of disturbance on Grey and Black Crowned Crane breeding productivity, and develop and implement management actions that will reduce its impact;
- Reduce disturbance to Siberian and White-naped Cranes by tourists and photographers at Poyang Lake NNR and Siberian Cranes at Momoge NNRs through better enforcement, public education, and visitor management;

- Work with local herdsmen communities in Mongolia, Russian Daurian Steppes, and northeast China to graze livestock away from core nesting sites during the six-week incubation season to reduce disturbance to breeding cranes; and

- To reduce impacts of legal spring hunting, establish small "peace sites" on key breeding areas in Dauria where spring hunting is prohibited; develop model program at Khanka Lake; continue work to stop spring hunting in all of Russia; conduct ecological education for hunters; and strengthen protection of crane habitats during hunting seasons.

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THREAT:

PROLONGED DROUGHT AND DESERTIFICATION, ESPECIALLY RELATED TO CLIMATE CHANGE

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Prolonged drought and desertification are ranked as the fifth most significant threats to cranes critically or significantly affecting 11 species, especially populations dependent upon habitats in arid or semi-arid regions for all or part of their life cycles. Drought is considered as a period of abnormally dry weather long enough to cause a serious hydrological imbalance (IPCC 2014), affecting soil moisture and water supplies. While periodic droughts are a natural feature of particular regions (e.g., unusually dry conditions in Australia, Southeast Asia, India, and south-central Africa associated with the El Niño Southern Oscillation), the frequency of El Niño events is forecast to increase with climate change (Cai et al. 2014). Changes in climate patterns and/or events outside the natural range of variation can seriously impact vulnerable species and ecosystems. Broad-scale changes in precipitation are occurring with climate change, including mean precipitation, variability, seasonality, extremes (such as droughts), and changes in timing of precipitation that are affecting hydrological cycles. Desertification is a form of land degradation occurring particularly, but not exclusively, in semi-arid areas. About 33% of the global land surface (42 million km^2) is subject to desertification (Eswaran et al. 2001).

Increases in the frequency or intensity of ecosystem disturbances such as droughts, windstorms, fires, and pest outbreaks have been detected in many parts of the world and in some cases are attributed to climate change (IPCC 2014). However, there is low confidence in observed global scale trends in droughts, for reasons including geographical inconsistencies in drought trends. Climate change over the 21st century is projected to reduce renewable surface water and groundwater resources in most dry subtropical regions, intensifying competition for water among sectors. In presently dry regions, the frequency of drought is forecast to likely increase by the end of the 21st century under at least one scenario (IPCC 2014). Examples of recent drought-affected regions that overlap with important crane areas include (https://en.wikipedia.org/wiki/List_of_droughts): the Sahel (2010), East Africa (2011–2012), Australia (1995–2009), southern North America (2010–2015), and the Amur Basin in Northeast Asia (1999–2012).

Threats associated with the occurrence of droughts include temperature extremes, fires (see threat section on *Impact of fires on cranes*), dust storms, conversion of marginal wetland habitats to agriculture (see *Conversion of wetlands for agriculture and other land development*), and increased disturbance of such habitats by livestock and people (see *Human interference/ disturbance, especially at nest sites*) with improved access from lower water levels.

The storage and diversion of water resources (see *Dams and water diversions*) has exacerbated the impacts of droughts on the wetland habitats of cranes. Problems of water supply are particularly intense in semi-arid regions, such as the Songnen Plain in northeast China, where rainfall is highly variable and droughts occur frequently. During the first decade of the 21st Century, prolonged drought coupled with water diversions led to serious desiccation of the network of wetlands set aside in protected areas in Songnen Plain (Harris 2009), impacting breeding and staging Red-crowned, White naped, and Siberian Cranes, among other species. With support from the Environment Programme (UNEP) management and wetland restoration plans for key wetlands for cranes (Zhalong, Xianghai, Keerqin, and Momoge National Nature Reserves), and water releases during unusually dry years financed by the government have since helped to mitigate these impacts (e.g., Harris 2009, 2011). A climate-change vulnerability assessment and adaptation planning project for Momoge and Tumuji National Nature Reserves (NNR) in northeast China has provided further assistance to develop climate resilient management plans and to serve as models for other sites (results of the WetAdapt Project activities, Jiang Hongxing et al., in preparation).

In North America, increasing frequency of droughts and long-term increases in temperature from climate change will have differential effects on the Aransas-Wood Buffalo Population (AWBP) of the Whooping Crane. As drought combined with intensive upstream water demand (see *Dams and water diversions*) continues to increase in the Guadalupe-San Antonio Basin, Texas, essential freshwater inflows to the estuaries surrounding Aransas National Wildlife Refuge continue to diminish. These decreases are especially critical by shifting salinity regimes and impacting the availability of primary foods like blue crabs (*Callinectes sapidus*) and Carolina wolfberry (*Lycium carolinianum*) fruits for wintering Whooping Cranes (Westwood and Chavez-Ramirez 2005). Warmer temperatures are already allowing establishment of black mangroves (*Avicennia germinans*), which may reduce habitat availability and quality for Whooping Cranes (Chavez-Ramirez and Wehtje 2012).

African species such as the Black Crowned, Wattled, and Blue Cranes are also at risk from drought and desertification. Droughts have both directly and indirectly impacted Black Crowned Crane habitat (e.g., in Sudan) because they force people to migrate to relatively moist, less populated regions, with associated pressures of wetland drainage and conversion for agriculture, overgrazing, fire, and pollution (Williams et al. 2003). Higher temperatures and evaporation, reduced rainfall, and reduced runoff will result in significantly reduced water availability for key large floodplain wetlands for Wattled Cranes, including Kafue Flats, Zambezi Delta, and Liuwa Plain (Beilfuss 2012). These factors are coupled with impacts of river regulation and wetland drainage in southern Africa. Potential changes in the timing and amount of rainfall under climate change may alter breeding and survival rates of Blue Cranes. The small breeding population in Namibia is vulnerable to extinction in the face of catastrophic events such as severe drought under climate change. The future for these species will depend on the extent of warming the world experiences and the extent to which societies embrace adaptation strategies to climate change that sustain the resources on which people and cranes depend (Hansbauer et al. 2014).

In Asia, White-naped and Red-crowned Cranes have been affected by a prolonged drought in the western parts of the breeding range in the Amur River Basin, perhaps influenced by long-term climate change. Associated with drought conditions are human-caused grass fires that destroy nests, eggs, young and/or vegetative cover (see *Impacts of fire on cranes*) and are exacerbated by water diversions and other human activities (see *White-naped* and *Red-crowned Crane* species reviews). These western regions have erratic rainfall and tend to experience cycles of drought and wet. On the Daurian steppe, where Mongolia, Russia, and China come together, these cycles span roughly 25–30 years (Simonov and Dahmer 2008). The decade after 2000 was characterized by increasingly severe drought, succeeded by increasing rainfall beginning around 2012–2014. In the west, during the drought years after 2000, crane reproduction was greatly reduced. Prolonged drought concentrated breeding birds, people,

Long-term drought has contributed to desertification at the Xianghai National Nature Reserve in China, compounded by irrigation canals diverting water for agriculture (Photographer: Jim Harris, International Crane Foundation)

and livestock within the shrinking areas of available water (Goroshko 2012). In recent years, water diversions and drought have meant that at Muraviovka Park in far-eastern Russia and other areas, deeper water habitats have evolved into shallow marshes and sedge meadows better suited to White-naped than Red-crowned Cranes (Sergei Smirenski and Tamaki Kitagawa, personal comm.).

Siberian Cranes depend on shallow wetlands during the long-term stopovers they make in both spring and fall in northeast China to replenish energy reserves (Harris 2009). The significant migratory stopovers (Momoge, Zhalong, Keerqin, and Xianghai NNRs) in the semi-arid region of northeast China have been affected by water diversions and cycles of drought and flood. Rainfall has been highly variable, and wetlands frequently dry. Since 2004, the number of Siberian Cranes at Momoge NNR has increased up to 3,600 Siberian Cranes due to sustained and seasonally timed water releases by the local government (Germogenov et al. 2011; Jiang Hongxing unpublished data). This site continues to be a critical stopover habitat for migratory Siberian Cranes during both autumn and spring migrations. The number of birds at Zhalong has decreased due to reduced water supply and wetland fragmentation within the reserve (Qiu et al. 2005).

For Black-necked Cranes, climate change is already having a significant impact on the Tibetan Plateau, with changing precipitation patterns and rapid glacial melt. In areas thus affected, wetlands are expanding, while outside the glacial region, wetland habitats for this species have been reduced. More drastic changes are expected in coming decades, with loss of glaciers leading to water shortages and extensive loss of wetlands (see *Black-necked Crane* species review).

Demoiselle Cranes have been affected by periods of drought since the early 2000s in the steppe and semi-desert zones of central Eurasia, mainly in the European part of Russia, the Trans-Baikal Region of Russia, Kazakhstan, and east and south Mongolia (see *Demoiselle Crane* species review).

In South Asia, Southeast Asia, and north-eastern Australia, Sarus Cranes are experiencing extreme fluctuations in precipitation levels and especially more frequent dry years due to climate. Predicted climate change is also likely to affect drying and flooding regimes of wetlands in Australia for the Brolga (see *Sarus Crane* and *Brolga* species review).

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Black Crowned Crane in West Africa, Sudan;
- Wattled Crane in southern Africa;
- Blue Cranes in the Western Cape of South Africa and in Namibia;
- White-naped and Red-crowned Cranes in western parts of the breeding range in the Amur Basin;
- Siberian Crane in northeast China (Songnen Plain);
- Demoiselle Crane in the steppe and semi-desert zones of central Eurasia (mainly in European part of Russia), the Trans-Baikal Region of Russia, Kazakhstan, and eastern and southern Mongolia;
- Black-necked Crane on the Tibetan Plateau;
- Sarus Crane in South Asia, Southeast Asia and north-eastern Australia;
- Brolga in Australia;
- Whooping Crane population in the Guadalupe-San Antonio Basin in Texas, USA; and
- Red-crowned Cranes in the Songnen Plain, Amur River Basin, and Daurian steppe; with
- Lesser impacts to Eurasian and Grey-Crowned Cranes.

RESEARCH AND MONITORING NEEDS

- Monitor and evaluate large scale climate change trends including predicted impacts of El Niño on drought and flood conditions on crane species in different regions;
- Strengthen knowledge of crane population trends, distribution, migration patterns, and use of site networks as a basis for strategic habitat conservation measures, especially for regions that are sensitive to climate change, and to identify sites that may be significant as refuge areas during extreme conditions (e.g., in East Asia);
- Long-term interdisciplinary research is needed to distinguish short- and mid-term climate cycles from long-term global climate change, especially for areas such as Dauria (Russia) with highly variable precipitation;
- Conduct long-term research on the ecology of key sites, including effects of changes in temperature, rainfall, and hydrological regime on wetland vegetation, food resources for cranes, and breeding habitat, to inform climate change adaptation planning. For the Whooping Crane, investigate the relationships among priority food sources and hydrologic and environmental conditions in the wintering areas; incorporate these findings into management and conservation plans;
- Conduct long-term monitoring of cranes and wetlands in breeding areas with focus on climate change; for the Black-necked Crane, cover areas not affected by glaciers (e.g., Ruoergai) and areas impacted by glacial melt and then by glacial shrinking (e.g., Shenzha); and
- Given the lack of knowledge about potential effects of climate change on certain crane species, investigate how it might impact on habitat suitability, potential changes to distribution, and changes to habitats.

PRIORITY CONSERVATION ACTIONS

- Strengthen networking among countries, partner organizations, and key sites to coordinate strategic conservation measures for crane populations at risk from climate change, drought, and related threats (e.g., for Black Crowned, Wattled, Blue, Sarus, and Black-necked Cranes);
- Review species action plans and site management plans to incorporate climate change adaptation considerations that address vulnerabilities to climate change;
- Protected areas should undertake assessment of their climate change vulnerabilities, particularly for wetlands, and identify adaptation measures to be incorporated into management plans and practice;
- Establish ecological networks of critical sites, secure their inclusion in national protected area systems, and strengthen their management effectiveness (e.g., for Black Crowned, Wattled, Black-necked, and White-naped Cranes). Such networks can provide site options based on annual or long-term variability in water availability and periods of flood or drought (e.g., in the Daurian Steppe in East Asia);
- Review the impact of forecasted climate change on water availability in key crane landscapes, trends in water resource demand, and the roles of governments and other key stakeholders in securing environmental flows to sustain key wetland habitats (e.g., in the Zambezi, Amur, Murray-Darling, and Guadalupe-San Antonio basins). Negotiate with authorities to maintain adequate water levels and quality in breeding, stopover, and wintering sites; monitor and adjust water releases to increase their effectiveness; and maintain current efforts and funding to implement environmental flows for key floodplains and individual wetlands;
- Promote sustainable land management in arid and semi-arid crane landscapes that are vulnerable to drought, desertification, or climate change impacts, including conservation of water resources, to benefit local communities and wildlife;
- Work with local communities to enhance management of grasslands (see also *Conversion of grasslands for* agriculture, afforestation, and other development) and water resources, reduce disturbance to breeding cranes, and stop agricultural fires (see also *Impacts of fire on cranes*) in breeding areas during spring for Red-crowned, White-naped, and other crane species;
- Communicate the significance of climate change including water shortages on short-term and long-term status of cranes to wildlife and wetland managers and relevant policy makers, as well as media and the general public, so that relevant adaptive measures can be implemented; and
- Evaluate development project impacts and regulatory changes, particularly related to water and agriculture, so they consider future impacts of climate change on cranes and other biodiversity and can be responsive to current and predicted conservation needs.

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THREAT:
CHANGES IN AGRICULTURAL LAND USE AND PRACTICES

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Cranes have adapted to many natural and anthropogenic changes over the centuries, including agriculture. Over the last 50–100 years, however, the pace of change in agricultural land use and practices has been extremely rapid (Ilyashenko 2018). The increase in both spatial extent and intensity of agricultural land use in many areas has substantially altered the abundance of food resources available to cranes, particularly on migration and wintering areas. In some cases, these changes have led to increased food availability and growth of crane populations (e.g., Eurasian Cranes in the Western Europe flyway; Nowald 2012), but changes in some areas have reduced food availability at critical times and places that can threaten the sustainability of crane populations (Krapu et al. 2004, Ilyashenko and King 2018). Changing agricultural land use and practices also can affect crane habitats and foods indirectly through environmental effects such as increased human disturbance, degraded water quality, pollution, or altered hydrology (Austin 2018; see also *Human Interference/Disturbance* and *Dams and Water Diversions*). This threat is considered the second most important direct threat to biodiversity (Salafsky et al. 2008) and is sixth highest for cranes globally.

Many cranes are adapted to using the open environments and foods found in agricultural landscapes (Nowald et al. 2018). Waste grain and weed seeds left in crop fields after harvest provide high-energy foods important to migrating and wintering cranes. Livestock grazing helps to maintain lower vegetative structure and species diversity important to grassland specialists such as Demoiselle and Blue Cranes, and often for nesting cranes. In flood-agriculture systems, e.g. rice (*Oryza sativa*) paddies, cranes benefit from residual seeds and aquatic biota supported in shallowly flooded ponds and paddies. Paddy systems are important as nesting and foraging habitat in India and Myanmar (Barzen and Seal 2001). In dryland agriculture, traditional or low-intensity farming practices typically involve a single annual crop, natural fertilizer, and hand labor, resulting in harvest inefficiencies that leave residual grains in the field and an abundance of weed seeds or other natural foods. Similarly, low-intensity paddy agriculture involves a single crop of rice or a secondary crop (e.g., wheat [*Triticum aestivum*], fish) rotated annually, with a long fallow period, hand labor, and little use of chemicals (Sundar and Subramanya 2010, Wood et al. 2010). Cranes can sometimes benefit from some multiple-cropping practices when foods remain available across crops, e.g., rice-crawfish ponds in the southern United States, used by reintroduced Whooping Cranes (Foley 2015). As natural habitats are converted to agriculture, fish farms, or urban development, cranes in some areas come to rely heavily on the foods found in agricultural fields and paddy wetlands, which often provide the best or only remaining wetland-like habitat (Sundar 2011, Sundar et al. 2015).

Development of modern agricultural practices, new technologies, and growing human populations and their desire for better livelihoods have led to substantial changes in agriculture. Farming practices in many areas are becoming modernized and increasingly intensive. Some of these practices have been beneficial to cranes whereas many others have been detrimental. The combined effects of improved machinery (allowing larger areas in cultivation) and use of fertilizers and pesticides and improved seed varieties (supporting higher yields) have led to increased availability of waste seed (mainly grains). Those abundant foods on migration and staging areas have helped support larger crane populations in some regions (Ilyashenko and King 2018). Irrigation development and selective crop breeding for drought or temperature tolerances also have allowed some crops to be grown in new areas, thereby expanding areas of food availability for cranes. Many modern practices, however, have resulted in reduced availability of both crop and natural foods useful to cranes, more intense or frequent human disturbances, and greater exposure to agricultural chemicals. Improvements in harvest machinery also improved harvest efficiencies, leaving less waste grain for cranes (Krapu et al. 2004), while pesticides and machines allowing deeper and more frequent tillage reduce availability of waste grain, weed seeds, and insects. Moreover, improved crop varieties, agrochemicals, and improved water management have allowed farmers in more areas to plant multiple crops each year and reduced the need to fallow fields periodically. The shift toward more intensive management and multiple crops not only reduces availability of residual grain or weed seeds through tillage and chemical use, but also increases the amount of human activity in fields, which can further deter crane use. An example of these combined challenges is on the wintering grounds of Black-necked Cranes in Bhutan. Under traditional farming practices, barley (*Hordeum vulgare*) left after the early winter harvest was an important food resource for the cranes. Increased use of fall tillage, addition of potatoes (*Solanum tuberosum*) and winter varieties of wheat as winter crops, and loss of cropland area to development have substantially reduced food availability for the wintering cranes; this change is considered to be one of the main threats to the population (Lhendup and Webb 2009).

Nest of a Blue Crane in a wheat field in the Western Cape, South Africa (Photographer: Wicus Leeuwner)

In arid and semi-arid grasslands important to Demoiselle and Blue Cranes, increased grazing pressures from higher densities of livestock and loss of traditional nomadic grazing threaten the long-term health of those ecosystems and their ability to sustain crane productivity (Bradter et al. 2005, Khishigbayar et al. 2015). Increased grazing and poor grassland management have led to degraded grasslands in Mongolia, Kazakhstan, and Central Asia that are important breeding grounds for Demoiselle Cranes, and in Mongolia and East Asia that are important breeding grounds for White-naped Cranes (see also *Conversion of grasslands for agriculture, afforestation, other development*). In KwaZulu-Natal, South Africa, Blue Cranes are threatened by continued conversion of pastures to cropland and to crops not used by cranes (DEA-SANBI 2012).

Practices for growing rice, the main paddy crop, also are undergoing major changes, particularly in Asia, to deal with changing climate and water resources and growing food demands (Qiu et al. 2016). More intensive management of paddy systems includes multiple cropping, greater use of agrochemicals, and more intensive water management (Cassman and Pingali 1995, Sundar and Subramanya 2010). Producing multiple crops requires greater input of fertilizers and pesticides, different flooding regimes and depths, or producing rice with much shorter flooding periods. Such practices can limit or eliminate the value of those fields to cranes by reducing food availability, altering water conditions, and increasing disturbances to nesting or foraging cranes. Alternatively, in large parts of India and parts of lowland Nepal an annual rotation of rice and wheat provides cranes with waste grain for twice as long as a single crop of rice.

Changing crop types on existing agricultural lands can dramatically change food resources critical to cranes, particularly on migration and in wintering areas. Rapeseed (*Brassica napus*) in Europe has substantially displaced grain crops beneficial to cranes (Galluzzi et al. 2011). Wetlands and paddy systems in some areas have been converted to aquaculture for fish or shrimp, reducing available habitat and food resources for Black-necked and Sarus Cranes (Song et al. 2014, Sundar et al. 2015). Planting of trees in grassland or former cropland has reduced habitat and food resources for cranes in portions of Africa, China (including Tibet), and the United States. In the Central Valley of California, orchards and vineyards are rapidly replacing crane-compatible agricultural crops in areas important to wintering Sandhill Cranes; such losses could limit the carrying capacity of some wintering landscapes (Ivey et al. 2014). In the Civilian Control Zone of Cheorwon, Republic of Korea (South Korea), multiple changes in agricultural practices on the major wintering grounds of the endangered mainland population of the Red-crowned Crane and the vulnerable White-naped Crane have reduced food availability (Lee 2010). Since 2002, plowing of rice paddies soon after harvest reduces availability of waste grains and weed seeds. Farmers also are increasingly using greenhouses on the dried paddies after rice harvest to grow vegetables and flowers. This practice not only reduces food availability in the paddy for wintering cranes but also increases human disturbances (Smirenski and Smirenski 2007; Kisup Lee, personal communication, 2009). In South Africa, commercial afforestation has consumed native grasslands important to Blue, Wattled, and Grey Crowned Cranes (McCann and Benn 2006, McCann et al. 2007). Economic incentives, government programs to reduce soil erosion, and emerging labor scarcity in rural areas are among the forces leading to increasing tree planting in areas important to Black-necked Cranes in Tibet and Yunnan (Ediger and Chen 2006, Frayer et al. 2014); those forces are likely to continue (Groom and Palmer 2012). However, although crane foraging habitats have been replaced by trees in some areas, forest restoration in degraded areas can provide long-term benefits to wetland habitats by reducing soil erosion and sedimentation in lowland areas. For a more complete discussion of changing agriculture and the forces influencing such changes over time, refer to Ilyashenko (2018) and Austin (2018).

These trends in agricultural modernization and intensification will continue as regions seek to grow more food more efficiently to meet growing human populations. Sustaining healthy crane populations in the face of these changes will require better monitoring and greater understanding of regional drivers of agricultural land use and how changes could affect cranes—both directly (food resources, disturbances to feeding or breeding birds) and indirectly (environmental effects). Indirect environmental changes may have subtle or hard-to-detect impacts to cranes that may require long-term or focused investigations. Examples include increased exposure to chemicals that could have long-term effects on crane health, survival, or reproduction; altered paddy hydrology or declining groundwater, affecting wetland function; or soil erosion, leading to sedimentation or eutrophication of wetlands (see also *Poisoning, Dams and water diversions* and *Pollution and environmental contamination*). A critical step in prioritizing conservation actions is identifying the key areas important to cranes that are also most at risk.

It is important to recognize that agricultural trends are not consistent across time and space, but continually change with socioeconomic and climatic forces. For example, following the collapse of the Soviet Union in the early 1990s, social, political, and economic drivers led first to massive abandonment of croplands, then later to partial recovery and altered agricultural activities (Ilyashenko 2018, Smirenski et al. 2018). Some of those changes benefitted crane populations while others have been detrimental (Ilyashenko and King 2018). Liu et al. (2013) and Qiu et al. (2016) described the temporal and spatial variability in rice cropping intensity across eastern China, as influenced by climate, water resources, and markets. Such changes in rice cropping will be particularly significant for the conservation of Sarus Cranes, which are closely tied to paddy systems in the Indian subcontinent (Sundar 2009).

The pace of agricultural change globally has intensified over the last 20–30 years, making timely and long-lasting conservation responses challenging. But agriculture also can be influenced by research and education directed toward more sustainable practices that can benefit both cranes and human livelihoods (e.g., Sundar 2009). Also important is balancing conservation needs and approaches with the concerns and needs of the farming community. Effective conservation planning and actions need to understand the interests of farmers and their communities, engage stakeholders in developing new approaches, and continue monitoring and research of where and how cranes and agriculture interact. For more thorough assessment and solutions relating to the interface between cranes and agriculture, refer to Austin et al. (2018).

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Blue Crane in KwaZulu-Natal and Western Cape Province of South Africa;
- Demoiselle Crane throughout its range;
- Black-necked Crane on wintering areas;
- Hooded Crane on migration and wintering areas;
- Red-crowned Crane on migration and wintering areas;
- Sarus Crane throughout its range; and
- White-naped Crane on migration and wintering areas; with
- Lesser threat for Black Crowned, Brolga, Eurasian, Grey Crowned, Sandhill, Wattled, and Whooping Cranes.

RESEARCH AND MONITORING NEEDS

- Investigate use of the agricultural landscape by Blue Cranes in the KwaZulu-Natal and Western Cape Provinces relative to vital rates and breeding success to understand the potential impact of the agricultural landscape changing through climatic and /or economic drivers;
- Conduct long-term monitoring of Demoiselle Cranes and agricultural trends in the Azov-Black Sea population, Caspian flock of the southern European population, southern parts of Kazakhstan and Central Asian population, and the southern Transbaikalia and northeast Mongolia flock of East Asia population to understand how agricultural patterns influence distribution and population dynamics;
- Conduct long-term monitoring and assessment of agricultural land use (crops and cropping practices) and crane use on ranges of Black Crowned Cranes to understand how agriculture is influencing crane use, distribution, and population dynamics, and to identify practices that could be modified to better benefit cranes;
- Identify important staging areas of Hooded Cranes and assess how agricultural land-use practices influence distribution, habitat use, and food availability for this species during migration and winter;
- Investigate effects of intensified paddy agriculture (multiple crops, hydrological change, agrochemical use, disturbance levels) on use, productivity, survival, and health of Sarus Cranes, to help identify ways to adapt practices to better benefit cranes;
- Investigate alternative management approaches for unprotected, community-managed wetlands of south Asia to concurrently sustain Sarus Crane populations and agricultural use; and
- Identify and assess potential agricultural land use practices that benefit cranes in collaboration with local farming communities to develop practices that are economically viable and provide sustainable livelihoods for farmers.

PRIORITY CONSERVATION ACTIONS

- Develop approaches to protect suitable grassland habitat in South Africa under the Biodiversity Stewardship Programme to prevent grassland conversion and secure Blue, Grey Crowned, and Wattled Cranes in the grasslands;
- Develop agricultural programs to promote cropland practices in the Korean peninsula that provide important wintering feeding sites and food resources for wintering White-naped, Hooded, and Red-Crowned Cranes;
- Work toward long-term security of natural areas and crane-friendly agriculture land uses in the Korean wintering sites along the Demilitarized Zone for Red-crowned, White-naped, and Hooded Cranes;
- Better integrate crane conservation with agriculture production by promoting environmentally friendly farming practices adjacent to wetlands and in paddy systems, reducing human disturbance, and better managing breeding habitat within farming areas;
- Work with area landowners and agencies to balance conservation and use of grassland and croplands with afforestation, based on ecologically sound decision-making; and
- Develop conservation programs for grazing lands that encourage grassland and wetland conservation and prevent grassland conversions, while providing sustainable livelihood for ranchers/herders.

- Identify and locate Sarus crane's habitats in the Irrawaddy Delta, Myanmar, and develop conservation programs to preserve these habitats within the agricultural landscape.

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THREAT:

URBAN EXPANSION AND LAND DEVELOPMENT INCLUDING MINING

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This threat category corresponds in large part to the *Residential and Commercial Development* threat defined in the classification of threats and actions in Salafsky et al. (2008), updated in 2015 (IUCN-CMP 2015). It concerns human settlements or other non-agricultural land uses with a substantial footprint, comprising threats tied to a defined and relatively compact area. Three components are identified in the IUCN-CMP classification: i) housing and urban areas; ii) commercial and industrial areas; and iii) tourism and recreation areas. For the purpose of this publication, we are also including land development for mining as a related threat. *Impacts of Pollution and environmental contamination, including oil development* are dealt with in a separate threat assessment.

Population growth and economic development are seen as ubiquitous drivers of environmental change with urbanization (UNEP 2012). In 1950, only 29% of the world population lived in urban settings, with only New York and Tokyo qualifying as megacities with over 10 million people each. The urban proportion reached 50% in 2010 with 20 megacities, with the bulk of the urban population in Asia and Latin America. The UN Population Division projects that between 2007 and 2050, the world's urban population will increase by more than 3 billion, with almost all future population growth expected to take place in the cities and towns of developing countries (Montgomery 2008). By 2050, more than 70% of China's population and 50% of India's is likely to be urban, with China expected to have 30 and India 26 additional cities of more than one million inhabitants (Seto et al. 2010). Recent studies suggest a significant increase in land requirements for urban uses in the next 40 years–potentially an additional 100–200 million hectares (Bettencourt et al. 2007).

Residential and commercial development is closely linked to other threats to cranes including conversion of crane habitats such as wetlands (see *Conversion of wetlands for agriculture and other land development*), agricultural land (see *Changes in agricultural land use and practices*), and grasslands (see *Conversion of grasslands for agriculture, afforestation, and other development*), to loss or fragmentation of habitat, infrastructure hazards to flying birds (see *Collisions and habitat loss associated with utility lines and wind turbines*), disturbance (see *Human interference/disturbance, especially at nest sites*), and pollution of rivers, lakes, coastal zones and lands (see P*ollution and environmental contamination, including oil development*). Residential and commercial developments impact cranes by reducing nesting and foraging habitat, especially for flightless young. Wetlands are entirely destroyed when converted to urban, commercial, or industrial uses. Urbanization is accompanied by increased density of roads and drainage, and fragmentation. The impacts on cranes

Mirande CM, Harris JT, editors. 2019. Crane Conservation Strategy. Baraboo, Wisconsin, USA: International Crane Foundation. 455 p.

are highly irreversible compared to other threats such as changes in agricultural land use practices and can cause frequent and intense disturbances to cranes.

There are several key regions where crane distribution overlaps with high human population density and rapid economic growth. Rapid rates of land development in East Asia are a particular concern, especially the massive and rapid loss of Yellow Sea coastal wetlands that has occurred in China and Korea for industrial development and other purposes (see MacKinnon et al. 2012, Davison 2014). Wetlands in the Korean Demilitarized Zone (DMZ), the Choerwon Basin, and Panmunjom Valley between the Republic of Korea (South Korea) and the Democratic People's Republic of Korea (DPRK, North Korea) provide critical staging and wintering areas for White-naped and Red-crowned Cranes and are likely candidates for industrial development zones, should political unification of the Korean peninsula occur (Higuchi and Minton 2000). The Han River estuary's population is currently impacted by disturbances such as continued housing construction, a military conservation area, and direct/indirect impacts from the location of a bridge (Soodong Lee, personal comm. 2016). The Korea/Japan population of Hooded Crane has also been impacted by removal of sand bars from the migration route along the Nakdong River and intensive development along the western coastline in Republic of Korea, and in the buffer zone of Suncheon Bay wintering area. Black-necked Cranes face localized development threats, including airport construction at Napahai, the primary wintering area for the central population of this species, and at Ruoergai, the most important breeding area for the eastern

A flock of White-naped Cranes lifts off from the Han River Estuary. In the 1970s, marshes and rice paddies bordered much of the estuary. Today a landscape of skyscrapers borders the water (Photographer: Soon Young Yoon, Korea Wild Birds Protection Association) population (Fengshan Li, personal communication 2017). Land conversion, especially of wetlands and crop fields to urban development, causes permanent attrition of breeding Sarus Crane pairs in north India, and is a threat far more serious than variations in rainfall caused by global climate change (Sundar 2011). Potential changes in national land use policy to favor transformation of agricultural land to industrial and urban requirements in South and South-East Asia would intensify this threat.

A major increase in demand for fossil fuels and mineral resources has driven a global increase in the amount of exploration and mining operations. This trend has resulted in rapid and dramatic landscape changes as well as ecological impacts on affected habitats such as grasslands and wetlands, including the diversion, usage, and pollution of water resources. In Asia, mining development is rapidly accelerating in Mongolia (Skorkowsky and Schnackenberg 2013) and also expanding in parts of Russia and China with potential impacts on White-naped, Red-crowned, Hooded, and Siberian Cranes. For example, coal mining is the main potential threat for the vulnerable breeding habitats for White-naped and Red-crowned Cranes in Xinliguole of Inner Mongolia, China. Siberian Cranes are vulnerable to the impacts of economic development including oil and gas exploration and production at key staging areas in northeastern China including Momoge, the Lena basin in Yakutia, southern Yakutia, and in the Ob basin in Western Siberia (e.g., Harris 2009; Nicolay Egorov, personal comm. 2016).

In North America, energy exploration activities in the watersheds that encompass the Whooping Crane breeding area at Wood Buffalo National Park pose threats of water and air contamination. Recent expansion efforts in this region exploiting tar sands have raised concerns of short- and long-term impacts to this sensitive environment. Surface and groundwater contamination may already be occurring, and water usage for energy production could impact water levels (Timoney 2012). Reclamation efforts at a landscape scale will prove challenging to minimize continued contaminant leakage into surface and ground waters and recreate functional ecosystems that already exceed 140,000 km^2 (Johnson and Miyanishi 2008). Texas experienced the highest population increase in the United States from 2000–2010, and coastal development continues to increase along the Whooping Crane wintering area on the Texas coast (You and Potter 2016), as construction continues to be permitted in low-lying areas. Associated with this population increase, water needs continue to increase in the Guadalupe-San Antonio Basin, Texas, while essential fresh water inflows to the estuaries surrounding Aransas National Wildlife Refuge (NWR) continue to diminish. Pollution and environmental contamination continue to be an eminent concern as the Gulf Intracoastal Waterway bisects the entire wintering range of Whooping Cranes at Aransas NWR and surrounding areas (Canadian Wildlife Service and U.S. Fish and Wildlife Service 2005).

Mining for energy resources poses a serious threat to habitats of Grey Crowned, Wattled, and Blue Cranes. Over 75% of Mpumalanga's grasslands in South Africa are either under mining or prospecting application, the majority of which are for open-cast coal mines that will permanently destroy the habitat (Mervyn Lötter, personal comm. 2010). Around 40% of the Karoo in South Africa is under consideration for gas exploration (Twine et al. 2012). Depending on the extent and distribution of the drilling operations, land will be transformed and water resources will be contaminated. In arid environments, all biodiversity and people depend on ground water. Gas exploration is being considered in parts of the eastern grasslands of South Africa as well. Blue, Wattled, and Grey Crowned Cranes are losing grasslands to mining (primarily coal) in the northeastern grasslands of South Africa, and Grey Crowned Cranes are affected by plans to extract peat from many of the large wetlands in Rwanda. Oil exploration in and near the wetlands in southern Sudan also poses a threat to Black Crowned Cranes (Williams et al. 2003).

A strategic response is needed to counter such threats driven by powerful economic development forces, focusing on those regional crane populations and key sites most at risk, supported by strong understanding of the distribution and ecological requirements of the species involved, and the nature of development impacts. Expansion of protected area systems (e.g., for the Siberian Crane), partnerships with conservation, government and industry bodies (e.g., for the Blue Crane in South Africa), providing input on key sites to development planners (e.g., for Suncheon Bay in the Republic of Korea and Aransas in Texas), and participatory site management and restoration are all significant in this context.

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK:

- Red-crowned Crane on wintering grounds in China and near the Korean DMZ and along the migration route in China;
- White-naped Crane at breeding areas and along migration routes in China and on wintering areas near Korean DMZ;
- Hooded Crane at migratory stopovers around the Korean DMZ, in the buffer zone of Suncheon Bay and at migratory stopover sites in Republic of Korea;
- Sarus Crane in South and Southeast Asia;
- Whooping Crane on wintering grounds in Texas and potentially on breeding grounds in Wood Buffalo National Park in Canada; and
- Blue Cranes in the Karoo of South Africa and Grey-crowed in eastern South Africa; with
- Lesser threats to Black-necked, Brolga, Sandhill, Siberian, and Wattled Cranes.

RESEARCH AND MONITORING NEEDS

- Conduct surveys and monitor crane usage of sites and wider areas subject to existing or planned urban, mining, and energy development to obtain baseline data and determine trends; and
- Monitor the status of crane populations at risk from such development.

PRIORITY CONSERVATION ACTIONS

- Conservation planning and strategic development that take account of crane habitat usage to facilitate the maintenance of healthy ecosystems in wetland, grassland, and agricultural landscapes and mitigate impacts from urban and industrial development through appropriate zoning and effective environmental impact assessments as well as protection of water resources in land use planning;
- Expand habitat protection through protected area network expansion and collaboration with private land owners for the crane populations most at risk from this threat. For example, expand and designate new protected areas for the Hooded Crane, and expand suitable wintering habitat and feeding resources in Japan and Korea. In the Republic of Korea, continue conservation action for the protection and restoration of key crane sites, including the core zone at Suncheon Bay and establish a program to prevent or mitigate development in the buffer area;
- Secure important wetland and grassland sites from unsustainable development in South Africa under the Protected Area network, in collaboration with private and communal landowners, including important Blue Crane sites in the grassy Karoo in view of fracking and gas extraction;

- Legally secure important grassland and wetland sites for Grey Crowned Cranes across their range, which will benefit cranes, people and biodiversity;
- Build capacity for the Black-necked Crane Network, to strengthen information sharing, coordinated survey, and public awareness-raising in western China, which along with monitoring activities will help develop recommendations for authorities dealing with mining, tourist. and other development in this region; and
- Collaborate with gas and oil companies in Russia and China to minimize risks to the Siberian Crane and its key habitats.

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THREAT:

COLLISIONS AND HABITAT LOSS ASSOCIATED WITH UTILITY LINES AND WIND TURBINES

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Reliable, clean sources of energy are essential to ensure global economic growth. Globally over 1.2 billion people are without access to electricity (International Energy Agency, World Energy Outlook 2011). Demand for electricity is increasing rapidly worldwide and will continue to grow in the coming years. Given the significance of electrical energy to societal and economic development (Das 2006, Modi 2007), access to this resource has been recognized by many world leaders, forums, and unions as a top priority for many nations. This political commitment is manifesting itself in numerous new energy developments and transmission and distribution networks being planned and built across the globe. Most electrification projects involve centralized power generation through a variety of means (coal, nuclear, natural gas, hydroelectric, wind, solar, and geothermal sources) and transmission/distribution to end users via thousands of kilometers of new power lines. Power lines are likely to traverse a variety of sensitive habitat types that are important to cranes, including wetlands, water bodies, grasslands, and arable lands.

It is in these areas that the risk of negative interactions between cranes and energy infrastructure are likely to be highest. In addition, with the drive to develop renewable energy resources in many parts of the world, wind farms and their associated infrastructure bring a suite of unknown consequences and potentially significant threats to cranes, particularly if these facilities are located within migratory flyways, near stop-over sites, or in areas where key daily movement paths between roosting, breeding a and foraging areas exist. Other threats associated with energy development include open-cast coal mines, gas extraction, and peat mining that destroy grassland and wetland habitats that are vitally important to crane survival.

The establishment of energy-generating facilities and the expansion of power line networks not only destroy and fragment habitat, they also pose significant risks to crane survival. Cranes are particularly vulnerable to any human-induced increase in mortality. Cranes are especially susceptible to colliding with power lines, resulting in injury and often mortality (Martin and Shaw 2010). Collision risks are highest in areas where power lines pass through breeding (Sundar and Choudhury 2005), roosting, and foraging habitats. Risks may be higher for migratory cranes that are often moving through less familiar areas, although data to assess seasonal differences in risks and mortality are limited. Black Crowned and Grey Crowned Cranes, species that are capable of perching, may also be killed by electrocution when they attempt to roost on top of power line poles.

Mirande CM, Harris JT, editors. 2019. Crane Conservation Strategy. Baraboo, Wisconsin, USA: International Crane Foundation. 455 p.

On a global scale, little information regarding interactions between cranes and energy infrastructure has been documented. What information is available is often fragmented, anecdotal, and generally insufficient to accurately assess the scale of the problem or the implications for the relevant species populations. The problems have been evaluated for some species and critical areas. Power line collisions are one of the main mortality causes for birds (Loss et al. 2015) and are believed to be an important source of mortality to migratory Whooping Cranes (Stehn and Wassenich 2008, Stehn and Stroble 2014), non-migratory Whooping Cranes in Florida (Folk et al. 2008), and Red-crowned Cranes wintering in Hokkaido (Masatomi 1987). A study on Sarus Cranes in south-central Nepal (Aryal et al. 2009) documented deaths of five birds but was not based on empirical evaluation. In Uttar Pradesh, India, a multi-year evaluation showed that <1% of Sarus are killed each year due to collisions (K S Gopi Sundar, personal comm. 2016). Several recent noteworthy examples of power line collisions include Sandhill Cranes staging along the Platte River (Wright et al. 2009) and Eurasian Cranes staging on a large wetland in Spain (Janss and Ferrer 2000). Estimates for Blue Cranes in South Africa suggested approximately 12% of the total Blue Crane population in the Overberg (Western Cape) area were killed annually from such collisions (Shaw et al. 2010).

Over a 21-year period (October 1996 to October 2017), 1,506 cranes mortalities were reported on energy infrastructure in South Africa (Endangered Wildlife Trust, unpublished data). Blue Cranes are reportedly the most heavily impacted species in South Africa through mortalities on energy infrastructure, with 1,258 individuals killed through collisions during this period. Because Grey Crowned Cranes are perching birds, they are killed through electrocutions in addition to collisions. Grey Crowned Cranes are one of top ten species with the highest number of energy infrastructure-related deaths in South Africa (Endangered Wildlife Trust, unpublished data). During the 21-year period, 233 individuals were killed through collisions and electrocutions. The Wattled Crane, possibly limited by its restricted distribution, is not commonly reported in the region, with only 15 mortalities recorded in the 21 years (Endangered Wildlife Trust, unpublished data).

Based on this data, it is not surprising that the collision and electrocution impacts associated with energy infrastructure is rated in the top ten threats to cranes and detrimentally affects all but two of the 15 species (i.e., Sandhill and Wattled Cranes). Collisions may become an important mortality factor for Siberian Cranes. There is a need to monitor impacts of a transmission line constructed in 2017 that crosses the Algama River, in southern Yakutia, Russia, multiple times along a narrow stretch of the migration route used by most of the world's Siberian Cranes (Nikolai Germogenov and Andrei Detyarev, personal comm. 2016). A power line was also constructed along a

Blue Crane killed by collision with a transmission line (Photographer: Jon Smallie, Endangered Wildlife Trust) migration route through the Middle Aldan region of Yakutia (Pshennikov et al. 2007). Scientists are seeking partnership with the power companies to mark the highest risk stretches along these routes and inspection staff will monitor mortality in this remote region.

For all populations of Whooping Cranes, collision with power lines has been identified as a source of mortality and a growing imminent threat as energy infrastructure supports increasing development. Understanding the impact from wind turbines for Whooping Cranes is incomplete, although permits have been approved and wind farms have been constructed in the migration corridor of the Aransas Wood Buffalo population (AWBP). An unpublished study by the American Bird Conservancy (ABC) revealed that 5,500 wind turbines existed within the U.S. portion of the Whooping Crane Migratory Corridor (as delineated by Pearse et al. 2015) and that another 18,500 were planned (ABC 2014).

Wind turbines are expected to become an increasing threat for other crane species. Development of wind farms requires new power line infrastructure that contributes additional disturbance and can further fragment or alter habitat. However, data about bird responses, altered habitat use in or around the wind farm, or actual collisions with turbine blades remains sparse, and much uncertainty remains. Online information on bird collisions gathered by the authorities of the federal state of Brandenburg in Germany in Germany (and Europe) (see http://www.lugv.brandenburg.de/cms/detail.php/bb1.c.312579.de) reported a minimum of 19 deaths of Eurasian Cranes from collisons with turbines in Europe from 2008–2016. However, the list is only a small sample of likely deaths since only people who find a dead bird and know about the list report it. Due to increasing needs of electrical energy, wind energy developers in Europe plan to construct and operate large numbers of wind farms with sometimes more than 100 turbines, each more than 200 m high. In the Baltic Sea, an environmental impact study estimated the annual cumulative collision impact on Eurasian Cranes at 2,620–2,700 birds for just a single wind farm (Danish Center for Environment and Energy 2015). Along the migratory path of Whooping Crane through the central USA, a three-year investigation found no dead or injured Whooping Cranes or Sandhill Cranes at five wind-energy facilities, and utility companies have developed contingency plans to detect and shut down turbines when cranes are present (Derby et al. 2018). In Australia, the majority of the Brolga population in the state of Victoria lies within areas preferred for wind farm development; the Victorian and Commonwealth governments have developed new guidelines to "manage the cumulative impact of multiple wind farms planned, assessed and operating independently within the Brolga's range in Victoria, so that there is no 'net effect' or, ideally, a positive effect can be achieved for the population" (Department of Sustainability and Environment 2012). In South Africa, preliminary results of the first year of operational monitoring efforts of power lines found no clear evidence of displacement, and no fatalities (Ralston Paton et al. 2017); previously three adult fatalities had been found over 21 months of monitoring (Endangered Wildlife Trust, unpublished data 2016).

The causes of bird interactions with energy infrastructure are complex (Bevanger 1994, Hunting 2002, Drewitt and Langston 2008) but are generally the result of species' physical and behavioral characteristics, environmental conditions, and the location of the energy generating facility and routing of power lines. Cranes are susceptible to collisions with power lines and wind turbines due to their large body size, flight behavior, visual field (Martin and Shaw 2010), and the manner in which they utilize the habitat. Young birds that are inexperienced and clumsy flyers as well as those birds that are unfamiliar with the area (i.e. non-breeding birds that disperse more widely) appear to be more vulnerable to collision than experienced adult birds (Brown 1992, Crowder and Rhodes 2001, Sundar and Choudhury 2005). Similarly, body size, age, lack of alternative perching space, and the availability of food sources in close proximity to power line infrastructure are all characteristics that contribute to an increased likelihood of electrocutions in crowned cranes.

The open habitats preferred by cranes are often preferred by utilities for energy production and transmission because they are easier to build in such areas and avoid conflict with existing urban areas and other existing infrastructure. Power lines, wind turbines, and associated infrastructure can result in actual and de facto habitat loss for cranes. Erection of turbines, construction of associated power line infrastructure, and operational maintenance results in increased disturbance and fragmentation or alteration of natural and cropland habitats. Cranes may be less likely to use habitat close to wind turbines and be more vigilant (Navarette 2011), and consequently less able to forage efficiently around wind turbines. These concerns have led to recommended minimum setbacks from wind turbines to important crane habitat (U.S. Fish and Wildlife Service 2012, Department of Sustainability and Environment 2012). Long arrays of wind turbines may also create partial barriers to bird movements, further affecting habitat use and energetics (Drewitt and Langston 2008). Such effects may be mitigated by providing gaps of at least 1.5 km between turbine clusters (Gerjets 2006).

A variety of mitigation solutions exist (Jenkins et al. 2010) and can be implemented at various stages of infrastructure development, but few of these have been tested in the field rigorously. The surest ways to prevent bird interactions with energy infrastructure are to locate and route the structures well away from areas known or considered likely to support species susceptible to interactions (Hunting 2002, Drewitt and Langston 2008) or construct bird-friendly structures from the outset. Most commonly, both new and existing power lines are marked at intervals with devices intended to increase the visibility of lines, although the efficacy of these devices for reducing mortalities is variable (Alonso et al. 1994; Jenkins et al. 2010; Barrientos et al 2011, 2012). Electrical infrastructure located near roost sites are particularly difficult to mitigate since collisions tend to occur at dawn, dusk, or after dark (Brown and Drewien 1995, Wright et al. 2009, Murphy et al. 2016 a,b). Testing of nocturnal anti-collision devices is underway and preliminary results suggest that these markers are effective at reducing nocturnal collisions (Murphy et al. 2009). In South Africa, the nocturnal "OWL" bird flight diverter device proved to reduce nocturnal collisions by more than 81% at test sites, over a 3-year period (Matthew Pretorius and Constant Hoogstad 2016, unpublished data). In areas with very high crane utilization, burying or moving power lines may be the only feasible option (Braun et al. 1978, Masatomi 1987, Bernardino et al. 2018).

With large-scale electrical power development planned and in progress around the world, coordination and communication across utility companies, government wildlife agencies, and conservation non-governmental organizations (NGOs) are critical in order to share lessons, develop capacity, pool resources, and accelerate collective learning towards finding innovative solutions to better understand and mitigate the impact of the energy sector on threatened crane populations (Antal 2010). In order to achieve measurable and comparable results, it will be vitally important to standardize methods to obtain mortality estimates (Ponce et al. 2010) and work with utility companies to develop guidelines for new electricity related developments and existing power line networks. The Avian Power Line Interaction Committee (USA) (APLIC 2012) and the Eskom-Endangered Wildlife Trust Strategic Partnership (South Africa) are examples of two successful partnerships that demonstrate how conservation organizations and utilities effectively work together to minimize risks of bird interactions with electrical infrastructure. These partnerships serve as models to the electrical utility industry worldwide on how to address the problem of wildlife mortality caused by electricity networks through non-confrontational, co-operative management. Best-practices guidelines and resources such as that developed for South Africa (Jenkins et al. 2012), the USA (APLIC 2012), and Australia (Department of Sustainability and Environment 2012) can provide a foundation for similar development in other regions.

While cooperation is important, equally important are appropriate regulatory mechanisms and

Marking power lines in South Africa to reduce collisions by cranes and other birds (Photographer: Constant Hoogstad, Endangered Wildlife Trust)

enforcement that hold energy developers accountable for appropriate siting and mitigation of energy infrastructure in order to help prevent or reduce bird fatalities. In the United States and Canada, wind energy developers are minimally regulated at present, which is leading to poor siting and likely increases in bird (and bat) mortality (Casey 2015). All fatality data should be collected by independent, third-party experts using standardized methods and reported directly to regulatory agencies (Ferrer et al. 2011, Rowe and Alexander 2012). If protected species are killed, even after all precautions have been taken, then energy companies should compensate the public for their loss in countries where supported by national laws. For example, a fund could be established to hold such monies, which could then be used for conservation purposes, such as the purchase of additional habitat away from the energy infrastructure (Hutchins et al. 2016).

The issues surrounding cranes and energy infrastructure are shared with many other bird species. Bernardino et al. (2018) conducted a systematic review of the literature available on bird collisions with power lines and examined species, site, and power line specific factors, and their effectiveness in reducing collision risk. They noted a scarcity of studies in Asia and Africa—regions that also have the greatest rates of electrical infrastructure development as well as many crane species. They identified knowledge gaps and provided suggestions for future research and development of innovative approaches in three areas: bird behavior (e.g. flight patterns and behavioral reactions, use of bio-loggers and collision sensors); impact assessment methods (e.g. understanding the drivers of mortality hotspots, assessing population-level impacts, developing methods for automatic detection of collisions); and effectiveness of mitigation measures (e.g. further need of before-after-control-impact approaches to compare the effectiveness of different power line marking devices).

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Blue Crane in the Karoo and Overberg regions in South Africa;
- Whooping Crane in Central Flyway (Saskatchewan to Texas), particularly along central Platte River;
- Grey Crowned Crane in Uganda and Kenya;
- Hooded Crane in the mid- and lower reaches of the Yangtze River, Eastern China;
- Red-crowned Crane in Cheorwon, Korea, and mid- and lower reaches of the Yangtze River, Eastern China;
- White-naped Crane in Cheorwon, Korea, mid- and lower reaches of the Yangtze River in Eastern China, and the Eurasian Steppes.

RESEARCH AND MONITORING NEEDS

- Conduct risk assessments on key sites identified as critical to populations and understand the drivers of mortality hotspots;
- Develop generalized crane population model to assess role of mortality and morbidity from collisions and electrocutions on population dynamics;
- Understand the behavior of birds relative to infrastructure types, placement, and different mitigation techniques, consider use of bio-loggers and sensors or developing methods for automatic detection of collisions;
- Aid in the development and evaluation of new, more effective, and inexpensive marking strategies including ground markers, that are effective across a range of light and environmental conditions;
- Standardize carcass survey methods to obtain accurate mortality estimates which are comparable among species and areas; and
- Understand the effects of wind farms on risks of collisions and habitat use.

PRIORITY CONSERVATION ACTIONS

- Work with governments, communities, and utility companies to increase awareness of risks of power line collisions and electrocutions and significance to crane populations;
- Encourage avoidance, re-routing, burying or marking lines in high-risk areas;
- Provide risk maps, recommendations, and guidelines on line placement, preferably as early in the network planning process as possible;
- Request or require mitigation for wetland loss in government and NGO programs that affect water-control systems and wetlands;
- Develop geo-referenced databases in collaboration with utilities and conservation organizations to share information on planned developments, identify potential areas of high risk for monitoring, and report information on bird interactions with electrical infrastructure; and
- Develop best-practices guidelines, policies, and regulations in collaboration with utilities, governments, and other stakeholders.

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THREAT:

ILLEGAL TAKE INCLUDING HUNTING, TRAPPING, AND POISONING

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Hunting and egg collecting are believed to have been a major cause for the near-extirpation of the Whooping Crane in North America and hunting and trapping for the precipitous decline of the Western/Central Asian population of the Siberian Crane. Several species and regional populations suffer from illegal hunting, accidental shooting, and disturbance during legal waterfowl hunting as well as from trapping and poisoning. Because crane populations grow slowly, any mortalities, particularly of adult breeding birds, can pose a significant threat to the long-term survival of the species. Illegal take represents a significant threat for Siberian, Whooping, Red-crowned, White-naped, Hooded, and Demoiselle Cranes and a lesser threat for Grey Crowned, Black Crowned, Blue, Wattled, and Eurasian Cranes.

Currently only abundant Sandhill Cranes are legally hunted, and hunting is not a significant threat on the species level. Sandhill Cranes are a game species in 14 states of the USA, two provinces in Canada, and three states in Mexico (Kruse and Dubovsky 2015). Diverse governmental agencies and stakeholders use strong science and public awareness to manage well-controlled and sustainable hunting practices. However, overhunting poses a potential risk to some populations (see details in *Sandhill Crane* species review). Although legally protected, the migratory subspecies *G. g. canadensis* are hunted for subsistence in Russia (Krapu et al. 2011). In the portions of the United States where Sandhill Cranes are hunted, cases of the incidental shooting of the Endangered Whooping Cranes have occurred on wintering grounds in Texas and along migration corridor (Kansas, South Dakota, North Dakota, and Oklahoma) (Condon et al. 2018). Research on mortality of the only wild self-sustaining Aransas-Wood Buffalo population from 1950 to 2009 indicated that 20% (n=10) of 50 recovered carcasses were killed by shooting (Stehn and Haralson-Strobel 2014). There are currently 27 known shooting incidents since the 1967 listing of the Whooping Crane as a Federally Endangered Species (Condon et al. 2018). Nature conservation agencies in Texas and Kansas have adopted a variety of strategies to address this problem while continuing to allow hunting of Sandhill Cranes (Linam et al. 2008). They include hunter education and issuing of licenses only after hunters pass an online certification test that includes background information about Whooping Crane conservation. In Texas, hunting seasons for Sandhill Cranes are delayed until most Whooping Cranes have migrated through the Sandhill Crane hunting zones. Kansas agencies elected to start shooting hours at sunrise one-half hour later than federal requirements, thus providing better visibility for proper species identification to avoid mistaken shooting of Whooping Cranes. Both Kansas and Texas close selected areas for hunting to protect Whooping Cranes. From 2010–2015 there were 14 documented Whooping Crane shootings, currently accounting for 19% of known adult mortality in the reintroduced population in the eastern United States (Harrel 2014). A few were killed because they were mistaken for legally-hunted species, but most appear to have been killed in acts of vandalism. A total of 27 known shooting incidents from accidental shootings and vandalism have been reported since 1967 when the Whooping Crane was listed as a Federally Endangered Species (Condon et al. 2018). In 2015 ICF initiated a *Keeping Whooping Cranes Safe* program to reduce human-caused mortality of Whooping Cranes with four objectives: create communities that care, involve citizen *Whooper Watchers* for protection, eliminate accidental shootings, and increase negative consequences for shooting a Whooping Crane (file:///C:/Users/econdon/Downloads/2016V42N2_Bugle.pdf).

Sport hunting for cranes is of increasing concern in Saudi Arabia and possibly in other countries of the Middle east and central Asia. Hunters attract Demoiselle and Eurasian Cranes to small, artificially created ponds or blue plastic sheets (set out to appear to be water) using decoys and calls. These techniques and modern automatic guns have contributed to mass, indiscriminant killing of crane flocks.

Illegal hunting is a significant threat to migratory cranes in West/Central Asia where three species are affected: Siberian, Eurasian, and Demoiselle Cranes. Regulation of hunting practices varies significantly between countries in the region, but in general, hunting legislation is weaker than in more developed regions, resources for enforcement are less available, and hunters generally lack any kind of systematic education regarding gun safety, quarry identification of protected species, and wildlife management. There is also a lack of consistency between countries in the region in terms of the scientific and rational basis for the management of hunting, especially in relation to the management of waterbird populations. Political decisions supersede management authority's decision on hunting seasons and permits (Khan 2004). This gives rise to unsustainable hunting practices that can impact regional waterbird populations. In Russia, cranes have been under legal protection for decades, but these laws have never been strictly enforced. In 2000–2010, hunters became much better equipped with modern weaponry, while their knowledge and environmental ethics declined. Numbers of Eurasian and Demoiselle Cranes known to be illegally hunted escalated in this region after the USSR collapse, especially in Azerbaijan (Elchin Sultanov, personal comm. 2004), Kazakhstan (Bragin 2014), and Uzbekistan (Mitropolsky 2011). In addition, sports hunting by urban and overseas visitors with varying degrees of commercialization is gaining popularity as international travel becomes more accessible and affordable, especially in private game areas.

Illegal hunting of Eurasian and Demoiselle Cranes has been advertised on the internet, contributing to declines of vulnerable populations of these species (Photographer: Unknown)

Along migration routes, crane hunting and trapping have deep-rooted traditions in the cultures of Afghanistan and Pakistan involving a variety of hunting and trapping techniques (Perveen and Khan 2010). These practices were formerly widespread in these countries and are believed to be a primary cause for the decline of the Siberian Crane population. Hunting and live trapping of Eurasian and Demoiselle Cranes for food, keeping in captivity as pets, and sale is a significant part of rural livelihoods. Recently hunting and trapping were made illegal in all areas in these two countries. However, uncontrolled hunting and trapping with nets and nooses still occur, especially in Khyber Pakhtunkhwa province of Pakistan and the tribal areas where it is difficult to control (Khan 2004). The ban on hunting, if not strictly implemented, may spread as far as to Wasta Lake in Balochistan, Pakistan, a recently discovered potential staging site for Eurasian and Demoiselle Cranes (GeoTV 2013). For instance, there are unofficial reports of Eurasian Crane harvests, using nets in reed beds at roosting sites in the Amudaria River Valley in Afghanistan (Alexander Sorokin, personal comm. 2011).

On the wintering grounds of the Siberian Crane in Mazandaran Province of Iran, gun shooting of waterfowl is strictly prohibited during the traditional waterfowl trapping season, which is an important livelihood in winter. Near the end of the wintering season, just before spring migration, Siberian Cranes become more vulnerable, as the number of waterfowl decreases and local people harvest ducks and geese using guns. To address this threat, the Department of the Environment has officially established a Non-Shooting Area in Fereydoonkenar (Sadeghi Zadegan 2011). A *Western/Central Asian Site Network for the Siberian Crane and Other Waterbirds* was launched in 2007 under Convention on Migratory Species (CMS) for strengthening species and habitat protection at key sites along Western/Central Asian Flyways. This effort was closely linked to the broader *Central Asian Flyway* initiative for migratory waterbirds led by Wetlands International (www.wetlands.org). Siberian, Eurasian, and Demoiselle Cranes, as well as other waterbirds including endangered and vulnerable species, use these flyways. In 2012 and 2014, projects on hunting regulation and hunter education was conducted in Russia, Kazakhstan, Turkmenistan, Uzbekistan, Afghanistan, and Pakistan with support from the Mohammed bin Zayed Species Conservation Fund. Guidelines on captive breeding of cranes were published in Pakistan with a goal to increase breeding success, which aimed to decrease crane capture from the wild. Investigation of poaching cases in Kazakhstan and Uzbekistan indicated a decrease in illegal hunting due to mass education targeted to different target audiences including hunters (Mitropolsky 2011, Bragin 2014).

Cases of illegal hunting of Eurasian Cranes increased along the Baltic-Hungarian Flyway in the Balkan region: in Albania, Bosnia-Herzegovina, Croatia, and Montenegro (Stumberger and Schneider-Jacoby 2013). Illegal hunting and legal waterfowl hunting led to a rapid decline of the Transcaucasia Eurasian Crane (*G. g. archibaldi*) in Turkey and Armenia due to disturbance and accidental or deliberate shooting that affected breeding productivity (Ilyashenko et al. 2008, Akarsu et al. 2013).

Red-crowned and White-naped Cranes are threatened by illegal hunting during both spring and autumn migrations in the Russian Far East, Transbaikalia, and Yakutia. Uncontrolled waterfowl hunting led to an increasing number of cases of illegal hunting of cranes that now occur almost every year during hunting seasons, for example, in Khanka Lake in the Russian Far East where spring hunting is traditional (Sergei Surmach, personal comm. 2010). In southern Yakutia, the Eurasian Crane flyway goes through places with traditional waterfowl hunting; illegal hunting therefore is a significant threat for this population, while poaching cases for Siberian and Hooded Cranes are very rare (Degtyarev 2011).

On the breeding grounds of Red-crowned and White-naped Cranes in the Russian Far East, cases of crane poaching are rare, for example in the Primorsky Region (Surmach 2005) and in Transbaikalia (Goroshko 2007). In most cases, cranes become unintentional victims of incorrect identification. The major contributor to disturbance and accidental shooting of cranes in these regions is associated with legal spring hunting of waterbirds. The hunting season opens after cranes begin breeding. Disturbance from shooting and human activity results in cranes losing most of their clutches and having extremely low or no breeding success outside the protected territories (Smirenski and Smirenski 2010, Goroshko 2015). In addition, gun shots and cigarettes from hunters caused widespread fires affecting crane habitats (see also *Impact of Fires on Cranes*). Spring hunting is a particular issue in Russia, causing concern due to high impact on breeding waterbird populations. Efforts to control spring hunting in some regions of Russia have met with strong opposition. Therefore, there is a need to promote a scientifically based rationale for managing waterbird populations including consideration of population trends and prevailing environmental conditions.

Considerable hunting pressure exists in African countries. In Namibia, illegal and unsustainable hunting of Blue Cranes for both meat and traditional medicinal uses is considered a major threat when the birds leave the confines of the Etosha National Park during the winter months (Ntinda et al. 2012). The targeting of Blue Cranes is an added stress that this small isolated population probably cannot sustain, and at the present rate this practice is expected to contribute to the disappearance of the cranes in Namibia. Illegal hunting of Black Crowned, Grey Crowned, and Wattled Cranes occurs both for food and for traditional purposes, which includes healing and practices that promote a particular behavior / outcome, such as monogamous relationships (Williams et al. 2003, Morrison and van der Spuy 2006, Morrison 2009).

In China, illegal hunting is not a significant problem due to strong gun control laws. However, Red-crowned, Hooded, White-naped, and Siberian Cranes become victims to snares illegally set on their wintering grounds by duck and goose hunters (Liying Su, personal comm. 2016). Some cranes may escape with an injured leg or the snare dangling behind, which can later become entangled.

Eggs or adults also may be intentionally taken for food. For example, eggs and chicks of Sarus Cranes in south-central Nepal are taken for food (Aryal et al. 2009). Nest destruction and taking of eggs or chicks is a greatest threat in paddy systems where cranes nest in close proximity to agricultural fields, often in crop fields (Borad et al. 2002, Sundar 2018). Conflicts between farmers and Sarus Cranes in paddy agrosystems are a likely cause of population decline for this species in the Kheda district of Gujarat, India (Borad et al. 2002). Improving community

Poisoned grain illegally placed to kill other species causes mortality of Critically Endangered, Endangered, and Vulnerable cranes. Deaths of breeding adults decreases the ability of the species to recover. (Photographer: Unknown) awareness and protection of breeding cranes can ameliorate such threats to crane populations. For example, protection of nests and eggs following the establishment of the Longbao National Nature Reserve in the Qinhai Province, China in 1986 was one of the main factors contributing to the quadrupling of the summer population of adult Black-necked Cranes (Farrington and Xiulei 2013).

Illegal take from poisoning, both intentional and unintentional, is a significant threat especially in countries where hunting is prohibited or guns are not affordable for poor people (see also *Unintentional and intentional poisoning or harassment of cranes related to agriculture*). Intentional poisoning is the primary way that poachers take wintering cranes (Lin 2005, Su and Zhou 2012). Agrochemicals have been used in bait for illegal harvest of other birds and resulted in cranes deaths. For example, 37 White-naped Cranes and 11 Hooded Cranes were killed in the Republic of Korea (South Korea) after consuming rice grains soaked in phosphamidon intended for illegal harvest of wild ducks (Kwon et al. 2004). On the breeding grounds of Blue and Wattled Cranes intentional poisoning has decreased dramatically over the last two decades; while data is limited, informal reports indicate that incidents of poisoning are still occurring, primarily for food (Kerryn Morrison, personal comm. 2016). Unintentional poisoning usually occurs as a result of ingesting of or exposure to various pesticides.

For all types of illegal take, there is concern regarding the lack of data and challenges to document and address these potentially significant and politically sensitive threats.

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Whooping Cranes on their traditional wintering grounds in coastal Texas, along the Central Flyway, and along the eastern flyway and in Louisiana where populations have been reintroduced (accidental shooting and vandalism);
- Red-crowned and White-naped Cranes on their breeding grounds in the Russian Far East and Transbaikalia (disturbance from spring waterfowl hunting) and on migratory wintering grounds in China (snares);
- Siberian, Demoiselle, and Eurasian Cranes along Western/Central Flyway in Central Asia and Azerbaijan, and in Afghanistan and Pakistan (illegal hunting, live trapping); and
- Siberian, Eurasian, Demoiselle, Red-crowned, Hooded, and White-naped Cranes in Russia, China, and Mongolia (intentional and unintentional poisoning); with
- Lesser threat to Black-crowned, Blue, Grey-crowned, and Wattled Cranes.

RESEARCH AND MONITORING NEEDS

- Identify key areas and monitor levels of illegal take and legal hunting pressure on cranes and other waterbirds in North America, East Asia, Western/Central Asia, and African countries using tracking and monitoring, consultations with experts, interviews/questionnaires of hunters and local communities, and literature reviews;
- Conduct studies on spring hunting to establish scientifically based waterbird population management practices that consider population trends and prevailing environmental conditions.
- Investigate cases and reasons for crane trapping and poisoning to develop scientifically based conservation measures to mitigate these threats. and

- Conduct study to estimate the impact of unintentional poisoning on threatened crane species and identify strategies using local actions on key sites and national laws and international treaties to minimize mortalities.

PRIORITY CONSERVATION ACTIONS

- Strengthen, adapt, or enforce regulations for legal waterfowl hunting (change dates, close zones for hunting, conduct education activities) and advocate for strengthened enforcement by governments;
- Reduce indirect disturbance to cranes associated with hunting of other species, especially spring hunting in Asia, through hunter education and collaboration with hunting agencies;
- Raise awareness of potential hunters of existing laws and penalties (fines, jail time) for illegal hunting and develop additional deterrents (social pressure);
- Develop strong local crane hunting networks (crane working groups, legal hunting groups), involve in crane censuses, and use as respondents for surveys on identification of rare crane sightings and determination of threats from illegal hunting, trapping, and poisoning;
- Apply African-Eurasian Migratory Waterbird Agreement (AEWA) guidelines on sustainable harvest of migratory waterbirds for the African-Eurasian flyway, and apply international experience (e.g. in the European Union and North America) on sustainable hunting practices;
- Address illegal hunting of Siberian, Eurasian, and Demoiselle Cranes along Western/Central Asia flyway through coordinated international actions by implementing approaches under CMS Siberian Crane MOU conservation plans; and
- Create awareness within governmental agencies, educate hunters, and build capacity of management authorities to reduce pressure on cranes in Pakistan and Afghanistan.

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THREAT:

UNINTENTIONAL AND INTENTIONAL POISONING OR HARASSMENT OF CRANES RELATED TO AGRICULTURE

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Global intensification of agriculture and concomitant increase in diversity and use of chemicals for control of plant, insect, and other pests threaten cranes that use agricultural landscapes. Crane mortalities have been linked to a range of chemicals, most commonly organophosphates and carbamates. Cranes also are expanding the types of agricultural habitats they use and foods they consume, which can expose them to novel chemicals or chemically treated situations. In developed countries, application of more toxic agrochemicals has declined as the most toxic chemicals have been banned, formulations have been improved for greater efficacy, and farmers' understanding of applications have improved, but use continues to grow in developing countries (Ecobichon 2001). Poisoning risks to cranes from misuse or illegal use of agrochemicals are higher in developing countries where governments lack strong regulatory, registration, and educational systems for proper usage. D. Nankinov (2009) considered poisoning with DDT as the main reason for the extirpation of Demoiselle Cranes on their breeding grounds in northeast Bulgaria. Residual levels of some of the more toxic agrochemicals remain high in some areas of South and Southeast Asia (Ali et al. 2014, Tran et al. 2014), exposing cranes to potentially damaging levels through their foods. For example, wetlands that Sarus Cranes use for breeding and non-breeding season in the Mekong River basin are hotspots of high concentrations of DDT and other persistent organic pollutants (Tran et al. 2014).

Cranes have been sickened or killed through both intentional and unintentional poisoning from agrochemicals, primarily pesticides (see also *Pollution and environmental contamination, including oil development*). The large number of reports and range of crane species (reviewed in Austin 2018) indicate poisoning by agrochemicals is a serious and possibly growing problem. Identifying where the problem exists is often difficult—documentation of poisoning can be problematic because of lack of reporting and limited resources for testing to verify the cause of death. Individuals may be uninterested or unwilling to report poisoning incidents. Death of a few birds often go unnoticed, whereas mass mortalities receive more attention and may be more representative of the severity of the problem. For example, 3–4 separate poisoning incidents around the South Luangwa National Park, Zambia, resulted in a total of 60 Grey Crowned Cranes killed in less than a year between 2015 and 2016 (Kerryn Morrison, personal comm. 2017). Where incidents have been reported, data quantifying the number of birds killed are often inadequate, and reasons for the poisoning often unclear.

Unintentional (accidental or incidental) poisoning appears to occur more frequently and cause more mortalities than intentional poisoning (killing in response to crop damage). Unintentional poisoning usually occurs when timing or location of chemical applications to crops coincides with crane foraging activities. Poisoned cranes often have ingested planted seeds that have been treated with insecticides or fungicides; others have been poisoned by ingesting seeds treated to prevent insect or rodent damage in storage. In the Grambower Moor region in northeastern Germany, 40 Eurasian Cranes were killed by ingestion of zinc phosphide, a rodenticide used to control voles (*Microtus*) in fields (Gunter Nowald, personal comm. 2017). Poisoning may be a significant factor in the decline in Red-crowned and White-naped Cranes, and mortalities may be much higher than suspected (Jim Harris, personal comm. 2016).

Red-crowned Cranes have been killed after consuming treated seeds in many locations in China, most often on migration or wintering areas (Su and Zou 2012). Six White-naped Cranes were accidentally poisoned at Duolun, China when they fed on winter wheat (*Triticum aestivum*) seeds treated with pesticides, a farming practice commonly used in China to protect seed from invertebrates; the incident was reported and four cranes later recovered after treatment (Jiao et al. 2014). Sarus, Siberian, and Eurasian Cranes died in several events from feeding on wheat seed treated with monocrotophos or the organophosphate insecticide chlorpyrifos at the Keoladeo National Park, India (Pain et al. 2004).

In Mongolia in 2002, more than 340 dead or dying birds, including 145 Demoiselle Cranes, were observed at several localities after about 3,500 km^2 of steppe were treated with the rodenticide bromadiolone, to control a population explosion of voles, although the full scale of mortality is unknown (Natsagdorj and Batbayar 2002, cited in BirdLife International 2004). In 2017, more than 260 Eurasian cranes were poisoned by indiscriminate aerial distribution of rodenticides on agricultural lands in the Aleksandrovsky and Petrovsky Districts of the Stavropol Region, Russia (Malovichko 2018). At the Khurkh River Valley in northeastern Mongolia, use of defoliants to prepare fields for planting led to a significant decline of the local population of Demoiselle Cranes and death of two Demoiselle Cranes in 1989 (Popov 2000). The Khurkh River Valley is also very important breeding and staging area for White-naped Cranes. In Russia, poisoning of Demoiselle and Eurasian Cranes increased significantly with indiscriminate application of agrochemicals used in no-till management (Malovichko 2011, 2018). In the Transbaikalia region of Russia, numerous cases of deaths of Demoiselle Cranes were reported during the 1970s–1980s, a period of active agricultural development, because of extensive use of rodenticides and pesticides on crop fields (Goroshko 2002). Few chemicals were used in the region during the 1990s–2000s because of economic problems and significant reduction of agriculture associated with the collapse of the Soviet Union (Ilyashenko 2018). However, since middle 2010s, the scale of agricultural production and chemical use has increased, renewing threats to cranes from agrochemical poisoning (Oleg Goroshko, personal comm. 2017). Demoiselle Cranes are under high risk of poisoning because this species is closely connected with agriculture fields during breeding and migration, more so than other crane species in Russia and Mongolia.

Fidelity of migrant cranes to breeding and wintering areas increases risks of large or repeated mortality events due to poisoning, which then may eliminate a portion of a population. Rapid, local declines of Blue Cranes in South Africa during the 1980s and 1990s coincided with many reported cases of poisonings from all parts of the country (McCann et al. 2001). The large number of poisoning incidents and evidence of high adult mortality for Red-crowned Cranes on their migration and wintering areas in China (Su and Zou 2012) suggest poisoning remains an important source of mortality for that endangered species. White-naped Cranes, which share a similar range, also may suffer substantial poisoning mortality. Protected areas that attract and hold concentrations of cranes are often very important to the conservation of a population; however, those cranes may then be exposed to treated crops when they leave protected areas to feed in the surrounding agricultural fields (Ma et al. 1999). Therefore, particular actions, such as regulations limiting use or pesticide training and education to minimize risks, may be needed to minimize pesticide exposure of cranes that feed on private lands around protected areas.

Some pesticides are particularly toxic to birds, and some of the most toxic chemicals have been discontinued at the global scale once their toxicity to birds was known (e.g., aldrin). However, others remain available and are used in limited areas. Carbofuran (also known as Furadan; any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government) is a carbamate insecticide and nematicide used to control insects and nematodes in a wide variety of field crops; it has been responsible for many bird mortalities around the world (Richards 2011). Its use is banned or highly restricted in most developed countries but is still widely used in Africa and Asia. Many bird species in Kenya have suffered extensive mortalities from carbofuran (Richards 2011), and its use continues to threaten Grey Crowned Cranes. The chemical remains locally available in eastern Africa and is still used by farmers and by poachers. Monocrotophos, a broad-spectrum, systemic organophosphate insecticide, is banned in the USA and European Union but is widely used elsewhere. Its use has resulted in a large number of cases of poisoning of non-target species, particularly birds, including Sarus and Eurasian Cranes in India (Pain et al. 2004).

Agricultural chemicals also have been used to intentionally kill cranes to prevent crop damage as well as for illegal harvest, although direct proof is usually lacking (see also *Illegal take, including hunting, trapping and poisoning*). Using poisons to take cranes is more likely in areas where hunting is prohibited or people cannot afford guns. In southern and eastern Africa, farmers have intentionally poisoned cranes and other birds that damaged crops (Williams et al. 2003, Ogada 2014). Farmers were more likely to consider poisoning cranes to reduce depredation when crops were stressed by drought. An uncertain number of Blue Cranes were poisoned with diazinon (used to control blowflies

Poisoned Blue Cranes found on a farm in the Western Cape of South Africa (Photographer: Wicus Leeuwner) in sheep) on a sheep and cattle farm over a three- to five-year period in the Northern Cape of South Africa after they were attracted to newly-planted fields and an irrigation pivot; estimates ranged from 200 to 1,000 killed (Wildenboer 2015). Musyimi (2008) found that poisoning of cranes in parts of Kenya to reduce crop depredation was a common occurrence. Intentional poisoning was identified as the cause of mortality of Sarus Crane families in a paddy crop ecosystem in India (Borad et al. 2002), and Black Crowned Cranes in East Africa (Williams et al. 2003). In Australia, a company was fined for intentionally poisoning at least ten Brolgas using the insecticide fenamiphos (District Court of Queensland 2014). Agrochemicals also have been used in bait for illegal harvest of birds and resulted in cranes deaths.

Farmers may harass or deliberately kill cranes when they believe their crops are threatened. In the Transbaikalia region of Russia, there are many cases of farmers shooting Demoiselle Cranes at staging areas as a response to crop damage; the less numerous White-naped, Hooded, and Eurasian Cranes were also shot (Goroshko et al. 2008, Goroshko 2012). Harassment of foraging cranes can reduce foraging time and food acquisition, force birds to feed on poorer quality sites, or take more risks to feed (Luo et al. 2012). Various harassment tactics are used to keep cranes out of crops, including scaring away territorial pairs, deploying flags, dogs, and other deterrents; removing eggs; and moving or destroying nests. Effects of such disturbances are most deleterious for breeding birds (see also *Human interference/disturbance, especially at nest sites*). Harassment or interference with nesting or chick-rearing cranes increases the vulnerability of eggs or chicks to predators and probability of reproductive failure. Nest destruction by farmers in Uganda is one of the most common threats to Grey Crowned Cranes (Olupot et al. 2009). Eggs or adults also may be intentionally taken for food (see details in *Illegal take, including hunting, trapping and poisoning*).

Our understanding of the occurrence and magnitude of unintentional and intentional poisoning, and the implications to crane health and vital rates, remains poor and relies largely on anecdotal information. Increased community awareness and education about crane biology and poisoning risks could improve reporting of poisoning events. Improved monitoring and focused research that incorporates biology and socio-economics will be important for developing effective measures to prevent further incidents (Loss et al. 2015).

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Black Crowned Crane in West Africa;
- Blue Crane in South Africa;
- Grey Crowed Crane throughout its range;
- Red-crowned Crane in China;
- Sarus Crane in India;
- White-naped Crane throughout its range; and
- Demoiselle Cranes throughout its range; with
- Lesser impacts to Brolga, Eurasian, Hooded, and Sandhill Cranes.

RESEARCH AND MONITORING NEEDS

- Improve monitoring, reporting, and documentation of poisoning events to more effectively detect and develop appropriate solutions to emerging problems;

- Develop and encourage non-chemical approaches to control pests or improve field nutrients, such as biocontrols, composting, and other more organic farming methods; and

- Develop strategies to help farmers deal with crop damage from cranes so they are not compelled to poison or harass birds intentionally.

PRIORITY CONSERVATION ACTIONS

- Strengthen regulation, control of distribution, and enforcement of chemical uses to prevent incidental and intentional misuse;

- Work with pesticide manufacturers and national and local stakeholders to reduce the use and environmental impacts of chemicals toxic to birds;

- Increase training and information resources available to farmers and agricultural agencies to improve awareness of pesticide toxicity and appropriate application methods; and

- Develop regional pesticide centers to provide authoritative information, public education, training, monitoring, and chemical testing for governments, farmers, NGOs, and the public (Ogada 2014).

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THREAT:

POLLUTION AND ENVIRONMENTAL CONTAMINATION, INCLUDING OIL DEVELOPMENT

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Environmental contaminants can cause serious disorders in wildlife, including both direct and indirect impacts on cranes. Acute exposure to toxic chemicals can cause mortality events, and chronic exposure can result in reduced reproductive fitness, hormonal abnormalities, immunologic compromise, and reduced resistance to fatal infectious diseases (Koller 1980). The problem is therefore significant, particularly in endangered species. Contaminants are considered an emerging threat for ten crane species, associated with increasing levels of pollution in some regions, impacting the quality of air, surface and ground waters, and soil. The known or potential impacts of different sources of pollution and environmental contamination on cranes are outlined below.

EXPLORATION AND EXTRACTION OF OIL, GAS, AND MINERALS

The recent global increase in the amount of exploration and mining operations represents a key source of environmental contamination. This has resulted in rapid and dramatic landscape changes and ecological impacts leading to habitat loss, wetland degradation, water diversion, and pollution of water resources.

There are particular concerns for Whooping Cranes at risk from oil industry activities near their wintering sites. Pollution and environmental contamination continue to be of pre-eminent concern as the Gulf Intracoastal Waterway (GIWW) bisects the entire wintering range of the Aransas-Wood Buffalo population at the Aransas National Wildlife Refuge and surrounding areas in coastal Texas, USA. Contaminants associated with oil and gas production have accumulated in sediments in the GIWW and adjacent bays (Ramirez 1988). The Texas economy is dependent on this mode of transportation, yet the proximity of pristine coastal marshes and bays to the barges daily carrying toxic chemicals and contaminants creates a serious danger: even one spill could have a devastating impact on the high density of Whooping Cranes in this area and their habitat and food resources (Gamble et al. 1989, Ramirez et al. 1993, Robertson et al. 1993, Canadian Wildlife Service and U.S. Fish and Wildlife Service 2005).

The massive and increasing industrial developments to exploit bitumen sands in Alberta, Canada, represent one of the largest energy projects in the world. This area is an important migratory corridor for large numbers of ducks, geese, cranes, and shorebirds, including both Sandhill and Whooping Cranes. Alberta's oil sands have the third largest oil reserves in the world, with production of about 2.3 million barrels per day in 2014 and a disturbed oil sands surface minable area of about 895 km^2 in 2013. The total area occupied by tailings ponds and associated structures was 220 km^2 at the end of 2013 (see Alberta Energy website: http://www.energy.alberta.ca/oilsands/791.asp). Development of Alberta's bitumen sands creates several hazards for these cranes, including exposure to air emissions, food web contaminants, and declining water quality; exposure to large tailings ponds with risk of oiling and ingestion of toxins; potential of spills from pipeline accidents; and expanding power line infrastructure (Wells et al. 2008, Kelly et al. 2010, Lee 2011, Swift et al. 2011). Energy exploration activities in the watersheds that encompass Wood Buffalo National Park pose threats of water and air contamination. Recent expansion efforts in this region exploiting tar sands have raised concerns of short- and long-term impacts to this sensitive environment (National Wildlife Federation 2011). Surface and groundwater contamination may already be occurring, and water usage for energy production could impact water levels (see above).

Oil and gas exploration and oil field development are impacting breeding and staging areas for several Asian crane species including: the primary breeding areas of the western populations of White-naped Cranes in Mongolia and expanding in parts of Russia and China, where mineral resources are being developed at a tremendous rate (Skorkowsky and Schnackenberg 2013), and the Western China plateau which is being impacted by mineral exploration and related development, critically threatening the plateau ecosystem including a region used by Black-necked Cranes for both breeding and wintering (Su and Junling 2007); and Siberian Cranes at key staging areas in northeastern China, and at breeding areas in the Lena basin in Yakutia and in the Ob basin in Western Siberia (e.g. Harris 2010; Nikolai Germogenov personal comm. 2016). Oil exploration and oil field development have taken place within several key crane reserves in China (Momoge, Liaohe Delta, and Yellow River Delta) as well as wider wetland areas (Wang et al. 2004, Han et al. 2005, Shan et al. 2005, Su 1992).

Oil pumps at edge of Momoge wetlands in northern China (Photographer: Crawford Prentice, International Crane Foundation)

There are also concerns for African cranes where environmental quality is being impacted by increasing industrialization including mining development and oil and gas extraction. The extractive mining industry for energy generation is increasing significantly across Africa. This includes open-cast coal mining, gas extraction, and geothermal development, all of which result in habitat loss and degradation and pollution risks. Areas impacted include the Eastern grasslands of Southern Africa that are home to Wattled, Blue, and Grey Crowned Cranes. Mining for energy resources poses a serious threat to Blue Crane habitats, including over 75% of Mpumalanga's grasslands in South Africa for open-cast coal mines (Mervyn Lötter personal comm. 2014) and around 40% of the Karoo in South Africa is under consideration for gas exploration (Twine et al. 2012). Depending on the extent and distribution of the drilling operations, land will be transformed and water resources will be contaminated. This in an arid environment in which all biodiversity and people depend on ground water. Gas exploration is being considered in part of southern KwaZulu-Natal in the grasslands of South Africa as well. Oil exploration in and near the wetlands in southern Sudan poses a threat to Black Crowned Cranes and could potentially raise this species from a lesser to a significant threat (Williams et al. 2003).

PERSISTENT ORGANIC POLLUTANTS AND HEAVY METALS

Elevated levels of metals and persistent organic pollutants (POPs) present an ongoing environmental threat and can have a variety of adverse effects on wildlife. Chronic metal exposure in birds may impair growth, development, reproduction, behavior, resistance to disease, and other physiological processes that may contribute to population decline (Ansara-Ross et al. 2013). Unfortunately, little information exists on the accumulation or potential impact of non-essential metals and metalloids and other pollutants on the cranes in general, with few recent comprehensive assessments conducted.

There is particular concern about the potential impacts on Red-Crowned Cranes of contaminants that accumulate in the environment because some of these cranes live in wetlands near developed areas for extended parts of each year. The diet of this species has a higher percentage of animal material than for most cranes, which may make Red-crowned Cranes more vulnerable than other crane species to the effects of bioaccumulation (Harris and Mirande 2013). Industrial chemical water pollution is a key threat, especially on the breeding grounds. Teraoka (2008) and Teraoka et al. (2007) report extensive mercury contamination in Red-crowned Cranes on eastern Hokkaido, and a 2% mortality rate from lead poisoning.

Luo et al. (2014a,b, 2015a,b) have undertaken some of the first evaluations of heavy metals in sediment, food sources, and tissues from endangered Red-crowned Cranes in the Zhalong wetland, northeastern China. Unfortunately, many of the estimates of heavy metal accumulation in this population are based on limited sample sizes. Luo et al. (2014b) found that concentration of mercury (Hg) in Zhalong Wetland (NE China) was elevated through the food chain, and the prey of the Red-crowned Crane contained measurable levels of total mercury (T-Hg) and methylmercury (MeHg). Elevated mercury levels were found in the buffer zone of Zhalong Wetland, and detectable levels of T-Hg and MeHg in Red-crowned Cranes, although the level of dietary exposure of the population of Red-crowned Cranes to mercury was considered to be below the threshold of its toxicity. Luo et al. (2015a) found similar results for arsenic (As) concentrations, which were elevated via food chain, with higher concentrations in sediments and water animals in the buffer zone than those in the core area and increased in higher trophic level animals. The dietary exposure level to the Red-Crowned Crane population appeared to be below arsenic toxicity threshold concentrations. Investigation of concentrations of copper (Cu), zinc (Zn), lead (Pb), chromium (Cr), and cadmium (Cd) in the sediments and six typical aquatic animal taxa by Luo et al. (2014a, 2015b) indicated that all detected concentrations of the five heavy metals in the sediments were higher than the natural background levels. Six common aquatic animal taxa were found to contain detectable heavy metal concentrations. The internal tissues of the Red-crowned Cranes contained significantly high metal concentrations compared with their external tissues (feather, feces, and residual eggshell). Cadmium concentrations in the feather and liver of Red-crowned Cranes exceeded a level considered to be potentially toxic in birds, with levels ranging from 0.41 to 3.06 mg kg^{-1} and 0.37 to 4.42 mg kg^{-1} (dry weight), respectively.

Pollution from heavy metals may be an emerging problem for White-naped Cranes on breeding, staging, and wintering areas in some heavily developed and industrial regions of China (Tang et al. 2014); Black-necked Cranes at Cao Hai (Li et al. 2014); and Siberian Cranes at stopover sites in Yakutia (Pshennikov et al. 2001). The rise of pollution from POPs and agricultural chemicals in the coastal waters and along the Yangtze River, major wintering areas for the China population of Hooded Crane, is having a detrimental effect on the Hooded Crane population, for example at Shengjin Lake (Fox et al. 2010). Despite their rarity, Whooping Cranes have been sampled for trace elements and POPs with considerable effort, but not since the late 1980s (Lewis et al. 1992).

The presence of potentially harmful concentrations of toxic pollutants has been revealed through analysis of a small sample of nonviable eggs of the endangered Mississippi Sandhill Crane (*G. canadensis pulla*; White et al. 1994). However, examination of 58 Sandhill Cranes collected along the central Platte River in Nebraska found that organophosphate and carbamate residues and some 20 inorganics (including lead, mercury, and boron) were generally below concern levels (Fannin 1992). Both studies are over 20 years old and no new publications were found in the literature. A recent study on the South African population of Wattled Cranes found that mercury levels in egg shells exceed the average, which may negatively affect productivity; however, sample size was again limited (Daso et al. 2015). This is likely not a point source contamination.

AGRICULTURAL CHEMICALS

Increased chemical use has broadly affected both upland and wetland ecosystems, through contamination of the food web, changes in the trophic structure, and eutrophication. Cranes living in association with agriculture are increasingly exposed to chemicals that affect them directly through consumption of contaminated foods, and indirectly through loss of important foods or altered habitats. Mortalities for 11 species of cranes have been linked to a range of chemicals, primarily pesticides (Austin 2018). Cranes in many regions fall victim to both accidental and deliberate poisoning incidents (for details see the threat sections on *Poisoning, deliberate killing, or harassment in response to crop depredation* and *Illegal take including hunting, trapping, and poisoning*).

In China, declining water quality in the wintering grounds (e.g., as a result of nutrient enrichment from agricultural runoff) could lead to poor conditions for *Vallisneria* and other food plants at Poyang Lake, or even a major shift away from macrophytes to a system dominated by phytoplankton that do not provide adequate food for Siberian, White-naped, or Hooded Cranes (Fox et al. 2010). Pollution from pesticides and herbicides is an emerging problem at the Siberian Crane stopover sites in Yakutia (Pshennikov et al. 2001). Indiscriminate pesticide application may be leading to harmful bioaccumulation of toxins affecting Black-crowned Cranes (Williams et al. 2003).

LEAD POISONING

Ingested lead has been found to cause lead poisoning in Whooping Cranes (Snyder et al. 1992), Sandhill Cranes (Wallace et al. 1983, Windingstad 1988, Franson and Hereford 1994), Red-crowned Cranes (J. Luo, personal comm. 2015; Teraoka et al. 2007, Teraoka 2008), and Siberian Cranes (Pshennikov et al. 2001). Lead poisoning is most likely due to ingestion of spent lead shot or fishing sinkers but may also be due to environmental deposition of lead from motor-vehicle exhaust where leaded gasoline is still used. Use of lead shot is restricted in many countries, but usually only in wetland areas.

URBAN AND INDUSTRIAL POLLUTION

Wetland ecosystems in Asia are suffering threats from heavy metal pollution due to rapid economic development and urbanization. Tang et al. (2014) documented increases of Cd, Cr, Cu, Ni, Pb, and Zn in wetlands used as stopover and wintering sites by Red-crowned, White-naped, and Hooded Cranes. Pollution of wetlands used by wintering Black-necked Cranes from nearby cities on the Yunnan-Guizhou Plateau is impacting ecological conditions of this species (Li et al. 2014). Industrialization accompanied by substantial increases in water pollution especially to rivers is a serious new threat capable of impacting Sarus Crane breeding habitat and breeding success (K S Gopi Sundar, personal comm. 2017). The Indo-Gangetic flood plains have among the highest mercury emissions globally (Pacyna et al. 2010) and have the potential to induce non-lethal effects on the most important population of Sarus Cranes.

The levels of exposure and potential impacts should be monitored for these species at key sites. See also *Urban expansion and land development, including mining.*

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Whooping Cranes on the Gulf Intracoastal Waterway in Texas and in watersheds around Wood Buffalo National Park, Canada;
- Black-necked Cranes on wintering areas near cities on the Yunnan-Guizhou Plateau;
- Hooded Cranes at wintering areas in the coastal waters and along the Yangtze River in China;
- Red-crowned Cranes at key staging areas in northeastern China and in Hokkaido;
- Siberian Cranes at key staging areas in northeastern China, stopover sites in Yakutia, and breeding areas in the Lena basin in eastern Siberia and the Ob basin in Western Siberia; and
- White-naped Cranes on breeding grounds in Mongolia, Russia, and China; at key staging areas in northeastern China; and on the wintering grounds in China.

RESEARCH AND MONITORING NEEDS

Overall, the impacts on cranes and their habitats of both pollution events (e.g., oil spills) and chronic exposure to contaminants (e.g., agricultural pesticides, heavy metals) requires investigation; increased understanding of these risks will help awareness, advocacy, and conservation planning efforts to reduce the long-term effects on crane populations. Specific needs are as follows:

- Conduct a comprehensive review (white paper) on environmental contaminant issues for cranes, followed by an executive summary and call to action for conservation managers and decision makers. As part of this review, prepare a resource list of those working on crane contaminants issues and collaborating technical experts in relevant fields (water quality, agricultural chemical use, toxicology, etc.);
- Conduct surveys and monitor crane usage of sites and wider areas subject to existing or planned industrial development including mining, oil, and gas, to obtain baseline data and determine trends, especially for areas affecting threatened crane species;

- Implement research projects to evaluate environmental contamination and crane exposure for key landscapes in different regions, especially for populations of threatened crane species (e.g., agricultural landscapes in East and South Asia, wetlands in Southeast Asia, areas of energy development in South Africa and North America);

- Establish baseline information for Black-necked Cranes on chemical contaminants, including heavy metals and pesticides, to assess the impacts of these factors;

- Continue long-term scientific monitoring on the White-naped Crane and Red-crowned Cranes and their habitats. Monitor instances of poisoning and determine the factors responsible. For all cranes under significant risk of contaminants, feathers and tissue samples from dead birds should routinely be collected and tested for heavy metals and other toxins;

- Assess the impacts of agricultural and industrial chemicals on Sarus Cranes and their food, especially in Nepal and India; and

- Develop and share basic protocols for investigation and laboratory analysis of suspected crane poisoning cases.

PRIORITY CONSERVATION ACTIONS

- Reduce probability of exposure of Whooping Cranes to contaminants through best conservation practices and collaboration with industry. Explicitly present adequate information about the conservation needs in land-use plans, environmental impact assessments, and approvals for industrial developments, including those in the Alberta oil sands region;

- Collaborate with gas and oil companies in Russia and China to minimize risks to the Siberian Crane and its key habitats. Identify, legally protect, and manage key staging areas in Yakutia, accompanied by mitigation of development impacts along the flyway. Maintain or improve water quality at key stopover and migration sites in China to avoid detrimental ecosystem change or direct impacts on crane survival;

- Understand and reduce the potential impact of the energy sector on Wattled Cranes and their habitats across their range. This will include minimizing the impact of open-cast coal mining and gas extraction in addition to physical obstacles; and

- Take measures to prevent or substantially reduce losses of White-naped Crane and Red-crowned Cranes to environmental contaminants based on results of long-term scientific monitoring and assessment of the factors responsible.

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THREAT:

CONVERSION OF GRASSLANDS FOR AGRICULTURE, AFFORESTATION, AND MINING

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The loss and degradation of grassland habitats and subsequent conversion of large natural areas to agriculture, afforestation, mining, and other development is a significant threat to cranes. The loss of natural habitat and associated increased human disturbance causes reduced nesting and foraging habitat for breeding pairs to raise young to fledging (Kaur et al. 2008, Goroshko 2012, Morrison 2015), as well as negatively impacting available foraging habitat for flocks. Cranes have proven to be adaptable to many changes to their habitats, as demonstrated by intensive use of agricultural fields by several crane species and the coexistence of cranes with people in both commercial and subsistence farming areas. This adaptability in part has helped species like the Sandhill, Blue, Eurasian, and Sarus Cranes to flourish in many parts of their range. However, not all crane species are equally adaptable to the utilization of agricultural landscapes (Nowald et al. 2018, Austin 2018). The increase in agricultural practices in key crane areas can unfortunately also increase the potential for crop damage by cranes as noted in the threat sections on *Changes in agricultural land use and practices* and *Poisoning or harassment of cranes related to agriculture* in this publication. Climate change or market dynamics may lead to changes in crop selection or agriculture practice, with significant impacts on the suitability of these agricultural lands for crane use (Ilyashenko 2018a,b).

Conversion of grasslands to agriculture is a significant threat for Blue, Sandhill, Wattled, and White-naped Cranes and a lesser threat for Black Crowned, Grey Crowned, Black-necked, Red-crowned, Demoiselle, Eurasian, and Sarus Cranes. For example, for non-migratory Sandhill Cranes the drier meadow, savannah, and other upland habitats have been widely altered by agricultural conversion and development; habitat modification (woody plant encroachment, agricultural expansion especially development of plantations, and fire suppression) is the principal current factor affecting crane habitat throughout Cuba (Galvez Aguilera and Chavez-Ramirez 2010). Grey Crowned Cranes are affected by transformation of wetlands and surrounding grasslands, savannas, or forest catchments into various forms of agriculture in East Africa, including the Rugezi Marsh in northern Rwanda and the catchment for Nyamuriro wetland in southwestern Uganda and in KwaZulu-Natal in South Africa; the species is also affected by the spread of sugarcane (*Saccharum*) and *Eucalyptus* plantations in parts of western Kenya. Breeding habitat for the Demoiselle Cranes was degraded on a wide scale as grasslands were left fallow due to the decline of agriculture in the former USSR (see the species review for *Demoiselle Crane* for changes in the last decade; Ilyashenko 2018a,b). Foraging habitat for Eurasian Cranes is negatively impacted by plowing of meadows and fallow fields for the intensive cultivation of rape (*Brassica napus*) and maize (corn, *Zea mays*) to produce biofuels for electric energy in Europe.

Grasslands that have been converted to agriculture, such as vineyards in South Africa, reduce foraging habitat available tor Blue Cranes and may place the birds at higher risk of poisoning (Photographer: Daniel Dolpire)

The impact of afforestation, mining, and other development on the cranes' grassland habitats results in more extreme landscape alteration. Even if afforested or mined areas are rehabilitated, the biodiversity value is much lower than before (Little et al. 2005). Forestry expansion continues to impact grasslands and wetland catchments and subsequently reduces crane breeding habitat (Van der Weijden et al. 2010).

Through the implementation of best practice guidelines for the planting and management of plantations, small areas, or corridors may be available as breeding and foraging sites for species such as the Grey Crowned Crane. Black-necked Cranes are impacted by afforestation on breeding areas in Rouergai Marshes and wintering in Tibet and Yunnan, especially plantations of willows (*Salix*) and poplars (*Populus*) in and near roost sites and tree plantations on grassland/farmlands on which the cranes forage in Yunnan. Although habitat loss as a result of afforestation across the grasslands contributed to a decline of the Blue Crane, it is no longer significant a threat.

For Blue, Wattled, and Grey Crowned Cranes, mining (primarily coal which is impacting over 50% of surface areas in certain provinces) in the northeastern grasslands of South Africa, and more recently oil and gas exploration in the same area, are major threats (see also threats section on *Urban expansion and land development*). Primary breeding areas for the western populations of White-naped Cranes occur in Mongolia where mineral resources are being developed at a tremendous rate (Skorkowsky and Schnackenberg 2013). Grassland degradation on the Western China plateau is being caused mainly by mineral exploration and related development (Su and Sang 2007), critically threatening the plateau ecosystem including a region used by Black-necked Cranes for both breeding and wintering.

Apart from the direct destruction of grasslands, indirect impacts include associated development such as power, transport, and communication infrastructure, which can cause losses to crane populations (see also threats section *Collisions and habitat loss associated with utility lines, wind turbines, and other human infrastructure*). A further threat associated with the developing world is linked to land reform from privately owned properties to community owned properties. These communal properties are intensively managed and heavily populated, leading to the loss of the former extensive intact grassland

Tree planting in Africa reduces grasslands habitats and alters water flow to wetlands (Photographer: Valentin Ilyashenko, Institute of Ecology and Evolution, Russian Academy of Sciences)

grazing areas. Encroachment by invasive alien plants such as *Mimosa* associated with the conversion of grassland to other uses can also have a devastating impact on natural grassland areas for cranes (see also *Invasive species*).

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

For Conversion of Grasslands for Agriculture:

- Blue Cranes in Mpumalanga, KwaZulu-Natal, Eastern Cape, and the Karoo of South Africa;
- Wattled Cranes in Zambia;
- White-naped Cranes on breeding grounds in Northeastern Mongolia; migratory stopovers at Duolun, Miyun, and other key sites in China; and wintering grounds at Poyang Lake;
- Non-migratory populations of Sandhill Cranes in Mississippi and Cuba;
- Grey Crowned Cranes in Rugezi Marsh in northern Rwanda, catchment for Nyamuriro wetland in southwestern Uganda, in eastern Kenya, and KwaZulu-Natal in South Africa;
- Black Crowned Cranes with key areas to be identified;
- Demoiselle Cranes on breeding grounds in former USSR; and
- Eurasian Crane foraging areas in Europe.

For Afforestation:

- Grey Crowned Cranes in parts of western Kenya;
- Blue, Wattled, and Grey Crowned Cranes in Kwa-Zulu Natal and Mpumalanga in South Africa;
- Black-necked Cranes on breeding areas in Rouergai Marshes, wintering areas in Tibet and Yunnan; and
- Mississippi Sandhill Cranes in Mississippi.

For Mining and Oil and Gas Development:

- White-naped Cranes on their breeding grounds in Northeastern Mongolia;
- Whooping Cranes on breeding grounds in Wood Buffalo National Park, Canada;
- Sandhill Cranes near the Platte River and the Rocky Mountain population, USA;
- Blue, Wattled, and Grey Crowned Cranes in South Africa; Grey Crowned Cranes in Rwanda and South Africa, and Wattled Cranes in Zambia;
- Siberian Cranes on breeding grounds and staging areas in southern Yakutia; and
- Black Crowned Cranes in Chad and South Sudan.

KEY RESEARCH AND MONITORING NEEDS

- Conduct migration studies to identify location, and threats, for key wetlands used by the migratory western population of White-naped Cranes;
- Conduct long-term monitoring of grassland/wetland habitats in relation with climate and human activities at Ruoergai and other sites in China;
- Conduct winter counts of Black-necked Cranes on Western China plateau every 5 years;
- Conduct long-term monitoring of cranes and grasslands/wetlands in Black-necked Crane breeding areas with focus on climate change, including at least one area not affected by glaciers (e.g., Ruoergai) and one area likely to be directly impacted by glacial melt and then by glacial shrinking (e.g., Shenzha);
- Understand the home range requirements for Africa's cranes for raising chicks successfully;
- Analyze potential risks arising from strategic long-term urban, infrastructure, energy, and land use development plans for Grey Crowned Crane habitat; and
- Model predicted impacts of extraction of underground fossil-fuel reserves if they continue to be extracted at current proposed and future expected rates.

PRIORITY CONSERVATION ACTIONS

- Work with governmental and other public institutions involved in development and infrastructural projects to carry out detailed environmental impact assessments and modified cost-benefit analyses that may affect cranes and/or their habitats;
- Secure important grasslands sites from unsustainable development in South Africa under the Protected Area network, in collaboration with private and communal landowners, thus protecting critical grassland habitat for Blue and Grey Crowned Cranes, as well as establishing no-go zones for critical biodiversity areas;
- Legally secure important grassland and wetland sites for Grey Crowned Cranes across their range in Africa, which will benefit cranes, people, and biodiversity;
- Work with local herdsmen communities in Mongolia to enhance management of grasslands and water resources, and to reduce disturbance to breeding White-naped Cranes;

- Advocate to protect and manage key migratory and wintering grassland habitat for White-naped Cranes in China, including Duolun and Miyun;
- Build capacity for the Black-necked Crane Network, to strengthen information sharing, coordinated survey, and public awareness-raising in western China, which along with monitoring activities, will help in developing recommendations for authorities dealing with mining, tourist and other development in this region;
- Increase focus on large-scale, land-use change currently being planned in Southeast Asia and Australia, focusing on areas important for Sarus Crane breeding and flocking;
- Work with local governmental authorities to integrate Sarus Crane habitat management with economic development planning; and
- Continue active savanna and prairie restoration efforts at the Mississippi Sandhill Crane National Wildlife Refuge (NWR), and secondarily at Grand Bay NWR. Work with agency and non-governmental partners to continue to expand mechanical removal of woody vegetation

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THREAT:

LIVE CAPTURE AND EGG COLLECTION FOR DOMESTIC AND INTERNATIONAL COMMERCIAL TRADE

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Cranes have long been an iconic species in captive collections and are playing an increasingly valuable role in promoting awareness of threats to wild populations and inspiring conservation action. However, based on reports from local scientists, removal of cranes or their eggs from the wild has become a threat for ten species of cranes. In Pakistan, 4,000–5,000 Eurasian and Demoiselle Cranes are live captured each year with growing numbers sold to both domestic and international markets (Ahmad Khan, personal comm. 2013). There is concern for China where numbers of wintering Red-crowned and White-naped Cranes are declining, that illegal collection of eggs, young, and adults may be a significant additive factor that combines with other threats, particularly for Red-crowned Cranes (Zhou et al. 2014, Zhou et al. 2016). All four species resident to Africa are affected, with significant numbers of Blue, Grey Crowned, and Black Crowned Cranes taken for domestic trade within countries where the cranes are resident, and large numbers exported internationally.

Trade is of gravest concern for the two species of African crowned cranes. Although revered by many cultures throughout Africa and the world, their beauty has ironically led to their decline. Illegal capture of wild Grey Crowned Cranes has contributed to the rapid decline of up to 80% over three generations (45 years) and the species has been up-listed to Endangered. The Black Crowned Cranes of western and central Africa have also declined significantly, potentially to the same degree as Grey Crowned Cranes, and most likely qualify as Endangered. Effectively addressing trade will require simultaneously dealing with the complex factors driving the supply and demand chains and working with governments and international agencies to establish and enforce protective laws (Morrison et al. 2007, Harris and Mirande 2013, Morrison 2015).

A few captured crowned cranes are eaten or used for traditional purposes, but most enter the pet trade within countries of origin and / or traded internationally, often through illegal markets. Demand within their countries is a tradition dating back centuries. Cranes symbolize prestige and wealth, are believed to protect the family from evil spirits, warn of approaching dangers, act as time pieces heralding in the dawn and ending the day, and eat insects around compounds. They are purchased or given as gifts. Recently demand has grown for displays at hotels in countries such as Rwanda. Preliminary research has suggested that removal of wild-caught cranes is unsustainable in some countries (Morrison et al. 2007).

Data from the Convention on International Trade in Endangered Species (CITES) as well as unofficial reports indicate that thousands of crowned cranes have been shipped from Africa, that the United

Arabic Emirates is a significant way station in this trade, and that much of the recent demand for these birds has been in the Middle East and the Far East. Too often these birds end up in suboptimal conditions, where reproduction of captive birds is low and mortality high due to inadequate care, poor diet, and lack of suitable facilities. These species have often been placed in groups in mixed species exhibits or free roaming where nests can be disturbed and predation risks may be higher.

There are over 12,000 captive facilities internationally, yet only around 10% belong to formal zoo associations. As of August 2017, the Species360 (formerly International Species Inventory System) database showed 933 (368 males, 368 females, 197 unknown sex) living Grey Crowned Cranes in about 250 institutions with 81% recorded as captive bred, 9% recorded as wild caught, and 10% as unknown origin (Laurie Bingaman Lackey, personal comm. 2017). Species360 data is primarily based on zoo association collections and hence only represents a small percentage of the real situation. The statistics would likely include a higher proportion of wild-caught birds in collections not part of zoo associations. Currently none of the captive populations of crowned cranes within these zoo associations are self-sustaining. As the impacts of trade on both species of crowned cranes have become evident, zoo associations in America, Europe, China, and Africa are working to reduce or eliminate the demand for wild-caught birds through collaborative, intensively managed breeding programs. The World Association of Zoos and Aquariums has recognized and branded the African Crane Trade Project (http://www.waza.org/en/site/conservation/waza-conservation-projects/african-crane-trade-project) to bring global attention to the trade problem. Zoos are developing awareness programs and providing increasing support for field research and community conservation projects. Moving forward, the impact of ongoing trade in wild birds must be addressed through work with collections not affiliated with zoo associations and the pet trade, the apparent sources for the current demand for wild cranes.

ICF and the Endangered Wildlife Trust (EWT, working in sub-Saharan Africa) have taken on the role of global ambassadors for Grey Crowned Crane conservation and are working to reduce habitat loss in Africa and stop illegal trade around the world. Current information and downloadable resources can be found on websites developed by the ICF (http://www.savingcranes.org/african-crane-trade.html) and EWT (http://www.ewt.org.za/accp/accp.html).

Preliminary case studies in nine African range countries indicated that 93% of all local community residents interviewed within crane habitats knew cranes were being taken from the wild (Morrison et al. 2007). The communities had noted decline in cranes and 25% of residents attributed the loss to trade. Everyone in the communities seemed to know that removal was illegal, and it was evident that individuals were benefitting from trade, not the community. The ICF/EWT Partnership is working on the supply side with local communities in key locations where cranes are being removed from the wild. The Partnership also involves close collaboration with governments on trade (e.g., Kenya, Rwanda, South Africa, Uganda) as well as influencing policy (e.g., DNA profiling to verify origin of birds is proposed for both domestic trade and export from South Africa). The Rwanda Wildlife Conservation Association and Rwandan Development Board have instituted an awareness campaign highlighting the illegal nature of keeping cranes in captivity in Rwanda and have initiated a process whereby all illegally held cranes are confiscated and either released into the Akagera National Park or rehabilitated and held in captivity rather than being released due to the health status of the birds rendering them non-releasable.

As noted in the species review, the Grey Crowned Crane was up-listed to Endangered on the IUCN Red List in 2012. CITES data have been a valuable tool to document trade, but there have been major gaps, errors, and discrepancies, in the database, and it is believed that most trade is illegal and

Fiona Nabwire returns a Grey Crowned Crane chick to Sio Siteko wetland. The heroic actions of this young girl in Kenya raises awareness for endangered cranes. (Photographer: Maurice Wanjala)

undocumented. In an effort to address international trade, a Significant Trade Review for both species of crowned cranes commenced in 2009. In 2015, trade in Black Crowned Cranes was suspended in Guinea, Sudan, and South Sudan and trade in Grey Crowned Cranes was suspended in Tanzania. In 2017, Mali was included in the suspension of trade in Black Crowned Cranes. This CITES decision to suspend trade from these countries will remain in place until the country in question can prove that export will not be detrimental to its wild populations and that it is able to diligently monitor export permits granted and actual exports, with the goal of regulating trade and limiting exports in order to maintain the species.

Chicks and egg removal affect the eastern population of Sarus Cranes in Cambodia (Clemens et al. 2010, 2013). A nest protection program, in which local people were paid for protecting Sarus Crane nests in the Northern Plain, Cambodia, seems to have provided positive results with significantly higher rates of hatching success (Clemens et al. 2013). It is, however, unclear whether such practices will be sustainable long term, and there are concerns about increasing human disturbances to cranes because of nest protectors and their domestic dogs (Triet Tran, personal observations).

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Grey Crowned Cranes, especially in Rwanda, South Africa, Uganda, and Tanzania;
- Black Crowned Cranes, especially in Guinea, Mali, Sudan, and South Sudan;
- Blue Cranes for domestic trade in South Africa;
- Demoiselle and Eurasian Cranes in Pakistan where birds are live captured annually through traditional practices; and
- Red-crowned Cranes in northeast China, where removal of eggs and chicks from the wild needs further investigation but appears to be a significant problem.

RESEARCH AND MONITORING NEEDS

- Investigate all illegal trade reports to increase understanding of the trade and its various elements as these change over time;
- Identify key locations across Africa supplying cranes to the illegal trade market and understand the factors driving this supply so that effective mitigation measures can be implemented;
- Determine steps in the market chain from the capture site to the final destination, and understand who benefits and the economic value of the crane trade at each stage;
- Investigate and understand sources of demand for wild caught crowned cranes including specifically the pet trade, private aviculturists, and zoos and wildlife parks outside the formal zoo associations;
- Monitor breeding populations of Red-crowned Cranes in China to determine breeding success and detect removal of eggs and chicks; and

- Apply innovative technological developments to support trade monitoring and identification of routes.

PRIORITY CONSERVATION ACTIONS

- Reduce gaps and errors in CITES database by supporting the capacity needs of management authorities in targeted countries;
- Monitor CITES recommendation to suspend trade under the Significant Trade Review for Guinea, Mali, South Sudan, Sudan, and Tanzania;
- Advocate for policy legislative development and implementation that effectively minimizes wild-caught cranes, and their derivatives, entering trade;
- Increase awareness and provide alternative livelihood options to communities actively involved in capturing cranes for the trade market, creating local social environments that serve to discourage live capture;
- Implement a large-scale media campaign to increase awareness of the status of crowned cranes and the threat that trade poses;
- Reduce or eliminate the demand for wild-caught birds through collaborative and intensively managed captive breeding programs within organized zoo associations and successful captive facilities; and
- Expand awareness programs to inform purchasers of the detrimental impacts of trade on wild populations, and promote responsible breeding, good husbandry, and exchange of captive bred birds.

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THREAT:
IMPACTS OF FIRE ON CRANES

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Extensive and intensive wildfires are hypothesized to significantly limit the breeding success of Red-crowned, White-naped, and Wattled Cranes. Wildfire has potential to be a lesser threat affecting populations of Grey Crowned, Black Crowned, Eurasian, Demoiselle, Hooded, Sarus, and Brolga Cranes where fire occasionally occurs during the breeding season and can lead to mortality of some chicks or eggs. However, further data are needed to determine if mortality from fires causes a decline on the population level. Conversely, fire suppression in fire-adapted ecosystems is also a lesser threat to non-breeding Sarus Cranes in the Mekong Delta of Vietnam and to breeding Wattled Cranes in the Zambezi Delta because fire suppression causes open habitats to convert to shrubby or forested environments, habitats that do not support crane use.

DIRECT IMPACT OF FIRES

During the nesting season, wildfire directly destroys eggs, kills flightless chicks, and occasionally kills adult birds. The degree to which fire can directly impact productivity depends on fire intensity, extent, frequency, and timing. If wildfires occur during the late stage of incubation or before fledging, breeding success for that year is reduced because re-nesting is less likely due to atrophy of the reproductive system (Gee and Russman 1996). In the Argun River valley (Transbaikalia, Russia), where Red-Crowned Cranes stopped nesting in 2003, fires annually destroyed 30–50% of nests after 1990 (Smelyansky et al. 2015). In Mongolia, fires diminished both hatching and fledging success for White-naped Cranes by 20–30% (Tseveenmyadag 2005). In the South-central, South African, and Ethiopian Populations of Wattled Crane, wildfire might directly affect crane nests, eggs, and chicks. In Zambezi Delta, fires ignited for clearing brush have caused mortality of young (Dodman 2000, Morrison and van der Spuy 2006). Since Wattled Cranes in the Zambezi Delta breed in the dry season, the threat of fire can be high.

During incubation, pairs will often desert nests after fires. However, if the nest and subsequent clutch is left unharmed, pairs may resume incubation even if very little standing vegetation remains around the nest. At Muraviovka Park in the Amur Province of Russia, two pairs of Red-crowned Cranes and three pairs of White-naped Cranes returned to continue incubation after a fire left only a small patch of dead grass around the nest (20–40 m^2), completely eliminated grass around the nest, or even scorched the nest (Sergei Smirenski, personal comm. 2016). Breeding success for these surviving nests, however, was low due to a lack of cover from predators (i.e., feral dogs [*Canis lupus familiarus*], Asian badgers [*Meles leucurus*], raccoon dogs [*Nyctereutes procyonoides*], red foxes [*Vulpes vulpes*], wolves [*Canis lupus]*, and crows [*Corvus* spp.]).

Also at Muraviovka Park, some Red-crowned and White-naped Cranes that lost their nests to wildfire remained in burned areas to forage while other pairs exposed to the same fate moved to other wetlands. If pairs lose clutches or chicks early enough in spring they may attempt to re-nest. In late April–early May 2012, one pair of Red-crowned and four pairs of White-naped Cranes at the park were observed constructing second nests following extensive burning of crane habitat in the southern Zeya-Bureya Plain. In spite of vast acreage damaged by this fire, a record number of White-naped Cranes nested that year (18 pairs), perhaps due to numerous patches of old grass in standing water or an influx of birds from other parts of the Amur Basin where wildfires were more damaging (Smirenski and Smirenski 2013).

Although infrequent, adult birds have been killed by fires. In May 2002, one incubating White-naped Crane died while taking off from a nest being engulfed in flames at Muraviovka Park. In June 2002, one molting (thus flightless) Red-crowned Crane died after it was unable to avoid fast moving flames (Smirenski 2003).

Red-crowned Crane nest destroyed by an uncontrolled fire (Photographer: Su Liying, International Crane Foundation)

Fires cause greater negative impact in dry years and in dry seasons within a given year when there is little to no surface water within wetlands. The lack of surface water exacerbates mortality from fire (see threat sections on *Prolonged drought and desertification especially related to climate change* and *Dams and water diversions*). Depending on the frequency and scale of fires, direct impacts of wildfire can decrease reproduction in local populations of Brolga, Eurasian, and Hooded Cranes, especially during dry years. For example, after an extremely hot summer in 2010, wildfires covered 58% of Kamsko-Bakaldinsky Wetland and Forest Complex in the Volga Region, decreasing breeding of Eurasian Cranes by 13% (Bakka and Kiseleva 2013).

INDIRECT IMPACT OF FIRES

Wildfires can indirectly impact crane habitats, both positively and negatively. In Africa, wetlands and floodplains form part of a grassland- or savanna-dominated landscape where fire plays a significant role in maintaining those habitats. The wetlands used by Wattled Cranes, therefore, require fire to remove dead vegetation that prevents effective foraging and movement of breeding pairs and their offspring. Density of breeding pairs of Red-crowned and White-naped Cranes and breeding success in wetlands burned in the fall and early spring could be relatively high. In northern forest wetlands, frozen soil thaws sooner in burned areas, producing standing water around nests, which creates a barrier for terrestrial predators. Burned areas become more attractive for forest species such as Hooded and Eurasian Cranes due to decrease of forest density (Surmach 2015; E. Khudyakova, personal comm. 2017). Fires promote sedge and grass environments while reducing shrub and tree growth in wetlands (Lugo 1995). Sandhill Cranes, and probably other crane species that nest in wetlands, prefer emergent habitats over shrub or forested habitats (Barzen et al. 2016). In the Amur River basin, however, trees and shrubs serve an important role as fire breaks, preserving a mosaic of sites suitable for crane nesting. Further, invertebrate production in wetland ecosystems tends to increase in the year following fire (Miao et al. 2010) which, in turn, provides more food for flightless young.

Conversely, fires that burn too great a proportion of available wetland habitat may have important indirect negative impacts. During the growing season following a fire, grass cover becomes unsuitable for Demoiselle Crane breeding (Belik et al. 2011). In Muraviovka Park, fires annually burn an average of 40% of crane breeding habitats, and up to 60% (2002 and 2009) or 90% (2011) in bad years (Smirenski 2011). In Transbaikalia, fires burned an average of 30% of White-naped Crane breeding habitat and up to 70% in bad years. In Mongolia, 70% of White-naped Crane habitat in Uldz River basin burned in 2000 (Goroshko 2001). At Khinganski State Nature Reserve (Amur Province of Russia), 45% of Red-crowned Cranes could not breed in 1985 because old grass was eliminated by fires (Andronov 2008). Thus, even though fires are needed to maintain grassland habitats, they should not consume too much of the available habitat in any one year. Typically, the suitable proportion of available habitat to burn is inverse to the fire interval (in years) needed to maintain grass ecosystems. For example, if grassland ecosystems need to be burned once every three years, then no more than a third of available habitat should be burned in any one year.

Fires consume residual vegetation that helps to conceal crane nests. Unprotected by tall grass, nesting cranes become sensitive to disturbance and leave nests when they see people from much longer distances than when the nest is surrounded by residual vegetation. In such cases, the size of the area around a nest that is inundated and the water depth are crucial for nesting success. When a nest is surrounded by water, incubating cranes can observe approaching ground predators even at night, and it is much easier for them to deter swimming or wading predators. Fires also reduce food availability from the time of the fire until vegetation regrows even though it increases food production in the long-term.

Following a fire, cranes can face food scarcity before new grass grows and insects, amphibians, and small rodents return to the area. At Muraviovka Park corvids, harriers, and terrestrial predators were observed to increase foraging in burnt areas, contributing to the decrease in food availability (Sergei Smirenski, unpublished observations). Further data are needed to determine if this short-term food reduction has a biological impact on crane productivity.

Importantly, few data have been used to evaluate long-term trends of crane productivity in relation to fire. A decline in crane productivity in any one year due to direct impacts of fire does not necessarily cause population decline in most long-lived crane species. At Argun Valley, extensive and intensive occurrence of fire during the nesting season recurring over 15 years extirpated the local breeding population, presumably through long-term lack of reproduction. In other examples, however, though fire may directly cause some mortality of eggs or chicks, it could also be important in indirectly maintaining habitat quality for breeding birds over the long term and provide a net gain to the population if the occurrence of fire and its negative direct impacts are balanced against the indirect positive impacts that occur in the same or subsequent years. This usually requires management of fire so that fire frequency, intensity, and timing minimize crane mortality while maximizing longer-term benefits to habitat quality. For example, with Wattled Cranes in hydrologically altered ecosystems, the quality of nesting habitat could decline overall if shrubs proliferated because Wattled Cranes require open areas that are dominated by emergent vegetation to breed. Without fires, shrub distribution could increase dramatically, reducing habitat quality for nesting cranes. Important metrics for the evaluation of fire impact on crane populations must, therefore, occur over several years and evaluate overall population dynamics in relation to direct, negative impacts of fire and indirect benefits of fire.

ORIGIN OF FIRES

Worldwide, fires can occur naturally, primarily through lightning strikes, and they can occur through human intervention for conservation purposes as well as through accident or arson. In North America, fire prevention has been effective by focusing on reducing arson and accidental fires. Most Americans, for example, know the educational message, “Only you can prevent forest fires,” arising from the popular icon Smokey the Bear (Ballard et al. 2012). Patterns of human-caused wildfire in Asia and elsewhere, however, differ from those in North America. In Russia, most fires originate from arson or accidents (Smirenski and Smirenski 2004, 2006, 2010). In steppe and semi-desert areas of Russia, the frequency of wildfires has increased due to the degradation and overgrowth of unused pastures and poor fire control since the early 1990s (Goroshko 2000, 2001, Bukreeva 2003, Bragin 2006, Badmayev 2006, Chernobai 2011). Other changing agricultural practices in Russia have also altered fire frequency. As cattle operations declined, for example, residual vegetation became a major contributor to wildfires in the Amur Province during the late 1990s. Fire frequency then declined in the south of Amur Province during the mid-2000s when arable lands were returned to agriculture and residual vegetation reduced. Fire frequency and human involvement in fire in Southeast Asia (Murdiyarso and Lebel 2007), Australia (Russell-Smith et al. 2003), and in Africa also differs from that of North America.

REVIEW OF RESEARCH DATA AND NEEDS

Current research data on the impact of fires on cranes are limited and further research is needed. Quantifying the influence of fire on propensities for population change is largely absent. In addition, fire is often a necessary management requirement in the landscape, but the frequency, extent, and timing of the fires is critical to balance crane population dynamics with ecosystem maintenance; typically, however, such analysis has only been qualitatively described. In South Africa, for example, the removal of fire for several years from a wetland critical for Wattled Crane breeding resulted in a steady decline in the overall number of pairs breeding in the wetland and productivity of nesting pairs. Fire-return intervals of every three years helped maintain Wattled Crane breeding productivity within the wetlands while minimizing negative impacts of fire (Bento et al. 2009). Fire management has also been used to increase Eastern Sarus Crane non-breeding habitat at Tram Chim National Park in Vietnam (Meynell et al. 2012).

Wildfires are frequently under-reported in Russia. For example, in 2011, fire swept across 6,000 ha of wetlands in Muraviovka Park, but the official published data reported only 50 ha were burned. In 2010, the Russian Academy of Sciences estimated that fires covered 10–12 million ha. The federal government has ordered the provincial governments to use satellite images to estimate wildfire extent, and they are grappling with the problem of wildfires. Monitoring and analysis of fire frequency, extent, and timing through remote sensing can help frame the problem and prioritize where solutions could most effectively be deployed (e.g. Russell-Smith et al. 2003).

BALANCING FIRE SUPPRESSION AND PRESCRIPTION TO IMPROVE CRANE HABITAT MANAGEMENT

The conservation conundrum with fire is that, in some regions, existing measures to prevent wildfire are inadequate and ineffective, whereas in other regions, wildfire suppression has been so successful as to cause afforestation or shrub encroachment in many open crane habitats. Thus, fires that occur both too frequently, and not frequently enough, can cause the quality of crane habitat to decline. In Vietnam, fire is being returned to Tram Chim National Park along with natural hydroperiods to increase habitats for Eastern Sarus Cranes during the non-breeding season (Meynell et al. 2012). In North America, fire is also being returned to many diminishing grass and wetland ecosystems but at rates too slow to reverse shrub encroachment and subsequently decrease nest density of Sandhill Cranes (Jeb Barzen, unpublished data; Barzen et al. 2016). In South Africa and across other parts of Africa, fire is a recognized management tool that is used to prevent wildfires and to maintain the habitat in a viable condition for biodiversity.

Prescribed burning in Muraviovka Park, Russia, is used to prevent or reduce damage from more severe wildfires (Photographer: Jeb Barzen, International Crane Foundation)

In Russia, local communities are concerned about wildfires that damage buildings, threaten livelihoods and sometimes people, but are less concerned about the impact of wildfires on wetlands and cranes. Despite governmental orders announcing a non-burning season and threatening arsonists with punishment, accidental fires still occur with high frequency. Fines or other punishment for loss of grassland are rarely enforced in Russia and few resources are devoted to proving who started a fire and whether the fire resulted in loss of nests or birds. Despite having legislation that regulates burning, wildfires are still a significant threat to Red-crowned, White-naped, and Demoiselle Cranes. Therefore, much effort is required to work with people who live alongside cranes to prevent wildfires that are not beneficial to wildlife, people, or ecosystems.

In Russia, published recommendations on grassfire suppression (Glushchenko and Bocharnikov 1989, Komarova et al. 2012), together with discussions of prescribed burn experiences and their role in protecting wildlife habitats at conferences and in publications, are promoting a paradigm shift among experts, authorities, and general public from banning any burns to developing technical guidelines on controlled burns (Buyvolov et al. 2012, Kuksin and Kreindlin 2014). Since 1998, Muraviovka Park has been conducting field studies on impact of wildfires on cranes and storks, testing techniques of proactive fire prevention, organizing field schools on prescribed burns (Barzen 2011; Smirenski and Smirenski 2012), providing efficient and affordable equipment to governmental firefighters, conducting children art contests, developing educational videos, and giving presentations to visitors and in local schools. Though oscillations between success and failure over the last decade have occurred while implementing prescribed burning in Russia, in 2016 governmental agencies organized large-scale cooperative efforts and conducted controlled burns in the spring and in the fall, protecting over 90% of the Park including 2,800 ha of crane habitat. Ministry leaders provided funding, equipment, and professional firefighters for this work because they now understand that controlled burns provide real protection to endangered species. Conversely, on the Chinese side of the transboundary Amur/Heilong Basin, severe wildfires in wetlands during the droughts of the early 2000s resulted in a strictly enforced ban on fires; the direct threats of fire to cranes have been greatly reduced but protected area managers are now unable to use fire as a management tool (Liying Su, personal comm. 2017). In North America, success with overly simplistic education that promoted fire suppression alone has led to fire frequencies that are insufficient to maintain fire-adapted ecosystems (Ballard et al. 2012), causing a decline in open habitats, many of which cranes depend on. Finding sufficient balance between suppression of wildfire and implementation of prescribed fire is an important future challenge.

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Red-crowned Cranes on their breeding grounds in the Amur-Heilong River Basin in Russia and China;
- White-naped Cranes on their breeding grounds in the Amur-Heilong River Basin in Russia and China, Transbaikalia, and Mongolia;
- Wattled Crane in Southern and South-Central Africa: including the flood plains of the Zambezi Delta and other large floodplains of Zambia, and the palustrine wetlands of South Africa and Zimbabwe; and
- Demoiselle Cranes in steppe and semi-desert areas of Russia and Kazakhstan.

RESEARCH AND MONITORING NEEDS

- Determine the impact of wildfires on long-term parameters of crane populations located in the key areas listed above;
- Determine the effect on breeding success of prescribed mosaic burns conducted in different seasons, habitats, and conditions to guide conservation management recommendations moving forward;
- Use satellite imagery to accurately estimate and report area of potential nesting habitat for Red-crowned and White-naped Cranes burned in the Russian Far East;
- Research impacts of fire on Eastern Sarus Cranes in dry forest in northern Cambodia if there is an early dry season;
- Study impacts and benefits of fire as an ecological management practices in the five floodplain systems that support 75% or more of the global Wattled Crane population, namely Kafue Flats, Liuwa Plain, and Bangweulu Swamps (and associated breeding grounds) in Zambia, the Okavango Delta in Botswana, and the Zambezi Delta in Mozambique; and
- Assess the timing when most chicks fledge and compare that to when most fires occur. If there is an overlap, early dry season fires could kill pre-fledged chicks that hatch late (e.g., a 6–8 week-old Sarus Crane chick was captured at Yok Don National Park, Vietnam, in December, so December or early January fires could have killed this chick).

PRIORITY CONSERVATION ACTIONS

- Expand and diversify public awareness programs to inform local communities about impacts of fires on endangered species, their habitats, and air and water quality to reduce deliberate or negligent actions that result in wildfires;
- Lobby for enforcement of laws that punish for initiating wildfires;
- Lobby for use of prescribed burns for fire protection and for ecosystem restoration in fire-adapted communities; also include other wildfire-preventive measures (e.g., reforestation) where appropriate;

- Promote the training of fire fighters and staff of Russian cooperatives to conduct prescribed burns near important crane sites;
- Provide efficient fire-related machinery and equipment to staff at critically important crane sites;
- Offer help to governmental agencies in development of a system for emergency information exchange among all parties involved in fire suppression activities, including data of satellite imagery; and
- Develop management guidelines for the key sites above that include fire management for the use by staff and custodians of sites to improve management of these wetlands.

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THREAT:

INVASIVE SPECIES

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Invasive species are diverse in terms of species, occurrence and distribution across continents that crane species inhabit, and have been ranked as 15th out of 19 identified threats to cranes worldwide. Invasive species can come from many groups of organisms, including plants, animals, and microorganisms. Invasive species that have been recognized affecting cranes are, however, mostly plants. Invasive plants affect cranes through outcompeting native plants and replacing native vegetation, thus reducing habitats available for cranes. The Red-crowned, Sarus, Wattled, and Whooping Crane have been recognized as being significantly impacted by invasive species in some or all portions of their range; Brolga, Grey Crowned, Hooded, Siberian, and White-naped Cranes are listed as having a lesser threat.

RED-CROWNED CRANE

Invasive smooth cordgrass (*Spartina alterniflora*) is spreading across the intertidal zone at Chinese wintering sites. *Spartina* grows aggressively, crowding out other vegetation, and so densely that cranes and other waterbirds cannot forage (Liu et al. 2009). In addition, *Spartina* traps sediments, impeding water flow so that interior mudflats dry out. The Red-crowned Crane has lost large areas of feeding habitat within the limited areas remaining of coastal wetland. In Yancheng National Nature Reserve in China, where some of the last natural coastal wetlands remain, the marshes are threatened by invasion of the aggressive cordgrass (Harris and Mirande 2013).

SARUS CRANE

In the lower Mekong countries (Cambodia, Laos, Thailand, and Vietnam), *Mimosa pigra*, a prickly shrub of South Central America origin, is one of the most widespread invasive weeds on wetlands. It is degrading habitat quality and impacting use by Eastern Sarus Cranes. In the Mekong Delta of Vietnam, *M. pigra* was documented in one province in 1979, and by 2000 it had spread to all 12 provinces (Triet et al. 2004). Mechanical control is usually implemented through stem cutting and can be effective in small areas where access is available. For example, after early detection at U Minh Thuong National Park, the invasive was eradicated for minimal cost using manual control methods. However, at Tram Chim National Park, because of a lack of awareness and slow intervention at the early stage of infestation, *M. pigra* advanced quickly and at one time covered as much as one third of the 7,500-ha land area of the Park (Triet et al. 2004). Field experiments conducted at Tram Chin National Park resulted in the recommendations of an aggressive approach that combines stem cutting, fire, flood, and herbicides that effectively targets a specific growth stage (Thi et al. 2004). A continuing effort to control *M. pigra* since 2005 has brought the invasion of this weed under control at Tram Chim National Park.

Local community members are hired to control the invasive shrub Mimosa pigra, which is displacing feeding grounds for Wattled Cranes and many other species at Lochinvar National Park of the Kafue Flats. The restoration workers use these funds to invest in school fees, house repairs, livestock, and other needs. (Photographer: Richard Beilfuss)

Little is known about the impact of invasive species on Sarus Cranes in South Asia, although the species has adapted to using rice fields as breeding habitat (Sundar 2009). The presence of water hyacinth (*Eichhornia crassipes*) may provide nesting material, although it is not known if this use affects nesting success (K S Gopi Sundar, personal comm. 2016). Similarly, the impact of invasive vegetation on Sarus Cranes in Australia is also unknown, but much research and management are needed as the increase of invasive species has been documented as an issue in native systems.

WATTLED CRANES

Mimosa pigra is expanding its range across the Kafue Flats in Zambia. More than 800 ha of invasive *M. pigra* was eradicated through aerial spraying and community-involvement in manual cutting from 2007–2009 in the Kafue Flats (Kamweneshe and Beilfuss 2002; Shanungu 2009), but these efforts were discontinued and the plant reestablished. In areas where it was reduced or eradicated, displaced wildlife including Wattled Cranes showed increased use. However, after the program was discontinued *M. pigra* has been rapidly reclaiming areas where it had been eradicated. In 2017, a new project to eradicate *M. pigra* was initiated again on the Kafue Flats under the ICF/EWT Partnership. Continued eradication efforts are needed to keep *M. pigra* from spreading.

Boyo Lake, a shallow wetland located in the Rift Valley, is one of the important sites for Wattled and Black Crowned Cranes in Ethiopia. Boyo Lake was invaded by *M. pigra* from early 1990s to around 2008. The invasion of *M. pigra* resulted in the loss of wetlands that were used not only by cranes but also by local people as grazing lands. *Mimosa*-invaded areas also hosted hyenas, which killed cattle. Confronted by livelihood impacts, local communities surrounding Boyo Lake organized themselves to get rid of the weed. By 2008, Boyo Lake's wetlands were virtually free of *M. pigra*. Field observations made in March 2017 found very few mature *M. pigra* at Boyo Lake. Mimosa's seeds, however, were still abundant in the topsoil and the risk of *Mimosa* re-invasion is, therefore, prevalent. A rapid field survey along the Ethiopian Rift Valley from Lake Chamo in the south to Lake Metahara in the north found no evident of wide-spread occurrence of *M. pigra* in the Ethiopian Rift Valley. The survey, however, found other important weeds, especially water hyacinth, *Lantana camara*, and *Prosopis julifolia*, *Lantana*, and *Prosopis* are invasive mostly on terrestrial ecosystems; their impacts on cranes are unclear (Triet Tran, personal comm. 2017).

WHOOPING CRANE

The invasive tree species black willow (*Salix nigra*) and eastern cottonwood (*Populus deltoides*) have become a problem in the Aransas-Wood Buffalo migration corridor at the Platte River, Nebraska, USA. Historic flows from Wyoming and Colorado, as well as western Nebraska, have been compromised by dams and water diversions, and significantly reduced river flow, pulses, and sediment discharges have been documented (O'Brien and Currier 1987). As a result, woody encroachment has reduced the width of the river channel and stabilized sandbars that historically provided shallow, braided river sandbars for roosting. The river valley bisects the migration corridor of the Whooping Cranes during their annual migration. Habitat conversion has limited roosting habitat at a major critical stopover location and concentrated flocks in limited areas (Davis 2001). Early attempts to use non-mechanical methods (primarily glyphosate herbicides) effectively killed vegetation, but standing material remained and regrowth could occur (Pfeiffer and Currier 2005). By using specialized equipment capable of working in water and mowing down brush and small trees, and customized disks pulled by rubber-tracked tractors for larger woody material, the program expanded the restoration on conservation lands. The reestablishment of wet meadows adjacent to the river channel is being achieved by completely killing shrubs and tree with herbicides, excavating sloughs, and removing dead material, followed by over-seeding with high diversity prairie/wetland seed mixtures. In recent years, the restoration work has expanded to private lands adjacent to the Platte River, and a small industry has evolved in the area providing large tree removal and annual maintenance activities. In 2003, about 80 km of river channel in the Central Platte Valley had been restored and maintained, and actively used by migrating Whooping Cranes and hundreds of thousand Sandhill Cranes and diversity of waterfowl.

BROLGA

In Australia, the invasives *Hymenachne* spp. and *Sporobolus natalensis/pyramidalis* have been identified as a problem across tropical Australia in wetlands and on wetland margins (Tim Nevard, personal comm. 2016). Brolgas do not feed on *Hymenachne* and it spreads over the water surface to the complete exclusion of crane forage species such as *Eleocharis* and *Nymphaea*. *Sporobolus natalensis* and *pyramidalis* (and their hybrids) are invasive and unpalatable to domestic and native species. Their establishment is crowding out native grasses and sedges and creating tall vegetation on wetland margins, which are ungrazed and not used by cranes, and is leading to abandonment of long-established roosts. Chemical herbicides (glyphosate/flupropanate) are largely ineffective (both also have emerging bio-toxicity issues), making control infeasible, uneconomic, and potentially damaging to non-target taxa. Grazing of *Hymenachne* by cattle, horses, and buffalo provides partial control.

HOODED CRANE

In the Yangtze River estuary, the introduction of smooth cordgrass (*Spartina alterniflora*) in the 1990s is considered one of the most harmful exotic invasive species in this system, which has outcompeted native species, including sea-bulrush (*Scirpus mariqueter*) and common reed (*Phragmites australis*) of the emergent marsh, and converted tidal flat to cordgrass marsh habitat (Li et al. 2009). This species was recognized as one of the 16 most harmful invasive exotic species by the state Environmental Protection Administration of China in 2003. The presence of smooth cordgrass has been shown to affect the distribution of the Hooded Crane in the upper reaches of the estuary at Dongtan, especially with the loss of sea-bulrush corms, which are a primary food of the cranes (Ma et al. 2003). A study was undertaken to evaluate the best control methods of cordgrass at Dongtan; because the plant grows both by vegetative propagules and seed, properly timed and repeated clippings were needed (Gao et al. 2009). A single clipping produced a higher productivity response as compensation to disturbance and also could increase the amount of sunlight to the substrate that could enhance seed germination.

Proper timing of clipping (initial clipping at early florescence) was more important than clipping frequency (always >1, 3 best), and closely depends on specific traits of the cordgrass's life cycle at a specific location and on the habitat characteristics.

WHITE-NAPED CRANE

In Poyang Lake, the most important wintering site for White-naped Cranes in China, crab (*Eriocheir sinensis*) farming in sub-lakes has been a problem for aquatic food plants such as *Vallisneria* (a major plant for Siberian Cranes) as the crabs may deplete the vegetation (Wu et al 2012). Currently crab farming is not prevalent at Poyang Lake and there are no signs that the wintering population of White-naped Cranes has been significantly impacted; however, crab farming needs to be monitored. Crawfish have also been recently introduced to Poyang Lake and its population has gone up and down. There have been no studies on this taxon at Poyang Lake.

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Red-crowned and Hooded Cranes in Yangtze River Estuary in China;
- Sarus Cranes in the lower Mekong countries (Cambodia, Myanmar, Laos, Thailand, and Vietnam);
- Wattled Cranes on the Kafue Flats in Zambia;
- Whooping Crane on migration corridor along Platte River, Nebraska;
- Hooded Cranes in Yangtze River Estuary;
- White-naped Crane at Poyang Lake; and
- Brolga in tropical Australia; with
- Lesser impacts to Grey Crowned on breeding areas.

RESEARCH AND MONITORING NEEDS

- Test solutions for controlling *Spartina alterniflora* at Yancheng NNR in China; and
- Monitor *Mimosa pigra* at Boyo Lake and other wetlands in the Rift Valley, Ethiopia.

PRIORITY CONSERVATION ACTIONS

- Identify and implement effective control mechanism for the invasive *Spartina alterniflora* in coastal wetlands of China;
- Develop and implement a long-term management plan to control *Mimosa pigra* on the Kafue Flats in Zambia;
- Maintain areas of reduced *M. pigra* at Tram Chim National Park and other sites within the Mekong Delta: and
- Identify Grey Crowned Crane sites threatened by alien invasive plants and develop and implement mitigation plans using methods that benefit the local community where possible.

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THREAT:

DISEASE RELATED TO INCREASING DENSITIES AND HUMAN CONTACT

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While numerous threats to crane populations are expected to result in losses and decline in populations, a combination of habitat constraints, management strategies, and strict protection have resulted in locally high concentrations of cranes. These phenomena are often the result of strategies designed to prevent or lessen agricultural crop damage (Goroshko 2012, Harris 2012, Austin and Sundar 2018) or improve overwinter survival (Amano 2009), including planting of lure crops or artificial feeding, and may also yield an added benefit of tourism centered on watchable wildlife (Nowald 2012a). Locally high concentration or overabundance of wildlife has important consequences for surrounding ecosystems, domestic animals, and human populations, particularly if there are sanitary problems (Sorensen et al. 2014). Overabundance of wildlife can lead to deleterious effects, such as changes to soils, vegetation, and other animal populations, lower mean body condition scores and lowered reproductive potential in the species of concern, increased parasite burdens, and create changes in dynamics of other infectious diseases and prevalence in the population (Gortázar et al. 2006, Süld et al. 2014). Once a population is defined as overabundant, even if there is specific evidence for disease problems, it is frequently difficult to establish corrective management actions.

In several areas, staging or wintering crane populations are managed through artificial feeding, either directly with broadcasting of feed in specific zones, or through the use of specific agricultural crops grown either to supplement the energy stores of the cranes or as a deterrent to crop depredation in nearby fields. Typically, extra feeding and access to fresh water and safe roosting habitat, combined with diminished contact with predators, allows local wildlife densities to rise (Fischer and Miller 2015). Traditional disease modeling suggests that higher density populations may experience greater disease spread among individuals than those at lower densities, through increased contact rates between infected and susceptible individuals that results in effective transmission (Gortázar et al. 2006, Wobeser 2006). Disease transmission can also be enhanced indirectly through feed as a fomite (material likely to carry infection) (Sorensen et al. 2014) or when feed is contaminated with a potential toxin. Infectious and non-infectious diseases of concern for cranes at high densities may include the following: avian influenza spillover from Anseriformes (orthomyxoviridae; Okuya et al. 2015), infectious bursal disease virus (birnaviridae; Candelora et al. 2010), avian cholera (*Pasteurella multocida*; Friend and Franson 1999), salmonellosis (*Salmonella* spp.; Friend and Franson, 1999), avian tuberculosis (*Mycobacterium avium*; Stroud 1986), coccidiosis (*Eimeria gruis*, *E. reichenowi*; Bertram et al. 2015), and mycotoxicosis (e.g., aflatoxicosis; O'Hara 1996), among others. Disease surveillance is a key element of monitoring with any feeding program that is instituted, along with implementation of other preventive measures to limit disease transmission (Sorensen et al. 2014).

Mirande CM, Harris JT, editors. 2019. Crane Conservation Strategy. Baraboo, Wisconsin, USA: International Crane Foundation. 455 p.

The provision of food may actually undermine or mask problems confronting the sustainability of crane populations, such as loss of migratory and wintering habitat, or other ecological factors. The occurrence of large concentrations of cranes also puts more birds at risk when they are focused near animal agriculture and human settlement. Infectious disease epizootics magnified in domestic animals (Cappelle et al. 2014), changes in agricultural practices (Jiang et al. 2014), degraded water quality and point-source pollution, disturbance, and direct losses from infrastructure and hazards (e.g., power line strikes, hits by car)—all would be expected to disproportionately impact cranes at higher concentrations than might naturally occur, especially in proximity to human activity.

Data on actual disease outbreaks in areas of high crane concentrations are fortunately limited and susceptibility of cranes so far has been low compared to other avian species. The wintering populations in Japan of Hooded Cranes (up to 80% of the world population) and White-naped Cranes (50% of the world population) are highly concentrated during night roosting in Izumi on a 104-hectare protected area in response to artificial feeding and loss of alternate wintering sites, raising concerns about the spread of disease through the population. In winter of 2010–11, nine White-naped Cranes were found dead at Izumi, although none were associated with the highly pathogenic H5N1 avian influenza virus. The same winter 55 Hooded Cranes were found dead, of which seven had died of H5N1 (Haraguchi 2015). In winter 2014–15, one White-naped Crane and four Hooded Cranes died of H5N8. In winter 2016–17, one White-naped Crane and 22 Hooded Cranes died of H5N6; Yuko Haraguchi, personal comm. 2017). Although this incident did not develop into a significant mortality event and cranes are currently thought to be less at risk from highly pathogenic avian influenza than waterfowl or many

Dense flocks of Hooded and White-naped Cranes gather on grain provided to winter flocks in Izumi, Japan (Photo credit: International Crane Foundation) other bird species, it is a reminder of how vulnerable these populations could be to a more virulent strains or other disease. There are also poultry farms holding about 5.2 million chickens in Izumi City, Kagoshima prefecture (Izumi Agricultural Department, personal comm. 2014). Regulatory authorities are very concerned about the presence of any infectious disease in the Izumi cranes and the resulting possible risks to the poultry industry; this concern could result in negative feelings and pressure for alternative management for the cranes (Haraguchi 2015).

For the island population of Red-crowned Cranes in Japan, there are heavy concentrations in both breeding and wintering areas that might cause major losses by infectious disease. Lack of habitat, especially in winter, brings many cranes in close proximity. As the population grows, this risk increases.

The concentrated migratory flocks of Sandhill Cranes along the Platte River during spring migration are potentially susceptible to outbreaks of avian cholera and other diseases. The precarious state of the Mississippi Sandhill Crane has focused scientific attention on a wide range of topics relevant to crane conservation including the role of disease (USFWS 1991).

A wintering population of Eurasian Cranes in the Hula Valley, northern Israel has grown from 5,000 to more than 42,000 birds (Shanni et al. 2012, 2018; Rubin Inbar, personal comm. 2017). Cranes are mostly concentrated here on a very small piece of land (200–400 hectares), thus creating a very dense wintering population, which is being fed throughout the winter in order to prevent damage to the surrounding 8,000 hectares of agricultural fields. There are also large concentrations of Eurasian Cranes found in the region Darss-Zingster Boddenkette and Rügen (old name: Rügen-Bock area), with 55,000–75,000 individuals; in the Rhin-Havelluchs near Berlin with 60,000–125,000 cranes; in the Diepholz moor lowlands in north-west Germany with 60,000–120,000; as well as at the Helme and Unstrut Reservoirs in Thuringia with 30,000–45,000 cranes (Nowald et al. 2010, Nowald 2012b, Prange 2013). Strategies have also been developed to deal with concentrations of up to 112,000 stopping at Hortobágy National Park, eastern Hungary (Végvári and Hansbauer 2018).

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

Species

- Hooded and White-naped Cranes at Izumi, Japan;
- Red-crowned Cranes at Hokkaido, Japan; and
- Whooping Cranes at Aransas National Wildlife Refuge, Texas, USA, particularly in drought conditions.

Concentrated Populations of Non-threatened Species

- Mississippi Sandhill Crane subspecies at Mississippi Sandhill National Wildlife Refuge, Mississippi, USA;
- Demoiselle Cranes at Kichan, India;
- Mid-continent population of Sandhill Cranes at Nebraska, USA; and
- Eurasian Cranes in the Hula Valley, Israel.

RESEARCH AND MONITORING NEEDS

- Identify high-risk sites where large concentrations of cranes living alongside human communities and domestic animals may be at heightened risk of epizootic disease;
- Investigate impacts of high density and related stress on bird populations, including mortality, and individual immune status and fitness that may affect species reproduction;
- Research habitat preferences of White-naped Cranes and Hooded Cranes in Japan to help establish and manage alternate wintering sites (see also Species reviews for *White-naped* and *Hooded Cranes*);
- Identify risks of disease transmission among domestic and wild birds at sensitive sites, and conduct predictive modeling for population outcome under different management scenarios; and
- Conduct research at captive breeding centers to detect and minimize disease outbreaks (see *Whooping Crane* species review).

PRIORITY CONSERVATION ACTIONS

- Identify and protect alternate wintering areas in Japan and facilitate the dispersal of significant numbers of cranes to those sites, reducing crane concentration at Izumi (see Hooded Crane species review);
- Reduce risk of disease at artificial feeding sites used by threatened species by altering feeding locations and strategies and by ensuring that feed used meets quality standards;
- Conduct high risk site evaluations following Scientific Task Force on Avian Influenza and Wild Birds recommendations;
- Create regional disease contingency plans that mitigate impacts of crane disease outbreaks; and
- Form a Wildlife Health Work Team under the IUCN Crane Specialist Group to address known and emerging health issues.

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THREAT:

LOSS OF COASTAL HABITAT DUE TO SEA-LEVEL RISE, ASSOCIATED WITH LAND SUBSIDENCE AND CLIMATE CHANGE

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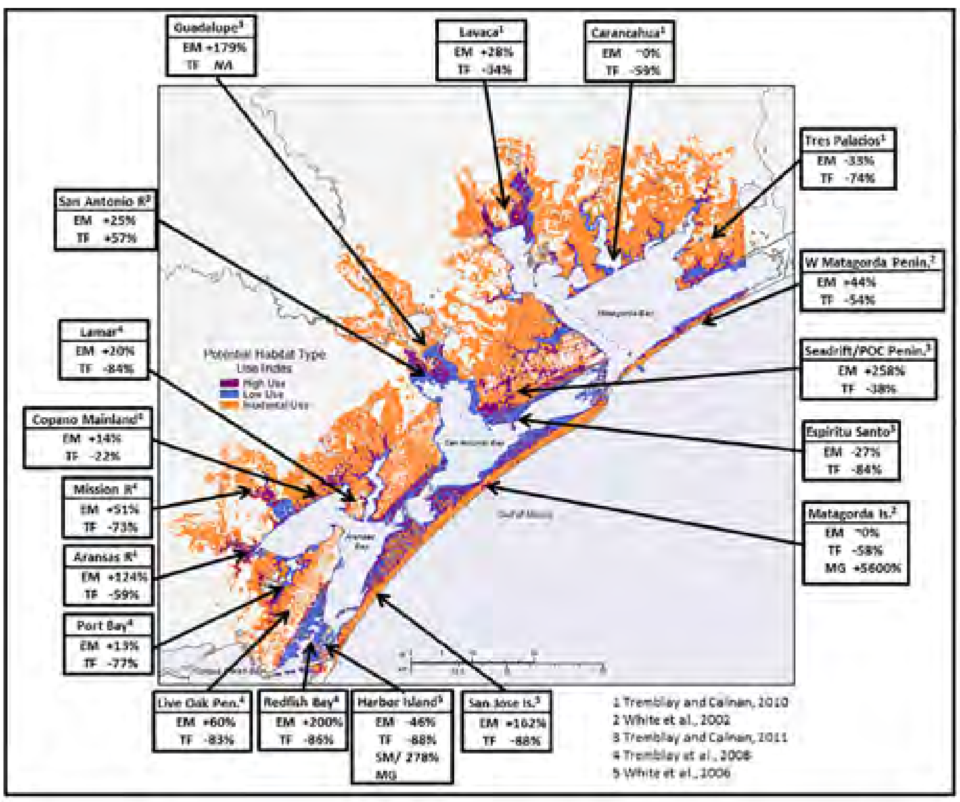
Coastal habitats are being lost due to rising sea levels and subsidence (gradual caving in or sinking of land) related to climate change. These processes are interrelated and currently affect and will undoubtedly continue to affect the habitats that several crane species depend upon. They are defined as a critical threat for Whooping Cranes, significant threat for Red-crowned Cranes, a lesser threat for Brolga, and Sarus Cranes, and an emerging threat for Hooded Cranes. Briefly, predicted climate change in the future is likely to affect the drying and flooding regimes of coastal wetlands. Coastal environments have always been affected by the inherent dynamic processes where continents meet the seas as a result of climate changes which affect sea levels. In recent centuries, the Earth's shorelines have been gradually retreating as low-lying uplands become inundated and converted to coastal wetlands and open water environments. Sea-level rise has been well documented and conservative estimates are given as at least 1-m rise in the next century; some models predict even higher levels in some areas of the world, and those impacts are not uniformly distributed (IPCC 2014). Two climate-related factors are mainly affecting sea-level rise: thermal expansion of sea water due to ocean warming, and water mass input from melting land ice and from land water reservoirs (Nicholls and Cazenave 2010).

Additional non-climate-related processes are the result of human-induced activities that result in ground subsidence, primarily from oil and groundwater extraction, and a reduction of sediment supplies from rivers to estuaries or seas due to sediment capture at dams built on rivers (McGranahan et al. 2007). The combination of these processes impact human habitations along the coast, where 10% of the world population lives in areas at less than 10-m elevation. In coastal environments, plant communities are also changing in response to warming temperatures and fewer chilling events. Crane species that utilize coastal environments are affected by all of these factors, particularly if portions of their limited ranges are located entirely in coastal wetlands.

SEA-LEVEL RISE

Whooping Cranes migrate each year from the freshwater wetland systems in central Canada to winter only in coastal wetlands along a limited extent of the Gulf of Mexico shoreline in Texas, USA. These productive wetlands provide the primary food items, blue crabs (*Callinectes sapidus*) and Carolina wolfberries (*Lycium carolinianum*), as well as other estuarine organisms. Each Whooping Crane pair and family requires a large territory (average 120 ha each) to maintain energy reserves for migration to the breeding area and a successful reproductive season (Stehn and Prieto 2010). Their protected core habitat within the Aransas National Wildlife Refuge, from which the Aransas-Wood Buffalo population recovered (less than 20 birds in the early 1940s), currently supports less than half of the population. Much of remaining winter habitat is subject to urban and industrial development, and it is also susceptible to sea-level rise (Smith et al. 2014). While recent modeling approaches are provisional, estimates of coastal Whooping Crane habitat loss from 1–2 m of sea-level rise ranges from 23 to 46% by 2100. Additional impacts from development may limit the inland migration of wetlands along the low-lying coastal fringe in coastal Texas as well. Preliminary models have incorporated potential development areas to identify future wetland areas for Whooping Cranes that should be prioritized for conservation (Metzger et al. 2014). Potential habitat that will convert to potential Whooping Crane habitat in the future has been incorporated in the conservation planning maps to ensure these areas are conserved to support the population as current habitat becomes submerged and unavailable (Metzger et al. 2014, Smith et al. 2014).

Sea-level rise and subsidence from geologic fault blocks are affecting the coastline of China, resulting in loss of coastal habitat and saltwater intrusion in groundwater (Cai et al. 2009). As part of an analysis of impacts from climate-induced sea-level rise on Ramsar sites, Yancheng National Nature Reserve (NNR) was evaluated for relative risk of habitat loss from 1-m and 2-m rise scenarios. About 43% (123,000 ha) of the site is at risk from 0–1 m sea-level rise and 57% (163,500 ha) from 0–2 m sea-level rise (Sherbinin et al. 2012). Continued development along the coast results in an additional impact to Red-crowned Crane habitat availability. In a recent study to delineate coastal wetland change in Yancheng NNR in Jiangsu Province, grass flat (the primary habitat for the cranes) significantly decreased from 1988–2006 whereas agriculture, aquaculture, and built-up areas have increased (Ke et al. 2011). Grass flats were primarily converted to agricultural fields and aquaculture ponds with a loss



Changes in area of estuarine marsh (EM), tidal flats (TF), and salt marsh/mangrove (SM/MG) between the 1950s and 2000s throughout the potential wintering range of the Aransas-Wood Buffalo population of Whooping Cranes in coastal Texas. Changes in the area and distribution of habitats have resulted from a combination of coastal subsidence, sea-level rise, and development of unprotected lands. From Smith et al. (2014)

of 66% decreasing from ~31,000 to ~25,000 ha from 1988–1997 to ~8,600 ha by 2006. These pressures, in conjunction with sea-level rise, subsidence, and climate change, reduce the resiliency of the coastal environment for the continued use by Red-crowned Cranes.

In the Republic of Korea (South Korea), wintering Red-crowned Crane concentrate at two coastal sites including the Han River estuary and Ganghwa Island. Effects of the sea-level rise include the direct impacts of losing feeding grounds and roosting sites, but accurate information such as population, food sources, feeding grounds, and roosting sites are still missing or incomplete. The Han River estuary's population is currently impacted by disturbances such as continued housing complex construction, a military conservation area, and direct/indirect impacts from the location of a bridge (Soodong Lee, personal comm. 2016), which compound the impacts of habitat loss from sea-level rise.

One of the last natural coastal wetlands used by Hooded Cranes in China encompasses only 10 km^2 of a 100 km^2 area in Dongtan, Yangtze River estuary (Ma et al. 2003). The development in the low-lying uplands could limit the conversion of these areas to future wetlands with sea-level rise, and the reclamation of this area to farmlands is an immediate threat. Similarly, the wintering grounds of the Hooded Crane in Suncheon Bay, Republic of Korea, continues to host more wintering cranes each year from about 60 in 1996 to about 300 in 2007 (Kim, 2008); recently more than 1,400 cranes wintered in 2016, with most roosting in the intertidal flats (Kisup Lee, personal comm. 2015). The only roosting site available is on the intertidal mudflat, with cranes having increasing difficulties staying there at night during high tides (Kisup Lee, personal comm. 2016). Sea-level rise is ultimately a long-term threat, while reclamation and human disturbance are current threats to this area (Kim 2008).

Brolga populations that nest along the northern Australia coast use freshwater habitats that are increasingly impacted by saltwater intrusion as a result of sea-level rise, as described in the Arafara Swamp in Northern Territories (Harrison et al. 2009, in Weston et al. 2012). Little information on the effects of these climate-induced alterations on Brolgas or Sarus Cranes is available.

SUBSIDENCE

Additional wetland losses from subsidence as a result of oil and gas extraction must also be considered in future modeling; it has been well documented in coastal areas along the northwestern coast of Gulf of Mexico (Morton et al. 2006). Regulatory mechanisms in the form of subsidence districts have been created in several coastal counties to minimize these impacts. However, this approach has not been implemented in the current wintering range of the Whooping Crane. In the USA, in more developed areas along the Texas coast groundwater withdrawals have also created subsidence impacts and decreased land values. Little information exists on how these impacts are affecting the habitats that these cranes depend upon in winter. Subsidence belts have been mapped along the China coast, which relate to broad-scale coastal erosion, as well as the additional impact of groundwater extraction exacerbating subsidence rates (Cai et al. 2009). As human populations continue to increase along the coast, additional wetland conversion to open water is predicted which will have an impact on the habitat available for Red-crowned Cranes. No work has been published on the effects of subsidence within their coastal ranges for Brolgas and Sarus Cranes.

The extensive hydrologic alteration to the Mekong Delta in Viet Nam from warfare and agricultural development dramatically degraded wetland functioning and use by Sarus Cranes (Beilfuss and Barzen 1994). Restoration of a portion of the delta at Tram Chim Reserve and immediate response by the wetland system and increase in Sarus Cranes are indicative of what could be accomplished at broader scale through the Delta. The importance of this wetland system to recovery of economic stability, and its vulnerability to effects of climate change which includes changes in precipitation regimes and saltwater intrusion, have been evaluated in detail and discussed in concert with integrated water resource management (Kakonen 2008, Xue et al. 2011, ICEM 2012). It is important that the international community assist in balancing the economic needs with restoring and sustaining the ecologic benefits of wetland restoration and management (Beilfuss and Barzen 1994).

SHIFTS IN TEMPERATURE AND PRECIPITATION PATTERNS

The increase in temperatures and concomitant decreases in chilling events can drive distributional shifts in species' ranges. In the northern Gulf of Mexico, the establishment of black mangrove (*Avicennia germinans*) may have a negative impact on the expansion of the wintering range of the Whooping Crane. While mangrove expansion has replaced salt marshes, only 6% of the 24% net loss of salt marsh was explained by mangrove increases (Armitage et al. 2015). It is probable that sea-level rise is the overriding driver of continued salt marsh loss along the Texas coast, although site-specific evaluations are necessary.

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Whooping Cranes on their wintering grounds in coastal Texas, in and near Aransas National Wildlife Refuge, USA;
- Red-crowned Cranes in Jiangsu and Panjin, China;
- Brolgas in northern Australia (Arafara Swamp, Northern Territories);
- Sarus Cranes in South Asia and Southeast Asia; and
- Hooded Crane in Yangtze River estuary, China and Suncheon Bay, Republic of Korea.

RESEARCH AND MONITORING NEEDS

- Map and identify locations and extent of habitat that will be converted from low coastal prairie to coastal marsh under various sea-level rise scenarios for wintering Whooping Cranes along northwestern Gulf of Mexico;
- Map and identify locations and extent of habitat that will be converted from fresh to brackish habitats under various sea-level rise scenarios in areas used by Red-crowned Cranes for foraging and breeding in Japan and by Brolgas and Sarus Cranes in Queensland, Australia;
- Compare breeding success and behavioral differences in breeding and foraging Red-crowned Cranes between brackish and freshwater habitats in Japan;
- Identify leading causes (sea-level rise, subsidence, climate change) of wetland impacts at regional scales for five species at risk to develop specific strategies that would minimize impacts to crane recovery and population persistence.

PRIORITY CONSERVATION ACTIONS

- Develop comprehensive action plans for Whooping Cranes, Red-crowned Cranes, Sarus Cranes, and Brolgas that incorporate future habitat areas as part of conservation strategies now, to preclude loss from incompatible development as sea levels change coastal environments;
- Prioritize future key areas that will be essential to maintain and support recovering crane populations for coastal wintering habitats for Red-crowned Cranes in China, Brolgas, and Sarus Cranes in Australia, Sarus Cranes in South and South-east Asia, and wintering habitat for Whooping Cranes in United States.

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THREAT:
PREDATION

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Predation has always affected cranes, especially eggs, chicks, and adults rendered flightless during summer molt. With large, healthy populations, predation probably has little effect at the population level. However, with declining populations of cranes (due to habitat loss, crane trade, hunting, etc.) or reintroduced populations (where numbers are small and captive-reared birds are learning to survive in the wild), predation may present an important additional source of mortality. Furthermore, the introduction of new predators and habitat changes such as wetland fragmentation may exacerbate the impact of predation on crane populations.

Since eggs, chicks, and flightless adults tend to be most vulnerable to predation, terrestrial predators are a contributor to crane mortality and low breeding success. Currently, predation poses a significant threat to reintroduced populations of Whooping Cranes and a lesser threat to Brolgas, Black-necked, Sarus, White-naped, and Demoiselle, Cranes. Although predation events have been documented for these crane species, little is known about whether predation is limiting crane populations and which predators present the greatest threat.

Release of captive-reared cranes has become an important tool in crane conservation. However, captive-reared birds may lack behavioral skills for recognizing threats in the wild and safe areas for roosting and defending their eggs or chicks from predators (Howard et al. 2016, 2018). Predation is a serious concern for the Whooping Crane reintroduction programs (Folk et al. 2010, Hartup et al. 2010, Keller and Hartup 2013). The release and breeding area of the Eastern Migratory population of Whooping Cranes in Wisconsin, USA, has many predators, including bobcats (*Lynx rufus*), wolves (*Canis lupus*), coyotes (*Canis latrans*), Common Ravens (*Corvus corvus*), and red fox (*Vulpes vulpes)*. Predation has accounted for more than 50% of the diagnosed causes of death within this population (Cole et al. 2009, Urbanek et al. 2010; unpublished data). At Necedah National Wildlife Refuge, the main breeding area, incubating cranes driven from their nests by black flies (*Simulium annulus*) have had eggs scavenged by raccoons (*Procyon lotor*), American Crows (*Corax brachyrhynchos*), and Common Ravens (Richard Urbanek, personal comm. 2016).

A camera trap shows a red fox taking an egg from a crane nest at night (Photographer: Tim Cleary)

Freshwater and estuarine wetlands along the Gulf Coast of the United States support two reintroduced populations of Whooping Cranes (wintering Eastern Migratory Population and the non-migratory Florida Population) and the non-migratory population of Mississippi Sandhill Cranes. Bobcats

Mirande CM, Harris JT, editors. 2019. Crane Conservation Strategy. Baraboo, Wisconsin, USA: International Crane Foundation. 455 p.

and coyotes are common predators that are known to take eggs and chicks (Whooping Crane Eastern Partnership 2012). At least ten Whooping Crane mortalities in the reintroduced Eastern Migratory Population from 2001 to 2012 are attributed to bobcats. Attempts to cull bobcats have been largely ineffective; the bobcat population in Florida, for example, is so dense that new individuals move into the territories of removed bobcats within weeks (Marianne Wellington, personal comm. 2016). Alligators (*Alligator mississippiensis*) also have been reported taking eggs, chicks, and fledged juveniles of Whooping and Sandhill Cranes in Florida and Georgia (Folk et al. 2014). Other mammalian predators such as raccoons and crows take eggs.

Whooping Cranes in the original and only self-sustaining population breed in Wood Buffalo National Park in the Northwest Territories of Canada. Black bears (*Ursus americanus*) and other mammals take eggs, and wolves, red fox, and Common Ravens kill chicks (Bergeson et al. 2001). The overall impact of predation on recruitment in this crane population remains uncertain but may be a factor in the 10-year population cycle (Boyce et al. 2005).

Domestic dogs (*Canis lupis familiaris*) also pose a predation risk to cranes. Feral dog populations have been increasing dramatically in India, making the country home to one of the largest populations of feral dogs in the world (Menezes 2008). Dogs are a suspected predator of Sarus Crane chicks in India, where the cranes nest in a human-dominated agricultural landscape (Mukherjee and Borad 2002). Disturbance and predation by dogs are also a serious concern for White-naped and Demoiselle Cranes in Mongolia and Black-necked Cranes in Bhutan. However, definitive evidence of dog predation and its effect on crane recruitment is lacking. In some parts of China, Black-necked Cranes may also be falling prey to free-roaming dogs (Fengshan Li, personal comm. 2017; Austin et al. 2018). In both China and Mongolia, most of these dogs belong to a household and are not feral in the truest sense. Since the local governments are unable to limit the number of household dogs in the area, efforts to control dog populations have focused upon asking owners to keep them tied or fenced.

In Australia, the introduced Eurasian red fox is considered a predation threat to Brolgas. The fox was introduced into Australia in the mid-1800s as a game species. The foxes quickly increased in numbers, spreading throughout most of the continent and playing a role in the decline of ground-nesting birds across their range (Australian Government 2010). The range of the Eurasian red fox does not penetrate that of the Brolgas living in Australia's northern tropical areas, but the small southeastern population of Brolgas may be vulnerable to this introduced predator. The southeastern population, estimated at approximately <1,000 individuals, is believed to be declining (DuGuesclin 2003) and is considered "Vulnerable." Predation by the European red fox is considered to be the main factor contributing to chick mortality and low breeding success in this population (Arnol et al. 1984, Herring 2001, Myers 2001, DuGuesclin 2003). However, there is limited empirical evidence addressing the threat of fox predation to Brolgas, and anecdotal reports from Brolga breeding areas have not presented a clear trend between fox presence and crane breeding success (Matthew Herring, personal comm. 2013).

Arctic tundra and boreal regions, important breeding regions for Siberian, Whooping, Eurasian, and Sandhill Cranes, are already experiencing the effects of a warming climate. Environmental effects include altered precipitation and wetland flooding regimes, changes in plant community and productivity, and altered food webs (e.g., Post et al. 2009, Pshennikov 2012, Patil 2018, Pastick et al. 2018). These changes in turn affect animal distributions and productivity, small-mammal cycles, and predator-prey relations (Bêty et al. 2002, Gilg et al. 2009, Schmidt et al. 2012). In the arctic, predation on bird eggs and chicks by avian and mammalian predators are influenced by availability of alternate prey, primarily small mammals such as collared (*Dicrostonyx groenlandicus*) and brown (*Lemmus trimucronatus*) lemmings. Lemming populations appear to be highly sensitive to climate change, and under warmer and shorter winters, their well-known high-amplitude population cycles may collapse

(Schmidt et al. 2012), pushing predators to focus on ground-nesting birds such as cranes. Whether changes in the predator-prey relations on northern breeding grounds due to warming climate will reduce crane recruitment is uncertain but warrants long-term monitoring of predators and alternate prey concurrent with monitoring crane reproduction. Also, northward expansion of some predators may increase predation risks for cranes. For example, the expansion of wolverines (*Gulo gulo*) into the tundra ecosystem of the north of the Indigirka River basin, in northeastern Russia, was first observed in 2008; this species has become a permanent resident of the tundra in the core breeding area of the eastern population of the Siberian Crane (Maria Vladimirtseva, personal comm. 2019). The impact of this new predator on crane nest success is uncertain, but observations suggest increased risks of egg predation.

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Reintroduced populations of Whooping Cranes in the Eastern Migratory Population and Florida population, particularly in Wisconsin and the southeastern United States along the Gulf of Mexico;
- Brolgas in southeastern Australia;
- Sarus Cranes in India;
- White-naped Cranes and Demoiselle Cranes in Mongolia; and
- Black-necked Cranes in China and India.

RESEARCH AND MONITORING NEEDS

- Identify key predators associated with mortalities in the wild and reintroduced Whooping Crane populations, especially at breeding grounds in Canada and Wisconsin;
- Determine the role of predation on Whooping Crane recruitment (survival of eggs, chicks, and juveniles) in both the wild and reintroduced Whooping Crane populations and the Mississippi Sandhill Crane population;
- Determine whether feral and free-roaming dogs affect reproductive success of Sarus and Black-necked Crane populations in India and China, and White-naped and Demoiselle Cranes in Mongolia;
- Assess whether European red foxes affect reproductive success of the southeastern Australian Brolga population; and
- Initiate long-term research and monitoring to understand changes in predator-prey relationships in arctic and boreal ecosystems under climate change and effects on reproductive success for cranes in those regions.

PRIORITY CONSERVATION ACTIONS

- Work with local herding families in the Khurkh and Khuiten River Valleys of Mongolia to restrict movements and provide more food to dogs during the one-month incubation period of White-naped and Demoiselle Cranes.
- Work with farmers at Ruoergai to keep dogs tied or fenced during the nesting period of Black-necked Cranes.
- Reduce disturbance to nesting Wattled Cranes in South Africa by restricting uncontrolled hunting with dogs.

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THREAT:

GENETIC AND DEMOGRAPHIC PROBLEMS OF SMALL POPULATIONS

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Many wildlife populations that were once widespread, numerous, and occupying contiguous habitat in different parts of the world have now been reduced to one or more smaller, isolated populations. The primary causes of the decline of many species are obvious and deterministic: loss of suitable habitat through land conversion (often involving agriculture); unsustainable harvest; reduced habitat quality through pollution; predators; diseases; and now climate change. Even if the threats caused by these activities are removed, a small isolated population is vulnerable to additional forces, intrinsic to the dynamics of small populations, which may drive the population to extinction (Soulé 1987).

Many stages in the life history of an organism, and the processes that define the history of a biological population, are essentially stochastic sampling phenomena. Births, deaths, dispersal, disease, sex determination, and transmission of genes between generations all are largely probabilistic processes. Small samples intrinsically have greater variance around the mean value of a given parameter than do large samples, and therefore small populations will experience greater fluctuations in births, deaths, sex ratio, and genetic variation than will larger populations. The fundamental problem facing small populations is that the fluctuations they experience due to the multiple stages of sampling each generation make it increasingly likely that the populations will, unpredictably, decline to zero. Once populations are small, the probability that they will become extinct can become more strongly determined by the amount of fluctuations in population size than in the mean, deterministic population growth rate. Thus, extinction can be viewed as a process in which once common and widespread populations become reduced to small, isolated fragments due to extrinsic factors, the small remnant populations then become subjected to large fluctuations due to intrinsic processes, the local populations occasionally and unpredictably go extinct, and the cumulative result of local extinctions is the eventual extinction of the taxon over much or all of its original range (Gilpin and Soulé 1986, Morris and Doak 2002).

The stochastic processes impacting populations have been usefully categorized into demographic stochasticity, environmental variation, catastrophic events, and genetic drift (Shaffer 1981). Demographic stochasticity is the random fluctuation in the observed birth rate, death rate, and sex ratio of a population even if the probabilities of birth and death remain constant. Assuming that births and deaths and sex determination are stochastic sampling processes, the annual variations in numbers that are born, die, and are of each sex can be specified from statistical theory and would follow binomial distributions. Such demographic stochasticity will be most important to population viability perhaps only in populations that are smaller than a few tens of animals (Goodman 1987), in which case the annual frequencies of birth and death events and the sex ratios can deviate far from the means.

Environmental variation is the fluctuation in the probabilities of birth and death that results from fluctuations in the environment. Weather, the prevalence of enzootic disease, the abundances of prey and predators, and the availability of nest sites or other required microhabitats can all vary, randomly or cyclically, over time. The fluctuations in demographic rates caused by environmental variation is additive to the random fluctuations due to demographic stochasticity. Thus, the difference between the observed variation in a demographic rate over time and the distribution describing demographic variation must be accounted for by environmental variation.

Catastrophic variation is the extreme of environmental variation, but for both methodological and conceptual reasons rare catastrophic events are analyzed separately from the more typical annual or seasonal fluctuations. Catastrophes such as epidemic disease, hurricanes, large-scale fires, droughts, and floods are outliers in the distributions of environmental variation. As a result, they have quantitatively and sometimes qualitatively different impacts on wildlife populations. Such events often precipitate the final decline to extinction. For example, one of two populations of Whooping Cranes was decimated by a hurricane in 1940 and soon after became extinct (Doughty 1989).

Genetic drift is the cumulative and non-adaptive fluctuation in allele frequencies resulting from the random sampling of genes in each generation. This can impede the recovery or accelerate the decline of wildlife populations for several reasons (Lacy 1993). Inbreeding, not strictly a component of genetic drift but correlated with it in small populations, has been documented to cause loss of fitness in a wide variety of species, including virtually all sexually reproducing animals in which the effects of inbreeding have been carefully studied (reviewed in Hedrick and Kalinowski 2000). Even if the immediate loss of fitness of inbred individuals is not large, the loss of genetic variation that results from genetic drift may reduce the ability of a population to adapt to future changes in the environment. Thus, the effects of genetic drift and consequent loss of genetic variation in individuals and populations negatively impact on demographic rates and increase susceptibility to environmental perturbations and catastrophes. These synergistic destabilizing effects of stochastic process on small populations of wildlife have been described broadly as the "extinction vortex" (Gilpin and Soulé 1986).

The Whooping Crane is the only crane that has lost significant levels of genetic variability on a species level. Consequences of a genetic bottleneck in Whooping Cranes are largely unknown. It is believed that the population has recovered from a low of 15–16 birds in 1941 with an estimated six to eight founders and one maternal haplotype. Haplotype diversity of mitochondrial DNA was also reduced by two thirds following the bottleneck (Snowback and Krajewski 1995, Glenn et al. 1999), and concerns of inbreeding depression and declining productivity have been raised. Two nonessential, experimental reintroduced population programs are actively underway in the US, supported by considerable monitoring, management, and research efforts to provide information for adaptive management decisions. These populations provide assurance for species survival in the event of a catastrophic event within the Aransas-Wood Buffalo population but are not currently sustainable due to high nest failure. A cooperatively managed captive population held at five breeding centers and seven display facilities provides a source for genetic material, eggs, and chicks for reintroduction programs as well as the capacity to head-start wild-laid eggs for later release. Ongoing research to maintain genetic diversity, detect and minimize disease outbreaks, and test new release techniques provides the scientific platform for the reintroduction programs. A recent population viability analysis (PVA) for the whooping crane metapopulations suggests that the Aransas Wood Buffalo population is robust but may be vulnerable to future climate change impacts and increased human-caused threats. The

A costumed worker walks Whooping Crane chicks through a wetland. The chicks raised in captivity are later released into the wild as part of the reintroduction programs in Wisconsin and Louisiana, USA (Photographer: Tom Lynn, International Crane Foundation)

two reintroduced populations provide a safety net through redundancy but will require good survival, improved reproductive rates, and additional releases for the next decade or so in order to develop into viable populations (Traylor-Holzer 2018).

Other crane species have small populations that may have limited gene flow with other populations, reduced genetic variability, and potentially skewed age distributions or sex ratios, which can each affect viability.

On a species level, the Siberian Crane has good genetic diversity (Ponomarevetal 2004). However, the Western/Central population is estimated to be down a remnant population of perhaps 10–20 birds in the wild, of which some are likely to be captive-released birds (Wetlands International 2014). This population is no longer genetically or demographically viable and is at risk of extinction in the near future. A 'Flight of Hope' reintroduction program has been attempted to bolster this remnant population with low survival and no confirmed reproduction of released birds (Shilina et al. 2011; see also Siberian Crane species review).

It is possible that the island population of the Red-crowned Crane on Hokkaido was founded by a small number of birds. Comparative studies between the continental and island populations based on morphology and DNA studies are underway (Kunikazi Momose, personal comm. 2016).

Two isolated populations of the Sandhill Crane have reduced genetic variation (see Sandhill Crane species review). The Mississippi Sandhill is a federally endangered subspecies and sub-population of the Greater Sandhill Crane that went through a bottleneck, resulting in reduced fitness and long-term investment to release captive birds to augment populations and bolster

Reduced genetic diversity may contribute to low recruitment in Mississippi Sandhill Cranes (Photographer: Scott Hereford, U.S. Fish and Wildlife Service) genetics (Seal and Hereford 1992, Henkel et al. 2011). The Cuban population has persisted at low numbers.

Two populations of the Eurasian Crane (Transcaucasia Eurasian Crane and Tibetan Eurasian Crane) show distinct morphological characteristics and have been proposed as subspecies and recommended for further research and conservation action (Haase and Ilyashenko 2012; see Eurasian Crane species review). However, analyses indicate high genetic variability across the species' range and little genetic differentiation between the western and eastern *G. grus* subspecies (Haase and Ilyashenko 2012, Mudrik et al. 2015). Despite the low level of differentiation, it remains important to consider subspecies and local populations of the Eurasian crane as separate conservation units.

Two isolated sub-populations of Wattled Crane occur in South Africa and Ethiopia. Although no subspecies of Wattled Crane are recognized, evidence suggests that the South African sub-population could be genetically distinct from those further north (Jones et al. 2006). Despite the current lack of evidence, it is also possible that the Ethiopian sub-population is genetically distinct due to its isolated nature (Burke 1996). As a result, both the South African and Ethiopian sub-populations have been recommended to be managed as distinct and separate sub-populations from the larger south-central African sub-population.

Two release programs have been conducted to reestablish local populations of cranes. From 2010–2014, the Great Crane Project conducted by the Wildfowl and Wetland Trust focused on the reintroduction of Eurasian Cranes to the United Kingdom. As of 2018, the population was reported at 180 resident birds with over 50 pairs breeding annually, half from the reintroduction project (http://www.thegreatcraneproject.org.uk/project, see also Eurasian Crane species review). A population of Sarus Cranes that disappeared from Thailand is being returned to part of its historic range by the Korat Zoo (https://www.savingcranes.org/travels-with-george-returning-sarus-cranes-to-thailand/; see also Sarus Crane species assessment). A release of captive-reared cranes began in eastern Thailand in 2011. As of 2017, 70 birds had been released and about 50 had survived. In 2017, nine juveniles were fledged from 11 pairs.

SPECIES AND KEY LOCATIONS CURRENTLY MOST AT RISK

- Whooping Cranes throughout its range;

Small or isolated populations at risk from genetic and demographic factors:

- Siberian Cranes – Western/Central population;
- Red-crowned Crane – Island (Hokkaido) population;
- Sandhill Cranes – Mississippi and Cuban populations;
- Eurasian Crane – Transcaucasia and Tibetan populations; and
- Wattled – South African and Ethiopian populations.

KEY RESEARCH AND MONITORING NEEDS

- Monitor captive and wild populations of Whooping Cranes for reduced reproductive success and decreased resistance to disease;
- Monitor wild Whooping Crane populations for climate change impacts and human-related mortalities;

- Promote improved fledging rate and juvenile survival in reintroduced Whooping Crane populations, and monitor reproductive success of subsequent wild-hatched birds;

- Research related to rarer Sandhill Crane taxa should focus on:

  o Continued studies of the factors behind poor reproduction and recruitment rates in the Mississippi Sandhill Crane population;

  o Clarification of the intraspecific genetic structure and phylogenetic relationships among the Cuban, Florida, and Mississippi Sandhill Cranes;

  o Expand research for Mississippi Sandhill Cranes on: micro-habitat use, chick food availability, alternative detection methods of egg/chick location, ways of increasing nest/chick defense behavior (including potential translocation of individuals with that behavior), possible causes of low survival rates in the population, including loss of genetic viability; and

- Conduct research to determine if Transcaucasia and Tibetan populations of Eurasian Cranes are monophyletic and qualify as evolutionarily significant units; and

- Management of the captive flock of South African Wattled Cranes as a reservoir for future supplementation in the event of a catastrophic decline in the wild population.

HIGHEST PRIORITY CONSERVATION ACTIONS

- Maintain captive breeding and reintroduction projects for Whooping Cranes that ensure genetic diversity and the improvement of release methods and reintroduction techniques that ensure high success;

- Maintain reintroduction projects for Whooping Cranes while first giving priority to addressing need for genetic diversity in the captive flock; and then ensuring diversity in the released populations; and

- Minimize or mitigate future increases in mortality of both wild and reintroduced cranes, such as those that may result from human-related activities, development and climate change;

- Promote higher reproductive success in reintroduced populations.

- Management of small populations of other species at risk from genetic and demographic problems should be assessed and actions implemented on a national or regional level.

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INDIRECT THREATS

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Our efforts to address direct (proximate) threats to cranes and their habits must occur in the context of significant indirect (ultimate) threats, such as poverty; poor reproductive health and health services, including family planning; lack of livelihood alternatives; lack of effective legislation, administration, and enforcement; and others. Often the ultimate threats exacerbate the impact of proximate threats, with dynamic interactions among them. We also must address multiple threats that are symptoms of larger societal challenges, such as climate change and expanding human populations. Many ultimate threats are regional or global in scale and beyond the capacity of the crane conservation network in itself to solve. Our work therefore must be part of larger efforts by the global community. Cranes, with their cultural significance, high visibility, extraordinary beauty, dramatic migrations, and striking behavior, can inspire significant contributions toward larger-scale solutions. Actions taken by Crane Specialist Group members have demonstrated positive impacts in addressing some of these ultimate threats, from improving reproductive health and health services and poverty alleviation to climate change adaptation. For example, the Cao Hai Community-based Conservation and Development Project in China engaged local communities to improve rural livelihoods while also enhancing wetland habitats for cranes and other waterbirds (Li 2018). Another example is the ICF/EWT Partnership's project in southwestern Uganda that integrates conservation with livelihood development, improvements in human health services, and access to reproductive health services, including family planning. By improving the resiliency of local communities in a changing climate and socio-economic scenario, cranes and wetlands will be considered more strongly for conservation. Continuing or additional opportunities to address indirect threats are outlined in the Objectives and Actions section.

At the heart of all the threats to cranes, both direct and indirect, is the rapid global increase in human populations and densities over the last century. The human population has grown from 2.5 billion in 1950 to 7.6 billion in 2015 and is expected to grow to 9.7 billion people by 2050 (United Nations, Department of Economic and Social Affairs, Population Division 2017). Poor rural communities in developing nations face the greatest barriers to use of and access to reproductive health services, including family planning. These barriers prevent women from choosing freely when and whether to have children, threaten family health, create challenges for girls who want to complete their education, and lead to higher levels of fertility and more rapid rates of population growth. While human populations have declined somewhat in Europe and parts of North America, over the last 80 years, they have increased markedly in sub-Saharan Africa and South/Southeast/East Asia—regions important to six of the 11 most threatened crane species. The impact of population growth is most apparent in sub-Saharan Africa and South/Southeast Asia, and most acute for five species: the Africa crane residents and the Sarus and Black-necked Cranes.

Cranes and people are closely linked through agriculture (Austin et al. 2018). The primary habitats of cranes, grasslands and wetlands, are also the most valuable—and most vulnerable to conversion—for agriculture. This is also apparent in the overlap of crane populations with the regions of the globe that best support crops and people, primarily temperate and tropical grasslands, savannas, and shrublands (Ilyashenko 2018). To support more people, food production will need to increase, through expansion of agriculture into new areas and intensification of agricultural practices, such as irrigation, fertilizers, pesticides, and mechanization. Food production to meet human needs is projected to increase by roughly 70% by 2050 and double or triple by 2100 (FAO 2009), with trends of greater increase in agricultural expansion in tropical regions (Foley et al. 2011). These pressures lead to further habitat loss, fragmentation, and altered ecosystems, as well as increased pressure on freshwater (FAO 2011). Concomitant with the growing human population are increased demands for economic growth and development, especially in rapidly developing regions of East Asia (home to four threatened crane species) and North America (home to Endangered Whooping Cranes). At the simplest level, people may seek economic growth and opportunities by converting more area to crops, shifting from subsistence agriculture to cash crops, or harvesting vegetation or wild foods beyond what the ecosystem can support. Greater economic growth also is sought by extracting greater value from the land through more intensiveagriculture practices, including larger grazing herds, greater use of agrichemicals, growing multiple crops annually, and developing irrigation systems, particularly in dry regions. In many areas reliant on subsistence and small-scale agriculture, as human populations have increased, the size of land worked by individual farmers has declined, and their intensified demands on their limited land have contributed to declining soil fertility. Many of the changes to the landscape under intensive subsistence agriculture has been so rapid that resiliency in a changing world has not been built into practices (Kerryn Morrison, personal comm. 2018). Programs and policies that build sustainable approaches to land use and diversification of livelihoods can help build resiliency of local communities to rapidly changing socio-economic and environment factors while also addressing ecosystem services and biodiversity (e.g., Pretty et al. 2011).

Agricultural activities—including irrigation, livestock, and aquaculture—currently accounts for 69% of annual water withdrawals globally (http://www.unwater.org/water-facts/water-food-and-energy). Such water usage is expected to increase unless better water conservation practices are implemented. Habitats important to cranes are converted for urbanization, industry, mining, and other intensive uses, which often leads to degraded and polluted landscapes. Greater economic demands are the driving force for the development of dams for energy generation, flood control, and irrigation. The development of dams, diversions for irrigation, and other hydrological impacts to riparian and wetland habitats are of critical concern for Sarus, Siberian, Wattled, and Whooping Cranes. Economic and development pressures leading to the conversion of grasslands and wetlands for mining extraction are significant concerns for Blue, Grey-Crowned, Hooded, Red-Crowned, Wattled, and White-naped Cranes. Implementation of sustainable development practices can help lessen or mitigate these externalized costs to cranes and the environment while also recognizing the value of ecosystem services and biodiversity. For example, integrated river basin development is an accepted tool for reconciling the competing demands of society and ecosystem health (Hooper 2005) and has been implemented in the Zambezi River system (Beilfuss et al. 2010).

These two indirect threats—increasing human population and increasing demand for economic growth and development—are the greatest ultimate threats to the 11 most endangered species of cranes. Ability of conservationists to address these two threats to crane populations is challenged by six often inter-related threats. How cranes are affected, and possible actions to address them, vary mainly by species and region and are strongly influenced by socio-economic and political factors (Ilyashenko 2018, Ilyashenko and King 2018).

- Lack of knowledge/ awareness/public support: A critical component to conserving a species and their habitat is knowledge of their ecology and populations — range, size, and demographics. Understanding the habitat needs, feeding ecology, and behaviors of a population is important for comprehending the nexus between the species and people on the landscape, and for developing appropriate conservation actions and partnerships. Whether at a local community, regional, or national government level, lack of knowledge leads to poor land use, development choices, or policies, potentially leading to conflicts with cranes. Monitoring and research are key to building and sharing such knowledge and awareness. Built upon sound information, greater awareness can in turn garner greater governmental and public support for needed conservation actions or land use decisions. Examples include better information about the impact of water allocation in Zhalong, or banning hunting of Siberian Cranes and other waterbirds in China. The lack of knowledge of a species' ecology and populations, and limited awareness and public support for cranes, is of significant concern for Black Crowned, Blue, Grey Crowned, Red-crowned, Siberian, Wattled, and White-naped Cranes, and in some areas even for Whooping Cranes.

- Lack of local conservation leadership for cranes and wetlands: Local leadership for the conservation of wetlands and cranes is critical for the development, acceptance, and implementation of effective protection of cranes and their habitats. This is a common obstacle to stewardship of local crane and habitat resources for 12 of the 15 crane species. Examples of the value of developing local conservation leadership are the Cao Hi Project (Barzen 2018, Li 2018) and Muraviovka Park (Smirenski et al. 2018). Lack of local conservation leadership is a critical concern for Black Crowned Cranes and significant for Grey Crowned, Red-crowned, Sarus, Siberian, Wattled, and White-naped Cranes. It is not a concern for Eurasian, Sandhill, or Whooping Cranes, as they occur in regions having a long history and strong conservation organizations at local, regional, and national levels.

- Warfare and political instability: Without stable governance, the institutions critical to the development and enforcement of laws protecting habitats and cranes are weak or absent, and ability to carry out conservation measure are greatly limited. Habitat can be degraded by over-exploitation or inappropriate uses; cranes may be poached, taken for trade, or experience greater disturbance from indiscriminate human activities. Black-crowned Cranes are critically threatened through indiscriminate shootings, hunting, and inability to implement conservation measures in the unstable regions of West and Central Africa. Red-crowned, White-naped, and Hooded Cranes face long-term uncertainties of the security of their Korean wintering sites along the Korean Demilitarized Zone and the adjacent Civilian Control Zone. Only Blue, Brolga, Sandhill, and Whooping Cranes are unaffected by warfare and political instability.

- Poverty and lack of livelihood alternatives: Areas with greater poverty and few livelihood alternatives beyond agriculture, together with poor agriculture practices, can result in over-exploitation of wetland and grassland resources (e.g., overgrazing) or poaching for food or trade. Farmers may also be less tolerant of crop damage to cranes as it directly affects their limited resources and food production, leading to destruction of nests or killing birds. Crowned Cranes and Wattled Cranes in Africa and Sarus Cranes in Asia are critically threatened by this issue.

- Lack of reproductive health services and family planning: Family planning contributes to women's empowerment, improves family and general health, advances education and life opportunities and, by slowing population growth, eases pressures on wildlife and ecosystems. Sustaining functional, biodiverse environments becomes less plausible in some areas if population growth follows average UN projections.

- Lack of effective legislation, administration, and enforcement: Without effective governance, efforts to protect cranes from illegal hunting, trade, or disturbance, and protecting critical habitats are often inadequate or ineffective. This is a significant threat to Black and Gray Crowned, Red-crowned, Siberian, and White-naped Cranes because of less effective governance in key countries in the cranes' ranges.
- Loss of traditional values and ties to land: In many regions, cranes hold special spiritual and cultural significance to the local communities, which helped protect cranes from hunting, disturbance, or destruction of nests (Didrickson 2010). For example, killing a crane for food is taboo in many Ethiopian cultures (Ayanlem et al. 2018). As people become more urban or seek greater economic opportunities, whether through greater intensity of land use or moving to different areas, those traditional values and ties to the natural landscape are being weakened or lost. People are also more likely to use unsustainable land-use practices. This threat is of significant concern for Black Crowned, Grey Crowned, Red-crowned, and Sarus Cranes, and is interconnected with many of the threats noted above.

Changing climate is an overlying, ultimate threat that intertwines with all threats. The effects of climate change on both ultimate and proximate factors vary substantially among regions in response to a multitude of biophysical and socio-economic factors (FAO 2011, Harris 2012, Tubbs 2012b). Overall, climate change is expected to negatively affect farming systems, particularly in semi-arid and semi-tropical areas, requiring new ways to sustain agriculture and the livelihoods of rural communities and to conserve cranes in the face of increasing competition for resources. The vulnerability of freshwater systems to these forces is of particular concern for cranes, as wetlands are critical in the life cycle of all cranes. For example, in far-eastern Russia and China, increasing water extraction from the Amur Basin to meet the demands of the growing population, and irrigation amplified the impacts of a prolonged drought in the 2000s–2010s on the riparian wetlands (Harris et al. 2012). This large basin holds the greatest diversity of cranes on the globe—six species, including four threatened species. The prolonged drought, fires, livestock overgrazing, and wetland drainage negatively affected the wetland and grassland habitats critical to cranes and may recur more often with climate change. Along coastlines, rising sea levels will greatly alter estuarine wetlands, such as those critical to wintering Whooping Cranes. Integrating climate change adaptation into the solutions developed to meet proximate threats will be critical to enable sustainable solutions into the future. Adaptation to climate change involves increasing the resiliency of both natural ecosystems and local communities, which also depend on wetlands and reliable water for their livelihoods (Tubbs 2012a). Greater resilience enables ecosystems and communities to function and adapt to changing water conditions.

Many of the challenges facing conservation efforts for cranes are shared with other conservation efforts, particularly for other wetland- and grassland-dependent species. Hence, there are opportunities for learning and partnering across taxa and organizations. Targeted opportunities to address these indirect threats are outlined in the Objectives and Actions and indicate opportunities for broader collaboration, such as described in FAO (2009, 2011) and Unisa et al. (2016). Among the lessons learned since the 1996 crane conservation plan is the importance of integrating people into our conservation planning and action when working outside protected areas—to find a balance between cranes and people that share the land and water. Examples include the Cao Hai Community-based Conservation and Development Project in China (Li 2018), Muraviovka Park along the Amur River in Russia (Smirenski et al. 2018), development of new tools to prevent crop depredation in the United States (Barzen and Ballinger 2018), and the Biodiversity Stewardship Programme in South Africa (Franke and Theron 2018).

Finally, it is important to note the important emerging focus on ultimate threats through the Population-Health-Environment-Sustainable Livelihoods framework (e.g., by Unisa et al. 2016). There is a renewed focus on the importance of addressing the stressors of expanding human populations and associated food demands with biodiversity, ecosystems, and wild populations (Ehrlich and Pringle 2008, FAO 2011, Rohde 2013, Crist et al. 2017). Crane conservation efforts are increasingly at the center of the global Sustainable Development Goals that are mainstreaming land and water conservation in government policy at the same level as human health, education, and welfare. Incorporating community populations and health into our conservation actions form the cornerstone of resilient communities. The 2030 Agenda for Sustainable Development includes the 17 Sustainable Development Goals and 169 targets. By aligning crane conservation programs and projects with these globally recognized goals—framing our work around global imperatives such as poverty reduction, social upliftment, and gender equity, as well as biodiversity conservation, water conservation, and climate change adaptation and mitigation—we increase the credibility and relevance of crane conservation wherever we work.

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ANNEX 2.
SPECIES REVIEWS

SPECIES REVIEW:

SIBERIAN CRANE (*Leucogeranus leucogeranus*)

Claire M. Mirande[1] and Elena I. Ilyashenko[2]

(with inputs from George W. Archibald, Nikolai Germogenov, James T. Harris, Borja Heredia, Eugenia Lanovenko, Tatiana Kashentseva, Tilman Schneider, Anastasia Shilina, Alexander Sorokin, and Maria Vladimirtseva)

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Siberian Cranes foraging at Momoge National Nature Reserve after water releases raised water levels (Photographer: Zheng Zhongjie, International Crane Foundation Contributing Photographer)

Red List Category: Critically Endangered
Population Size: 3,600–4,000
Population Trend: Overall probably stable
Distribution: Siberia to China, India, and Caspian Sea

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DISTRIBUTION AND STATUS OF KEY SITES

Subspecies/Populations

The Siberian Crane is a monotypic species with two isolated populations. The East Asian population spends the winter in China on Poyang Lake in the Lower Yangtze River Basin and breeds in the northeast Siberian tundra between the Yana and Kolyma Rivers. The Western/Central Asian population is divided into a Western Asian flock and a Central Asian flock. The former winters near the Caspian Sea shores of the Islamic Republic of Iran and nests in the central part of Western Siberia, but only a single individual remains. The Central Asian flock, at least formerly, wintered in northern India and bred in Western Siberia near the low reaches of the Ob River (Meine and Archibald 1996).

East Asian Population

The East Asian flyway stretches for nearly 6,000 km. The migration corridor of the population, including areas of flight concentrations and stopover sites, has been documented by the use of satellite transmitters and ground surveys (Kanai et al. 2002, Markin et al. 2005). The main breeding locations provide the basis for site protection and monitoring of the population (Germogenov et al. 2013). Core breeding sites have been well protected by the Yakutian government, and long-term ecological research is being conducted. Non-breeding individuals range widely and are sometimes observed during the summer near their breeding grounds and adjacent areas as well as in the Russia-Mongolia-China transboundary region (Degtyarev and Labutin 1991, Ilyashenko et al. 2010). Important stopover sites in the Aldan basin in Russia have been identified and protected in the last decade and serve as a key monitoring network to assess the status of the species (Germogenov et al. 2013).

On the southbound migration after reaching northeast China, Siberian Cranes need to rest and replenish energy reserves. In the 1980s, Siberian Cranes stopped primarily at Zhalong National Nature Reserve (NNR) in Heilongjiang Province and Momoge NNR in Jilin Province, while small flocks also used Keerqin NNR in Inner Mongolia and Xianghai NNR in Jilin as well as other sites (Li and Li 1991, Wu et al. 1991). The important migratory stopovers in northeast China have been affected by water diversions and drought. Rainfall has been highly variable, and wetlands frequently dry. Since 2004 the number of Siberian Cranes at Momoge NNR has increased up to 3,600 Siberian Cranes due to sustained and seasonally timed water releases by the local government (Germogenov et al. 2011; Jiang Hongxing, unpublished data). This site continues to be a critical stopover for migratory Siberian Cranes during both autumn and spring migrations. The number of birds at Zhalong has decreased due to reduced water supply and wetland fragmentation within the reserve (Pang et al. 2005).

Almost all individuals in the East Asian population winter at Poyang Lake in southern China, which is the largest freshwater lake in China. The lake faces severe threats including changes in hydrology, land use, climate, and economic development (Harris and Zhuang 2010). Legal protection of the cranes at Poyang Lake has been strengthened with two national-level, two provincial-level, and 15 county-level NNRs; however, protection of the fragile wetlands is facing enormous challenges.

Western/Central Asian Population

The Siberian Cranes in the Western/Central Asian population use two flyways. Both the Western and Central Asian flocks use the same migration route from their breeding grounds in Russia to Kazakhstan, where Siberian Cranes make their first long-term migration stopovers for up to 1.5–2 months, mostly in the Naurzum Lake System in the Kostanay Region of Kazakhstan (Bragin 2008). Until 2014 one or two Siberian Cranes were sighted almost every year in the Naurzum Lake System (Bragin 2008, 2011, 2014). After resting in Kazakhstan, Siberian Cranes continue their migration in one of two directions: along the Central Flyway to India and along the Western Flyway through the Volga Delta along the western coast of Caspian Sea to Iran. There are no recent records of Siberian

Cranes in Turkmenistan, Afghanistan, and Pakistan along the Central Flyway to India, whereas in Uzbekistan there have been reports of Siberian Cranes in the last decade, mostly in flocks of Eurasian Cranes (Shilina 2008, Fundukchiev and Belyalova 2008). Along the Western Flyway, a few Siberian Crane records continue to come regularly from the Volga Delta at the Astrakhan State Nature Reserve in Russia and from Kurinskaya Kosa in Gyzyl-Agach Nature Reserve in Azerbaijan (Shilina 2008; Sultanov and Kerimov 2008; Rusanov 2011, 2014; Rusanov et al. 2013; Rusanov, unpublished 2015 data). A single bird has arrived in Iran during each winter since 2006–07. The last pair was sighted in India on wintering grounds in winter 2001‑02 (Vardhan 2002). The wintering areas for the other recorded birds are unknown. From 1996 to 2016 there are records in each year of Siberian Cranes on the breeding grounds in West Siberia or in the southern part of West Siberia along the Western/Central Flyway (Shilina 2008, Ilyashenko et al. 2010, Shilina et al. 2011, Sorokin and Shilina 2013; Alexander Sorokin and Anastasia Shilina, unpublished 2016 data). The last record of one Siberian Crane was in September 2016 in Tyumen Oblast (Province) in the southern part of West Siberia (Alexander Sorokin, personal comm. 2016).

Reintroduction efforts have resulted in the release of 181 birds into this flyway since 1991 (Tatiana Kashentseva, personal comm. 2016), out of which 152 started migration (Anastasia Shilina, personal comm. 2016). A total of 39 eggs, produced at the Oka Crane Breeding Center and International Crane Foundation, were placed in Eurasian Crane nests for cross-fostering in West Siberia on the breeding grounds in the Kunovat River basin and Konda and Alymka Interfluves. There were two sightings of Eurasian Cranes with Siberian Crane chicks. In the southern Ural, two injured cranes were found during the year of their release: in 2003 one juvenile Siberian Crane in the vicinity of Ekaterinburg, and in 2004 a one-year old Siberian Crane in the Republic of Bashkiria. Both cranes were returned to Oka Crane Breeding Center. Two banded Siberian Cranes released in previous years were sighted in Russia: one bird in spring 2001 in Omutninskiy District, Tyumen Region (Shilina et al. 2011), and one bird in spring 2008 in Khanty-Mansy Autonomous Region (Shilina et al. 2011).

ECOLOGY

The Siberian Crane is the most aquatic of the crane species and is dependent on shallow wetlands and wet mud. In winter and on migration the birds primarily eat tubers of aquatic plants. Until very recently, the eastern population had rarely been seen in rice (*Oryza sativa*) paddies or other agricultural lands.

Poyang Lake offers reliable wintering habitat to over 400,000 waterbirds each winter due to the remarkable fluctuations in water levels that occur between summer and winter (Liu and Ye 2000, Qian et al. 2009, Shankman et al. 2009). For most of the year, Poyang empties into the Yangtze River, but during summer floods Yangtze waters may flow the other way, into Poyang Lake. The rainy season extends through the warm seasons, after which water levels drop dramatically in autumn, falling as much as 11 m to expose vast shallows and mud flats in winter. Wind moves shallow water across this flat basin, so that feeding areas are diverse and constantly changing and thus can support East Asia's largest concentration of wintering waterbirds.

The Siberian Cranes feed primarily on tubers of submerged aquatic plants by digging in shallow waters and wet muds, with the most favored winter food being the submerged aquatic plant, wild celery (*Vallisneria*). *Vallisneria* in turn is sensitive to summer water levels, requiring good light penetration through the volume of water during the early summer growth period. Increases in turbidity, one effect of the sand dredging now occurring on a large scale at Poyang, reduce light penetration and thus impede growth of submerged aquatic plants (de Leeuw et al. 2010). In autumn, when water levels drop, the parts of *Vallisneria* above the substrate break away, leaving behind tubers buried in mud.

The cranes thus depend on suitable water conditions in summer for the growth of *Vallisneria* and on shallow water in winter so that they can readily dig the tubers (cranes cannot dig them out of dry lakebed or deep water) (Barzen 2008).

Siberian Cranes also depend on shallow wetlands during the long-term stopovers they make in both spring and fall in northeast China (Harris 2009). This semi-arid region has highly variable rainfall influenced by long-term cycles of drought and flood, so that wetland conditions change drastically from year to year. At Momoge NNR, the primary food is two species of *Scirpus*, emergent plants that also store nutrients in tubers buried in the mud. Distribution and availability of *Scirpus* tubers are influenced by seasonal and multi-year fluctuations in water level, salinity, and plant succession (Lim et al. 2000, Li and Zhang 2013). While a wide array of wetlands has historically provided a range of habitats in any one season, continued destruction of wetlands and growing human demand for water mean there is less flexibility in choice of habitats for cranes on their long journeys.

NUMBERS AND TRENDS

The Siberian Crane is the world's third rarest crane and the most endangered. The total population is estimated at 3,600–4,000 birds, almost all in the East Asian population. The Siberian Crane disperses across vast, inaccessible wetlands so double counting (or missing some cranes) may be impossible to avoid. Accordingly, complete counts depend on days when birds are highly concentrated or when multiple counting parties can be coordinated. This population estimate is based on years of synchronized winter counts at Poyang Lake (Li et al. 2012), supplemented by years of migration counts at Momoge where in recent years almost all Siberian Cranes have congregated on one large wetland (Jiang Hongxing, unpublished data). The Western/Central Asian flocks are almost gone and now estimated at 10–20 individuals. The last known pair of the Central Asian flyway was seen in Keoladeo National Park in India in the winter of 2001–02 (Vardhan 2002); in the Western Asia flock the number of birds has decreased and only one Siberian Crane has arrived in Iran each winter from 2006–07 to 2015–16 (Sadeghi Zadegan et al. 2009, Vuosalo Tavakoli 2014; Sadegh Sadeghi Zadegan, personal comm. 2016). There are regular sightings of up to 10–20 birds on the West Siberia breeding grounds and at migration sites, suggesting the existence of unknown additional wintering grounds for the central and western flyways (Shilina 2008, Sorokin and Shilina 2013, Rusanov et al. 2013, Rusanov 2014, Wetlands International 2014).

The Western/Central Asian population is no longer genetically or demographically viable and is at risk of extinction in the near future. The East Asian population remains stable or slightly increasing. Unfortunately, virtually all the East Asian population winters at a single site, Poyang Lake.

THREATS

East Asian Population

- Plans have been advanced for many years to dam the outflow of Poyang Lake to stabilize water levels to enhance navigation and other economic activities throughout the year. If such a plan were implemented, current crane habitats might be flooded and the population would likely suffer a dramatic decline;

- Knowledge is inadequate for stopover sites from Liaoning Province to Poyang Lake as a basis for habitat protection measures, especially for alternative sites that may be significant in very dry or very wet years;

- Dams and diversions of water alter critical wetlands in China (e.g., Poyang, Momoge, and Zhalong), with impacts exacerbated by climate change and by lack of greater cooperation between governmental agencies;

- Habitats are lost and degraded in China due to conversion to agriculture, livestock grazing, and oil drilling;
- Use of water resources is unsustainable and occurs within nature reserves in China (e.g., sand dredging and aquaculture practices such as crab farming); these activities contribute to reduced wintering habitat quality. In particular, crab farming can eliminate all aquatic plants and thus destroy habitats important for cranes and other waterbirds;
- Effective management is lacking for some sites including Huanzidong and Wolong Reservoirs, important stopover sites in Liaoning Province;
- Declining water quality may result in macrophyte-dominated wetlands changing to phytoplankton-dominated systems that do not provide adequate food for cranes. This sudden change has happened at lakes in the mid-Yangtze Basin (Fox et al. 2010);
- Human disturbance prevents cranes from utilizing suitable habitat. Energetics may be altered due to disturbance during foraging, especially at Poyang and Momoge;
- Disturbance from waterfowl hunters and mammoth bone collectors, competition from Tundra Swans (*Cygnus columbianus*) and Sandhill Cranes (*Grus canadensis*), and predation by wolverines (*Gulo gulo*) may be contributing to nest failure (Germogenov et al. 2015);
- Increased use of continuous or caterpillar-tracked transportation across the tundra is leading to loss of lichens, soil erosion, and replacement of tundra lichen cover with grasses (Flint 1987, Degtyarev and Labutin 1991, Bysykatova and Krapu 2009);
- Economic development may alter staging areas in southern Yakutia including river regulation, infrastructure development, oil and gas and mining industries, and power line construction (Nikolai Germogenov, personal comm. 2016);
- A significant disease event (e.g., a highly pathogenic avian influenza virus or avian cholera) could occur, especially at sites where wild birds, such as dabbling ducks, mix freely with domestic poultry and where Siberian Cranes are concentrated (e.g., Poyang, Momoge);
- Pollution from pesticides, herbicides, and heavy metals is an emerging problem along the flyway, including ingestion of lead shot at a stopover site in Yakutia (Pshennikov et al. 2001); and
- Climate change is degrading breeding habitat through erosion of lake edges by waves and ice melt increasing the surface area of lakes, and through loss of nesting islands and isthmuses in lakes used for nesting (Germogenov et al. 2013).

Western/Central Asian Population

- Traditional hunting along the flyways, especially in Afghanistan and Pakistan, is believed to be a primary cause of decline of this population. Crane hunting was formerly widespread in these countries but was recently been made illegal in all areas. Hunting is difficult to control, however, especially in tribal areas. Following the collapse of the USSR, hunting escalated in Azerbaijan, Kazakhstan, and Uzbekistan;
- Human densities are high at wintering areas in Iran. The remaining habitats at Ezbaran and Fereydoonkenar are privately owned and dependent on the goodwill of local rice farmers and the persistence of the traditional livelihood of duck trappers who restrict hunting. The Department of the Environment has officially established a Non-Shooting Area at Fereydoonkenar (Sadeghi Zadegan 2011); and

- The breeding grounds of both the Western and Central flocks have potential for gas and oil production that can contribute to disturbance of the Siberian Crane and habitat degradation; and

- Disease is a risk as noted above, especially at wintering areas in Iran.

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

- Sixteen sites of importance to the Siberian Crane that are also significant to global biodiversity were included in the UNEP/GEF Siberian Crane Wetland Project (SCWP, 2003–2009), which aimed to protect an ecological network of these sites (http://www.scwp.info). Community and science-based management plans were developed for all project sites (Harris 2009, Mirande and Prentice 2010);

- Eleven range states developed the seventh Conservation Plan for the species (2010–2012) under the UNEP/Convention on Migratory Species (CMS) Siberian Crane Memorandum of Understanding (MOU) (see http://www.cms.int/species/ siberian_crane/sib_cnspln.htm for details). The Siberian Crane MOU was the first MOU developed under the auspices of CMS in 1993 (http://www.cms.int/en/legalinstrument/siberian-crane);

- The East Asian-Australasian Flyway Partnership oversees the East Asian Waterbird Site Network that includes major sites for the Siberian Crane;

- China's State Forestry Administration and Chinese provincial agencies manage critical wetlands, assess impacts of water management, and conduct monitoring, research and outreach, networking with local, national, and international organizations;

- Siberian Crane is listed in Red Data Book of the Russian Federation, providing the highest status of nature protection legislation for the species in Russia;

- Cranes and their key wetlands have been monitored and studied on the breeding grounds (Yana-Indigirka tundra) and migratory sites (basins of upper Indigirka and Middle Aldan) by the Institute for Biological Problems of the Cryolithozone (IBPC, Yakutian Science Center) in Russia, and the Amur/Heilong River basin (migration sites) by nature reserve staff in China;

- The Ministry of Nature Protection of Sakha Republic (Yakutia) has increased protection and management at key stopover sites in the Aldan River Basin;

- The Ministry of Nature Protection, Sakha Republic (Yakutia) strengthened protection and management of key areas of breeding and migratory stopovers, including 19 specially protected nature areas key to Siberian Crane conservation, and developed a state program of protection and monitoring of the Siberian Crane in Yakutia in 2016–2020. The status of Kytalyk Republic Resource Reserve was raised in 2014 to a Republic-level Wildlife Refuge. It is on a list to be elevated to a Republic-level Nature Park;

- The Oka Crane Breeding Center, Cracid Foundation/Weltvogelpark, International Crane Foundation (ICF), and zoos maintain a species bank with the capability of providing birds for release (Kashentseva and Belterman 2014); and

- A "Flight of Hope" project has been conducted by Russia (All-Russian Research Institute for Nature Protection, Sterkh Foundation, Administrations of Yamalo-Nenetski and Khanty-Mansiski Autonomous Regions, Oka State Nature Biosphere Reserve, and ITERA and Petroresurs Oil Companies) in collaboration with Uzbekistan (Gosbioncontrol, Institute of Zoology of Academy of Science of the Republic of Uzbekistan, Center for Breeding of Rare Animals) (Shilina et al. 2011). The project aims to develop a viable technique for reestablishing the Western/Central Asian flocks.

CHANGES SINCE 1996

The Western/Central Asian population has declined from 55 (Meine and Archibald 1996) to an estimated 20 individuals in 2008 (Shilina 2008). Data on numbers of birds at current breeding and wintering sites are scarce. Genetic and demographic viability of the Western/Central Asian population are poor due to reduced numbers. The recorded numbers of the East Asian population have risen from 2,900–3,000 to 3,600–4,000 birds. This increase may be attributed in part to concentrations of birds at key sites as other areas are lost or degraded and also to more complete counts, but the population appears stable or increasing.

Beginning with winter 2010–11, following a major flood that destroyed most *Vallisneria* across the Poyang Lake Basin, Siberian Cranes have been observed more frequently feeding in sedge meadows and rice paddies away from the mudflats and shallow waters (Barzen et al. 2011; ICF, unpublished 2011 data). On migration in southern Russia and northeast China, Siberian Cranes now sometimes join other cranes to feed in corn (maize, *Zea mays*) fields (Harris 2009, Bragin 2014; Sergei Smirenski and Hongxing Jiang, personal comm. 2016).

Croplands were rarely used in the past by this most aquatic of East Asia's cranes. The change may be the result of several factors combined: less fear of people, frequent use of croplands for foraging by other crane species in the flyway, and deteriorating natural habitats. Implications of this behavioral change for conservation may be significant – on the one hand, opening up large new areas for foraging, but on the other exposing these birds to agricultural poisons and poachers.

Coordination and communication among the range states have been strengthened through regular meetings and conservation planning under the auspices of the CMS MOU. Substantial progress was achieved under the SCWP including improved legal protection, application of sound science to management decisions, and engagement of local communities and stakeholders (Prentice at al. 2006).

There has been a significant increase in protected areas since 1996. Under SCWP, the legal protection of flyway wetlands at the project sites was strengthened for over 2.4 million ha in the four countries, including creation of new specially protected areas (SPAs), upgraded status and expanded size of the existing SPAs, and designation of buffer zones. Twelve of the 16 project sites have been officially designated as Wetlands of International Importance under the Ramsar Convention and nominations are in preparation for the remaining four sites (Mirande and Prentice 2010). A Western/Central Asian Site Network for Siberian Crane and Other Migratory Waterbirds was created under CMS, with 12 sites in six countries officially designated (Ilyashenko and Mundkur 2011, Siberian Crane Flyway Conservation Program 2016).

During 2012–2015, the International Crane Foundation collaborated with the Research Institute for Forest Ecology, Environment and Protection in China, as well as with Momoge and Tumuji NNRs, to develop Climate Change Vulnerability Assessments for each of the two nature reserves, and then the Climate Change Adaptation Plans. This project increased capacity of the reserves to sustain Siberian Cranes and other waterbirds through the fluctuating water conditions typical of semi-arid regions; this variability is expected to increase with climate change.

In 2014, the Disney Conservation Fund selected the Siberian Crane as one of ten flagship species under a ten-year Reverse the Decline initiative. The project focuses on the eastern flyway and applies the Open Standards for Conservation to intensive conservation planning and adaptive management. A strategic planning process has been undertaken, prioritizing key threats and developing strategies with result chains that link actions to key results and measurable outcomes (Conservation Measures Partnership 2013) with access provided through the International Crane Foundation.

PRIORITY RESEARCH AND CONSERVATION ACTIONS

- Strengthen conservation of major wetlands in China that serve as critical migration and wintering habitat for the East Asian population through research, management, and policy activities:
  - o Water management at Poyang needs to sustain wetland productivity and ensure that extensive mudflats and shallow water areas are available throughout the winter;
  - o Manage the most important wetland habitats in the 27 sublakes in the Poyang Lake and Nanjishan NNRs (also located at Poyang Lake) to integrate waterbird conservation with fisheries management and use as a model for management across the entire lake basin;
  - o Strengthen integrated water management at migratory stopover sites in Northeast China, guided by on-going monitoring of the condition of these wetlands, to support wetland ecosystems that provide growing conditions for abundant crane food resources and access to that food during Siberian Crane migration;
  - o Maintain or improve water quality at key stopover and migration sites to avoid detrimental ecosystem change or direct effects on crane survival;
  - o Continue long-term research on the effects of changes in water levels on aquatic plants and water birds at Poyang and sites in Northeast China; and
  - o Protect and manage additional stopover sites, especially from Liaoning to Jiangxi Provinces, based on further investigation of migratory habitats.
- Use telemetry and color banding to identify locations of unknown and important habitat (stopover, summering, and breeding), movements, and habitat use by Siberian Cranes during all stages of the annual cycle, and assess threats and conservation opportunities;
- Through community awareness activities, build capacity and inspire conservation leaders and boost community pride in having wetlands that support Siberian Cranes, leading to changed attitudes and deepened community involvement in protection of their wetlands and wildlife;
- Develop a model visitor management program at Poyang Lake to change behavior of bird watchers, tourists, and especially photographers that approach birds too closely, interrupting their feeding or forcing them to find other habitats;
- Upgrade protection of Sakha Republic-level Kytalyk Wildlife Refuge to a Sakha Republic-level Nature Park;
- Strengthen legal protection of nesting sites in the Yana River Delta at the Yana Mammoths Wildlife Refuge, including changing zoning so that crane nesting sites are more strictly protected (Bysykatova and Krapu 2009, Bysykatova 2012);
- Investigate potential impacts of climate change on breeding grounds in Yakutia;
- Identify, legally protect, and manage key staging areas in Yakutia, accompanied by mitigation of development impacts along the flyway;
- Provide technical assistance on wildlife health monitoring and management practices at staging and wintering areas;

- Continue and improve monitoring of Western/Central Asian population during annual cycle (breeding and non-breeding territories, migration stopover sites, and wintering areas);
- Continue and improve work by Russian specialists on captive breeding and reintroduction to the wild Western/Central Asian population using new data, technologies, and achievements;
- Incorporate management of *Western/Central Asian Site Network for Siberian Cranes and other Migratory Waterbirds* under the broader Central Asia Flyway management for migratory birds under CMS (http://www.cms.int/en/legalinstrument/central-asian-flyway);
- Foster relationships with hunters to improve awareness and promote sustainable hunting of waterbirds and to engage hunters in protecting and reporting sightings of Siberian Cranes, especially in Western and Central Asia; and
- Cooperate with gas and oil companies in Russia and China to minimize disturbance of the Siberian Crane and habitat degradation.

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SPECIES REVIEW:

WHOOPING CRANE (*Grus americana*)

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(with input from George W. Archibald, Jane E. Austin, John French, Tim Grunewald, Wade Harrell, James T. Harris, Barry K. Hartup, Sammy King, Anne Lacy, Claire M. Mirande, Glenn Olsen, Richard Urbanek, and Sara Zimorski)

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Whooping tending nest and eggs (Photographer: Ted Thousand, International Crane Foundation)

Red List Category: Endangered
Population Size: 689
Population Trend: Increasing
Distribution: North America

Mirande CM, Harris JT, editors. 2019. Crane Conservation Strategy. Baraboo, Wisconsin, USA: International Crane Foundation.

DISTRIBUTION AND STATUS OF KEY SITES

Subspecies/Populations

Four populations of Whooping Cranes currently exist in the wild. The Aransas-Wood Buffalo (AWB) population is the only self-sustaining remnant of the original migratory population. This population breeds mainly in Wood Buffalo National Park (WBNP) along the Sass and Klewi Rivers, Canada, and winters in and adjacent to the Aransas National Wildlife Refuge (NWR), central Texas coast, USA. Pursuant to the goals of the International Whooping Crane Recovery Plan (Canadian Wildlife Service and U.S. Fish and Wildlife Service 2005), three additional distinct populations have been introduced within the United States (French et al. 2018). (1) Florida (FL) population: An attempt was initiated in 1993 to establish a non-migratory population at and surrounding Kissimmee Prairie in central Florida, USA. This reintroduction effort was terminated in 2008, and about 14 individuals were still within the area as of August 2016. (2) Eastern Migratory (EM) population: An effort was initiated in 2001 to create an eastern migratory population that is intended to breed in central Wisconsin and winter between the central Gulf Coast of Florida and southeastern United States. This reintroduction effort is ongoing and 103 adults were present as of April 2018. (3) Louisiana (LA) population: An attempt to establish a non-migratory population in southwestern Louisiana was initiated in 2011. Sixty-seven individuals were present as of April 2018 and reintroductions are ongoing. The FL, EM, and LA populations are considered "experimental" and "nonessential" to the Whooping Crane population as designated by the Endangered Species Act of 1973. "Experimental" is a designation given reintroduced populations established outside a species' current range, but within its historic range. "Nonessential" is a determination that a given reintroduced population is not essential to the continued existence of a species. The purpose of the designation is to reduce regulatory restrictions on reintroductions considered nonessential. A fifth population, the Rocky Mountain (RM) population, the first experiment to reintroduce Whooping Cranes to their historic range initiated in 1975, has died off. A total of 160 Whooping Cranes are maintained in 12 facilities in the U.S. and Canada through March 2017 (French et al. 2018).

Aransas-Wood Buffalo Population

The AWB population is the remnant of the migratory population (Allen 1952). It is recovering from a low of 15–16 birds in 1941, increased to 283 in the 2010–11 winter census, and in the winter of 2017–18 had an estimated 505 birds (95% CI = 439.2–576.6; CV = 0.069), which was a record high for this population (Butler and Harrell 2018). The population breeds and winters in very restricted areas and migrates 4,000 km through a narrow, 270-km wide corridor. Critical habitat areas in the migratory corridor in the United States was identified in 1978 in the breeding primary migratory corridor includes the Platte River Area and Quivira NWR in Kansas; Salt Plains NWR, Oklahoma; and the wintering area within surrounding Aransas NWR, Texas (Federal Register 43 FR 20938-942; U.S. Fish and Wildlife Service 1994). In Canada, critical habitat for the species is within Wood Buffalo National Park (Parks Canada 2008).

Breeding habitat in Canada is not believed to be a limiting factor for continued growth of the AWB population, as suitable habitat quantity within WBNP appears sufficient to support 250 nesting pairs (Olson and Olson Planning and Design Consultant, Inc. 2003, Tischendorf 2003 in Environment Canada 2007). However, protection may not be afforded outside the park, where new territories have become established.

The migration corridor encompasses a long, narrow portion of the central region of North America (Pearse et al. 2015). Earlier assessments identified most mortality as occurring during the seven weeks spent migrating to and from breeding and wintering grounds (Lewis et al. 1992, Canadian Wildlife Service and U. S. Fish and Wildlife Service 2005, Stehn and Haralson-Strobel 2014). However, results from birds marked with satellite telemetry transmitters, providing evidence less biased by season, indicate more mortality occurs in winter (~45%) and summer (~40%) than during migration (~15%) (Pearse et al. 2018). Habitat availability along the migration corridor does not appear to be limiting recovery. However, the potential for power line collisions if the lines are sited where Whooping Cranes are on the ground during migration is a serious concern (Stehn and Haralson-Strobel 2014). The potential avoidance of areas caused by energy development infrastructure needs to be closely monitored.

Human impacts resulting from increasing urbanization on the wintering grounds may limit the recovery potential for Whooping Cranes. These impacts include impaired freshwater inflows affecting bay salinities, an increase of pollution and environmental contaminants, and habitat loss (Smith et al. 2018). As the AWB population has continued to increase in numbers, cranes have moved out from the protection of the Aransas NWR into private lands and public waters. Conversion of this habitat from coastal marshes, freshwater marshes, and shallow seagrass beds to urban and industrial development will limit the ability of the landscape to support birds at recovery levels (Stehn and Prieto 2010, Smith et al. 2018).

The U.S. Fish and Wildlife Service discontinued the census method used the previous 29 years and initiated a standardized survey process in autumn 2011 based on distance sampling, which allowed for measurement of the precision of abundance estimates and improved repeatability (Butler et al. 2014b, Strobel and Butler 2014).

Florida Non-migratory Population

There were records of Whooping Cranes in Florida until the 1930s. An effort to reintroduce a sedentary population was initiated there in 1993. The Florida peninsula provided extensive areas of suitable crane habitat that supported a stable population of 4,000–6,000 Florida Sandhill Cranes (Nesbitt 1996). Florida offered a unique opportunity to establish a non-migratory population of Whooping Cranes similar to the non-migratory population that occurred in Louisiana until the late 1940s (Gomez 1992). Feasibility studies of establishing a population of Whooping Cranes in Florida began in 1980 (Nesbitt and Carpenter 1993) and the first experimental release occurred in 1993. Between 1993 and 2006, 289 Whooping Crane were released (Folk et al. 2010) within Lake, Osceola, and Polk counties in central Florida. Juveniles were raised in captivity using costume- and parent-reared techniques and were soft-released (held in pens for several weeks before being released in the wild) into lowland habitats used for cattle grazing (Folk et al. 2005). Although cattle encroachment into crane areas was an issue during drought periods, grazing was an efficient management tool to reduce shrub encroachment (Folk et al. 2010). In early years, cranes were more susceptible to predation, primarily bobcat (*Lynx rufus*) and to a much lesser degree alligator (*Alligator mississippiensis*), as they were selecting roosting areas on dry ground (Nesbitt et al. 1997, Folk et al. 2014). The inclusion of shallow water in pens for nocturnal roosting improved post-release survival rates (Gee et al. 2001). After the discovery of metal fragments in the digestive tracts of over 50% of cranes that died (Spalding et al. 1997), materials used in original pen construction were also modified and levels of metal ingestion were reduced (Nesbitt et al. 2001).

From 1995–2005, 47 nesting attempts by the FL population resulted in four fledged chicks. Environmental conditions or disease have been suggested as factors in low fertility and hatching rates (Spalding et al. 2009). Drought conditions may be responsible for the dispersal of individual Whooping Cranes from the release site (including some outside of Florida), which increased potential for predation and power line strikes, and decreased potential for pair formation in maturing birds (Folk et al. 2010). A severe drought in Florida, which coincided with the maturation of the introduced cranes, reduced water levels in wetlands and likely had a strong influence on nesting attempts and success (Folk et al. 2005, Spalding et al. 2009). Some of the Whooping Cranes associated with Sandhill Cranes. Although an evaluation did not disclose the factors that contributed to this association, they may have included gender, rearing method, release site or year, small population size, or low availability of Whooping Cranes as mates (Folk et al. 2010). Poor productivity within this experimental population was related to adult mortality (especially older males), a high proportion of delayed and non-productive birds, and poor hatching in some years (Spalding et al. 2009). The FL population also experienced health issues. Some of the released birds were confirmed to have Infectious Bursal Disease, which is not generally found in wild populations (Candelora et al. 2008).

In 2008, the International Whooping Crane Recovery Team reviewed ongoing population modeling results for the FL population that identified a lack of productivity through fledging (Moore et al. 2012) and a possible lack of genetic diversity (Converse et al. 2013) as contributing to low population viability. They recommended that additional releases of captive-reared birds be terminated. The population, as of March 2016, totaled approximately 14 birds. That year at least five wild-hatched chicks from this population were still alive and a pair of chicks fledged from a nest (Harrell and Bidwell 2016). Much essential information has been gained throughout this attempt to establish this experimental population. Research and monitoring continue that will contribute further insights for the other Whooping Crane introduction programs (Folk et al. 2010). An Environmental Assessment was completed in April 2018 by the U.S. Fish and Wildlife Service, enabling the translocation of the remaining Whooping Cranes to Louisiana over the next several years (David Oster, personal comm. 2018).

Eastern Migratory Population

Whooping Cranes historically nested in the interior portions of the upper Midwest USA (Allen 1952, Austin et al. 2018). Their numbers declined as a result of wetland drainage, the conversion of prairie into farmland, and shooting. There are also several anecdotal accounts of the presence of the birds documented in the autumn and winter along the southeastern Atlantic Coast (Allen 1952). The EM population program began in 2001 and continues to present, with a total of 268 juveniles released on the breeding grounds through 2016 (Whooping Crane Eastern Partnership 2016). In the beginning of the program, the primary method of reintroduction focused on releasing costume/isolation-reared juveniles at Necedah NWR, in central Wisconsin, USA. The juveniles received on-site flight training to follow ultralight (UL) aircraft in preparation for learning the migration route (Lishman et al. 1997). The autumn migration route (2,010 km) was a relatively direct path from Wisconsin to the intended wintering site on Chassahowitzka NWR on the central Gulf coast of Florida (Urbanek et al. 2010a). An evaluation of how social learning and innate abilities affect migration was conducted using migration data from 2001–2009. Results indicated the importance of having older, experienced birds for younger sub-adults to follow back along the EM population migration corridor (Mueller et al. 2013). More recent evaluations to address why more birds are not completing the original migration further indicated that older individuals elected to winter further north along the autumn migration path, using sites closer to the breeding range (Teitelbaum et al. 2016, Mueller et al. 2018).

In 2005, the UL flock began stopping at Halpata Tastanaki Preserve, Marion County, Florida, that is located 42 km north of Chassahowitzka NWR. This delay allowed older birds that had already arrived at Chassahowitzka NWR time to disperse to inland sites primarily throughout west central Florida and reduced potential conflicts with arriving juveniles. In 2005, an alternative rearing and release method (Direct Autumn Release – DAR) was introduced, where costume-reared juveniles were released in the autumn at Necedah NWR near adult Whooping Cranes. Association with older EM population birds in Wisconsin prior to migration was intended to provide the opportunity for the older UL birds to guide the DAR birds' first autumn migration (Urbanek et al. 2010a). In an attempt to improve hatching success, the reintroduction location was changed in 2011 to locations further east, at Horicon Marsh NWR and the White River Marsh State Wildlife Area, where densities of black flies (Simuliidae) were lower than at Necedah NWR (see notes on black flies below). Both rearing and release techniques were used until the UL technique was discontinued in 2015 (Harrell and Bidwell 2016). For the period 2001–2010, survival to one year from the start date of the UL-guided migration was 0.76 among 156 cranes (Hartup 2018a). For 2005–2010, survival to one year from autumn release for 44 DAR cranes was 0.68. The primary causes of death were predation, trauma from power line strikes (Cole et al. 2009), and shootings, which alone accounted for 19% of all mortality where the cause of death could be determined (Condon et al. 2018).

Lessons learned from previous experimental population programs, as well as advances in understanding through the EM population program, have led to successful results with respect to migration (for both UL and DAR birds) as well as homing ability for subsequent migration cycles, exploitation of available habitats, pair formation, territory establishment, laying of fertile eggs, and initiation of incubation. However, poor reproductive success due to abandonment of nests during incubation and poor chick survival has been the limiting factor thus far in the EM population (Urbanek et al. 2010a, Converse et al. 2012, Converse et al. 2018). From 2005 through 2008, all first nesting attempts failed. In 2006, two chicks hatched from one nest and one of these chicks fledged. Targeted research provided support for the hypothesis that the timing of emergence of blood-feeding black flies in each year contributed to nest abandonment and failure (Urbanek et al. 2010b, Converse et al. 2013, Barzen et al. 2018). Other hypotheses of factors contributing to poor productivity include environmental conditions (low food availability in wetlands) and bird-specific factors (effects of rearing method on subsequent reproduction or genetic structure) (Barzen et al. 2018, Converse et al. 2018). Challenges to reproductive success persist; through 2016, 86 chicks were produced in 178 nesting pair-years, a 46% nest success rate, but few chicks have survived to fledging (Whooping Crane Eastern Partnership 2017).

Beginning in 2011, DAR birds were also released at the Horicon NWR in an effort to encourage future breeding locations away from the range of black flies and because of low realized productivity at the Necedah NWR. A total of 101 adults were documented to be present in the EM population through March 2017 with 27 nesting pairs (Whooping Crane Eastern Partnership 2017).

Louisiana Non-migratory Population

The Chenier Plain and prairie terrace uplands of southwestern Louisiana were historically used by both migrating and non-migrating cranes (Gomez 1992). However, the two populations were extirpated from the region by 1918 and 1950, respectively (Allen 1952). Efforts to reintroduce an experimental, non-migratory LA population began in February 2011 with the release of ten captive-reared Whooping Cranes, hatched in 2010, at White Lake Wetlands Conservation Area near Gueydan. By May 2011, two individuals were missing (one later confirmed dead, presumably killed by a predator) and the remaining eight cranes had dispersed throughout Vermilion, Evangeline, and Acadia parishes as a consequence of drought conditions throughout the northwestern Gulf of Mexico states (King and Perkins 2011). By March 2014, all birds from the 2010 cohort were dead. One-year survival post-release of the 40 cranes released from 2010–2013 was 0.64 (Hartup 2018a). Maximum size of the Louisiana non-migratory population at the end of April 2018 was 67 individuals (32 males, 33 females, and 2 newly hatched chicks) (Szyszkoski 2018). A total of 125 chicks were reintroduced to the LA population between 2011 and 2018 (Sara Zimorski, personal comm. 2018). The first Whooping Crane chicks to successfully hatch in Louisiana in 75 years were observed in 2016. This nest was located in an actively farmed crawfish pond (Louisiana Department of Wildlife and Fisheries 2016). This population has experienced the highest rates of shooting mortalities, with nearly one in four Whooping Cranes killed by hunters (Harrell and Bidwell 2013, Condon et al. 2018).

Rocky Mountain Migratory Population

The fifth population, the experimental Rocky Mountain (RM) population, has died off. This initial reintroduction effort involved an attempt to cross-foster Whooping Crane chicks with wild pairs of adult Sandhill Cranes. Between 1975 and 1988, 289 Whooping Crane eggs were removed from the AWB population and captive pairs at the Patuxent Wildlife Research Center and placed in active Sandhill Crane nests at Grays Lake NWR, Idaho, USA. This cross-fostering attempt resulted in the surrogate Sandhill Crane parents hatching eggs, raising chicks, and successfully teaching the juveniles the migration route to the wintering range in the Rio Grande Valley and surrounding areas at Bosque del Apache NWR, New Mexico, USA. The young Whooping Cranes, however, imprinted on their Sandhill Crane parents instead of other Whooping Cranes. High mortality rates from predation on the breeding grounds (Drewien et al. 1985) and from power line collisions during migration (Brown et al. 1987), combined with no reproductive success depleted the introduced population numbers to 33 birds in 1988. In addition, the potential for sexual imprinting with Sandhill Cranes resulted in a decision to terminate the cross-fostering program in 1989 (Lewis 1990). The reintroduction effort continued with experimental "guide bird" (Drewien et al. 1997) and ultralight-led migrations (Clegg and Lewis 2001) of captive-raised Whooping and Sandhill Crane chicks. The last Whooping Crane in the RM Population died in 2002.

ECOLOGY

The AWB population of Whooping Cranes is a wetland-dependent species nesting in a freshwater mosaic of ponds and marshes within forested ridges in the northernmost portion of the Boreal Plains ecoregion in Canada (Timoney 1999). The birds migrate through the Prairie Pothole and Great Plains ecoregions in central USA and winter in the Gulf Coast Prairies ecoregion in Texas. In Canada, adults feed primarily on invertebrates and small vertebrates (Allen 1952, Novakowski 1966), and parents feed their chicks mostly dragonfly (Odonate) nymphs (88%) (Bergeson et al. 2001a). They utilize grain fields in their major staging area in central and south Saskatchewan and along the migratory corridor (Canadian Wildlife Service and U.S. Fish and Wildlife Service 2005) and feed primarily on blue crabs (*Callinectes sapidus*), Texas wolfberries (*Lycium texanum*), and assorted estuarine invertebrates in the Texas wintering grounds (Hunt and Slack 1989, Chavez-Ramirez 1996, Westwood and Chavez-Ramirez 2005). Black mangrove (*Avicennia germinans*) stands are replacing salt marsh as a result of warming temperatures, which will limit habitat availability in the wintering grounds (Chavez-Ramirez and Wehjte 2012). Continued sea-level rise may reduce the available coastal habitat area by at least 25% in the next century (Smith et al. 2014, 2018). Unlike most other migratory crane species, Whooping Crane pairs in the AWB population defend territories on their wintering grounds in Texas.

The EM population resides in landscapes with more agriculture and development on summer and wintering grounds than the AWB population. Territorial cranes used a variety of landscapes, from the mosaic of wetlands and restored prairie within Necedah NWR to area cranberry (*Vaccinium erythrocarpum*) farms; non-territorial cranes often used cultivated cropland and wander widely (Barzen et al. 2018, Mueller et al. 2018). During summer, the population remains closely affiliated with wetlands: territorial cranes spent 75% of their time in wetlands, and during the remigial molt individuals spent nearly all their time in wetlands (Barzen et al. 2018). During migration and winter, however, cranes make less use of wetlands except for roosting, use a variety of habitats (particularly croplands), and do not establish winter territories. Migration is variable and has become shorter over time, as winter distribution has shifted northward away from their original release sites in Florida

(Urbanek et al. 2014, Mueller et al. 2018). Conservation planning for this population will therefore need to take into account the greater flexibility, large spatial scale of crane movements, and extensive reliance on private (mostly agricultural) lands during the non-breeding period.

The Louisiana population has been reintroduced into the freshwater marshes in the southwestern portion of the state where the resident flock occurred. Historically, this non-migratory flock used freshwater marshes for nesting and foraged in marshes, agricultural lands, and coastal prairie (Allen 1952). During the first year of the reintroduction, in June through November 2011, the birds were documented using the agricultural landscape, rice (*Oryza sativa*, 42%), and crawfish (18%) habitats, as well as freshwater wetlands (25%) (Louisiana Whooping Crane Reintroduction Research Team 2012). Since many of the 2010 (first cohort) individuals immediately moved from protection of the White Lake Wildlife Conservation Area to occupy private lands, understanding private landowner interest and support of the project was essential to its long-term success. Landowner sentiment varied from actively engaged (67%) to willing to learn about the project with no interaction (21%), to indifferent to the project and to presence of cranes on their property (13%). However, all landowners did allow access to their property (Louisiana Whooping Crane Reintroduction Research Team 2012). By 2016, about 150 individual landowners have been contacted and engaged in the reintroduction project and monitoring; landowner endorsement has remained strong (Louisiana Department of Wildlife and Fisheries 2016). Success of this reintroduction will depend on the answers to three questions: 1) can captive-reared Whooping Cranes reproduce at a great enough rate to sustain a viable population; 2) will crawfish farming operations be compatible with Whooping Crane reproduction in crawfish ponds; and 3) can shootings of Whooping Cranes be reduced or eliminated (King et al. 2018)?

NUMBERS AND TRENDS

The Whooping Crane is the rarest of the world's 15 species of cranes and is classified as Endangered in the 2011 IUCN Red List Categories. The total global population (i.e., wild, reintroduced, and captive populations) was estimated at around 764 as of March 2017 (French et al. 2018). The total population in the wild, including reintroduced populations, inhabits Canada and USA and was estimated to be 689 as of March 2018, as summarized below. The majority of the population exists in the AWB Population. Using a standardized survey protocol, the U.S. Fish and Wildlife Service estimated the abundance of Whooping Cranes in the AWB population for the winter of 2017–18. Those survey results indicated 505 Whooping Cranes (95% CI = 439–577; CV = 0.069) inhabited the primary survey area (Butler and Harrell 2018). This population has continued to increase since its low of 15–16 birds in 1941.

Fourteen Whooping Cranes remained in the experimental, non-migratory FL population in August 2016 (Tim Dellinger, personal comm. 2016), 103 in the experimental EM population in April 2018 (Thompson 2018), and 67 adults in experimental, non-migratory LA population in April 2018 (Szyszkoski 2018). The last bird in the experimental, migratory Rocky Mountain population died in 2002.

A total of 160 Whooping Cranes were maintained in 12 facilities in the U.S. and Canada as of March 2017 (Black and Swan 2018).

The current Whooping Crane recovery plan provides for down-listing the species from endangered to threatened if one of the following three alternatives is met; each requires that population levels be sustained for 10 years. Criterion 1: there are two experimental, introduced populations each with 100 individuals and 25 productive pairs, and the AWB population has 160 individuals and 40 productive pairs; or, Criterion 1A: one experimental, introduced population with 120 individuals and 30 productive pairs, and the AWB population has 400 individuals and 100 pairs; or, Criterion 1B: AWB population has 1,000 individuals and 250 productive pairs (Canadian Wildlife Service and U.S. Fish and Wildlife Service 2005). One population recovery model indicated that the AWB population could attain 400 birds by 2040 (Butler et al. 2013). Another model projected that the AWB population may reach 700 by 2035 and the 1,000 target may not be reached until mid-2060s (Gil-Weir et al. 2012). While the AWB population has been steadily increasing at an average of 4% per year (Harrell and Bidwell 2016), conditions within the breeding, migratory, and wintering range ultimately have an influence on long-term recovery potential.

THREATS

Range-wide

- The killing of Whooping Cranes, both through vandalism and incidental hunting, is an increasing concern. Twenty-seven shooting mortalities of Whooping Cranes have been confirmed in the AWB, EM, FL, and LA populations between 1967 and 2016 (Condon 2018). This may be a minimal number because few of the AWB birds have been radio-marked (most of the EM and LA birds have radio transmitters or satellite transmitters). Seventy-seven percent of the confirmed shooting cases have taken place in the reintroduced populations (Condon et al. 2018). Any loss of individuals, especially breeding age adults, affects the potential growth of small, reintroduced populations by reducing the number of productive pairs or limiting potential for pairing;

- Collision with power lines has been reported as a cause of mortality, as were guy wires associated with telecommunication towers (Howe 1989, U.S. Fish and Wildlife Service 1994, Brown and Drewien 1995, Brown et al. 1987, Lewis et al. 1992). Mortality of 45 Whooping Cranes from collisions with power lines was documented from 1956–2006 with nine deaths in the AWB population, 20 in the FL population, three in the EM population, and 13 in the former RM population (Stehn and Wassenich 2008). Mortality from collisions with power lines remains difficult to quantify and death rates are likely higher. Energy infrastructure is significantly expanding and has potential to affect all Whooping Crane populations;

- Consequences of a genetic bottleneck in Whooping Cranes are largely unknown. It is believed that the population has recovered from a low of 15–16 birds in 1941 with an estimated six to eight founders and one maternal haplotype. Although the loss of genetic material is calculated as about 66% and concerns of inbreeding depression and declining productivity have been raised, this has not been observed in the AWB population (Wade Harrell, personal comm. 2017). A 2018 population viability analysis for the AWB population indicated a demographic sustainable and genetically robust population, with high genetic retention, and no risk of extinction over 100 years (Traylor-Holzer 2018).

- Predation is not a major threat to adult cranes unless they are flightless (undergoing a simultaneous wing molt) or weakened by disease. However, egg and chick mortality by predation is a concern (Bergeson et al. 2001b; John French, personal comm. 2017). Predation is an important mortality factor on the breeding grounds for all populations. A recent study showed 45% of deaths of birds marked with satellite transmitters from the AWB population occurred on wintering grounds; though predation was suspected in many of these events, causes of death could not be determined for most of them (Pearse et al. 2018). Predation risks for LA eggs and chicks is yet not known as pairs have only recently began nesting and hatching chicks in this young population.

Aransas-Wood Buffalo Population

Breeding

- Natural factors that can affect breeding success include warm and dry conditions, which often reduce water levels and thus suitable nesting ponds and chick-rearing habitat. Increased wildfires, although a natural component of the boreal ecosystem, may be a concern. As recently as summer 2015, fires covered almost 16,000 ha (3.8%) of designated critical habitat which was much higher than the 25-year average of 0.9% (Harrell and Bidwell 2016);

- Long-term increases in temperature from climate change will have differential effects on the breeding grounds of the Aransas-Wood Buffalo Population. Warmer wetland conditions may improve aquatic food resources; however, increases in precipitation in conjunction with more frequent rainfall may flood nests or decrease chick survival via chilling (Chavez-Ramirez and Wehtje 2012). In addition, by decreasing fire frequencies, open areas used for nesting may be converted to brush habitat and decrease nesting habitat quality. Juvenile recruitment appears to be the limiting factor to AWB population recovery in recent investigations that incorporated climate change factors, including changes in the breeding ground hydrology and survival in the autumn migration corridor (Butler et al. 2017); and

- Other threats that may impact the breeding habitat outside the WBNP include forestry, oil, and gas activities that could dramatically affect the region's hydrologic regimes, habitat loss and fragmentation, and disturbance to nesting Whooping Cranes (Environment Canada 2007, Johnson and Miyanishi 2008, Timoney 2012).

Migration

- Energy exploration activities in the migration corridor south of WBNP pose threats of water and air contamination. Recent expansion of these activities in this region for the exploitation of tar sands have raised concerns of short- and long-term impacts to this sensitive environment. Surface and groundwater contamination may already be occurring, and water usage for energy production could affect water levels; and

- The impacts of wind turbines have yet not been documented for Whooping Cranes, although permits have been approved and wind farms have been constructed in the migration corridor. In Nebraska, a model developed to assess locations that would have good potential for wind energy and high probability of overlap with Whooping Cranes encompassed 30% of the state (Belaire et al. 2014). A spatial model of habitat use developed for North and South Dakota (Niemuth et al. 2018) will be useful to guide the siting of new wind, oil, and electrical transmission infrastructure to minimize potential conflicts with Whooping Cranes and also to identify threats and associated opportunities for mitigation such as transmission line marking and wetland restoration. An unpublished study by the American Bird Conservancy (2014) indicated that 5,500 turbines already existed within the Whooping Crane migratory corridor and 18,500 new turbines were planned. More direct effects of wind turbines on cranes (e.g., mortality from strikes, habitat avoidence) remains uncertain and likely vary with crane numbers, weather, and landscape features (see also *Collisions and habitat loss associated with utility lines, wind turbines, and other human infrastructure*).

Wintering

- As human demand for water continues to increase in the Guadalupe-San Antonio Basin, Texas, essential fresh water inflows to the estuaries surrounding Aransas NWR continue to diminish. Decreases in fresh water inflows are especially critical because they cause salinity to increase throughout the coastal system, which reduces the availability of primary food items (particularly blue crabs and wolfberry fruits) for wintering Whooping Cranes;

- Recovery efforts to increase the AWB population will require sufficient quantity and quality of coastal habitat be available in the wintering range. Texas experienced the highest human population increase in the U.S. from 2000–2010, and coastal development continues to increase along the Texas coast as construction is permitted in low-lying areas. An estimated 51,000–71,000 ha (Stehn and Prieto 2010) of coastal marsh habitat is needed to support 250 nesting pairs in the AWB population, one of the criteria alternatives for down-listing this species from endangered to threatened status. A more recent effort to estimate available habitat extent, habitat selection by wintering Whooping Cranes, and what is needed to support these criteria was made in the U.S. Fish and Wildlife Service's Landscape Conservation Design model (Smith et al. 2014). Further spatial analyses indicated that the AWBP will need to expand beyond contiguous coastal systems and seek additional estuarine marsh mesohabitats as well as freshwater habitats to satisfy the target spatial requirements (Smith et al. 2018);

- Pollution and environmental contamination continue to be a major concern because the Gulf Intracoastal Waterway bisects the entire wintering range of the AWB population at Aransas NWR and surrounding areas. The Texas economy is dependent on this mode of transportation, yet the proximity of coastal marshes and bays to barges carrying toxic chemicals and contaminants creates a serious risk to the high concentration of wintering Whooping Cranes. The potential for chemical and pollutant spills within the wintering range is ever present; the Gulf Intracoastal Waterway traverses through the sensitive marsh complex within and adjacent to the Aransas NWR (Ramirez et al. 1993);

- Loss of existing coastal habitat is a serious concern. The effects of climate change are evident in the wintering grounds, as warmer temperatures have allowed the establishment of black mangrove (*Avicennia germinans*), which reduces habitat availability and quality for Whooping Cranes. Sea-level rise affects coastal habitats directly by converting upper transitional and high marsh habitats to low marsh, and drowning low marsh to become subtidal habitats. When development practices, such as construction of bulkheads or roads, are located along the transition between uplands and marshes, wetlands are unable to migrate inland and are lost. Preliminary estimates of habitat availability that would support recovery indicate that all remaining coastal habitat in Texas is essential to support down-listing the Whooping Crane (Smith et al. 2014, Smith et al. 2018);

- Effects from drought exacerbated by water withdrawals from the Guadalupe River include reduced prey populations, scarcity of dietary drinking water, and lower health conditions prior to spring migration that may affect subsequent breeding ability (Chavez-Ramirez 1996, Westwood and Chavez-Ramirez 2005). Long-term changes to inflows have also occurred in the Guadalupe River from permitted withdrawals, which provides two-thirds of the water to the receiving estuary (Johns et al. 2004). Extended drought conditions in the region can result in increased bird loss (Butler et al. 2014a). The recent drought of 2008–2009 resulted in the deaths of at least 23 cranes and lowered the population to 243 birds. The return of more normal water levels in the following years increased the total AWB population past previous levels, and almost 300 birds were expected to arrive at Aransas NWR in autumn 2011. However, these birds encountered severe to exceptional drought conditions throughout Kansas, Oklahoma, and Texas during migration as well as continued exceptional drought conditions throughout the autumns and winters of 2011–2014, and breeding grounds experienced recent wildfires within the critical habitat area. More normal water levels returned in 2015 and 2016; and

- Since the species received protection under the Endangered Species Preservation Act in 1967, documented mortalities from shooting have been primarily in winter (4) and spring migration (3); two occurred during autumn migration (Condon et al. 2018). Six of the nine shooting events have been related to hunting, but hunter intentions in those cases are unclear. In most instances, the hunter was in violation of additional laws.

Reintroduced Populations

- Low reproductive success of reintroduced populations has limited recovery efforts. While the RM population advanced our knowledge of surrogate parenting and migration skills, the cross-fostering approach was unsuccessful. Improved techniques of parent-rearing chicks, transporting them to the site, and soft releases were used in the FL population. However, low fertility rates, disease, high mortality from power lines and predators, and poor parenting hampered the reproductive success of this reintroduced population (Dellinger 2018). The EM population was trained to migrate from Wisconsin to Florida following ultralight aircraft and returned successfully to their release site in the spring (Duff 2018). However, the young adult pairs experienced several setbacks from nest abandonment, primarily attributed to blackfly disturbance, and low chick survival, presumably from predation or limited habitat quality.

CHANGES SINCE 1996

The total number of Whooping Cranes in the wild was 205 in 1996; that number has steadily increased to about 604 in March 2017, with substantial growth in the AWB population. However, the RM population dropped from three in 1996 to zero in 2002, and the FL population decreased from 52 in 1996 to 14 by December 2015. Two new, experimental flocks have been established since 1996; 103 individuals comprised the EM population in April 2018, and the LA population, established in 2011, had 67 birds as of April 2018. In addition, 160 cranes were housed in 12 captive breeding facilities in April 2017, a substantial increase from 91 birds in 1996.

One of the actions defined in 1996 involved integrating the USA and Canadian recovery plans. This action was completed in 2007 (Canadian Wildlife Service and United States Fish and Wildlife Service 2005), achieved under the authorities of the Canada Wildlife Act of 1974 and Canadian Species at Risk Act of 2003, and U.S. Endangered Species Act of 1973. The 2007 document exemplifies the international collaboration that is necessary to affect the recovery of an endangered species requiring conservation efforts in two countries.

Land protection is essential for the Whooping Crane as their ecological and social needs require large amounts of nesting, staging, migrating and wintering habitats. WBNP afforded regional protection, and the nesting area is further protected between 15 April and 31 October by government designation (Canada Gazette 2008). In Canada, the Whooping Crane was designated as Endangered in November 2000 by the Committee on the Status of Endangered Wildlife in Canada and was also listed as Endangered on Schedule 1 of the Species at Risk Act.

As a follow up to the Population Viability Assessment (PVA) workshop conducted in 1991, more information was generated in another PVA that indicated the likelihood that the AWB population would continue to increase in numbers (low probability of <1% of extinction) over the next century (Mirande et al. 1997). A more recent effort was undertaken in 2015 to update a PVA with more recent information. The International Recovery Team has in preparation a revision of the Whooping Crane International Recovery Plan (Miller et al. 2016). The meta-population model included five populations (AWB, EM, LA, FL, and captive), each with their own demographic rates, initial population structure, and management options. The second workshop to finalize the Population and Habitat Viability

Analysis was held in December 2016; this process is expected to be completed with the development of a Population and Habitat Viability Analysis.

Continued economic growth and development along the Texas coast and within the Guadalupe-San Antonio basin in Texas has precipitated concerns over freshwater inflows into the critical habitats of the Whooping Crane. These inflows are essential to maintain a balance of salinity gradients, food productivity, nutrients, and sediment that maintains a sound ecological environment (Texas Parks and Wildlife 1998). Several studies were initiated since 1996 to better understand the relationship between freshwater inflows, salinities, blue crab and wolfberry fruit production, and Whooping Crane mortality (Westwood and Chavez-Ramirez 2005, Houston Advanced Research Center 2006, Pugesek et al. 2008, Wozniak et al. 2012). The Texas state legislature passed several bills to initiate a process to set environmental flow regimes for each basin in Texas, and these rulings were finalized in 2012. However, the scientist and stakeholder inputs were not followed rigorously, and new permits will be allowed to divert more freshwater from the rivers than recommended potentially impacting blue crab populations.

One primary area of concern for the long-term conservation of the AWBP is the protection of winter habitat within its current range, as well as the identification and protection of future habitat areas that would support the potential growth of the population and expansion of their wintering range (Canadian Wildlife Service and United States Fish and Wildlife Service 2005). In recent evaluations of potential impacts under different climate change scenarios, sea-level rise (SLR) was identified as one of the primary concerns for future habitat availability on the winter range along the Texas coast (Chavez-Ramirez and Wehtje 2012, Harris and Mirande 2013). Projected habitat changes related to future sea-level rise have been evaluated using the Sea Level Affecting Marshes Model (SLAMM) (Clough and Larson 2010), to predict effects of sea-level rise on current and potential Whooping Crane habitat at a broader scale (Smith et al. 2014, 2018). Overall, habitat changes modeled within and surrounding Aransas NWR showed a 50% decrease in estuarine habitats at 1- and 1.5-m SLR by 2100, and a modest 23% increase in 2-m SLR. Recent advances on an improved SLAMM and broader extent of potential wintering habitat along the central Texas coast is nearing completion by U.S. Fish and Wildlife Service. Protecting remaining habitat is critical and identifying additional areas that will become habitat as sea levels continue to rise is imperative to the continued recovery of the AWB population.

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

A large mapping project was undertaken to identify potentially suitable habitat for nesting and non-breeding summer range in Canada. The findings indicated that sufficient habitat is available to support 107–472 breeding pairs (Olson and Olson Planning and Design Consultant, Inc. 2003). Currently, only 10% of that area is actively used. Therefore, the limiting factor for Whooping Crane growth and recovery will not be breeding habitat availability.

Conservation strategies in the wintering grounds have been funded through government and non-governmental programs, especially in coastal Texas. Several thousand hectares have been protected through conservation easements and acquisition, which will ensure the coastal habitats are conserved for Whooping Crane use. A collaborative project that will identify coastal habitat areas suitable for Whooping Crane use now and under various sea-level regimes is underway. A work plan will be developed to implement conservation options on key areas in the wintering range.

Two reintroduction population programs are actively underway in the USA, supported by considerable monitoring, management, and research efforts that provide information for management decisions. Reintroduced populations are important to maintain multiple populations within the species and provide assurance for species survival in the event of a catastrophic event within the AWB population.

Captive breeding programs at five breeding centers and nine display facilities provide eggs and chicks for reintroduction programs. The ongoing research to maintain genetic diversity, detect and minimize disease outbreaks, and test new release techniques provides the scientific basis for the reintroduction programs.

The Whooping Crane Tracking Partnership (WCTP) is comprised of members from the U.S. Geological Survey, U.S. Fish and Wildlife Service, Canadian Wildlife Service, Platte River Recovery Implementation Program, and Crane Trust, with support from Parks Canada, Gulf Coast Bird Observatory, and International Crane Foundation. The team began banding and attaching Platform Transmitting Terminals with Global Positioning System capabilities (GPS-PTTs) to a total of 68 Whooping Cranes beginning in 2009 and completed the banding and GPS-PTT portion of the study in winter 2013 (Whooping Crane Tracking Partnership 2014). Thirty-three chicks were fitted with bands and GPS transmitters during late summer, and 35 adults and sub-adults were captured via noose traps and fitted with the equipment at Aransas NWR during winter. The primary objective of the multi-year project involves increasing our knowledge of the breeding, migratory, and wintering ecology, as well as completing a population health assessment (Hartup 2018b) and identifying threats to survival and demographics. This project is expected to continue until 2019. The data collected will enable researchers to examine individual, group, and family movements across the entire range of the AWBP.

PRIORITY RESEARCH AND CONSERVATION ACTIONS

- Continue land protection of high-quality habitats critical in the breeding, staging, migration, and wintering ranges of Whooping Crane populations to ensure populations will be supported as they continue to increase in numbers;
- Ensure appropriate amounts and timing of freshwater inflows to Aransas, San Antonio, and Matagorda Bays, Texas, are maintained to provide a sound ecological environment for Whooping Cranes and their associated food items;
- Improve enforcement of shooting laws as well as public and hunter education in current and adjacent ranges of Whooping Cranes to reduce human-caused mortalities in the populations;
- Reduce mortalities from power lines and contaminants through best conservation practices and collaboration with industry;
- Fully understand the relationships among priority food sources and hydrologic and environmental conditions in the wintering, staging, and breeding areas and incorporate these findings into management and conservation plans;
- Collaborate among partners to effectively monitor, research, and manage reintroduced populations and achieve reproductive success;
- Maintain captive breeding and reintroduction projects that ensure genetic diversity and the improvement of release methods and reintroduction techniques that ensure high success; and
- Monitor each population using direct observations and telemetry that provide information on total population size, mortality, adult/juvenile ratios, territories, and expansion movements useful for management decisions.

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SPECIES REVIEW:

RED-CROWNED CRANE (*Grus japonensis*)

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(with input from George W. Archibald, James T. Harris, Elena I. Ilyashenko, Kisup Lee, Fawen Qian, Liying Su, Sergei M. Smirenski, and Sergei Surmach)

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Red-crowned Cranes with two chicks (Photographer: Wang Keju)

Red List Category: Endangered
Population Size: 2,800–3,430
Population Trend: Increasing, but declining in China
Distribution: Northeast Asia

Mirande CM, Harris JT, editors. 2019. Crane Conservation Strategy. Baraboo, Wisconsin, USA: International Crane Foundation.

DISTRIBUTION AND STATUS OF KEY SITES

The Red-crowned Crane has two separate populations. The continental population is migratory and breeds in northeastern China and in the south of far-eastern Russia, wintering along the east coast of China and on the Korean Peninsula. The island population is resident on the Hokkaido Island in northern Japan and the Kunashiri Island.

Continental Population

The Red-crowned Crane breeds in Heilongjiang Province, Jilin Province, Liaoning Province, and Inner Mongolia in China; and Amur Oblast (Province), Jewish Autonomous Province, Khabarovsk Province, Primorsky Province, and recently discovered sites in Zabaikalsky (Transbaikal) Province in Russia. They winter at Yancheng and Yellow River Delta in China and along the Demilitarized Zone of Korea.

The exact migration routes have not yet been disclosed. Satellite tracking indicates that Red-crowned Cranes from Primorsky, at the easternmost part of the continental range, migrate back and forth to the Korean Peninsula (Masatomi 2013). The continental population migrates along the east coast of China with stopovers at Liao River Estuary National Nature Reserve (NNR), the coast of Beidaihe, Jianjin, and the Yellow River Delta NNR of Shandong Province. The Liao River Estuary is the most important stopover with peak spring counts of about 400 birds in recent years (Li et al. 2012).

Island Population

This resident population used to be confined to southeastern Hokkaido but is now dispersing its breeding habitats to northwestern Hokkaido and to the Kunashiri Island where a pair wintered for the first time in the winter of 2015–16 (E. Kozlovski, personal comm. 2016).

ECOLOGY

Red-crowned Cranes are aquatic and territorial with large breeding home ranges in wetlands (Meine and Archibald 1996). For nesting, they prefer relatively deep water, nesting on reed or other floating vegetation mats or on mounds surrounded by standing water. They are thus sensitive to changing water levels among or within years and will abandon sites when waters become too deep or too shallow. If waters rise during the incubation period, they will build their nests up, but sudden water releases from impoundments or heavy rainfall can flood nests. In Hokkaido, due to a combination of a large crane population, limited wetland habitat, and strict protection by people, they are utilizing more diverse sites and even nesting in wet meadows (Koga 2008).

Red-crowned Cranes are omnivorous, eating wide varieties of both animal and plant foods, picking food items from the substrate and shallow water (Su 1993). Compared to other cranes, they rely more upon animal foods such as fishes, frogs, snakes, as well as snails and other invertebrates. On the continent, in contrast to White-naped Cranes at Muraviovka Park where both species breed, Red-crowned Cranes seldom leave the wetlands to forage on farmlands during the breeding period, although they will do so in autumn (Smirenski et al. 2012, 2018). The winter diet varies depending on the food availability of the site. The island population highly depends on artificial feeding during winter. The cranes wintering in Korea mainly rely on waste rice (*Oryza sativa*) grain in fields within the Civilian Control Zone (CCZ, part of Demilitarized Zone, or DMZ), animal food in mudflats and within the DMZ where the birds roost at night, and Job's Tears (*Coix lachryma-jobi*) fruit in fields on steep hill slopes in Republic of Korea (South Korea). Artificial feeding of birds has been recently initiated in the Korean Civilian Control Zone of the DMZ. At Yancheng, the cranes prefer natural coastal wetlands, but loss of that habitat has led cranes to use farmlands where conflicts with farmers may arise and cranes may die from poisons illegally set out to catch ducks and geese for the market.

Tolerance for people is markedly different between the continental and island populations. In China, the cranes are highly wary and will not use habitat that otherwise appears suitable due to human disturbance from fishing or plant gathering, or people simply walking through or beside the marsh (Su 2008). Similarly, small to medium sized fragments of habitat will not be used. In Russia, experimental releases of hand-reared birds have aimed to introduce more tolerant birds into the population, so that habitats closer to human activity can be used (Andronova 2006). In Korea, the cranes are more tolerant of humans, as they feed on agricultural waste in fields near the DMZ. In Hokkaido, strict protection, artificial feeding, human encroachment on wetlands, and frequent close proximity of tourists and bird watchers have led to a steady decrease in the distance between habitat of cranes and that of humans (Koga 2008).

As a family (Gruidae), cranes are for the most part confined to freshwater wetlands (Meine and Archibald 1996). Aside from the wintering population of Whooping Cranes along the coast of Texas, USA, and Brolga that forage on sedge tubers in saltwater wetlands during the dry season and even have special salt glands to excrete salt, the chief exception is the Red-crowned Crane. The China wintering population occurs along coastal China (Shandong and Jiangsu Provinces), while the main migratory stopover is the Liao River Estuary in Liaoning Province, where two rivers enter the sea (Su and Zou 2012). Small numbers winter in tidal areas on the west coast of Korea, and coastal wetlands provide limited but significant habitat for breeding Red-crowned Cranes in Hokkaido. Coastal wetlands are under extreme development pressure in Asia, particularly along the Yellow Sea (MacKinnon et al. 2012, Ma et al. 2014). In addition, sea-level rise associated with climate change may have increasingly negative impacts.

NUMBERS AND TRENDS

The Red-crowned Crane is the second rarest crane in the world and had an estimated total wild population of 2,800 in early 2013 (International Red-crowned Crane Network, unpublished data). The continental population was estimated at 1,400 and not increasing compared to previous years. The wintering subpopulation in Republic of Korea was estimated at 1,050 and was stable to slightly increasing; that in DPRK (North Korea) had disappeared; and that in China was decreasing and estimated at 357 in winter 2012–13 (Momose et al. 2013), with 350 at Yancheng and seven birds at the Yellow River Delta (International Red-crowned Crane Network, unpublished data). The latter location could become increasingly important with climate change. The island population in 2012–13 was estimated at 1,400 and still increasing.

Counts the following two winters continued to grow. Given the opportunities for missing individuals or double counting, three-year averages (for winters 2012–13, 2013–14, and 2014–15) have been calculated as 580 in China; 1,000 in Korea; and 1,470 in Hokkaido. The most recent official count for 2017–18 indicates a total of 3,431 individuals: 580 in China, 1,251 in Korea, and 1,600 for Japan. The world population is thus estimated at 2,800–3,430.

There have been efforts in the recent years to restore a wintering population at Anbyon in DPRK by employing live decoys to encourage passing migrants to land; results have been promising (Healy 2011).

Annual counts in winter have included counts of juveniles, which have comprised 10–25% for the continental population in recent years (Wang et al. 2005, Lee 2009; Liying Su, unpublished data). For Hokkaido, the mean proportion of chicks present in the entire population during 1991–2004 has been 11.64% (Masatomi 2008). Thus, the continental population, which has been stable to decreasing, has a higher chick ratio than the island population, which is increasing. These data suggest the continental population is experiencing high mortality of adults or subadults (Harris and Mirande 2013).

THREATS

Continental Population

- Habitat loss and degradation. Dramatic changes in habitat for all parts of the year have occurred on the continent, especially in China and Korea. In China, wetland development, primarily to create agricultural lands, has continued trends of previous decades. Wetland loss during 1976–2005 has been 69.43% in Small Sanjiang Plain (the northeast part of the Sanjiang Plain in Heilongjiang Province; Zhang et al. 2009), while 87.30% of wetlands were lost from Naoli River Basin during 1950–2000, and 75.28% lost for the same period from Bielahong River Basin (Liu at al. 2005). On the wintering grounds, the cranes currently occupy about 8% of the winter range of the 1980s (Su and Zou 2012);

- Fluctuation of breeding population in the middle and upper Amur River Basin and Transbaikalia at the end of 20th–early 21st centuries could be the result of joint impacts of habitat loss to wetland development in Heilongjiang Province of China and climate changes (Smirenski and Smirenski 2009, Smirenski et al. 2018);

- Fragmentation. Remaining wetland areas are often small, closely surrounded by farms, roads, and human activities. In the key wintering area at Cheorwon Basin in Korea, crane foraging areas in the Civilian Control Zone are increasingly affected by greenhouses, power lines, and agricultural activity now allowed for longer parts of the year. The Civilian Control Zone has also been reduced in size (Lee 2009);

- Changes in hydrology, due to water control/diversions that do not account for ecological needs of wetlands and for climate change, leading to habitat degradation. While a network of nature reserves has been established for cranes and other waterbirds, protected wetlands are highly vulnerable to dams and water diversions upriver, reducing the water supply and resulting in drying up of the wetlands (Harris 2009). Thus in the 2000s, important sites like Xianghai and Keerqin NNRs lost their breeding Red-crowned Cranes. At Zhalong, currently the most important breeding habitat, canals built around the marsh cut off water supply, leading to changes in vegetation and fires that swept across the wetlands even during the breeding season. The UNEP/GEF Siberian Crane Wetland Project in response provided support for development of water management plans for four reserves, with implementation occurring in part for three of the sites (Harris 2009). At Zhalong, for example, provincial and municipal governments have paid for annual water releases and a monitoring program to evaluate results of the releases. Dam construction on Hailaer River in China has had negative impacts on Red-crowned and White-naped Crane breeding habitats in the valley of Argun River (Muratshina 2015). As another example, construction of dams on the Zeya and Bureya Rivers in Amur Region of Russia has prevented the major floods that used to scour side channels and wetlands, removing sediments and accumulating vegetation, so wetlands such as Muraviovka Park are gradually becoming shallower and less suitable for many bird species including Red-crowned Cranes. Damming of small rivers (Giltchin, Ivanovka, Zavitaya, Arguzikha, Alim) in the southern part of Zeya-Bureya Plain resulted in higher evaporation, frequency and scale of floods, and shrinking and fragmentation of breeding and feeding habitats (Kazachinskaya 2012; Sergei Smirenski, personal comm. 2016). According to personal communication of Seok-wo Li (Smirenski 2015), construction of the Gunnam Dam, which changed the flood regime of the Imjin River, caused a decline in the availability of fish and mollusks for cranes, overgrowth on sand bars by tall grasses and shrubs, and more frequent attacks on cranes by the Leopard Cat (*Prionailurus bengalensis*);

- Spread of the invasive smooth cordgrass (*Spartina alterniflora*) across the intertidal zone at Chinese wintering sites. *Spartina* grows aggressively, crowding out other vegetation, and so densely that cranes and other waterbirds cannot forage (Liu et al. 2009). In addition, *Spartina* traps sediments, impeding water flow so that interior mudflats dry out. The Red-crowned Crane has lost large areas of feeding habitat within the limited areas remaining of coastal wetland;

- Grass fires in the breeding habitats. Spring is a dry and windy season across much of the continental population's breeding range, and lower water levels allow fires to sweep across breeding marshes destroying nests, eggs, and even birds. One molting Red-crowned Crane was killed in June 2001 by a grass fire in Muraviovka Park (Smirenski and Smirenski 2009). Fires in the fall or early spring eliminate dead vegetation necessary for nest protection. As a result, Red-crowned Cranes annually cannot not use 30–70% of their breeding habitats in middle and lower Amur River Basin of Russia (Andronov 2008, Goroshko 2015b, Smirenski and Smirenski 2015a). Food items in burned areas are quickly consumed by crows, other birds, and mammals. Better visibility in burned areas increases impacts of predators and human disturbance, especially during incubation.

- Disturbance during the breeding period. As noted earlier, wetland fragmentation leaves remaining habitat susceptible to disturbance especially about its edges. For example, the narrow corridor of wetlands protected along the Naoli River in Sanjiang Plain has summering Red-crowned Cranes but also excessive human disturbance (Liying Su, personal comm. 2016). Disturbance also has increased the effects of predators (Smirenski and Smirenski 2009, 2015b);

- Poisons and pesticides. As noted earlier, high counts of chicks for the continental population suggest high adult mortality. Su and Zou (2012) summarize known reports of mortality of Red-crowned Cranes from poisons, yet they believe many instances are never reported. Some of these cases involve grain purposely set out with poisons to kill waterfowl, but cranes coming to feed on farmlands also are killed and the incidence of poisoning has been increasing in recent years (Su and Zou 2012, Luo et al. 2016). In other cases, highly toxic pesticides used on crops inadvertently poison cranes. According to personal communication by Seok-wo Li (Smirenski 2015), several Red-crowned Cranes were killed by rat poison in a ginseng (*Panax ginseng*) plantation in Korea's DMZ;

- Illegal hunting. Poisoning is the primary way that poachers take cranes in China, but snares also catch birds; the cranes may escape with an injured leg or the snare dangling behind. Some cranes and their eggs are taken for the captive trade (Su and Zou 2012). Among a total of 1,520 captive Red-crowned Cranes in China in 2013, probably 244 birds came from the wild by taking eggs and capturing juveniles or adults (Zhou et al. 2016);

- In Russia, spring hunting probably leads to some crane mortality. A wounded Red-crowned Crane was rescued in November 2009 near Muraviovka Park by the border control soldiers and shipped to the Rare Bird Reintroduction Station at Khingansky State Nature Reserve (Smirenski and Smirenski 2009). Two Red-crowned Cranes were shot by wildlife managers in Transbaikalia while collecting birds for avian flu studies (Goroshko 2007). The bigger impact, however, is high disturbance to nesting cranes by human presence and gunshots;

- Collision with power lines was a major cause of mortality in Hokkaido during the late 1960s and early 1970s, but collisions were substantially reduced through marking of problem segments of power lines (Masatomi 1991). Power lines are increasing in number and size near habitats of the continental population and their impact needs further study. In the Amur Region, there were no documented cases of the Red-crowned Crane mortality caused by collisions with power lines, but there are cases of injured or killed White-naped Cranes, a more numerous species (Sergei Smirenski, personal comm. 2016);

- Industrial chemical water pollution especially on the breeding grounds in the state border area along the Argun River (Goroshko 2007, Muratshina 2015). The species has been found to carry high levels of heavy metal contamination at Zhalong (Luo et al. 2016). Teraoka (2008) reports extensive mercury contamination in Red-crowned Cranes on eastern Hokkaido. Given the degree of industrial pollution across the crane's range on the continent, mortality from environmental contaminants is a threat needing further study. Some toxins bio-accumulate, so that the significant animal component of this species' diet may make Red-crowned Cranes more vulnerable than other crane species;

- Lack of long-term security for Korean wintering sites along the DMZ and the adjacent CCZ. Most of the continental population winters on lands kept undeveloped due to the current political relations on the peninsula. Cranes could immediately be affected in the case of war, while conversely reunification could lead to rapid development of lowland habitats now protected within the DMZ. The DPRK (North Korea) built the Hwanggang Dam on the upper stream of Imjingang River which enters Republic of Korea (South Korea) above an important Red-crowned Crane roosting site. The DPRK controls the water flow and made a canal to supply water to another river (Yeseonggang River). To manage potential drought or a sudden flooding, Republic of Korea has built its Gunnam Dam where about 200 Red-crowned Cranes spend winter in the DMZ and CCZ (in Yeoncheon County). Gunnam Dam keeps the water level high in winter to prevent drought in spring. All these changes have made the situation worse for Red-crowned Cranes;

- Changes in crops or agriculture practice on the wintering grounds. Cranes depend on farmlands for foraging in Korea; they disappeared as a wintering species in DPRK when waste grain no longer was available. With losses in coastal wetlands, cranes increasingly depend on buffer zones under agriculture for foraging. Increased cotton (*Gossypium*) growing (in China), greenhouses, and fall plowing reduce habitat and food availability for cranes. Farmers are converting dry paddies used by cranes from edible Job's Tears and corn (maize, *Zea mays*) to ginseng monoculture;

- In Republic of Korea, small streams within rice paddies are straightened and concrete walls built reducing natural animal food and limiting access by cranes; and

- Lack of knowledge, awareness, public support, and local conservation leadership.

Island Population

- Habitat loss and degradation. Even today, after major wetland losses on the continent, wetland habitat for cranes is much less extensive on Hokkaido than in the continental breeding range for the species. Cranes use the Hokkaido habitat intensively, and even breed in marginal sites exposed to predators (e.g., foxes [*Vulpes*]) and human activity;

- Heavy concentration in both breeding and wintering areas that might cause major losses by infectious disease. Lack of habitat, especially in winter, brings many cranes in close proximity. As the population grows, this problem becomes worse;

- Excessive habituation to humans leading to collisions with utility lines, traffic accidents, and other human-induced deaths. Limited habitat and foraging options bring cranes in close proximity to people and dangerous infrastructure; and

- Lack of knowledge, awareness, public support, effective legislation, administration, and enforcement.

CONSERVATION EFFORTS UNDERWAY

- Synchronized census and population monitoring under the International Red-crowned Crane Network;

- Scientific research on ecology, habitat, and migration routes employing GPS/PTT transmitters, aerial surveys, banding, and geographic information systems;
- Comparative studies between the two populations based on morphology and DNA studies;
- Scientific and social studies toward dispersion of breeding and wintering habitats, including international cooperation for sustainable agriculture and restoration of the crane wintering area at Anbyon, DPRK;
- Habitat protection and restoration projects. Huanzidong, an important stopover in Liaoning Province, China, has been designated a National Wetland Park. Water releases and wetland restoration are being conducted at Zhalong, Xianghai and Momoge NNRs in Songnen Plain, China. Muraviovka Park (Smirenski and Smirenski 2012, 2015) and Khinganski State Nature Reserve (Parilov and Parilova 2013) conduct fire prevention and suppression programs;
- Artificial feeding during severe weather conditions in early spring, and development of diversion crops at Muraviovka Park in the Amur Province of Russia (Smirenski and Smirenski 2014). These efforts involve expanded collaboration with state and local administrations related to land and water use;
- A demonstration project for climate change vulnerability assessment and climate change adaptation planning to support conserving wetlands at Momoge and Tumuji NNRs, including a community livelihoods component;
- Experimental releases of captive-produced Red-crowned Cranes in Russia (Andronova 2006, Andronova and Andronov 2015) and China;
- Spring hunting of waterbirds was prohibited in Zabaikalsky Province in Russia during 2004–2010 but resumed in part because neighboring provinces continued spring hunting;
- Education and awareness projects based on scientific and social/cultural studies conducted in the range states. These activities have included production of awareness materials in multi-language formats that emphasized the international nature of problems and solutions. Some examples are annual "Crane Day Celebrations" in many range countries organized by the Crane Working Group of Eurasia; "Crane Schools" in Republic of Korea; annual (since 1994) International Environmental Camps, art contests and exhibits, and exchange visits of Russian educators for training in the USA organized by Muraviovka Park (Smirenski et al. 2011, Smirenski and Smirenski 2013); International Ecology Camps that invite participants from the range states; training of volunteers in China to participate in monitoring, education, and protection efforts on the migration corridor including the coast of Bohai; and a campaign successfully aimed at reducing human disturbance at nests at Hui River NNR; and
- The Wetlands International – IUCN Species Survival Commission Crane Specialist Group, aside from developing the Crane Conservation Strategy, has formed a global network dedicated to sharing information and successful experience with reducing crane collisions with power lines. Conservationists from the range of the Red-crowned Crane are active in this network.

CHANGES SINCE 1996

The total estimated population in the wild has risen from 1,700–2,000 in 1995–1996 to 3,050 in 2012–2015 and 3,431 in 2017–18. This increase reflects mainly an increase in the island population, which rose from 600 in 1995–1996 to 1,400 in 2012–1913, although numbers for the continental population have are also grown, perhaps in part due to increasing concentrations of the cranes at fewer sites which make counting easier. Red-crowned Cranes no longer winter in Democratic People's Republic of Korea due to insufficient waste grain in winter, while numbers concentrated along the DMZ and CCZ in Republic of Korea have increased dramatically. Numbers wintering in China had decreased from the highest record of 1,163 in 1999–2000 (Wang et al. 2005, International Red-crowned Crane Network unpublished data) to 357 in winter 2012–13 (Momose et al. 2013), with numbers again growing in 2013–14 (see *Current Number and Status* above).

Growth in the population has occurred despite shrinking areas of habitat available (see the range map for Red-crowned Crane, which shows an extremely fragmented range). Red-crowned Cranes no longer breed at Keerqin, Xianghai, and Momoge NNRs in China, while the population at Liao River Estuary is roughly half the size present 20 years earlier (Li et al. 2012, Qian et al. 2012). At Muraviovka Park in Russia, only three pairs have bred in 2016–2018, in contrast to 5–10 pairs breeding a decade ago (Smirenski et al. 2018; see also *Wildfire Impact on Cranes*). In Zabaikalsk Province, a gradual increase in population numbers (which began in the mid-1980s) accelerated noticeably by the early 2000s. A peak occurred in 2004 with 22–24 territorial pairs in the Russian part of the Argun River valley, after which the population trended downward to a catastrophic level by 2008, at which point the habitat area was reduced by 95% and the population size by 75% (Goroshko 2012). In 2014, only one pair nested there (Goroshko 2015). To the east, a similar dynamic was observed on the Zeya-Bureiya plain and the Arkhara lowlands although to lesser degree. The population went from 170 individuals (24 pairs) in 1998 to 100–120 individuals (13–16 pairs) by 2004 (Darman and Andronov 2011). Results of monitoring showed that in some parts of this region this negative trend continued. In the south of the Amur Province, the number of cranes fell from 24–33 territorial pairs in 2003 to 14 pairs in 2012 (Andronov et al. 2013). Further east, in the Jewish Autonomous Region, a significant population increase has been noted since the beginning of the 2000s, from 3–5 pairs in the 1980s–1990s to 20–22 pairs in 2004, with a subsequent stabilization at the level of 10 pairs (Averin 2011). Populations in the Khabarovsk Province have seen a prolonged downward trend from 25 pairs in 1976 to 15 or fewer pairs by the end of the 1980s (Smirenski and Roslyakov 1982, Shibaev 1982). The population has not increased there, even during years of temporary population increases elsewhere within Russia (Nikitina et al. 2006). The situation is stable in the Khanka lowlands, at the extreme south of breeding range in Russia. At the beginning of the 1960–1970s, the number was estimated at 30–40 breeding pairs (Leonovich 1965). The results of the first aerial surveys confirmed this estimate. In 1980, 92–106 individuals (39 pairs) were counted (Shibaev and Glushchenko 1982). From 2003 to 2016, five full aerial surveys found 38 pairs in 2003, 53 pairs in 2012, 41 pairs in 2013, 52 pairs in 2014, and 63 pairs in 2016; the number of birds counted at the start of the nesting season varied from 96 to 138 individuals during these years, while the number of nesting pairs progressively increased from 23 to 35, and non-breeding territorial pairs from 38 to 63 (Sergei Surmach, personal comm. 2013).

The rapidly changing situation for Red-crowned Cranes along the Argun River, which forms the international border between China and Russia, illustrates the vulnerability of the species to changes in rainfall and river flows. This semi-arid region experiences a roughly 30-year climate cycle, with the wet phase filling wetlands in the river's floodplain so an estimated 45–70 territorial pairs of Red-crowned Cranes were present here in 2004 (Goroshko 2009). In subsequent years, wetlands shrank and dried up, and crane numbers dropped rapidly with only an estimated 9–15 territorial pairs in 2008–2009. Goroshko (2012) suggested that probably only up to three pairs had chicks in 2008–2009 but he documented only one pair successfully breeding in each of these years. The following years were similar or worse. Since 2011, no adult Red-crowned cranes came to the area (Goroshko 2015a). In 2016, only one immature bird was sighted (Goroshko 2016). While in past times, such fluctuations in water conditions meant the cranes moved to alternate locations, wetland development has greatly reduced the options available to cranes. Such populations, already stressed by habitat loss and changes in water supply, are then susceptible to mortality causes such as poisons, disease, or collisions with power lines.

The International Red-crowned Crane Network (IRCN) was established in the fall of 2009 following three years of discussion at international meetings hosted by the then Tancho Protection Group, now the Red-crowned Crane Conservancy, to facilitate conservation activities based on scientific and social studies throughout the Red-crowned Crane range states. International cooperation and communication among the range states have been strengthened since.

PRIORITY RESEARCH AND CONSERVATION ACTIONS

A series of international workshops held in Hokkaido, that served to develop the International Red-crowned Crane Network, formulated a program for conservation of the species. See Koga et al. (2008, 2009, 2010) for more detailed information.

For the Species as a Whole

- Conserve habitats of importance for breeding, migrating, and wintering cranes. While this need is urgent throughout the species range, especially critical are better protection and restoration of coastal wetlands at Yancheng in China and of crane habitats along the DMZ in Korea;
- Continue long-term scientific monitoring of the cranes and their habitats;
- Study seasonal (early, middle, and late winter) changes in roosting sites in rivers and reservoirs located outside of CCZ in Republic of Korea;
- Monitor instances of poisoning, determine the factors responsible and take measures to prevent or substantially reduce such losses. Feathers and tissue samples from dead birds should routinely be collected and tested for heavy metals and other toxins;
- Study the impact of global climate change upon the Red-crowned Crane and its habitats;
- Improve national and international legislation aimed at the conservation of the Red-crowned Crane and its habitats across national borders, and strengthen its enforcement;
- Strengthen education and awareness programs at different levels of interest, based on attitude and behavior surveys; and
- Maintain close cooperation among those in the range states to learn from each other. This networking should occur at local, national, and international levels and is crucial particularly in the case of habituation to humans so that the continental population will not follow the same path as the island population.

For the Continental Population

- Negotiate with authorities to maintain adequate water levels and quality in breeding, stopover, and wintering sites; monitor and adjust water releases to increase their effectiveness;
- Develop efficient fire prevention and suppression programs, including legislation and law enforcement against illegal burning and practical approaches to conduct and control burning in agriculture fields; promoting sound farming techniques; and training in prescribed burning and development of fire breaks in crane habitats, as well as public education about the origin and impact

of grass fires on endangered species, and human health. Such activities will reduce frequency and scale of agricultural grass fires in breeding areas;

- Investigate the migration routes to facilitate conservation of stopover sites, and protect regularly used sites. Such studies could confirm whether there is any exchange between subpopulations wintering in Korea and in China. In preparation for reunification on the Korea peninsula, it is essential to identify migration routes, stopovers, and alternative wintering sites in the DPRK;

- Identify key crane habitats in the DMZ and CCZ in Korea and work with governments to establish laws to protect these areas prior to execution of DMZ development plan;

- Develop economically viable and crane friendly alternatives for farmers converting rice paddies to greenhouses or dry paddies with commercial crops (i.e., ginseng). The government of Republic of Korea should be encouraged to buy rice paddies in the CCZ to maintain land uses suitable for cranes or compensate farmers for crane friendly farming;

- Restore alternative wintering areas on the Korean Peninsula (Anbyon in DPRK and possibly Paju, Han River, or a southern part of Republic of Korea);

- Identify and implement effective control mechanism for the invasive *Spartina alterniflora* in coastal wetlands of China; and

- Stop spring hunting of waterbirds in Siberia and Far East in Russia.

For the Island Population

- Disperse cranes to more locations and increase the distance between cranes and humans to lessen habituation.

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SPECIES REVIEW:

GREY CROWNED CRANE (*Balearica regulorum*)

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(with input from Megan Diamond, Damien Nindorera, Laurent Ntahuga, William Olupot, Ann Scott, Griffin Shanungu, Jon Smallie, and Wilfred Versveld)

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Grey Crowned Crane spreading its wings
(Photographer: Shawn Olesen)

Red List Category: Endangered
Population Size: 26,500–33,500
Population Trend: Declining
Distribution: Eastern and southern Africa

Mirande CM, Harris JT, editors. 2019. Crane Conservation Strategy. Baraboo, Wisconsin, USA: International Crane Foundation.

DISTRIBUTION AND STATUS OF KEY SITES

Subspecies/Populations

There are two subspecies, the East African (*B. r. gibbericeps*) and Southern African (*B. r. regulorum*) Crowned Cranes that are separated by the Zambezi River system.

Overall Range

The range of the Grey Crowned Crane extends in the north from the eastern Democratic Republic of Congo, South Sudan, Uganda, and Kenya in Eastern Africa, south to the southeastern parts of South Africa in southern Africa. They undertake variable local and seasonal movements.

The Grey Crowned Crane is the national bird of Uganda.

Status of Key Sites

Grey Crowned Cranes are most often found outside of protected areas, often in close proximity to human activity and in agricultural lands. However, we are finding an increasing proportion of Grey Crowned Cranes within protected areas, where they depend on the habitat still available for nesting and the security afforded to them. The number of protected areas and their extent within the range of the species is very limited. Zambia though is the exception, where the majority of the Grey Crowned Crane population is found in national parks and Game Management Areas, most notably the Kafue Flats and the associated Lochinvar and Blue Lagoon National Parks, Liuwa Plains National Park, Busanga Swamps in the Kafue National Park, and South Luangwa National Park. Besides Liuwa Plans National Park, and the Luangwa Valley in Zambia, no other protected areas in sub-Saharan Africa hold at least 1% of the population.

In South Africa, a number of the protected areas included in the Biodiversity Stewardship Programme contain Grey Crowned Cranes. This legislative process enables landowners voluntarily to enter into legally binding agreements with the government to place their properties in the Protected Area network of South Africa, with the added commitment of managing their properties for biodiversity. Likewise, Kenya and Uganda have legislative processes that allow for the development of community-based conservation areas, affording protection to sites which are then managed in collaboration with local communities. A number of key Grey Crowned Crane sites have been identified for these community-based conservation areas in Kenya and Uganda.

The main centers of distribution, containing at least 1% of either the population for the Southern (at least 75 individuals) or the East African Crowned Cranes (at least 250 individuals) respectively are:

South African Grey Crowned Crane

- Moist Drakensberg Foothill Grasslands of the southern KwaZulu-Natal and northern Eastern Cape Provinces of South Africa;
- Mpumalanga Highveld Grasslands of South Africa, encompassing in particular the Chrissiesmeer Lakes District and Steenkampsberg West Grasslands;
- Enkangala Grasslands of South Africa, straddling the grasslands of northern KwaZulu-Natal, southern Mpumalanga and the north eastern Free State;
- KwaZulu Natal Midlands of South Africa;
- Driefontein Grasslands encompassing the districts of Gutu, Chirumanzu, and Chikomba, located in the central region of Zimbabwe; and
- The irrigated farms and pans in the Nkayi and Lupane districts in the western region of Zimbabwe.

East African Grey Crowned Crane

- The Bulozi Floodplains, encompassing Liuwa Plains and the Barotse Floodplain in western Zambia, and extending north westwards into eastern Angola;
- The Luangwa Valley in Zambia;
- Kafue Flats and associated breeding grounds in Zambia;
- The northeast Lake Victoria Basin in western Kenya encompassing the counties of Busia, Bungoma, Nandi, Uasin Gishu, and Trans-Nzoia; and
- The west-southwest Lake Victoria Basin, encompassing south western Uganda and northern Rwanda, and extending marginally westwards into the catchment of Lake Edward.
- Northwest Tanzania.

ECOLOGY

Grey Crowned Cranes require a mixed wetland-grassland habitat, and are often found in wetlands, on riverbanks, around dams, in open savannas, and in the grasslands adjacent to such sites (Urban 1988, Meine and Archibald 1996). They are also often found foraging in agricultural land wherever available in close proximity to any of the habitats listed here.

They nest within or on the edges of permanent or temporary wetlands but will also use well-vegetated farm dams. The nests are often within tall reedy wetland vegetation around 1 m in height (e.g., *Typha* reed beds), concealed from terrestrial predators and screened from view. They are, however, easily seen from the air. The area around nests is trampled into a relatively circular platform up to a 20-m diameter, supposedly to reduce the chance of predation (Pomeroy 1980, Tarboton 1992, McCann and Wilkins 1995, Smallie 2002). They will also rarely nest in trees (Steyn and Ellman-Brown 1974, Steyn and Tredgold 1977, Ewbank 2003).

Grey Crowned Cranes forage in short to medium height open grasslands, feeding on grass seeds, insects, frogs, lizards, crabs and other invertebrates (Pomeroy 1980, Frame 1982, Gichuki 2000, Muheebwa-Muhoozi 2001). They also forage in agricultural lands, including pastures, irrigated areas, fallow fields, and newly harvested and planted cereal crop fields. This habitat use unfortunately often brings them into conflict with farmers as a result of both the actual and perceived damage caused to crops. The Grey Crowned Crane's generalist foraging strategy has resulted in them adapting to human settlement and they are therefore often seen in human-modified environments (McCann and Wilkins 1995, Meine and Archibald 1996).

Grey Crowned Cranes roost primarily in tall trees in the vicinity of wetlands, but they are also found roosting on overhead electricity transmission towers, and in some cases, on the ground in open wetland-grassland systems. The cranes leave their roosts between dawn and an hour after dawn and return around nightfall (Pomeroy 1980, Olupot 2014).

NUMBERS AND TRENDS

The Grey Crowned Crane was considered the most common crane in Africa in 2004 with the population estimated at 50,000–64,000 individuals (Beilfuss et al. 2007). It has, however, been experiencing a steady, long-term decline across much of its range. When this species was up-listed from Least Concern to Vulnerable in the 2009 Red List update, there was some evidence to suggest that declines may have exceeded a rate of 50% during the past three generations or 45 years (Beilfuss et al. 2007), but data were regarded as patchy and an overall decline of 30–49% was considered a more reasonable estimate.

With the addition of more complete data, the calculated rate of decline in 2012 was ~65–80%. This sharp decline, together with the fact that the issues causing this decline, has been in existence since the 1960s and are showing no signs of abating, led to the up-listing of Grey Crowned Cranes from Vulnerable to Endangered in the 2012 Red List update (Birdlife International 2012).

In 2014, there were between 19,500 and 26,000 East African Grey Crowned Cranes and between 7,000 and 7,500 Southern African Grey Crowned Cranes, with a total of between 26,500 and 33,500 Grey Crowned Cranes (Table 1). They are most abundant in Kenya, South Africa, and Uganda, although Kenya and Uganda continue to suffer significant declines in numbers. South Africa currently has the most stable and viable numbers on the African continent, and the large floodplains of Zambia support smaller, yet substantial numbers. Mozambique, Rwanda, Tanzania, and Zimbabwe all have relatively small but still viable numbers of between 100 and 2,000 birds each. Burundi, Botswana, Malawi, and Namibia have very few Grey Crowned Cranes remaining, and the status of the species in Angola and the Democratic Republic of Congo is largely unknown. A recent exploratory visit to the Cuvelai Catchment in south-eastern Angola, though, had no sightings of Grey Crowned Cranes, and none of the local communities approached knew this crane (Scott and Scott 2014). John Mendelsohn (personal comm.) also reported no Grey Crowned Cranes during mammal surveys of the Bulozi Floodplain in eastern Angola but reported the potential for good numbers due to the suitable habitat available. Of note is that Southern Sudan has recently reported sightings of Grey Crowned Cranes, a new species for the country, but still in very low numbers. This occurrence is likely a range extension of the species up the Nile River, from the northern parts of Uganda (Timothy Dodman, and Perez Olindo, personal comm. 2016).

Table 1: Estimated number of Grey Crowned Cranes per country

Country	**1985 (Urban 1988)**	**2014 (Morrison 2015)**
East African Grey Crowned Crane		
Angola	100	0–100
Burundi	<600	10–100
Democratic Republic of Congo	5,000	300–1,000
Kenya	35,000	10,000–12,500
Malawi	100s	0–100
Northern Mozambique	1,000s	50–100
Rwanda	<1,000	50–500
South Sudan	0	0–10
Tanzania	Low 1,000s	600–1,000
Uganda	35,000	6,500–8,000
Zambia	1,000s	2,000–2,500
East African subspecies total	*>90,000*	*19,500–26,000*
Southern African Grey Crowned Crane		
Botswana	100	<20
Southern Mozambique	1,000s	>250
Namibia	100	<20
South Africa	Low 1,000s	6,500
Zimbabwe	Several 1,000s	200–700
Southern African subspecies total	*10,000*	*7,000–7,500*
TOTAL	**>100,000**	**26,500–33,500**

THREATS

An International Single Species Action Plan for Grey Crowned Cranes outlines clearly the current threats to the species and their level of threat (Morrison 2015). The unlawful removal of wild cranes for the illegal trade market is a significant threat to the species (McCann and Wilkins 1995, Hudson 2000, Smallie 2002, Morrison et al. 2007). Most often, chicks are removed and, through a well-developed market chain, either end up in domesticated situations within country or in the local or international captive trade markets. Kept at hotels in Burundi and Rwanda or in private households in the Democratic Republic of Congo, Rwanda, South Africa, and Uganda, Grey Crowned Cranes have been sought after as status symbols or as "decoration" for gardens. They are also acquired for captive facilities around the world, adding beauty and value to mixed savanna exhibits or contributing to private bird collections. Although Europe and the United States of America were key contributors to this threat in the 1970s and 1980s, it is now the Middle and Far East that pose the greatest threat. Although Grey Crowned Cranes are strongly sought after for captive facilities and can breed well under the correct conditions, there are currently no viable managed populations in captivity in the world. This situation is changing as zoos belonging to formalized zoo associations have acknowledged the concern and are now initiating collaborative programs to rectify the situation. However, the challenge is in working with the 90% of captive facilities around the world that do not belong to a zoo association and do not collaborate with other such facilities in any meaningful manner.

There has been significant loss and degradation of suitable wetlands for nesting, and in the surrounding catchment for foraging, as a result of agriculture, afforestation, changes in hydrology, mining, and siltation. The rate of transformation of wetlands and surrounding grasslands, savannas, or forest catchments into various forms of agriculture in Eastern Africa is particularly alarming. This transformation started in earnest in the 1970s across many parts of Eastern Africa. In several places, catchments have now been completely transformed into subsistence agriculture, such as the catchment for Rugezi Marsh in northern Rwanda and the catchment for Nyamuriro wetland in southwestern Uganda. In other areas, the speed and rate of transformation is increasing, such as the spread of sugarcane (*Saccharum*) and Eucalyptus plantations used to supply the power line industry in parts of western Kenya and rice (*Oryza* spp.) production in Uganda. The 2011 South African National Biodiversity Assessment predicted that by 2050 no natural habitat would be left outside of protected areas in KwaZulu-Natal, based on the current rate of transformation; this area is key for Grey Crowned Cranes in South Africa. In addition, proposed coal mining and gas extraction have become an increasing concern for the grasslands and wetlands in South Africa, and plans to extract peat from many of the large wetlands in Rwanda for power production are major concerns for the future of the species in these countries.

The rate of fragmentation of natural habitat, growing human populations, and increase in agricultural activity have resulted in increased human activity and disturbance levels around wetlands where Grey Crowned Cranes would naturally breed. Disturbance has impacted on breeding success, with pairs no longer breeding in areas with high disturbance and a reduced productivity in other areas where fewer chicks are raised to fledging (Morrison 2015).

Habitat loss and degradation, disturbance, and illegal trade are linked threats that can escalate each other. For example, as habitat fragmentation increases there is a corresponding intensification of human activities that results in higher disturbance levels. Breeding cranes become more visible to communities living in the area, and with improved access to the cranes, the removal of cranes from the wild escalates.

The fourth major threat is poisoning. Persecution is a major threat in certain areas, most often in the form of poisoning, in an attempt to reduce the real or perceived damage that cranes cause to crops (Johnson and Barnes 1986, Smallie 2002, McCann 2003, Morrison 2015). Being opportunistic, Grey Crowned Cranes are often seen foraging in agricultural lands. Although eating insects and other potential pests and weeds, they do also cause damage to germinating maize (corn, *Zea mays*), wheat (*Triticum aestivum*), beans, cabbages (*Brassica oleracea*), cobs of maize when ripe, and other crops. Whether on subsistence or commercial agriculture, this behavior results in conflict frequently resolved through deliberate poisoning. In addition, farmers that target other birds causing crop damage inadvertently poison and kill cranes. Finally, cranes are sometimes incidental in poisoning aimed at obtaining other birds and mammals for food. Cranes are often left after poisoning and not eaten because they do not have a crop (or croup, a muscular pouch near the throat used as temporary storage for food), and the belief is that if crops are removed quickly enough after ingestions then the poison will not harm the people eating the meat. In other cases, local taboos against eating cranes may also be at play.

The final major threat to Grey Crowned Cranes is related to energy generation and transportation, including collisions with overhead power lines, electrocutions on electrical infrastructure, and the possible collision with turbines on wind farms. Power lines pose a collision hazard to both young inexperienced birds and adults, particularly in poor weather or low light conditions, and transformer boxes and t-pole structures on 11 and 22 kV lines pose an electrocution risk when Grey Crowned Cranes attempt to roost or perch on electrical infrastructure (McCann and Wilkins 1995, Smallie 2002). Power line interactions are a major cause of mortality for Grey Crowned Cranes in South Africa but appear at present still to be a low threat in other African countries, perhaps due to the relatively restricted power line network and lack of systematic and dedicated/frequent power line surveys. As the African continent continues with its electrification plans, and more power lines are erected across the continent, so will this threat grow for Grey Crowned Cranes.

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

Conservation Action

- An African-Eurasian Migratory Waterbird Agreement (AEWA) Single Species Action Plan has was developed for Grey Crowned Cranes across their range. The development of the plan brought together government department representatives and crane experts from each of the significant range countries, in a coordinated and focused approach to secure the future of Grey Crowned Cranes. The plan was endorsed at the AEWA Meeting of the Parties in November 2015. An International Working Group will be established to ensure the plan's implementation;

- A Biodiversity Management Plan for Species is being developed for cranes in South Africa, a legislated process to outline and ensure relevant conservation action for the future of the species in the country. Such plans are being developed for Grey Crowned, Wattled, and Blue Cranes in collaboration with all relevant stakeholders;

- The International Crane Foundation (ICF) / Endangered Wildlife Trust (EWT) Partnership is addressing trade through the African Crane Trade Project. This project works simultaneously with the supply side of the market where cranes are removed from the wild, on the compliance and legislative areas, and with the demand sector both in Africa and globally;

- In Rwanda the crane trade and domestication of Grey Crowned Cranes is being addressed through a collaboration of a number of key stakeholders, including the Rwanda Wildlife Conservation Association, Rwanda Development Board, Akagera National Park / African Parks Collaboration, and others. The project is creating awareness of the threat and is confiscating all illegally held cranes, either to be released or to be held in a suitable captive situation;

- The ICF/EWT Partnership has a Cranes, Wetlands and Communities Project aimed at securing and improving the ecological integrity of wetlands and catchments in key crane areas across Africa. This effort involves collaboration with local communities and relevant authorities and includes the development of livelihoods as alternatives to practices that degrade wetlands, or that add value to the wetland. In South Africa, full-time EWT staff cover the grasslands of Mpumalanga, KwaZulu-Natal, and the north Eastern Cape grasslands. In other countries, the ICF/EWT Partnership works through partnerships with in-country organizations to achieve this goal;

- The ICF/EWT Partnership, working with the Zambian Wildlife Authority, has initiated a crane and wetland project in Zambia. This project aims to obtain a good understanding of the status of Grey Crowned Cranes across the large flood plains of the country and to unlock the interrelationship between crane distribution and breeding and the hydrology of these systems. In addition, the threats to cranes and their habitats are being investigated and mitigation measures explored, for example, for the control of *Mimosa pigra* on the Kafue Flats;

- The Kipsaina Crane and Wetland Conservation Group and Community Action for Nature Conservation (CANCO), in partnerhsip with the ICF/EWT partnership, are working to increase awareness, and to secure and improve the ecological integrity of sites important to cranes in western Kenya;

- In partnership with the ICF/EWT partnership, Nature Uganda has a community-based crane and wetland project focused on increasing awareness and securing and improving the ecological integrity of important crane sites in the country;

- Nature and Livelihoods, a non-governmental organization, is conducting research to better understand Grey Crowned Cranes in the eastern part of Uganda;

- BirdLife Zimbabwe has a project in the Driefontein Grasslands in Zimbabwe that supports crane and wetland conservation in collaboration with local communities, and has been exploring ways to mitigate for crop depredation caused by cranes;

- The Rwanda Polytechnic: Kitabi College and the ICF/EWT Partnership have partnered to ensure the ecological integrity of Rugezi Marsh in Rwanda, together with enhancing local community livelihoods and involving relevant government authorities;

- In a study conducted by the ICF/EWT Partnership, University of Massachusetts, and the Tanzania Bird Atlas, the only sustainable Grey Crowned Crane population in Tanzania outside of protected areas was found in the Rungwe Region. Further investigations are required to explore the options for a community-based conservation project in this area;

- The ICF/EWT Partnership is working with an agrochemical company in South Africa to explore the registration of a crop deterrent used effectively in the USA to deter Sandhill Cranes from eating germinating crops. This substance would be used in commercial agriculture to reduce damage that cranes and other birds cause to crops;

- The EWT's Wildlife and Energy Programme (WEP) has a strategic partnership with Eskom, South Africa's power utility company, aimed at addressing and mitigating the threat that power line collisions, electrocutions, and the wind energy industry represent for cranes and other bird species. A project aimed at sharing the skills and expertise gained in South Africa and building capacity in other countries in Africa is preparing a proactive approach to this threat; and

- The Wetlands International/IUCN Crane Specialist Group has a focus on cranes and power lines, and has developed a plan for shared learning and proactive action globally.

CHANGES SINCE 1996

Grey Crowned Crane numbers have declined dramatically since 1996, with less than 33,500 individuals remaining. The threats to the species have escalated and intensified since 1996 and currently show no signs of abating, only of escalating further.

PRIORITY RESEARCH AND CONSERVATION ACTIONS

The top priorities for research and conservation action for Grey Crowned Cranes have been drawn from the AEWA Single Species Action Plan, ICF's Strategic Vision for 2020, and this Crane Conservation Strategy developed for the Wetlands International / IUCN Crane Specialist Group. Note that the actions below are not in any particular order.

Research

- Develop standardized monitoring techniques for Grey Crowned Cranes across their range so that population trends and breeding success can be assessed, providing information on the status of the population and guidance for the adaptation of conservation action required;
- Obtain an understanding of the factors that influence the population dynamics of the species, including the influence of disturbance and other factors that specifically affect breeding productivity and adult and juvenile mortality;
- Understand the types and extent of damage that cranes cause to food crops and test methodologies that are both cost effective and efficient for use to reduce conflict between people and cranes in subsistence agriculture;
- Understand the interaction between cranes and people and how this relates to habitat requirements and extent of suitable habitat available for Grey Crowned Cranes;
- Analyze potential risks and opportunities arising from strategic long-term urban, infrastructure, energy and land use development plans;
- Understand the impacts of climate change on habitats and cranes and how the interactions between cranes and people will also change;
- Better understand the extent of poisoning across the Grey Crowned Crane range;
- Understand the ecological and economic value of cranes;
- Develop protocols to measure the effectiveness of conservation measures and encourage uptake of the protocol;
- Understand the trade demand for cranes and the market chains being used; and
- Understand crane movement patterns seasonally and temporally.

Conservation Actions

- Secure and improve the ecological integrity of key crane sites and their catchments, in collaboration with local communities and the relevant authorities, using sustainable management practices that benefit both cranes and people;
- Reduce disturbance during the breeding season by increasing awareness, and regulating the use of key sites through management plans or designating sites as protected areas;
- Minimize the impact of the wild-caught crane trade through sustainably managing captive populations, reducing demand and supply, increasing awareness, and improving capacity and law enforcement through the market chain;
- Reduce the risk of poisoning through the development of cost-effective and affordable methods to reduce crop damage, promote responsible agrochemical use, and strengthen law enforcement and regulations as they relate to poisoning;
- Reduce the impact of mortalities from power lines by providing cost-effective mitigation measures, and by implementing the resolutions and applying the conservation guidelines on avoiding and mitigating the impact of power lines on birds, adopted under AEWA and CMS;
- Proactively seek to prevent planned afforestation that would have impact on crane habitat;
- Reduce the destruction and degradation of key crane habitats as a result of agriculture through the provision of alternative livelihoods and the development and implementation of best practice guidelines for environmentally friendly agriculture;
- Strengthen law enforcement and regulations relating to habitat destruction and degradation at key Grey Crowned Crane sites;
- Identify Grey Crowned Crane sites threatened by alien invasive plants, and develop and implement mitigation plans to remove this threat, where possible using methods that benefit the local community; and
- Address the impact of energy development, including power lines, wind farms, coal mines, peat extraction and gas extraction, in sites important to cranes.

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SPECIES REVIEW:
WHITE-NAPED CRANE (*Grus vipio*)

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(with input from Yachang Cheng, Oleg Goroshko, Yumin Guo, Yuko Haraguchi, Hall Healy, Elena I. Ilyashenko, Yifei Jia, Kisup Lee, Kunikazu Momose, Kirk Olsen, Ri Kyong Sim, Sergei M. Smirenski, Liying Su, and Seungwha Yoo)

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White-naped Crane in reed marsh in China (Photographer: Crane Wu)

Red List Category: Vulnerable
Population Size: 6,700–7,700
Population Trend: Mixed; eastern population increasing; western population decreasing
Distribution: Northeast Asia

Mirande CM, Harris JT, editors. 2019. Crane Conservation Strategy. Baraboo, Wisconsin, USA: International Crane Foundation.

DISTRIBUTION AND STATUS OF KEY SITES

The White-naped Crane (*Grus vipio*) shares a similar breeding range to the continental population of Red-crowned Cranes (*Grus japonensis*), occurring in wetlands across much of the Amur/Heilong Basin and adjacent areas in Russia, China, and Mongolia (Meine and Archibald 1996). Agriculture development has greatly reduced and fragmented its distribution (Jim Harris, personal comm. 2017). Preferring shallower waters than the Red-crowned and more readily foraging on uplands, the species ranges farther west than the Red-crowned (the latter species is rare in Mongolia, where the greatest density of breeding White-naped Cranes occurs) (Liying Su, personal comm. 2017).

The breeding sites for the majority of White-naped Cranes are found in northeastern Mongolia (Mongol Daguur Strictly Protected Area, Onon River Basin, Khurkh and Khuiten River Valleys, and several other locations), northeastern China (including Zhalong, Tumuji, Hui River, Dalai Lake National Nature Reserves, and several wetlands in Sanjiang Plain, particularly in the Naoli-Qixing River Basin), and wetlands in southeastern Russia (including Muraviovka Park, Daurski, Khinganski, and Khankaiski State Nature Reserves, and several game refuges). White-naped Cranes that breed in the western part of the range are believed to migrate through China to winter at Poyang Lake, China (Jia 2016), and (at least formerly) in surrounding areas, while birds that breed in the eastern part of the range migrate south through Korea. Approximately 50% of the global population of White-naped Crane has been documented in Mongolia (Wildlife Conservation Society 2013). However, less than a quarter of the known population overwinters in China (Li et al. 2012).

The Korean Demilitarized Zone (DMZ) is a wintering or staging area for more than 3,000 White-naped Cranes (over half of the world population). Departure or arrival of White-naped Cranes at different wintering areas varies according to local conditions. Individuals are known to winter in or near the DMZ (primarily at Cheorwon Basin and with small declining numbers at the Han River Estuary) and small numbers elsewhere in the Republic of Korea (ROK, South Korea). Many others continue south to winter at the Izumi Feeding Station in southern Japan. Some birds, however, depart late from Cheorwon in the DMZ for Japan, and others return early to the DMZ from Japan so that varying numbers are present in the DMZ through the cold months (Kisup Lee and Yuko Haraguchi, personal comm. 2015). An estimated 4,500–5,000 move between Korea and Japan (Kisup Lee and Yuko Haraguchi, personal comm. 2015), and counts are being conducted several times each winter to investigate movement patterns.

While some sites on both breeding and wintering grounds receive protection, important sites remain outside the network of protected areas including breeding areas at the Khurkh and Khuiten River Valleys in Mongolia and wintering habitat in the Cheorwon Basin in ROK. There is a need to designate additional protected areas for wetlands used during dry periods in the forest-steppe zone of Russia and Mongolia. Similarly, most migratory stopover sites are not protected. Recent research has identified at least two significant areas in China in need of protection, including Miyun Reservoir and Duolun (Jia 2016); no stopover sites are protected in ROK. Telemetry work conducted by Japanese colleagues in the 1990s identified important resting sites in the Democratic People's Republic of Korea (DPRK, North Korea), including the Baekchon wetlands (DPRK Natural Monument No. 164), the Eunyool fields (DPRK Natural Monument No. 133), and wetlands near Mundok, Kumya, Orang, and Sonbong (Chong et al. 1994).

Protected wetlands are highly vulnerable to actions that would affect hydrology of crane habitats within the watersheds but outside boundaries of the protected areas. As one example, construction of hydropower dams on the Zeya and Bureya Rivers in the Amur Province of Russia has prevented the major flood events that occasionally scoured out lowland areas in downriver parts of the floodplain, removing sediments and vegetative debris. As a result, wetlands are gradually filling in, with a reduction in habitat suitable for cranes (Kazachinskaya 2012).

Subspecies/Populations

There are no subspecies of White-naped Cranes. There are two main wintering populations, one in the mid Yangtze Basin of China and the other in ROK and at Izumi, Japan. The extent of exchange between these two populations is unknown. While it is believed that most cranes breeding in Mongolia winter at Poyang Lake, one individual is documented to have taken the eastern flyway into Korea (Tseveenmyadag Natsagdorjign, personal comm. 2012).

ECOLOGY

For breeding habitat, White-naped Cranes rely on shallow wetlands and wet meadows typically found in broad river valleys, lake edges, and in lowland or mixed forest steppes (Meine and Archibald 1996). This species will also utilize these habitats for foraging, as well as nearby grasslands and farmlands. During migration and on their wintering grounds, cranes mainly feed on tubers, seeds, and waste grain, which they find in mudflats, wetlands, rice (*Oryza sativa*) paddies, and other farmland. In natural wetland habitats, individuals often stand in one place and dig for tubers of aquatic plants, in contrast to Red-crowned Cranes that share many of the same habitats but normally walk about while foraging and picking food from the surfaces of plants or water (Su 1993). Red-crowned and White-naped Cranes often breed in the same wetlands, with the Red-crowned Cranes preferring deeper water than the White-naped Cranes. These distinctive ecological differences between the two species apparently allow them to inhabit the same areas without inter-specific territoriality. At Muraviovka Park during the breeding season, single White-naped Cranes regularly fly out from the wetlands to forage on farmlands; once chicks can walk well, families sometimes venture onto the uplands as well. Red-crowned Cranes utilize these farmlands to a much lesser extent, mainly by non-breeding individuals or during migration but seldom adults with eggs or chicks during the breeding season (Sergei Smirenski, personal comm. 2016).

The two species thus have different vulnerabilities to human activity. In the 1990s, as local farmers encroached on the wetland edges at Zhalong, the White-naped Cranes were more adversely affected (Liying Su, personal comm. 2015). But in more recent years at Muraviovka Park and other areas, water diversions and drought have meant that deeper water habitats have evolved into shallow marsh and sedge meadows better suited to White-naped than Red-crowned Cranes. While Muraviovka Park formerly supported 5–10 breeding pairs of each species, in 2012 Muraviovka Park had 18 nesting pairs of White-naped Cranes but only three pairs of Red-crowned Cranes (Sergei Smirenski and Tamaki Kitagawa, personal comm. 2015).

Winter diet and foraging habitat for White-naped Cranes vary among the three main wintering areas. In Japan, the cranes are artificially fed although some forage on nearby farmlands. In the DMZ, most cranes feed on waste grain in rice and other fields, although artificial food is sometimes provided during severe weather. At Poyang Lake, White-naped Cranes feed in shallows and wet muds on tubers of *Vallisneria* in company with Siberian Cranes, or in the drier and slightly higher sedge-grass zone in company with Hooded Cranes. Occasionally, the White-naped Cranes may forage in fallow rice paddies.

NUMBERS AND TRENDS

This species is more easily counted on its wintering grounds where it concentrates in only a few locations. Its current population is estimated at 7,000 to 7,800. However, there are challenges to getting accurate counts for both populations. The western population wintering in China ranges over the vast, inaccessible shallows and mudflats of Poyang Lake where aerial and ground surveys can easily miss birds or double- count those moving during the count period. On its eastern flyway, while the vast majority winter in very limited areas along the DMZ and at Izumi, individuals have been spending more of the winter in Korea, with a substantial number only moving south to Izumi in mid-winter. Counts are therefore being carefully synchronized among the locations, in particular between Korea and Japan.

The wintering population of White-naped Cranes at Poyang Lake 15 years ago was estimated at 3,000 and has since dropped by two-thirds, to >1,000 or fewer cranes. Results of multiple counts averaged over a period of years serve as a more reliable indicator of population change than counts for single winters. The average of eight basin-wide counts from 1996–2004 was 2,278 White-naped Cranes. In contrast, the average of six counts from 2005–2012 was 1,167 (Li et al. 2012).

In contrast, the White-naped Crane population is increasing in the eastern parts of its range, growing from 4,900–5,300 (Meine and Archibald 1996) to 5,500–6,500 individuals (Wetlands International 2012). The last years have seen more rapid growth to a current 6,200–6,500, based on multiple counts from winters 2012–13, 2013–14, and 2014–15 (Haraguchi 2014a,b; Kisup Lee and Yuko Haraguchi, personal comm. 2016).

The trends in the two populations may be attributed to White-naped Cranes shifting from the western to the eastern flyway. Alternately, the changes in size of the two populations may be due to conditions on the breeding grounds related to rainfall patterns, which have been distinctly different in the western and eastern parts of the range (Simonov and Dahmer 2008). This part of Asia exhibits a strong gradient of declining rainfall from east to west. Eastern portions of the range lie within forested or formerly forested regions with relatively stable rainfall from year to year (700–800 mm rainfall annually on average in the Ussuri Basin on the Russia-China border). But as one moves west, conditions become less favorable for forests or croplands until rainfall is too erratic to support crops without irrigation, and grasslands supporting cattle, sheep, and other livestock now predominate (annual rainfall of 300 mm or less for the Onon River Basin of northeast Mongolia). These western regions have erratic rainfall and tend to experience cycles of drought and wet. On the Daurian steppe where Mongolia, Russia, and China come together, these cycles span roughly 25–30-year cycles. The decade after 2000 was characterized by increasingly severe drought, succeeded with increasing rainfall beginning around 2012–2014.

In the western part of the breeding range, during the drought years after 2000, crane reproduction had dropped dramatically (Goroshko 2012). While data on crane reproduction from the eastern part of the range is lacking, conditions remained more stable during this decade and may have favored successful nesting. In addition, cranes migrating as far south as Izumi have an abundant food supply of artificially provided food at the feeding stations, which likely has favored survival of chicks.

THREATS

Range-wide

- Conversion of wetlands to agriculture on breeding and migratory areas, especially in China and Far East of Russia;
- Changes in agricultural land use on wintering sites in China and Korea;
- Poisoning of cranes, either from chemicals placed on bait to catch waterfowl and other birds for the market, or from cranes eating seeds coated with chemicals to kill invertebrate pests. Poisoning of Red-crowned Cranes, a species that occupies a similar range, is believed to be a significant cause

for decline of this species on its western flyway (Su and Zou 2012). Dead Red-crowned Cranes, due to the cultural prominence of this species and its white color, are likely to be reported with much greater frequency than the predominantly dark White-naped Cranes. But the latter species utilizes farmlands more frequently and may be more vulnerable to poisoning. Two of three White-naped Cranes tracked migrating north from Poyang Lake in spring 2014 appear to have been poisoned at Duolun, Inner Mongolia, a major unprotected stopover area for the species. One crane tracked on its way south in fall 2014 was rescued in a poisoning incident involving six White-naped Cranes. Fortunately, four of the cranes were rescued and released (Shengwu Jiao, personal comm. 2015); and

- Collisions with power lines.

Breeding Grounds

- Changes in hydrology and loss of suitable habitat due to water control projects;
- In western parts of the breeding range, prolonged drought associated with the dry portion of 30-year climate cycles reported for this region, perhaps also an indication of long-term climate change;
- Fires that destroy nests, eggs, young, and/or vegetative cover. Fire danger grows much more severe during drought or when diversions and other human activities reduce water levels in the wetlands;
- Disturbances from people and livestock. This problem has become more severe due to fragmentation of breeding habitats in the eastern part of the range, where pressures to expand farmland are greater, and in more sparsely inhabited western parts of the range due to prolonged drought that caused concentration of breeding birds, people, and livestock within the shrinking areas of available water (Goroshko 2012). Predation from free-roaming dogs may be a problem and is being studied in Mongolia;
- Spring hunting is serious threat in Russia. Although the White-naped Crane is not a game species, legal spring hunting of other waterbirds creates intensive disturbance for breeding cranes;
- Taking of eggs by people. This problem may be growing due to wetland fragmentation and expanding human activities in China;
- Illegal hunting of cranes in Russia; and
- Mining development. Mining is accelerating in Mongolia and also expanding in parts of Russia and China, leading to habitat loss, wetland degradation, water diversion, and pollution of waterways.

Wintering Grounds

China

- Dams and diversions of water that alter critical wetlands. Plans have been advanced for many years to dam the outflow of Poyang Lake with a goal to stabilize water levels and enhance economic activities year round. If implemented, this plan could flood current crane habitat that might result in a dramatic decline in crane populations (Harris and Zhuang 2010). Even if operation of a dam provided for preservation of shallow water areas, stabilization of water levels could negatively impact productivity of the wetland, including the tuber-producing submerged aquatic plants, an important food source for White-naped Cranes;
- Recent years have seen greater fluctuation in water among years, with more frequent floods and droughts at unseasonable times. For example, during the normally dry late autumn period in 2015, heavy rains raised water levels of Poyang by 5 m in 20 days (Guanhua Liu, personal comm. 2015).

While waterbirds appeared still able to find food, they shifted away from typical habitats (in many cases within protected areas) to areas of greater human use such as fallow rice paddies. Aside from the high water that prevented birds from accessing food, early flooding in summer 2015 may have wiped out the favored food *Vallisneria*, forcing a shift in diet. These extreme events may reflect climate change and also result from changes in the watershed and encroachment on wetland edges around Poyang;

- Sand dredging, that for years was concentrated near the outlet to Poyang Lake, appears responsible for early and rapid outflow from the lake in autumn, causing shortages of water needed for irrigation (de Leeuw et al. 2010, Lai et al. 2014). Low water levels in early autumn are one reason a water control structure across the lake outlet has received close consideration over the last five years. Sand dredging also raises turbidity of the water, a negative trend for growth of *Vallisneria* that needs a clear water column so that light can penetrate to the rising stems and leaves;

- Declining water quality could lead to poor conditions for *Vallisneria* and other food plants at Poyang Lake, or even a major shift away from macrophytes to a system dominated by phytoplankton (Fox et al. 2010);

- Human disturbance;

- A recent ban on grazing of water buffalo (*Bubalus bubalis*) around the exposed meadows surrounding Poyang as waters recede in winter—to reduce the spread of schistosomiasis among local people—is already leading to changes in the sedge/grass community. Tall, rank vegetation discourages foraging by cranes and other waterbirds, especially geese that depend in part on this habitat (Jiefeng Jin, personal comm. 2014); and

- Poisoning in agricultural areas.

Japan

- The severe loss of wetlands across the wintering grounds of White-naped Cranes and the artificial feeding at the Izumi Feeding Station in Japan have caused an unnaturally high concentration of birds, which are now dependent on intensive and costly feeding and security measures. If Kagoshima Prefecture and the Japanese government discontinue land rental, purchase of wheat (*Triticum aestivum*), artificial feeding, or roost protection, the birds would be forced to disperse without adequate alternative wintering sites;

- Daytime foraging areas on private lands outside the protected area are threatened by human disturbance, road development, and power lines at Izumi;

- The cranes at Izumi use the nearby rice fields, and resulting damage to vegetables and to water dikes between rice fields causes conflict with humans. Local community values could shift to prioritize development over crane-compatible agriculture; and

- Because of the high density of birds at the Izumi Feeding Station, there is a risk of a significant disease outbreak. In winter of 2010–11, nine White Naped Cranes were found dead at Izumi, although none were associated with the highly pathogenic H5N1 avian influenza virus. The same winter 55 Hooded Cranes were found dead, of which seven had died of H5N1 (Haraguchi 2011). Although this incident did not develop into a significant mortality event and cranes are currently thought to be less at risk from H5N1 than waterfowl or many other bird species, it is a reminder of how vulnerable these populations could be to a more virulent H5N1 or other disease. There are also poultry farms holding about 5.2 million chickens in Izumi City, Kagoshima prefecture

(Izumi Agricultural Department, personal comm. 2014). Regulatory authorities are very concerned about the presence of any infectious disease in the Izumi cranes and the resulting possible risks to the poultry industry; this concern could result in negative feelings and pressure for alternative management for the cranes.

Korea

- Commercial development of the Civilian Control Zone (CCZ) buffer area, which is the primary location where cranes feed on rice gleanings. In recent years, the Republic of Korea's government has allowed expanding human activity in the CCZ, leading to increased disturbance from photographers and construction of greenhouses by farmers. The Ministry of National Defense removed about 504 ha of land from the CCZ near Yangjiri in 2013, and removal of more land is expected;
- Double cropping, greenhouses, plastic sheeting on crops, plowing land after harvesting, collecting all straw for livestock feed, and spraying of liquid manure all reduce food availability for cranes in the CCZ;
- Development of lowland parts of the DMZ, which is the most important feeding and roosting habitat for cranes;
- Increase in power lines and disturbance, partly to provide light and heat for greenhouses across feeding areas important to cranes;
- Low sense of urgency and environmental consciousness among major governmental and corporate decision makers about the importance of protecting the DMZ and CCZ habitats;
- Disturbance from increasing tourism including photographers and birdwatchers at roosting sites outside of DMZ or CCZ; and
- Political tension between nations, leading to a breakdown in conservation activities and resulting in vulnerability of DMZ habitats.

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

General

- The species has some level of protected status in all range countries; most locations currently used by the species have some degree of protection by national or local governments with the major exception of Cheorwon Basin and the DMZ, which have persisted in a natural state due to the security situation;
- Monitoring cranes and their key wetlands have been carried out in parts of the Amur/Heilong River Basin, and at wintering sites at Poyang Lake, Cheorwon in ROK, and Izumi in Japan. Long-term studies of White-naped Cranes have been carried out by staff of Daurski State Nature Reserve and Muraviovka Park in Russia, with similar efforts in northeast Mongolia. Data on numbers and migration are regularly shared among researchers along the flyway;
- Some sites important to the White-naped Crane belong to the waterbird flyway site network under the East Asian – Australasian Flyway Partnership, and/or are proposed to be nominated for designation as Ramsar sites;
- A workshop, Conservation and International Cooperation for Hooded and White-naped Cranes, held in Japan in November 2003, provided updates on current population surveys, banding and telemetry work, range and habitat assessments, and migration stop-over and wintering range (Korea

and Japan) conservation actions. The idea of forming a White-Naped and Hooded Crane East Asia Network was discussed;

- A White-naped and Hooded Crane Network was initiated in 2015 and met in March 2015 near Huanzidong wetland in Liaoning Province of China; and

- North-east Asian Subregional Programme for Environmental Cooperation (NEASPEC) selected two species of cranes including the White-naped Crane and Hooded Crane as priority flagship species; scoping surveys and joint studies are underway in transboundary areas in Mongolia, China, Russia, and ROK including threat assessments, population monitoring, community awareness, and crane counts at wintering and breeding sites.

Western Population

- Protected areas at Poyang Lake have expanded to cover over half the wetlands of the lake basin, and capacity is growing for research and management by Poyang Lake and Nanishan National Nature Reserves;

- Research, monitoring, public education, and technical advice regarding the Poyang Lake ecosystem is ongoing, involving numerous organizations such as International Crane Foundation (ICF), World Wildlife Fund, Beijing Forestry University, and others within and outside China;

- Global Environment Facility (GEF) funding, through the United Nations Food and Agriculture Organization (FAO), is expected for the Poyang Lake National Nature Reserve. Another GEF project, through UN Development Programme, is planned for the migratory stopover at Shengjin Lake in Anhui;

- Research and advocacy is ongoing for water supply to sustain wetlands important for cranes in northeast China.

- ICF is cooperating with the Chinese Academy of Science and Momoge and Tumuji National Nature Reserves on a demonstration project assessing climate change vulnerability, developing climate change adaptation plans, and implementing pilot activities;

- The Asian Development Bank recently implemented a major project on behalf of six protected areas with White-naped Cranes in Sanjiang Plain; GIZ (German Corporation for International Cooperation) funded a four-year project to improve capacity in two reserves in Sanjiang and the Yellow River Delta;

- ICF, Wildlife Science and Conservation Center, Mongolian Academy of Science, U.S. Forest Service, Beijing Forestry University, Poyang Lake National Nature Reserve, and the Korean Crane Network are cooperating on a migration tracking study for cranes nesting in the Khurkh and Khuiten Valleys of Mongolia and wintering at Poyang Lake;

- The Wildlife Conservation Society (WCS) chose the White-naped Crane as one of two primary focal species for its Living Landscapes Program on the Daurian Steppe (including Russia, China, and Mongolia). Research and conservation planning for the species were conducted by WCS in northeastern Mongolia;

- ICF, Wildlife Science and Conservation Center, Mongolian Academy of Science, and U.S. Forest Service are collaborating to conduct research on nesting ecology, hydrology, and rangeland management in the Khurkh and Khuiten Valleys of Mongolia and promoting protection of this key breeding habitat;

- Ecological education of local people living near crane breeding sites located outside of protected areas has been conducted by staff of the Daurski State Nature Reserve in Russia; and

- Efforts by the Daurski State Nature Reserve to reduce crop depredation by cranes has significantly reduced illegal shooting of cranes by farmers.

Eastern Population

- Research and advocacy in ROK for crane protection in the DMZ, CCZ, and Han River has been carried out;

- At Izumi, rental and flooding of roosting habitat, artificial feeding, monitoring, and measures to reduce conflict with farmers are being put forth; and

- ROK and Japan have been coordinating to conduct accurate winter counts.

CHANGES SINCE 1996

The global population of the White-naped Crane has substantially increased in the past 20 years. Currently however, the eastern and western populations are not following the same trends. In the west, where natural habitat in winter is available, numbers have fallen by half. In the east, the species continues to increase even though very little natural habitat is left either in the Korean Peninsula or Japan.

The eastern population is increasingly dependent on the fragile situation on Cheorwon Plain where people increasingly use the CCZ; the future of the DMZ itself as a refuge for cranes and other wildlife depends on continuing the current balance between war and peace maintained by an uneasy truce. Izumi becomes increasingly crowded. While numbers of White-naped Cranes wintering there are reduced as more birds stay at Cheorwon, numbers of Hooded Cranes are increasing year by year.

During the past decade, the greatest loss of wetlands has probably occurred along coastal areas of the Yellow Sea in China and Korea (MacKinnon et al. 2012). Along China's 18,000-km coastline, for example, sea walls had been constructed along 11,000 km or 61% of the coastline by 2010. Bird watchers reported increasing crane numbers at Miyun Reservoir near Beijing. In spring 2014, 1,330 White-naped Cranes were counted (Yifei Jia, personal comm. 2014), a number representing most of the population wintering within China. However, the cranes are no longer using this site due to habitat alteration (Spike Millington, personal comm. 2018). An inland migration route leaves this population less vulnerable to coastal development. In 1985–1986, Williams et al. (1991) reported only small numbers migrating past Beidaihe on the coast of Bohai (part of the Yellow Sea), suggesting that the species may have long preferred the inland route. Yet a tracking study in the early 1990s indicated use of coastal wetlands by White-naped Cranes at that time (Harris et al. 2000).

Over the past 20 years, while additional sites have come under protection, the overall quality of habitats for White-naped Cranes has declined for breeding, migratory, and wintering periods as sites should be identified for quality assessment. Fragmentation of habitat—in particular after reclamation of most wetlands in the major crane breeding area of Sanjiang Plain in China—means that many birds may now be too disturbed by human activity to breed successfully (Liying Su, personal comm. 2014).

Factors that reduce breeding success—wetland reclamation, fires, human disturbance, habitat fragmentation—also force cranes into greater human proximity on farmlands and leave the species increasingly vulnerable to mortality factors such as poisoning and power line collisions.

PRIORITY RESEARCH AND CONSERVATION ACTIONS

General

- Sustain efforts for the long-term water supply to maintain wetland functions for key cranes habitats in all parts of the flyway;
- Designate additional protected areas, including wetlands used during dry periods in the forest-steppe zone of Russia and Mongolia, the breeding area at the Khurkh and Khuiten River Valleys in Mongolia, additional stopover sites on migration including Daedong and Cheongcheon River Estuaries in the DPRK, Miyun Reservoir, and Duolun in China, parts of the Cheorwon Basin in the ROK, Borzya River in Russia, and alternate wintering locations in Korea and Japan;
- Study migration routes and habitats used by cranes along its flyways, identify additional stopover locations, and determine if there is exchange between populations wintering in China and Korea/Japan;
- Develop strategies for responding to climate change impacts on the species and/or its habitat;
- Better integrate crane conservation with agriculture production by promoting environmentally friendly farming practices adjacent to wetlands, reducing human disturbance and better managing breeding habitat within farming areas (particularly in the Sanjiang Plain in China and Cheorwon and Yeoncheon in the ROK), and developing mitigation methods for crop depredation that meet local community needs;
- Improve enforcement of conservation regulations near crane habitats particularly for the western flyway;
- Develop monitoring program to gather reports of poisoned cranes and secure information from tissue samples from dead cranes (whether poisoned or not) of levels of toxins including heavy metals;
- Develop strategies to reduce mortality from poisoning resulting from cranes ingesting poisoned baits illegally placed to capture ducks and geese and crane, and from cranes ingesting seeds treated to increase crop yield. Strategies should include awareness, better monitoring, local community, and forestry bureau cooperative action, increased enforcement, and poisoning "hotlines"; and
- Improve crane population estimate methods and assess effectiveness of count techniques and timing. Collect data to investigate population trends for Daurian, Primorye, and middle Amur regions.

Western Population

- Closely monitor changing wetland conditions and food supply for White-naped Cranes at Poyang Lake and develop mechanisms to better integrate waterbird conservation with management for fisheries of winter sublakes at Poyang Lake;
- Reduce disturbance to cranes by tourists and photographers through better enforcement, public education, and visitor management;
- Work with local herdsmen communities in Mongolia, Russian Daurian Steppes, and northeast China to enhance management of grasslands and water resources, and to reduce disturbance to breeding cranes;
- To reduce effects of legal spring hunting, establish small "peace sites" on key breeding areas in Dauria where spring hunting is prohibited; develop model program at Khanka Lake; continue work to stop spring hunting in all of Russia; conduct ecological education for hunters; and strengthen protection of crane habitats during hunting seasons; and

- Increase prevention and control of grassfires on breeding grounds in Russia and Mongolia.

Eastern Population

- Reduce threats to quality of Korean wintering habitats in CCZ (Cheorwon and Yeoncheon) including power lines, greenhouses, ginseng (Panex) fields, and other farming practices adverse for cranes, and disturbance from tourists, photographers, and birdwatchers. Develop a protection and sustainable development strategy to reduce conflict between crane habitat protection, farmers' economic needs, and tourism;

- Continue international collaboration to find alternate sites in case the critical habitats of the DMZ and CCZ are developed;

- To offset impacts of urban development, develop alternative feeding sites in Gimpo and Imjin River Estuaries in ROK;

- Coordinate effort to protect and manage alternate wintering areas in Japan and facilitate the dispersal of significant number of cranes to those sites, reducing the need for intensive feeding and resulting crane concentration at Izumi. Conduct research on habitat selection preferences to help manage alternate wintering sites;

- Work with Japanese and Izumi City Governments to develop contingency plans for emergency response to a significant disease event at Izumi and other concentration areas building on model for highly pathogenic avian influenza;

- Coordinate counts between Japan and Korea to provide accurate winter numbers;

- Investigate the use of wetlands during migration through DPRK and coordinate with migration dates/numbers from Russia and other countries as appropriate;

- Advocate for strengthened regulations and raise awareness of disturbance to migrating Red-crowned, White-naped and Hooded Cranes at stopovers in DPRK;

- Communicate with local government and farm leaders to limit usage of agricultural chemicals including pesticides in DPRK; and

- Train managers and rangers in nature reserve and wetland management for stopover sites in DPRK.

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SPECIES REVIEW:

WATTLED CRANE (*Bugeranus carunculatus*)

Kerryn L. Morrison

(with inputs from Yilma Abebe, George Archibald, Rich Beilfuss, Brent Coverdale, Tariku Mekonnen, Ann and Mike Scott, Tanya Smith, and Hadis Tadele)

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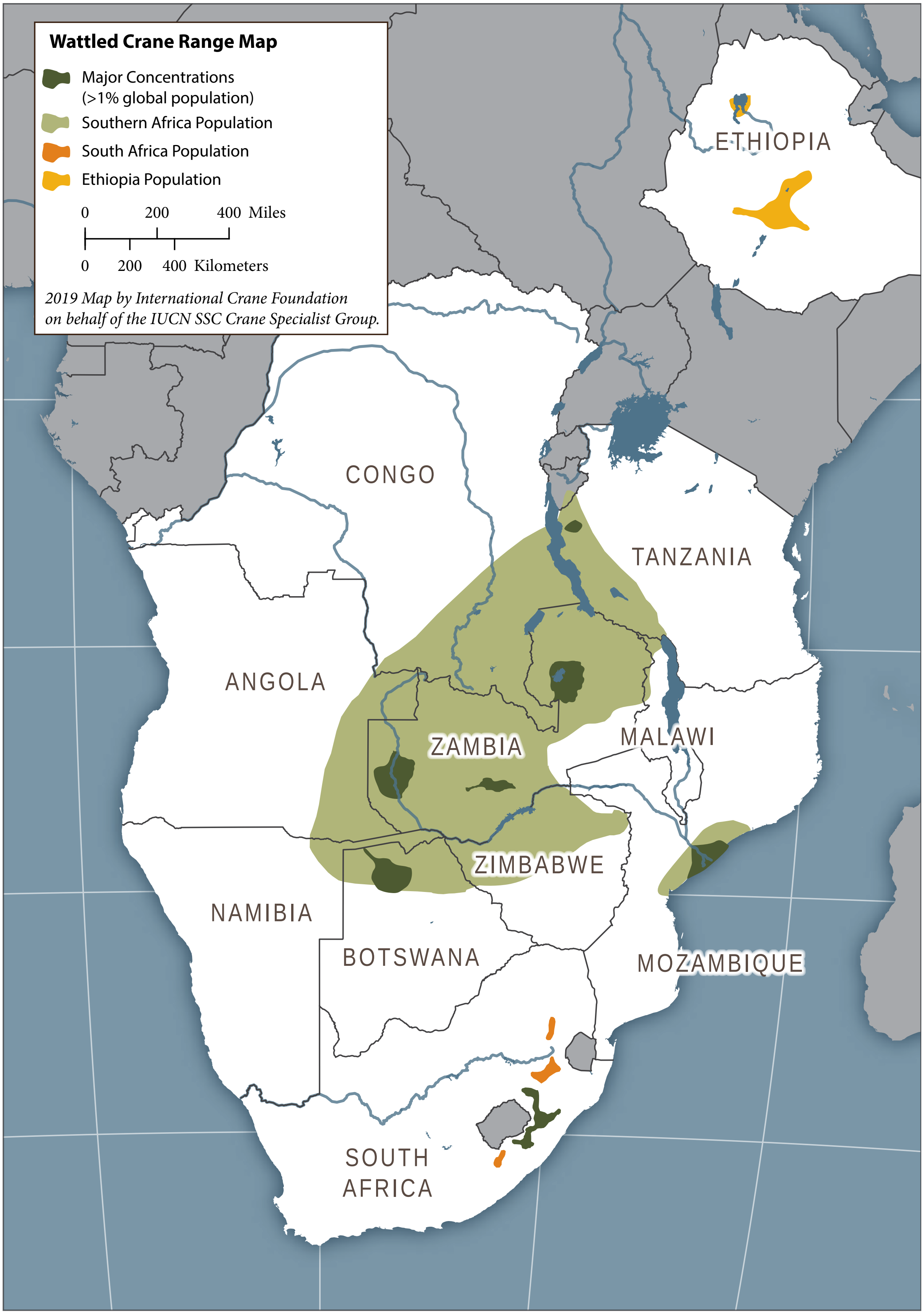
Wattled Crane with chick at nesting South Africa (Photographer: Daniel Dolpire)

Red List Category: Vulnerable
Population Size: >9,600
Population Trend: Probably decreasing
Distribution: Eastern and southern Africa



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DISTRIBUTION AND STATUS OF KEY SITES

Three isolated populations of Wattled Crane are recognized: two small isolated populations in South Africa and Ethiopia, and a larger, widespread, floodplain population in south-central Africa. Although no subspecies of Wattled Crane are recognized, evidence suggests that the South African population could be genetically distinct from those farther north (Jones et al. 2006). Despite the current lack of evidence, it is also possible that the Ethiopian population is genetically distinct due to its isolated nature (Burke 1996). As a result, both the South African and Ethiopian populations should be managed as distinct and separate populations from the larger south-central African population.

South-central Africa Population

Almost 95% of the world's population of Wattled Cranes is found in the south-central population. Around 75% of the south-central population is distributed across five key flood plains, namely the Okavango Delta in Botswana, the Kafue Flats, Barotse Floodplains, and Bangweulu Swamps in Zambia, and the Zambezi Delta in Mozambique (Beilfuss et al. 2007). Although each of these sites is legally protected to some degree, the level to which this protection is enacted differs among each of the regions.

- The Kafue Flats (~2,900 Wattled Cranes; Shanungu et al. 2015) in the southern region of Zambia occur on the lower Kafue River, a tributary of the Zambezi River. It is recognized as a Wetland of International Importance under the Ramsar Convention and is protected in part by two national parks, Lochinvar on the south bank and Blue Lagoon on the north bank, and by the Kafue Flats Game Management Area that surrounds both parks. About 60% of Blue Lagoon and 50% of Lochinvar National Parks are located on the floodplain and are inundated by annual floodwaters. The greatest threats to the Kafue Flats for Wattled Cranes at this time are the invasion of the alien invasive plant, *Mimosa pigra*, and the disruption of hydrological flows as a result of the hydroelectric dam at the start of the Flats.
- The Liuwa Plain National Park, a protected area on the Barotse Floodplain (~1,600 Wattled Cranes; Viljoen 2015), is located in the western part of Zambia along the upper Zambezi River basin between the Luanginga and Luambimba Rivers. The core floodplain area is almost completely protected by the Liuwa Plain National Park and the Upper Zambezi Game Management Area on the Park's northern and western boundaries.
- The Okavango Delta (~1,200 Wattled Cranes; Hancock 2008), a Wetland of International Importance under the Ramsar Convention, was declared a World Heritage Site in 2014 and comprises a mosaic of protected lands. Around 40% of the Delta is protected by the Moremi Game Reserve and the remaining area is protected under 18 Wildlife Management Areas and Controlled Hunting Areas. The biggest threat to the Okavango Delta for Wattled Cranes at this time is the proposed development of dams upstream in the Okavango River, and the resultant changes in hydrological flows.
- The Bangweulu Swamps (~1,000 Wattled Cranes; African Parks Foundation, personal comm. 2015), located in the northern reaches of Zambia, form part of the upper Congo River Basin. They are protected in part by Isangano National Park covering the areas northeast of Lake Bangweulu, and the Bangweulu and Chambeshi Game Management Areas to the south and southwest of the lake.
- The Zambezi Delta and the adjacent Cheringoma Escarpment in central Mozambique are known as the Marromeu Complex (~400 Wattled Cranes, with historic counts exceeding 2,500; Bento et al. 2007). Designated as a Wetland of International Importance under the Ramsar Convention, this area is protected by the Marromeu Buffalo Reserve and four hunting concessions (Coutadas).

In addition to these key sites, the vast Makgadikgadi Pan in Botswana occasionally serves as a major flocking ground for Wattled Cranes, with as many as 2,000 individuals reported. This irruptive population of Wattled Cranes is likely drawn from the Okavango Delta population and other surrounding wetlands when water conditions on the pan are optimal (Beilfuss et al. 2007).

The remaining 25% of the south-central population is distributed across smaller wetland systems in Angola, Democratic Republic of Congo, Malawi, Mozambique, Namibia, Tanzania, Zambia, and Zimbabwe. More specifically, more than 1% of the south-central population (>73), can be found in the Busanga Plains in Zambia, Moyowosi Swamps in Tanzania, Upemba Swamps in the Democratic Republic of Congo, Driefontein Grasslands in Zimbabwe, and Nyae Nyae in Namibia (76–95 birds, 1990–2006; Namibia Crane Working Group, unpublished data). Up to three birds have been recorded in the company of Blue Crane within the Etosha National Park since 2013, which is a new distribution record (Ann Scott, personal comm. 2015).

South African Population

Wattled Cranes are distributed across the eastern temperate grasslands of South Africa. More than 90% of this population is distributed across the Midlands (around 65%) and the Southern Drakensberg (around 35%) of the KwaZulu-Natal Province. The vast majority of cranes are on private land, with a few protected areas scattered across this region, supporting between one and six breeding pairs each. These sites include the uKhahlamba World Heritage Site (two pairs), Karkloof Nature Reserve (four pairs), Umgeni Vlei Nature Reserve (which is also a Wetland of National Importance under the Ramsar Convention; up to six pairs), Ntsikeni Vlei Nature Reserve (which is also a Wetland of International Importance under the Ramsar Convention, four pairs), Impendle Nature Reserve (one pair), and Umvoti Vlei (three pairs) (Tanya Smith, personal comm. 2015).

The remaining pairs and individuals are scattered across the northern, southern, and western parts of the temperate grasslands in the country, spanning the Eastern Cape, Free State, and Mpumalanga Provinces. Wattled Cranes are only protected in this area through the Verloren Valei Nature Reserve in Mpumalanga, also a Wetland of International Importance under the Ramsar Convention (one pair).

Additionally, South Africa has national legislation that allows for the proclamation of protected areas on private or communally owned land. By entering into voluntary legally binding agreements with government, landowners can enter their properties into the protected area network as either Protected Environments or Nature Reserves. Under the auspices of the Biodiversity Stewardship Programme, management plans for the properties are developed and implemented that consider both biodiversity and water resource management. There are a number of sites under this program that have been legally gazetted or are in process, which will secure either Wattled Cranes and/or suitable habitat.

Ethiopian Population

Wattled Cranes in Ethiopia are distributed across the Rift Valley wetlands of Archuma, Boyo, Chuche, and Wachinco, the Bale Mountains, and in the Jimma and Kefa Zones, all south of Addis Ababa, and alongside Lake Tana in the north west of the country (Tadele 2015). The only protected area for Wattled Cranes in the country is the Bale Mountain National Park, located 400 km southeast of Addis Ababa. This national park, though, is under significant pressure from livestock grazing and associated human disturbances in the wet season when Wattled Cranes breed. Lake Tana is registered as a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site and also is under significant human and livestock pressure. The remaining sites are within densely human populated areas under extreme pressure from subsistence agriculture, industrial development and human disturbance.

ECOLOGY

Of Africa's crane species, the Wattled Crane is the most wetland dependent. The majority of cranes are on the large riparian wetlands and floodplains of southern Africa's large river basins, especially the Zambezi and Okavango, but they will utilize smaller upland wetlands throughout their range. Though Wattled Cranes are non-migratory, they will make irregular local movements based on water availability (Archibald and Meine 1996, del Hoyo et al. 1996, Ellis et al. 1996).

They feed primarily on aquatic vegetation (Bento 2002) but in drier habitats they will also eat waste grain, seeds, and insects (Hancock et al. 2003). Wattled Cranes will also take animals, including small aquatic snails, fish, and frogs (Hockey et al. 2005). There is a significant relationship between the presence of Wattled Cranes and *Eleocharis* and floodplain grasslands in many of the systems in the south-central population (Bento et al. 2007, Ndirima 2007). This link is largely because *Eleocharis* produces tubers while some of the grasses produce rhizomes as a result of the seasonal inundation that occurs on floodplains, providing a nutritious food source for Wattled Cranes. It has been speculated that a similar process of tuber and rhizome formation could occur in higher-altitude wetlands as a result of seasonal changes in temperature rather than water levels, for example in South Africa (Damian Walters, personal comm. 2014).

Wattled Crane flocks, comprised of non-breeding adults and immature birds in the breeding season, are joined by adult pairs and family groups in the non-breeding season. Although flocks become larger and denser when food density is at its highest, food intake is reduced due to the increased aggressive behavior and interactions (Kamweneshe 2004). Flock size is influenced by environmental factors (food, predators, and temperature), individual condition, and individual behavior. Most specifically, Kamweneshe (2004) noted that flocks provide for security, the opportunity for pair formation, and feeding optimization.

Similar to other cranes, Wattled Crane pairs are highly territorial during the breeding season, defending an area greater than 1 km^2 (Konrad 1981), usually in shallow wetlands with little human disturbance (Archibald and Meine 1996, Ellis et al. 1996, Morrison and Bothma 1998). Home ranges though are much bigger, and in South Africa average 16.64 km^2, with the core breeding area only 2.3% of the home range (McCann and Benn 2006). Although home ranges in South Africa were dominated by open natural grasslands, wetlands made up at least 7.1% of the home range and wooded areas, temporarily irrigated and dryland cultivated agriculture the remainder (Coverdale 2006, McCann and Benn 2006). Although the cranes are tolerant to a degree of disturbance and habitat transformation in South Africa, Coverdale (2006), McCann and Benn (2006), and Wojtaszekova (2008) found that there was a higher probability of breeding when the land cover matrix within a 1,000-m radius of the nest was predominantly natural grassland and wetland habitat, and when disturbances associated with agricultural activities in the area were kept to a minimum.

Nests are usually within short wetland vegetation (Morrison and Bothma 1998, John et al. 2012), dominated by long-stamen rice (*Oryza longistaminata*), Chinese water chestnut (*Eleocharis dulcis*), southern cutgrass (*Leersia hexandra*), and cape bulrush (*Typha capensis*) (John et al. 2012). Breeding productivity also significantly improved if soil penetrability around a nest was good and if the water depth was significant (Wojtaszekova 2008, Wojtaszekova et al. 2009). In Tanzania, John et al. (2012) recorded good breeding success if the water level was less than 100 cm but still significant.

Coverdale and McCann (2003) recorded the age of first successful breeding as seven years. Wattled Cranes start nesting as floodwaters or wetland water levels begin receding after peak flooding (Penry 1994, Kamweneshe and Beilfuss 2002). Wattled Cranes lay one or two eggs (Couto and Couto 2000, Hancock et al. 2003, Brown et al. 2015) with only one precocial chick ever being raised and the other egg abandoned in clutches of two (Pittman 2007). This clutch size is the lowest average for any species of crane. The incubation period is 33–36 days, the longest of any crane species (Hancock et al. 2003). The fledging period is 90–130 days (Hockey et al. 2005), also the longest of any crane species, with fledged chicks typically continuing to follow their parents through their first year (Hancock et al. 2003).

NUMBERS AND TRENDS

The Wattled Crane population was estimated at between 13,000 and 15,000 in 1985 (Urban 1988) and less than 7,700 in 2004 (Beilfuss et al. 2007). Although it is acknowledged that the species has declined over this period, the extent is questionable due to improved accuracy in population estimates since the early 2000s (Beilfuss et al. 2007). Using the recent numbers outlined below, the current global Wattled Crane population is >9,600 individuals. Although a significant increase from the estimates in 2007 (Beilfuss et al. 2007), it is doubtful that the current figure is a true increase in numbers, and further research is required to better understand the movements among the five large flood-plain systems in south-central Africa, and the seasonal movements cranes undertake, coming together at key sites in the non-breeding season.

South-central Population

Synchronized surveys conducted in the early 2000s over the five large flood plain systems in south-central Africa concluded that the Okavango Delta in Botswana held the single largest population of Wattled Cranes, estimated at 1,300 individual birds (Kamweneshe et al. 2003b, Motsumi et al. 2007, Hancock 2008); the Kafue Flats in Zambia was estimated to contain 1,000 individuals (Kamweneshe and Beilfuss 2002); the Bangweulu Swamps in Zambia held approximately 1,000 individuals (Kamweneshe et al. 2003a); Liuwa Plains in Zambia had around 700 Wattled Cranes (Kamweneshe et al. 2003b); and the Zambezi Delta in Mozambique had 120 breeding pairs (Bento et al. 2007). In addition, smaller groups of Wattled Cranes were scattered across other wetland systems and *dambos* in Zambia, including the Lukanga and Busanga Swamps (Kamweneshe et al. 2003a).

However, recent surveys suggest the current population in the Kafue Flats (~2,900 Wattled Cranes; Shanungu et al. 2015), Liuwa Plain (~1,600 Wattled Cranes; Viljoen 2015), and Bangweulu (~1,000; African Parks Foundation, personal comm. 2015) are much higher than previously reported. The most recent figures for the Okavango Delta (~1,200; Hancock 2008) and the Marromeu Complex (~400; Bento et al. 2007), however, are older and numbers likely have changed over the past eight years. We can estimate, though, based on these figures, that around 7,100 Wattled Cranes are distributed across the five large floodplain systems in south-central Africa. Further research though is underway to determine whether these higher counts represent an overall population increase or reflect shifts in population distribution.

The Moyowosi Swamps in Tanzania and Upemba Swamps in the Democratic Republic of Congo formerly supported substantial numbers of Wattled Cranes, but recent counts suggest fewer than 200 and 300 individuals respectively (Beilfuss et al. 2007). The Driefontein Grasslands population in Zimbabwe, holding 75% of the country's Wattled Crane population, has declined from 127 individuals in 1996 (Couto and Couto 2000) to 35 in 2010 (Fakarayi 2010). The Namibian population, which was estimated at 60 individuals in 2004 (Beilfuss et al. 2007), is estimated now to be between 100 and 150 (Ann Scott, personal comm. 2015). Although Nyika Plateau of Malawi used to hold a few pairs of Wattled Cranes, it appears now that no pairs are resident, although pairs are periodically seen moving through. If we assume that 25% of the south-central population is found outside of the five large flood-plain systems (Beilfuss et al. 2007), we can estimate between 2,000 and 2,500 Wattled Cranes in these areas in south-central Africa.

The Wattled Crane population in south-central Africa is therefore >9,100 individuals.

South African Population

In 2004, the Wattled Crane population in South Africa was estimated at 250 individuals (Beilfuss et al. 2007). This population low was reached in 2000, a 38% decline from its 1980 estimated population size of 380 individuals (McCann 2000). Standardized annual aerial surveys in KwaZulu-Natal, the species' stronghold in South Africa, have been carried out since 1994. The next 12 years showed a slowly increasing population, with the 2014 survey recording 311 individuals and 76 active Wattled Crane nesting sites (Smith and Craigie 2014), the highest number recorded in 21 years and a real increase in the population. A further increase was found in the November 2018 aerial surveys, with 380 Wattled Cranes and 80 active Wattled Crane nesting sites in KwaZulu-Natal (Rennie et al. 2018). Although the KwaZulu-Natal population is increasing, the species has continued to decline across the rest of its range in South Africa and now numbers between 16 and 25 individuals.

Ethiopian Population

Beilfuss et al. (2007) estimated the Ethiopian population at less than 200 in 2004. More recent estimates though suggest there are 250–300 individuals in the country (Wetlands International 2012; Tariku Mekonnen, personal comm. 2015; Yilma Abebe, personal comm. 2015). This number represents a more accurate estimate rather than a realized increase. Furthermore, Tadele (personal comm. 2015) suggests that coordinated efforts to survey Ethiopia could identify new sites for Wattled Cranes.

THREATS

General (Harris and Mirande 2013):

- Habitat loss through changes to hydrology, dams and water diversions, the conversion of wetlands and grasslands for agriculture and other land development, and changes in agricultural land use;
- Human poverty and lack of livelihood alternatives is the key ultimate or indirect threat; and
- Spread of the invasive shrub, *Mimosa pigra*, that destroys habitat of major population in Kafue Flats, Zambia; also a problem in Ethiopia and perhaps some other areas.

South-central Population

- Large dams and diversions of water that alter the timing, magnitude, and extent of water availability on the large floodplains (very significant for floodplain population, and likely to have more serious impacts in the next 20 years, especially water diversions) (Archibald and Meine 1996, Bento 2002, Kamweneshe and Beilfuss 2002, Beilfuss and Browne 2010);
- Destruction of nests, eggs and chicks due to wildfires;
- Loss of large mammal grazing systems that maintain good foraging conditions on feeding grounds (Kamweneshe and Beilfuss 2002);
- Spread of invasive plant species, such as *Mimosa pigra* in the Kafue Flats (Kamweneshe and Beilfuss 2002, Shanungu 2009);
- Reduced productivity of breeding pairs on the pans in the Liuwa Plains National Park in Zambia due to increased human disturbance and the collection of eggs and chicks for food as local fishermen exercise their rights to fish each of the pans according to local tradition (Rob Reid, personal comm. 2015);
- Live capture for commercial trade in Tanzania, where the level of exports is believed to exceed known legal exports (Morrison and van der Spuy 2006);

- Live capture, especially through snaring for consumption in Zambia, is known to occur. Eggs of Wattled Cranes are also collected for consumption, further reducing the breeding success of the birds; and

- Mining and large-scale commercial agriculture, particularly for sugarcane (*Saccharum*), in wetlands pose a threat.

South African Population

- The primary threat to the species in South Africa is the widespread degradation and loss of breeding habitats, most often caused by the draining or damming of wetlands (McCann 2000);

- In the future, open-cast coal mining will most likely significantly impact the habitat availability within the Mpumalanga Province's grasslands;

- Power lines pose a collision hazard to young inexperienced birds and adults on misty days;

- Because Wattled Cranes are winter (dry season) breeders, the threat of fire to both eggs and chicks is high;

- Human disturbance and trampling by livestock cause destruction of nests, eggs, and chicks (Morrison and Bothma 1998, McCann and Benn 2006, Morrison and van der Spuy 2006);

- Other threats include disturbance at nesting areas and uncontrolled hunting with dogs (McCann 2000);

- Reduced breeding productivity due to human disturbance can result in adults spending more time off the nest or away from the chick, especially in cold temperatures; and

- Mercury levels in egg shells exceed the average which may negatively affect productivity (Daso et al. 2015). This situation is likely not from a point-source contamination.

Ethiopian Population

- Destruction of breeding and foraging habitats due to the conversion of wetlands for agriculture and grazing, overgrazing, and over-harvesting of wetland resources (Aynalem et al. 2011);

- Spread of the invasive *Mimosa pigra* shrub at wetlands in the Rift Valley (George Archibald, personal comm. 2015; Tadele 2015);

- Destruction of nests, eggs, and chicks by wildfires; and

- Killing of chicks and juveniles by children (Aynalem et al. 2011).

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

South-central Population

- The International Crane Foundation (ICF) / Endangered Wildlife Trust (EWT) Partnership, in partnership with the Zambian Department of National Parks and Wildlife, coordinate the Zambian Crane and Wetland Conservation Project. This project is aimed at better understanding the status and distribution of Wattled Cranes and their relationship to hydrology and to herbivores, and at improving the management of and reducing threats to their key ecosystems;

- The Zambezi River Basin Environmental Flows Partnership (WWF; ICF; Zambezi River Authority; Zambezi Electrical Power Supply Company; Ministries of Water Affairs in Zambia, Zimbabwe, and Mozambique; and national universities of Zambia, Zimbabwe, and Mozambique) is working with operators and government authorities responsible for all large dams in the Zambezi River basin to improve water management for downstream species and water users. Project goals include incorporating environmental flows into the operational rules for the dams on a basin-wide basis, reviewing and modifying new dam developments to minimize downstream impacts, and improving the management of key floodplains in the system;

- ICF, the Mozambique Museum of Natural History, and other partners are working with hunting concession operators, agribusinesses, local communities, government agencies, and other non-government organizations to conserve biodiversity and improve human livelihoods through the provision of ecosystem services in the Zambezi Delta, as a model for managing large floodplains in the Zambezi River system and elsewhere;

- BirdLife Zimbabwe is monitoring Wattled Cranes and working with local communities for the conservation of Wattled Crane's highland breeding grounds in the Driefontein grasslands in Zimbabwe;

- The Namibia Crane Working Group promotes the conservation of three crane species in Namibia, including the Wattled Crane, collating data and promoting awareness/education; and

- The African Parks Foundation provides logistical support for research and monitoring of Wattled Cranes in the Liuwa Plain National Park and Bangweulu Swamps, with specific focus on the effects of fishing communities on Wattled Cranes and other waterbirds.

South African Population

- The ICF/EWT Partnership has a long-term project in the Drakensberg region of South Africa, focused on monitoring Wattled Cranes, understanding and improving their wetland habitats, and securing critical areas in collaboration with local landowners and users under South African legislation;

- A monitoring plan has been adopted by the provincial conservation authority, Ezemvelo KwaZulu-Natal Wildlife, for Wattled Cranes in the KwaZulu-Natal Province, which is implemented in partnership with the EWT;

- A Wattled Crane Recovery Programme (WCRP) was established in 2000 as a result of workshop led by the IUCN Conservation Breeding Specialist Group, which led to the development of a Population and Habitat Viability Assessment and conservation plan. The WCRP aimed to establish a viable captive population of Wattled Cranes of South African origin and to supplement the wild population to prevent further decline. The program was driven by five partner organizations: the Johannesburg City Parks and Zoo, Ezemvelo KwaZulu-Natal Wildlife, EWT, KwaZulu-Natal Crane Foundation, and the African Association of Zoos and Aquaria. Due to the gradual increase in the wild population, a decision was made in 2015 not to release birds in a supplementation program. The captive population is managed under the African Association of Zoos and Aquaria's (PAAZA) Wattled Crane African Preservation Programme and now aims to develop a sustainable captive population. This captive population serves as an insurance policy for the wild population should it be struck by a catastrophe or in the event that the species declines again; and

- The KwaZulu-Natal Crane Foundation has an active school education and awareness program in the KwaZulu-Natal Midlands, aimed at increasing awareness of cranes and their habitats.

Ethiopian Population

- Faculty and graduate students at Bahir Dar, Addis Ababa, and Jimma Universities, with help from the German Crane Working Group, Nature and Biodiversity Union, and ICF, are undertaking status surveys and field research towards the conservation of Wattled Cranes in Ethiopia;

- A research project on Wattled Cranes in Boyo Wetland and Bale Mountains National Park is being undertaken by the Addis Ababa University, which will include an investigation into the genetic differences between the Ethiopian and south-central populations; and

- Studies of Wattled Cranes in southeastern Ethiopia by researchers at Jimma University have resulted in an environmental education program to protect wetlands where these cranes breed.

CHANGES SINCE 1996

Although we know that the South African population is slowly increasing, the status of the south-central and Ethiopian populations is unclear, with evidence to support both increasing and decreasing population trends.

Mimosa pigra, an alien invasive plant species, is expanding its range across the Kafue Flats in Zambia and the Rift Valley wetlands in Ethiopia, contributing further to habitat loss and degradation. In the Kafue Flats, more than 800 ha of invasive *Mimosa pigra* was eradicated through aerial spraying and community-involvement in manual cutting during 2007–2009 (Shanungu 2009), but these efforts were discontinued and the plant reestablished. In areas where it was reduced or eradicated, displaced wildlife including Wattled Cranes showed increased use. However, after the discontinuation of the program *Mimosa* has been rapidly reclaiming areas from which it had been eradicated. Continued eradication efforts are needed to keep *Mimosa pigra* from spreading. In Ethiopia, *Mimosa pigra* has been planted in the wetlands to provide fuel for local people.

Collision with overhead electrical wires (power lines) has been a threat to cranes in South Africa for many years. As Africa moves forward with its plans to provide power to the majority of people to reduce poverty and encourage economic growth, the power line network in Africa has started expanding significantly and will escalate over time. There is a need to learn from the South African experience and to proactively minimize this threat in other countries.

The extractive mining industry for energy generation is increasing significantly across Africa. These activities include open-cast coal mining, gas extraction, and geothermal development, all of which result in further habitat loss and degradation.

PRIORITY RESEARCH AND CONSERVATION ACTIONS

General

- Develop and implement an International Single Species Action Plan, under the African Eurasian Migratory Waterbird Agreement, with a key focus on international collaboration and multi-stakeholder implementation; and

- Understand and reduce the potential impact of the energy sector on Wattled Cranes and their habitats across their range. This effort will include minimizing the effects of power lines, open-cast coal mining, gas extraction, and wind farms.

South-central Population

- Focus on direct threats to Wattled Cranes by developing and implementing ecological management practices (environmental flows, invasive species control, and fire management) that support cranes, biodiversity, fisheries, agriculture, and other livelihoods in the five floodplain systems that support 75% or more of the global Wattled Crane population, namely Kafue Flats, Barotse Floodplain, and

Bangweulu Swamps (and associated breeding grounds) in Zambia, the Okavango Delta in Botswana, and the Zambezi Delta in Mozambique;

- Maintain current efforts and funding to implement environmental flows for key floodplains;
- Anticipate the impact of climate change on water availability in the region, the demand for water resource development, and the role both of African governments and Chinese investment in this future;
- Develop and implement a long-term management plan to control *Mimosa pigra* and other emerging threats and monitor wildlife recovery;
- Adapt a permitting system for traditional fishing in the Liuwa Plain National Park in Zambia to reduce the negative effect on Wattled Crane breeding productivity; and
- Understand the local community perceptions and cultural significance and attitudes towards cranes as a way of leveraging their conservation support. This effort will help prevent deaths from poisoning and capture for consumption.

South African Population

- Improve our understanding of the habitat requirements for Wattled Cranes, address key threats, and improve the ecological integrity of key wetland habitats;
- Consider appropriate management of Wattled Crane home ranges to reduce disturbance around nesting sites;
- Secure key habitats using the Biodiversity Stewardship Programme, a protocol set up to implement national legislation aimed at increasing the Protected Area network in the country through voluntary collaboration with local landowners;
- Continued engagement with landowners on whose property the birds occur in order to ensure that the appropriate management actions are implemented; and
- Management of the captive flock as a reservoir for future supplementation in the event of a catastrophic decline in the wild population.

Ethiopian Population

- Effective outreach will be the key for limiting the impact of human activity on nesting sites as the population grows and settlement starts in crane areas in Ethiopia; and
- Improve our understanding of the distribution, threats to, and status of Wattled Cranes and their habitat for the development and implementation of effective conservation projects aimed at securing Wattled Cranes and improving the ecological integrity of their habitats.

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SPECIES REVIEW:

BLACK-NECKED CRANE (*Grus nigricollis*)

Fengshan Li

(with inputs from George W. Archibald, Mary Anne Bishop, Pankaj Chandan, Dejun Kong, John Farrington, Fawen Qian, James T. Harris, Claire M. Mirande, Qiang Liu, K S Gopi Sundar, and Xiaojun Yang)

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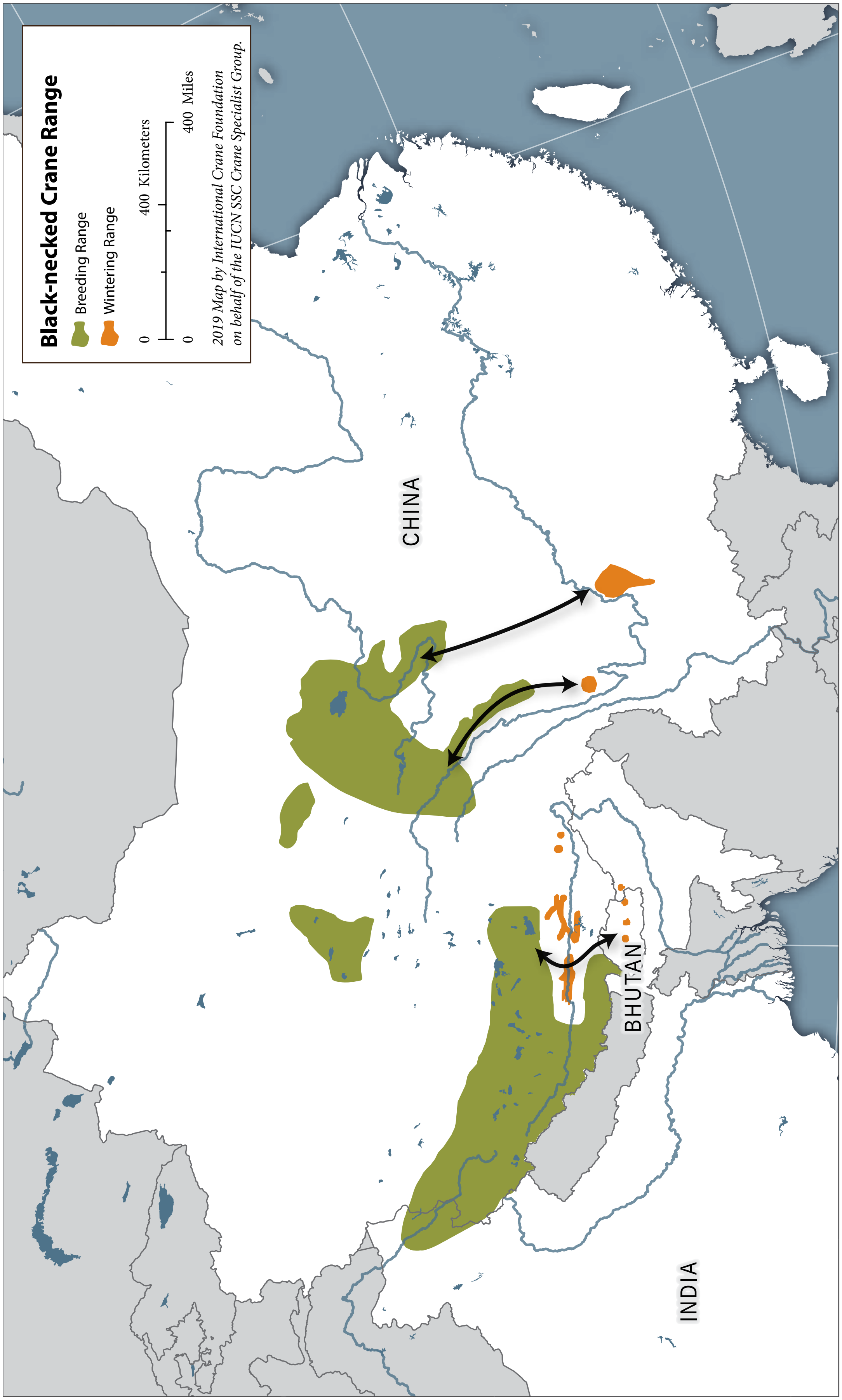
Black-necked Crane pair nesting at Yanchiwan, China, with melting glacier in the background (Photographer: Yongjun Se, Yanchiwan National Nature Reserve)

Red List Category: Vulnerable
Population Size: 10,000–10,200
Population Trend: Increasing
Distribution: Central Asia



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DISTRIBUTION AND STATUS OF KEY SITES

The Black-necked Crane breeding range includes much of the Qinghai-Tibetan Plateau in western China, with a small breeding population occurring in adjacent Ladakh in India. Wintering grounds include lower elevations of the Qinghai-Tibet and Yunnan-Guizhou Plateaus in China, with several hundred occurring in Bhutan and few birds in Arunachal Pradesh in northeast India. There are approximately 10,000–10,200 Black-necked Cranes remaining in the wild (Li 2014).

Subspecies/Populations

The Black-necked Crane is a monotypic species. No genetic study has been done on sub-populations or subspecies. The summer breeding range of this crane stretches throughout mostly continuous plateaus. There are three isolated wintering populations.

Breeding Grounds

The Ruoergai marshes, located on the north-eastern edge of the Qinghai-Tibet Plateau, have the largest population estimated at about 2,500 Black-necked Cranes (Liu et al. 2009). The marshes include two national, one provincial, and two county reserves (Ministry of Environmental Protection of People's Republic of China 2010), with Ruoergai National Nature Reserve (NNR) designated as a Ramsar site.

Celin Cuo Black-necked Crane NNR probably has the largest concentration of Black-necked Cranes in Tibet. Although no counts have been done for the entire reserve, a survey at Shenzha, located in the southern part of the reserve, recorded a total of 16 nests in 1991 (Dwyer et al. 1992). Surveys in the same region in 2000 revealed a minimum of 30 breeding pairs, suggesting an increase of the population on the breeding grounds (Archibald 2005). From July–August 2008, the National Bird Banding Center and the Wildlife Conservation Society (WCS) jointly conducted a breeding population survey of this species in Changtang region of Tibet, covering Anduo, Bange, Shenzha, and Nima of Naqu prefecture; Cuoqin, Gaize, Geji, Gaer, Ritu, Zhada, and Pulan of Ali Prefecture; and Zhongba and Saga of Shigaze Prefecture.

A total of 514 Black-necked Cranes were recorded including 38 chicks, mostly concentrating in Cuoe Lake, Shibu Cuo, Mujiu Zangbu, Mujiu Cuo, Rebanggou Wetland, and Mapangyong Cuo (Zhang et al. 2015).

There are more Black-necked Cranes than previously thought in Xinjiang, with an estimated 220 breeding or summering, and an additional 137 birds recorded at the Altun NNR during the migration period (Ma et al. 2011). There were potentially six areas with Black-necked Cranes in central Xinjiang, as well as locations adjacent to Tajikistan, Kazakhstan, and Mongolia (Ma et al. 2011).

The number of resident Black-necked Cranes at Longbaotan in Qinghai Province was about 100–125 cranes in the summer of 2011. The highest count (of 16 counts) was 216 in April 2011. Thirty breeding pairs were present in 2011. Minimum count of 16 counts was 81 in 2011. Peak count (of two counts) in 2012 was 178 (Farrington and Zhang 2013).

A newly rediscovered place is a plateau along Shaluli Mountains, including Daocheng, Xinlong, Litang, and Baiyu (Liu et al. 2010, Zhu et al. 2009, Liu et al. 2012). This species was seen to be abundant in migration in Litang over 70 years ago by Dolan (1939). During summer surveys in Daocheng alone in 2007 and 2008, 29 Black-necked Cranes were recorded, including seven pairs (Zhu et al. 2009).

Ladakh is the only breeding area for Black-necked Cranes in India, with a total of 64 birds including 51 adults and 13 chicks in 2004 (Chandan et al. 2005). The population increased to 15 breeding pairs and a total of 81 cranes in 2008. During a count conducted by the World Wildlife Fund (WWF)-India team in Ladakh in October 2012, the Black-necked Crane population in Ladakh had further increased to 139 birds. This count included 128 adults and 11 juveniles, the highest number of birds ever recorded in Ladakh (Chandan et al. 2014).

Where old data are available, for three widely separated locations, the numbers of breeding pairs have been increasing: Shenzha (see earlier paragraph), Longbaotan (only six pairs in 1988; Farrington and Zhang 2013), and Ladakh only (12 breeding pairs in 1998; Pfister 1998).

Wintering Grounds
Black-necked Cranes spend the winters mainly in three populations:

Eastern population (northeastern Yunnan and northwestern Guizhou Provinces): Three national nature reserves on the Yunnan-Guizhou Plateau in this flyway (Dashanbao, Cao Hai and Huize) have a total of 2,469 Black-necked Cranes (2004 data), accounting for 69% of the total population in this flyway (Li and Yang 2005). Satellite tracking data of eight birds and two color-banded cranes show birds from Dashanbao and Cao Hai migrate to Ruoergai for breeding (Qian et al. 2009, Wu et al.1993).

Central population (northwestern Yunnan): Napahai Provincial NR has a stable population of 270 Black-necked Cranes, an increase from less than 100 in the 1980s and before 1997 (Zhao and Yu 2005, Wang et al. 2009). Napahai is the winter home for >90% of Black-necked Cranes in the central flyway.

Western population (south-central Tibet and Bhutan): Along the Lower and Middle Reaches of the Yarlung Tsangpo (Brahmaputra) River Basin, the Middle Yarlung Tsangpo Black-necked Crane NNR hosts the majority of wintering Black-necked Cranes in Tibet. This reserve, established in 1993 (Ministry of Environmental Protection of People's Republic of China 2010), covers almost all wintering areas in Tibet, although there has been virtually no active management.

Black-necked Cranes are recorded in four wintering sites in Bhutan at Phobjikha, Bumdeling, Khotokha, and Bumthang. Among the four sites, 437 birds were counted at Phobjikha and Bumdeling combined, accounting for 95% of the total population in Bhutan (Royal Society of Protection of Nature 2012). In the winter of 2014–15, there were 544 birds in Bhutan (Royal Society of Protection of Nature 2015).

ECOLOGY
The Black-necked Crane is the only exclusively alpine species among the 15 species of cranes in the world, with breeding grounds ranging from 2,600–4,800 m above sea level and wintering grounds at 2,000–3,800 m above sea level (Wu et al. 1991, Dwyer et al. 1992). Black-necked Cranes roost in shallow water on lakes, river banks, or small ponds. Throughout the year they forage in agricultural fields, shallow wetlands, and grasslands. However, in many breeding areas at high altitudes where crops cannot be grown, they forage mainly in wetlands and heavily grazed pastures. By nesting at high altitudes Black-necked Cranes, in contrast to other migratory cranes, have relatively short migration routes, with the longest ~700 km (Wu et al. 1993, Gao et al. 2007, Qian et al. 2009), while the shortest extends 200 km or less (Wangmo 2007, Liu et al. 2010). The cranes migrate both altitudinally and along north–south routes. The migration route from the wintering area in Bhutan to the breeding area in China is 120 km (Sherub, personal comm. 2014).

NUMBERS AND TRENDS
Numbers of Black-necked Cranes have been monitored annually over many years in representative wintering sites practically across the entire range of the species. The world population of Black-necked Cranes grew from about 5,000–6,000 in the early 1990s (Meine and Archibald 1996) to about 11,000

a decade later (Bishop and Tsamchu 2007). While the higher numbers may be due in part to more complete counts, significant growth also seems to have occurred. The current world population of Black-necked Cranes is estimated at 10,000–10,200, based on most recent counts of 3,687 (eastern population; Yang and Zhang 2014), 232–300 (northwest Yunnan; Yang and Zhang 2014; Qiang Liu, personal comm. 2014), 5,558 (Tibet; Zhang et al. 2014), 550 (Bhutan; Phuntsho and Tshering 2014), and ~10 (India; Chandan et al. 2014).

Over a ten-year period of 2000–2010, the population is believed to have been stable, based on close monitoring of this species at several key wintering sites. In the western population, counts in Bhutan averaged 458 from 11 counts (ranging from 425–509) (Royal Society of Protection of Nature 2012). In Shigaze, where ~3,600 cranes overwinter, their numbers were relatively consistent during 2006–2010 (Bishop et al. 2012). In the central population, counts from 2001–2007 recorded an average of 290, ranging from 263 to 320, although this population might be experiencing a slight decline since the juvenile recruitment was 8.4% in winter of 2009 (Qiang Liu, personal comm. 2014), compared to 11.84% in 2002 (Li and Yang 2005). In the eastern population, Cao Hai and Dashanbao have recorded about 1,000 birds each.

THREATS

This conservation success may be partly attributed to improvement of natural breeding habitats through glacier melting, as well as to lower mortality throughout the year due to warm temperatures and the enforced protection of cranes, especially in China, where hunting of cranes by Han Chinese in Tibet was perhaps widespread from 1960–1990. It stands in marked contrast to significant population declines for most waterbirds in Asia over the same period. Still, this species faces significant threats. In India, due to sustained conservation efforts during the past two decades, the population is showing increasing trends. Threats to the nesting birds, however, are still very serious and the recruitment rate is very low compared to the overall population (Pankaj Chandan, personal comm. 2014).

Overall Range

Climate change is already having significant impact on high-altitude regions of central Asia, with changing rainfall patterns and rapid glacial melt. Climate models indicate that the Tibetan Plateau will undergo even more drastic changes in coming decades, with loss of glaciers leading to water shortages and extensive loss of wetlands that will threaten breeding waterbirds of the region including Black-necked Cranes. Open water area at Seling Lake is increasing while Longbao and Ruoergai are drying up. Lakes are getting bigger at present from glacier melt and increased rainfall, but many shallow wetlands used by cranes are believed to be disappearing due to permafrost degradation (Farrington 2009, Ma et al. 2009, Qiu 2012). Similarly, in Ladakh in India, Lake Tsomoriri (a closed basin) showed a rise in water between 2000 to 2006 and then suddenly the water level started decreasing, whereas Tsokar Basin is regularly shrinking (Pankaj Chandan, personal comm. 2014).

Developmental activities have been dramatic in the range of the Black-necked Crane in the past decade, specifically:

- Growing human populations with increasing water demands that negatively impact the availability and quality of water in the marshes;
- Development of tourism, resulting in disturbance from road construction, vehicles, and disposal of waste;
- Changes in wetlands due to natural and man-made causes;

- Wetland reclamation for agriculture, and changes in agricultural practices (e.g., traditional crops replaced by higher yield crops, and land plowing in the fall instead of spring) in farmlands used by cranes; and

- Power lines and wind turbines installed to meet the rapid economic development.

Breeding Grounds

- Overgrazing and destruction of habitat by domestic yaks (*Bos grunniens*), cows (*Bos taurus*), sheep (*Ovis aries*), and goats (*Capra hircus*) within the marshes and surrounding habitats, fencing of wetlands throughout the breeding range, and—especially threatening—livestock spend more time grazing on wetlands due to deterioration of less resilient upland dry pastures;

- Disturbance and predation of eggs and chicks by feral dogs (*Canis lupus familiaris*) in Ladakh and China;

- Overgrazing at Ruoergai, which leads to vegetation degradation, desertification in local areas, and increasing populations of rodents;

- Chemical applications to control rodents, one of the food items of Black-necked Cranes at Ruoergai (Dejun Kong, personal comm. 2014);

- In some cases, as in Hanle in Ladakh, development of tree plantations in high-altitude wetlands have severely impacted the breeding habitat of Black-necked Cranes; and

- Wetland reclamation for agriculture and construction activities.

Wintering Grounds

- Plantations of willows (*Salix*) and poplars (*Populus*), especially in and near roost sites in Tibet, and tree plantations on grassland/farmlands on which cranes forage in Yunnan (Kong et al. 2011);

- Increased mortality due to collision with power lines, especially in winter areas in Tibet and the Yunnan-Guizhou Plateau (Li et al. 2011). Rapid development of wind farms has been proposed in many areas across the species' range, and could become a problem;

- Mortality from poisoning due to farmers mixing seeds with chemicals, mainly for rodent and insect control, in China;

- Change from traditional to modern crops, methods, and tools in Tibet (e.g., barley [*Hordeum vulgare*] to winter wheat [*Triticum aestivum*], fall plowing, conversion of barley fields to greenhouse agriculture);

- Water pollution within wetlands from nearby cities on the Yunnan-Guizhou Plateau, degrading/damaging wetland ecosystems; and

- Regular floods in the wintering habitat at Bomdeling in Bhutan and at Sangti in India have washed away major wintering habitat in both areas.

Along the Flyway

Very little has been done for study or conservation of habitats along the flyways because there are no major staging areas and Black-necked Cranes make many short stops (Li et al. 2007, Qian et al. 2009). Individually, these small wetlands may not have additional wildlife values. However, they are crucial to the survival of this species. Lack of knowledge prevents identification of threats or effective conservation responses, or assessment of significance of individual wetlands or groups of wetlands. Little is known about Black-necked Crane flyways west of Sichuan.

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

Regionally

- A Black-necked Crane Conservation Network was formed in China in 2006, and has held meetings every 12–18 months at key crane sites;
- Regional coordinated winter counts, at different scales of coverage by varying methods, were conducted several times in the past and should be repeated with coordination of timing and methods every five years;
- WWF-India and the Royal Society for the Protection of Nature have been taking a leading role in coordinating conservation work for Black-necked Cranes respectively in India and Bhutan;
- Long-term cooperation among partners, such as Kunming Institute of Zoology of the Chinese Academy of Sciences, the Tibet Plateau Institute of Biology, the National Bird Banding Center of China, and ICF;
- A network of protected areas for Black-necked Cranes has been established in China, covering a total of 89,073 km^2, including 10 national-level, eight provincial-level, and four county-level reserves by the end of 2009 (Ministry of Environmental Protection of People's Republic of China 2010); and
- Much information on Black-necked Cranes has been reported in China Crane News, including a special issue on the species, published in 2015 (China Crane and Waterbird Specialist Group 2015).

Locally and at Sites

- Kunming Institute of Zoology of the Chinese Academy of Sciences has conducted research on the ecology of Black-necked Cranes in Sichuan, Yunnan, and Guizhou Provinces since 2004;
- Cao Hai and Dashanbao NNRs were designated under the Northeast Asia Crane Site Network (they are now part of the East Asian – Australasian Waterbird Site Network);
- The Tibet Plateau Institute of Biology has worked on winter surveys and breeding and winter ecology of the crane for over two decades in Tibet;
- The Royal Society for Protection of Nature (Bhutan) has conducted monitoring and education in wintering areas of this species in Bhutan for many years;
- At Cao Hai, multiple domestic and international organizations have targeted a wide range of issues, and implemented activities including research, conservation, education and community development for the past two decades;
- At Ruoergai, long-term monitoring of wetland habitats in relation with climate and human activities has been conducted by ICF working with local universities in Sichuan and Gansu Provinces;
- A waterbird survey was conducted in Tibet, including Black-necked Cranes, by the National Bird Banding Center of China and Wildlife Conservation Society in Tibet in summer of 2008;
- Longbao population study was conducted by WWF in 2011; and
- In Ladakh and Arunachal Pradesh in India, WWF-India is taking the lead role in coordinating various conservation and research activities on the species.

CHANGES SINCE 1996

Over the past 15 years, China's economic growth has been over 8% annually, resulting in pressure on land and water resources as well as other development related pressures, including tourism. Although regions in western China and other countries with Black-necked Cranes have been developing more slowly due to harsh physical conditions, changes in habitats have been dramatic. For example, in Napahai, the primary wintering area for the central population, an airport was constructed close by the wetland, with direct impacts as well as increasing the inflow of tourists. At present, an airport is in the planning phase for Ruoergai, the most important breeding area for the eastern population of this species. Unplanned developmental activities, plantations in wetlands, drainage of wetlands to create more cropland, increasing population of feral dogs, and disturbances from tourists threaten the welfare of cranes in Ladakh, India. And in eastern Bhutan, warmer winter facilitates winter crops on fields that formerly in winter were harvested rice fields with gleanings for cranes.

In terms of protection status, five out of 22 Black-necked Crane nature reserves in China have been established since 1996. Among 10 national reserves, eight have been upgraded from either the provincial or county level since 1996. Increasing the number of protected areas and upgrading reserve levels do not necessarily mean these areas have been secured, rather it indicates how urgently these areas are under environmental and economic pressure.

Research on Black-necked Cranes has improved knowledge dramatically for habitat selection, response to power lines, foraging and other behaviors, migration, and breeding distribution. Studies using satellite telemetry have greatly improved our understanding of migration of this species, with a total of 18 satellite transmitters deployed in China and Bhutan; among them, 17 were actually tracked for a full migration or more. The Black-necked Crane has been a focal species of the bird group at the Kunming Institute of Zoology of the Chinese Academy of Sciences since 2002; mainly due to its Black-necked Crane work, the Bird Group was re-established at the Kunming Institute of Zoology in 2011. The National Bird Banding Center, as a coordinating agency in crane conservation in China, has played an important role in establishment of Black-necked Crane Conservation Network and regional coordination in the species' conservation and management. WWF-India has conducted a long-term research on the breeding biology of the species in Ladakh. At regional level, WWF-India has linked conservationists and managers from the range states to enhance regional cooperation for the species. And in Bhutan, where cranes are revered, the Black-necked Crane is the symbol of a leading political party, as well as of the Royal Society for the Protection of Nature.

PRIORITY RESEARCH AND CONSERVATION ACTIONS

Recently, discussions to undertake potential downgrading of the status of Black-necked Cranes have been initiated. Any actions taken on Black-necked Cranes, especially down-listing, should be taken with great caution. The stability and growth of the population of this species, in part due to successful conservation interventions, stands in marked contrast to significant population declines for most waterbirds in Asia over the past two to three decades. The increase in Black-necked Cranes may be also due in part to improved survival in both summer and winter due to global warming. Climate models indicate that the Tibetan Plateau will undergo even more drastic changes in coming decades, however, with loss of glaciers leading to water shortages and extensive loss of wetlands that will threaten breeding waterbirds of the region, including Black-necked Cranes. Also, the melting of the permafrost will result in the disappearance of "perched" wetlands where cranes breed. Furthermore, the Black-necked Crane is an important flagship species in the high-altitude wetlands. Almost all wetland nature reserves, especially national wetland nature reserves on the Western China plateau, were established almost exclusively because of Black-necked Cranes. In the state of Jammu & Kashmir in India, the Changthang Cold Desert Wildlife Sanctuary and many wetland conservation reserves have been established only because of the presence of Black-necked Cranes (Pankaj Chandan, personal comm. 2014). The bird is also the State Bird of Jammu & Kashmir State of India. Downscaling the conservation status of Black-necked Cranes would mean less intensive management and less enforcement for these plateau wetlands, which are already very fragile, and could jeopardize the future for Black-necked Cranes and other species that depend on these habitats.

The priority actions are as follows:

- Conduct long-term monitoring of cranes and wetlands in breeding areas with focus on climate change, including at least one area not affected by glaciers (e.g. Ruoergai) and one area likely to be directly impacted by glacial melt and then by glacial shrinking (e.g., Shenzha);
- Conduct study and assessment of the impact of tourists on crane habitat in China;
- Conduct coordinated, range-wide counts in winter every five years;
- Strengthen networking among range countries and key sites to share information on threats and conservation responses;
- Promote strategies for using this flagship species to preserve fragile high-altitude wetland ecosystems and other biodiversity;
- Build capacity for resource managers, especially nature reserve staff;
- Conduct genetic study within and among different populations, especially wintering populations which are separate on wintering grounds;
- Establish baseline information on chemical contaminants, including heavy metals and pesticides, to assess the impact of these factors on cranes, if any;
- Educate locals around crane wintering and breeding sites about threats to cranes;
- Educate livestock herders about methods they can use to reduce disturbance to cranes and crane habitat;
- Regular coordination and sharing of information among various stakeholders in the crane habitats; and
- Ensure coordination among developmental and conservation agencies in the crane landscapes.

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SPECIES REVIEW:

HOODED CRANE (*Grus monacha*)

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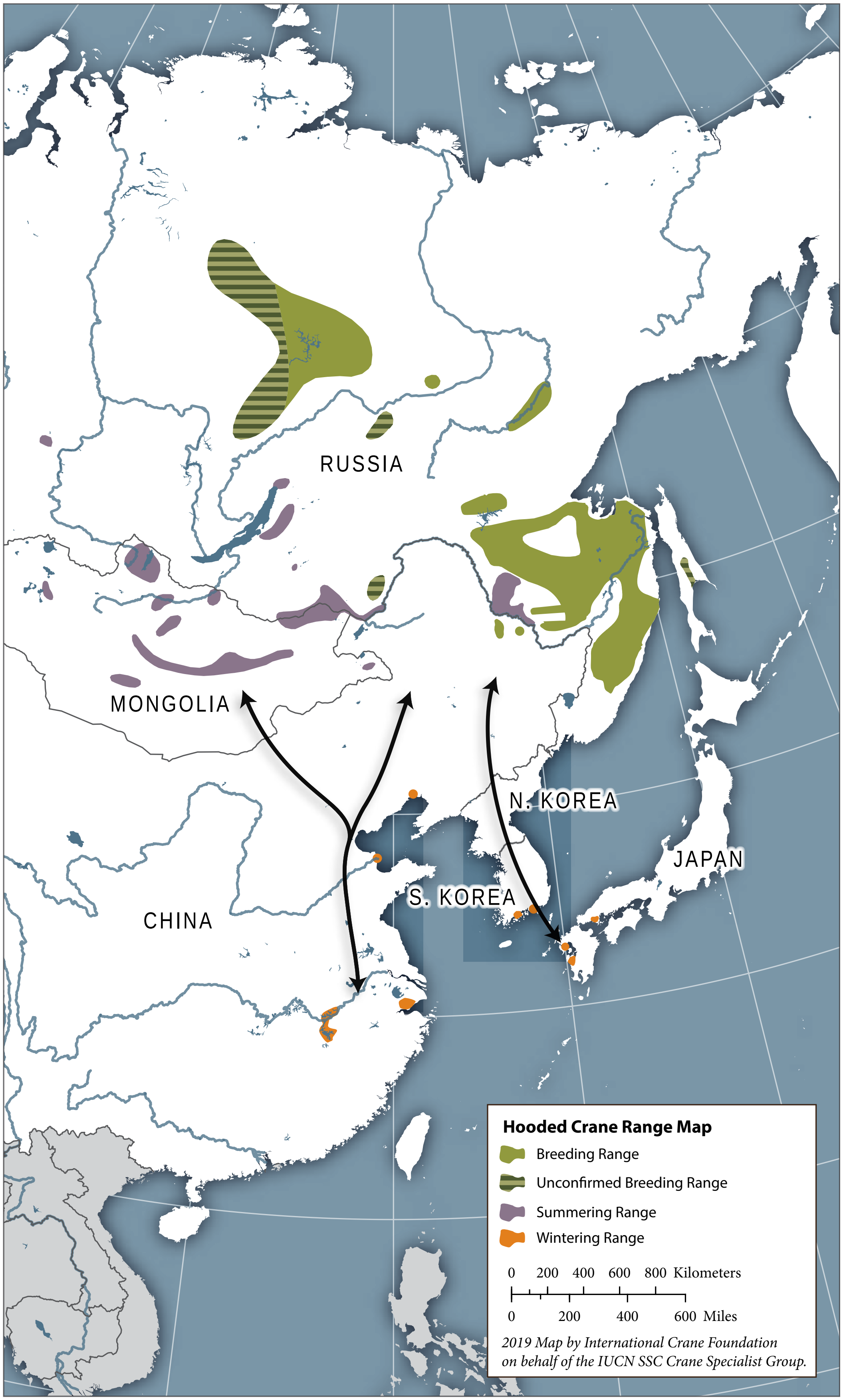
Hooded Crane teaching its chick to forage (Photographer: Ted Thousand, International Crane Foundation)

Red List Category: Vulnerable
Population Size: 14,500–16,000
Population Trend: Increasing
Distribution: Northeast Asia, China, Japan



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DISTRIBUTION AND STATUS OF KEY SITES

Subspecies/Populations

The Hooded Crane is a monotypic species. Almost yearly a few hybrids between Hooded and Eurasian Cranes are sighted on the wintering grounds (Haraguchi 2014). Annually from one to six mixed pairs of Hooded and Eurasian Cranes with hybrid offspring are spotted at the staging area at Muraviovka Park in Russia (Sergei Smirenski, personal comm. 2016) during the fall migration.

DNA analysis reveals close relationships to the Black-necked Crane (Krajewski et al. 2010).

Overall Range

Almost the entire breeding range is located in Russia, where the breeding grounds extend across an interrupted strip from the north of Central Siberian Plateau in Yakutia to Middle Sikhote-Alin Range in the Russian Far East (Neufeldt 1977, Flint 1987, Andronov et al. 2009). In Yakutia (Republic of Sakha) there are four breeding flocks in the Middle Lena River Basin, which are located in Central Siberian Plateau in Upper Vilyui River, Middle Aldan River, Chara River Basin on the Olekma-Chara Plateau, and Makharchan River Basin (Lena River tributary) (Germogenov 2001, Labutin 2003, Degtyarev et al. 2011). It is estimated that 7–9% of the world population breeds in the Lena River Basin, according to counts of migrating birds in the Amur Basin (Degtyarev 2000). The biggest breeding flock probably inhabits the Upper Vilyui Basin, while in the Middle Aldan River a breeding flock estimated at 100 pairs was discovered recently (Degtyarev et al. 2011). Other breeding groups are not significant with small numbers of pairs (Degtyarev et al. 2011).

The other big breeding area covers the Middle and Lower Amur River Basin (Amur and Khabarovsk Provinces and Jewish Autonomous Province) (Smirenski and Smirenski 1980, Smirenski and Roslyakov 1982, Andronov et al. 2009, Averin 2011), and Bikin and Iman River Basins as well as river basins that flow into the Japanese Sea, with the main group in Samarga River Basin (Primorsky Region) (Surmach and Shibayev 2015). There are some suspected breeding sites in taiga in the north of Zabaikalye Region (Goroshko 2012), in the northeast of Irkutsk Region (Popov 2010), and in Krasnoyarsk Region (Savchenko and Savchenko 2012), but nests were not discovered. In northeastern China there are two breeding flocks in Lesser Khingan Mountains in Heilongjiang Province with an estimated total number of 500 breeding pairs (Guo 2007, 2014). Breeding has not been confirmed in Mongolia (Nyambayar Batbayar, personal comm. 2015).

Over 30% of the world population of Hooded Cranes gather for a month in spring and for 1.5 months every autumn in the main staging area in Russia—the southern part of Zeya-Bureya Plain in the Amur Province. More than 3,000 Hooded Cranes were recorded during one survey in 2015 in Muraviovka Park and Amurski Game Refuge (Smirenski and Smirenski 2016). Cranes roost and feed at additional places near these two protected areas. In 2016, over 2,000 Hooded Cranes were recorded at two roosting sites in Muraviovka Park and over 700 cranes at another site within 4 km east of the park (Sergei Smirenski, personal comm. 2016).

Most of the global population migrates through the Korean Peninsula along the west coastal area or along the Nakdong River, resting for short periods of time in wetlands in Democratic People's Republic of Korea (North Korea) (Chong 1994). Most Hooded Cranes continue their journey to Izumi in the southern Kyushu Island in Japan. Gumi Haepyung wetland was the most important stopover site during autumn migration and Cheonsu Bay was the most important during spring migration. Other stopover sites in Korea included the Nakdong and Han River estuaries and Ganghwado (Lee 2014). Some cranes stop for winter in Suncheon Bay, and their number has increased during the last ten years (Lee 2015). Cranes from western parts of the breeding grounds of Russia migrate to Republic of Korea (South Korea) and Japan through northeastern China (Chong 1994). Recent investigations have indicated that cranes breeding in China may also migrate to Japan for winter (Guo 2015).

The lesser part of the world population migrates through northern China and eastern Inner Mongolia to the Middle Yangtze River Basin, reaching their wintering grounds at Poyang Lake, Shengjin Lake, Chongming Island, occasionally in Hubei, and a few at Dongting Lake. Shengjin Lake had the largest winter population of this species, but in recent years it seems many have shifted to Poyang Lake for winter. The most important migration stopover in China is located in Lindian County in Heilongjiang Province, on the east side of Zhalong Marsh (Guo et al. 2004, Luo et al. 2012). Other sites include Tumuji (Inner Mongolia), Xianghai (Jilin Province), and Huanzidong Reservoir (Liaoning Province). Bohai is believed to be important but needs further investigation (Liying Su, personal comm. 2016).

A small number of non-breeding Hooded Cranes spend the summer in Mongolia, Russia (Zabaikalsky and Amur Provinces, and the Republic of Buryatia), and in China (Inner Mongolia Province).

ECOLOGY

During the breeding season, Hooded Cranes are very secretive, nesting and feeding mostly in remote bogs throughout the taiga in Russia and in wetlands in the mountain valleys of China. They tend to avoid areas that are heavily forested or very open. These breeding areas are not usually suitable for agriculture or other development, and this species' habitat has been much less affected than breeding areas for Red-crowned and White-naped Cranes.

The Hooded Crane uses a wide variety of habitats during migration and in winter months, such as grasslands, wetlands, and agricultural fields. It is less aquatic than Siberian, Red-crowned, or White-naped Cranes and readily forages in croplands (Meine and Archibald 1996). Muraviovka Park and Amurski Game Refuge in the Amur Province of Russia (Sergei Smirenski, personal comm. 2016) and Lindian (the east side of Zhalong Marsh) in China provide safe roosting areas for migrant cranes that visit nearby farmlands during the day.

NUMBERS AND TRENDS

The Hooded Crane is listed as Vulnerable. Its number has increased from 9,600, estimated in the 1990s (Meine and Archibald 1996), to an estimated 14,500 to 16,000 in winter 2014–15. About 80% of the world population winters in Japan, almost all at Izumi in Kagoshima Prefecture of Kyushu Island. In winter 2017–18, about 14,000 Hooded Cranes were counted in Izumi (Yuko Haraguchi, personal comm.). A small number of cranes (less than 10 individuals) winter at Shunan (Yamaguchi Province) and Isahaya (Nagasaki Province) (Haraguchi 2015). About 100 Hooded Cranes spent the winter in Shikoku in 2014–15 (Yuko Haraguchi, personal comm. 2016). In 2017–18, about 1,700 wintered in the coastal wetlands of Suncheon Bay in Republic of Korea, an increase from about 200 in 1996 (Yuko Haraguchi, personal comm.). Guo (2014) estimated 1,500 wintering birds in China, while Shengwu Jiao estimated 1,000 to 1,150 (personal comm. 2015).

The wide range in the current population estimate reflects the difficulty of counting the dense flocks of cranes at Izumi and the lack of recent range-wide winter counts for China.

THREATS

- In Yakutia, a part of breeding habitats were flooded after construction of the Vilyui Hydro Power Plant, and in Upper Vilyui River Basin an industrial development is maintained (Germogenov 2001);

- Many wetlands are being drained for agricultural purposes, and changes in agricultural land use degrade crane habitat;
- Forest fire is a significant threat on the breeding grounds (Andronov et al. 2009);
- Human disturbance and fish nets prevent cranes from using otherwise suitable habitats;
- Conflicts with farmers from eating corn (maize, *Zea mays*) in autumn and pulling corn seedlings in spring (Guo 2014);
- Poaching at stopover sites (Germogenov 2001, Goroshko 2012, Guo 2014);
- Deteriorating water quality in the coastal waters and along the Yangtze River at major wintering areas in China is reducing the availability of preferred foods such as tubers of *Vallisneria* and other aquatic plants (Fox et al. 2010);
- Dams and diversions of water, such as the Three Gorges Dam, alter critical wetland habitat, including Poyang Lake in China;
- Loss of migratory habitat due to removal of sand bars from the migration route along the Nakdong River and coastal area development along the western coastline in Republic of Korea (Lee 2014);
- Development (greenhouses, power lines, etc.) in the buffer zone adjacent to the core wintering area at Suncheon Bay in Republic of Korea. Although a commercial building was removed from the core area, another commercial building was constructed in the buffer zone for servicing increasing numbers of visitors;
- Tourism impacts are rapidly growing at Suncheon Bay in Republic of Korea, and additional protection is needed for foraging sites in the buffer area;
- Through the "Four Rivers Project," a key winter roosting site in Republic of Korea was lost to dredging of sandbars at the Haepyong wetland near Daegu (Soodong Lee, personal comm. 2015);
- Land development, most notably development proposed in the Korean DMZ/Han River basin;
- The Japanese wintering population (80% of the world population) is highly concentrated during night roosting in Izumi on a 104-ha protected area in response to artificial feeding and loss of alternate wintering sites, raising concerns about the spread of disease through the population. Although avian influenza (HPAI) virus occurrences have not caused significant numbers of crane deaths, this risk is still a serious problem for both cranes and people because poultry farming is the major industry of Izumi city (Haraguchi 2015); and
- Artificial feeding is increasing at Suncheon and leading to similar risks from disease and competition as at Izumi; and
- A potential future threat from a strong competitor for habitat—the Sandhill Crane. This species is expanding its breeding range west- and southward in northeastern Russia and some are now wintering in Japan and China.

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

- Investigation of breeding grounds in Middle Aldan River was conducted in Yakutia (Degtyarev et al. 2011);

- Monitoring cranes and their key wetlands in the Amur/Heilong River basin (the areas observed are migratory stopovers, not breeding sites);
- Consulting by domestic and international experts for crane conservation in the DMZ/Han River Basin of Korean Peninsula, areas that provide significant migratory habitat;
- Ongoing research, management, and technical assistance by nature reserve management authorities and domestic and international experts for the Poyang Lake ecosystem (Li et al. 2012); the International Crane Foundation is working with Poyang Lake and Nanjishan National Nature Reserves on sublake and visitor management as well as community awareness;
- A workshop on "Conservation and International Cooperation for Hooded and White-naped Cranes" held in Japan provided updates on current population surveys, banding, range, and habitat assessments, and migration stop-over and wintering range (Korea and Japan) conservation actions;
- The Hooded and White-Naped Cranes International Network was established in Faku (Liaoning Province, China) in 2015;
- Muraviovka Park and Amurski Wildlife Refuge in the Amur Province of Russia provide safety at this important staging area from mid-August through October to over 30% of the world population of the species (Smirenski and Smirenski 2016); Muraviovka Park plants corn fields to divert cranes from agricultural crops and keep the cranes inside the protected area;
- BirdLife International and the Wild Bird Society of Japan, cooperating with Korean conservationists from several institutions, are attempting to work with government agencies on dispersal of wintering cranes (government is careful to avoid steps that might result in cranes dying in public view, and most communities do not want cranes);
- A Memorandum of Understanding on cooperation in crane conservation and environmental education was signed by the Mayor of Suncheon City, Vice Mayor of Izumi Cite, Director of Dazhanhe Nature Reserve, and President of Muraviovka Park;
- A tiny and dwindling winter crane population at Yashiro, Japan is artificially fed; local conservationists work to keep them returning to this location;
- Dr. Guo Yumin of Beijing Forestry University has studied Hooded Crane breeding areas in Heilongjiang and encouraged establishment of protected areas and improvements in management. He has established an international non-governmental organization for Hooded Crane conservation, registered in Britain; the organization is running a small research grant program in China; and
- Crane monitoring in Republic of Korea has been conducted by local volunteers, bird watchers, and researchers, but only at some important areas due to limited funds, with annual meetings to exchange information (Lee 2014).

CHANGES SINCE 1996

The total population has increased from 9,600 to 14,500–16,000 individuals. Counts at Izumi indicate crane numbers increasing from near 10,000–12,000 in 2008–2013 to 13,500 in winter 2014–15 (Haraguchi 2015).

Notable expansion of the species has occurred to the east (to the eastern slopes of the northern Sikhote-Alin Mountains and presumably to Sakhalin Island). Hooded Crane distribution is determined by distribution of larch (*Larix*), thus excluding expansion of the breeding area to the south (Meine and Archibald 1996). The potential for area expansion to the east is almost exhausted, as the species has occupied almost all optimal habitats in central and eastern Sikhote-Alin Mountains, up to heights of 700–800 m above sea level. Only Sakhalin Island remains vacant, where Hooded Cranes have been sighted but not seen breeding (Surmach and Shibayev 2015).

The number of Hooded Crane sightings has increased on the breeding grounds due to increasing crane numbers as well as attention to this species by scientists.

This species has the best prognosis of the threatened cranes in East Asia and has been increasing under current levels of conservation effort, although natural habitats for migratory stopovers and wintering are extremely limited for Korea/Japan.

PRIORITY RESEARCH AND CONSERVATION ACTIONS

- Study and evaluate action needed to mitigate effects of dams and diversions (the threat on the breeding grounds is less severe than for the White-naped or Red-crowned Cranes);
- Use banding and telemetry studies to identify major breeding sites, staging sites, migration routes, and links between breeding and wintering sites. Increase band monitoring in Japan and Korea;
- Expand and designate new protected areas;
- The most urgent actions are to secure and expand suitable wintering habitats in Japan and Korea, in part to avoid risks of disease or other catastrophe;
- It is important that the dispersed population wintering in China continues to thrive and have suitable habitats available;
- Conduct intensive monitoring of disease risk and incidence and develop a proactive mitigation plan for response to disease threats;
- Understand the movement of this species among wintering areas within the lower and middle Yangtze and conduct a study comparing use of winter habitats;
- In Republic of Korea, continue conservation action focused on the core zone at Suncheon Bay and establish a program to prevent or mitigate development in the buffer area;
- Investigate options to develop a site restoration plan for destroyed roosting and foraging habitat at the Haepyong wetland;
- Although data are available on wintering numbers, population fluctuations, and habitat use characteristics, there is a need to collect basic data on movement patterns among wintering sites, food preferences, and behavior; and
- Continue and expand programs to prevent and suppress forest fires in breeding areas.

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SPECIES REVIEW:

SARUS CRANE (*Grus antigone*)

K S Gopi Sundar

(with input from Rupak De, John Grant, Kandarp Kathju, Timothy Nevard, Simon Mahood, Elinor Scambler, Rajendra Suwal, Triet Tran, Myo Sander Winn, and Robert van Zalinge)

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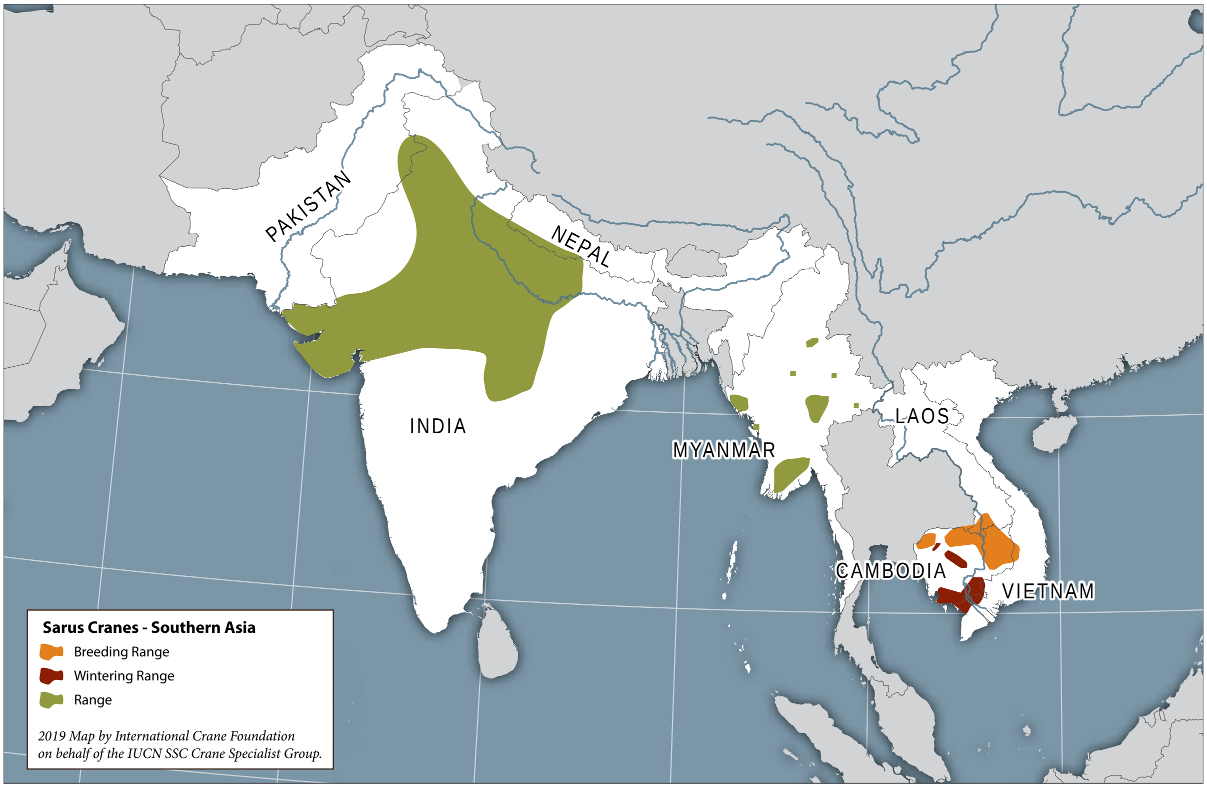
Sarus cranes unison call in rice fields in India (Photographer: K S Gopi Sundar, International Crane Foundation)

Red List Category: Vulnerable
Population Size: 15,000–20,000
Population Trend: Stable or decreasing
Distribution: India, southern Asia, Australia



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DISTRIBUTION AND STATUS OF KEY SITES

Populations

The Sarus Crane is a monotypic species with populations spread out across tropical and sub-tropical parts of South Asia, Southeast Asia, and Australia. Three subspecies have been identified using morphological and plumage characteristics: Indian (*Grus antigone antigone*), Eastern (*G. a. sharpii*), and Australian (*G. a. gillae*); a fourth, the Phillipine subspecies (*G. a. luzonica*), is presumed extinct. The genetic study by Jones et al. (2005) indicated the three extant subspecies probably represent a fragmented cline with limited, but evolutionarily important, gene flow between all populations. Current reproductive isolation of populations and potential genetic introgression with the Brolga (Archibald 1981) led to the recommendation of managing the subspecies separately (Jones et al. 2005). The four populations are located in South Asia, China-Myanmar, Lower Mekong, and Australia. The species is suspected to be extinct or occurring in very small numbers in Bangladesh, China, Lao People's Democratic Republic, Papua New Guinea, and the Philippines (Archibald et al. 2003) and is being reintroduced into Thailand (N. Purchkoon and N. Tiertisup, personal comm. 2017). Genetic studies suggest that the Australian population was separated from the Southeast Asian population about 30,000 years ago (Jones et al. 2005). There is no evidence that the South and Southeast Asian populations inter-breed, but it is possible that such interactions occur in Myanmar (Archibald et al. 2003).

South Asia

Sarus Cranes are primarily concentrated along the Gangetic floodplains in Uttar Pradesh state in India (~6,000). Significant populations also occur in Gujarat and Rajasthan states in western India (~3,000), and small, scattered populations are known from Madhya Pradesh, Maharasthtra, and Bihar states (~500) in central India. A small but contiguous population (~800) occurs in Nepal, primarily in the districts of Rupandehi and Kapilvastu where land use is dominated by cultivation and floodplain marshes and lakes (K S Gopi Sundar and S. Kittur, unpublished information). Occasional pairs are sighted in Pakistan but the species has not been recorded breeding here for three decades (Sundar and Choudhury 2003).

The largest breeding population and highest number of flocking sites have been recorded in the Indian population. The majority of breeding Sarus Cranes in South Asia use irrigated rice (*Oryza sativa*) fields. Breeding areas are therefore spread out across a large area, especially where non-mechanized cultivation and favorable farmer attitudes persist (Sundar 2009, 2011).

Flocks mostly occur seasonally in response to wetlands drying in the summer, but in some areas flocks comprise young birds and birds without breeding territories and are perennial. Several flocking sites are recorded, but documentation in a large part of the populations' distribution range is absent. Important flocking sites include key reservoirs in Gujarat (Mukherjee et al. 1999, Singh and Tatu 2000), reservoirs as well as perennial wetlands supported by irrigation canals in Rajasthan (Kaur 2007), and a relatively large number of medium-sized shallow wetlands that are maintained as community lands for human use in Uttar Pradesh (Sundar and Choudhury 2003, 2008; Sundar 2005). In Nepal, the most important flocking site is along the banks of the rivers Tinau, Danob, and Banganga in Rupandehi and Kapilvastu districts (Rajendra Suwal, personal comm. 2017).

China-Myanmar

This population is the most poorly studied and understood of all Sarus Cranes. In Myanmar, Sarus Cranes were sighted in five out of seven states (Kachin, Shan, Kayah, Rakhine, and Mon) and in five out of seven regions (Ayeyarwady, Sagaing, Mandalay, Bago, and Yangon; Tin New Latt, personal comm. 2017). Breeding has been confirmed in the states of Kachin, Shan, and Rakhine in Myanmar

(Barzen et al. 1996). A resident population of over 150 cranes, including 23 nests, was discovered during surveys by the Myanmar Crane Team of the Yangon University during 2016–2017 from the Ayeyarwady delta (Myo Sander Winn, personal comm.). Another small, apparently isolated, population is known from the Rakhine state of southwestern Myanmar using both freshwater and brackish coastal marshes for nesting (Tin New Latt, personal comm. 2017). A small, probably breeding population is known from the western Yunnan province and Yunxiang County in China contiguous with the population in Kachin and Shan states of Myanmar (Barzen and Seal 2001).

Lower Mekong Basin

Sarus Cranes in the Lower Mekong Basin (LMB) occur primarily in northern Cambodia, the Tonle Sap lake basin, the Mekong Basin, and parts of Vietnam (Archibald et al. 2003, Barzen 2004, van Zalinge and Tran 2016). Barzen and Seal (2001) referred to this population the Southeast Asia Population. A small number of Sarus Cranes are seen in southern Laos. Similar to populations in South Asia, Sarus populations here are both sedentary (Cambodia, Vietnam) and migratory. Sarus Cranes of the LMB migrate between breeding sites, mainly in Northern Cambodia, to non-breeding flocking sites in the Tonle Sap Lake basin and the Mekong Delta (Robert van Zalinge, personal comm. 2017).

Known breeding sites are located in temporarily inundated grassland patches within open Dipterocarp forests in the low-lying plains of north and north-east Cambodia especially Preah Vihear, but also Stung Treng, Rattanakiri, and Mondulkiri provinces (Barzen 2004).

Nesting in northern Cambodia has been documented to occur between July and September (Clements et al. 2009a). The most important known breeding area is located in the Northern Plains, an area comprising Preah Vihear Protected Forest and Kulen Promthep Wildlife Sanctuary, with more than 50 nests counted annually (Clements et al. 2013). A 2001 aerial survey of northern Cambodia conducted in September (end of breeding season) found clusters of Sarus Cranes present in the above-mentioned Northern Plains area and east of the Mekong around Lomphat Wildlife Sanctuary (Barzen 2004). Results from a recent tracking study conducted in 2015–2017 suggest that cranes that are present in the northern Tonle Sap floodplains (including Ang Trapeang Thmor) in the dry season breed in the Northern Plains, particularly Kulen Promtep Wildlife Sanctuary and south towards Boeung Per Wildlife Sanctuary (Robert van Zalinge, personal comm. 2017), while the breeding area of cranes that use the Mekong delta in the dry season seems divided between east of the Mekong (particularly Lomphat WS) and the eastern section of the Northern Plains, i.e. Preah Vihear Protected Forest (Robert van Zalinge, personal comm. 2017).

After breeding, around half the population moves towards the Tonle Sap floodplain and the other half towards the Mekong delta, aggregating at several wetland sites in Cambodia and Vietnam (Barzen and Seal 2001, Watson et al. 2007, van Zalinge et al. 2011). A few individuals, pairs, or family units will stay in the northern forests the whole year, but permanent wetlands are scarce here in the dry season. Ang Trapeang Thmor, Boeung Prek Lapouv, and Anlung Pring are sites that often have peaks of more than 200–300 cranes from January to March, even as late as April in Ang Trapeang Thmor, while earlier in the dry season the majority of cranes will forage in the floodplains of the Tonle Sap lake floodplain and at Boeung Prek Lapouv in the floodplain of the Bassac River (van Zalinge et al. 2011). There are also several other sites in the Vietnamese Mekong Delta that are used by cranes but usually in lower numbers or less regularly than the above-mentioned sites. These include Phu My, Kien Luong Protected Forest, Tram Chim, Hon Chong, Lang Sen, and Hon Dat Protected Forest. Rapidly changing and intensified land use has reduced Sarus Crane use of many sites in the Vietnamese part of the delta. At the beginning of the century more than 300 cranes were still flocking to Hon Chong in Kien Luong province, but this has declined to only a few individuals in recent years due to habitat loss. Tram Chim itself also has seen a sharp decline from being the premier site in the non-breeding season with more than 1,000 cranes recorded in 1988 (BirdLife International 2001) to around 100 or less in the last decade.

Australia

Sarus Cranes occur in far north-eastern Australia, largely concentrated in Queensland. The few studies on Sarus Cranes in Australia have focused on the main breeding areas along the southern and eastern shores of the Gulf of Carpentaria, and flocking areas in the Atherton highlands (Archibald and Swengel 1987, Grant 2005; John Grant and Elinor Scambler, personal comm. 2017). Breeding records are primarily from the coastal regions in the Gulf of Carpentaria and Cape York Peninsula (Archibald and Swengel 1987, Marchant and Higgins 1993, Barrett et al. 2003, Franklin 2008; J. Grant, S. Kittur, E. Scambler, K S Gopi Sundar, Michael A. McCarthy, and Inka Veltheim, personal comm. 2017). Most breeding records from the lowlands of the Gulf of Carpentaria are in the Gilbert and Norman River basins where cranes use natural wetlands, flooded open and forested grasslands, artificial wetlands that provide drinking water to cattle, and seasonally flooded borrow pits that were created during road construction (Barrett et al. 2003; J. Grant, S. Kittur, Elinor Scambler, K S Gopi Sundar, Michael A. McCarthy, and Inka Veltheim, personal comm. 2017). Family groups with juveniles have been observed in several other areas, such as Arnhem Land floodplain areas, but breeding at those sites has not been confirmed by observation of nests (John Grant and Tim Nevard, personal comm. 2017). Part of the Sarus population remains in the Gulf area outside the breeding season, where flocks of varied sizes with adults, sub-adults, and juveniles form (John Grant and Tim Nevard, personal comm. 2017). The only other known major flocking site is the Atherton Tablelands where flocks include young of the year allowing a crude estimate of recruitment rates (Marchant and Higgins 1993, Grant 2005). The source of cranes to this wintering site is unknown. Expanded surveys to ascertain the full extent of distribution of breeding and flocking sites in Australia are needed.

ECOLOGY

Studies on Sarus Cranes have been disproportionately from the Indian subcontinent while the populations in China-Myanmar and Australia remain the least studied. Long-term restoration studies on Sarus' habitat are restricted to the Lower Mekong Basin. Surveys and studies on breeding ecology constitute the majority of scientific attention on Sarus Cranes (Archibald et al. 2003, Sundar and Choudhury 2003).

Breeding pairs maintain perennial territories not exceeding 50 ha in southwestern Uttar Pradesh in India, where flocks consist of non-breeding birds, constitute roughly 50% of the total regional population, and can be seen throughout the year (Sundar 2005, 2009, 2011). Everywhere else in their distribution range, Sarus pairs form seasonal flocks with non-breeding cranes in response to wetland drying (Ramachandran and Vijayan 1994, Mukherjee 1999, Kaur 2007) and during seasonal migration like those seen in the Lower Mekong Basin and Australia (Archibald et al. 2003). Sarus Crane flock sizes increase in the Lower Mekong Basin as the advancing dry season reduces wetland habitat (Jeb Barzen and Triet Tran, personal comm. 2017).

Extensive studies on breeding ecology have been carried out in India (Mukherjee 1999; Mukherjee et al. 2000; Kaur 2007; Sundar and Choudhury 2003, 2008; Sundar 2009, 2011). Sarus Cranes nest during the rainy season or the monsoon, with a minor nesting season in early summer usually involving a small proportion of pairs that failed to raise chicks in the regular nesting season. Breeding pairs repeatedly use the same nest site that might be small patches of wetlands amid rice (*Oryza sativa*) fields, wetlands formed by leaking irrigation canals, on dikes used to separate wetlands from agricultural fields, or on dikes separating agricultural fields. Nest sites are preferentially wetlands that may be either remnant flooded natural marshlands or small unused areas within agricultural fields, though rice fields and dikes within rice fields are also used.

In the Lower Mekong Basin, Sarus were initially thought to nest only in the vast undisturbed wetland complexes or in inaccessible large wetlands, but it is now known that they breed in very small wetlands (0.5–2 ha) that are largely seasonal in nature and are scattered within a landscape of open Dipterocarp forests, such as found in the low-lying plains of northern and northeastern Cambodia (Archibald et al. 2003, Barzen 2004, Clements et al. 2009a).

In Australia, shallow wetlands on cattle (*Bos taurus*) stations and seasonally-inundated grasslands among trees are used, with nests often placed beside *Eucalyptus* tree trunks, sometimes in close proximity to Brolga nests (Archibald and Swengel 1987, Beruldsen 1997; John Grant, personal comm. 2017). Nests in India can be located as close as 3 m to major roads and 20 m to villages. Nests further away from roads have a higher probability of hatching, underscoring the strong role of humans in egg mortality. Preference for wetland nest sites occurs at both the landscape scale as well as within individual crane territories (Sundar 2009).

In India, nest initiation and nesting success are closely matched with farming practices particularly timing of flooding of fields using irrigation canals. Rainfall intensity also has a significant effect, with pairs improving breeding success in years of normal or high rainfall (Sundar 2011). Nest success in Rajasthan and Gujarat is higher when nests are located in wetlands, but evidence for nesting habitat affecting nest success is equivocal in Uttar Pradesh. Average nest success (proportion of nests with at least one egg hatching) varies between 54 and 71% with significant annual variations at each site. Human disturbance and removal of eggs either to reduce crop damage or for food are the principal reasons for egg mortality, and a small amount of egg predation by crows (*Corvus*) occurs. Fledgling success has been calculated using different metrics in three separate studies and varies between 32 and 41% with substantial annual variation. Reasons for chick mortality are largely unknown, though predation by a growing population of feral dogs (*Canis lupus familiaris*) is suspected to be the most important reason. Breeding success declines with low rainfall, conversion of wetlands in crane territories to agriculture fields, and most seriously due to conversion of agricultural land to other forms of more urbanized development. Areas with smaller nesting densities like the semi-arid Rajasthan state experience much larger inter-annual variations relative to wetter areas with high number of nesting pairs as in Gujarat and Uttar Pradesh.

Pairs occurring in landscapes with flooded rice cultivation are more successful in raising chicks relative to pairs in landscapes with drier crops such as soybean (*Glycine max*) and sugarcane (*Saccharum*; Sundar et al. 2000, Sundar and Choudhury 2006). Favorable attitudes towards cranes by farmers results in improved breeding success. In areas with high egg mortality due to humans, complete egg mortality can be prevented only by active nest guarding (Kaur et al. 2008).

In Southeast Asia, Sarus Crane nests are most successful when in inaccessible wetland complexes, and experience near-total egg mortality when they nest in crop fields or near human habitation (Barzen 2004, Handschuh et al. 2010). Even in the remote forest areas of northern Cambodia, the Wildlife Conservation Society has for several years started employing local nest guards for as many nests as possible, due to the high risk of predation by people.

Monitoring of yearlings in non-breeding, flocking sites in the Atherton Tablelands in Australia showed annual recruitment to fluctuate between 5–8% (average of 6.6%, Grant 2005). Similar assessments in the Indian subcontinent from various locations provided a much larger variation annually and between sites with a range of 4–19% (average of 9.22; Sundar and Choudhury 2003). Regional and annual variations are therefore important to understand before using these metrics.

Sarus Cranes are omnivorous with their diet including a long list of individual items ranging from grass shoots, wild tubers from sedges (*Carex*), potatoes (*Solanum tuberosum*), and grains, to bird and turtle eggs, snakes, and amphibians (Sundar and Choudhury 2003). Seasonal movements of Sarus are most visible during the summer in the semi-arid areas of Gujarat and Rajasthan (Mukherjee et al. 1999, Singh and Tatu 2000) and during the post-breeding season starting as early as October in Southeast Asia (Watson et al. 2007, van Zalinge and Tran 2016).

Movements in winter, likely in response to winter temperatures as well as drying conditions, occur in Australia (Grant 2005) and in northern India (Bal and Dua 2010). The most regular seasonal migrations have been observed in the Lower Mekong Basin where Sarus Crane use few large wetlands after the breeding season (Watson et al. 2007, van Zalinge and Tran 2016) and at the Atherton Tablelands in Australia (Marchant and Higgins 1993, Grant 2005; Elinor Scambler, personal comm. 2017). Regulating flooding regimes and active vegetation management using fire in protected wetland areas are crucial to maintain wintering habitat for Sarus Cranes in Southeast Asia (Meynell et al. 2012).

NUMBERS AND TRENDS

Sarus Cranes are considered to be declining due to expanding agriculture and declining wetland areas (Meine and Archibald 1996, BirdLife International 2001). A total global population of 15,000–20,000 is estimated (Archibald et al. 2003). Robust population estimation, however, is absent for the Sarus, precluding a sound understanding of trends. Long-term monitoring is biased towards flocking sites and provides a snapshot of the complexities inherent in estimating population sizes and trends of this species.

South Asia

An estimate of 8,000–10,000 was provided for the Sarus Crane population in India, Pakistan, and Nepal (Archibald et al. 2003). Though presumed to have declined precipitously in South Asia due to expansion of agriculture (BirdLife International 2001), historical literature points to increases in the network of irrigation canals and flooded rice cultivation (Mann 1999), suggesting that Sarus Cranes witnessed a huge expansion of their distribution on the subcontinent during the 1700s and 1800s. This range expansion is continuing today with irrigation canals spreading from new large dams to erstwhile dry areas in Gujarat and Rajasthan (Kaur 2007; K S Gopi Sundar and S. Kittur, unpublished information). However, rice fields, combined with unfavorable farmer attitudes and landscapes with reducing wetland areas, have the potential to become ecological traps (Sundar 2009, Sundar and Kittur 2012). The greatest population declines of Sarus Cranes are therefore likely from this time forward.

Several national, state-wide, and more local surveys using multiple methodologies and metrics have been conducted in South Asia. Two national surveys for India based largely on roadside observations were conducted in 1987–88 and 1998–99 (Gole 1989, Sundar et al. 2000) but had differing objectives and metrics, making a direct comparison in estimates impossible. Gole (1989) provided an estimate of ~13,000 Sarus Cranes in India based on crude roadside densities. Sundar et al. (2000) do not provide an estimate of the entire population based on the surveys but include relative abundances of each surveyed area. Both surveys, however, confirmed that most of the Sarus population occurred in Uttar Pradesh, Gujarat, and Rajasthan, with small populations in Maharashtra and Madhya Pradesh and no cranes seen east of Uttar Pradesh. Both surveys also identified southwestern Uttar Pradesh as having the highest concentration of Sarus Cranes in the region.

The most comprehensive state-wide surveys have been conducted in Gujarat using volunteer visits to rural areas with reservoirs and wetlands (Singh and Tatu 2000). An estimate of ~2,000 cranes has been provided from this survey with the majority of crane located in the districts of Kheda and Ahmedabad, with smaller populations scattered in the districts of Bharuch, Junagadh, Panchmahal, Surat, and Valsad. A previous estimate of 12,000 cranes in Gujarat is thought to be inflated; surmises of significant declines of Sarus populations in the state are suggested to be incorrect (Singh and Tatu 2000). Currently, however, Gujarat is experiencing the most rapid industrial development of any state in India, and this process is likely occurring at the cost of wetlands and other habitats important for Sarus Cranes (Kandarp Kathju, personal comm. 2017).

An estimate of 6,000–8,000 cranes was provided for Uttar Pradesh (Sundar and Choudhury 2003). However, more detailed studies including a landscape-scale occupancy modelling exercise and an annual state-wide Sarus census conducted by the Uttar Pradesh Forest Department indicates that this is an underestimate (Sundar 2005, Sundar and Kittur 2012; Rupak De, personal comm. 2017). Rainfall in the state is experiencing rapid variations with a higher frequency of extreme events (Sundar 2011). If this forces changes in the major crops from rice to drier crops like corn (maize; *Zea mays*), Sarus Cranes will be very severely affected. Land-use change in the state, especially urbanization of agricultural lands and attrition of wetlands, are the most serious threats and can cause rapid declines in breeding populations of cranes (Sundar 2011). These rapid, large-scale changes are currently heavily localized suggesting that Sarus declines will be limited in the near-term in Uttar Pradesh.

Annual counts in Rajasthan's Keoladeo-Ghana Bird Sanctuary show a decline of Sarus numbers from 238 in 1983 to <40 cranes in recent years (Krishna Kumar, personal comm. 2017). However, Sarus Cranes outside the sanctuary show stable to increasing numbers, suggesting that the reduced numbers are related to altering hydrological regimes in the sanctuary, and it is not possible to relate counts inside the sanctuary to a population decline of the species in the region (K. R. Anoop and Krishna Kumar, personal comm. 2017). Similar detailed surveys are lacking in most of the other parts of the Sarus distribution in South Asia and are needed.

Comprehensive multi-year surveys in the entire potential distribution range in lowland Nepal have not been conducted. Surveys and studies have been restricted largely to Rupandehi district, which is suspected to have the highest Sarus Crane population in the country (Rajendra Suwal, personal comm. 2017). The crane population in Rupandehi and the adjacent Kapilvastu district is around 800 birds (K S Gopi Sundar and S. Kittur, unpublished data). To accommodate increased visitation to the birthplace of the Buddha, southern Rupandehi has experienced increased development. Industrialization accompanied by substantial increase in water pollution to rivers is a serious new threat capable of reducing the quality of existing Sarus Crane breeding habitats (Bhante Vivekananda and Rajendra Suwal, personal comm. 2017).

China-Myanmar

Sarus Cranes are most seen in the Ayeyarwady Delta. Surveys conducted here by the International Crane Foundation and Myanmar Forest Department recorded 122 and 61 Sarus cranes in 1996 and 1998, respectively (Barzen et al. 1996; Curt Meine, personal comm. 1998). Thet Zaw Naing (personal comm.) recorded 88 Sarus Cranes in April 2004 and 128 Sarus Cranes in May 2005 at Tawntay Township, Ayeyarwady Delta. Recently, a research team from Zoology Department of Yangon University conducted a survey at three townships in the Ayeyarwady Delta during August–September 2015 and found 60 Sarus cranes (Myo Sander Winn, personal comm. 2017). The same team conducted more extensive surveys at 74 villages in nine townships across four districts of the Ayeyarwady Region during June 2016–March 2017 and recorded 158 Sarus Cranes and 23 nests (Myo Sander Winn, personal comm. 2017).

In northern Myanmar, Sarus Cranes were recorded in small numbers around Indawgyi Lake, Kachin State, with as many as 28 counted in February 1999 (Eleanor Briggs and Tin New Latt, personal comm. 2003; T. Z. Naing and Joost van der Ven, personal comm. 2017; A. Si, personal comm. 2017). In western Myanmar, T. N. Latt (personal comm. 2017) reported 38 Sarus Cranes, including four juveniles at several locations in the Rakhine State. In central Myanmar, Sarus Cranes have inhabited the Mandalay Region (Eleanor Briggs and Tin New Latt, personal comm. 2017). Sarus Cranes were also frequently observed in small numbers, including breeding pairs, around Inle Lake, Shan State, and Moneyingyi Bird Sanctuary, a Ramsar Site in the Bago Region (Barzen et al. 1996; Curt Meine, personal comm. 2017; Tin New Latt, personal comm. 2017). Additional sightings of Sarus Cranes have been recorded recently at various locations in Sagaing Region (Eleanor Briggs and Tin New Latt, personal comm. 2017), and there are old unconfirmed records from Mon State (Tin New Latt, personal comm. 2017).

Previous field observations suggest that Sarus Cranes in the Ayeyarwady Delta are non-migratory, often use paddy fields as breeding habitat, and are tolerant of the presence of humans (Barzen et al. 1996, Meine 1999). These sedentary behaviors and nesting habitats are similar to those displayed by the Sarus Cranes in south Asia. Outside of the Ayeyarwady Delta and perhaps in the Rakhine area, Sarus Cranes in Myanmar may have seasonal movements between breeding and non-breeding seasons (Barzen et al. 1996, Barzen and Seal 2001).

Results from recent surveys in the Ayeyarwady Delta (Myo Sander Winn, personal comm. 2017), combined with previous records from other regions, suggest an estimate of 300–400 Sarus Cranes in Myanmar.

Lower Mekong Basin

Vast areas of the Mekong delta and large wetlands areas like the Plain of Reeds have been affected by war and in more recent times have been drained and reclaimed for agriculture (Archibald et al. 2003, Tran et al. 2004a). A population estimate of 800–1,000 cranes was been provided for the Sarus in Southeast Asia (Archibald et al. 2003, van Zalinge et al. 2011), although results from recent years of crane counts suggest a rapid decline now occurring (van Zalinge and Tran 2016, Triet et al. 2018). Annual counts are believed to have the potential to capture a good majority of the crane population but lack precision due to annual climatic and hydrological variations, the complexity and size of the landscape being considered, and the lack of information on crane ecology, movements and distribution (Watson et al. 2007, van Zalinge et al. 2011). New breeding and flocking sites are being discovered regularly in the region, although some of the flocking sites are not used annually, indicating that cranes shift to new sites depending on food availability; this makes annual monitoring of the population very difficult (Watson et al. 2007, van Zalinge et al. 2011; Triet Tran, personal comm. 2017). Highest records since the annual counts began in 2001 have been 878 in 2002 and more recently, 869 in 2011 (van Zalinge et al. 2011). However, counts have recently shown a dramatic decline from 671 in 2014 to 572 in 2015, 433 in 2016, and 253 in 2018 (Triet et al. 2018). Simultaneous tracking of individuals showed that birds tagged or ringed in 2015 stayed at the catch sites for most of the dry season and returned again in 2016. In 2017 some juveniles shifted from Stoung (a site within the Tonle Sap floodplain) to Ang Trapeang Thmor, but adults returned to the same sites as in other years (Robert van Zalinge, personal comm.). Therefore, a high degree of site fidelity is shown and, if counts are maintained at the same sites each year (as is done), a sharp population decline is currently occurring.

Australia

Estimates of 5,000–10,000 Sarus Cranes are provided for Australia, but these are thought to be unreliable (John Grant and Elinor Scambler, personal comm. 2017). The only reliable counts are 1,200–3,000 individuals flocking on the Atherton Tableland from 1997–2016, but it is not known what proportion of the total population these birds represent (Elinor Scambler, personal comm. 2017). Population trends in Australia are currently unavailable.

THREATS

A large number of threats have been documented for all the Sarus populations. These include: increasing urbanization and industrialization; deforestation (mainly affecting breeding habitats of the population found in the Lower Mekong Basin); intensive farming practices on rice paddies; variations in rainfall due to global climate change; increased predation of eggs by humans and pre-fledged chicks by dogs; excessive harvest or poaching of young birds; mortality due to electrical wires and barbed-wire fences; unintended poisoning in agricultural landscapes by chemicals applied to crops; poisonous baits used in waterbird hunting; deterioration of quality of important wetland sites due to invasive species, changes in flooding regimes, and inadequate vegetation management; potentially low recruitment rates (due to unknown reasons); conversion of common-use wetlands for aquaculture; and permanent displacement of breeding and flocking cranes due to urbanization (Muralidharan 1993; Mukherjee 1999; Mukherjee et al. 2000; Pain et al. 2004; Tran et al. 2004b,c; Grant 2005; Sundar and Choudhury 2005; Kaur 2007; Sundar 2009, 2011; Barzen and Tran 2010; Meynell et al. 2012; Sundar et al. 2015; Jeb Barzen, Elinor Scambler, Kandarp Kathju, and Rajendra Suwal, personal comm. 2017).

A number of potential threats that may occur at very large scales, given uncertainties related to climate change and acceleration of development, might cause rapid declines of Sarus populations. These threats are emerging particularly in South Asia and Southeast Asia and include shifts in primary crops from flooded rice to drier crops like corn, soybean and sugarcane; extreme fluctuations in precipitation levels, especially increased frequencies of dry years and years with decrease in rainy days due to global climate change; changes in national land-use policy to favor transformation of agricultural land to industrial and urban requirements; potential displacement and mortality from increasing wind farms; increased invasiveness of exotic, invasive species in wetland sites of importance; and increased pesticide use on crops. Outside of Australia, documentation and studies of wetlands in the rest of the distribution range of Sarus Cranes have been very sparse, indicating that the large-scale threats will have unknown effects on the habitat.

The Southeast Asian population is experiencing the most precipitous decline and threats of any Sarus population. Vast areas of the Mekong Delta such as the former Plain of Reeds have been drained and reclaimed for agriculture (Archibald et al. 2003, Tran et al. 2004a), and changing hydrology and other factors have altered most of the remaining wetlands, causing reductions in numbers of cranes using the Mekong Delta in the non-breeding season. The last five years in Cambodia have seen the highest acceleration of deforestation worldwide. Particularly the more open deciduous forests in which cranes breed are targeted for conversion to large agricultural plantations; if the current trend is followed it looks like the protected area system in Cambodia will also increasingly be compromised and altered. The collection of eggs and chicks for consumption and trade is common and widespread, although nest protection occurs in at least two important breeding areas (Handschuh et al. 2010, Clements et al. 2013), but on top of this hunting and wildlife trade are at unprecedented levels as Cambodia's human population grows, previously undisturbed areas are opened up, and trade networks become more efficient and far-reaching (Robert van Zalinge, personal comm. 2017).

An emerging potential threat in Australia is the development of irrigated agriculture in northern Australian river systems. Impoundment of water for irrigation and 'pest control' issues may possibly impact cranes, which are already under illegal pressure in some agricultural areas near the Atherton Tablelands (Tim Nevard, personal comm. 2017). The Gilbert River basin, one of the key sites for breeding Sarus, has been identified as one of the first northern catchments for agricultural expansion (John Grant, personal comm. 2017). Land-use changes to favor sugarcane and declining rainfall at Atherton Tablelands, the most important non-breeding flocking site for Sarus in Australia, are additional threats in Australia (John Grant, Elinor Scambler, and K S Gopi Sundar, unpublished information).

A significant threat to conservation efforts especially in South Asia is dilution of local belief systems via payment-based conservation projects that tend to be implemented over very small scales and are usually short-lived (Sundar and Choudhury 2003). In Cambodia, nest protection via payments to individuals was useful to increase breeding success, but the program benefited very few people, causing jealousies and inciting deliberate disturbance of nesting birds (Clements et al. 2013). These experiences suggest that payment-based conservation interventions require very careful implementation, but also that it may be useful to seek alternative interventions that strengthen existing positive attitudes where present as in south Asia. Social upheavals due to perceived and real changes in allocation of water and other ecological services due to protectionist conservation efforts can lead to significant declines in quality of wetlands that support important Sarus Crane populations (Lewis 2003). Continuing with the protectionist paradigm to convert community wetlands into protected wetland sites can result in the increase of such social upheavals in some areas like South Asia.

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

Sarus Cranes are protected via national legislation in most of the countries in their distribution range. But the vast majority of cranes occur in private crop and grazing lands and in community lands, rendering typical conservation strategies requiring designation of individual sites as reserves ineffective. Research and conservation efforts have therefore focused on understanding how to reconcile land use vis-á-vis ecological requirements of Sarus Cranes, developing regional and local initiatives to reduce pressures on wetlands and other sites used by cranes, and improving prospects for continued long-term efforts via collaborative training involving universities, non-profits, international conservation initiatives, and the government. Although in Cambodia cranes breed mostly in state-owned protected forests and in three key wetlands that have been officially designated as Sarus Crane reserves (these three sites regularly hold 20–30% of the regional population), human use and influence within these areas is large and will only increase. In Southeast Asia there is also a real need to work with farmers, communities, and civil society in general to improve crane and wetland conservation in the region.

South Asia

The greatest understanding of Sarus Crane ecology comes from research conducted by universities, governmental agencies, and non-profits in India and Nepal. Long-term research and use of robust field and analytical methods are improving greatly. Some of the major developments in research are listed below.

- Development of survey techniques, specifically methods that focus beyond ongoing long-term monitoring efforts at wetlands (Sundar 2005), and implementation of landscape-scale surveys away from roads (Sundar and Kittur 2012). Occupancy modelling has helped identify erstwhile unknown landscapes with good crane populations and helped clarify the importance of retaining community wetlands at the landscape scale;

- Strong understanding of breeding ecology, particularly nesting site preference, hatching and fledgling success, and impacts of rainfall variations and land-use change on breeding success (Mukherjee 1999; Mukherjee et al. 2000; Sundar and Choudhury 2003; Kaur 2007; Sundar 2009, 2011). Research has been carried out at multiple sites at varying spatial scales, providing a strong understanding of how differing land uses and local attitudes and cultures affect Sarus breeding success. Research over longer periods, providing very high resolution understanding of Sarus population trends, behavior, and factors affecting key population metrics, have begun in multiple locations;

- Improved understanding of the impacts of major threats such as farmer removal of eggs, egg removal for food, impacts of mortality of pre-fledged chicks on population structure and growth, and population-level impacts due to mortality by collision with electrical wires (Mukherjee 1999, Mukherjee et al. 2000; Sundar and Choudhury 2005; Kaur 2007; Sundar 2009, 2011). Repeated occurrence of poisoning events due to pesticide application is documented at one site (Muralidharan 1993, Pain et al. 2004);

- Importance of small-holder farmer practices with minimal mechanization for Sarus Crane persistence and relatively high bird diversity, and the critical need to encourage positive farmer attitudes to enable Sarus breeding in private lands has been highlighted in multiple locations (Mukherjee 1999; Sundar 2009, 2011; Sundar and Kittur 2012);

- Development of key population metrics and landscape-scale monitoring protocols for use in volunteer, citizen-science efforts, and mass awareness are underway in India and Nepal;

- State-sponsored, state-wide Sarus Crane censuses to help bring wildlife outside of protected areas into focus, and to understand annual trends in Sarus numbers have begun in Gujarat and Uttar Pradesh (Singh and Tatu 2000; Rupak De, personal comm. 2017);

- State-sponsored education efforts have been carried out by the Forest Departments of Gujarat and Uttar Pradesh in India, and similar efforts by non-profit organizations in association with local and national governments have been undertaken in Nepal. These efforts have enabled completion of films documenting Sarus ecology, radio programs to highlight the importance of Sarus Cranes, and printed material (posters and pamphlets) to showcase the importance of Sarus in ecology and culture. These programs and education materials are being improved on, and plans to undertake wider-scale education are currently underway in India and Nepal; and

- Efforts are underway among the Lumbini Crane Conservation Center, Nature Conservation Foundation, International Crane Foundation, and other national and international institutions to develop collaborative projects to understand institutional frameworks that assist in retaining community wetland areas in important Sarus Crane areas. Projects will focus also on determining wetland values, institutional mechanisms important in retaining wetlands, and the role of caste and economics in maximizing the retention of community wetlands important for Sarus Cranes.

Conservation and restoration efforts have been sparse since the vast majority of the Sarus Crane population occurs in working landscapes, particularly private cropland and community lands. These efforts are therefore largely focused on wetland sites of national importance, and in areas on the periphery of the Sarus' distribution where declines and impacts of threats are readily visible on the already-sparse population.

- Nest guarding using payments to local communities to improve breeding success in areas with very high egg mortality (Kaur et al. 2008);

- Community participation and focused administrative efforts at the district level to locate and conserve important wetland sites are taking place in a few locations and are increasing. Two significant examples are worthy of mention. One is the effort by the District Magistrate in Sitapur district, Uttar Pradesh, to survey wetland sites for Sarus, and implement formal conservation policy (S. Kumar, personal comm. 2017). The second is the active protection and purchase of key crane nesting sites at Chandrapur and Gondia districts, Mahasrashtra, by local non-profits to prevent loss of wetland sites to development, and to improve Sarus Crane persistence and breeding success (B. Katdare, A. K. Bharos, S. Bahekar, and Rajkamal Job, personal comm. 2017);

- Using the strength of cultural and religious values to protect important wetlands and bring about wider awareness and support for the importance of wetlands and Sarus Cranes. This approach has been ongoing in the Lumbini region of Nepal for over two decades, resulting in the conservation of an invaluable wetland area close to the birthplace of Lord Buddha (Suwal 1999); and

- Organising new water sources for Keoladeo-Ghana National Park, which is also a recognized UNESCO site, in Rajasthan has been ongoing. Regular water supply was affected due to local conflicts with farmers and grazers (Lewis 2003), and water supply using an alternative source has been established (K. R. Anoop, personal comm.). This effort has revived the breeding populations of Sarus Cranes in the Park (K. R Anoop and Bijo Joy, personal comm. 2017).

China-Myanmar

The greatest advancements in research efforts have been carried out in this region. Political changes in Myanmar have facilitated collaborations that are yielding new information on the populations and requirements of Sarus Cranes. A collaboration forged between the International Crane Foundation and the Yangon University has led to increases in field surveys since 2015, primarily in the Ayeyarwady Delta region. As part of this collaboration, it is anticipated that surveys will be expanded to additional areas, and ecological research with a focus on conservation requirements of Sarus Cranes will be increased in the region (Triet Tran and Myo Sander, Winn, personal comm. 2017).

Lower Mekong Basin

Conservation efforts have been the most sustained in Southeast Asia, although as pointed out above the population is also the most at risk. Very little research on Sarus Crane ecology has been done due to decades of wars in the region and the slow rebuilding of institutional capacity. Most of the crane related research in the region has been carried out in Vietnam. The focus has been more on population monitoring and developing innovative solutions with local communities to link livelihoods with wetland conservation. Crane breeding sites are very difficult to access, hampering research on this vital aspect of crane ecology, although the nest protection program in Preah Vihear has offered some opportunities to collect important data (e.g., Handschuh et al. 2010), and recently a study has been conducted on nest-site selection in the Northern Plains (Robert van Zalinge, personal comm. 2017). Achievements to date have been:

- Documenting key sites for conservation of Sarus Cranes and other birds, designating three key wetlands in Cambodia as Sarus Crane reserves, and the ongoing evolution of their management (van Zalinge et al. 2011);

- Aerial surveys over inaccessible forested wetland complexes to locate Sarus Crane breeding sites, and to understand importance of these sites to other species of global conservation importance (Barzen 2004);

- Annual monitoring of non-breeding Sarus Cranes at key sites in Cambodia and Vietnam (Watson et al. 2007; van Zalinge et al. 2010, 2011; van Zalinge and Tran 2016). Efforts have increased from one or two sites by single non-profit organizations, to covering a network of sites with new areas being discovered regularly as part of a sustained collaborative partnership among various local, national, and international institutions;

- Improving water regimes and initiating management of vegetation and select faunal taxa using fire and control of invasive species at key wetland sites (Tran et al. 2004a,b,c; Meynell et al. 2012; van Zalinge and Tran 2016);

- Protecting the extensive deciduous Dipterocarp forest with its network of small wetlands across the entire breeding range of Sarus Crane in Cambodia, with a particular emphasis on Preah Vihear Province (which satellite telemetry and field data indicate is the most important breeding area) is ongoing. However, efforts to prevent loss of forest and in particular grassy wetlands that are a target for small-holder rice cultivation need to be scaled up (Simon Mahood, personal comm. 2017);

- Initiating a region-wide University Network and evolving a wetland training course conducted annually in a different country (Tran et al. 2003, Barzen 2009). This effort, alongside other international efforts to help sustain the unique Lower Mekong River Basin, is helping enhance training to local students and university faculty in a range of aspects of wetland ecology. The network is providing strong and sustained impetus to larger-scale region-wide collaborations to understand wetland dynamics, level of chemical pollution in wetlands, other key threats, ecology of focal species like Sarus Cranes, and highlight the importance of wetlands potentially leading to meaningful interventions in national and regional developmental policies to achieve wetland conservation;

- Hiring local guardians to protect nests located within protected areas of northern Cambodia (Clements et al. 2013) and other community participative and livelihood generation initiatives using locally relevant and innovative approaches at key sites to promote conservation interest and change attitudes, such as handicraft production using natural resources, community-based ecotourism, and wildlife-friendly rice marketing (Tran et al. 2003, Clements et al. 2009b); and

- An instance of captive breeding to reintroduce Sarus Cranes in Thailand—where the species is presently extirpated in the wild—is being undertaken as a national enterprise with support from the Royal Family and several local zoos (N. Purchkoon and B. Sariaroonnat, personal comm.). Eighty-five post-fledged juveniles have been released at wetlands near flooded rice paddies; in 2015, 42 birds survived. There are 151 captive Sarus Cranes in various Thailand zoos and private collections; a few are from the Australian population (received via a donation from the International Crane Foundation), while most are from the eastern population (obtained from poachers who had illegally procured the birds from unknown locations, but most likely from Cambodia). Protocols are currently being developed for captive rearing to maximize breeding success (including a detailed investigation into their pedigree), habitat management and protection at release sites, and appropriate training for all personnel, in part through international collaborations with agencies undertaking crane releases. The first chick from released cranes that paired and nested in the wild fledged in 2016, and another two chicks fledged in 2017 (N. Purchkoon and B. Sariaroonnat, personal comm. 2017).

Australia

Until recently, remarkably little research has been conducted in Australia on Sarus Cranes. Most of the recent effort to connect crane enthusiasts, increase research, and initiate collaborative efforts on the continent has been due to volunteer efforts (Elinor Scambler, personal comm. 2017).

- Long-term monitoring of crane numbers, recruitment rates, and foraging ecology studies at the Atherton Highlands, the primary flocking site known for Sarus Cranes in the region, with standardized counts since 1997 (Grant 2005; Elinor Scambler, personal comm. 2017). These efforts have resulted in the declaration of the Atherton Tablelands as an Important Bird Area;

- Development and maintenance of a website (www.ozcranes.net) to help connect crane enthusiasts; provide updates of ongoing and completed crane research; improve efforts for long-term monitoring via collaborations with national and international institutions, universities and the government; improve understanding of critical conservation issues that may require focussed research attention,;and provide a platform for discussions with Sarus Crane researchers internationally (Elinor Scambler, personal comm. 2017);

- Initiating robust landscape-scale monitoring protocols to understand potential impacts of land use and intervention by landowners such as burning regimes and control of vertebrate pests including pigs (*Sus scrofa*) on Sarus Crane breeding success, distribution, and populations; and

- Evolving partnerships with Sarus Crane researchers and conservationists between Australia and South Asia to provide comparative and collaborative frameworks within which to understand Sarus Crane ecology and develop an understanding of local conservation requirements. This effort is led by the International Crane Foundation and the Nature Conservation Foundation, along with the University of Melbourne and is expected to involve several additional organizations and agencies in both Australia and South Asia.

CHANGES SINCE 1996

Since the writing of the 1996 Crane Action Plan, considerable new research, restoration effort, collaborations, and coverage of areas with varied land use as well as social and cultural norms have provided a much fuller understanding of Sarus Crane ecology and conservation requirements. The on-going conservation and research efforts are outlined in the previous section. Thorough reviews of literature to help interested researchers and governmental agencies have been compiled on the species (Archibald et al. 2003, Sundar and Choudhury 2003). Information provided to BirdLife International on sites important for Sarus Cranes has been critical for recognition of several sites as Important Bird Areas. Improvements in knowledge and field action have been less active in China, Myanmar, and Australia. However, recent efforts to undertake collaborative research and action along with several international and national institutions in Australia promise to change that situation soon (Elinor Scambler and John Grant, personal comm. 2017).

South Asia

Scientifically robust surveys to determine distribution as well as factors affecting distribution and breeding success have been initiated (Sundar and Kittur 2012). Detailed research was restricted largely to one site in Rajasthan (Ramachandran and Vijayan 1994) but has since substantially developed also in Gujarat and Uttar Pradesh. Long-term monitoring at one wetland site continues, and new long-term research in agricultural landscapes has been initiated providing novel findings of global significance (Mukherjee 1999, Kaur 2007, Sundar 2011; Krishna Kumar, personal comm. 2017). Several new populations have been discovered and multiple census efforts at the state level have been initiated (Singh and Tatu 2000; Rupak De, personal comm. 2017). Advances have been most significant in the detailed understanding of the formerly unknown degree of use of farmland landscapes by breeding and flocking Sarus Cranes (Mukherjee et al. 1999; Kaur 2007; Sundar 2009, 2011). A strong understanding of the population-level impacts of mortality due to electrical wires has been developed, and several key areas for focused intervention have been identified (Sundar and Choudhury 2005).

The previous plan recommended enacting strong laws to secure key wetlands and crane populations, but considerable research and restoration efforts show that creative and locally relevant strategies need to be evolved; maintaining community lands with local support can aid in long-term persistence of significant Sarus Crane populations in many areas within the cranes' distribution range. A large set of general recommendations to improve research, collaborations, and conservation legislation was provided in 1996, and a major proportion of these remain to be carried out.

China-Myanmar

A long-term initiative to learn more about the conservation needs of Sarus Cranes has been initiated in Myanmar, which is yielding necessary information regarding the distribution, population, breeding ecology, and relationship with habitats such as natural wetlands and flooded rice fields (Myo Sander Winn and Triet Tran, personal comm. 2017).

The Lower Mekong Basin

Wetland conservation and restoration using active interventions and systematic monitoring to understand critical needs of key wetland sites have been developed at various sites in Southeast Asia. The most important development has been the protection of habitat in the breeding and non-breeding grounds, and in particular the direct protection of nests, without which the decline of Sarus Cranes here would have been much more pronounced (Simon Mahood, personal comm. 2017). A significant progress has been the development of the region-wide collaboration via the University Network, as well as the growing efforts to monitor large wetland sites with flocking non-breeding Sarus Cranes. Progress with these collaborative, regional efforts at the time of writing of the 1996 plan was greatly limited. A collaborative research between the International Crane Foundation and several universities in Cambodia and Vietnam was conducted during 2014–2016 to describe and map wetlands in Kulen Promtep Wildlife Sanctuary Cambodia and Yok Don National Park Vietnam (Triet Tran, personal comm.). A captive breeding and release experiment is ongoing in Thailand.

Australia

Ongoing research collaboration between Charles Darwin University, the International Crane Foundation, and the University of Greifswald has recently seen three papers published (Nevard et al. 2018, 2019a, 2019b). Using genetic analyses of shed feathers and other samples, findings include definitive genetic evidence of past and ongoing introgression between Sarus Cranes and Brolgas and the first confirmation of movement of cranes between breeding and flocking areas. The research also investigated habitat partitioning of Sarus Cranes and Brolgas; distribution, foraging behaviour and food selection in their non-breeding wintering sites on the Atherton Tablelands; and investigation of agriculture-crane interactions and farmer attitudes, including threats and opportunities for crane conservation. Genetic analysis of shed feathers based on the Lincoln-Peterson Index was undertaken to estimate population size (Nevard et al. 2019b). The research team collaborated with colleagues from Myanmar, Cambodia, Thailand, and Germany to re-visit genetic relationships between Sarus Crane populations including the extinct Philippine population (Nevard et al. in preparation). Further work in New Guinea will commence in late 2019.

In addition, a long-term collaborative program focusing on the ecology and conservation requirements of Sarus Cranes in both breeding and wintering areas has been initiated by the International Crane Foundation, the Nature Conservation Foundation, and the University of Melbourne, in association with independent crane researchers and other experts. This collaboration has provided the first empirical information on landscape scale habitat preferences, robust estimates of breeding success derived from tracking individual breeding pairs, relationship of timing of nesting with rainfall, variation in diet derived from isotopic analyses of shed feathers, and behavior (Sundar et al. 2019). Surveys have since expanded to include all known areas in Queensland with breeding Sarus Cranes and is expected to provide a comprehensive picture of the relationship of crane demography with rainfall, land use, and climate change to build an effective conservation plan.

PRIORITY RESEARCH AND CONSERVATION ACTIONS

Research

- Initiate Sarus Crane population monitoring using robust methods in areas that are poorly covered in past surveys, particularly in the Gulf Plains of Australia; in Nepal especially in Nawal Parasi, Banke, Bardia, Kailali, and Kanchanpur districts; in India especially in Madhya Pradesh and Rajasthan states and also in several districts of Uttar Pradesh not covered by Sundar and Kittur (2012); and in Myanmar especially across the entire Ayeyarwadi Delta; and the Lower Mekong Basin. Surveys and monitoring should be continued and improved for the rest of the distribution range where previous information exists. Surveys should include identification and counts of juveniles to monitor annual reproductive output of the populations;

- Assess impacts of agricultural and industrial chemicals on Sarus Cranes and their food throughout their distribution range;

- Initiate studies on the link between crane mortality and poisoning and the prevalence of poisoning in Cambodia and Vietnam;

- Undertake carefully designed movement studies of (1) dispersal of young birds from natal territories in areas with perennially territorial birds and (2) seasonal movements of cranes in other areas;

- Document areas important for flocking Sarus and understand impacts of surrounding land use on these sites; prepare management plans that explicitly include local stakeholders such as district development committees in Nepal, village councils in India, and landholders in grazing and agricultural areas of tropical Australia;

- Collect more data on distribution of Sarus Cranes breeding sites in the northern and northeastern forests of Cambodia; study the ecology of these sites and requirements of cranes in this landscape;

- Undertake studies to understand factors causing mortality of eggs, chicks, and older birds to enable implementing preventive strategies across the entire distribution range. Improve and enlarge studies on mortality due to electrical wires and barbed-wire fencing in South Asia and Australia, and initiate interventions to minimise these incidents in collaboration with land owners, state, and central agencies;

- Improve understanding of the utility of Sarus landscapes for other wildlife and for human livelihoods to facilitate improvements in policy and prevent myopic development of such areas;

- Increase studies on population genetics, especially to understand the impacts of population sizes on genetic structure and, in Australia, determine the impacts of potential interbreeding with Brolgas; and

- Initiate studies on health of wild Sarus populations and develop indicators of landscape health and chemical use, and develop an understanding of variations due to invasive versus non-invasive techniques.

Habitat Management and Protection

- Continue and expand wetland restoration activities in Southeast Asia and enable information exchanges on these experiences to other areas in the Sarus Crane's distribution range to help initiate locally relevant restoration projects where necessary;

- Expand initiatives to protect breeding and non-breeding wetland sites and Sarus Crane nests in the Lower Mekong Basin;

- Initiate multi-disciplinary studies in South Asia and Australia to understand levels of reliance of farmers and other people on wetlands and rivers; understand socio-political and institutional mechanisms that help retain important breeding and flocking sites; and increase research on wetland ecology, especially sociological perspectives that are currently severely under-explored. These explorations will be particularly important to understand formal and informal mechanisms available to protect and restore important Sarus sites and landscapes;

- Continue to provide information on Sarus flocking sites to key international organizations such as the Important Bird Areas program of BirdLife International and the Key Biodiversity Areas coordinated through IUCN to help highlight these sites and landscapes;

- Initiate detailed exploration of the potential impacts of sea-level rise on the salinity of coastal and inland wetlands in the Lower Mekong Basin and western Queensland to understand upcoming impacts of global climate change, and to prepare for potential changes in habitat conditions for breeding Sarus Cranes;

- Improve and expand research to understand more completely the impacts of climate change in South and Southeast Asia, especially variations in rainfall patterns on probable changes in cropping patterns that in turn can drastically deteriorate habitats and conditions for Sarus persistence;

- Increase focus on large-scale land use change currently being planned in Southeast Asia and Australia focusing on areas important for Sarus Crane breeding and flocking, as well as the implications of changing hydrology at the scale of entire river basins;

- Develop community-based programs and activities to help protect wetlands that cranes use during breeding and non-breeding seasons in Cambodia, Laos, and Vietnam;

- Work with local governmental authorities to integrate crane habitat management with economic development planning; and

- Continue to work with governments to enhance protection at key state owned reserves, particularly in the Lower Mekong Basin.

Education and Awareness

- Improve and expand the demonstration wetland site in Lumbini garden to help showcase importance of small wetlands to Sarus Cranes and other biodiversity. Use the site to enhance awareness among the hundreds of thousands of visitors each year regarding relationships between cranes and religion, and importance of retaining wetlands to help human livelihoods;

- Initiate mass awareness programs in Sarus Crane range countries to increase sensitivity of policy makers towards the importance of wetlands that are otherwise considered as wastelands in some countries, and the multi-functionality of agricultural areas in producing foods and retaining significant populations of globally-threatened species;

- Understand needs of land owners, especially those with breeding Sarus Cranes, and help communicate their important role in conserving cranes to a wider audience including policy makers and local government;
- Initiate and support regular interactions and knowledge exchanges internationally among researchers and managers in Sarus Crane range countries to facilitate improvements in research, restoration, and conservation;
- Improve exchange of information from research findings to policy makers in all the Sarus range countries with intent to help stem large-scale decisions based on usually single dimensions like agricultural production or rural land-use planning;
- Document and highlight local efforts to preserve and restore Sarus populations and habitat to help initiate additional efforts especially at the boundaries of the Sarus distribution range (e.g., Chandrapur in Maharasthtra State, Sitapur District in Uttar Pradesh State in India);
- Work in partnership with civil and religious organizations in developing and implementing educational programs to promote crane conservation (Cambodia, Laos, Myanmar, and Vietnam);
- Support ongoing (e.g., the annual Atherton Tablelands' Crane Week in Australia) and start new local initiatives to celebrate cranes and their habitats in key locations across their distribution range; and
- Explore the potential of developing sustainable ecotourism, and associated manufacture of crane-friendly products (e.g., as in Tram Chim) in key locations across the Sarus' distribution range by engaging the tourism, farming, and local government sectors in each locality.

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SPECIES REVIEW:

BLUE CRANE (*Anthropoides paradiseus*)

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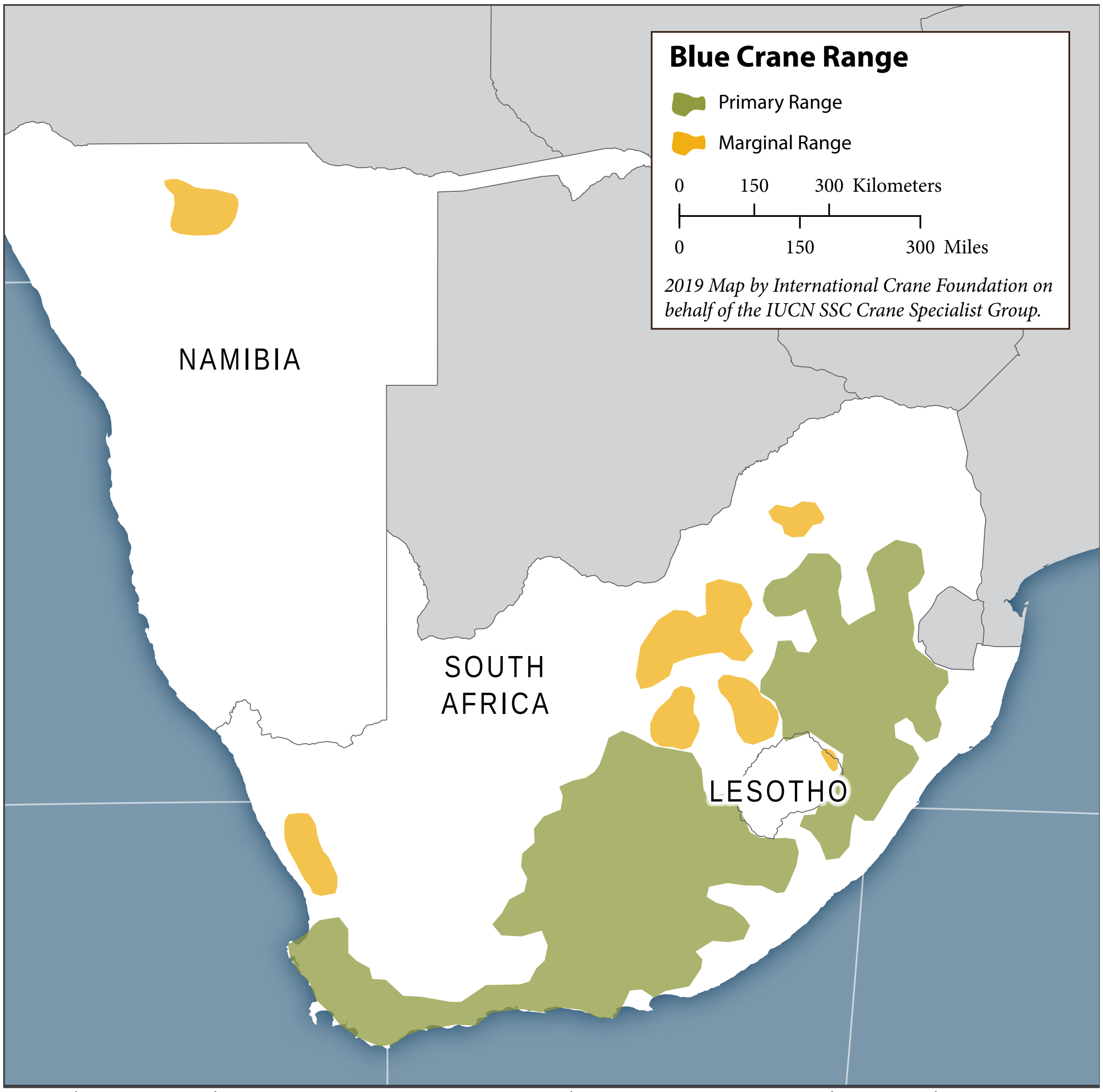
Blue Crane in South Africa (Photographer Jon Smallie, Endangered Wildlife Trust)

Red List Category: Vulnerable
Population Size: 25,000–30,000
Population Trend: Increasing in South Africa, declining in Namibia
Distribution: South Africa and Namibia



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DISTRIBUTION AND STATUS OF KEY SITES

Distribution

The Blue Crane is a near endemic to South Africa, where over 99% of the global population is estimated to occur (McCann et al. 2007). It is the world's most range-restricted crane species and the national bird of South Africa. In South Africa, there are three core population areas. The majority of the global population is found in the agricultural landscape of the Fynbos biome in the Overberg and Swartland regions of the Western Cape Province, with a slow expansion northwards into Namaqualand (Simmons 2011). A widespread population in the Karoo (Northern Cape, southern Free State, and Eastern Cape Provinces) is expanding into the more arid parts of the Karoo and into the Succulent Karoo biome. A third area is in the eastern grasslands (spanning the KwaZulu-Natal, Mpumulanga, and the northeastern Free State Provinces) (Shaw 2003, Allan 2005, McCann et al. 2007, Simmons 2011, Hofmeyer 2012). According to the National Crane Census held in 2002, 47% of the population of Blue Cranes resided in the cereal crop and dryland pasture mosaic of the Western Cape Province, 29% in the natural grassy Karoo, and 23% in the eastern grasslands of South Africa (McCann 2002). However, the Coordinated Avifaunal Road Counts conducted by the University of Cape Town suggest that the population in the Western Cape increased by between 200 and 300% from 1987 to 2010 (Hofmeyer 2012), most likely significantly increasing the percentage of the global population currently found in the area.

A fourth small core population of Blue Cranes occurs in Namibia (Simmons et al. 2006). This isolated population breeds in and around the Etosha National Park and moves northwards, outside the Park, during the winter months (Simmons et al. 2006, Scott et al. 2011, Scott et al. 2015). Numbers have declined from 80 in 1988 (Brown 1992, Simmons et al. 1996) to only 23 in 2013 (Scott and Scott 2013b).

Occasional sightings of Blue Cranes have also been recorded in the southeastern areas of Botswana, Swaziland, and Lesotho (Allan 2005).

Status of Key Sites

Western Cape

The Overberg and Swartland regions of the Western Cape Province have largely been transformed into an agricultural landscape—predominantly a rotational system of small grain (predominantly wheat [*Triticum aestivum*] but also barley [*Hordeum vulgare*] and oats [*Avena sativa*]) and dryland pastures for small stock (mostly sheep [*Ovis aries*]). In certain areas of the Overberg, ostrich (*Struthio camelus*) farming is also practiced. This agricultural landscape, which is currently highly suitable for Blue Cranes, is under increasing potential for change. It is agricultural land and not formally protected for conservation. The Western Cape Province is considered one of the regions in South Africa to be most at risk from climate-induced warming and changes in precipitation (Midgley et al. 2005). Furthermore, history has shown that the response to economic pressure is quick and that existing land use can change dramatically, especially in the light of climate change (Morrison et al. 2012).

Karoo

The majority of the Blue Cranes in the Karoo occur on privately owned land, with a few individuals occurring in protected areas. Sheep farming on natural vegetation is predominant in the Karoo and, therefore, some areas are being considered for proclamation under the Biodiversity Stewardship Programme. This legislated process under South African law (National Environment Management: Protected Areas Act, Act 57 of 2003) enables private landowners to voluntarily enter into legally binding agreements with government to secure and manage the land for biodiversity. Lands proclaimed under this system at the level of Protected Environment or Nature Reserve are included in the protected area network of the country. However, more than 155,000 km^2 of the Karoo is currently under consideration for hydraulic "fracking" for gas extraction (Twine et al. 2012). Depending on the extent of the fracking operation, suitable habitat could be lost and disturbance levels at each of the drill sites could render the area unsuitable to cranes. However, the greatest concern is the impact that fracking could have on underground water supplies, the primary water source for all farmers, livestock, and biodiversity in this very arid region.

Grasslands

The most threatened biome in South Africa is the grassland biome, with large parts converted to mining, forestry, and maize (corn, *Zea mays*). It is estimated that 58% of this biome has been transformed (Low and Rebelo 1996), and current transformation rates are alarming. The South African National Biodiversity Assessment 2011 (DEA-SANBI 2012) predicted that by 2050, no natural habitat would be left outside of protected areas in KwaZulu-Natal based on the current rate of transformation. The Mpumalanga grasslands are also under significant threat, but from mining. Already, around 75% of the Mpumalanga grasslands are already being mined or are under mining application, largely in the form of open-cast coal mining (Mervyn Lötter, personal comm.).

Namibian Population

This small, isolated population occupies grassland habitats associated with wetlands, breeding within the Etosha National Park (ENP) during the summer and moving northwards to the Omadhiya Lakes, including Lake Oponono, for the winter months, with isolated records in the Zambezi (formerly Caprivi) Region (September 2007; Scott and Scott 2007) and Kavango Region (October 2012; Scott and Scott 2013b) of Namibia. Further potential movements to other, unknown locations are possible (Scott and Scott 2013a, Scott et al. 2011, Scott et al. 2015). Due to the semi-aridity of the core distribution area for Blue Cranes in Namibia, wetlands appear to play a critical role for the species' survival (Simmons et al. 2006, Simmons 2015).

ECOLOGY

Blue Cranes are found across a diversity of ecosystems, including the open and wet highland grasslands of South Africa, the arid ecotone between the grasslands and Nama Karoo biomes, the relatively dry agricultural landscape of the Western Cape Province, and the semi-arid grasslands in and around the Etosha National Park in Namibia (Shaw 2003, Allan 2005, Simmons et al 2006). Blue Cranes have adapted to transformed habitats and are making extensive use of agricultural lands across their range. This is particularly evident in the Western Cape Province, where they are found year-round in the wheat land/pasture mosaic, and less so across the remainder of their range, where they are found on agricultural lands during certain periods of the year, particularly the winter months when foraging (Hofmeyer 2012). Together with the Demoiselle Crane, these two species are the least dependent on wetland habitats of all the cranes.

Blue Cranes nest in secluded areas on bare ground, in short dryland vegetation, and occasionally in wetlands with short vegetation. In the Overberg of the Western Cape, Blue Cranes are found nesting more often in pastures than in cereal crops, where nest survival is also higher. Most nests, though, are in close proximity to natural Fynbos vegetation, which is a source of cover for chicks prior to fledging (Bidwell 2004). In the Nama Karoo, cranes select nesting sites in vegetation of a low height but with good cover for hiding chicks (Gibbons 2007). Across the grasslands, Blue Cranes nest in short grassland or wetland vegetation (McCann and Wilkins 1995, Morrison 1998). Across all of these areas, though, Blue Cranes select nesting sites in close proximity to water and avoid roads and areas of high disturbance (McCann and Wilkins 1995, Morrison 1998, Bidwell 2004, Gibbons 2007). Most of the water points across the drier parts of their range in South Africa take the form of artificial water points, which are also facilitating range expansion into areas previously unsuitable for cranes (Hofmeyer 2012).

Within the Etosha National Park in Namibia, the cranes breed in grasslands in or near wetland areas on the southern and eastern edges of the Etosha Pan (Simmons et al. 2006). Such wetlands are important for roosting and predator evasion, including for young chicks, and for surviving high temperatures in these semi-arid habitats.

NUMBERS AND TRENDS

The Blue Crane is currently listed globally as Vulnerable on the IUCN Red Data List as a result of the rapid decline it experienced over a two-decade period in the late 1900s (IUCN 2019). Although historically estimated at approximately 100,000 individuals (Allan 2005), the South African National Crane Censuses, conducted over a 10-year period between 1996 and 2005, estimated the population at around 25,000 (McCann et al. 2007). Cranes in the four core regions have had mixed fortunes since then, with the Southern African Bird Atlas Project 2 data showing that the decline in the traditional grassland stronghold has continued (SABAP2 2013), in particular in Mpumalanga and the Free State Provinces. However, the national aerial surveys conducted by the Endangered Wildlife Trust and Ezemvelo KwaZulu-Natal Wildlife indicate that the population in the Drakensberg regions of the KwaZulu-Natal grasslands increased by more than 35% in the decade prior to 2013 (Smith and Craigie 2013). While the central Karoo population has probably remained stable in this largely untransformed landscape, the Western Cape population has continued to expand and increase as Blue Cranes have adapted to the wheat land/pasture land-use system (Shaw 2003, Allan 2005, McCann et al. 2007). Although we do not have current population estimates, the probable stability across the grassland and Nama Karoo populations, and the significant increases that have since been recorded in the Western Cape Province, suggest that the South African population is increasing (Hofmeyer 2012). As a result, the Blue Crane has been down-listed to Near Threatened in South Africa (Taylor et al. 2015). However, modeling has suggested that any increase in adult mortality or decline in breeding productivity could result in a sudden and significant decline in the Western Cape Population (Pettifor et al. 2009). Considering the various threats to the species, both current and in the near future (outlined below), this scenario is a strong possibility and should be monitored carefully.

Sadly, the Namibian population continues to decline and may be facing extinction. Numbers have declined from 138 in the 1970s (Berry 1984; R. Miller, personal comm.) to 80 in 1988 (Brown 1992, Simmons et al. 1996), 60 in 1994 (Simmons et al. 1996) and 2006 (Scott et al. 2015), with further declines to 35 in 2011 (Scott et al. 2011), and only 23 in 2013 (Scott and Scott 2013b). As a result of this decline, the Blue Crane is classed as Critically Endangered in Namibia (Simmons 2015).

THREATS

Current Threats

- Blue Cranes are highly susceptible to collisions with overhead power lines (Jenkins et al. 2010), particularly young inexperienced birds and adults on days with poor visibility (McCann and Wilkins 1995, Smallie 2002). Up to 12% of the Western Cape population is lost to power line collisions annually (Shaw et. al. 2010), and collisions remain the key threat to Blue Cranes in the Karoo where recorded collision rates are higher than those from the Overberg (Shaw 2013);

- The illegal removal of crane chicks from the wild for the captive trade markets, both for domestic purposes and internationally, is a threat in South Africa. In many instances, legally kept cranes are used to legalize wild-caught chicks under the pretense that they are the legal pair's chicks;

- Mining for energy resources poses a serious threat to the habitat that Blue Cranes are found in:
  - o Over 75% of Mpumalanga's grasslands in South Africa are either under mining or prospecting application, the majority of which are for open-cast coal mines that will permanently destroy the habitat (Meryn Lötter, personal comm.);
  - o Around 40% of the Karoo in South Africa is under consideration for gas exploration (Twine et al. 2012). Depending on the extent and distribution of the drilling operations, land will be transformed and water resources will be contaminated. In this arid environment, all biodiversity and people depend on groundwater; and
  - o Gas exploration is being considered in part of southern KwaZulu-Natal in the grasslands of South Africa as well;
- At the current rate of transformation of grassland to agriculture in KwaZulu-Natal, the South African National Biodiversity Assessment in 2011 suggested that there will be no natural habitat left outside of protected areas by 2050 (DEA-SANBI 2012);
- Very recently, changes in the climatic conditions and an increase in drought situations have seen a reduction in the tolerance of farmers to cranes on their wheat fields, pastures, and recently lupine (*Lupinus*) fields (where they are perceived to cause damage) in the Western Cape Province, resulting in isolated poisoning events (Jessica Shaw, personal comm.). This could potentially increase over time. Potential changes in the timing and amount of rainfall as a result of climate change may also alter breeding and survival rates of Blue Cranes (Altwegg and Anderson 2009);
- Blue Cranes, because of their tendency to feed from feed troughs, can and have been blamed for recent outbreaks of avian influenza on ostrich farms in the Overberg region, resulting in sporadic retaliation (Jessica Shaw, personal comm.);
- High levels of disturbance around nesting sites reduce breeding productivity;
- Poisoning has decreased dramatically over the last two decades. However, incidents of poisoning are still occurring, primarily to secure cranes as food. At present though, this threat is minimal for the species;
- In Namibia, illegal and unsustainable hunting for both meat and traditional medicinal uses is considered a major threat when the birds leave the confines of the Etosha National Park during the winter months (Ntinda et al. 2012). The targeting of Blue Cranes for such purposes can be viewed as an added stress which marginal populations probably cannot sustain, and at the present rate this practice is expected to contribute to the disappearance of the cranes in Namibia;
- Blue Cranes in the semi-arid habitats of Namibia are dependent upon water bodies for survival, roosting, and the rearing of their chicks; any changes in the water regime, including borehole drilling to the north of the Etosha National Park, will eventually reduce the permanence and reliability of such sources and threaten their survival, particularly during times of severe drought when competition for water increases (Simmons and Brown 2015); and
- Isolated and small populations can be prone to inbreeding effects if genetic heterogeneity has been lost (Westemeier et al. 1998). The small breeding population in Namibia could rapidly be pushed to extinction in view of its declining numbers and apparent genetic isolation, especially when coupled with hunting pressure and catastrophic events such as severe drought under global climate change (Simmons 2015).

Potential Future Threats

- A large proportion of the proposed and successful applications for wind farms is currently in the Western Cape and Karoo regions, where over 80% of the world's population of Blue Cranes occurs. At present, the impact of the turbines and the wind farms themselves are poorly understood (Jenkins 2011);
- In the Western Cape Province (their stronghold), Blue Cranes are dependent on the current agricultural landscape of winter wheat and pastures. Any changes in agricultural land use caused by climate change, land redistribution, or another economic driver could have an impact. Research has suggested that the current growth in the crane population is as a result of the usually high breeding productivity resulting from this productive landscape (Hofmeyer 2012). As a result, the estimated mortality rate of 12% (Shaw et. al. 2010) from power line collisions is not having an effect on the population. However, should the habitat change to something less suitable and breeding productivity be reduced, a sudden and rapid decline in the population could occur; and
- In Etosha National Park and in the drier areas of Namibia, the effect of climate change could impact breeding Blue Cranes. Under normal conditions, animals move away from the water holes and seepages following the start of the rains, allowing the Blue Cranes the opportunity to nest close to the waters. However, if the rains are late, or the rains stop, animals quickly move back to the water holes, and herders also move their livestock back, increasing the risk of trampling eggs and chicks.

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

Conservation

- Within the Western Cape Province, the Overberg Crane Group works in collaboration with CapeNature (the provincial conservation authority) and landowners to increase awareness and to mitigate threats that arise;
- The International Crane Foundation / Endangered Wildlife Trust Partnership, together with the relevant government authorities in each province and other NGOs, are working with landowners and communities in the grassland biome of South Africa. These efforts include increasing awareness, promoting the involvement of communities in the sustainable use and management of their farms, and securing land for biodiversity and cranes. Using the Biodiversity Stewardship Programme, a legislated process in South Africa whereby landowners voluntarily enter into legally binding agreements with government to secure and sustainably manage their land, we aim to maintain a viable population of Blue Cranes in the grasslands;
- The Endangered Wildlife Trust's Wildlife and Energy Programme has a longstanding strategic partnership with Eskom, South Africa's only power utility company, to mitigate the impacts of power lines on large birds. This partnership includes both a reactive approach to improving the visibility of power lines that are or pose a risk, and proactively improving our understanding of the factors that contribute to collisions. In collaboration with the Percy FitzPatrick Institute at the University of Cape Town, Eskom-EWT currently has a large-scale marking experiment in place in the Karoo to test the effectiveness of different line markers for Blue Cranes and other large terrestrial birds, and they are collecting long-term collision mortality data in the Karoo and Overberg (Shaw et al. 2011, Shaw 2013);
- The International Crane Foundation / Endangered Wildlife Trust Partnership has an African Crane Trade Project aimed at reducing the impact that the wild-caught trade is having on wild populations. This project is addressing and developing mitigation actions at both supply and demand sides as well as along market chains. In particular, efforts are underway to include in legislation the need for

parentage testing for all cranes in trade. This requirement will reduce the illegal permitting of wild caught chicks as a front as chicks from legal cranes; and

- The Namibia Crane Working Group is active in understanding, studying, and conserving the Blue Cranes of Namibia by facilitating surveys, ringing and tracking, education, and protection in line with the Namibia Crane Action Plan (Simmons et al. 2006; Scott et al. 2009, 2011, 2015).

Research

- The International Crane Foundation / Endangered Wildlife Trust Partnership is conducting a study that will outline the use that Blue Cranes make of the agricultural landscape in the Western Cape, both temporally and spatially for foraging, nesting, and roosting. This research will provide baseline information required for objective input into applications for power line and wind farm development and will also provide a basis against which projected landscape changes as a result of climatic or economic conditions can be tested;

- The characteristics and distribution of roosting sites across their range need to be established—vital information for development and power line applications;

- An improved understanding of the molting characteristics and behavior of Blue Cranes during this time is required to fully understand the threats posed to them when flightless. As a key part of their life history, this information is essential when considering conservation action; and

- Future studies in Namibia will continue to monitor the Blue Crane population, ring birds, and study their movements, habitat use and diet, and to confirm whether this population is indeed genetically isolated from that in South Africa (Scott et al. 2015). Further research is needed to verify why the Namibian population is in decline; in particular, the use of satellite transmitters will provide key information on yet-unknown potential wintering destinations, where unnatural mortalities are suspected to be taking place (see Ntinda et al. 2012).

CHANGES SINCE 1996

The distribution of the Blue Crane and its core populations have changed since 1996. Originally with a stronghold in the grasslands, the Overberg and Swartland of the Western Cape now hold the vast majority of the global Blue Crane population. This area is a fraction of the size of the former stronghold range in the grasslands (Hofmeyer 2012). Over the past two decades, the global population has stabilized and, although still declining in certain areas of its range and stable in others, the increasing population in the Western Cape has likely resulted in the population increasing at present. However, this situation is precarious. An increase in adult mortality or reduction in breeding productivity could potentially cause a rapid reduction in the population.

The reasons for the decline prior to 1996, which included predominantly poisoning and habitat loss as a result of afforestation across the grasslands, are no longer significant threats. Poisoning at the time was largely in response to crop damage and the deliberate poisoning of cranes, or as a result of the misuse of agrochemicals. Although poisoning still occurs, it is currently relatively insignificant, resulting from rural communities accessing poisoned grain to obtain animals for food. Current threats are now primarily power line collisions, loss of habitat to agriculture and mining operations, and trade. There are also a number of future activities that could pose significant threats to the species, including wind farms, fracking, land redistribution, and climate change.

The small population in Namibia is declining and appears to be facing extinction in this country (Scott et al. 2015).

PRIORITY RESEARCH AND CONSERVATION ACTIONS

- The development of a Biodiversity Management Plan for Species – Cranes, a legislated process under South Africa law, will provide a detailed plan for the conservation of the Blue Crane in South Africa;
- The primary concern now is the energy sector, through mining, power lines, and wind farms. Addressing these issues is sensitive as energy development is required for development of the country. Research is therefore required to better understand the potential and actual threats to the species and effective mitigation measures, so that conservation action can be determined and implemented;
- Improve our understanding of how Blue Cranes use the agricultural landscape in the Western Cape Province, both for objective input into wind farm developments and for understanding the potential effects of the agricultural landscape changing through climatic and economic drivers such as land redistribution. This research will form a strong basis for future conservation action;
- Securing suitable grassland habitat under the Biodiversity Stewardship Programme is imperative to securing Blue Cranes in the grasslands;
- Further study the impacts and risk factors involved in power line collisions, and use the results of this research to make hazardous power lines more visible with appropriate devices (Barnes 2000, Shaw et al. 2010);
- Increase enforcement, rationalization of the provincial legislation, and improve implementation of legislation related to illegal trade;
- Sustainably manage captive flocks to reduce the wild-caught demand and discourage the taking of fledglings from the wild; and
- Continue to identify/verify localities where illegal hunting of Blue Cranes is believed to be taking place in Namibia, using means such as satellite tracking and interviews/questionnaires, and promote targeted, effective conservation awareness and law enforcement measures among the relevant communities.

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SPECIES REVIEW:

BLACK CROWNED CRANE (*Balearica pavonina*)

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(with inputs from Abebayehu Aticho, Shimelis Aynalem, Timothy Dodman, Lorna Labuschagne, and Idrissa Ndiaye)

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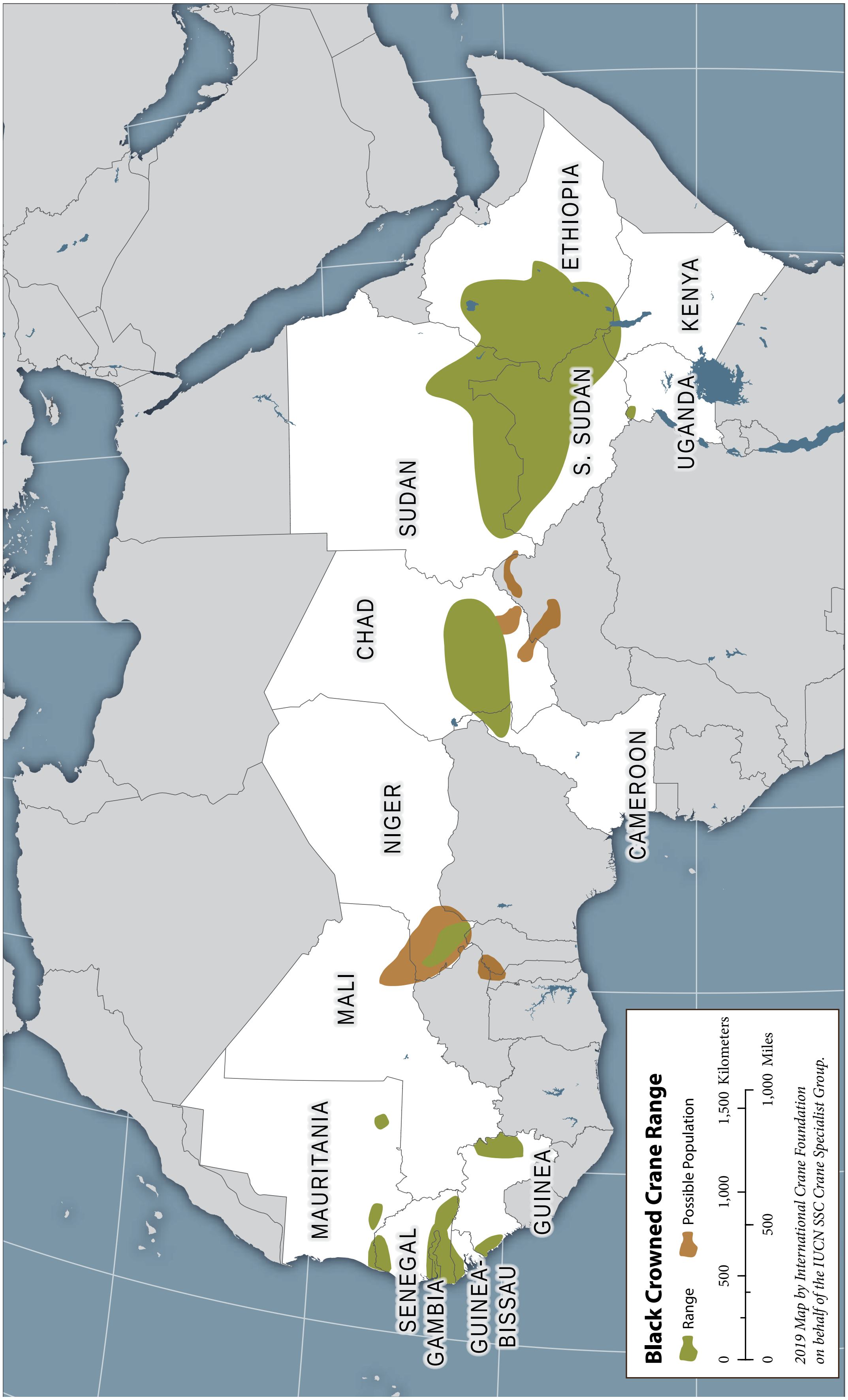
Black Crowned Cranes in a courtship dance at Zakouma National Park in Chad (Photographer: Michael Lorentz, African Parks)

Red List Category: Vulnerable
Population Size: 43,000–70,000
Population Trend: Decreasing
Distribution: Western Africa, Sudan, Ethiopia



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DISTRIBUTION AND STATUS OF KEY SITES

Subspecies/Populations

There are two subspecies of the Black Crowned Crane: West African Crowned Crane (*B. p. pavonina*) and Sudan Crowned Crane (*B. p. ceciliae*).

Overall Range

The Black Crowned Crane is a resident of the Sahel and Sudan Savannah regions of Africa, occurring in disjunct subpopulations from Mauritania to Guinea on the Atlantic coast in West Africa to the western Ethiopian Highlands and Rift Valley in Ethiopia. The biogeographical separation between the two subspecies is unclear but likely is east of Lac Fitri in central Chad (Williams et al. 2003, Beilfuss et al. 2007). However, recent photos of Black Crowned Cranes in Chad (shared by Lorna Labuschagne) suggest that the separation could be west of Chad, based on the pattern of the red cheek patches that separate the two subspecies. For purposes of this assessment though, we will consider the split to be east of Lac Fitri. Although considered year-round residents in most of the crane areas, they do undertake local seasonal migrations in response to rainfall, and daily movements are considered to be extensive (Williams et al. 2003, Gichuki 2004).

West African Crowned Crane

The West African subspecies, although once widespread and occurring in almost a contiguous distribution across West Africa, is now severely fragmented with large gaps between many of the subpopulations (Williams et al. 2003, Beilfuss et al. 2007). Most Black Crowned Cranes are now clustered into a few regions, most notably the Senegal River Delta of Senegal and Mauritania; the coastal region from southern Senegal (Casamance) to northern Guinea; Waza National Park in Cameroon; and Lac Fitri, Zakouma National Park, and surrounds in Chad (Tréca 1996, Williams et al. 2003, Beilfuss et al. 2007; Tim Dodman, personal comm.; African Parks Foundation, personal comm.). Sadly, they are now extinct or close to extirpation in several countries, including Nigeria where it is the National Bird (Williams et al. 2003).

Sudan Crowned Crane

Studies provided in Williams et al. (2003) suggest that the Sudan subspecies too had undergone some reduction in range, but further surveys are needed to verify this. They too are clustered into a few regions, with the highest concentrations (based on historic record) by far in the northern regions of the Sudd between South Sudan and Sudan; and smaller concentrations around Lake Tana and the southwestern parts of Ethiopia (Beilfuss et al. 2007, Diagana et al. 2006).

ECOLOGY

The ecology of Black Crowned Cranes is similar to Grey Crowned Cranes in several respects, but it may be a somewhat more wetland-dependent species. Black Crowned Cranes breed and feed in many of major water bodies across their range, including the coastal deltas of West Africa, the inland delta of Mali, the large floodplains of Waza National Park, the Sudd, and other sites. Many aspects of their ecology are, however, still very poorly understood. Dodman et al. (2014) noted that they frequented water points, an indication of their dependency on water. This species is found in wet and dry open habitats but prefers freshwater marshes, wet grasslands, and the peripheries of water bodies, often in association with agricultural lands, especially rice (*Oryza*) fields (Daddy and Ayeni 1996, Meine and Archibald 1996, Ojok 1996, Dodman et al. 2014). Non-breeding flocks throughout the year and large flocks in the dry season are often seen in rice fields and harvested or plowed agricultural lands (Tréca 1996, Tréca and Ndiaye 1996, Ojok 1996, Gichuki 2004, Kone et al. 2007, Dodman et al. 2014).

This species is a generalist omnivore (Eljack 1996, Tréca 1996, Williams et al. 2003). Their diet ranges from insects (grasshoppers, flies), mollusks, millipedes, crustaceans, fish, amphibians, and reptiles to seed heads, grass tips, agricultural grain, and tubers, for which they dig in soft ground (Urban 1996, Eljack 1996, Tréca 1996).

Their breeding seasons are not yet well understood, with several variations recorded. In West Africa, Brouwer and Mullié (1996) and Tréca and Ndiaye (1996) noted that the breeding season coincided with the wet-season months of September to January. Dodman et al. (2014) and Diop (2015) reported the peak breeding season in Senegal to be between July and September, although both nests and young chicks have been recorded between August and October (Idrissa Ndiaye, personal comm.). Similarly, Diagana and Diawara (2015) reported the breeding season in Mauritania to extend between July and October, coinciding with the rainy season. The variance in reporting exists too for the Sudanese subspecies. Daddy and Ayeni (1996) and Ojok (1996) noted that the South Sudan subspecies nested between July and October. Shimelis et al. (2011), however, recorded peak nesting between August and December in Ethiopia.

Black Crowned Cranes generally nest on a loosely constructed platform or mound of vegetation within wet grasslands and in shallow water bodies, often along river tributaries that are relatively inaccessible (Gichuki 2004, Ligtvoet and van Dommelen 2005, Dodman et al. 2014). Very often these nests, at least in Senegal, are either on small islands within river tributaries or on floating platforms surrounded by water in large wetland systems (Idrissa Ndiaye, personal comm.). In the Inner Niger Delta, Kone et al. (2007) found that they preferred vegetation dominated by *Echirochloa stagnina*, and Dodman et al. (2014) recorded them nesting predominantly in *Sporobolus robustus* with *Sesygium portulacastrum* in the Casamance and Senegal River Delta regions of Senegal.

In general, Black Crowned Cranes lay between two and five eggs per clutch, incubate for 28–31 days, and fledge their chicks at between 60 and 100 days. At the same time, a detailed study of the breeding habits of Black Crowned Cranes in the Casamance region of Senegal varied considerably from this, recording an average clutch size of three eggs, an incubation period of 22–25 days, and fledging at between 35 and 40 days (Dodman et al. 2014; Idrissa Ndiaye, personal comm.). They also found that nests were reused between seasons and noted that chicks left the nest after hatching to hide in the grass. In Senegal, active nests are often found in very close proximity to each other, and several nests from previous seasons are often visible in the same area (Idrissa Ndiaye, personal comm.). Idrissa Ndiaye (personal comm.) also reported adult pairs hiding their chicks in extensive wetlands or on islands in rivers whilst they moved off a considerable distance to forage in rice fields. Sexual maturity appears to be around four to five years of age (Diagana and Diawara 2015).

Breeding success varies significantly between seasons. For example, Scholte (1996) recorded 25% of the population as juveniles in northern Cameroon and Western Chad, whereas Ligtvoet and van Dommelen (2005) recorded only 13.7% of the population as juveniles in northern Cameroon. This difference needs further investigation as it could be a result of the semi-arid environment and unpredictability of the weather where they occur, or an indication of reduced breeding productivity associated with a population decline.

Black Crowned Cranes generally roost in trees or, in some areas where they are available, on wooden or steel overhead transmission structures (Allan 1996, Tréca 1996). In the Casamance, Senegal, Dodman et al. (2014) found these cranes roosting in young baobab (*Adansonia digitate*) trees as well as in saline pans. However, in the Lake Tana area in Ethiopia, cranes will also roost in the middle of the wetland on a drier, higher area surrounded by deep water (S. Aynalem, dissertation research 2016, unpublished).

NUMBERS AND TRENDS

The western subpopulation (*B. p. pavonina*) is estimated to have declined from 15,000–20,000 individuals in 1985 to 15,000 individuals in 2004 (Beilfuss et al. 2007), and strong anecdotal evidence suggests that number could be lower at present. Although the eastern subpopulation may have undergone a comparable decline (50,000–70,000 individuals estimated in 1985 to 28,000–55,000 individuals estimated in 2004), the accuracy of initial and current counts is questionable, so stating a trend based on these data is not advisable (Beilfuss et al. 2007). Therefore, based on data from *B. p. pavonina* populations alone, the species is estimated to have declined between 0–25% from 1985–2004. Given the uncertainty around these estimates, we provisionally estimate a worst-case decline of 30–49% over 45 years (three generations), though the true figure may be higher depending on the status of *B. p. ceciliae* (BirdLife International 2012).

The species, although once widespread across its range, has undergone dramatic declines in certain countries, such as Mali, and may even have been extirpated in others, such as Nigeria (Diagana et al. 2006, Garba 1996, Turshak and Boyi 2007).

THREATS

Black Crowned Cranes have declined primarily due to habitat loss and degradation, domestication and illegal trade, and human and livestock disturbance around nesting sites.

Habitat loss and degradation are significant threats, occurring through drought, wetland drainage and conversion for agriculture, large irrigation schemes in floodplain wetlands, siltation, overgrazing, fire, agricultural and industrial pollution, industrial construction, and dam construction (flooding wetlands upstream and desiccating those downstream) (Boyi and Polet 1996, Brouwer and Mullié 1996, Eljack 1996, Garba 1996, del Hoyo et al. 1996, Olofin 1996, Scholte 1996, Stopfords and Mustafa 1996, Williams et al. 2003, Gichuki 2004, Beilfuss et al. 2007, Turshak and Boyi 2007, Shimelis et al. 2011, Dodman et al. 2014, Diagana and Diawara 2015, Diop 2015, Lecoq et al. 2015, Diagana 2016, Gemeda 2016). In the Senegal Delta and in the rice fields behind the coastal mangroves in southern Senegal / Guinea-Bissau, climate change and dams upstream have caused changes in the hydro-agriculture of these regions, resulting in the deterioration of the rice fields that serve as important feeding sites for cranes (Tréca and Ndiaye 1996, Dodman et al. 2014). Of particular concern too is the potential construction of the Jonglei Canal for the Sudd in Sudan, which would drain the swamp for pastoralists to raise livestock if its construction were resumed (Eljack 1996, Ojok 1996, Beilfuss et al. 2007).

Droughts have both directly and indirectly impacted this species' habitat. A series of dry years has resulted in significant shrinkage of and changes within key wetland areas (Turshak and Boyi 2007, Diagana and Diawara 2015, Diop 2015) and in increased salinity of the coastal wetlands, such as the case for the Casamance region of Senegal, that caused habitat loss (Dodman et al. 2014). Indirectly, droughts have forced people to migrate to relatively moist, less populated regions, which are then subjected to the associated pressures mentioned above (Boyi and Polet 1996, Brouwer and Mullié 1996, Garba 1996, Tréca 1996, Tréca and Ndiaye 1996, Williams et al. 2003, Gichuki 2004). The resultant increase in disturbance from both people and livestock also has a negative effect on the breeding productivity of cranes (Brouwer and Mullié 1996, Daddy and Ayeni 1996, Scholte 1996, Turshak and Boyi 2007, Diagana and Diawara 2015, Lecoq et al. 2015, Diagana 2016). Disturbance will result in reduced number of breeding pairs and decreased number of chicks that fledge due to more time being spent observing potential danger than provisioning for the chicks. A study by Ligtvoet and van Dommelen (2005) showed that Black Crowned Cranes were far more sensitive to people than they were to cars and were less sensitive to disturbance when in a large flock than in small flocks or family groups.

The illegal removal of cranes from the wild for the domestic and international captive trade markets is a significant threat to this species (Brouwer and Mullié 1996, Scholte 1996, Tréca 1996, Beilfuss et al. 2007, Kone et al. 2007, Turshak and Boyi 2007, Morrison 2009, Lecoq et al. 2015). The domestication—keeping of cranes around homesteads, hotels, and other local places of interest—is reportedly common practice across several range states of the Black Crowned Crane. A detailed study conducted in the Inner Niger Delta in Mali suggested that there were more Black Crowned Cranes in domestication than there were in the wild (Kone et al. 2007). Cranes are held to symbolize prestige and wealth, to bring good luck, to keep compounds free of insects, to keep watch over the house, to serve as time pieces, and protect the family from evil spirits. Kone et al. (2007) noted that up to 90% of all captured birds died before reaching their destination, and that many more died prematurely in domestication due to a lack of care. Also notable is the fact that Black Crowned Cranes could be found for sale in markets in Nigeria at least into the 2000s, despite the fact that they had been essentially extirpated from the country (Turshak and Boyi 2007).

International trade, however, is also of concern. From 2004 and 2014, between 343 and 372 Black Crowned Cranes were reported as being exported from Sudan and South Sudan (CITES trade statistics derived from the 2016 CITES Trade Database, UNEP World Conservation Monitoring Centre, Cambridge, UK). A study conducted by Hashim (2010), however, found that government officials only reported 37% of the traded cranes that they knew about and only provided CITES certificates for 12% of these. This information suggests a much larger number are being exported than reported in the CITES Trade Database. Recent unsubstantiated reports also suggest that Sudan and South Sudan are significant trading countries for Black Crowned Cranes. Guinea also appears to currently be a key export country for Black Crowned Cranes and serves as a gateway to international markets for cranes captured across the West African region (unconfirmed reports from confidants).

Warfare and political instability affect nations across the range of the species and may pose a very significant threat to the species both through indiscriminate shootings and inability to implement conservation measures. Many of the past and present core population centers for the West African subspecies are highly threatened by warfare associated with various insurgencies, including the Inner Niger Delta of Mali, Waza National Park in Cameroon, northern Nigeria, and much of southern Niger and Chad. The Sudan subspecies has suffered from chronic warfare in (now) South Sudan for more than 50 years, as well as southern areas of Sudan / northern Kenya / southwestern Ethiopia, where the implementation of conservation measures has frequently been impossible to proceed (Tréca 1996, Tréca and Ndiaye 1996, Williams et al. 2003, Gichuki 2004). Oil exploration in and near the wetlands also poses a threat (Williams et al. 2003).

In addition to indiscriminate shooting associated with warfare, Black Crowned Cranes are hunted in parts of their range, although not a common occurrence (Brouwer and Mullié 1996, Ojok 1996, Gichuki 2004, Diagana 2016). Parts of dead Black Crowned Cranes, notably the head and wings, are used in traditional healing (Williams et al. 2003, Diagana and Diawara 2015, Diop 2015). In Ethiopia children have been observed collecting eggs and catching and killing chicks (Shimelis et al. 2011), although adult cranes are strictly protected through cultural taboos.

Indiscriminate pesticide application that may be leading to harmful bio-accumulation of toxins, and direct poisoning to reduce crop depredation also have been reported in East Africa (Williams et al. 2003, Gichuki 2004).

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

Range-wide

- The Black Crowned Crane is listed on Appendix II of the Convention on International Trade in Endangered Species (CITES), which means that any trade in this species should be carefully regulated (http://www.arkive.org/black-crowned-crane/balearica-pavonina/);
- In 1999–2002, the International Crane Foundation and Wetlands International launched a Black Crowned Crane Programme to determine the status of the species and to prepare an action plan. A Status Survey and Conservation Action Plan for the Black Crowned Crane *Balearica pavonina* was developed as a result of this programme (Williams et al. 2003);
- The ICF/EWT Partnership is working on the African Crane Trade Project, which focuses on research and monitoring to understand trade issues, increasing awareness of the threat, advocacy for needed policy changes and legislation, and advocating for the development of sustainable captive populations negating the need for wild caught trade; and
- The International Waterbird Census coordinated by Wetlands International includes monitoring of a number of key sites for Black Crowned Cranes across its range.

West Africa Subspecies

- Wetlands International has been supporting a range of initiatives focused specifically on the Black Crowned Crane in Mauritania, Senegal, Guinea-Bissau, Guinea, Mali, and Nigeria, most notably in the rice-growing region of the western coastline;
- Birdlife International launched a regional project on the conservation of migratory birds in 2011 in the coastal zone of West Africa between Mauritania and Sierra Leone, working closely with the Wadden Sea Flyway Initiative and Wetlands International. This Conservation of Migratory Birds (CMB) Project deals with the development and implementation of national species action plans, including, in some countries, the Black Crowned Crane;
- BirdLife International, Wetlands International, the African Eurasian Migratory Waterbird Agreement, Nature Mauritania, Vogelbescherming Nederland, and the MAVA Foundation have developed a National Species Action Plan for Black Crowned Cranes in Mauritania (Diagana et al. 2015);
- BirdLife International, Wetlands International, the African Eurasian Migratory Waterbird Agreement, Human-Centered Design for Smallholder Families, and the MAVA Foundation have developed a National Species Action Plan for Black Crowned Cranes in Senegal (Diop 2015);
- BirdLife International, Wetlands International, the African Eurasian Migratory Waterbird Agreement, MAVA Foundation, Organização para a Defesa e Desenvolvimento das Zonas Húmidas, Gabinete de Planificação Consteira, and Instituto da Biodiversidade e das Áreas Protegidas have developed a National Species Action Plan for Black Crowned Cranes in Guinea-Bissau (Lecoq et al. 2015);
- Birdlife International, the African Eurasian Migratory Waterbird Agreement, MAVA Foundation and Guinee Ecologie, in collaboration with the Ministère de l'Environnement, des Eaux et Forêts, and Office Guinéen des Parcs et Réserves (OGUIPAR) Rapport, have developed a National Action Plan for Black Crowned Cranes in Guinea (Diagana 2016); and
- Bird monitoring and conservation activities, including cranes, have been carried out in parts of Chad, yielding some recent data about Black Crowned Crane numbers.

Sudanese Subspecies

- NABU (Nature and Biodiversity Conservation Union, a German Crane Working Group) and the Ethiopian Wildlife Natural History Society had a monitoring programme (now discontinued) aimed at gathering baseline information and an awareness project around Lake Tana in Ethiopia that included Black Crowned Cranes;
- Research projects, linked to Bahir Dar University and Jimma University, are currently underway on Black Crowned Cranes around Lake Tana, supported by ICF; and
- Efforts towards establishing a waterbird monitoring programme in South Sudan have been made by the Wildlife Conservation Society, Office National de la Chasse et de la Faune Sauvage (ONCFS), and Wetlands International.

CHANGE SINCE 1996

Black Crowned Crane numbers have declined dramatically since 1996, with less than 70,000 individuals estimated to be remaining. Unfortunately, this is likely an overestimate as our understanding of the species, its status, and threats is very limited at this time. The threats to the species have escalated and intensified since 1996 and currently show no signs of abating – likely these threats will escalate further in the face of climate change, water scarcity, agricultural conversion of wetlands, persistent regional conflict, and other challenges. Large parts of the range of this species are no longer easily accessible to researchers and conservationists due to political instability, warfare, and the presence of violent extremist organizations.

PRIORITY RESEARCH AND CONSERVATION ACTIONS

Research and Monitoring

- Understand the breeding biology and ecology of the species and their habitat requirements;
- Conduct a status, distribution, and threats assessment of the crane population in Guinea-Bissau, a key part of the West African coastal population, for which limited information is available;
- Conduct regular monitoring of cranes in the Senegal Delta across both Senegal and Mauritania, and investigate breeding productivity;
- Understand the distribution, status and breeding productivity of Black Crowned Cranes in Casamance, Senegal;
- Undertake surveys to determine whether cranes exist in the northern regions of Guinea;
- Conduct surveys of the large wintering flocks in Zakouma National Park, Chad, in January / February when juvenile cranes can still be identified. This effort will provide information on the population size in that area and an indication of the recruitment rate in this subpopulation. During the breeding season, assess the distribution of Black Crowned Cranes outside of Zakouma National Park and conduct threat assessments in key breeding areas identified;
- Monitor population trends through regular standardized surveys;
- Monitor local migration (movement) through regular standardized methods;
- Assess the biogeographical separation between the two subspecies; and
- Consolidate information on and monitor the rates of habitat loss and degradation and the key threats and drivers behind this threat.

Conservation Action

- Secure and improve the ecological integrity of key crane sites and their catchments across their range, in collaboration with local partners, communities, and relevant authorities, using sustainable management practices that incorporate climate change and promote alternative livelihood practices that benefit both cranes and people;
- Reduce disturbance during the breeding season by increasing awareness and regulating the use of key sites through management plans;
- Minimize the impact of the local and international wild-caught crane trade by sustainably managing captive populations, reducing demand and supply, increasing awareness, and improving capacity and law enforcement through the market chain. Consider a national pride campaign to raise particular awareness about the impact of domestication on wild cranes;
- Develop projects to minimize the domestication of cranes across West Africa;
- Reduce the risk of poisoning through the development of cost-effective and affordable methods to reduce crop damage, promote responsible agrochemical use, and strengthen law enforcement and regulations as they relate to poisoning;
- Through training and capacity building, establish a network for monitoring cranes across their range;
- Increase awareness of Black Crowned Cranes, their habitats, and their threats at key sites;
- Contribute to the development of policy and legislation for the conservation of the species and their habitats in countries holding key populations of the species; and
- Develop a consolidated action plan for the species across their range, focusing primarily on countries where conservation action can be implemented.

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SPECIES REVIEW:

BROLGA (*Grus rubicunda*)

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(with inputs from John Grant, Richard Hill, and Elinor Scambler)

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Brolga and chick in breeding habitat near Normanton, Queensland, Australia (Photographer: Tim Nevard, International Crane Foundation Associate)

Red List Category: Least Concern
Population Size: 50,000–100,000
Population Trend: Unknown; decreasing in parts of its range
Distribution: Australia, New Guinea

Mirande CM, Harris JT, editors. 2019. Crane Conservation Strategy. Baraboo, Wisconsin, USA: International Crane Foundation.

DISTRIBUTION AND STATUS OF KEY SITES

Populations

The Brolga is a monotypic species, which occurs in New Guinea and Australia. Single individuals have been recorded in New Zealand in 1947 and 1968 (Marchant and Higgins 1993), but the species is an accidental visitor there.

The Australian population occurs in northern and southeastern parts of the country; the species is mostly absent from the dry interior (Marchant and Higgins 1993). The northern and southeastern populations may be considered discrete due to geographic isolation and different timing of wet and dry seasons (DuGuesclin 2003). These populations were assigned a subspecies status in the past (Johnsgard 1983) but are currently considered to be one species (Marchant and Higgins 1993).

New Guinea

The distribution and status of key sites in New Guinea is unknown. There is practically no information on any aspects of the species' biology, ecology, movements, or threats in New Guinea.

Northern Australia

In northern Australia, distribution of the Brolga extends from northwestern Western Australia, across northern to southeastern Northern Territory through to Queensland. In Queensland, the species has been recorded throughout the state (Marchant and Higgins 1993).

Brolgas are common to abundant in northern Australia and their status is 'Least Concern' (IUCN 2012). During the dry season, large flocks of 100s to 1,000s gather together (Marchant and Higgins 1993), and breeding occurs throughout the range (Marchant and Higgins 1993, Barrett et al. 2003).

Little is known about location and details of key breeding and flocking sites, or about inter-annual variability in site use in northern Australia. The information outlined below is based on aerial counts (Chatto 2006, Kingsford et al. 2012), BirdLife Australia atlas data (Blakers et al. 1984, Barrett et al. 2003), and unpublished accounts.

Breeding sites: In Queensland, breeding sites are found in high densities in the Normanton-Karumba area southeast of the Gulf of Carpentaria (John Grant, personal comm.). Cape York Peninsula may also hold concentrations of breeding Brolgas (Marchant and Higgins 1993, Chatto 2006).
In Northern Territory, a number of major Brolga breeding sites have been identified (Chatto 2006). These sites include wetlands associated with McKinley, Margaret, and Upper Adelaide Rivers, Liverpool floodplain, Blythe River floodplain and coastal flats between Millingimbi and the mouth of the Glyde River, Buckingham Bay, and Goromoru River along the southern shore of Arnhem Bay, Grindal and Jalma Bays, Walker River, and Bennett Bay, Miyankala Creek, and Roper River (Chatto 2006).

Breeding records from Western Australia are scant, although there are some records in the Kimberley region (Marchant and Higgins 1993, Collins 1995, Barrett et al. 2003). It is unclear whether this scarcity is due to lack of breeding habitat or survey effort.

Flocking sites: The current global population estimate for Brolgas is approximately 50,000 (Kingsford et al. 2012) to 100,000 individuals (Meine and Archibald 1996). Sites of national or international significance are those that have more than 1% of the global population of a species (Ramsar Convention on Wetlands 1971). For Brolgas such sites would be defined as those containing at least 500–1,000 individuals based on the current population estimate.
Key flocking sites, which fit the above criteria, are listed below (Blakers et al. 1984, Collins 1995, Halse et al. 1998, Barrett et al. 2003, Halse et al. 2005, Chatto 2006; Elinor Scambler, personal comm.; John

Grant, personal comm.). Little is known about many of these sites and much of the information below is based on occasional counts.

- Western Australia: the Kimberley area including Roebuck Plains (Lake Eda), Munja Swamp (northeast of Derby), Mandora Marsh/Eighty Mile Beach area, and Lake Gregory/Paraku;
- Northern Territory: Fogg Dam/Kakadu, Blyth River, Finnis River floodplain, Alligator Rivers, Arnhem Bay, Caledon Bay, Calvert River area, Anson Bay, Arafura Swamp, Blue Mud Bay, Gove area, Boucaut Bay, and Tomkinson River floodplain south of Maningrida;
- Queensland: southeastern part of the Gulf of Carpentaria area, Cape York Peninsula, areas along the east coast from south of Townsville to Cairns, and adjacent inland areas, including the Atherton Tablelands.

Southeastern Australia

In southern Australia, distribution of the Brolga extends from southeastern New South Wales, through Victoria and into southeastern South Australia (Marchant and Higgins 1993). The southeastern populations of Brolgas are threatened and listed under each state's legislation.

*Breeding sites***:** Breeding has been recorded throughout the Brolga's range in southeastern Australia, but records are based on infrequent surveys or occasional observations. In New South Wales, breeding has been recorded in the Riverina area in southeastern part of the state (Herring 2001, Barrett et al. 2003). In the northern part of the state, Macquarie Marshes are also thought to be an important breeding area (Meine and Archibald 1996, Barrett et al. 2003). In Victoria, concentrations of breeding records are from the Skipton, Streatham, Darlington, Derrinallum, Lake Bolac, Lake Corangamite areas, between Penshurst and Portland, and west and south-west of Casterton (Blakers et al. 1984, Barrett et al. 2003). In South Australia, Penola, Naracoorte, Mt Gambier, and Millicent areas appear to be important for breeding Brolgas (Bransbury 1991, Marchant and Higgins 1993). There are also records from the Lake Eyre basin (Marchant and Higgins 1993).

Flocking sites: The total southeastern population of Brolgas was estimated to consist of approximately 1,000 individuals (Meine and Archibald 1996). Due to the small size of the population, few of the known flocking sites would qualify as nationally or internationally significant using the >1% criterion. The definition used here for key flocking sites is therefore based on a >1% criterion for the southeastern Brolga population, thus including sites that regularly have more than 10 individuals from year to year (Herring 2001, Sheldon 2004, Victorian Department of Environment, Land, Water and Planning [DELWP], unpublished data).

- New South Wales: Leeton, Jerilderie, and Barooga;
- Victoria: Corop, Dingee, Cressy, Penshurst, Willaura, Streatham/Nerrin Nerrin, Darlington, and Kaladbro;
- South Australia: Bool Lagoon, and Mingbool.

ECOLOGY

Movements and dispersal patterns of Brolgas are poorly understood (Marchant and Higgins 1993). The Brolga undertakes seasonal movements between non-breeding (flocking) and breeding habitats in response to rain and wetland availability similar to other species of cranes in Asia and Africa (Marchant and Higgins 1993, Meine and Archibald 1996). Flocks are formed during dry parts of the year and pairs disperse to breeding sites during wet parts of the year. Pairs may stay at breeding sites during wet years and not disperse until breeding sites dry up (Marchant and Higgins 1993).

Brolgas nest and roost in wetlands (Marchant and Higgins 1993) and forage in multiple habitats, primarily using freshwater wetlands and agricultural crops (Marchant and Higgins 1993, Pizzey 1994, King 2008). Brolgas are omnivorous and opportunistic, and their diet consists of various grains, insects, frogs, small mammals, birds, and reptiles, as well as sedge tubers in northern Australia (Marchant and Higgins 1993).

Nesting biology of Brolgas is well known and documented, especially their wetland habitat requirements (Arnol et al. 1984, White 1987, Harding 2001, Herring 2001, Myers 2001). Brolgas prefer shallow freshwater marshes and meadows that are herb dominated (Corrick 1982, White 1987, Marchant and Higgins 1993). Of known nesting attempts in three different studies, 20–39% have been observed to be successful with at least one chick fledging (Herring 2001, 2005; Myers 2001). Rates of post-fledging survival are poorly known. In a recent study, all 19 chicks that were captured and banded as pre-fledglings survived to fledging and 16 of these survived at least 12 months post fledging (I. Veltheim, unpublished data). Predation by the European red fox (*Vulpes vulpes*) is considered to be the main factor contributing to chick mortality and low breeding success (Arnol et al. 1984, Herring 2001, Myers 2001, DuGuesclin 2003). Maintaining water levels until fledging is likely to be important to improve post-hatching chick survival (Herring 2005).

NUMBERS AND TRENDS

The Brolga population in northern Australia is considered stable and was estimated to consist of 50,000–100,000 individuals (Meine and Archibald 1996, Kingsford et al. 2012). The southeastern population has been estimated at 1,000 individuals and is thought to be declining (White 1987, Bransbury 1991, Meine and Archibald 1996, DuGuesclin 2003). Precise numbers and trends are absent due to a lack of systematic multi-year surveys.

Currently, the minimum population estimate for the global population is 50,000 (based on Kingsford et al. 2012; see below), while there is as yet no evidence to change the upper limit of 100,000 from Meine and Archibald (1996).

Northern Australia

The only on-going systematic surveys have been carried out in northeastern Queensland, with 4,000–4,500 individuals being recorded (Elinor Scambler, personal comm.). In Northern Territory, surveys of coastal wetlands between 1990 and 2005 recorded just over 15,100 individuals (Chatto 2006). Morton et al. (1993) estimated a maximum population of 24,000 in the Cooper and Alligator River region of Northern Territory during aerial surveys in 1981–1984. However, they stated uncertainty in the reliability of this figure due to a large difference between aerial and ground survey data.

Kingsford et al. (2012) provided the most comprehensive count of Brolgas for the entire continent of Australia, as part of a nationwide waterbird survey undertaken in 2008. A total of 51,969 Brolgas were recorded during these surveys, with 51,834 of these being from northern Australia. Although this is not a population estimate as such, it provides important information on the numbers of Brolgas in northern Australia. At least for southeastern Australia, the count of 135 individuals is an underestimate.

Southeastern Australia

Although the southeastern Australian Brolga population has been the focus of more attention than the northern Australian population, estimating numbers and trends is impossible due to lack of systematic efforts. The account below provides information on counts. A more robust population estimate for the region is currently unavailable.

Anecdotal observations and reports document range contraction and reduction in numbers in southeastern Australia since the early 1900s (White 1987, Bransbury 1991). In Victoria, flocks of over 1,000 individuals recorded up until 1915 are no longer seen (White 1987). At Willaura, which is one of the key flocking sites, there is a report of 1,450 birds counted on one day between 1939 and 1945. Since then, a maximum count for this site has been approximately 200 (White 1987).

White (1987) estimated numbers of Brolga in Victoria at 600–650 individuals, which is the current accepted population estimate (DuGuesclin 2003). However, this was based on a count of three sites—Bool Lagoon (South Australia), Willaura (Victoria), and Streatham (Victoria)—and informed guesses for numbers in small flocks and breeding pairs remaining at breeding sites elsewhere within the state. More recent counts in southwestern Victoria have included several more flocking sites and counts from the early 1990s to 2012 have fluctuated between 402 and 694 individuals for southwestern Victoria (Sheldon 2004, DELWP, unpublished data). In 2012, a more systematic count was carried out simultaneously at multiple flocking sites in southwest Victoria. The count total for sites in southwest Victoria and South Australia was 907, comprised of adults and sub-adults (Richard Hill, personal comm.). The difference between the White (1987) and the more recent count is the number of sites counted. Simultaneous counts in 1980 (White 1987) included three sites and age structure was not reported. The more recent 2013 DELWP count included these three and five additional sites: Bool Lagoon in South Australia, and Willaura, Streatham, Penshurst, Lake Bolac, Darlington, Camperdown, and Strathdownie in Victoria.

In northern Victoria 50–100 individuals have been counted (White 1987). Between 60–70 individuals were recorded from 1981 to 1996 in northern Victoria (DuGuesclin 2003), and similar numbers were counted by Herring (2001, 2005) in the early 2000s. There are no recent formal counts from New South Wales.

THREATS

Major threats throughout Australia are related to loss and degradation of habitat due to farming practices; changes to hydrological processes due to water impoundment and crop irrigation; predation of eggs and chicks by introduced feral pest species; hunting and poisoning; collision and mortality from power lines and fences; and potential displacement and mortality due to wind farm development (White 1987, DuGuesclin 2003, DSE 2011; Elinor Scambler and John Grant, personal comm.). Mortality due to hunting and poisoning is mentioned as being historically significant threats contributing to the species' decline, but it is not known if these practices continue to be threats (White 1987). None of these threats has been quantified, and it is not known which are more serious, or if there are regional differences in major threats.

Hybridization with Sarus Cranes (*Grus antigone*) has been considered a threat in the past, but observations suggest that hybrid pairs are rare (Elinor Scambler and John Grant, personal comm.). As well as current threats outlined below, predicted climate change in the future is likely to affect drying and flooding regimes of wetlands. These factors may have substantial effect on Brolga habitats and population persistence due to potential further losses of wetland habitat in southeastern Australia and intrusion of saltwater into freshwater wetlands in coastal areas of northern Australia. The potential impact of future climate change on Brolgas has received no attention to date.

Threats specific to northern Australia include:

- Spread of invasive weed species into floodplain systems and wetlands;
- Grazing and burning regimes; and
- Harvesting of eggs.

Threats specific to southeastern Australia include:

- Loss of breeding habitat due to blue gum (*Eucalyptus globulus*) plantations;
- Reduced breeding success due to loss and modification of breeding habitat; and
- Disturbance, particularly at flocking sites during duck-hunting season;

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

Brolga is protected as a migratory species under the Australian federal Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). It is also protected under each territory and state's legislation. The majority of Brolga habitat occurs on private land, suggesting that traditional strategies such as protecting areas under legislation are ineffective. Government, other management authorities, and non-government conservation organizations have initiated some habitat protection programs on private land since 1996, particularly in Victoria. Other efforts include:

- Regular, systematic counts of Brolga in the northern Queensland (Elinor Scambler, personal comm.);
- Research into breeding ecology in northern Australia, undertaken in conjunction with Sarus Crane research (John Grant, personal comm.);
- Collaborative projects among academic, government, non-government, community groups, and private landholders involving habitat protection initiatives and development of educational pamphlets to landholders (e.g., Herring 2007);
- Development of crane-friendly fencing guidelines and liaison with non-governmental organizations to encourage safer wetland fencing for wildlife (Elinor Scambler, personal comm.);
- Basic ecological and behavioural studies, including studies into breeding ecology and habitat use in Victoria and New South Wales (Harding 2001, Herring 2001, Myers 2001, Sheldon 2004; King 2008, unpublished information);
- Government program, 'The south-west Victoria Brolga Project', including a doctoral research project into movements, habitat use, and population ecology of Brolgas; development of a population viability analysis to assess impacts of wind farms on Brolga in Victoria (McCarthy 2008); and establishment of a scientific panel overseeing methodologies to assess and mitigate Brolga and wind farm infrastructure interactions;
- Yearly population counts in Victoria, organized by the Department of Environment, Land, Water and Planning (DELWP);
- A captive breeding program at Serendip Sanctuary that resulted in a release of individual birds into the wild in Victoria in the mid-1990s. No further releases are planned;
- Updated Flora and Fauna Guarantee Act 1998 action statement with recommended management actions (DuGuesclin 2003);
- Establishment of a community-based friends group in Victoria, 'The Brolga Recovery Group,' which focuses on advocacy, education and provision of information to landholders on protecting Brolgas and their habitat; and

- Six BirdLife International Important Bird Areas (IBA) that together contain >1% of Brolga's global population: Lake Gregory/Paraku; Mandora Marsh/Anna Plains; Cadell/Blyth Floodplains; Blue Mud Bay; Arafura Swamp; and Alligator Rivers Floodplains.

CHANGES SINCE 1996

The main changes in conservation, management, and research efforts since 1996 are outlined in the previous section. The majority of priority conservation measures in management and action plans have been addressed only partially. In Victoria, management actions outlined in DuGuesclin (2003) that have been addressed include conducting annual counts of adults, juveniles, and first year birds at breeding sites; submission of breeding and flocking records into the government fauna database; undertaking a banding program to mark pre-fledged young; predator control at some sites; restoration of breeding sites; and covenanting wetlands and promotion of wetland conservation through support schemes.

The lack of knowledge on the New Guinean population remains unchanged since 1996.

The distribution of Brolgas appears to have remained unchanged since 1996 but requires confirmation through well-designed surveys. New key sites, particularly in northern Australia, have been identified during aerial surveys (Chatto 2006, Kingsford et al. 2012) and incidental observations (Blakers et al. 1984, Barrett et al. 2003). These sites have been detailed under the section 'Distribution and Status of Key Sites.' New key flocking sites identified in Victoria within the last 10 years include new sites in the Penshurst and Darlington areas. Systematic and longer-term surveys with robust landscape-scale design are needed to understand population numbers and inter-annual variations. The northern population consists of at least 50,000 Brolgas currently (Kingsford et al. 2012) and is considered to be stable and secure.

PRIORITY RESEARCH AND CONSERVATION ACTIONS

Surveys and Monitoring

Across the entire range of Brolgas, regular, annual, systematic, and standardized surveys are required to establish and refine the total population estimate, as well as status and trends. In Victoria and northeast Queensland, annual counts should be continued and expanded. In other states, key flocking sites should be identified and counted annually. Juveniles and sub-adults should be counted at all key sites to establish recruitment rates.

Regular, standardized, surveys will allow the monitoring of population trends and accurate establishment of the status of Brolgas in northern and southeastern Australia. These actions are important in order to establish whether the populations are stable or declining. Surveys and monitoring for the purposes of population counts should be undertaken during the driest part of the year when Brolgas congregate in large flocks.

Research

Many knowledge gaps remain in our understanding of basic ecology, population dynamics, and threat to habitats of Brolgas. This lack of knowledge makes it difficult to identify and quantify threats and apply appropriate management actions. As a first and most important priority, in conjunction with efforts towards habitat protection and enhancement, it is recommended that focused and high-quality research be undertaken into a number of aspects of the species' ecology.

As breeding success is poorly known and is important to understand for appropriate management and conservation planning, the following should be undertaken:

- Support and expand current research in northern Australia on breeding sites and breeding success; and
- Identify key nesting areas and factors affecting breeding success in Victoria, New South Wales, and South Australia.

Other priority research actions should include the following:

- Investigate survival and mortality rates and their causes for fledglings, sub-adults, and juveniles to identify the age groups most vulnerable to risks and factors limiting the populations; this information will aid in managing risks to prevent population decline;
- Complete and continue dispersal and movement studies beyond the current research project in southwest Victoria to help establish Brolga in the South Australian, Victorian, and New South Wales are one population or several sub-populations;
- Quantify known key threats to the northern Australian population, including effects on habitat, breeding success, recruitment, and population numbers;
- Undertake monitoring at wind farms overlapping Brolga habitat in Victoria (proposed and existing) to study their effects on the species. This effort would provide information on whether wind-farm development in southwest Victoria poses a threat to the regional Brolga population; and
- Movement studies for other important populations are also desirable, given the near-complete lack of information on this aspect for Brolgas.

Habitat Protection and Enhancement

- Undertake a thorough review of literature and a gap analysis of the extent of wetland habitat degradation and loss of suitable Brolga habitat in northern and southern Australia;
- Given the lack of knowledge about potential effects of climate change on the species' persistence, investigate how changing climate might impact habitat suitability, potential changes to distribution, changes to habitats through land-use shifts at a landscape scale, and effects of increased salinity through sea-level rise, especially in important coastal habitats;
- Identify how many of the currently known key flocking sites in northern Australia are in protected areas and on private land, to establish the current level of protection and threat to these habitats;
- Investigate the success of historical habitat protection and enhancement programs in Victoria (or the southeastern population more generally) and establish how many of these sites currently have breeding pairs and successful breeding;
- Develop and support programs to protect and enhance Brolga breeding habitat, especially in southern Victoria;
- Promote protection of key breeding habitat through legislation, landholder incentives, and cooperation with private landholders; and
- Find strategies to protect flocking habitat in southern Australia as it is limited.

Education and Communication

- Support international and collaborative links between Australia and other countries on crane research, conservation, and management; and
- Further educate private landholders on crane-friendly fencing and breeding habitat enhancement, especially in southeastern Australia where the population is threatened with extinction.

Socio-economic Studies

The majority of Brolga habitat is within private properties; therefore, any successful management and conservation program needs to incorporate working with landholders to achieve successful outcomes. For example, in Victoria, up to 95% of Brolga breeding sites are on private properties. The following activities are important:

- Understand land owners' attitudes towards cranes and their habitats, and explore mechanisms to strengthen their ability to protect and restore populations; and
- Enhance knowledge of landholders sympathetic to protecting Brolgas on their property and highlight their efforts to help inspire further such conservation efforts.

New Guinea

Virtually no information exists on the Papua New Guinea population of Brolgas. It would be pertinent to establish population numbers, flocking, and breeding sites as well as whether there is movement and population exchange between Australia and Papua New Guinea. However, this is currently considered a low priority for global Brolga conservation and management.

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SPECIES REVIEW:

DEMOISELLE CRANE (*Anthropoides virgo*)

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(with input from Yuri Andryushchenko, Nyambayar Batbayar, Victor Belik, Iderbat Damba, Igor Fefelov, Oleg Goroshko, Fenqi He, Anatoly Kovshar, Ming Ma, Liying Su, and Tseveenmyadag Natsagdorjiyn)

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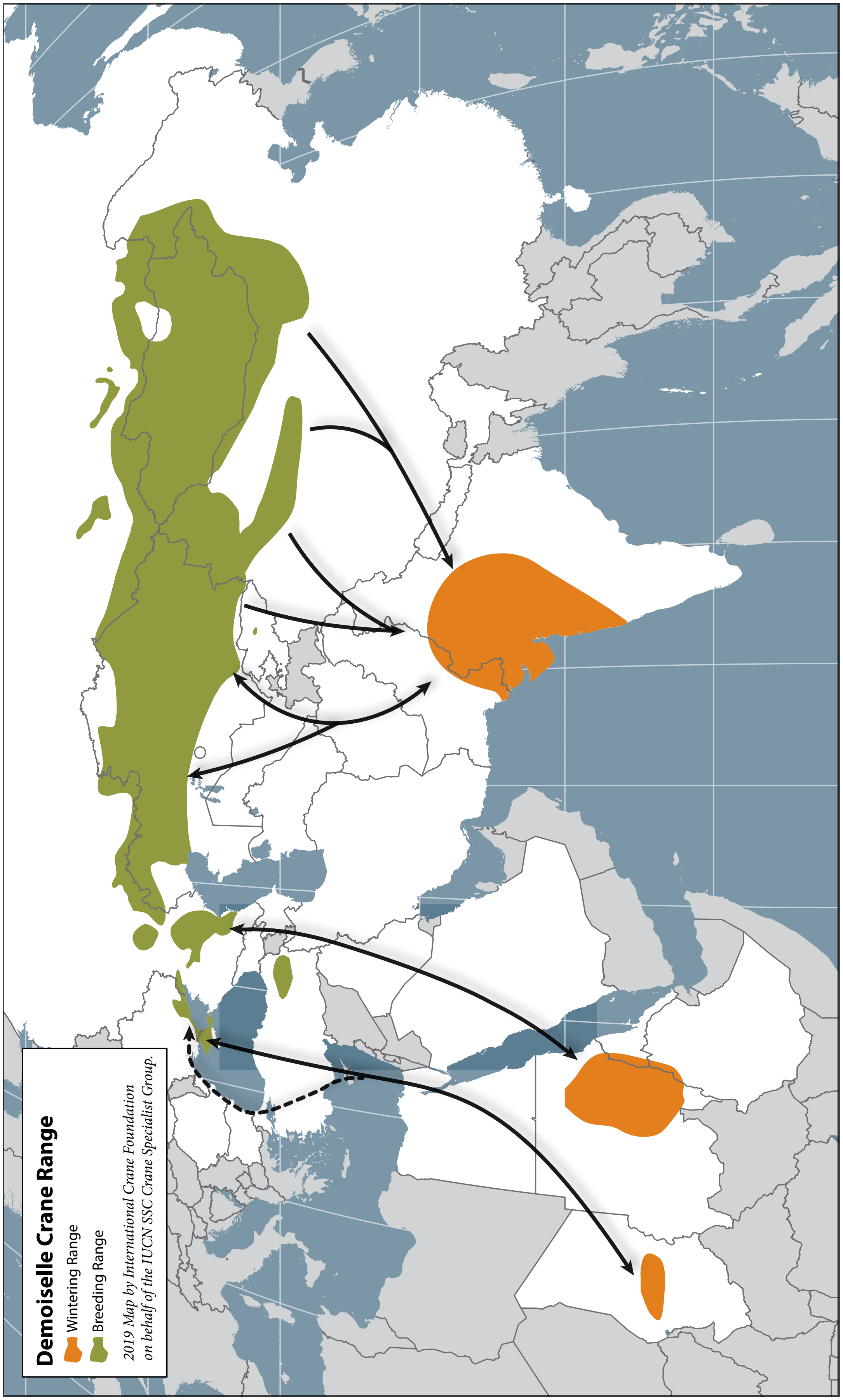
Demoiselle Crane in Kazakhstan steppe (Photographer: Oleg Belyalov, Kazakhstan Union for the Protection of Birds)

Red List Category: Least Concern
Population Size: 170,000–220,000
Population Trend: Decreasing
Distribution: Eurasia, winter in Africa and Indian subcontinent



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DISTRIBUTION AND STATUS OF KEY SITES

Overall Range

The current breeding range in Eurasia spreads from the south of Ukraine through the south of Russia, Kazakhstan, Kyrgyzstan, and across Mongolia to northeast China covering steppe and semi-desert zones of Central Eurasia.

Status of Key Sites

The extensive breeding range of the Demoiselle Crane on the Central Eurasian steppe can be conditionally divided into European, Kazakhstan/Central Asia, and East Asia parts. The most fragmented *European part* includes Azov-Black Sea, Middle Don, Caspian and Volga-Ural breeding flocks (Belik et al. 2011). Cranes of the most western Azov-Black Sea breeding flock inhabit southeast regions of Ukraine, Crimea, and Taman Peninsulas and southwest Rostov Province of Russia (Andryushchenko 2015). The smallest, the Middle Don River breeding flock, occurs mainly in Volgograd and partly Rostov Provinces. The Caspian breeding flock covers Republics of Dagestan and Kalmykia as well as Astrakhan, Rostov, Stavropol, and partly Volgograd Provinces, while the Volga-Ural breeding flock is located in Volgograd, Astrakhan, Saratov, and Samara Provinces in Russia and West Kazakhstan and Atyrau Provinces in Kazakhstan. The *Kazakhstan and Central Asia part* spreads from the South Ural (Orenburg, Chelyabinsk, and Kurgan Provinces), south of Central Siberia (Krasnoyarsk Province and Republic of Khakassia) and Altai in Russia through steppe, semi-desert, and desert to southeast foothills of Kazakhstan and foothills of Kyrgyzstan (Davygora and Gavlyuk 1991, Zavyalov et al. 2003, Berezovikov and Kovshar 2006, Kulagin 2014). The *East Asia part* covers Tyva and south of East Siberia (Baikal and Transbaikalia regions) of Russia (Ryabtsev 1999, Goroshko 2012), Mongolia (Tseveenmyadag 2005), and northern China (Inner Mongolia, Xinjiang, Heilongjiang, Gansu, and Jilin provinces) (Fan et al. 1994, Ma and Ma 2001). There were also two remnant disjunctive populations occurring on the *Atlas Plateau of northern Africa* (non-migratory population in Morocco, Tunis, and Algeria) (Latta and Archibald 1980, Urban 1987) and in *Eastern Turkey* (Kasparek 1988, Akarsu et al. 2013), both of which are probably now extinct.

Demoiselle Cranes from the European part of the range fly to wintering grounds in Chad, Sudan in the Blue and White Nile Basin, and Ethiopia (Urban 1987, Gebremedhin et al. 2009). Birds from Azov-Black Sea breeding flock migrate to the Republic of Chad through Turkey, Cyprus, and Egypt, crossing Black and Mediterranean Seas and making stopover in Sivash Bay in Crimea and in Cyprus (Atta 1996, Andryushchenko 2015). Cranes from Caspian, Volga-Ural, and probably Middle Don breeding flocks fly over the Caucasus Range through Dagestan in Russia, Georgia, Azerbaijan, Armenia, Iran, Iraq, and Saudi Arabia. Their main staging area is in the Manych-Gudilo Lake System in North Caucuses Region of Russia, and migration stopovers are in the Aras River Basin in Nachichevan Autonomous Region of Azerbaijan and Urmia Lake in Iran (Belik et al. 2011, Andryushchenko 2015, Ilyashenko et al. 2018).

Cranes from Kazakhstan and Central Asia, as well as from East Asia part of the range, migrate to wintering grounds in Rajasthan and Gujarat Provinces, mainly in Arabian Sea coast, in the Indian subcontinent (Kanai et al. 2000, Guo and He 2017). They cross Uzbekistan (Lanovenko et al. 2011), Kyrgyzstan (Toropova and Kulagin 2011), Afghanistan, Pakistan (Ahmad and Shan 1991), and the Tibetan Plateau in China (Kanai et al. 2000). Largest staging areas are known in north Kazakhstan (Bragin 2011); cranes then fly almost nonstop, with only short-term rests. Data from satellite-telemetry tracking has indicated that birds from eastern Kazakhstan use two migration routes: one flying directly over the Himalayas, with the other detouring around the Hindu Kush Mountains (Kanai et al. 2000). The bulk of the East Asian part migrates to India through Nepal over the Himalayas, with the major stopovers at Torey Lakes in Transbaikalia in Russia (Goroshko 2012), in Buyant River

Valley in Mongolia (Bukreev et al. 2011), and in Brakol Lake (Xinjiang Province) in China (Kanai et al. 2000). Major pre-migration gathering sites in Mongolia include Baruun Turuun, Tarialan, Zereg Lake, Airag Lake, Tsagaannuur, Selenge River Delta, Kharkhorin, Khurkh River Valley, Bayan-Adraga, Norovlin, and Bayan-Uul fields, and Mongol Daguur. Demoiselle Cranes from Khurkh River Valley staged in the southern part of Inner Mongolia and then flew across the Tibetan Plateau and Nepal then over the Himalaya to reach their wintering grounds (Nyambayar Batbayar, personal comm. 2017). Research indicates that at least some cranes from East Asia make a circular migration during autumn and spring: they return to breeding grounds through northwest Pakistan, Afghanistan, Uzbekistan, and Kazakhstan (Gavrilov 1977, Kovshar and Berezovikov 1991, Gavrilov and Van der Ven 2004, Lanovenko and Kreitsberg 2006, Lanovenko et al. 2011, Toropova and Kulagin 2011, Guo and He 2017). Occasional cranes winter in eastern China, with reports from Hubei, Henan, Jiangxi, and Anhui Provinces (Fan et al. 1994, Ma and Ma 2001).

ECOLOGY

The Demoiselle Crane is one of the least water-dependent species among the cranes of the world. Across the great part of its breeding range, like any other steppe species, it is greatly affected by cyclic climate conditions of this geographical zone. Demoiselle Cranes usually stay relatively close to rivers, shallow lakes, or other natural wetlands, as well as artesian water sources and irrigation systems, to have access to drinking water. In dry years, cranes move to the forest-steppe zone for breeding (Bold et al. 2004, Tseveenmyadag 2005; Oleg Goroshko, personal comm. 2016). In years with high precipitation, Demoiselle Cranes can inhabit semi-deserts and even true deserts if water is available (Bold et al. 2004). The Demoiselle Crane prefers open plain or hilly habitats with low and very sparse grass or even without vegetation in both natural and transformed landscapes (Andryushchenko 2011). Birds in the *European part*, and partly in *Kazakhstan/Central Asia* and *East Asia parts*, have adapted to nesting in agricultural fields (Andryushchenko 2011, Goroshko 2012, Belik 2015). In pre-migratory and migratory seasons and at wintering grounds, crane flocks gather in agricultural fields and roost at night in shallow open water. Winter habitat in east-central Africa includes savannas, grasslands, and riparian areas, while in the Indian subcontinent Demoiselle Cranes feed in agricultural fields and roost on sandbars and mudflats surrounded by water (Meine and Archibald 1996). They can successfully winter even in deserts of Rajasthan, where artificial feeding is provided by local people in Khichan Village (Pfister 1996).

NUMBERS AND TRENDS

The total population of the Demoiselle Crane is estimated at 170,000–220,000 birds (Table 1), which is lower than the estimate in the 1996 estimate of 200,000–240,000 (Meine and Archibald 1996). The increases in the central and northern parts of the species' range has only partially compensated for population decreases in the south, west, and east of the breeding range. Long-term drought and the agriculture crisis following the collapse of the Soviet Union (Ilyashenko 2018) led to the shifting of their range to the north in the forest-steppe zone, where numbers slightly increased as crane bred on fallow lands. The southern edge of their range also moved to the north due to long-term drought.

In the *European part*, the crane numbers have diminished mainly in the Caspian and Azov-Black Sea breeding flocks, where breeding habitat continue to decrease due to the continued crisis in livestock farming, drought, and intensification of arable agriculture (Belik et al. 2011, Andryushchenko 2015). The total number in the Volga-Ural breeding flock is relatively stable or slightly increased, with declining numbers in the south, stable numbers in the center, and increasing numbers in the north of this area (Bidashko et al. 2006). Similar changes occurred in the *Kazakhstan/Central Asia part,* with total numbers decreasing, mainly because of rapid decline in the south and southeast (Kovshar 2010).

Table 1. Comparison of size of Demoiselle Crane populations in mid-1990s and 20 years later.

Parts of the range (*Breeding flocks*)	**Estimated numbers mid-1990s**	**Current estimated numbers mid-2010s**	**Trend**
European Part (Ukraine, Russia, and West Kazakhstan)			
Azov-Black Sea	600–700 (Andryushchenko 1999)	540–600 (Andryushchenko 2015)	Decrease
Middle Don	Not determined	200–300 (Belik et al. 2011)	?
Caspian	40,000–50,000 (Mishchenko et al. 2004)	30,000–40,000 (Belik et al. 2011)	Decrease
Volga-Ural	Not determined	15,000–17,000 (Bidashko et al. 2006, Belik et al. 2011)	Decrease
Subtotal	Over 50,000–60,000	45,000–58,000	Decrease
Kazakhstan and Central Asia Part (Russia, Kazakhstan, and Kyrgyzstan)			
South Ural	Few hundreds (Davygora 2005)	2,500–3,000 (Korovin 2009)	Increase
Altai	Not determined	4,000 (Irisova 2007)	Increase
Kazakhstan flock	100,000 (Berezovikov and Kovshar 2006)	50,000–60,000 (Kovshar 2010)	Stable in the north and center and decrease in the south, east, and west
Kyrgyzstan flock	100–120 (Toropova and Kulagin 2011)	20–40 (Kulagin 2014)	Decrease
Subtotal	Over 100,000	57,000–67,000	Decrease
East Asia Part (Russia, Mongolia, China)			
South of Central Siberia	600–700 (Prokofiev 1991)	3,000 (Savchenko and Yemelianov 2012, 2014)	Increase
Baikal and Transbaikalia	22,000–27,000 (Goroshko 2002, Goroshko and Tseveenmyadag 2002)	12,000–15,000 (continue to decline) (Goroshko 2012)	Decrease
Mongolia	80,000–90,000 (Tseveenmyadag 2005)	40,000–70,000 (N. Batbayar, personal comm.)	Stable in the north and center, but decrease in south, east and west
North-west China	Not determined	10,000 (Xing et al. 2005; L. Su, personal comm. 2016)	Decrease
Subtotal	Over 110,000–120,000	Over 65,000–98,000	Decrease
Atlas Plateau population (Northern Africa)	Few birds (JDR Vernon, ICF archive)	0 (no records since 1983) (Ilyashenko and Ilyashenko 2011; G. Scheres, personal comm.)	Probably extirpated
Eastern Turkey	40–60 (Kasparek 1988)	0 (no records since 2004) (Akarsu et al. 2013)	Probably extirpated
TOTAL	**Est. 200,000–240,000** (Meine and Archibald 1996)	**Est. 170,000–220,000** (Ilyashenko 2016)	**Decrease**

In the *East Asia part*, numbers have diminished in eastern Chinese provinces due to fast economic development (Liying Su, personal comm. 2016). In Transbaikalia in Russia and in the east, south, and west of Mongolia, numbers have declined due to long-term drought since the early 2000s, while in the center and north it is stable or slightly increased (Goroshko 2015; Nyambayar Batbayar and Tseveenmyadag Natsagdorjiyn, personal comm. 2016).

THREATS

Overall Range Threats

- Rapid economic development (intensive agriculture and livestock farming, wetlands transformed to reservoirs, urbanization) has caused habitat degradation, especially in Ukraine, northeast China, eastern Turkey and North Africa (Ilyashenko and Ilyashenko 2011, Akarsu et al. 2013; G. Scheres, personal comm. 2016);

- Disturbance during agricultural work, livestock grazing, and uncontrolled hunting as well as unorganized tourism on the breeding grounds, staging areas, stopovers, and wintering grounds (Pfister 1996; Tseveenmyadag 2005; Gebremedhin et al. 2009; Andryushchenko 2011, 2015; Goroshko 2012; Kulagin 2014); and

- Collision with power lines (Gombobaatar and Monks 2011, Malovichko et al. 2011).

Migration Flyways

- Live trapping and hunting in Pakistan and Afghanistan along the flyway for food, captive breeding, sale, and sport purposes (Perveen and Khan 2010); uncontrolled hunting in Central Asia, especially in private game areas (Bragin 2011, Mitropolsky 2011); and mass, indiscriminant killing of crane flocks in Saudi Arabia for sport purposes.

- Shooting in response to crop depredation in staging areas and wintering grounds (Parasharya et al. 1998, Goroshko 2010); and

- Secondary poisoning (cranes killed from consuming poisoned grain set out to kill rodents).

Breeding Grounds

- Changes in agricultural land use in Ukraine, Russia, and Kazakhstan after the collapse of the Soviet Union. This led to declines in livestock, overgrown pastures, and disappearance of artesian wells, increasing the area of abandoned fields, and breakdown of irrigation systems that had provided valuable crane habitat (Bragin 2011, Belik 2015, Ilyashenko 2018). The collapse also caused declines of crop cultivation and in turn overgrown, abandoned fields with weeds (mainly in the *European part* of the range);

- Expansion of the areas under agricultural crops unfit for cranes (certain perennial grasses, vineyards, olive [*Olea europaea*] groves and orchards), or crops that need frequently watered land (rice [*Oryza sativa*] paddies), especially in Ukraine, Turkey, and Morocco (Andryushchenko 2011, Ilyashenko and Ilyashenko 2011);

- Overgrazing, mostly in *Kazakhstan/ Central Asia* and *East Asia parts* (Gombobaatar and Monks 2011, Kulagin 2014; O. Belyalov, personal comm. 2015);

- Destruction of crane clutches by machines in agricultural fields during farm work, especially in Azov-Black breeding flocks where row crops prevail (Andryshchenko 2011);

- Poisoning against rodents in agricultural lands and crane roosting sites (Nankinov 2009, Andryushchenko 2011, Goroshko 2012, Belik 2015);

- Reduction of water resources due to climate warming, long-term severe drought (2000–2016) in steppe and semi-desert zones of central Eurasia, and destruction of irrigation systems (Belik et al. 2011, Goroshko 2011, Malovichko et al. 2011);

- Declining water availability both in breeding and non-breeding seasons caused by concreting of canals, overgrowth of reeds and brush around artesian wells and canal banks, and reduction of irrigation canal use due to high cost of water and inappropriate management (Andryushchenko 2015);

- Extensive fires in steppe and semi-desert areas of *European part* and Tranbaikalia Region of Russia and Kazakhstan caused by the degradation and overgrowing of neglected pastures and poor fire control since the beginning of the 1990s, after the collapse of the USSR (Bukreeva 2003, Bragin 2011, Goroshko 2012, Belik 2015). This threat was worsened by the long-term drought during the last decade. Grass composition afterwards is changed and such areas can become unsuitable for Demoiselle Crane breeding (Belik et al. 2011);

- Misguided management in special protected areas in the steppe zone in Russia and Ukraine, such as a ban on moderate livestock pasturage (Belik 2015), which led to heavier vegetative cover in previously suitable breeding habitats;

- Increase in number of predators, primarily herding and stray dogs (*Canis lupus familiaris*) and corvids (*Corvidae*) (Bukreeva 2003, Gebremedhin et al. 2009, Andryushchenko 2011, Goroshko 2012);

- Collection of eggs and chicks for illegal trade and exchange between private collectors and breeders (Andryushchenko 2011);

- Significant disturbance at sites where cranes gather in summer and before migration due to tourism developing in Black and Azov Seas coast area (Andryushchenko 2015); and

- In Mongolia, significant disturbance from livestock gathering at shallow water points is widely observed during spring and summer periods, causing cranes to move to unsuitable areas.

CHANGES SINCE 1996

- Apparent extirpation of the Atlas Mountains population in North Africa (there have been no confirmed sightings of birds for over 20 years) and of the breeding population in Eastern Turkey due to rapid economic development;

- Shrinkage and fragmentation of habitats at the southern border of the species' breeding range related to long-term drought in the Central Eurasia steppe and the agriculture crisis in the former Soviet Union region, as well as with declining crane numbers in the dry steppe and semi-desert zones (Kovshar 2010, Belik et al. 2011). On the other hand, the breeding range had expanded in a northern direction into the forest-steppe up to 52-53°N, where crane numbers increased (Fefelov 2008, Korovin 2009, Goroshko 2012);

- Recovering of steppe habitats in 8-10 years after their conversion from agricultural fields to fallow lands during the crisis in agriculture led to the stabilization of Demoiselle Crane numbers in Ukraine (Andryushchenko 2011) and even to its increase in the south of Russia (Zavyalov et al. 2003, Korovin 2009), northwestern and northern parts of Kazakhstan (Bragin 2011), and in Mongolia (Nyambayar Batbayar, personal comm.2016), especially when they are moderately grazed; and

- Significant reduction in number and area of wetlands due to creation of numerous dams and redistribution of water resources. Plowing of flooded meadows has led to conversion of riparian meadows to canals with steep banks overgrown with reeds and declining water availability for cranes (Andryushchenko 2015).

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

- There are a number of regional and local crane working groups (Crane Working Group of Eurasia, Ukrainian Crane Working Group, Uzbekistan Crane Working Group, Kazakhstan Bird Conservation Union, Indian Crane and Wetlands Working Group, and the Doga Dernegi in Turkey) that coordinate conservation efforts for Demoiselle Cranes across its range, including monitoring, networking, research, and ecological education activities;

- Satellite-telemetry tracking studies of migration routes in eastern Kazakhstan and East Asian (Transbaikalia) region of Russia and Mongolia were conducted in cooperation with the Wild Bird Society of Japan (Kanai et al. 2000);

- Researchers from the Wildlife Science and Conservation Center of Mongolia and the Mongolian Academy of Sciences have started tracking 22 Demoiselle cranes from the Khurkh River Valley in northeast Mongolia since June 2016;

- A project for long-term monitoring of the breeding population in the Khurkh and Khuiten River Valley has started in Mongolia with the cooperation from the Wildlife Science and Conservation Center of Mongolia, Mongolian Academy of Sciences, and the International Crane Foundation;

- A project on hunting regulations and hunters' education was implemented in Afghanistan, Pakistan, Kazakhstan, and Uzbekistan along the Demoiselle Crane flyways, supported by Mohamed bin Zayed Species Conservation Fund. Under this project, "*Guidelines on crane captive breeding*" was published in Pakistan as a tool intended to reduce captures of cranes for captive keeping;

- At the wintering grounds in Rajasthan in India, cash donations from local people and visitors are managed by "*Kuraj Samrakshan Vikas Sansthan, Pakshi Chugha Ghar, Khichan,*" a society established in Khichan for crane protection. Marwar Crane Foundation (MCF) has been set up recently to recognize and support the initiative of a villager from this community, whose crane feeding activities brought national and international attention to this village as an excellent bird watching site. The Government of Rajasthan has recently recognized this place as a tourist destination;

- New protected areas at the key breeding grounds of the Demoiselle Crane were established in Southeast Siberia (Goroshko 2012); and

- Daursky State Nature Reserve (Transbaikalia Region, Russia) worked with farmers on establishing lure crop fields to reduce crop damage near Torey Lakes at the sites of mass pre-migratory and migratory concentrations of cranes, and to reduce conflicts between farmers and the nature reserve (Goroshko 2010).

PRIORITY RESEARCH AND CONSERVATION ACTIONS

At present, on a species level the Demoiselle Crane has sufficiently robust numbers and a wide enough range to absorb current threats. Yet its numbers are in decline in many areas. Priority actions include the following:

- Identify priority areas for monitoring of the Demoiselle Crane in the different parts of the breeding range to determine long-term impacts of climate change and anthropogenic factors. Give priority to areas where the species' numbers have declined or are critically small, such as Azov-Black Sea and Caspian breeding flocks in the *European part*, south and southeast Kazakhstan and remaining pairs in Kyrgyzstan in *Kazakhstan/Central Asia part*, and Transbaikalia and Inner Mongolia in *East Asia part*;

- Establish a coordinated scheme to count cranes at pre-migration gathering sites across the range. Something like a "*Mid-August Sandhill crane count*" event, engaging all countries within the species range, could be useful to monitor the population numbers;

- Identify current wintering grounds in Northeast Africa (Ethiopia, Sudan, Chad) through tagging of Demoiselle Cranes in the *European part* with color plastic rings, and satellite and cellular transmitters. Received data will also provide information about individual movements at breeding grounds and migration stopovers along flyways;

- Determine key sites along flyways and use the international flyway program data to assess their protection status and needs;

- Promote sound captive breeding, ecological education, and implementation of alternative livelihood projects to reduce shooting and live-trapping of migrating cranes in Afghanistan and Pakistan;

- Strengthen control of hunting and education of hunters to reduce illegal hunting at the key stopovers in southeast Siberia, Kazakhstan, and Central Asia and along flyways;

- Increase education and public awareness activities for herdsmen, volunteers, children, and other members of the public in regions where cranes migrate, rest, and winter;

- Provide appropriate management of crane flocks and education of farmers to reduce conflicts between cranes and farmers;

- Maintain or restore regional populations through effective protection of the cranes and habitats in Turkey and in southern Ukraine, and consider a future possibility for restoration of the species in southwestern Ukraine, the Balkans, and the Iberian Peninsula;

- Prevent crane collisions with power lines and wind power turbines at major crane staging areas and migration stopovers. Power lines at these locations should be marked or otherwise modified to reduce the incidence of accidental collisions;

- Improve management at breeding and wintering sites, including adequate protection and organized tourism (Kichan, other sites in India);

- Develop preventive measures against steppe fires and organize effective management of wild fires;

- Develop and provide legislative support for measures to restore Demoiselle Crane habitats within steppe reserves and national parks in the *European part* of the range through creation of water sources and moderate grazing; and

- Increase awareness among herders and farmers on how to prevent herding dogs from depredating the eggs and chicks of cranes.

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SPECIES REVIEW:

EURASIAN CRANE (*Grus grus*)

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(with inputs from Ferdi Akarsu, Javier A. Alonso, Juan Carlos Alonso, Yuri Andryuschenko, Nicola Baccetti, Victor Belik, Eugeni Bragin, Damon Bridge, Olivier Combreau, Victor Degtyarev, Patrick Dulau, Petro Gorlov, Valentin Y. Ilyashenko, Antti Karlin, Anatoly Kovshar, Zev Labinger, Eugenia Lanovenko, Aivar Leito, Fengshan Li, Petr Lumpe, Sigvard Lundgren, Ming Ma, Yuri Markin, Sebastien Merle, Wolfgang Mewes, José Miguel, Iwona Mirowska-Ibron, Maxim Mitropolsky, Pekka Mustakallio, Gunter Nowald, Ivar Ojaste, Fawen Qian, Sasha Pekarsky, Polina Redchuk, Juhani Rinne, Eldar Rustamov, Sadegh Sadeghi Zadegan, Alain Salvi, Jostein Sandvik, Itai Shanni, Liying Su, K S Gopi Sundar, Marketa Tichackova, and Zsolt Végvári)

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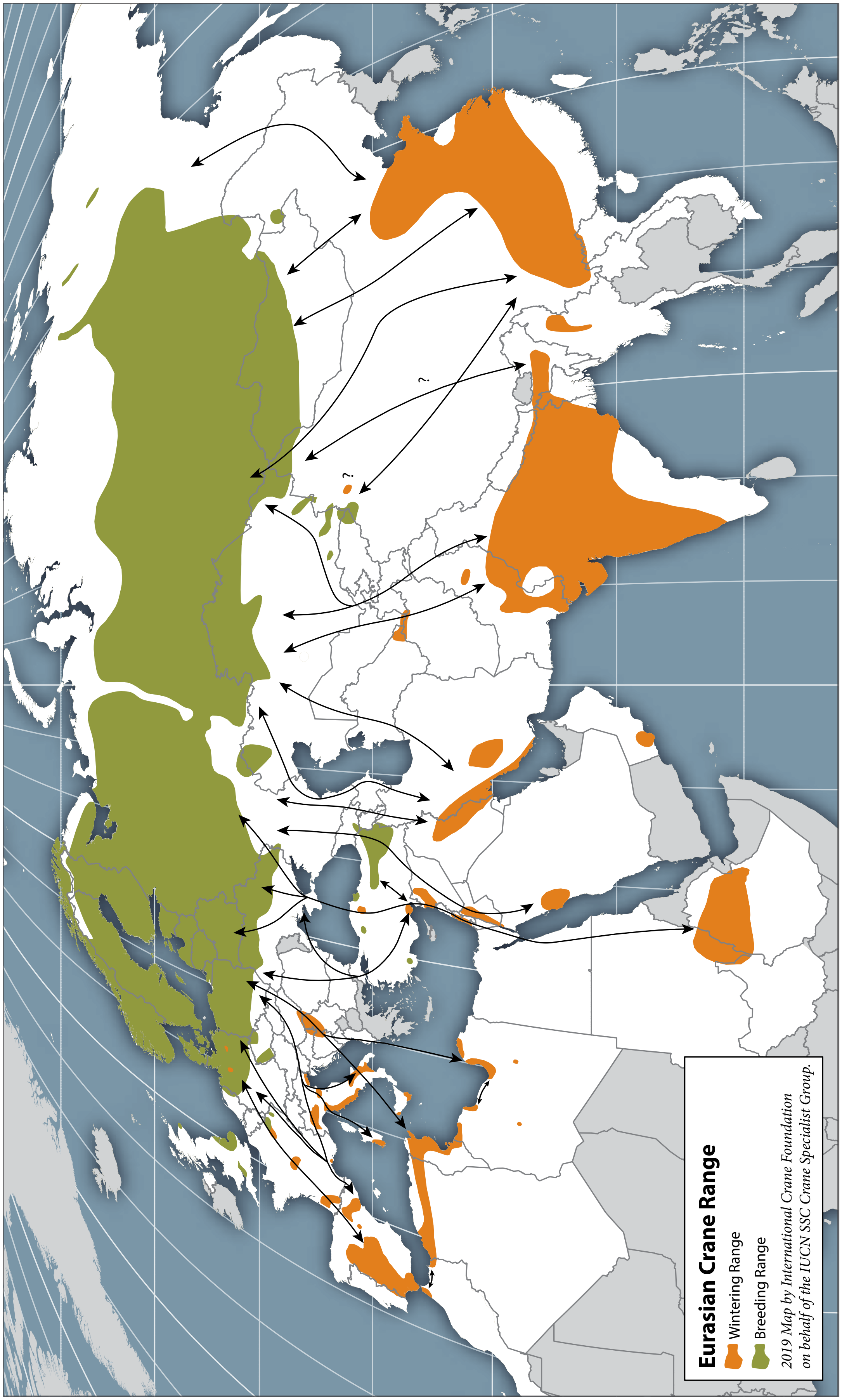
Eurasian Crane family in Crane Motherland Wildlife Refuge in Russia (Photographer: Igor Bartashov)

Red List Category: Least Concern
Population Size: >700,000
Population Trend: Increasing in western populations, declining in the east
Distribution: Eurasia



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DISTRIBUTION AND STATUS OF KEY SITES

Subspecies/Populations

Four subspecies have been described. The Western Eurasian Crane (*G. g. grus*) and the Eastern Eurasian Crane (*G. g. lilfordi*) are separated by the Ural Mountains (Gill and Donsker 2017); two new subspecies have been proposed, including the Transcaucasian Eurasian Crane (*G. g. archibaldi*; Ilyashenko et al. 2008) and the Tibetan Eurasian Crane (*G. g. korelovi*; Ilyashenko and Belyalov 2011). Previously these two new subspecies were considered as isolated populations. They exhibit morphological and biological differences from Western and Eastern Eurasian Cranes (Ilyashenko 2013). The low phylogenetic relatedness and the small genetic distances within the Eurasian Crane suggest that the genetic diversity is fairly young. This further suggests that morphological differentiation, in particular of putative *G. g. archibaldi* and *G. g. korelovi*, has evolved rapidly. To demonstrate that these two new subspecies are truly monophyletic and qualify as evolutionarily significant units, more samples are necessary (Haase and Ilyashenko 2012). Western Europe is the only region where Eurasian Cranes with completely black tertiary feathers breed, and distribution and taxonomic status of this population require further research.

Overall Range and Subspecies Distribution

The Palearctic distribution area of the Eurasian Crane extends from the forest-tundra zone in the north to the sub-tropical zone in the south. Its breeding range extends across Eurasia from northern and western Europe to eastern Siberia and the Russian Far East and north-eastern China (0°W / N to 125–130°E longitude), as well as between northern Europe and Asia to Middle Europe, and the steppe zones of south-eastern Europe and Asia (67–69°N to 50–52°N latitude).

Western Eurasian Crane

The breeding grounds of the Western Eurasian Crane spread from North and West Europe to the Ural Mountains. This subspecies can be conditionally divided into three populations on the basis of their ecological features.

West European population

In the north, in Scandinavia the breeding range of the population extends far north of the Arctic Circle. The northernmost breeding place is at 70°39'N, which is not far from the Barents Sea and ca. 450 km north of the Arctic Circle (Svensson et al. 1999, Ottosson et al. 2012; Jostein Sandvik, personal comm. 2016). The population has the highest breeding density in the northern parts of Europe (Norway, Sweden, Finland, Baltic countries) and in the central ones (Poland, Germany). Denmark (Tofft 2013) and Czech Republic (Tichackova and Lumpe 2014) have small but increasing breeding populations. A slowly growing population inhabits Great Britain in different districts, most of them in Norfolk/east England (Bridge 2014). The distribution in West Europe has reached the Netherlands (about 10 pairs) and eastern France (15–20 pairs in 70–80 birds; Salvi 2013, 2014, 2015; Prange 2016). The Eurasian Crane is extinct as a breeding species in Ireland (D´Arcy 1999), southern France (Salvi et al. 1996), and Spain as well as in northern Italy (Brichetti and Fracasso 2004).

The West European flyway is used by cranes from northern Europe (Norway, Sweden, and partly from Finland) across the Baltic Sea and from the eastern Europe (Poland and partly from Baltic countries), through Germany, Netherlands, Belgium, and Luxembourg, to the wintering grounds in France (up to 160,000; Salvi 2015), Spain (up to 266,000; Roman et al. 2014), Portugal (near 8,000) and, in a marginal way, in Morocco (1,000–1,300) (Roman et al. 2014, Salvi 2016). During the last two decades, numbers of crane wintering in Germany have increased up to 20,000 birds, with large yearly differences depending on weather conditions (Prieta and Del Moral 2008; Onrubia et al. 2009; Prange 2010a, 2010b, 2012, 2015, 2016; Salvi 2012a,b). In Poland during the winter 2013–14, 122 observations were documented of over 1,500 cranes with a flock size up to 350 birds (Nowald and Broniarek 2014). The relative numbers of Eurasian Cranes wintering in the south of the West European flyway (South Spain and Morocco) have decreased, while they have increased on northern wintering grounds in Spain, France, and Germany (Prange 2016).

The most important staging areas and migration stopovers are located:

- In Finland, 9,000 in Söderfjärden and Waasa, 13,000 in Muhos, and 3,000 in Puurijärvi (Harry Seppälä, personal comm. 2016) and Tiira (BirdLife Finland, www.birdlife.fi 2016);
- In Sweden, up to 50,0000 cranes simultaneously (all sites) at the southern lakes of Hornborga, Kvismaren, Takern, and on the Öland Island (Nilsson and Månsson 2012);
- In West Estonia, including Matsalu Bay, Haapsalu Bay, Hiiumaa Island, and Saaremaa Island with recently up to 30,000 cranes, according to state monitoring data of the Eurasian Crane in Estonia (Leito 2015);
- In Poland, about 100 sleeping sites with up to 80,000 cranes simultaneously were known in the years 2009–2013 (Iwona Mirowska-Ibron, personal comm. 2013; Sikora et al. 2015). In the last decade, the yearly increase of crane breeding and resting was about 7%. The biggest sleeping sites are located at Lower Odra Valley (15,000 max. in 2012, mainly feeding in northwestern Germany) (Jochen Haferland, personal comm. 2012) and on lowland at the mouth of the Warta River (17,800 max. in 2015 before leaving for Odra Valley) (Arkadiusz Broniarek, personal comm. 2015; Prange 2016).
- In Germany, with recently 250,000 resting cranes on average (in 2012, simultaneously 290,000; in 2015, 350,000) at about 100 resting areas with near 200 roosting sites, with maximum number of resting cranes changing from year to year (Prange 2015);
- The biggest concentrations in Germany are found in Darss-Zingster Boddenkette and Rügen (old name: Rügen-Bock area) regions with 55,000–75,000; Rhin-Havelluchs near Berlin with 60,000–125,000 cranes; Diepholz moor lowlands in the North West Germany with 60,000–120,000; as well as at the Helme and Unstrut Reservoirs in Thuringia with 30,000–45,000 cranes (Nowald et al. 2010a; Nowald 2012, 2015; Prange 2000–2009, 2010a, 2010b, 2013, 2016);
- In France, with the biggest resting sites in Lorraine (plain of Woëvre, up to 30,000 simultaneously), Champagne-Ardenne (Lac du Der Chantecoq and Lac du Temple, up to 200,000), and Aquitaine (military camp of Captieux and former coal mine of Arjuzanx, up to 50,000) (Salvi 2013); and
- In Spain, at the Extremadura Autonomous Community with up to 133,000; the Lagoon of Gallocanta with up to 60,000 cranes in autumn and up to 115,000 in spring (Alonso et al. 2014); as well as the lagoon of Sotonera with up to 70,000 in spring for only a few days before crossing the Pyrenean Mountains (Roman et al. 2014).

East European population
The breeding grounds of this population are located in Finland and in the eastern parts of the Baltic countries, in the north-west of European Russia, in Belarus, and Western Ukraine. The species became extinct as a breeding bird in the Balkan countries.

Recent research has confirmed the existence of a European-wide web of migration routes of Eurasian Cranes, which know and are able to use this web and take one of the routes on the basis of genetic and social memory and affected by weather and social connections on routes (Suorsa 2015, Leito et al. 2015; Aivar Leito, personal comm. 2016). However, the majority of cranes of the East European population use the Baltic-Hungarian (Central European) flyway, although cranes from Finland, Estonia, and northwest of Russia may migrate along both the West European and Baltic-Hungarian flyways, in some cases performing loop migrations. The latter flyway goes from the northwestern part of Europe via Estonia to the south through Slovakia and Hungary. After the stopover in Hungary, this route divides into several branches running to the south-west and south. The southwestern course passes through the Balkan countries (former Yugoslavia), goes across the Adriatic Sea and southern tip of Italy (Mingozzi et al. 2013, Leito 2015), and ends in Tunisia, Libya, and Algeria (Houhamdi et al. 2008, Hafid et al. 2013, Saurola et al. 2013, Leito et al. 2015). Some cranes from Baltic-Hungarian flyway also reach Lake Tana in Ethiopia, flying over the Sahara Desert (Ivar Ojaste, person. comm. 2018). The West European and Baltic-Hungarian (Central European) flyways are partly mixing in the eastern areas of Finland, Estonia, in East Poland, and the northwest of European Russia (Sierakowski et al. 1969, Saurola et al. 2013, Leito et al. 2015).

The main staging areas and migration stopovers along the Baltic-Hungarian flyway are located in Estonia with about 80,000 migrating cranes. The biggest of numerous migration stopover areas is in the west of Estonia, including the Matsalu Bay, Haapsalu Bay, Saaremaa Island, Hiiumaa Island, and Lahemaa National Park in northern Estonia (Leito 2015). The situation in other Baltic countries and in Belarus is poorly known. Eastern Hungary is the most important resting area on this flyway. The Hortobágy National Park is a huge resting site with several roosts and 50,000–140,000 cranes resting in autumn and spring; the autumn average in the last decade was 75,700. Several other resting sites are in the southeast of Hungary (Kiskunság and Körös-Maros National Parks) with up to 45,000 cranes; the maximum numbers are reached two weeks later than in Hortobágy (Végvári et al. 2010). Since the 1980s crane have begun wintering in Hungary, mainly in the south (Kiskunság and Körös-Maros National Parks) due to developed protection, plentiful maize (corn, *Zea mays*) cultivation, and warmer winters (Fintha 2003/04/05, Végvári et al. 2010). Crane numbers vary from 10,000 to 20,000 birds (max. 27,900 individuals in January 2012), depending on weather conditions (Prange 2016).

Migration stopovers are known in several Balkan countries, for example, in the "Podpanj" Bird Sanctuary at the Hungarian-Croatian border at the Drava River near the city Donji Miholjac (http://www.wdpa.org/podpanj-special-reserve), as well as in the "Slano Kopovo" Nature Reserve, Serbia/Vojvodino, where up to 14,000 cranes stop for rest and around 20,000 for migration (Knezev 2013, Stumberger and Schneider-Jacoby 2013, Leito 2015, Prange 2016).

In the last decades, new wintering areas have been colonized in southeastern France in the Camargue near the mouth of the Rhone River, with up to 10,000 birds, outside the big traditional migration routes of cranes (Salvi 2016). Data and flight-corridor analysis shows that the Camargue has become a convergence area between the Western European and the Baltic-Hungarian (Central) flyways. The first flyway leads the birds from the north along the valleys of the Rhine and the Rhône and is supposed to drive the cranes toward Catalonia using a newly adopted route close to the Gulf of Lion, and only passing by the Camargue with a stopover or not. The second flyway leads the cranes by Austria along the Alps, crossing Italy to the south and Germany to the north to the Camargue, where they will spend the entire winter (Salvi 2016). Increasing numbers of these cranes are also crossing Switzerland in a southwest or northeastern direction in autumn and spring, respectively (Nowald and Schmid 2012). These increasing numbers of cranes wintering in the Camargue coincide with a simultaneous dramatic decrease in North Africa, particularly in Algeria, due to negative changes of habitat conditions there (Hafid et al. 2013). At the same time, numbers of wintering cranes are increasing in North Italy (Zenatello et al. 2014).

Israel has important migratory and wintering sites. The biggest site is the well-managed Hula Valley in the very north of the country. Hula Valley may be a stopover and wintering site for cranes of both Eastern European and European Russia populations coming from northwest, north, and northeast, though the actual numbers and their exact origin are not known yet (Pekarsky et al. 2015). An estimated 60,000–80,000 migrating cranes use staging and wintering areas in Israel, including a growing wintering population of 35,000–42,000 cranes at Hula Valley and some 5,000–10,000 spread around other sites further south (Shanni et al. 2012; Rubin Inbar, personal comm. 2017).

European Russia population

The breeding grounds are located in Belarus, East Ukraine, and the European part of Russia, as well as smaller breeding sites in northwestern Kazakhstan. A possible transitional zone between the two subspecies—*G. g. grus* and *G. g. lilfordi*—is located in northwestern Kazakhstan and south from the Ural Mountains (Ilyashenko 2013).

This population uses the East European flyway with two branches: Baltic-Pontic and Russia-Pontic (Redchuk et al. 2015). Cranes from the northern and central parts of European Russia perform broad-front migration south (Russia-Pontic course) (Flint and Pancheshnikova 1985) to the wintering grounds in the Near East and North-East Africa. After reaching Ukraine, some of them proceed westerly around the Black Sea, cross the Mediterranean Sea to their wintering grounds in Turkey, Israel, and Ethiopia. A larger flock crosses the Black Sea over the Crimea Peninsula down to the same wintering grounds: Turkey, Israel, Saudi Arabia, Jordan, and Ethiopia. Cranes from Finland, part of the cranes from Baltic countries, Belarus, and the western part of Ukraine (Baltic-Pontic course) reach the Crimea Peninsula and then also cross the Black Sea to these wintering grounds (Redchuk et al. 2015).

In European Russia, there are 570 gathering sites with crane numbers varying between 30 and up to 3,000 individuals (Ilyashenko and Markin 2013). The biggest sites with numbers from 1,000 to 3,000, which served as both staging areas and migration stopovers, are located in Vologda, Kaliningrad, Kirov, Moscow, and Smolensk Regions.

The main migration stopovers where the Baltic-Pontic and Russian-Pontic routes of the East European flyways, as well as in part Baltic-Hungarian flyways, cross are located in Askania-Nova Nature Reserve (Kherson Region of the Ukraine), with crane numbers from 20,000 to 45,000, and at Sivash Bay in the Crimea Peninsula of the Black Sea with up to 60,000 (Gorlov 2012, Redchuk et al. 2015).

Cranes from central and eastern European Russia can also fly over the Caucasus Mountains through Georgia, Armenia, and Azerbaijan to wintering grounds located in Iran and Iraq, as well as in Israel, Jordan, and North East Africa (Caucasus flyway). This flyway became more significant at the end of the 20th century and the beginning of the 21st (Belik 2006, Sultanov et al. 2011, Markin 2013). The biggest migration stopover along this flyway is known in the Rostov and Stavropol Regions in Manych-Gudilo Lake Valley (up to 5,000–10,000 cranes simultaneously; Belik 2006).

At Manych-Gudilo Lake, cranes of the Caucasus Flyway can join with cranes from the trans-Volga Region, northwestern Kazakhstan, and South Ural region where the transition zone of two subspecies is located and use the Volga-Iranian Flyway (Flint and Pancheshnikova 1985, Flint 1987, Farhadpour 1987). Cranes following the Volga-Iranian route cross Manych-Gudilo Lake and then fly along the western Caspian Sea coast through Dagestan and Azerbaijan and reach wintering grounds in southwestern Iran, northeastern Iraq, and Jordan. However, these wintering grounds became insignificant during the last two decades due to long-term drought (Sadegh Sadeghi Zadegan, personal comm. 2016). This flyway crosses paths with the small branch of the West Siberian Flyway (*G. g. lilfordi*), which also goes along the western coast of the Caspian Sea.

Some authors combine Caucasus and Volga-Iranian Flyways into one Volga-Caucasus Flyway with the significant stopover at Manych-Gudilo Lake (Redchuk et al. 2015).

Eastern Eurasian Crane

West Siberian and Central Asian populations

Breeding grounds are located in Russia east of the Ural Mountain in West Siberia as well as in North and Central Kazakhstan. The majority of cranes migrate along the West Siberian Flyway, which extends from the north with biggest migration stopovers in Tyumen, Chelyabinsk, and Kurgan Regions of Russia (up to 10,000 simultaneously) (Ilyashenko and Markin 2013) and in the lake systems of Kostanai Region in North Kazakhstan (Bragin 2011). Then the cranes cross Central Asian countries (Turkmenistan, Kyrgyzstan, and Uzbekistan), Afghanistan, and Pakistan to the wintering grounds in eastern Iran and western and central India with the main wintering grounds in Gujarat Province. From the late 1990s to early 2000s, some of the migrating flocks began staying for winter in the Amudaria River Valley on the border between Afghanistan, Uzbekistan, Turkmenistan, and Tajikistan (Lanovenko et al. 2011, Rustamov et al. 2011, Toropova and Kulagin 2011).

Some cranes, after resting in Kazakhstan, can use the same flyway as the Siberian Crane and fly to the west, crossing the Volga Delta and then following the western Caspian Sea coast to wintering grounds in the southwest of Iran and eastern Iraq. However, this flyway is quite small (Sultanov et al. 2011). This route to Iran can merge with the Volga-Iranian Flyway of the West Eurasian Crane. Some cranes that cross Turkmenistan in a southwestern direction fly over the foothills of the Eastern Kopetdag Range Mountains through southern Turkmenistan to wintering grounds in Iran (Efimenko 2002, Rustamov et al. 2011). Thereby, both subspecies *G. g. grus* and *G. g. lilfordi* can be sighted at wintering grounds in Iran. At the end of the 20th century cranes began wintering in Tejen River Valley in southern Turkmenistan with their number increasing from up to 50 (Efimenko 2002) to near 1,300 birds (Rustamov et al. 2011).

Central/Eastern Siberia and North China population

The breeding grounds of this population are located in central and eastern Siberia, northern Mongolia, and northern China. Birds from central and East Siberia, Kazakhstan, and the Tibetan Plateau fly through Mongolia to central and western China and Myanmar (Chan 2003) (East Asian Flyway). Cranes from the northeast and southeast of Siberia use also the Far East–Chinese Flyway, which crosses Primoriye Region (Russia) and proceeds along the coast through Liaodong and Bohai Bays to wintering grounds of the Yangtze River valley in China, as well as to Myanmar and North Vietnam. Eurasian Cranes stop in Russia for roosting at Torey Lakes (Goroshko 2002) and Muraviovka Park, where some immature birds also spend summers (Sergei Smirenski, personal comm. 2016), and later at Zhalong and Shandong Huanghe Delta National Nature Reserves in China, where they join mixed flocks with other crane species.

Transcaucasian Eurasian Crane

Breeding grounds are located in the Anatolia and Armenia Uplands. They are restricted to Central and East Turkey and the border area of Armenia, Georgia and northern Iran. This proposed subspecies is isolated from the southern edge of the East Eurasian Crane's (*G. g. grus*) core range by a distance of more than 1,100–1,200 km (Ilyashenko et al. 2008). This subspecies is probably close to being resident; cranes have insignificant vertical migrations or regional movements, spending the winter in south Turkey (Nowald et al. 2014) and Georgia (Abuladze 2002). In recent years in Hula Valley (Israel), at the Eurasian Crane mass for wintering, some birds were showing features from the Transcaucasian Eurasian Crane (Itai Shanni, personal comm. 2010; Rozenfeld 2011).

Tibetan Eurasian Crane
Breeding grounds are wet valleys in high mountain regions at the border between the Eastern and Central Tien-Shan (Xinjiang–Uyghur Autonomous Region) and in frontier regions of three countries—Kazakhstan, Kyrgyzstan, and China (Ilyashenko 2011, Ma et al. 2011). Wintering grounds are unknown. Probably cranes spend the winter together with Black-necked Cranes (*G. nigricollis*) in the south part of Central Tibet and on the Yunnan-Guizhou Plateau in the southeast foothills of Tibet at altitudes from 2,000–3,400 m above sea level.

ECOLOGY

Eurasian Cranes breed in the northern tundra and boreal and temperate taiga, as well as in deciduous forest zones and the more southern forest-steppes and open steppes. Typical nest sites are found in wetlands dominated by alder (*Alnus*) and birch (*Betula*) trees, raised bogs, fens, and swamps, and at the reed borders of shallow lakes, fish ponds, and other water bodies. In Europe during the last three decades, the species has adapted to nesting in ponds in fields and wet meadows within agricultural lands, sometimes near roads and human settlements (Mewes 2010; Sigvard Lundgren, personal comm. 2010), and has colonized numerous abandoned gravel and sand quarries and small sea islets in the Baltic Sea (Leito et al. 2003, 2005, 2006).

The Tibetan and Transcaucasian Eurasian Cranes use aquatic habitats. Territorial cranes breed in seasonal wetlands at altitudes from 1,900 to 3,900 m above sea level. They build nests in completely open habitats (Ilyashenko et al. 2008, Ilyashenko and Belyalov 2011).

For hundreds of years Eurasian Cranes have adapted to foraging on agricultural fields during migration and wintering. Over the last 50 years, the extension of maize production and intensification of agriculture in West Europe have caused a rapid increase in crane numbers, and the problem of crane damage to crops has gained increasing attention (Leito et al 2008, Nowald et al 2010a, Prange 2010b, Nowald 2012).

NUMBERS AND TRENDS

The world population is estimated at over 700,000 cranes (Prange 2013, 2016).

Western Eurasian Crane
Presently, the Western Eurasian Crane population is estimated at 590,000 birds, of which around 350,000 migrate on the West-European Flyway, 150,000 on the Baltic-Hungarian (Central European) Flyway, (Prange 1999a, 1999b, 2010a, 2010b, 2013, 2014, 2016; Fintha 2003, Végvári et al. 2010, Nowald 2012), and up to 10,000 on the Austrian- Italian and Austrian-Bavarian Flyways (Salvi 2013, 2014, 2016; Prange 2016). The East European and Volga Caucasus Flyways are estimated to host approximately 80,000 cranes (Gorlov 2012, Ilyashenko and Markin 2013). The West Eurasian Crane population shows positive breeding trends during the last three decades. Overall, the population has been increasing for several decades, more in the west of Europe with 5‑8% growth per year in the last three decades and to a lesser extent in the east (Mewes 2010, Prange 2016).

Eastern Eurasian Crane
The Eastern Eurasian Crane population is estimated at up to 110,000‑112,000 birds. Nearly 100,000 cranes use the West Siberian Flyway according to censuses carried out on the wintering grounds of Amudaria River Valley with around 30,000 birds (Rustamov et al. 2011, Sorokin et al. 2011) and in India with about 70,000 cranes (Rahmani et al. 2016). The size of the Central/Eastern Siberian and North Chinese subpopulations are estimated at approximately 12,000, with several major wintering grounds such as Yunnan-Guizhou Plateau (1,500; Yang and Zhang 2014), Poyang Lake (~7,000; Jin

2015), Shanxi (2500; Liu et al 1989), and Shannxi (~1,000; Wu et al. 1998). Numbers at wintering grounds in Yellow River Delta, Beijing outskirts, and Myanmar are not stable. Yellow River Delta was a major wintering site, but the number of Eurasian Cranes there has declined to almost zero after year 2000 (Shan et al. 2005), while in Myanmar the numbers have been increasing during the past two decades.

Transcaucasian Eurasian Crane
At the turn of the 19th–20th centuries, Eurasian Cranes in Transcaucasia were quite common and hunted. However, until recently data on their biology, distribution, and numbers had been extremely scarce because a strict boundary regime has been set up in this area since the early 1920s.

The total number is now estimated at 250–300 individuals including 70–80 breeding pairs. In Iran, three or four pairs bred southwest of the Maku Village in 1997 (Ra'naghad and Ebrahimi 2007). Since that time there is no new information from northern Iran (Amir Mahdi Ebrahimi, personal comm. 2009). In Georgia, Eurasian Cranes breed near the border with Turkey and Armenia (Javakhishvili et al. 2013). During censuses in 1998, 1999, and 2008, from 11 to 17 breeding pairs were documented (Alexander Abuladze, personal comm. 2016). In Armenia in 2008, two to three pairs bred near the border with Georgia and Turkey (Ilyashenko et al. 2008). In Turkey, the number is estimated at 40–60 breeding pairs (Ferdi Akarsu, personal comm. 2017).

Tibetan Eurasian Crane
The total number of the Tibetan Eurasian Crane is estimated at 1,000 individuals in China (Ma et al. 2011) and around 10 breeding pairs in Kazakhstan and Kyrgyzstan, showing decreasing trends (Ilyashenko and Belyalov 2011).

THREATS

- Loss and degradation of breeding and roosting habitats in southern Russia, Kazakhstan, Central Asia, Mongolia, and North China due to drainage, urbanization, agricultural expansion, crop alteration, and fires that were enhanced by drought during the previous decade. Ongoing drought followed wetland losses along the migration routes in the Middle East, in northeast Africa, India, and China (Ilyashenko et al. 2008, Goroshko 2011, Ilyashenko and Belyalov 2011, Hafid et al. 2013). Unstable water levels due to lack of cooperation on water control/diversions and due to climate change have impacted on crane habitats especially in forest-steppe, steppe, and mountain zones. Recent climate warming could threaten crane populations in the Mediterranean climate zone as well in in northern and eastern Africa, particularly Ethiopia (Leito et al. 2015);

- Negative impacts on crane habitats due to afforestation and plowing of meadows and fallow fields for more intensive cultivation of rape (*Brassica napus*) and biogas-maize as biofuels to produce electric energy in Europe;

- Collisions with power lines regularly occur in Europe near roost sites as well as during migration on foggy days. Collions in other regions are less well documented. Construction of power stations near staging areas and migration stopovers decreases the area for crane movement and foraging. Rapidly increasing construction of wind farms in Europe is an emerging and potentially significant threat (Danish Center for Environment and Energy 2015);

- In Afghanistan and Pakistan, crane poaching and capture with nets and nooses is still widespread (Khan 2004, Perveen and Khan 2010). Uncontrolled hunting and poaching increased in the Commonwealth of Independent States countries (11 out of the 15 former Soviet Republics—Azerbaijan, Armenia, Belarus, Kazakhstan, Kirgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan, Uzbekistan, and Ukraine—are member states) after the collapse of the USSR in 1991 because of the worsened living standards caused by the economic and agriculture crises (Bragin 2011, Degtyarev 2011, Mitropolskiy 2011, Toropova and Kulagin 2011; Oleg Goroshko, personal comm. 2016). On the other hand, following the economic recovery private hunting companies were created in Russia and Kazakhstan where the control over hunting is difficult (Eugeni Bragin, personal comm. 2016). Shooting of cranes is known from the Balkan region (Stumberger and Schneider-Jacoby 2013) and in Near East and North African countries (Nowald et al. 2010b);

- Poisoning causes occasional crane deaths in Mongolia, Russia, and European countries (Prange et al. 1999, Prange 2000–2009, Thiel 2003, Hohl 2004, Malovichko 2011) and is a growing problem in China, although Eurasian Crane numbers continue to increase there (Jim Harris, personal comm. 2016);
- Predators such as racoon dogs (*Nyctereutes procyonoides*) have become a serious threat in the Ukraine and other countries; foxes (*Vulpes*) are a danger everywhere for young birds and sometimes for the adults too, if they are roosting outside of water bodies; and
- Lack of knowledge, awareness, public support, and local conservation leadership are concerns for Transcaucasian and Tibetan Eurasian Cranes (Ilyashenko et al. 2008, Ilyashenko and Belyalov 2011).

CONSERVATION EFFORTS UNDERWAY

The increase in numbers of breeding cranes, as well as the recovery of breeding areas and their extension to the south, north, and west in the western parts of Europe, are results of progressive legislative actions for wetlands and species protection combined with an improved environmental awareness of the public.

Habitat protection has been strengthened in many countries. In Germany and France, nearly 80% of the roosting sites are officially protected; most of the others are supervised by members of administrations, national crane working groups, or local organizations. As a result, about 90% of migrating cranes are under relatively secure conditions. In Estonia, there are more than 36 crane breeding areas (total area 3,892 km^2) and 17 roosting sites (3,400 km^2) with protection status, according to the "Eurasian Crane Conservation Management Plan" (Leito et al. 2006). In Russia, Ukraine, China, and India, habitat management takes place mainly within strictly protected areas set up to protect other, endangered crane species but also beneficial for the Eurasian Crane. Human pressure on wetlands and crane habitats in China and India is being regulated by legislation and reduced by protection activities. Full or partial protection is provided for migrating cranes at key sites in Near East and Iran (Sadeghi Zadegan 2011), in Central Asia, China, and India.

Monitoring is underway every year in several European countries. Many honorary members of local groups supervise the breeding and resting sites.

In Great Britain, the "Great Crane Project" was founded by the Wildfowl & Wetlands Trust, the Royal Society for the Protection of Birds (RSPB), and Pensthorpe Conservation Trust to support the recovery of the breeding population of the Eurasian Crane through reintroduction, and help in the restoration of wetlands in Somerset, southwestern England. The project gathered 137 eggs from 84 nests in Brandenburg, Germany (Eberhard Henne and Beate Blahy, personal comm. 2012), and 122 viable eggs were transported to the UK. During 2010–2014 about 20 birds were released annually by the project partners on the RSPB's West Sedgemoor Nature Reserve in Somerset. The first breeding of the 93 released birds (at three years old) was in 2013 without success, but in 2015 three breeding pairs fledged four chicks, and three pairs fledged a further three chicks in 2016 (Damon Bridge, personal comm. 2016).

Monitoring, conservation, education, and management planning were conducted at several wintering sites in Ethiopia through implementation of a project by Crane Protection Germany (NABU [Natural and Biodiversity Conservation Union], World Wildlife Fund, Lufthansa) in collaboration with the NABU Working Group for Africa, the University of Jimma, and the Ethiopian National Wildlife and History Society (Nowald et al. 2010b, Aynalem et al. 2013, Leito et al. 2015).

Effective crane-agricultural management has been implemented at larger crane migratory resting sites in Europe since the 1970s in Sweden, Estonia, East Germany, France, Israel, and Spain by the crane researchers of these countries (Mansfeld 1972; Alonso and Alonso 1987; Prange 1989, 1995; Swanberg and Bylin 1993; Dornbusch 1995; Bräse and Weiß 2005; Lundin 2005; Leito et al. 2006; Nowald et al. 2010a; Salvi 2012a). Farmers were occasionally subsidized for damage in France, Spain, Estonia, Latvia, Germany, Sweden, and other European countries. Instead of compensation, "diversion feeding" has been successfully undertaken near large resting sites as an alternate method to reduce damage and conflicts with farmers. The most intensive diversionary feeding for Eurasian Cranes is practiced in Hula Valley in northern Israel, where this technique is combined with education and tourism (Shanni et al. 2012).

Color-marking and radio-tracking of Eurasian Cranes were conducted successfully mainly in European countries and Israel, with the first ringing in Sweden where 90 cranes were marked from 1985 to 1991; the first satellite tracking begin in Finland in 1991 and later expanded to various other countries (Alonso and Alonso 1990, 1999). The European Crane Banding Group (ECBG) was established in 1985 during the first European Crane Workshop in Hungary with members from six countries. Thanks to its active work, about 4,500 cranes were banded with national tri-color codes (left leg) and individual tri-color codes (right leg) as well as satellite or global-positioning-system (GPS) transmitters from 1988 to 2010 in Finland, Sweden, Norway, Estonia, Poland, Germany, and Spain (Alonso et al. 1995; Alonso and Alonso 1999, 2003; Leito et al. 2006; Donner and Nowald 2008; Nowald 2010; Saurola et al. 2013; Satelliittikurjet 2016), and more recently in Estonia (Leito 2015), as well as in Germany (Nowald and Broniarek 2014, Nowald et al. 2016). At the Hula Valley in Israel, marking with GPS transmitters has gathered valuable knowledge about Eurasian Crane flyways (Alon et al. 2003). A few cranes were also banded in Iran. ECBG organized training on crane capture and banding in Germany and Poland with participation of Russian, French, Ukrainian, Polish, Turkish, and Spanish ornithologists.

In Russia, nearly 200 cranes were color banded in the 1980s in Oka State Nature Reserve, and this activity was resumed there in 2016 with marking of cranes by GPS-GSM (geographic positioning system – global system for mobile communications) loggers under support of the Movement Ecology Laboratory in Israel. The Crane Working Group of Eurasia published Guidelines on Crane Capture and Banding with descriptions of different techniques used around the world (Markin and Ilyashenko 2010).

In Turkey from 2014 to 2016, 45 Transcaucasian Eurasian Cranes including 39 juveniles and 6 molting adults were color banded and/or marked with GPS-GSM loggers by an international team representing Turkey, Germany, Spain, and France with support by Crane Conservation Germany, Department of Wildlife Management Ministry of Forestry and Water Affairs (Turkey), Doğa Araştırmaları Derneği (Nature Research Society, Turkey), Lufthansa Group, and TR2011/0135.15 – Civil Society Dialogue Programme – Fourth Phase Grant Scheme – Project Ref No: CSD-IV/ENV/34.

Knowledge and research on the Eurasian Crane distribution, biology, ecology, and conservation status have expanded significantly over the last four decades, and international cooperation was strengthened through organization of international conferences, workshops, meetings, training sessions, and publication of proceedings, as well as through cooperation in color-banding and transmitter-tagging of cranes among various countries and monitoring the sightings of these marked cranes through databases and websites. Joint fieldwork was conducted at crane breeding, migration, and wintering sites (Europe, Turkey, Ethiopia, Israel, Russia, Armenia, Uzbekistan, Kazakhstan, Turkmenistan, and other countries). As a result, the exchange of knowledge and information has also improved. Numerous articles in national and international workshop and conference proceedings, journals, newsletters, and yearly reports were published. A major contribution to this increase in knowledge was stimulated by the yearly monitoring in several European countries. A trial of comprehensively summarizing the knowledge of the Eurasian Crane was made by Hartwig Prange (2016).

A Western/Central Asian Site Network for the Siberian Crane and other Waterbirds was launched in 2007 under the Convention of Migratory Species with a goal of strengthening species and habitat protection at key sites along the Western/Central Asian Flyways used by Siberian, Eurasian, and Demoiselle Cranes as well as other waterbirds including endangered and vulnerable species. In 2010–2012, a project on hunting regulation and hunter education was conducted in Russia, Kazakhstan, Uzbekistan, Afghanistan, and Pakistan with support from the Mohammed bin Zayed Species Conservation Fund (Ilyashenko and Mirande 2014).

Transcaucasian and Tibetan Eurasian Cranes

Status of the subspecies was discussed at the 7th European Crane Conference (Stralsund, Germany, 2010) and the International Conference "Cranes of Palearctic: Biology, Conservation, Management (in memory of Academician P.S. Pallas)" organized by the Crane Working Group of Eurasia (Volgograd, Russia, 2011).

Field studies were conducted in Eastern Turkey in 2010 and in Central Tien-Shan, Kazakhstan, in 2010 and 2011 to determine the current status of cranes in these isolated populations of the Eurasian Crane and to assess subspecies status.

To assess possible subspecies status, Russian and German scientists conducted genetic research (Haase and Ilyashenko 2012).

CHANGES SINCE 1996

Most changes in crane populations have been caused by climate warming, agriculture changes, and wetland management.

The major increase of the European breeding populations has been caused by changes in agriculture and good water management, elevated protection, and possibly also by climate warming (Leito et al. 2006; Prange 2010a, 2010b; Nowald 2012; Salvi 2012a, 2012b; Mewes et al. 2013). Breeding grounds in Western Europe have expanded to the north, south, and west. In Sweden the breeding range expanded north- and southwards during the last two decades of the 20th century and now includes all counties (Lundgren and Lundin 2003). In Germany the breeding areas were doubled by expansion in the last three decades to the north (50 km), the south (60 km), and particularly to the west (240 km) (Mewes 2010). In the Czech Republic, the number of breeding pairs has increased to 40–50 pairs and is still increasing (Tichackova and Lumpe 2014); the breeding range continues spreading to the south and now there is also one breeding pair in Slovakia. In the UK at the end of the 1970s, a small breeding population began in the Norfolk Broads (Buxton 1987), slowly growing and spreading in the east of the UK over the next 30 years. With the additional 93 released birds, by 2016 there were around 160 birds in the UK with 38 breeding pairs, two of which were in Scotland (Damon Bridge, personal comm. 2017). Over the decades up to the year 2000, the rearing success there was very low (average of 0.24 fledged juveniles per breeding pair 1980–2000), but since then it has increased to 0.51 per pair (2001–2006, not including the reintroduced population) (Damon Bridge, personal comm. 2017). In eastern France, the first breeding pair was discovered in 1995, and the population has grown to about 15–20 pairs by 2015 (Salvi 2015).

Crane numbers have increased along the West-European Flyway (from 50,000–60,000 birds in the 1980s to about 350,000 in 2014) and the Baltic-Hungarian Flyway (from about 30,000–40,000 to 120,000–150,000) for the same period (Prange 1989, 2010a, 2010b, 2013, 2016; Fintha 2003/2004; Végvári et al. 2010; Alonso et al. 2014). This change is probably owing to manifold increase of breeding pairs over four decades in the northern and central parts of Europe as well as to the eastwards shift of the border between the two flyways with more intensive migration from the Baltic States, Finland, and northwestern parts of Russia. The cause of such alteration in migration routes seems to be the reduced food resources at the eastern resting areas due to the agricultural crises after the breakdown of the Soviet Union (Prange 2010a, 2010b; Ilyashenko and Markin 2013).

Due to increasing crane numbers in Western Europe, numerous small migration routes have appeared in the 2000s–2010s, most significantly the Austrian-Italian migratory path in the south and the Austrian-Bavarian migratory path in the north, both running along the Alps Mountains (Salvi 2013, 2014; Hansbauer et al. 2014; Salvi 2016; Prange 2016). Most of these cranes winter at the new site in the Camargue in the southeast of France (Salvi 2016).

An increase in the breeding population from 40,000 to 80,000 in European Russia (Ilyashenko and Markin 2013, Markin 2013) has probably occurred due to a decline of the breeding pair numbers in the south of the breeding range in Russia, Ukraine, and Kazakhstan. That decline was related to long-term drought, especially in the forest-steppe zone and likely was intensified by economic development (Ravkin et al. 2002, Kovshar 2010).

The decline of the breeding populations of Transcaucasian and Tibetan Eurasian Cranes is a result of landscape transformation and drying out of wet breeding habitats in mountainous regions as well as by increasing human disturbances, sometimes with shooting, and by lack of protection measures (Ilyashenko et al. 2008, Akarsu et al. 2013).

The wintering range has expanded to the north. In Europe, new wintering grounds of the Western Eurasian crane appeared across France and northwest Germany as well as in the south of Hungary due to increasing food availability, landscapes modifications, and global warming (Salvi at al. 1995; Alonso and Alonso 1996; Le Roy 2002; Alonso et al. 2003, 2008; Salvi 2003a, 2003b, 2012a, 2012b, 2013, 2014, 2015; Prange 2010a, 2010b; Végvári et al. 2010). As a result, between 1997 and 2007 the median migration distances of cranes breeding in northeast Germany decreased from 2,041 to 677 km on average (Donner and Nowald 2008, Nowald et al. 2013). New wintering grounds of the Eastern Eurasian Crane came to existence in Central Asia (in the Amudaria River Valley at the border among Uzbekistan, Afghanistan, Tajikistan, and Turkmenistan, as well as in the Tejen River Valley in south Turkmenistan) as a result of mild winters during the last two decades as well as changes in agriculture after the Soviet Union collapse. The most part of cotton (*Gossypium*) fields were replaced by cereal crops (wheat [*Triticum aestivum*] and rice [*Oryza sativa*]), creating favourable food conditions for cranes. A large portion of cranes (20,000–30,000) that formerly migrated to India and Iran started to spend winters in Central Asia (Rustamov et al. 2011, Sorokin et al. 2011, Ilyashenko and Markin 2013).

A growing wintering population from 5,000 to more than 42,000 birds has been reported from Hula Valley in northern Israel (Prange 1989, Shanni et al. 2012; Rubin Inbar, personal comm. 2017). Cranes are mostly concentrated here on a very small piece of land (200–400 ha), thus creating a very dense wintering population that is being fed throughout the winter in order to prevent damage to the surrounding 8,000 ha of agricultural fields.

Changes have occurred in the spring and fall migration in West Europe and European Russia associated with global warming, but the median migration date is nearly without change. The latest crane flocks depart in autumn about four weeks later and they arrive nearly 2–3 weeks earlier in Sweden and Finland and 4 weeks earlier in Germany (Lundgren et al. 2003; Leito et al. 2005, 2006, 2015; Mewes 2010; Prange 2010a, 2010b, 2015; Hermansson and Karlsson 2013; Markin 2013). In European Russia, cranes start autumn migration 2–3 weeks later than in the 1990s (Volkov et al. 2013; Olga Grinchenko, personal comm. 2016; Yuri Markin, personal comm. 2016). Changes in timetable for stopovers and wintering, as well as redistribution of staging areas and migration stopovers, were also connected with alteration in agriculture systems (Bautista et al. 1992, Alonso et al. 1994).

Staying several weeks longer than in the 1970s in the resting and wintering areas along the West European and Baltic-Hungarian Flyways (Central European Flyway) is closely correlated with the improved foraging and roosting possibilities, including intensive maize and grain cultivation, building of new reservoirs in Spain, France, and Germany, and wetland reconstructions of peat bog areas in northwest Germany and the Netherlands (Prange 2000–2009, 2012, 2013; Lundin 2005; Leito et al. 2006, 2015; Salvi 2013). For example, at the Rügen-Bock area in Germany in the 1970s with a maximum of 15,000 cranes, only 6% of the cranes visited fields that had cultivated maize, but in the 2000s with up to 60,000 resting cranes, 46% of the visited fields had maize stubble in autumn (Prange 2010b, 2016). The conversion of the traditional land-use system in the Iberian Peninsula, with open Holm oak (*Querus ilex*) woodlands changing to intensive cereal crop fields, brought more energy-rich food for cranes, but destroyed in part a traditional rural culture (Sànchez Gusmán et al. 1993, Almeida 1995).

Redistribution of pre-migratory staging areas, their disappearance, and changes in their numbers as well as in crane numbers at staging areas in the Baltic countries, and Russia, came as a result of the agriculture crisis happening after the collapse of the Soviet Union in 1991 (Leito et al. 2008, Ilyashenko and Markin 2013). In European Russia, crane assemblages moved from the north to the west and the south (Ilyashenko and Markin 2012). Since 1999–2000 the crisis has been overcome and both agriculture and crane staging have bounced back, especially in the Baltic countries and in the South and the Volga regions of Russia (Rostov, Stavropol, Nizhny Novgorod, Kirov Regions, and Tatarstan; Ilyashenko and Markin 2013).

Damage by cranes to agricultural fields has increased. In European countries, crop damage has grown due to the increase of crane numbers at staging areas and migration stopovers as well as to longer staging of cranes (Leito et al. 2008; Nowald et al. 2010a; Prange 2010a, 2010b; Fanke et al. 2013). In Russia, Kazakhstan, and Central Asian countries, crane damage coincided with the decline in crop growing during the economic crisis, and redistribution of crane flocks followed the changes in the agricultural system (Bragin 2011, Ilyashenko and Markin 2013).

PRIORITY RESEARCH AND CONSERVATION ACTIONS

Research and Monitoring

- Continue to conduct research on further increase/decrease of populations, pair formation, breeding success, life history, tolerance of disturbances, diseases and reasons for mortality, positive/negative influences of climate change on the habitat, and population status across the whole range of the Eurasian Crane in relation to the environment conditions;

- Continue to conduct research along flyways at resting and wintering sites on migration behavior of different subpopulations using crane marking and other tools;

- Conduct genetic, morphological, and photographic identification research for differentiation of the Eurasian Crane subspecies and populations;

- Organize crane censuses at key sites in the European, Baltic, and Central Asian countries, in Russia, Ukraine, and Belarus as well as in China, Korea, and Japan (at breeding, migration, and wintering sites); involve hunters and other task groups in crane censuses, and use hunters as respondents for questionnaires on crane distribution in Turkey, the Caucasian countries, in Russia and Asia; and

- Continue to coordinate crane banding by the European Crane Banding Groups in Europe; involve other countries and crane working groups in crane banding; organize international trainings on crane capture and banding, and use central databases to share information on all banded and radio-tagged cranes among members of crane working groups, NGOs, and professional ornithologists. Furthermore, one day each in autumn and winter should be established for crane monitoring in all countries along the West-European flyway.

Species Protection

- Enforce existing hunting regulations or adopt new ones to prevent uncontrolled hunting, poaching and disturbances at crane breeding grounds and migration stopovers during the hunting season;

- Monitor incidents of crane poisoning, develop necessary regulations, and strengthen law enforcement in accordance with local situations; and

- Prevent crane collisions with power lines and wind power stations at crane resting areas. Power lines at key sites should be marked or otherwise modified to reduce the incidence of accidental collisions. Construction of wind power stations should be regulated in accordance with the national environmental legislation.

Habitat Protection and Management

- Cooperate between national governments and hunting organizations along the East Adriatic coast on providing and enforcing safe crane migration stopovers before and after the Adriatic Sea crossing, reducing illegal hunting, and strengthening protection at nature reserves and national parks to ensure that these areas are recognized and accepted by hunters;

- Cooperate between the International Crane and Agriculture Working Group, farmers, and other stakeholders to improve management at crane gathering sites to avoid damage by cranes and their poaching, poisoning, and chasing;

- Work with governmental and other public institutions involved in development and infrastructural projects to carry out detailed environmental impact assessments and modified cost-benefit analyses for projects that may affect cranes and/or their habitats;

- Undertake administrative measures and maintain a suitable water balance to protect breeding and roosting habitats in view of the substantial threats by wetland destruction; manage wetland recreation projects to increase the potential for crane breeding, resting, and wintering;

- Use international flyway program experience for establishing protection status for key sites; and

- Create internationally protected areas or ecological corridors along the West Siberian Flyway, that will include crane migration stopovers and wintering grounds in the Amudaria River Valley through cooperation among Kazakhstan, Afghanistan, Uzbekistan, Turkmenistan, and Tajikistan (due to Eurasian Cranes using the same migration route as Siberian Cranes); explore potential creation of a new wintering ground for the Siberian Crane in the Amudaria Valley.

Education and Public Awareness

- Increase education and public awareness for hunters, volunteers, children, and other members of the public in countries and regions with crane migration, resting, and wintering;
- Reduce crane disturbance by tourism, forestry, agriculture, and hunting activities through establishing buffer zones around roosting sites in Europe;
- Improve the relationship between crane protection and farming by addressing the reasons for crop damage and implementing prevention measures. This objective can be reached through the following activities:
  - o Successful cooperation with land owners (farmers, foresters, hunters) and provision of incentives for those whose management practices benefit the cranes;
  - o Adaptation of crane-agriculture management programs to local conditions;
  - o Compensation for heavy crane damage or organization of diversionary feeding along the migration routes in special situations; and
  - o Support traditional agricultural systems that benefit cranes (e.g., choice of crops, timing of plowing), especially in the southern wintering areas; and
- Continue to improve international cooperation through implementation of joint conservation programs and management strategies, organizing international workshops and trainings, publishing articles, and promoting information exchange.

Transcaucasian and Tibetan Eurasian Cranes

Research and Monitoring

- Advocate international efforts for the research and protection of the endangered Transcaucasia and Tibetan Eurasian Cranes by their range states;
- Demonstrate that these two newly described subspecies are truly monophyletic and qualify as evolutionarily significant units, by collecting and analysing more samples (Haase and Ilyashenko 2012);
- Conduct geographic information system analyses to determine potential breeding sites for these Eurasian Cranes subspecies in their Range States;
- Develop and conduct questionnaires for hunting societies about sightings of the Transcaucasia and Tibetan Eurasian Cranes;
- Continue to capture cranes and mark with transmitters and colour bands to investigate migration routes and wintering grounds;
- Cooperate with Israeli ornithologists to determine possible wintering grounds of the Transcaucasia Eurasian Cranes in Israel. Identify wintering individuals from Turkey, Armenia, and Georgia; and

- Cooperate with Chinese ornithologists to determine possible wintering grounds of Tibetan Eurasian Cranes in Tibet.

Species Protection

- Enforce measures to prevent illegal hunting in Armenia, Turkey, Kazakhstan, Kyrgyzstan, and other Middle Asia countries to ensure that poachers are identified and prosecuted; and

- Create captive breeding groups for both threatened populations of Eurasian Cranes on the basis of international collaboration among Armenia, Turkey, Georgia, and Iran (Transcaucasian Eurasian Crane), as well as among the Himalaya countries (Tibetan Eurasian Crane) on the basis of international collaboration among China, Kazakhstan, and Kyrgyzstan, and in cooperation with Walsrode Ornithological Park (Weltvogelpark Walsrode, Germany), and other interested zoos and breeding centers as well as related international agencies, to start a "genetic bank."

Habitat Protection and Management

- Provide and enforce safe breeding sites for the threatened Transcaucasian and Tibetan Eurasian Cranes; and

- Establish a transboundary protected area in Turkey, Armenia, and Georgia.

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SPECIES REVIEW:

SANDHILL CRANE (*Grus canadensis*)

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(with inputs from George W. Archibald, Inga Bysykatova, and Scott Hereford)

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Sandhill Cranes unison call at nest (Photographer: Ted Thousand, International Crane Foundation)

Red List Category: Least Concern
Population Size: 827,000
Population Trend: Increasing
Distribution: North America and eastern Siberia

Mirande CM, Harris JT, editors. 2019. Crane Conservation Strategy. Baraboo, Wisconsin, USA: International Crane Foundation.

DISTRIBUTION AND STATUS OF KEY SITES

The Sandhill Crane is one of the most abundant of the 15 crane species (Harris and Mirande 2013), with populations distributed widely across North America, including Mexico, extending to Russia's Far East, and as far south as Cuba. Small numbers of Sandhill Cranes even occur regularly in China during winter (Harris and Mirande 2013). Six subspecies have been recognized based on plumage and morphological characteristics, including three migratory subspecies, Lesser Sandhill Crane (*G. c. canadensis*), Canadian Sandhill Crane (*G. c. rowani*), Greater Sandhill Crane (*G. c. tabida*), and three non-migratory subspecies, Florida Sandhill Crane (*G. c. pratensis*), Mississippi Sandhill Crane (*G. c. pulla*), and Cuban Sandhill Crane (*G. c. nesiotes*; Walkinshaw 1973, Lewis 1977, Tacha et al. 1985, Meine and Archibald 1996). Mitochondrial DNA analysis of these subspecies indicates two evolutionary lineages: lineage I, which is comprised primarily of G. c. canadensis; and lineage II, which contains the remaining five subspecies (Rhymer et al. 2001). Studies concluded that only two of the three migratory subspecies were phylogenetically distinct and that *G. c. rowan*i and *G. c. tabida* should be consolidated (Rhymer et al. 2001, Glenn et al. 2002, Petersen et al. 2003). Further, variation in the migratory subspecies is generally clinal from north to south, and *G. c. rowani* is intermediate in morphology, geography, and genetics, suggesting consideration as a transitional form (Jones et al. 2005).

Flyway Councils have formally designated six populations of migratory Sandhill Cranes for management purposes, including Pacific Coast (PCP), Central Valley (CVP), Lower Colorado River Valley (LCRVP), Rocky Mountain (RMP), Mid-Continent (MCP), and Eastern (EP) (Dubovsky 2018). In addition, Krapu et al. (2011) delineated four breeding affiliations for the MCP—Western Alaska-Siberia, Northern Canada-Nunavut, West-central Canada-Alaska, and East-central Canada-Minnesota—to improve management of crane groups within the MCP. Meine and Archibald (1996) also recognized a Prairie Population of Greater Sandhill Cranes that overlapped with the latter breeding affiliation, breeding in in western Minnesota, southwestern Ontario, and southern Manitoba. Additionally, non-migratory Florida, Mississippi, and Cuban subspecies are considered separate populations (U.S. Fish and Wildlife Service [USFWS] 1991, Meine and Archibald 1996).

While some sites that are important to the MCP are protected, numerous other key sites have little permanent protection. For example, the major staging area that has developed in South Dakota for Greater Sandhill Cranes in recent decades remains largely unprotected, as does much of the spring staging habitat used by Lesser Sandhill Cranes in Saskatchewan. For migratory cranes using staging areas along the Platte River in central Nebraska, it is highly important to secure adequate instream flows to help maintain sufficient roosting habitat, along with securing additional protection for other key staging and wintering areas (Graf et al. 2005). For the EP, protected staging and wintering areas include Jasper-Pulaski Fish and Wildlife Area (Indiana), Hiwassee State Wildlife Refuge (Tennessee), and Wheeler National Wildlife Refuge (NWR) (Alabama), but many other areas important to the population remain unprotected. For the RMP, LCRVP, CVP, and PCP, a number of national wildlife refuges and state wildlife areas provide key staging and wintering sites; however, the vast majority of these populations of Greater Sandhill Cranes rely on unprotected private lands in western states for breeding. Needs for the non-migratory subspecies include acquisition and protection of additional habitats of the Florida Sandhill Crane to ensure that the range of the species remains contiguous throughout the Florida peninsula and securing existing and potential habitats for the Mississippi and Cuban Sandhill Cranes.

ECOLOGY

Sandhill Cranes are primarily birds of open freshwater wetlands, shallow marshes, wet meadows, and adjacent uplands; however, populations breeding along the Pacific Coast use tidal brackish wetlands for foraging, and Cuban Sandhill Cranes nest in uplands (Walkinshaw 1973). Peak Greater Sandhill Crane nesting densities occur where wetlands and agricultural habitats intermix (Barzen et al. 2016) because Sandhill Cranes often place their nests in wetlands but feed their young in both wetland and upland habitats located within each territory (Miller and Barzen 2016). Sandhill Cranes utilize a broad range of habitat types, from bogs, sedge (*Carex*) meadows, and fens to open grasslands, agricultural fields, savannas, and intertidal zones. They are omnivorous, feeding on a wide variety of plant materials (including waste grains), invertebrates, and small vertebrates, both on land and in shallow wetlands and estuaries. Critical components of habitats at staging and wintering areas include large, undisturbed, shallow wetlands or flooded agricultural fields for roost sites and foraging. Large concentrations of cranes also use associated agricultural landscapes dominated by grain crops (Ivey et al. 2014a). For reviews of the species' breeding, migration, and winter habitats, food habits, behavior, breeding biology, and demographics, see Walkinshaw (1949, 1973); Johnsgard (1983); Tacha et al. (1992, 1994); Krapu et al. (2014); and Gerber et al. (2014).

The endangered Mississippi and Cuban Sandhill Cranes are confined to drier or seasonally flooded habitats. Within their limited territory, Mississippi Sandhill Cranes use wet pine savannas and coastal prairies dominated by wiregrass (*Aristida*) and a rich herbaceous community with scattered longleaf pine (*Pinus palustris*), slash pine (*P. elliottii*), pond cypress (*Taxodium*), riverine swamp strands, estuarine marsh and occasionally open pine flatwoods (Valentine and Noble 1970, USFWS 1991, Gee and Hereford 1995). Much of this habitat has been altered since the 1940s by afforestation, fire suppression, and urban and agricultural development (Smith and Valentine 1987). The Cuban Sandhill Crane occupies relatively dry upland grasslands, hammocks, and pine and palmetto (*Sabal palmetto*) savannas, often associated with wetlands (Walkinshaw 1949; Faanes 1990; Xiomara Galvez, personal comm. 2017). Some pairs of the non-migratory cranes remain on their breeding territories throughout the year (particularly Okefenokee-nesting Florida Sandhill Cranes and Mississippi Sandhill Cranes). Others gather in flocks and forage on agricultural gleanings, in pastures, and (in the case of the Mississippi Sandhill Crane) supplemental food plots within wildlife refuges (Scott Hereford, personal comm. 2017).

NUMBERS AND TRENDS

An estimate of total number of individuals for all populations is 827,000 birds. Estimates and status by population and subspecies are:

Eastern (EP): 87,000 Greater Sandhill Cranes (three-year average; Dubovsky 2018). A coordinated fall index survey indicated a long-term growth rate of 4.4% (Dubovsky 2018). Greater Sandhill Cranes are increasing more rapidly in the eastern portion of their range than in other regions (Urbanek 1994, Lacy et al. 2015).

Mid-continent (MCP): Total of 660,000 cranes (three-year average; Dubovsky 2018), composed of about 65% Lesser Sandhill Cranes (Krapu et al. 2011), 30% putative Canadian Sandhill Cranes, and 5% Greater Sandhill Cranes, which are found largely in the East-central Canada-Minnesota breeding affiliation (Krapu and Brandt 2010). Greater Sandhill Cranes have failed to re-occupy most of their former extensive breeding range in the northern Great Plains (Krapu and Brandt 2010). The numbers of Sandhill Cranes in the West-central Canada-Alaska and East-central Canada-Minnesota breeding affiliation (composed of Greaters and putative Canadians) may be declining due to a disproportionate harvest (Krapu et al. 2011). Overall, the MCP is stable to increasing, but counts have high interannual variability (Dubovsky 2018).

Pacific Coast (PCP): Total of 41,500, including 36,500 Lesser Sandhill cranes, believed to be stable or increasing (Ivey et al. 2014c), and 5,000 putative Canadian Sandhill Cranes, considered stable (Ivey 2014c).

Central Valley (CV): Total of 8,500 Greater Sandhill Cranes, (Ivey et al. 2014c); this population is increasing at a more moderate pace in the western portion of the range than in the EP (Collins et al. 2015).

Lower Colorado River Valley (LCRV): 2,500 Greater Sandhill Cranes (three-year average; Dubovsky 2018).

Rocky Mountain (RMP): 22,000 Greater Sandhill Cranes, considered stable (three-year average; Dubovsky 2018).

Florida: Non-migratory population of 5,000 Florida Sandhill Cranes, including an Okefenokee subpopulation of ~400. Florida Sandhill Cranes have been thought to be declining due to significant habitat destruction (Bennett 1988, Nesbitt and Hatchitt 2008). However, recent data from North American Breeding Bird Surveys, conducted in May each year, suggest that the subspecies' population in Florida is stable or perhaps increasing as cranes adapt to more human-defined habitats (W. A. Cox, T. Dellinger, R. Kiltie, B. Bankovich and B. Tornwall, unpublished data).

Mississippi: A non-migratory population of 133 Mississippi Sandhill Cranes, as of January 2018 (Hereford 2018). Numbers in the wild are increasing through augmentation with captive-bred birds; reproduction in the wild is below replacement level but increasing (Scott Hereford, personal comm. 2017).

Cuba: Non-migratory population of 526 of Cuban Sandhill Cranes. The population is decreasing in some areas (Galvez-Aguilera and Chavez-Ramirez 2010).

THREATS

- Loss and degradation of wetlands, as well as upland foraging habitats, are the most important threats to populations. For the migratory subspecies, this threat is of greatest concern in staging and wintering areas, where changes in land use, hydrology, and vegetation have reduced available habitat and concentrated the flocks during the non-breeding season (Krapu et al. 1982, Tacha et al. 1994, Drewein et al. 1996). Changes in agricultural landscapes, which reduce availability of grain crops within important wintering and staging sites, could limit populations in the future (Krapu et al. 2004, 2005, Pearse et al. 2010, Barcelo 2012, Ivey et al. 2014c). The drier meadow, savanna, and other upland habitats to which the non-migratory subspecies are partially adapted have also been widely altered by agricultural conversion, development, and fire suppression;

- Construction of upstream dams, other flood-control structures, and water withdrawals have altered wet meadow and roost site suitability at spring staging areas along the Platte River in Nebraska (U.S. Fish and Wildlife Service 1981). This change is of special concern because of the Platte River's importance to the MCP and other migratory birds (see USFWS 1981, Johnsgard 1984, Currier et al. 1985, Krapu et al. 1985, VanDerwalker 1987, Faanes 1992, Graf et al. 2005). With about 80% of the MCP using the Platte River during spring, the long-term degradation and loss of high-quality habitat at this site constitutes a major threat to the species. Intensive channel management for cranes, after taking into account crane roost-site requirements (U.S. Fish and Wildlife Service 1981, Krapu et al. 1984, Pearse et al. 2017), has helped to stabilize distribution and use of nocturnal roosts in the Central Platte River Valley in recent decades (Krapu et al. 2014). These management activities likely will need to continue for the foreseeable future because of growing demands on available water resources;

- Overhunting poses a potential risk to some populations. The migratory subspecies are hunted for recreation in some parts of Canada, United States, and Mexico. They are also hunted for subsistence in arctic Alaska, Canada, and Russia. MCP Greater Sandhill Cranes are the first to stage during fall in the northern plains and are harvested disproportionately to their numbers based on their patterns of exposure to hunting obtained through monitoring a random sample of satellite-monitored cranes (Krapu and Brandt 2010, Krapu et al. 2011). Since the mid-1980s, the estimated overall annual crane harvest (including crippling losses) in the MCP has ranged between 25,000 and 31,700, or about 4–5% of the fall population (Sharp and Vogel 1992, Tacha et al. 1994, Central Flyway Webless Migratory Game Bird Technical Committee 2006). Failure of Greater Sandhill Cranes to reoccupy most of their former breeding range in the northern Great Plains occurred concurrently with a disproportionate harvest resulting from their arrival on fall staging areas several weeks before subarctic- and arctic-nesting cranes arrive, as well as the later departure of Greater Sandhill Cranes (Krapu and Brandt 2010, Krapu et al. 2011). In North Dakota, Greater Sandhill Cranes accounted for 60, 28, 35, and 44% of birds shot in Benson, Pierce, Sheridan, and Stutsman counties respectively (Kendall et al. 1997), despite their relatively small numbers in the MCP (Krapu et al. 2011). The Sandhill Crane has the lowest recruitment rate of any bird hunted in North America (Drewien et al. 1995, Wheeler et al. 2019), which increases the need for detailed information on recruitment and survival rates to effectively manage hunted populations. The core breeding population of Greater Sandhill Cranes in Wisconsin consistently has as few as 0.20 chicks/territory that survive to fall migration each year which, if widespread, would be comparable to approximately 5% of the winter population composed of chicks produced that year (Jeb Barzen, unpublished data from 1993–2017); and

- Cranes are exposed to a variety of threats while on wintering grounds and during spring migration. In the northern State of Chihuahua, Mexico, the arid climate has resulted in extensive development of irrigation for agriculture, resulting in water being diverted from wetlands used by Sandhill Cranes (Drewien et al. 1996). Elsewhere, mycotoxins ingested through the consumption of waste peanuts (*Arachis hypogea*) have caused large-scale mortality events (up to 5,000 individuals), while lead poisoning and collisions with fences and power lines also cause significant injury and death (Brown et al. 1987, Windingstad 1988, Allen and Ramirez 1990, Ward and Anderson 1992, Franson and Hereford 1994, Wright et al. 2010). The dense concentrations of migratory flocks along the Platte River are potentially susceptible to outbreaks of avian cholera and other diseases particularly under low flow conditions (Krapu et al. 2014).

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- Several major gaps in information on the MCP have been filled, in part using satellite telemetry to monitor tagged cranes throughout the annual cycle (Krapu et al. 2011, 2014). Four breeding affiliations have been delineated for management purposes (Krapu et al. 2011);

- Corn (maize, *Zea mays*) has been the food of choice for Sandhill Cranes on wintering grounds where available, including the Chihuahuan Desert in northern Mexico (Barcelo 2012) and the Middle Rio Grande Valley in New Mexico (Boggie et al. 2018). Along the Platte River, a sharp decline in corn residues due to more efficient corn harvesting techniques, growing competition for corn (particularly from snow geese [*Anser caerulescens*]), and an expansion in production of soybeans (*Glycine max*), a crop poorly suited for meeting crane nutritional needs (Krapu et al. 2004, Pearse et al. 2010), has led to reduced fat storage by Greater Sandhill Cranes. This larger-bodied subspecies has higher maintenance energy requirements than do the smaller Lesser Sandhill Cranes, leaving less corn being synthesized into fat (Krapu et al. 2014). A reduction in corn residues in the absence of a high-energy replacement has prompted concern that reduced fat storage in the future could adversely affect reproduction and reduce recruitment of young into the MCP. Spring staging areas in Saskatchewan serve as important sites for fat storage in Lesser Sandhill Crane (Krapu et al. 2014), as likely do spring staging sites in South Dakota for Greater Sandhill Cranes. Fat storage may be less critical for spring migrants of the EP as the migration itself can be completed in as little as one day (Thompson and Lacy 2016). Also, during inclement weather, breeding birds can retreat south instead of relying solely on stored fat for energy requirements when food is unavailable (Thompson and Lacy 2016). EP cranes, however, still stage for significant time periods in both fall and spring, presumably to acquire fat reserves (Thompson and Lacy 2016, Fronczak et al. 2017).

- Sandhill Crane harvest has increased in recent decades. The MCP appears to have remained stable at about 660,000 cranes during the past three decades, but changes identified in Krapu et al. (2011) have been occurring within segments of the population, and the number of Greater Sandhill Cranes in the East-central Canada–Minnesota and West-central Canada–Alaska breeding affiliations may be declining due to an apparent disproportionate harvest on fall staging areas (Krapu and Brandt 2010, Krapu et al. 2011). The current breeding distribution of the East-central Canada-Minnesota breeding affiliation of Greater Sandhill Cranes is centered along the northern periphery of the its historic range. Their inability to re-occupy much of the original breeding range in the northern Great Plains likely is linked, in part, to high mortality from early hunting seasons on key fall staging areas in the northern plains. Fall harvest of MCP Greater Sandhill Cranes increased starting in 2010 when Minnesota initiated a relatively liberal fall hunting season on a major breeding ground not previously open to crane hunting (Krapu and Brandt 2010). The most compelling evidence that hunting is keeping the number of MCP Greater Sandhill Cranes well below carrying capacity comes from failure of this subspecies to re-occupy most of its former vast breeding range in the northern Great Plains despite habitat remaining plentiful;

- A warming climate has led to significant numbers of Sandhill Cranes overwintering in the Central Platte River Valley in some years and migrants arriving earlier in late winter or early spring (Harner et al. 2015). Changes in climate likely also have contributed to cranes leaving the Central Platte River Valley earlier in spring and the development in recent decades of a major Sandhill Crane spring staging area in eastern South Dakota (Krapu et al. 2011, 2014).

- The breeding and wintering distributions of Sandhill Cranes in the Pacific Flyway became better understood during the past two decades. A study of migration of PCP cranes breeding in southwest Alaska described their migration route and important staging and wintering areas (Petrula and Rothe 2005). An important advance was the discovery that a separate subpopulation of the Canadian Sandhill Crane breeds on islands in southeastern Alaska and along the coast of British Columbia, stages along the lower Columbia River, and winters primarily in the Sacramento Valley of California (Ivey et al. 2005);

- The EP has been the fastest growing population of Sandhill Cranes for the past 40 years, and population growth has been accompanied by major range expansion on breeding and wintering grounds (Lacy et al. 2015). However, an estimated 66% of the population still breeds in Wisconsin (Lacy et al. 2015), and at least some portions of the EP are no longer growing (Wheeler et al. 2019). The breeding range has expanded to the eastern United States and Canada along with Minnesota and Iowa (Lacy et al. 2015, Wolfson et al. 2017). Wintering cranes in the EP have expanded their distribution dramatically north, concurrent with population growth, and simultaneously with changing habitat conditions and warming trends (Lacy et al. 2015). Population studies have estimated 95% annual survival for the population as a whole (Fronczak et al. 2015), 94% for territorial individuals (Wheeler et al. 2019), and 92% survival from first migration to independence (Hayes and Barzen 2016a). Satellite-telemetry studies also provided new insight into migratory habits and wintering distribution of the EP (Fronczak et al. 2017, Wolfson et al. 2017). In addition, individuals from the same breeding area can be found widely across the EP winter range (Thompson and Lacy 2016, Hayes 2015). Finally, damage to planted corn caused by Sandhill Cranes has been markedly reduced in the Midwest through deployment of anthraquinone (Avipel®), a seed treatment purchased and applied by the agricultural community and without necessitating expenditure of funds designated for conservation (Lacy et al. 2013, Barzen and Ballinger 2018). Crop damage was cited as one reason for hunting proposals being considered (Barzen 1997, Skasa and Barzen 2010);

- Destruction and degradation of habitats comprise the most important current threat to the Greater Sandhill Crane, especially on wintering grounds in California (Ivey et al. 2014c), New Mexico (Boggie et al. 2018), Florida (Nesbitt and Hatchitt 2008), and southern Great Plains (Iverson et al. 1985); breeding grounds in the American upper Midwest (Barzen et al. 2016); and migration stopover areas on the Platte River (Krapu et al. 1982) or other sites in the plains states (Drewien et al. 1995). The habitats of the RMP, CVP, PCP, and LCRVP are increasingly affected by development, changing agricultural practices and conversion to incompatible crop types, wetland drainage, water diversions, oil and gas development, and other land-use changes. Habitat in Florida is being fragmented by development (Nesbitt and Hatchitt 2008). Habitat needs have been described for Greater Sandhill Cranes on breeding areas in the EP (Su 2003, Barzen et al. 2016, Hayes and Barzen 2016b, McKinney et al. 2016, Miller and Barzen 2016) and on staging as well as winter areas (Thompson and Lacy 2016);

- The Mississippi Sandhill Crane continues to face a broad range of interrelated threats leading to low reproduction and survival rates, and this population continues to rely on releases of captive-bred birds to bolster its numbers (Scott Hereford, personal comm. 2017). Smoke management concerns affect ability of land managers to use frequent, low-intensity prescribed fire to maintain open habitat; and

- The Cuban Sandhill Crane is subject to similar threats facing other non-migratory cranes: changes in the hydrology and fire regime of its savanna habitat and loss of habitat to deforestation, development, land reclamation, and agricultural expansion (Galvez-Aguilera and Chavez-Ramirez 2010). Results of a comprehensive research project that began in 1996 have been used to consider development of additional protected areas. For example, establishment in 2004 of Gran Humedal Norte de Ciego de Avila Reserve was justified in large part to support one of the largest Sandhill Crane populations in the country. Most in-depth studies (e.g., habitat use, reproduction, movement rates) were conducted on the Isle of Youth; however, research activities continue in other areas such as Ciego de Avila Province. Monitoring activities of breeding and productivity continue on the Isle of Youth and Ciego de Avila Province.

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

International Cooperation, Legal and Cultural Protection

The Sandhill Crane experienced marked declines in the late 19th and early 20th centuries from uncontrolled hunting (Walkinshaw 1949), but populations rebounded by the mid-20th century in response to extensive conservation efforts and changes in American agriculture that allowed the birds to congregate in large numbers on remaining suitable habitats. See Walkinshaw (1973); Johnsgard (1983, 1991); Tacha et al. (1992; 1994); Krapu and Brandt (2010); and Krapu et al. (2011) for overviews of these efforts. The five countries supporting Sandhill Crane populations (Canada, Cuba, Mexico, Russian Federation, and United States) are signatories of the Ramsar Convention. In Canada and the United States, the species falls under the protection of the Migratory Bird Treaty Act of 1918, which declared Sandhill Cranes a game species with a closed season. The Treaty allows for regulation of hunting and other forms of direct exploitation. Hunting was prohibited until increased size of the MCP resulted in major crop depredation, prompting initiation of harvest seasons in Canada starting in 1959 and in the United States in 1961 (Subcommittee on Rocky Mountain Greater Sandhill Cranes 2007). Currently, Sandhill Cranes are legally hunted in Alaska, Arizona, Colorado, Idaho, Kansas, Kentucky (added in 2011), Manitoba, Minnesota (added in 2010), Montana, New Mexico, North Dakota, Oklahoma, Saskatchewan, South Dakota, Tennessee (added in 2013), Texas, Utah, and Wyoming. In 1936, the United States and Mexico signed a similar Treaty for the Protection of Migratory Birds and Game Mammals; however, while considered a species at risk under Mexican law (NOM-059-ECOL-2010), cranes have been legally hunted there since at least 1940 in eight northern and central states. In Russia, the Sandhill Crane is a protected species but subsistence harvest is allowed. Crane biologists from the Russian Academy of Science, Institute for Biological Problems of the Permafrost Zone at Yakutsk in the Sakha Republic (Yakutia), and researchers from the U.S. Geological Survey Northern Prairie Wildlife Research Center have been conducting a joint study of Sandhill Cranes breeding in Russia since 2009.

Both the Cuban and Mississippi Sandhill Cranes are protected under the U.S. Endangered Species Act. The former is also listed as Endangered in Cuba, and the latter is listed as Endangered and is also protected under Mississippi's Nongame and Endangered Species Act of 1974 (USFWS 1991). Since 1994, crane conservationists in Cuba and the United States have worked more closely on Cuban Sandhill Crane conservation efforts (Galvez-Aguilera and Perera 1995). The Florida Sandhill Crane is listed as Threatened on the Florida Endangered and Threatened Species List (Florida Fish and Wildlife Conservation Commission 2013). Greater Sandhill Cranes are listed as Threatened by California and Endangered by Ohio (http://wildlife.ohiodnr.gov/species-and-habitats/species-guide-index/birds/sandhill-crane; accessed May 4, 2017). Sandhill Cranes are also listed as Endangered in Washington (Littlefield and Ivey 2002).

Protected Areas

Sandhill Cranes use many national, provincial, and state protected areas as well as private conservation lands. A few areas, such as the Platte River corridor, are especially significant for cranes and have been the focus of protection efforts primarily for that reason (VanDerwalker 1987, Graf et al. 2005). In most cases, however, cranes are only one of many species that benefit from the protected status of these areas. The MCP Canadian breeding grounds lie mostly on federal and provincial lands in remote regions where development usually is less prevalent than on privately-owned lands, and many birds nest in regions where terrain limits the likelihood of major development (e.g., James Bay Lowlands). In contrast, most nesting areas for the EP of Greater Sandhill Cranes are found on privately owned lands (Lacy et al. 2015, Barzen et al. 2016).

Protected areas have played a key role in the protection and recovery of other Greater Sandhill Crane populations in the United States, especially in the Rocky Mountain and Pacific states.

Protected areas have been especially important in efforts to protect the non-migratory subspecies. Large areas of Florida habitat are protected within a matrix of state parks, preserves, state wildlife areas and private conservation lands. These areas are important to both Florida Sandhill Cranes and wintering EP cranes. However, due to habitat loss, alteration, and lack of management, the Florida Sandhill Crane population was reported to have declined an estimated 36% from 1974 to 2003 due to habitat loss (Nesbitt and Hatchitt 2008). More recent analysis, based on Breeding Bird Survey data, suggests that actual crane numbers may have stabilized or possibly increased as individuals have adapted to more urbanized landscapes (W.A. Cox, T. Dellinger, R. Kiltie, B. Bankovich and B. Tornwall, unpublished data). To what extent this adjustment by cranes can continue, however, is unclear. Much of remaining crane habitat in Florida is under management that does not appear to favor cranes. Okefenokee NWR (Georgia) protects critical Florida Sandhill Crane habitat. The Mississippi Sandhill Crane NWR was established to protect habitat for the Mississippi Sandhill Crane. Purposes of Grand Bay NWR (Mississippi, Alabama) include providing habitat and a reintroduction site for Mississippi Sandhill Cranes. Eight of the 10 areas supporting Cuban Sandhill Cranes are protected, either as formal reserves and wildlife conservation areas or forestry management areas (Galvez-Aguilera and Chavez-Ramirez 2010). Protected areas include Birama, Cayo Romano, Norte de Moron (Gran Humedal Norte de Ciego de Avila), Cienega de Guayaberas, Cienega de Zapata, Majaguillar, Jucaro, and Los Indios Sabana Grande.

Habitat Protection and Management

Sandhill Cranes have benefitted from many national, provincial, and state policies as well as programs to conserve wetlands. Cranes have also benefited from work by private conservation organizations, especially in parts of the United States where populations were reduced or extirpated and in the Platte River Valley. This pertains to habitat both within protected areas and on private lands. Restoration of hydrological regimes through re-flooding and management of water levels has played a critical role in re-establishing the ecological functions of previously drained wetlands, especially in the upper Midwest (e.g. Necedah National Wildlife Refuge [NWR; Wisconsin], Seney NWR [Michigan], and Sherburne NWR [Minnesota]). In some areas, habitat management programs have been undertaken specifically for cranes. The Platte River Whooping Crane Habitat Maintenance Trust (now the Crane Trust) was established by a federal court ruling. The Crane Trust has acquired, through fee title and conservation easement, over 4,050 ha (10,000 ac) for Sandhill and Whooping Cranes in the Central Platte River Valley (Strom 1987, Currier 1991). In recent decades, efforts to protect and maintain crane habitat have been undertaken by the National Audubon Society, The Nature Conservancy, the Crane Trust, and the Nebraska Public Power District, the latter in conjunction with habitat restoration efforts for cranes under the Platte River Recovery Implementation Program (Platte River Recovery Implementation Program 2017). The Nature Conservancy, Ducks Unlimited, Inc., and government agencies from county to federal level have cooperated in wetland restoration and habitat management for wintering cranes at the Cosumnes River Preserve in the Central Valley of California. Management of wetland habitats to produce food for cranes in winter has been intensive in some areas such as New Mexico (Taylor and Smith 2005). Frequent burning and mechanical removal of woody vegetation is critical to maintain open meadows and savannas in Mississippi, Texas, and other areas used by cranes (Scott Hereford, personal comm. 2017). Food crops have been planted in many of the important staging areas, both to benefit cranes directly and to lure them away from commercial croplands (USFWS 1991, Gee and Hereford 1995).

In the EP, the majority of breeding Sandhill Cranes use private lands. As such, solving problems that result from the resurgence of this population is important for people who provide Sandhill Crane habitat. Management actions include mitigating crop damage issues where they arise, such as with planted corn (Barzen and Ballinger 2017, 2018), and developing consensus in the public arena over how to best use cranes as a resource (Harris and Barzen 1996, Barzen 1997, Beilfuss 2012). Successful solutions to crop damage have been developed, particularly the development and registration of anthraquinone (Avipel®) for use as a taste deterrent for seeds (Lacy et al. 2013, Barzen et al. 2018, Lacy et al. 2018), which can be deployed at landscape scales (>40,500 ha; Barzen and Ballinger 2018).

Ultimately private landowners will protect numerous, scattered wetlands that nesting cranes need if required by federal and state laws, are guided by a land ethic (Leopold 1968), or for other reasons feel it is in their interest to do so. Management assistance is particularly needed in areas where lands are predominantly in private ownership.

Surveys/Censuses/Monitoring

The MCP has been monitored through annual March surveys in the Platte River Valley since 1957 (Lewis 1979). Development of aerial infrared videography to survey cranes while on nocturnal roosts in the Platte River has been shown to be a particularly effective tool for obtaining reliable estimates of population size (Kinzel et al. 2006). The RMP and EP are monitored via autumn pre-migration and staging-area surveys (Dubovsky 2018). Coordinated roost counts are used to monitor winter crane numbers in the Central Valley of California (Ivey et al. 2014c). Differential detection rates for territorial and non-territorial social groups of cranes during summer has been determined (McKinney et al. 2016).

Research

The Sandhill Crane is among the most thoroughly studied of crane species. Research has been conducted in various parts of the species' range and has focused on a wide array of topics involving life history, breeding biology, ecology, ethology, migration, and demography. Genetic relationships have been the subject of numerous investigations over the past 20 years focusing on mitochondrial DNA to define more precisely the phylogenetic relationships and degree of genetic variance within the species (Krajewski and Fetzner 1994), subspecies (Rhymer et al. 2001, Petersen et al. 2003, Jones et al. 2005), and populations (Hayes 2015). Results from many studies have been reported in the proceedings of the North American Crane Workshop and international crane workshops. The Unison Call, the biannual newsletter of the North American Crane Working Group, provides regular summaries of ongoing studies.

For the MCP, studies are underway evaluating current geographic distribution and ecology of Sandhill Cranes breeding in Russia (Gary Krapu, unpublished data), and results of studies estimating annual recruitment and survival rates in the MCP currently are being prepared for publication (Aaron Pearse, personal comm. 2017).

For the EP, a 25-year study of marked Greater Sandhill Cranes breeding in a region of high population density (Barzen et al. 2016) showed mate switches are frequent (Hayes and Barzen 2006, Hayes 2015), productivity is low (Wheeler et al. 2019), extensive interactions occur between breeding and non-breeding individuals in the summer flock (Hayes and Barzen 2006, Hayes 2015, Barzen and Gossens 2014), and extra-pair paternity is possible (Hayes et al. 2006). Habitat selection in relation to crop damage (Barzen et al. 2018) and other factors (Su 2003, Hayes and Barzen 2016b, Miller and Barzen 2016) occurs at multiple geographic scales. Areas of overlap between crane populations have also been studied on breeding areas (Krapu et al. 2011, Wolfson et al. 2017). On staging and winter areas, crane movements have been studied in ways similar to the MCP (Aborn 2011, King et al. 2011, Fronczak 2014, Fronczak et al. 2015, Fronczak et al. 2017). Studies also have been conducted on wintering grounds and staging areas in the southeastern United States (Aborn 2010, Hannah et al. 2014, Thompson and Lacy 2016) that included intensive monitoring of marked individuals in Florida (Nesbitt and Carpenter 1993) and Georgia (Bennett and Bennett 1989).

For the RMP, LCRVP, and CVP, recent research using satellite telemetry has helped to establish connectivity among these western populations (Collins et al. 2015). Results to date show the primary breeding grounds of the LCRVP are located in northeastern Nevada and southwestern Idaho with breeding extending into west-central Idaho where their breeding distribution was found for the first time to overlap with the RMP. To date, no evidence has been found of CVP cranes overlapping on their breeding grounds with either the RMP or LCRVP.

For the CVP and PCP, recent research on Greater and Lesser Sandhill Crane wintering ecology in the Central Valley of California has defined roost site and foraging habitats (Ivey et al. 2014a), distribution of wintering flocks (Ivey et al 2014b, 2014c, 2016), described how the two subspecies use winter landscapes and their differences in home range sizes (Ivey et al. 2015), and crop selection patterns (Shaskey 2012, Ivey 2015). Recommendations for conservation and management strategies are provided by Shaskey (2012), Ivey et al. (2014c), Ivey (2015), and Ivey et al. (2015).

The precarious state of the Mississippi Sandhill Crane has prompted scientific attention on a wide range of topics relevant to crane conservation including habitat management, causes of mortality and nest failure, evaluation of release techniques, genetic management, effects of predators, the role of disease, and dispersal patterns (USFWS 1991). A Population and Habitat Viability Assessment was conducted for the Mississippi Sandhill Crane (Seal and Hereford 1992), resulting in a number of recommendations aimed at increasing nesting success reducing mortality of wild cranes, dividing the captive flock, and addressing health issues. A number of these recommendations have been implemented. Research is underway to evaluate food availability for chicks. A habitat suitability model was recently completed but is under revision before publication.

Information on Cuban Sandhill Cranes has been limited, historically, because of insufficient funds being available for training and hiring of personnel. Until recently only a few non-Cuban researchers have been able to conduct studies (Faanes 1990, Galvez-Aguilera and Perera 1995; E. Santana, personal comm. 1991; Xiomara Galvez, personal comm. 2017). In 1996, a research project was initiated to study life history traits of the subspecies, resulting in a Master thesis (Marrero Garcia et al. 2003), dissertation (Galvez 2002), and several scientific articles.

Population Management and Recovery Plans

Flyway Councils have developed management plans for formally designated populations of migratory Sandhill Cranes. These include the PCP, CVP, LCRVP, RMP, MCP, and EP (Subcommittee on the Pacific Flyway Population of Lesser Sandhill Cranes 1983; Pacific Flyway Council 1995, 1997; Central Flyway Webless Migratory Game Bird Technical Committee 2006, Subcommittee on Rocky Mountain Greater Sandhill Cranes 2007, Ad Hoc Eastern Population Sandhill Crane Committee 2010). Recovery plans have been prepared for several Sandhill Crane subspecies and populations: Mississippi Sandhill Crane Recovery Plan (USFWS 1991); Florida Species Action Plan for the state-threatened Florida Sandhill Crane (Florida Fish and Wildlife Conservation Commission 2013); and Washington State Recovery Plan for all three state-endangered migratory subspecies (Littlefield and Ivey 2002). Additionally, several national wildlife refuges have included Sandhill Cranes as a focal species for management in their 15-year Comprehensive Conservation Plans: Mississippi Sandhill Crane NWR (USFWS 2007), Grand Bay NWR (USFWS 2008), Conboy Lake NWR (USFWS 2014a), Columbia NWR (USFWS 2011), Malheur NWR (USFWS 2013), and San Luis Valley NWR Complex (USFWS 2014b).

Non-governmental Organizations

The North American Crane Working Group has played a key role in focusing interest on the Sandhill Crane through regular workshops, publications (many now available at https://digitalcommons.unl.edu/nacwg) and other activities. The group hosted its 14th workshop at Chattanooga, Tennessee, in January 2017. Private conservation organizations have contributed to the protection of valuable

Sandhill Crane habitat. For example, The Nature Conservancy (TNC) has played an instrumental role (beginning in 1974) in acquiring lands for the establishment and expansion of the Mississippi Sandhill Crane NWR (USFWS 1991) and manages 728 ha (1,800 ac) of savanna habitat between the refuge Gautier and Ocean Springs Units. Important spring staging areas along the Platte River are held by TNC, the National Audubon Society, the Crane Trust, and the State of Nebraska (Logan et al. 1976, Currier et al. 1985, VanDerwalker 1987, Strom 1993). TNC also manages reserves in California that support wintering Sandhill Cranes (Staten Island, Cosumnes River Preserve). The International Crane Foundation (ICF) has focused on the Sandhill Crane in many of its education, research, training, and habitat management programs. ICF has also sought sustainable solutions to problems arising from the recovery of Sandhill Crane populations (Lacy et al. 2013; Barzen and Ballinger 2017, 2018).

Education and Training

As a wide-ranging, abundant, and easily identified species, the Sandhill Crane has been incorporated into many conservation education programs and projects, especially those focusing on wetland values, functions, and conservation. These programs include the annual Midwestern crane count, which not only provides data on the size of breeding populations and status of habitat quality but allows participants to learn about crane and wetland conservation in the process (Dietzman and Swengel 1994). Annual crane festivals have been organized at key staging and wintering grounds, including the Platte River staging grounds, the Sacramento-San Joaquin Delta (Lodi, California), Hiwassee State Wildlife Area (Tennessee), Columbia NWR (Othello, Washington), Monte Vista NWR, Colorado, and Bosque del Apache NWR (New Mexico). A new headquarters and Visitor Center for the Mississippi Sandhill Crane NWR was built in 2008, and a full-time Refuge Ranger was hired, expanding crane education efforts there. In addition to the key role that Sandhill Cranes play in public education programs, the species also has been used extensively as a model for professional training in field research, captive propagation, and reintroduction methods. Practices that have been applied mainly to other species have often been "tested" first on Sandhill Cranes. These include the development of techniques for isolation rearing (Horwich 1989), banding (Melvin et al. 1983, Dickerson and Hayes 2014), and migration studies (Melvin and Temple 1983). Sandhill Cranes have also been used in experiments to teach migration routes to captive-reared cranes (see the Whooping Crane species review).

PRIORITIY RESEARCH AND CONSERVATION ACTIONS

Research

Research related to the rarer Sandhill Crane taxa should focus on:

- Continued studies of factors responsible for poor reproduction and low recruitment rates in the Mississippi Sandhill Crane population;
- Clarification of intraspecific genetic structure and phylogenetic relationships among the Cuban, Florida, and Mississippi Sandhill Cranes; and
- Quantitative analysis of genetic distinctiveness and long-term viability of Okefenokee nesting Florida Sandhill Cranes.

Research related to more abundant Sandhill Crane taxa should focus on:

- Improved assessments of population dynamics of the MCP. Identify factors affecting accuracy of surveys, develop alternative and/or supplemental means of monitoring, and continue to evaluate annual recruitment rates;

- Improved techniques for controlling and minimizing crop depredation on cereal grains and potatoes (*Solanum tuberosum*);

- Improved understanding of energetic needs in relation to conservation planning to maintain carrying capacities of crane wintering landscapes; and

- Increase assessments on effect of climate change on Sandhill Crane populations.

Legal and Cultural Protection

- Secure adequate Platte River inflows to meet crane needs and provide for protection, restoration, and maintenance of habitat (both upland and riverine) within areas traditionally used by migrating cranes; and

- Assess the need for listing of the Florida Sandhill Crane by the U.S. Fish and Wildlife Service.

International Agreements and Cooperation

- Support continued international efforts for research and conservation for the Cuban Sandhill Crane (see below); and

- Expand cooperation among biologists studying MCP Sandhill Cranes on wintering grounds in Mexico with those working in other parts of the winter range and on breeding grounds of this population.

Habitat Protection and Management

- Protect and restore essential wetland or upland habitats of the non-migratory subspecies including: acquisition and protection of additional habitats for the Florida Sandhill Crane to ensure that the range of the species remains contiguous throughout Florida and southern Georgia; secure potential habitats for the Mississippi and Cuban Sandhill Cranes; and provide management of these habitats to maintain appropriate vegetation and ecosystem function;

- Protect and restore additional vital staging and wintering areas of the migratory subspecies, including: the seasonal playa lakes of western Texas (Iverson et al. 1985); wet meadows and riparian roosting areas along the North Platte and Platte Rivers (Krapu et al. 1984, Tacha et al. 1994); basin wetlands and adjacent native grasslands in eastern South Dakota (Gary Krapu, 2017); prairie pothole landscapes in central and western Saskatchewan (Krapu et al. 2014); EP wintering grounds in Florida (Nesbitt and Hatchitt 2008); wetlands of the Intermountain West (Austin et al. 2007, Collins et al. 2015), California, and the American Southwest (Taylor and Smith 2005); and Laguna de Babicora and other wintering areas in northern Mexico (see Drewien et al. 1996); and

- Promote habitat conservation on private lands on key breeding, staging and wintering areas. Since much of the non-breeding habitat of migratory populations (and breeding habitat of migratory populations of Greater Sandhill Cranes) occur on private land, it is important that conservationists and private landowners collaborate in efforts to protect, improve, and restore wetlands, to exchange information, and to monitor and respond to crop depredation problems. Greater attention to trends in agricultural policy and agricultural practices, and their impact on habitat conditions, is needed. Cooperative agreements, easements, and other methods of habitat protection should be explored (see Subcommittee on Rocky Mountain Greater Sandhill Cranes 2007; Ivey et al. 2014c; Barzen and Ballinger 2017, 2018; Barzen 2018). Conservation on private lands is becoming increasingly important as Mississippi Sandhill Crane foraging habitat off refuge is being lost to development and fire suppression (Scott Hereford, personal comm. 2017).

Recovery of the Mississippi Sandhill Crane

- Update and fully implement the Mississippi Sandhill Crane Recovery Plan (USFWS 1991);
- Complete a refuge Habitat Management Plan for both Mississippi Sandhill Crane and Grand Bay NWRs;
- Complete a crane Inventory and Monitoring Plan; and
- Give special consideration, within the framework of the Recovery Plan, to the following:
  - o Continue active savanna and prairie restoration efforts at the Mississippi Sandhill Crane NWR, and secondarily at Grand Bay NWR; continue to expand mechanical removal of woody vegetation. With reduced funding for prescribed burning program, find additional ways to continue frequent burning of refuge;
  - o Increase number of cranes that defend nests and chicks from predators. Consider efforts to translocate defense behavior from wild Florida Sandhill Cranes, including transfer of pairs or sub-adults and or transfer of Mississippi fledglings hatched and reared under successful Florida pairs;
  - o Expand education outreach activities directed to refuge visitors and the local community;
  - o Initiate additional releases of cranes in suitable habitat at Grand Bay NWR, and potentially in Hancock County, Mississippi, and southwestern Louisiana, based on studies of the potential for reintroduction in other areas of the subspecies' historic range and identify specific release sites;
  - o Continue to improve captive-rearing to produce cranes that enable expansion of the subspecies genetic heterozygosity;
  - o Expand research on causes of low recruitment, micro-habitat use, chick food availability, ways of increasing nest defense behavior, possible causes of low survival rates in the population, including loss of genetic viability; and
  - o Publish habitat suitability model based on geographic information system data for the subspecies (see Research above).

Developing a Cuban Sandhill Crane Conservation Program

To protect and restore the highly endangered population of the Cuban Sandhill Crane and its habitats, a comprehensive conservation program needs to be developed and implemented. This program should include the following components:

- Disseminate and publish information on the ecology and threats to the population;
- Establish a monitoring program to provide accurate assessments of population trends. This could involve conducting regular surveys, at least every 3–5 years, for different breeding areas to determine changes. Monitoring may be particularly important in the small breeding areas that appear to be declining (Galvez-Aguilera and Chavez-Ramirez 2010);
- Research the potential implementation of habitat management and restoration options, such as the role of fire and water level manipulations;
- Explore opportunities for collaboration and training involving Cuban and non-Cuban field ecologists, ornithologists, and conservationists; and

- Develop an education program to communicate the importance, status, and conservation needs of the subspecies.

Anticipating and Responding to Crop Depredation

Crop depredation is difficult to predict because it is often caused by non-territorial cranes during summer (Barzen et al. 2018). Damage can be intermittent and limited to certain geographic areas, crop types, and times of the year. These characteristics offer opportunities to conduct research, to anticipate future occurrences of damage, and to prepare effective responses (Barzen and Ballinger 2018). To do so, programs should:

- Continue to develop crop damage solutions that can be implemented through the marketplace as an alternative to compensation programs;
- Determine timing and extent of crop depredation in regions where damage patterns are unclear;
- Use habitat management techniques (e.g., taste deterrents) to minimize potential damage (Barzen et al. 2018, Lacy et al. 2018);
- Develop extension and public education programs involving farmers (Barzen and Ballinger 2018); and
- Investigate new techniques for preventing damage that can be integrated into current agricultural systems in crops, such as with potatoes (Barzen and Ballinger 2018).

Understanding the Impact of Hunting

Hunting of Sandhill Cranes has been controversial in some regions, particularly when occurring on or near breeding grounds. Sandhill Cranes became extirpated from most of the historical breeding range of the putative Prairie Population in the northern plains (including Prairie Pothole Region) by 1900 and have failed to re-occupy most of this region despite suitable breeding habitat being widely available. Their absence likely is linked to overharvest resulting in an insufficient number of breeders surviving to re-occupy most of this region (Krapu and Brandt 2010, Krapu et al. 2011). Studies utilizing satellite telemetry have shown a remnant population of Greater Sandhill Cranes from the East-central Canada-Minnesota breeding affiliation are now located mostly along the northern edge of their historic breeding range. These birds congregate on fall staging areas in mid-August to early September that are often located near breeding areas. Primarily local birds gather several weeks before subarctic and arctic breeders arrive, coinciding with the early to mid-September opening of hunting seasons on Sandhill Cranes in the northern plains. An early arrival along with a later departure, as compared to more northern-nesting cranes results in the East-central Canada-Minnesota breeding affiliation being exposed to much higher levels of hunting activity than northern breeders (Krapu and Brandt 2010, Krapu et al. 2011). Greater Sandhill Cranes in the East-central Canada-Minnesota breeding affiliation, therefore, form a disproportionate part of the fall crane harvest in the northern plains (Kendal et al. 1997). The impact of the early hunting season is exacerbated in Saskatchewan where hunting regulations allow a five-bird daily limit in seasons from early September to December and crane hunting extending throughout the province. Based on current knowledge on levels of exposure of cranes in the East-central Canada-Minnesota breeding affiliation to hunting seasons in the northern plains, the associated disproportionate harvest, and the vast area of unoccupied former crane breeding habitat existing in the northern plains, the size of the East-central Canada-Minnesota breeding affiliation likely is far below historic levels, and the decline may be continuing.

Minnesota initiated a Sandhill Crane hunting season for the first time in 2010 and set an early September opening after concluding that a major part of the harvest would come from migrant cranes staging in the hunting zone (Lawrence et al. 2012). This decision did not take into account evidence from satellite telemetry studies suggesting that locally reared Greater Sandhill Cranes from the East-central Canada-Minnesota breeding affiliation would account for most of the crane harvest in Minnesota and that significant numbers of Minnesota-reared cranes are harvested in the states of Kansas, Oklahoma, and Texas (Krapu and Brandt 2010, Krapu et al. 2011). August roadside surveys conducted in the hunted area in northwestern Minnesota in 2011, the summer following the first hunt on this population, recorded 43% fewer cranes than in 2010 (Jeff Lawrence, personal comm. 2012).

The apparent disproportionate harvest of Greater Sandhill Cranes in Minnesota starting in 2010 did not take into account that Greater Sandhill Cranes breeding in northwestern Minnesota are a remnant of the original Prairie Population that has been displaced from much of its historical breeding range (see Krapu and Brandt 2010). Harvest may have been sufficient to significantly reduce numbers of local individuals of the Prairie Population in Minnesota although Sandhill Crane survey data gathered in Minnesota are inconclusive on this matter (Lawrence et al. 2012, 2016). For further discussion on movements, population ecology and harvest rates of the Prairie Population of Greater Sandhill Crane see Melvin and Temple (1983), Meine and Archibald (1996, p. 108), and Krapu and Brandt (2010). In 2012, the start of the Minnesota crane season was moved from early September to mid-September, and bag limit of cranes was reduced from two to one per day which has reduced annual harvest in the state (Jeff Lawrence, personal comm. 2012).

In Wisconsin, where crane hunting has been proposed and an estimated 66% of the Eastern Population of Greater Sandhill Cranes currently breed (Lacy et al. 2015), it will be important to understand the impacts of fall hunting and harvest on density and distribution of cranes that breed in the state. To provide a sound scientific basis for understanding impacts of hunting on crane populations (including the accidental taking of Whooping Cranes), for informing policy debates, and for making policy decisions, the following measures should be given high priority:

- Evaluate the impact of proposed harvest rates on the EP where hunting would occur in or adjacent to summer breeding areas;
- Evaluate origin of cranes being shot where hunting is occurring on or near crane breeding grounds; and
- Continue monitoring of the legal kill, crippling losses, and poaching in all hunt areas.

For the Mid-continent Population that is hunted across part of four nations (United States, Canada, Mexico, and Russia), the following steps are needed:

- Improve documentation of the annual mortality from sport and subsistence hunting in Mexico, and from subsistence hunting in Russia, Alaska, and Canada; and
- Improve communication among crane managers in Canada, the United States, Mexico, and Russia about the impacts of hunting on crane populations, as well as about hunting practices, regulations, and prohibitions;
- Develop and test hunting strategies that have the potential to lessen the harvest of Greater Sandhill Cranes breeding along the northern edge of the Northern Plains; and

- Expand research comparing effects of hunting on different populations, effect of timing of hunting seasons on harvest by age, subspecies, and subpopulation, and long-term effects of hunting disturbance on crane distribution.

Education and Training

Because Sandhill Cranes are well studied, conspicuous, widespread, and migrate over great distances, they present many opportunities for innovative education programs. Specific educational priorities include:

- Involve students and citizen scientists in crane counts and censuses (https://www.savingcranes.org/education/annual-midwest-crane-count/);
- Involve students and citizen scientists in long-term monitoring programs for non-migratory populations;
- Develop cooperative projects involving schools in Russia, Canada, U.S, and Mexico in the study of avian migration, using cranes as a model;
- Develop primary and secondary school curriculum materials that use Sandhill Cranes to communicate information about the biology, status, and conservation of the species, other crane species, and wetlands. These materials should include field studies that stress the role of cranes as wetland "umbrella" species (i.e., species whose conservation can provide protection for a wide range of species and ecosystem processes); and
- Use present knowledge of crane social behavior to communicate lessons about the role of animal behavior in conservation.

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ANNEX 3. ACRONYMS

Organizations

ABC	American Bird Conservancy (USA)
AEWA	African-Eurasian Migratory Waterbird Agreement
APLIC	Avian Power Line Interaction Committee (USA)
AWB	Aransas-Wood Buffalo (Whooping Cranes)
AZA	Association of Zoos and Aquariums (USA)
BFU	Beijing Forestry University (China)
CAS	Chinese Academy of Sciences (China)
CAZG	Chinese Association of Zoological Gardens (China)
CBBNEP	Coastal Bend and Bays Estuaries Program (USA)
CPSG	Conservation Planning Specialist Group
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
CMP	Conservation Measures Partnership
CMS	Convention on Migratory Species of Wild Animals
CMS MOU	Memorandum of Understanding Concerning Conservation Measures for the Siberian Crane under CMS
CWGE	Crane Working Group of Eurasia
DELWP	Department of Environment, Land, Water and Planning (Australia)
PDRK	Democratic People's Republic of Korea (North Korea)
EAAFP	East Asian–Australasian Flyway Partnership
EAZA	European Association of Zoos and Aquaria
ESKOM	South African Electric Utility Company
EWT	Endangered Wildlife Trust (South Africa)
FAO	Food and Agriculture Organization (United Nations)
GEF	Global Environment Facility (United Nations)
GIZ	German Corporation for International Cooperation
ICF	International Crane Foundation
IPCC	Intergovernmental Panel on Climate Change
IRCN	International Red-crowned Crane Network
IUCN	International Union for Conservation of Nature
MoLEP	Ministry of Land and Environmental Protection (DPRK)
NABU	Natural and Biodiversity Conservation Union (Germany)
NCF	Nature Conservation Fund (India)
NEASPEC	North-east Asian Subregional Programme for Environmental Cooperation
NGO	Non-governmental organization

NNR	National Nature Reserve
NWR	National Wildlife Refuge
OGUIPAR	Office Guinéen des Parcs et Réserves (Guinea)
ONCFS	Office National de la Chasse et de la Faune Sauvage (Sudan)
PAAZA	Pan African Association of Zoos and Aquaria
PLNNR	Poyang Lake National Nature Reserve (China)
PWRC	Patuxent Wildlife Research Center (USA)
RIFEEP	Research Institute of Forest Ecology, Environment and Protection, Chinese Academy of Forestry (China)
ROK	Republic of Korea (South Korea)
RSPB	Royal Society of the Protection of Birds (UK)
SABR	San Antonio Bay Partnership (USA)
SFA	State Forestry Administration (China)
TNC	The Nature Conservancy (USA)
TPWD	Texas Parks and Wildlife Department (USA)
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USFS	United States Forest Service (USA)
USFWS	United States Fish and Wildlife Service (USA)
USGS	United States Geological Survey (USA)
USA	United States of America
USSR	Union of Soviet Socialist Republics
WBNP	Wood Buffalo National Park (Canada)
WCRT	Whooping Crane Recovery Team (USA and Canada)
WCS	Wildlife Conservation Society
WSCC	Wildlife Science and Conservation Center of Mongolia
WWF	World Wildlife Fund
WWT	Waterfowl & Wetland Trust (UK)

Other acronyms

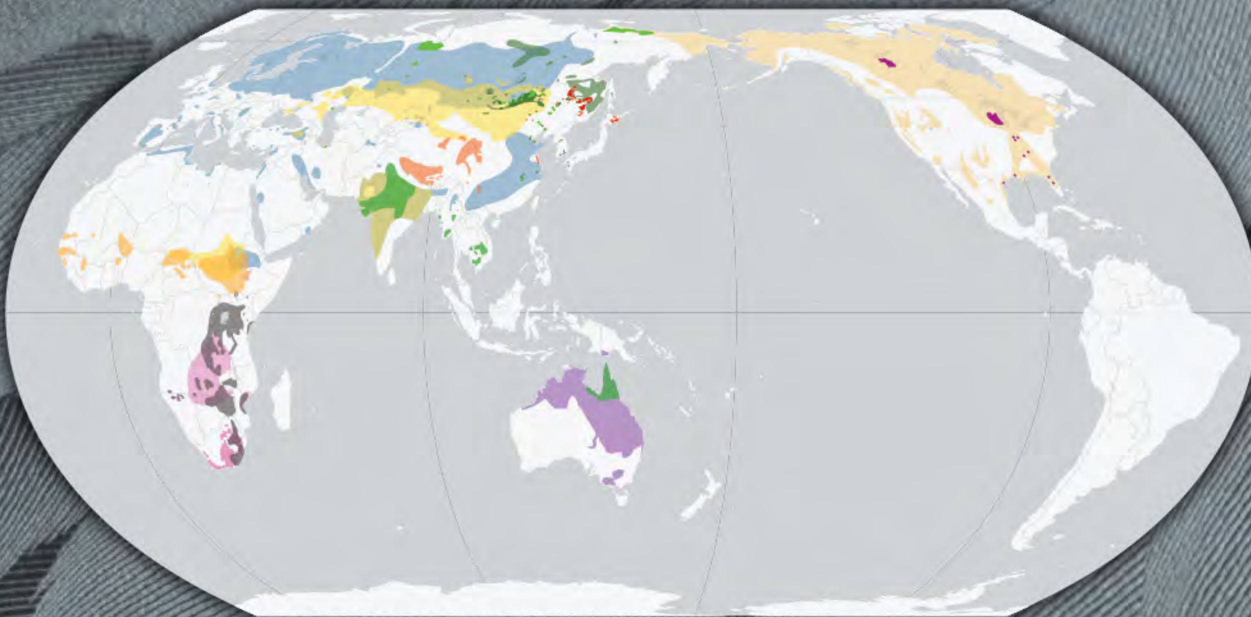
CCZ	Civilian Control Zone
CVP	Central Valley Population (Sandhill Crane)
DAR	Direct Autumn Release
DMZ	Demilitarized Zone
EM	Eastern Migratory Population (Whooping Crane)
EN	Endangered
EP	Eastern Population (Sandhill Crane)
FL	Florida (USA)
GIS	Geographic information system
GIWW	Gulf Intracoastal Waterway (USA)
GPS-GSM	Geographic positioning system – Global system for mobile communications
HPAI	Highly-pathenogenic avian influenza
IBA	Important Bird Areas (BirdLife International)
LA	Louisiana (USA)
LCRVP	Lower Colorado River Valley Population (Sandhill Crane)
LMB	Lower Mekong Basin
MCP	Mid-Continent Population (Sandhill Crane)
PAOC	Pan-African Ornithological Congress
PCP	Pacific Coast Population (Sandhill Crane)
PTT	Platform transmitter terminal
RMP	Rocky Mountain Population (Sandhill Crane)
SABAP	South Africa Bird Atlas Project
SCWP	Siberian Crane Wetland Project
SPA	Specially Protected Areas
UL	Ultralight-led
WCRP	Wattled Crane Recovery Programme

INSPIRATIONAL PIECE

CRANE BOY
By Steven Harris

Before I could see,
when light burned my eyes,
I knew cranes
from Mama's voice.
I knew they soared
like angry, beautiful humans,
arms wider than mine, language like mine
for open sky.
Mama didn't know the meanings
just as she couldn't hear my words.
I thought, when I grow tall,
I might join wild flocks.
I wanted flying lessons, no need to walk.
Someday Father will give me crane eyes.
I have never stopped waiting.

February 10, 2013
Baraboo, Wisconsin, USA



World distribution of all 15 crane species.

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