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# A global overview of cranes: status, threats and conservation priorities

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**Abstract** This paper reviews the population trends and threats for the 15 species of cranes, and comments on conservation priorities for the family as a whole. Cranes occur on five continents, with greatest diversity in East Asia (nine species) and Sub-Saharan Africa (six species). Eleven crane species are threatened with extinction according to the IUCN Red List, including one species Critically Endangered, three species Endangered, and seven species Vulnerable. Of the four species of Least Concern, population sizes for the Demoiselle (*Anthropoides virgo*) and Brolga (*Grus rubicunda*) are not well known but these species are declining in some areas. The Sandhill (*G. canadensis*) and Eurasian Cranes (*G. grus*) are the most abundant cranes and have rapidly increased in part due to their flexible selection of foraging habitats and use of agriculture lands and waste grain as a food source. Status for six species — Grey Crowned (*Balearica regulorum*), Blue (*Anthropoides paradise*), Black-necked (*G. nigricollis*), Red-crowned (*G. japonensis*), Sandhill, and Siberian (*G. leucogeranus*) — are summarized in more detail to illustrate the diversity of population shifts and threats within the crane family. A crane threat matrix lists the major threats, rates each threat for each species, and scores each threat for the crane family as a whole. Four of the five greatest threats are to the ecosystems that cranes depend upon, while only one of the top threats (human disturbance) relates to human action directly impacting on cranes. Four major threats are discussed: dams and water diversions, agriculture development, crane trade, and climate change. Conservation efforts should be strongly science-based, reduce direct threats to the birds, safeguard or restore habitat, and strengthen awareness among decision makers and local communities for how to safeguard cranes and wetlands. Especially for the most severely threatened species, significantly stronger efforts will be needed to incorporate our understanding of the needs of cranes and the ecosystems they inhabit into decisions about agriculture, water management, energy development and other human activities.

**Keywords** cranes, climate change, habitat loss, wetlands, wildlife trade

## Introduction

Cranes, the family Gruidae, include 15 living species that occur on five continents. Due to their striking appearance and behavior, their cultural significance in most parts of the world, and the population declines experienced by most, but not all species, cranes have been intensively studied for many years. This paper summarizes current status and trends for the 15 species together with more detailed accounts of six species, provides an overview of threats, discusses current conservation activities and the highest priority needs, and comments on the future for cranes.

The greatest threat to cranes is the loss of habitat. Thirteen of the 15 species depend on wetlands for breeding and all species depend to varying degrees on wetlands during non-breeding portions of the year (Meine and Archibald, 1996). Most vulnerable to habitat loss are those species that are highly aquatic and migrate long distances, so that survival requires maintaining suitable water conditions on breeding and wintering

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grounds as well as across a network of stopover sites on migration. Even the Blue Crane (*Anthropoides paradisea)* and the Demoiselle Crane (*A. virgo)*, least aquatic of cranes, are threatened by loss of their grassland habitats to intensification of agriculture and afforestation.

Cranes have great charisma and have been effectively used in many areas as flagship species to gain recognition and support for broader conservation efforts. Cranes have inspired the protection of millions of hectares of wetlands on five continents. The greatest diversity of cranes occurs in East Asia, with nine species. Europe and West Asia together have three species, although the population of Siberian Cranes (*Grus leucogeranus)* has almost been extirpated from that region. Africa has six species, including two that migrate south for winter from western Eurasia and four endemic to the continent. North America has two species, with the Sandhill Crane (*G. canadensis)* also breeding in northeast Siberia in growing numbers. Australia has two species, one of them shared with South and Southeast Asia.

China has more crane species than any other country — nine species, including six that are threatened with extinction. In addition, China has significant impact on cranes in other parts of the world, in particular due to its rapidly growing need for natural resources, its assistance to African countries in dam building and electrification, and the fact that China appears to be a significant destination for cranes traded internationally. This paper, however, will not focus on China but provide a global overview for the cranes on the assumption that experience in different parts of the world offers lessons for research and conservation in other countries. In addition, except for the Black-necked Crane (*G. nigricollis*), most or all individuals from each of China's crane species spend parts of the year outside China, so that international communication and cooperation are required.

## Status of the 15 crane species

All 15 crane species have been heavily impacted by human activity. Table 1 summarizes the status, distribution, and population numbers of the 15 species together with the most severe threats. Current trends refer to changes since a similar summary was prepared by Meine and Archibald (1996).

Currently, eleven species are classified as threatened by the International Union for Conservation of Nature (IUCN), including one species Critically Endangered, three species Endangered, and seven species Vulnerable. Thus cranes are among the most threatened families of birds. Of the four non-threatened species, recent evidence suggests that two are declining.

Most species have learned to forage on agricultural lands as their natural grassland and wetland habitats have dwindled (Meine and Archibald, 1996). In particular, the spectacular growth of the world's two most abundant cranes — the Sandhill and the Eurasian (*G. grus*) can be in large part attributed to the opportunities to forage on agricultural lands during different phases of their life cycle. In Europe during the last decades the Eurasian Crane has adapted to breeding near ponds in fields and wet meadows within agricultural land, sometimes near to roads and human settlements (Mewes, 2010; S. Ludgren, pers. comm.)

Cranes face the most severe threats in Asia and Sub-Saharan Africa, with large human populations, intensive land use, and economic development often poorly integrated with environmental protection. The degree of dependence of each crane species on aquatic habitats in part determines how cranes respond to landscape change — of the four species that are Critically Endangered or Endangered, three have high to very high dependence on aquatic habitats. The four species of Least Concern have low to moderate dependence on wetlands.

Cranes are comparatively easy to count, given their large size, preference for open landscapes, and the relative ease of securing funds for field studies due to their cultural significance and threatened status. Particularly in East Asia, where the vast majority of wetlands have been developed, cranes concentrate into a few locations. The continental population of Red-crowned Cranes (*G. japonensis*), for example, relies on four clustered sites near the Korean Demilitarized Zone and two sites in coastal China in winter. Once such concentrated wintering sites are established, these flocks tend to draw in other cranes. About 85% of the world's Hooded Cranes (*G. monacha*) winter on a few hectares of artificially maintained rice paddy at Izumi, Japan, together with a maximum count of 3142 White-naped Cranes (*G. vipio*) in 2009 (Meine and Archibald, 1996; S. Chan *in litt.* 2012; BirdLife International, 2013). The dense flocks are vulnerable to disease outbreak or weather catastrophe and cause damage to nearby farms. Yet efforts to disperse the cranes to more locations have had very limited success due in large part to the cranes' behavior — they do not move readily away from established

**Table 1** Summary of status, numbers, and key threats for the 15 crane species. Population numbers from Waterfowl Population Estimates, Fifth Edition (Wetlands International, 2012)

| Species name | Red List Status* | Distribution | Estimated population size | Current trend | Degree of dependence on aquatic habitats | Chief threats |
|---|---|---|---|---|---|---|
| Siberian Crane (*Grus leucogeranus*) | CR | Asia | 3525–3835 | Eastern population stable to increasing; western/central pop. almost extirpated | Very high | Habitat loss, especially due to changing hydrology |
| Red-crowned Crane (*G. japonensis*) | E | North East Asia | 2910–3100 | Continental population decreasing; island population increasing. | High | Habitat loss, poisoning |
| White-naped Crane (*G. vipio*) | V | North East Asia | 5500–6500 | Eastern population increasing; western population decreasing | Moderate | Habitat loss, especially due to changing hydrology |
| Hooded Crane (*G. monacha*) | V | North East Asia | 11550–11650 | Increasing | Moderate | Habitat loss; overly concentrated at remaining winter sites |
| Black-necked Crane (*G. nigricollis*) | V | Central Asia | 10000–11000 | Stable to increasing | Moderate | Habitat loss and degradation |
| Sarus Crane (*G. antigone*) | V | South Asia, Australia | 24300–26800 | Stable or decreasing** | Moderate | Habitat loss |
| Demoiselle Crane (*Anthropoides virgo*) | LC | Eurasia, some winter in Africa | 225630–260760 | Probably decreasing** | Low | Habitat loss |
| Eurasian Crane (*G. grus*) | LC | Eurasia, some winter in Africa | 491200–503200 | Increasing | Low to moderate | Habitat loss, hunting in a few areas |
| Grey Crowned Crane (*Balaerica regulorum*) | E | East and Southern Africa | 32000–49000 | Decreasing | Moderate | Habitat loss, trade |
| Black Crowned Crane (*B. pavonina*) | V | West Africa, Sudan, Ethiopia | 33000–70000 | Decreasing | Moderate | Habitat loss including desertification, trade |
| Wattled Crane (*Bugeranus carunculatus*) | V | East and Southern Asia | 8060–8110 | Probably decreasing | High | Habitat loss, especially due to changing hydrology |
| Blue Crane (*A. paradisea*) | V | South Africa, Namibia | 25535 | Stable to increasing | Low | Habitat loss and changes in land use, power line collisions |
| Whooping Crane (*G. americana*) | E | North America | 397–403 | Increasing | High | Hydrological changes to wintering habitat, sea level rise, collisions with power lines and other infrastructure |
| Sandhill Crane (*G. canadensis*) | LC | North America, North East Siberia | 670237–830237 | Mid-contintent population increasing, other migratory populations generally stable, non-migratory stable or decreasing | Low to moderate | Habitat loss in some areas due to changes in agriculture or water managment, powerline strikes, conflicts with agriculture |
| Brolga (*G. rubicunda*) | LC | Australia, New Guinea | 25000–110000 | Unknown** Decreasing in parts of its range | Low to moderate | Habitat loss, climate change |

* IUCN Red List categories include Critically Endangered (CR), Endangered (E), Vulnerable (V), and Least Concern (LC).
** Little information available to assess current numbers or trend for the species as a whole.

locations.

Some population estimates remain very rough despite years of monitoring effort. Although almost all the Siberian Cranes winter at Poyang Lake, the 400000 hectares of wetland are so vast and difficult for human access that we cannot secure consistent counts. It is possible that the high counts, of 4000 birds and higher, reflect observer error or double counting (Li et al., 2012). Better counts come from the relatively small wetland stopover sites used on migration at Momoge National Nature Reserve in northeast China.

Further counts and research are needed. For example, we know that Black Crowned Cranes (*Balaerica pavonina*) are declining across much of their range, and disappearing from some countries, but we do not know the geographic extent or rate of decline. The four species of Least Concern, being spread across vast areas, are most difficult to census — e.g., the best estimates for Brolgas (*G. rubicundus*) range from 25000 to 110000 (Wetlands International, 2012)! The Demoiselle may be declining significantly but the degree of decline has thus far been impossible to determine.

The Wetlands International - IUCN Species Survival Commission (SSC) Crane Specialist Group is preparing a Crane Conservation Plan, assessing all 15 species, and thus serving as an update for the IUCN Crane Action Plan (Meine and Archibald, 1996). The new plan, to be completed in 2014, will summarize status and trends for all the species. In the meantime, for this paper, we provide summaries for six of the species to illustrate the range of situations for individual crane species. We consider changes in populations over time — declines, increases, or sometimes both in the same species — as such changes may offer insight into the future outlook for cranes.

## Status summaries for six crane species

### Grey Crowned Crane

Of the four crane species endemic to Africa, Meine and Archibald (1996) reported the largest populations for the Grey Crowned Crane (*B. regulorum*), a total of 85000–95000 individuals. At that time, due to declines in both subspecies, they recommended that the southern race be given Endangered status (for its total population of about 10000 occurring in Zimbabwe and South Africa) while the East African subspecies should be designated Vulnerable (for its population estimated at 75000 to 85000). The species breeds in a great variety of wetlands, including small habitat patches in human-altered landscapes, and forages extensively on croplands and pastures as well as natural grasslands (McCann and Wilkins, 1995; Meine and Archibald, 1996).

Yet the declines noted 17 years ago have continued. Once considered the most secure crane species in Africa, the wild population of Grey Crowned Cranes has been reduced by 50%–75% over the last 45 years (Beilfuss et al., 2007, http://www.birdlife.org/datazone/speciesfactsheet.php?id=2785). More recent surveys in East Africa indicate the decline could be much greater. Data collated from the National Biodiversity Data Bank in Uganda (publication in preparation) indicate that the species may have declined by more than 70% since the 1970s. Existing estimates suggest a decline of about 30%–40% in Kenya between 1994 and 2004 (Beilfuss et al., 2007). These data are particularly significant since Uganda and Kenya are believed to hold 60%–70% of the species' entire population. Declines of up to 75% over a 20–year period have also occurred in Tanzania (Morrison et al., 2007). While the Grey Crowned Crane is currently stable in South Africa at about 4000 birds, numbers are significantly less than the estimates in Meine and Archibald (1996).

Two major threats, emerging in the last two decades, are thought to account for the accelerating decline: habitat loss and the illegal trade in wild caught cranes. Habitat loss can be attributed primarily to the ever increasing pressure that local communities, industry and agriculture place on wetlands. Unregulated human activities such as farming, livestock grazing, and settlements have led both to the reduction in overall wetland size and the fragmentation of wetlands, resulting in less suitable habitat for breeding and increased disturbances around nests. These changes have forced Grey Crowned Cranes to use more open areas allowing poachers easier access to crane nests.

Illegal removal of eggs, chicks, and adults from the wild for commercial trade, domestication, and medicinal purposes is significantly impacting wild populations, exacerbated by the easier access to chicks as suitable habitats become smaller (Hudson, 2000; Smallie, 2002; Morrison et al., 2007). Birds have been shipped locally, elsewhere in the nation (for example, most chicks in Rwanda are taken for sale to hotels within the country, where they are kept in gardens; Morrison, pers. comm., 2012), or for international shipments, particularly, to Europe (now regulated), the Middle East and

China. Details on the actions needed to mitigate crane trade are addressed later in this paper. Other threats include collisions with power lines and electrocution while perching on electric structures. Both direct and indirect poisoning have become significant issues where cranes forage on croplands and cause real or perceived damage to crops (Smallie, 2002; McCann, 2003; Morrison, pers. comm., 2013). Modeling has indicated that crane populations are particularly sensitive to threats that increase mortality among adults (Mirande et al., 1992).

**Blue Crane**

This species has the most restricted range of any crane species. Aside from a small isolated population in Namibia, the species occurs only in South Africa where it is the national bird. It was formerly common across much of the country (Meine and Archibald, 1996); historically the population approximated 100000 (Allan, 1993). This crane inhabits grasslands, often nesting at a distance from water, although a water source is needed within the breeding territory. The population fell dramatically following the 1970s due to conversion of grasslands to croplands and forest plantations and widespread intentional poisoning in response to crane damage to crops. The Blue Crane was listed as Vulnerable in 2000 (McCann, 2000).

Currently, the population is roughly 25000, with half the birds located in the southwest of the country where historically the species was scarce or absent (McCann et al., 2007). Conversion of the shrub biome *fynbos* to farmlands with winter wheat as the predominant crop opened new habitats to the species. Yet the dependence of this population on farmlands leaves it vulnerable to changes in agricultural practices, whether brought about by market conditions or climate change. The latter is predicted to have particularly strong impacts on this southern tip of Africa (Morrison et al., 2012).

Currently, the chief threat to Blue Cranes is collision with power lines, with mortality greatest for young birds or during weather with poor visibility. As much as 12% of the Western Cape population is lost to power line collisions annually (Shaw et al., 2010). The Endangered Wildlife Trust has developed a unique national partnership with the electric utility that serves South Africa, ESKOM. Close collaboration focuses on marking or moving problem power line segments as well as taking collision risks into account when planning routes for new lines. Wind farm expansion is now occurring primarily in the Karoo and Western Cape of South Africa. Growing threats to Blue Crane grassland habitats in the eastern and central parts of the range are expansion of coal mining (including 50% of Mpumalanga grasslands which are now under mining application; Otter, pers. comm., 2013) and gas exploration in the Karoo (Morrison, pers. comm., 2013).

**Black-necked Crane**

This species (*Grus nigricollis*) has the most restricted range of the cranes, after the Blue Crane, being confined to the high altitude Tibetan-Qinghai Plateau for breeding, with short migrations to lower elevations in winter (using habitat that is primarily 2000 m and more above sea level). Through the 1980s the species was poorly known due to its remote range. Until recently, the breeding grounds (primarily 4000 to over 5000 m above sea level) have been relatively little impacted by the herdsmen and livestock living with the cranes, but the winter descent brings the birds into farm areas with many people. Although population estimates from the 1980s of 700–800 birds were probably incomplete, they reflect a sharp population decline believed due to loss of wetland habitat in winter and hunting. In the decade following China's Cultural Revolution, as the crane flocks were rediscovered, a network of nature reserve was established in both breeding and wintering areas (Harris, 1992).

A coordinated winter survey in 1990 found 5600 Black-necked Cranes, including about 500 that migrate a short distance over the Himalayas to winter in Bhutan. In the early 2000s, the surveys were repeated and found 11000 Black-necked Cranes (Bishop and Tsamchu, 2007). More complete counts may have contributed to this increase, but significant population growth occurred during this period probably due to protection from hunting, improved management of protected areas, and the abundance of waste grain available to foraging cranes during winter. The Black-necked Crane is unusual among larger Chinese wildlife: its populations have benefitted significantly from agriculture and these cranes can live in close proximity to human activity.

Yet conditions on the breeding grounds no longer appear as favorable as in past decades. Over-grazing is a widespread problem, leading to degradation of vegetative cover (Yang et al., 1996; Yang et al., 2005) and possible disturbance of nesting cranes by herdsmen and livestock. Climate change impacts are particularly pronounced in high altitudes of Tibet and Qinghai. While conditions vary from place to place, many glaciers and permafrost are melting, and glacier-fed shallow lakes and wetlands are drying up (Wang et al., 2006). Impacts of climate change on cranes are complex, as milder conditions in both summer and winter may favor survival, particularly of young cranes. Yet more extreme conditions, especially periods of severe cold at any season, may increase mortality.

The species faces further uncertainties. For example, in Tibet the wintering flocks roost on sandbars in the Yarlung Tsangpo River and its tributaries. Changing rainfall and construction of water control structures may affect these roost sites that are essential for the cranes, as few marshes remain in the valleys (Bishop et al., 2012). Changing agricultural practices — including conversion of barley fields to winter wheat and a shift from spring to fall plowing — has reduced winter food availability.

The most urgent needs for this species are more comprehensive ecological studies of how the cranes are using the breeding and wintering landscapes and assessments of how climate change and intensified human activities will affect them. Recent satellite tracking studies have provided evidence for three separate populations and have also led to identification of previously unknown migration stopover and breeding sites (Liu et al., 2012). A Black-necked Crane Network has formed, to encourage information exchange, and involves researchers, wildlife officials, and protected area managers.

**Red-crowned Crane**

This species is closely related to the Black-necked Crane but its ecology and status are very different. Two entirely separate populations of Red-crowned Cranes exist. The island population is limited to Hokkaido, Japan where cold summer conditions have discouraged conversion of wetlands to agriculture. Here a tiny, nonmigratory population survived through the mid 1900s by roosting and feeding in swift-flowing streams that did not freeze in winter. In 1952, a severe winter froze these streams. Local people provided grain, and when the cranes responded, the practice continued and enabled the population to grow steadily to almost 1500 individuals by 2011 (Swengel, 1996; Momose, pers. comm., 2013). Estimates of how large the population could grow, based on available wetland nesting habitat, have been exceeded again and again. The cranes nest even in small wetlands close to people and forage in close proximity to people in both winter (at the feeding stations) and summer (Koga, 2008). The situation is highly artificial; the crowding of many cranes together at the feeding stations results in heightened risk of a disease outbreak.

In contrast, the cranes of the continental Red-crowned Crane population, which breed primarily in the Amur River Basin of China and Russia, remain afraid of people and only nest in large wetlands where disturbance is low. Here the major threats have been loss and degradation of wetlands for agriculture (Su, 2008). Even after many wetlands were designated as protected areas in both Russia and China, dams and water diversions affected water supply so that conditions often did not allow this highly water-dependent species to breed (Harris, 2009). Fires sweep through the marshes during nesting periods, and people and predators could easily access areas formerly impassable due to high water. Winter habitat, on the coast of China and along the Korean Demilitarized Zone, has steadily deteriorated. In China, the wintering range is reduced to less than 300 $km^2$, about 8% of the estimated range in the 1980s (Su and Zou, 2012). Even Yancheng National Nature Reserve in China, where some of the last natural coastal wetlands remain, is threatened by invasion of the aggressive alien plant *Spartina alterniflora*. The crane winter sites in Korea have not yet been developed due to the tense political relations between the two Koreas. Should the two Koreas unite, however, current plans would lead to rapid changes in these lowland areas.

The continental population of Red-Crowned Cranes has steadily declined, particularly in China, where over 1000 birds were present in 1999–2000 but only about 400 were counted in 2008/09 (Su and Zou, 2012). In both China and Korea, the percentage of chicks in the wintering flocks exceeds 15%, which normally would indicate a growing population and is higher than the percentage of chicks for the island population, which is known to be growing. Steady or declining population numbers, with high recruitment, suggest high adult mortality. While data are not systematically collected, Su and Zou (2012) documented known mortality events from poisoning. Some poisonings appear to be from use of agriculture chemicals that inadvertently kill waterbirds while other cranes die from chemicals used to harvest waterfowl for the market. With loss of wetlands, the cranes more frequently use farmlands;

conflicts with farmers may then occur and risk of intentional poisoning increase.

As will be discussed later in this paper, water management is now maintaining or restoring Red Crowned Crane breeding habitat. In some areas, breeding failure may be due to people disturbing nests or taking eggs and chicks; patrolling and enforcement of legal protections are needed to minimize these threats. A monitoring system should be developed to investigate and document poisoning incidents; feathers of live birds and body tissues of dead birds should be routinely analyzed for heavy metals and other contaminants (Teraoka, 2008). 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 waters near developed areas for extended parts of each year, and the diet of this species has a higher percentage of animal material than for most cranes.

**Sandhill Crane**

This North American species is the most abundant of all cranes. Meine and Archibald (1996) estimated the population at 520000, while the latest estimate exceeds 700000 (Wetlands International, 2012; Krapu, in preparation). It is widely (though intermittently) distributed throughout North America, extending into Cuba and into northeastern Siberia. Six subspecies have been described. The three migratory subspecies — the Lesser (*G. c. canadensis*), Greater (*G. c. tabida*), and Canadian (*G. c. rowani*) Sandhill Cranes — are relatively abundant. The other three subspecies — the Mississippi (*G. c. pulla*), Florida (*G. c. pratensis*), and Cuban (*G. c. nesiotes*) Sandhill Cranes — exist as small, non-migratory populations with restricted ranges in the southern United States and Cuba.

For all populations, strict protection from hunting, and restoration of large wildlife areas that offered breeding habitat to wary cranes, enabled the recovery to begin (Hunt and Gluesing, 1976; Krapu, in preparation). For example, the Rocky Mountain Population rebounded from 400–600 birds in the mid-1940s (Walkinshaw, 1949) to about 17000 today (Kruse et al., 2012). In Wisconsin, changes in crane behavior in response to human behavior were documented; due in part to the lack of hunting, Sandhills increasingly foraged on agricultural landscapes and began to nest in smaller, less remote wetlands. Now the state population exceeds 13000 (Su et al., 2004; International Crane Foundation, unpublished data). Breeding behavior has changed where there is high population density, with quick replacement of lost mates and mate switching (Nesbitt and Tacha, 1997; Hayes and Barzen, in preparation). Recovery in some areas has been slower and Sandhills are only now recolonizing eastern parts of the United States and Canada. In spite of protection, some local populations may be declining such as the Rocky Mountain and Lower Colorado populations that are threatened by water, climate, and agricultural changes on their wintering and migration areas (http://www.fws.gov/migratorybirds/NewReportsPublications/ Research/WMGBMR/Priority_Information_Needs_for_Sandhill_Cranes_10-09-09_FINAL.pdf).

On a continental scale, a portion of the Lesser Sandhill Crane population migrates across the Bering Strait and has been extending its range in northeast Siberia, now as far west as the western edge of the Indigirka-Yana Interfluve, about 300 km southeast of the Lena River Delta (G. Krapu and I. Bysykatova, unpublished data, 2010). A few birds migrate south into Japan, Korea, and China each autumn rather than crossing back into North America for the winter. With time, a distinct Asian population may develop.

While the small non-migratorysubspecies of Sandhills in Cuba and Mississippi are endangered, for the species as a whole, current threats are low to moderate, perhaps resulting in slowed population growth rather than population declines. Success of the species has led to growing numbers on farmlands and corresponding conflicts with farmers. In Wisconsin, the most serious damage occurs to seedling corn (*Zea maize*) during the two weeks after planting. Without a conservation response to crop losses, these conflicts could have serious impact since most Sandhills now nest on farms and other private lands. The International Crane Foundation (ICF) has worked the past 20 years to develop a solution: anthraquinone (sold commercially as Avipel) is a taste deterrent that is inexpensive, non-toxic, persistent on the corn seeds, and compatible with farming equipment (Lacy et al., 2010; Lacy, in preparation). ICF is now working to adapt this approach to other regions including Europe and South Africa.

**Siberian Crane**

In recent decades, small populations of Siberian Cranes in West and Central Asia have almost disappeared; the only viable population of this species now occurs in eastern Asia, migrating 5000 km from the Yakutian tundra of Russia across highly developed eastern China to winter at Poyang Lake in the mid Yangtze River Basin. The migration corridor is very narrow, so that almost all birds must stop to rest on a limited number of wetlands with hydrology that varies considerably from year to year due to rainfall and human activities. As this species is the most exclusively aquatic of all cranes, it is highly vulnerable to impacts of water diversions and other wetland management actions, particularly in northeast China where its flyway passes through semi-arid areas (Harris, 2009).

This species' Russian breeding grounds are vast and sparsely inhabited but a warming climate is changing patterns of melting snow and ice and movement of water. Pshennikov (2012) has documented expansion of lakes due to wave action eroding perimeters of palustrine wetlands and submerging the crane breeding areas.

The species pauses to rest on migration in Songnen Plain of northeast China. In the late 1980s, hundreds of Siberian Cranes staged at Zhalong and Momoge National Nature Reserves (Li and Li, 1991; Wu et al., 1991). By the early 2000s, drought and water diversions had dried these locations so that the birds moved elsewhere. In fall 2004, the largest number was reported at Tumuji National Nature Reserve (UNEP/GEF Siberian Crane Wetland Project, unpublished data). Etoupao wetland at Momoge, where crane concentrations had not previously been reported, had been drained after 1998 then restored by supply of water from the nearby Nen River. Etoupao attracted increasing numbers, up to 3600 Siberian Cranes in 2012, essentially all of the remaining population of this species (H.X. Jiang, pers. comm., 2012). This dramatic habitat restoration success story has inspired much interest, with a Crane Festival nearby each autumn and an auto tour road constructed around the Etoupao wetland. Yet in fall 2013, water levels were too high for cranes to feed in most of this wetland; the flocks moved a few miles west to another site with sufficient water during this season but not on an annual basis. This event highlights the importance of managing a network of sites providing alternate migration stopover locations and also the need for more research on the ecology of these wetlands. Without appropriate water management, vegetation succession might lead to *Scirpus* sedges (a major food plant for Siberian Cranes) being replaced by *Phragmites* reeds that formerly grew here; reed beds, however, might attract Red-crowned Cranes that no longer breed in the reserve.

The situation for Siberian Cranes at Poyang Lake is precarious due to growing human impacts on this complex of lakes and rivers where waters fluctuate as much as eight meters or more between summer wet seasons and winter dry seasons. Management of the Three Gorges Dam has reduced water levels in the mid Yangtze in autumn (Guo et al., 2012); additionally, thousands of dams in the catchment to Poyang hold water back or divert it for irrigation and other purposes (Liu et al., 2009). Sand dredging is occurring on a massive scale (de Leeuw et al., 2010), humans encroach on the margins of the lake during dry periods, and the growing frequency of floods and droughts may reflect changing climates.

The Siberian Cranes depend on shallow waters and wet mud flats where they dig for tubers of *Vallisneria* and other submerged aquatic plants. Sluice gates proposed for the lake's outlet could bring major hydrological change, submerging crane foraging habitat (Harris and Zhuang, 2010). Siberian Cranes appear to have nowhere else to winter, in part because poor water quality in other wetlands causes submerged aquatic plants to be replaced by phytoplankton (Fox et al., 2010). Management of the Poyang ecosystem to preserve critical feeding and roosting habitat is essential for the survival of this species.

## Threats to the cranes

A threat matrix (see Table 2) has been developed for the 15 crane species; it lists the principal threats and rates their significance for each species. This matrix, based on Meine and Archibald (1996), has been updated and expanded by program staff of ICF, and reviewed by the Steering Committee of the WI-IUCN SSC Crane Specialist Group and by 15 experts gathered in Beijing in 2012 for a two-day workshop on the Crane Conservation Plan.

The scores for each threat across all species are tallied, so that the threats can be roughly ordered according to their significance to the crane family as a whole. It is noteworthy that four of the top five proximate threats affect the ecosystems that cranes use. Only the fifth-ranked threat, human interference/disturbance (especially at nest sites), directly acts upon cranes.

A later section of this paper reviews the diversity of conservation responses, underway or needed, to this array of threats. During the remainder of this section, we will examine the top ranked threat (dams and water diversions), threats posed by agriculture, one grow-

**Table 2** Most important threats to cranes and severity of threat to each species

1. Direct (proximate) threats

| Rank | Most important 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Dams & water diversions (changes in quantity, timing, quality of water) | Changes in quantity, timing, quality of water that degrade critical nesting, feeding, and roosting sites; dry conditions leading to increases in wildfires | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 33 |
| 2 | Conversion of wetlands for agriculture & other land development | Render former crane habitats unsuitable for nesting, feeding, roosting & migration stopovers | 2 | 2 | 1 | 1 | 1 | 1 | 3 | 2 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 31 |
| 3 | Over-exploitation of wetlands, including grazing & harvest activities | Disturbance of cranes, reduced habitat quality or food resources | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 3 | 3 | 2 | 2 | 1 | 24 |
| 4 | Changes in agricultural land use (runoff & erosion, cropping practices) | Interference with feeding/breeding on agriculture lands, reduced food resources, increased exposure to agriculture poisons or human disturbance | 1 | 2 | 3 | 1 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | | 23 |
| 5 | Human interference/disturbance, especially at nest sites | Reproductive failure, chick mortality | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | | 2 | 1 | 2 | 2 | 2 | 23 |
| 6 | Drought & desertification, especially related to climate change | Reduced food supplies, increased vulnerability of nests & chicks to predation | 3 | 2 | | 2 | 2 | | | | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 22 |
| 7 | Illegal or overhunting including poisons & nets | Mortality rates that reduce regional populations or species viability | 2 | 1 | 1 | | 2 | 1 | 2 | 2 | 2 | | 1 | 2 | 1 | 2 | 2 | 21 |
| 8 | Collision with utility lines & other human infrastructure | Mortality, crippling | 1 | 1 | 3 | 1 | 1 | | 2 | 2 | 2 | | 2 | | 1 | 2 | 2 | 20 |
| 9 | Live capture for commercial trade (includes also domestication) | Removal of adults from the population, reduced breeding success, increases in mortality, risks of disease introduction to wild populations | 3 | | 3 | 1 | 1 | 1 | 3 | | 2 | | 2 | | 1 | | | 17 |
| 10 | Pollution & environmental contamination, including oil development | Impacts on habitat quality (food sources), reduced health or reproductive fitness, increases in mortality | 1 | 2 | | | | 1 | | 2 | 2 | | 1 | 2 | 1 | 2 | 3 | 17 |
| 11 | Conversion of grasslands for agriculture, afforestation, other development | Reduced breeding & foraging habitat | 1 | 1 | 2 | | 1 | | 1 | | 2 | 2 | 1 | 1 | 2 | 2 | | 16 |
| 12 | Wildfire impacts on nests, eggs, chicks | Mortality, increased predation, nest bandonment | 2 | | 1 | 1 | 2 | | 2 | | 2 | | 2 | | 2 | 2 | | 16 |
| 13 | Urban expansion & land development | Reduced nesting & foraging habitat (e.g. flightless young), increased human disturbance | | 1 | 1 | 1 | | | | 2 | 2 | 1 | 2 | 1 | | 2 | 2 | 15 |
| 14 | Crane mortality related to crop depredation | Increased mortality and human disturbance, reduction of reproductive capacity | 2 | | 1 | 1 | 1 | | 2 | 1 | 2 | 0 | 2 | 0 | 0 | 2 | | 14 |
| 15 | Invasive species | Decreased quality (or loss) of important habitats due to reduced food resources, roost and nesting sites, increased risk of predation | | | | 1 | | | | 2 | 2 | | 2 | | 2 | | 1 | 10 |
| 16 | Disease related to increasing densities & human contact | Mortality, reduced fitness, risks from farm regulatory disease control measures | | | | | | | | 3 | 2 | | | | | 2 | 2 | 9 |
| 17 | Sea level rise | Loss of coastal wetland habitats, salinity increase in coastal freshwater habitats | | | | 1 | | | | | 2 | | 1 | | | | 3 | 7 |
| 18 | Predation | Often associated with habitat changes — reproductive failure, population impacts for rare species | | 1 | | 1 | | | | 1 | | | 1 | | | | 2 | 6 |
| 19 | Genetic & demographic problems of small populations | Reduced reproductive success, decreased resistance to disease | | | | | | | | | 1 | | | 1 | | | 3 | 5 |

2. Indirect (ultimate) threats

| Rank | Most important 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Human population density & growth | Driving force for land development, habitat fragmentation, etc. | 3 | 1 | 2 | 1 | 1 | | 3 | 3 | 2 | | 3 | 2 | 2 | 2 | 1 | 26 |
| 2 | Demand for economic growth & development | Driving force behind dams, diversions, wetland & upland development, pesticide use, etc. | 1 | 1 | 2 | | 1 | | 1 | 2 | 2 | 1 | 3 | 3 | 1 | 2 | 3 | 23 |
| 3 | Lack of knowledge/ awareness/public support | Results in poor land-use & development choices by policy-makers and communities | 2 | 1 | 2 | 1 | 1 | | 2 | 1 | 2 | | 1 | 2 | 2 | 2 | | 19 |
| 4 | Warfare & political instability | Reduced enforcement of laws protecting habitats & cranes, habitat degradation, poaching | 3 | 1 | | | 1 | 1 | 2 | 1 | 2 | | 2 | 1 | 1 | 2 | 0 | 17 |
| 5 | Poverty & lack of livelihood alternatives | Can result in over-exploitation of wetland & grassland resources, poaching, etc. | 3 | | 1 | | | | 3 | | 1 | | 3 | 2 | 3 | 1 | | 17 |
| 6 | Lack of effective legislation, administration, & enforcement | Inadequate protection of cranes & critical habitats | 2 | 1 | | | 1 | | 2 | 1 | 2 | | 1 | 2 | 1 | 2 | | 15 |
| 7 | Loss of traditional values & ties to land | Contributes to unsustainable land-use practices | 2 | 2 | 1 | | 1 | 1 | 2 | | 2 | | 2 | | | 1 | | 14 |
| 8 | Lack of local conservation leadership for cranes & wetlands | Common obstacle to stewardship of local crane & habitat resources | 2 | | | | | | 2 | | 2 | | 2 | | 1 | 2 | | 11 |

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).

ing direct threat to cranes (live capture for commercial trade), and one cross-cutting, ultimate threat — climate change.

## Dams and water diversions

Over the last century, loss of wetland habitat due to changes in hydrology — whether impoundment behind dams, reduced 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, 1993; Finlayson and Spiers, 1996; 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., 1998; Brander et al., 2006). The Lower Zambezi River in southern Africa provides a good example of the impacts of a major dam, the Cahora Basa, 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 (2002) studied the ecology of the highly aquatic Wattled Cranes (*Bugeranus carunculatus*) 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 *Eleochoris*, the main food for these cranes. *Eleochoris* had vanished from the rest of the delta because the Cahora Basa Dam had ended 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, but Bento, Beilfuss, and colleagues studied the many values of the delta to subsistence livelihoods and commercially important industries such as sugar cane (*Saccharum*) and shrimp production. 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 Basa could restore ecosystem services to the wildlife and humans while still providing for production of electricity. Two decades of work are now leading to experimental water releases with careful monitoring of ecological and economic impacts (Beilfuss, 2009, 2010). Recommendations have also been developed for future water releases which will be needed to mitigate impacts of climate change (Beilfuss, 2012).

For threats affecting cranes at an ecosystem scale, the conservation response must come at a commensurate scale and involve expertise and stakeholders with much broader interests than cranes. Changes to freshwater flows on the Guadalupe River in coastal Texas in the United States are an example analogous to Cahora Basa, for a river that is much smaller than the Zambezi yet still critical to the survival of the Whooping Crane (*G. americana*). The only self-sustaining wild population of this species winters within a relatively small area of estuarine habitat where freshwater mixes with salt water and creates conditions suited to blue crabs (*Callinectes sapidus*), a main winter food for the cranes. When freshwater inflows drop below certain thresholds, salinity of these habitats rises so that the blue crabs retreat to deeper water inaccessible to the cranes (Chavez-Ramirez and Wehtje, 2012).

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 becoming more frequent and severe in southern Texas; at those times, rights already granted for water from the Guadalupe River exceed in-stream flows. A diverse community of local governments, businesses dependent on water resources, and conservationists has formed to legally challenge the State of Texas to manage water to preserve the ecological character and ecosystem services of the river estuaries (Beilfuss, 2013).

Problems of water supply are particularly intense in semi-arid regions, such as southern Texas or the Songnen Plain of northeast China, where rainfall is highly variable and droughts occur frequently. Drought coupled with water diversions led, in the early to mid 2000s, to the drying out of the entire network of wetlands set aside in protected areas in Songnen Plain (Harris, 2009). Water management is key to the effectiveness of protected areas for wetlands and must encompass the larger watersheds of which these wetlands are just a small part. Through the United Nations Environment Programme/Global Environment Facility Siberian Crane Wetland Project, water management plans were developed for several reserves of global importance to cranes and other waterbirds. The largest of these sites, Zhalong, which includes 200000 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.

Although cranes have disappeared from many local wetlands due to changes in hydrological character, thus far it has not been demonstrated that cranes are well suited as indicators for wetland health as cranes show a degree of flexibility in habitat selection, and are not sensitive — at least in the short term — to certain environmental changes affecting flora or other fauna. Also, due to their rarity, it is likely that cranes may be absent from some locations due to small population sizes and decline in numbers rather than changes in local habitat conditions.

**Agricultural development**

As agricultural activities have expanded and intensified over the past 50–75 years, landscapes have been substantially altered in nearly all regions. These changes in agriculture bring both benefits and threats to cranes and their habitats. By working with farmers and agricultural agencies to identify and implement practices that are economically viable and ecologically friendly, we can help cranes.

For cranes, plant products rich in energy are crucial for migration and winter survival; foraging strategies for many crane species rely on agricultural lands (Nowald and Fanke, in preparation a). Crane selection of farmlands for foraging, however, depends on proximity to wetlands and to agriculture practice. For example, in Su (2003) found that Sandhill Cranes preferred feeding in spring on soybean (*Glycine max*) fields that had been planted in corn the previous year because these fields were not tilled and waste corn from the previous year remained accessible to the cranes. Corn fields planted in corn both years were less attractive because the fields were plowed before planting with corn.

Wetlands are at risk from agricultural activities. Most wetlands losses have been attributed to drainage for dry-land farming or conversion for growing water-dependent crops such as rice (Dugan, 1993; OECD, 1996; An et al., 2007). Agricultural activities also can markedly change wetlands' natural hydrology, functions, biotic communities, and in turn their value to cranes. Wetlands in arid and semi-arid regions have been altered as water supplies are diverted for irrigation, which often degrades crane habitat. As human populations grow in rural areas, more families seek a living on the land. Farmers are intensifying their agricultural activities by increasing the proportion of land under cultivation and increasing their reliance on commercial fertilizers and pesticides to improve crop yields. 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, in preparation). In several countries the traditional agricultural practices that had benefitted cranes are shifting to new practices and crops detrimental to cranes. As expectations for yields and input costs rise, and space to expand becomes more limiting, farmers' tolerance for real or perceived crop damage is declining and in some areas results in intentional killings. These pressures have broken down the historic harmony that often existed between farmers and cranes, when farmers tolerated and, in some cultures, even revered cranes (Austin, in preparation).

In addition to the loss of wetlands, grasslands, and historically used agricultural habitats, threats associated with agricultural activities are diverse. Burning is a common practice for a variety of crop types in many regions (Korontzi et al., 2006); these fires can destroy crane nests or habitats (Johnson and Barnes, 1991; Goroshko and Tseveenmyadag, 2002; Kong et al., 2007). Yet many wetland and grassland habitats important to cranes have evolved with natural disturbance events such as fire. Fire can be important for maintaining healthy ecosystem function and the more open habitats preferred by cranes (Grice et al., 2010). Understanding the ecological and economic implications of fire, and educating farmers about fire and fire management, will be key to finding the appropriate balance for judicious use of fire for cranes, agriculture, and ecosystem health.

Cranes in agricultural areas can be intentionally or unintentionally disturbed by normal farming activities, such as planting or harvesting, as well as by foot and vehicle traffic. Repeated, intensive, or targeted disturbances can result in reproductive failure, abandonment of breeding territories, or avoidance of roosting or foraging areas (Austin, in preparation). Disturbances on foraging areas also may reduce foraging time and food acquisition, force birds to feed at poorer quality sites, or take more risk to feed (Luo et al., 2012). During the breeding season, human disturbances may keep adults off the nest or away from young chicks, providing greater opportunities for predation (Borad et al., 2002; Olupot et al., 2010).

Sustainable agricultural practices can harmonise the growing need for food production with ensuring a future for wetlands and cranes in an era of climate change and declining food and water security. To date, several steps have been taken to understand the problems and to develop strategies moving forward (e.g., Harris, 2012a). A 2012 workshop in China attended by 100 specialists from 11 countries produced a *Call to Action: Recommendations for Expanding Sustainable Agriculture's Benefits to Cranes, Wetlands, and People in Northeast Asia* (http://www.savingcranes.org/whats-new/2013/02/crane-specialist-group-call-to-action). While the statement focuses on Northeast Asia, the message is pertinent to crane conservation globally. Government agencies are being urged to make wetland protection part of agricultural development, by implementing agricultural policy to minimize harmful effects such as chemical inputs, soil erosion, water management, fire, and livestock where they affect crane habitats. Financial and political support should be provided to all nature reserves to integrate management of wetlands and cranes with adjacent agricultural lands. Laws need to be enacted and enforced against deliberate and accidental poisoning of waterbirds including cranes.

Research is needed to identify and disseminate solutions to reduce damage by cranes to crops and to minimize conflicts with farmers. For example, creating more roosting and feeding areas can help reduce concentration of cranes and resulting crop damage near a few sites (Austin, 2012; Nowald and Fanke, in preparation, a, b). Research is also needed to evaluate water and land management programs designed to benefit wildlife and farmers, and results need to be incorporated into policy.

## Crane trade

Crowned cranes symbolize beauty, wealth, longevity, and good fortune. Although they are revered by many cultures throughout Africa and the world, their unique beauty has ironically led to their decline. The illegal capture of wild Grey Crowned Cranes is a serious threat, causing significant, rapid decline of populations over the past two decades. The Black Crowned Cranes of western and central Africa are similarly affected, and the Wattled Cranes of Southern Africa may be as well. 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).

A few of the captured crowned cranes are eaten or used for medicinal purposes, but most are domesticated within the countries of origin or traded internationally, most often through illegal markets. Possession of wild caught crowned cranes within their countries of origin is a tradition that dates back centuries. The cranes are symbols of prestige and wealth, and are believed to protect the family from evil spirits. They warn of approaching dangers and eat insects around compounds. They may be purchased or given as gifts. Reproduction of captive birds is low and mortality high due to poor care, poor diet, and lack of suitable facilities. Recently it was discovered that demand is high for displays at hotels in countries such as Rwanda. Preliminary research has shown that removal of wild caught cranes is most likely unsustainable in some countries (Morrison et al., 2007).

The Convention on International Trade in Endangered Species (CITES) data and 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 demand for these birds is in the Middle East and the Far East. Too often these birds end up in suboptimal conditions, where they have little to no opportunity to breed, and live shorter lives.

Although there are over 12000 captive facilities internationally, only 10% belong to formal zoo associations. As of February 2009 there were 833 living Grey Crowned Cranes in 228 institutions in 41 countries listed in the International Species Information System. Of these, 14% are recorded as wild caught and 16% as unknown origin (L. Bingaman Lackey, pers. comm., 2013). It is believed that many more birds exist in captivity and are not registered. Currently none of the captive populations of crowned cranes within these zoo associations are self-sustaining. As responsible managers have become aware of the impacts of trade on both species of crowned cranes, efforts have begun to reduce or eliminate the demand for wild caught birds through collaborative and intensively managed breeding programs. For example, the American Association of Zoos & Aquariums (AZA) has developed masterplans for 295 Grey Crowned Cranes and 90 Black Crowned Crane in member institutions. By improving and equalizing representation of wild-caught founders and consistent reproduction, AZA will be able to achieve the goal of preserving 90% of the genetic diversity for 100 years that is needed to maintain viable populations (Reisse and Marti, 2011; Murphy and Schad, 2013). The Chinese Association of Zoos and Aquariums is actively developing breeding and awareness programs for both species. In the past decade there has been minimal import of wild caught cranes into zoos belonging to formal zoo associations. The World Association of Zoos and Aquariums has recognized and branded the African Crane Trade Project to bring global attention to the trade problem. Zoos are developing awareness programs and providing small, but increasing support for field research and community conservation projects for crowned cranes.

ICF and the Endangered Wildlife Trust (South 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. A website has been created (http://www.savingcranes.org/african-crane-trade.html) with a downloadable fact sheet outlining *How Zoos Can Help* (http://www.savingcranes.org/ images/stories/pdf/act/ACTfct_Oct12.pdf).

There is an urgent need to investigate and understand the origins of the current demand for wild caught crowned cranes. It is suspected that wild caught birds are primarily going to zoos and safari or wildlife parks outside the formal zoo associations. Crowned cranes have also been popular among private aviculturists. Awareness programs are needed to inform purchasers of the detrimental impacts of trade to wild populations, and promote responsible breeding and exchange of captive bred birds. A video entitled "*Grey Crowned Cranes Need Our Help!*" has just been released (http://www.savingcranes.org/african-crane-trade.html).

To understand and mitigate the supply side of trade it is important to understand the views and perceptions of communities about the decline of the Grey Crowned Crane. We need to determine the steps in the market chain from the capture site to the final destination, and to understand who benefits and what the economic value of the crane trade is at each stage. Preliminary case studies in nine range countries indicated that 93% of all people interviewed knew cranes were being taken from the wild (Morrison et al., 2007). The communities had noted a decline in cranes and 25% attributed the loss to trade. Everyone knew removal was illegal and that individuals were benefitting, not the community.

In 2012, the Grey Crowned Crane was uplisted to Endangered on the IUCN Redlist. CITES data has been a valuable tool to document trade, but there have been major gaps and errors in the database and it is believed that most trade is illegal and undocumented. As an effort to address international trade, a Significant Trade Review for both species of crowned cranes commenced in 2009. In 2013, trade in Black Crowned Cranes was suspended in Guinea, Sudan and South Sudan and trade in Grey Crowned Cranes was suspended from Rwanda, Uganda and Tanzania. This CITES suspension is in place until the country in question can prove that export will not be detrimental to the wild population and that they are able to successfully monitor export permits granted and actual exports, with the goal of limiting exports in order to maintain the species.

**Climate change**

The stresses brought by climate change to the world's biodiversity, including cranes, will in many cases make the existent threats more severe. By effectively addressing current threats, we can increase the resilience of cranes and their ecosystems to changes yet to come (Harris, 2012b). Cranes, with their dependency on water, are most sensitive to the impacts that climate change will have on hydrology.

As with other ultimate threats such as poverty or warfare (see Table 2), crane conservationists cannot directly address the causes of climate change except as we participate in larger movements. This aspect of responding to climate change is termed mitigation, and includes strategies for reducing the release of carbon dioxide and other greenhouse gases into the atmosphere. Adaptation, on the other hand, involves strategies in response to climate changes we are experiencing, or will experience, that minimize the impacts on communities, whether natural or human. For example, selection of crops less dependent on water will reduce vulnerability of rural communities near crane marshes to less stable water supplies and at the same time reduce demand for water diversions or groundwater extraction for irrigation. Climate change adaptation needs to be incorporated into all conservation efforts.

Some crane species, like many short distance migrants, have already been responding to milder winters and earlier springs. For example, Sandhill Cranes are wintering farther north than previously recorded in eastern North America, and returning to breeding grounds in Wisconsin and elsewhere up to two weeks earlier (Harris, 2012b). Similarly, Eurasian Cranes are now wintering as far north as Germany, Uzbekistan, and Beijing, China. But factors additional to climate change are likely contributing to this trend; these cranes are also responding to the abundant food supply provided by waste grain, and there are simply many more individuals of these two species so that changes in winter distribution in the flyway could be expected.

Because warm air holds more moisture than cool air, climate change will lead to more rainfall. Yet arid regions, where water already is scarce, will lose water through more rapid evaporation. Furthermore, even where annual rainfall holds steady, the rain will come in less frequent but more violent storms. Unless reservoirs or natural wetlands are maintained or restored to hold water back, runoff will occur more rapidly with less benefit to local human needs.

Arid and semi-arid regions, such as the flyway for Siberian Cranes through northeast China, already have cycles of drought that stress natural systems and cause economic losses. With climate change, droughts are likely to become more frequent and more severe. Economic development that has not taken into account water scarcity and variability will lead to years when water supply cannot meet human demand. The common response is to develop additional water diversions and reservoirs, and to expand use of ground water even though water tables may already be falling. These approaches lead to the drying of wetlands critical to breeding and migratory cranes, as has happened at Xianghai and Zhalong National Nature Reserves. While cranes have some ability to adapt to changes in their environment, the loss of suitable habitat for Siberian Cranes at Zhalong, or at Momoge until Etoupao wetland was restored, is indicative of the limits to change through which cranes can survive.

Fortunately, water management planning can restore ecosystem services of wetlands, as has successfully occurred at Momoge National Nature Reserve (Harris, 2009). Wetlands can fulfill important roles in evening out water flow during flood and dry periods, and thus wetland conservation that takes into account an increasingly variable water supply will benefit people as well as cranes and other biodiversity. ICF is now undertaking a demonstration project for Momoge and nearby Tumuji National Nature Reserves that has begun with Climate Change Vulnerability Assessments for the natural systems and also for a human community. Climate change adaptation plans will next be developed, to guide nature reserve management and help people near the wetlands pursue economic development while reducing their vulnerabilities. Water conservation, crop selection, and diversification of economic activities will all be part of the plans.

Effective response to climate change depends upon continued research on crane and wetland ecology, and forecasting future changes. In coastal Texas, for example, warmer temperatures have created conditions for the spread of Black Mangroves (*Avicennia germinans*), which may reduce habitat quality and availability for Whooping Cranes (Chavez-Ramirez and Wehtje, 2012). Sea levels are expected to rise, flooding coastal wintering areas for Red-crowned Cranes in China and Whooping Cranes in Texas, USA. In Texas, ICF, The Nature Conservancy and government agencies are working together to model the impacts of expected sea level rise, predict where future crane habitat may occur, and to protect those lands now before they are lost to incompatible development (Chavez-Ramirez et al., 2013).

## Conservation action

### Knowledge gaps

Lack of knowledge impedes many conservation efforts. Field experiments and systematic monitoring are needed, for example, to determine whether, and under what conditions, wind farms pose threats to cranes. Numerous wind farms are under construction or planned for sensitive crane areas such as coastal China, the Western Cape in South Africa, and the migration corridors for Whooping and Siberian Cranes through the Great Plains of North America and the northeast of China.

Causes for crane population changes are often not clear, including which vital rates are affected and how. For example, why is the continental population of Red-crowned Cranes declining when there is such a large percentage of chicks on the wintering grounds? Studies are needed of the cranes' productivity and the impacts of human disturbance, especially in eastern parts of the breeding range, where water conditions are more stable. The causes for the suspected high mortality of adults need clarification, starting with better documentation of poisoning incidents and systematic analysis of feathers and body tissues for contaminants. Without understanding the threats and how they operate, conservation responses may be ineffective, failing to stem population declines.

In many cases, conservation solutions must be customized or adapted for a specific landscape or culture. For example, crop damage by cranes has led to strong conflicts with farmers in some regions, yet effective solutions that are ecologically, socially, and economically acceptable in some locations (such as the deterrent Avipel mentioned in the Sandhill Crane section) cannot be applied in others — subsistence farmers in East Africa suffering the loss of corn seedlings to cranes cannot afford a chemical deterrent.

Climate change will affect both the natural systems on which cranes rely and the human use of water and other natural resources. To predict crane responses to different climate change scenarios, we need better understanding of crane ecology. We need to know how the Blue Cranes currently respond to changing patterns of land cover in the Western Cape in order to predict vulnerabilities and opportunities for conservation response, as agriculture practices and crop types continue to change. Similarly, studies of Black-necked Crane ecology in agricultural landscapes in the valleys of south-central Tibet need to continue as the climate changes, so that crane conservation can be integrated with future agriculture planning for this area.

### Communication of crane ecology and conservation needs

Most decision-makers, engineers, media representatives, and the general public lack an intuitive understanding of wetland ecology and hence tend to think of wetland systems in terms of more familiar terrestrial systems. Inadequate knowledge about wetland productivity, ecosystem services, and hydrological variation leads to decisions that may have severe and unintended negative consequences. Scientists need to disseminate research results to these diverse audiences, providing the best science to inform crane and ecosystem management.

A great challenge to implementing an ecosystem approach to management of Poyang Lake has been lack of understanding of the critical role that the dramatic fluctuations in water levels within and between years has in maintaining the productivity of the system (Harris and Zhuang, 2010). Similarly, at Zhalong National Nature Reserve and many other locations, lack of awareness of the connectivity of wetlands to surrounding uplands, and the watershed as a whole, has led to degradation of wetlands through incompatible land uses, disruption of natural hydrology, and severe pollution through leaking of toxic chemicals or erosion of soil and nutrients into the water (Harris, 2009). On the other hand, in coastal Texas, foraging studies of cranes led to management of uplands in order to provide additional food sources, and the Whooping Crane forages extensively on acorns and wolfberries that increased as a result of prescribed burning at Aransas National Wildlife Refuge (Chavez-Ramirez et al., 1996).

Lack of awareness of the water retention and flood control functions of wetlands can lead to decisions contributing to wetland loss by the same officials and communities concerned about water supply or floods. Better communication of the ecosystem services of wetlands, and valuation of both short-term and long-term benefits, can lead to stronger awareness programs at key crane areas.

## Scales of conservation action

Threats to cranes operate at different scales. Crane conservation must address the many threats that affect crane populations directly by increasing mortality or decreasing productivity. Yet the most severe threats (identified in Table 2) act upon the ecosystems on which cranes depend. Hence our knowledge base and set of conservation tools must be effective at this larger and more complex scale where highly diverse expertise is needed, ranging from hydrology and aquatic botany to wetland restoration or grazing management. As we have seen, wetlands hosting cranes are in turn dependent on changing conditions in their watersheds, which are sometimes vast in scale and complexity. Poyang Lake, winter home for 98% of the world's Siberian Cranes, is fed by five tributary rivers with watersheds encompassing 98% of Jiangxi Province. In addition, Poyang empties into the Yangtze, but the rate of outflow (or even a reverse flow from the Yangtze into Poyang in summer) is affected by management of the Three Gorges Dam and numerous dams constructed in upper parts of the Yangtze Basin (Guo et al., 2012). Given the importance of Poyang Lake to the livelihoods of millions of people, effective management only becomes possible with a strong knowledge base about natural systems and the benefits they bring to people.

Many crane species are highly migratory, and even tropical species like the Sarus Crane (*G. antigone*) move between wet and dry seasons. Conservation attention continues to focus on understanding the crane flyways and developing international cooperation. Color banding and satellite tracking of White-naped Cranes in Mongolia, for example, suggests that most of these birds migrate to Poyang Lake in winter (T. Natsagdorj, pers. comm., 2012). Conditions on the breeding grounds have been poor, due to prolonged drought leading to low productivity (Goroshko, 2012). Winter counts at Poyang indicate the population has dropped in the past two decades from about 3000 to 1500 or less (Li et al., 2012). But we know little about the migration corridors or stopover sites for this population. Satellite tracking about to commence in northeast Mongolia will aid in identifying stopover locations so that conditions and threats at these important sites can be assessed.

The Wattled Cranes of eastern and southern Africa primarily inhabit large floodplain systems that have highly variable water conditions. It is believed the cranes move among sites (Beilfuss et al., 2003, 2007), but we lack data to understand whether these movements are regular, how many birds are involved, and what conditions trigger these movements. Again, coordinated cross-boundary regional studies are needed.

## Networks at local, regional, and global scales

Given the diversity of expertise and experience needed to respond to the most pressing threats to crane species, the development of networks of specialists who promote crane conservation has had important benefits at all scales. Local networks can reach out personally to stakeholders — such as farmers or water officials. Regional networks facilitate cooperation among countries and between key cranes sites so that flyway scale conservation is achieved. Global networks, such as the Wetlands International - IUCN SSC Crane Specialist Group, with 250 members from 50 countries, enable lessons learned in one crane region to benefit cranes elsewhere in the world. Within such broad groups, more specialized working groups can play an important role — such as the recently formed global network to address the threat of crane collisions with power lines.

### The future for cranes

The threat matrix presents a daunting array of proximate threats linked to ultimate threats that will require cooperation on an unprecedented global scale to effectively address them. We are seeing progress against some threats and need to creatively and actively promote collaboration among decision makers, scientists, managers, and local communities to find and pursue shared solutions to many others.

Fortunately, some crane species have shown remarkable resilience. The recovery and geographic spread of Eurasian and Sandhill Cranes can in part be explained by the adaptability of these species in foraging strategies and increased availability of food resources during the breeding and nonbreeding seasons. Their future will be closely linked to ongoing changes in agricultural practices and the way they share the landscape with farmers. A note of hope is that even the endangered Red-crowned Crane has dramatically increased in Hokkaido following decades of strict protection. The species now lives close to people, utilizing small wetlands and uplands in strong contrast to the continental population that has not benefited from such protection; artificial feeding and over-familiarity with people, however, has brought its own set of challenges for this population. The rapid decline of both species of African crowned cranes illustrates how cranes, once their numbers are reduced due to habitat loss, are highly vulnerable to direct causes of mortality or removal from the wild. Unless current trends in trade of these species are reversed, crowned cranes will vanish from the remaining parts of their ranges. Cranes have also been responsive to wetland restoration efforts; the return of the highly specialized Siberian Crane to restored wetlands at Momoge National Nature Reserve in China is perhaps the most dramatic example.

A long term strategy to secure the future of cranes must focus on reducing direct threats to the birds while safeguarding or restoring habitat and strengthening awareness among decision makers and local communities for how to safeguard cranes and wetlands. The cultural significance of cranes, and their charismatic appearance and behavior, have meant that cranes inspire people to support conservation and indeed lead to actions that benefit large numbers of other species including people. For those crane species that are most severely threatened, significantly stronger efforts will be needed to incorporate our understanding of the needs of cranes and the ecosystems they inhabit into decisions about agriculture, water management, energy development, and other human activities.

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# 全球鹤类现状、威胁及优先保护综述

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**摘要**：本文综述了全球范围内 15 种鹤类的种群动态趋势及受胁状况，并对鹤类的优先保护行动作了总体评价。全球五大洲均有鹤类生存，其中东亚种类最多（9 种），其次是撒哈拉以南非洲地区（6 种）。IUCN 红色名录中 11 种鹤类为受胁而濒临灭绝物种，其中 1 种为极危物种（CR），3 种为濒危物种（EN），7 种为易危物种（VU）。在目前无危的 4 个鹤类中，蓑羽鹤（*Anthropoides virgo*）和澳洲鹤（*Grus rubicunda*）种群现状不是十分明确；但在某些地区，这两种的种群数量也在不断下降。沙丘鹤（*Grus canadensis*）和灰鹤（*Grus grus*）的数量最为丰富，种群数量也在快速增长，部分原因是它们能够灵活选择觅食地，并利用农田中废弃谷物作为食物来源。本文更为详细地总结了灰冠鹤（*Balearica regulorum*）、蓝蓑羽鹤（*Anthropoides paradise*）、黑颈鹤（*G. nigricollis*）、丹顶鹤（*G. japonensis*）、沙丘鹤及白鹤（*G. leucogeranus*）的现状，以说明鹤类家族内种群多样性的变化以及受胁情况。列出了鹤类面临的主要威胁，对各种鹤的威胁进行了逐一评价，并对鹤类家族所受的各种威胁计分。5 种主要威胁中的 4 种均对鹤类赖以生存的生态系统产生直接影响，而另外一种则来自于人类活动的直接干扰。特别讨论了 4 种主要的威胁，即：水坝及河流改道、农业开发、鹤类贸易、气候变化。对鹤类的保护措施应切实具备科学依据，减少对鹤类的直接威胁，保护或修复栖息地环境，增强决策者及群众关于保护鹤类及湿地的意识。对受胁极其严重的鹤类，需要付出更多的努力来综合理解鹤类的需求及其所栖息的生态系统，并与农业、水资源管理及能源发展的决策结合起来。

**关键词**：鹤类，气候变化，栖息地丧失，野生动物贸易