SPECIES REVIEW:

RED-CROWNED CRANE (*Grus japonensis*)

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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

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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.

REFERENCES

Andronov VA. 2008. Red-crowned (*Grus japonensis* P.L.S. Muller, 1776) and White-naped (*Grus vipio* Pallas, 1811) Cranes of the Arkhara Lowland (Middle Amur Basin). Dissertation abstract. Vladivostok, Russia: Far-eastern Federal University. 23 p. (In Russian.)

Andronov VA, Parilov MP, Darman YA. 2013. Results of air census of cranes in the south of Amur Region, Russia, in spring 2012. Newsletter of Crane Working Group of Eurasia 12:7–9. (In Russian with English abstract.)

Andronova RS. 2006. Captive chick raising and reintroduction into natural populations of Red-crowned Crane *Grus japonensis* and White-naped Crane *Grus vipio* (put into practice at the Khinganski Nature Reserve). Dissertation. Moscow, Russia: Moscow State University. (In Russian.)

Andronova RS, Andronov VA. 2015. Results of Red-crowned and White-naped Cranes reintroduction in their breeding grounds. In: Ilyashenko EI, Winter SW, editors. Cranes of Eurasia (Biology, distribution, captive breeding), 5. Proceedings of the IV International Scientific Conference "Cranes of Eurasia: biology, conservation, management", Transbaikalia, Russia, 1–4 September 2015. Moscow – Nizhniy Tsasuchei, Russia: Crane Working Group of Eurasia. p 362–376. (In Russian with English abstract.)

Averin AA. 2011. Cranes in the Jewish Autonomous Region. In: Ilyashenko EI, Winter SW, editors. Cranes of Eurasia (biology, distribution, migrations, management), 4. Moscow, Russia: Crane Working Group of Eurasia. p 131–140. (In Russian with English abstract.)

Darman YA, Andronov VA. 2011. Red-crowned Crane status in the Russian part of Amur River basin. In: Ilyashenko EI, Winter SW, editors. Cranes of Eurasia (biology, distribution, migrations, management), 4. Moscow, Russia: Crane Working Group of Eurasia. p 226–235. (In Russian with English abstract.)

Goroshko OA. 2007. Global ornithological importance of the upper part of the Argun River and problems of its conservation. In: Cooperation in Nature Conservation between the Chita Province (Russian Federation) and the Autonomous Region Inner Mongolia (People's Republic of China) in transboundary ecoregions. Materials of the International Conference. Chita, Russia. (In Russian.)

Goroshko OA. 2009. Status of Red-crowned Crane populations in Trans-Baikal region (Russia) and on the Russian-Chinese Argun River (the upper Amur River Basin). In: Koga K, Hu D, Momose K, editors. Toward the future: the Red-crowned Crane and people. Kushiro, Japan: Tancho Protection Group. p 20–29.

Goroshko OA. 2012. Red-crowned Cranes on the Russian-Chinese Argun River and neighboring parts of the Daurian steppes. Chinese Birds 3(3):230–237.

Goroshko OA. 2015a. Status of Cranes in Dauria (Transbaikalia). In: Ilyashenko EI, Winter SW, editors. Abstracts of the IV International Conference "Cranes of the Palearctic: Biology, Conservation, Management," 5. Moscow – Nizhniy Tsasuchei, Russia: Crane Working Group of Eurasia, p 30–31. (In Russian with English abstract.)

Goroshko 2015b. Population dynamics and current status of cranes in Dauria (Transbaikalia and Mongolia). In: Ilyashenko EI, Winter SW, editors. Abstracts of the IV International Conference "Cranes of the Palearctic: Biology, Conservation, Management," 5. Moscow – Nizhniy Tsasuchei, Russia: Crane Working Group of Eurasia. p 116–134. (In Russian with English abstract.)

Goroshko OA. 2016. A Daurian summer of the Red-crowned Crane. Available at Daursky State Nature Reserve website at http://daurzapoved.com/index.php/ru/novosti/nauka/725-daurskoe-leto-yaponskogo-zhuravlya (accessed 16 December 2016; in Russian).

Harris J. 2009. Safe flyways for the Siberian Crane: a flyway approach conserves some of Asia's most beautiful wetlands and waterbirds. Baraboo, Wisconsin, USA: International Crane Foundation. 99 p.

Harris J, Mirande C. 2013. A global overview of cranes: status, threats, and conservation priorities. Chinese Birds 4(3):189–209.

Healy H. 2011. A vision for cranes in a divided Korea. The Bugle 37(1):1–3.

Kazachinskaya S. 2012. The Amur River dynamics of climate and hydrological regime in its middle stream during the last hundred years. In: Harris J, editor. Cranes, agriculture and climate change, proceedings of a workshop organized by the International Crane Foundation and Muraviovka Park for Sustainable Land Use. Baraboo, Wisconsin, USA: International Crane Foundation. p 145.

Koga K. 2008. The status review of the Tancho in Hokkaido: current threats. In: Koga K, Hu D, Momose K, editors. The current status and issues of the Red-crowned Crane. Proceedings of the Meeting, "Establishment of a Feasible International Project for Protection of the Tancho *Grus japonensis* in 2007." Kushiro, Hokkaido, Japan: Tancho Protection Group. p 13–20.

Koga K, Hu D, Momose K, editors. 2008. The current status and issues of the Red-crowned Crane. Proceedings of the Meeting, "Establishment of a Feasible International Project for Protection of the Tancho *Grus japonensis* in 2007." Kushiro, Hokkaido, Japan: Tancho Protection Group. 231 p.

Koga K, Hu D, Momose K, editors. 2009. Toward the future: the Red-crowned Cranes and people. Kushiro, Hokkaido, Japan: Tancho Protection Group.

Koga K, Hu D, Momose K, Lee K, Ilyashenko E, Momose YS, editors. 2010. Cranes and people: prologue to a new approach for conservation of the Red-crowned Crane. Kushiro, Hokkaido, Japan: Tancho Protection Group. 120 p.

Lee K. 2009. Wintering status of Red-crowned Crane and current problems in Korea. In: Koga, Hu, Momose, editors. Toward the future: the Red-crowned Crane and people. Kushiro, Hokkaido, Japan: Tancho Protection Group. p 12–19.

Leonovich VV. 1965. The Ussuri crane should be protected. Hunting and Game Management 9:5. (In Russian.)

Li Y, Song C, Yang Y, Li X, Li F, Huang J, Huang X. 2012. Monitoring population dynamics of the migratory Red-crowned Crane (*Grus japonensis*) at Shuangtaihekou National Nature Reserve, northeastern China, from 1991 to 2012. Chinese Birds 3(3):225–229.

Liu C, Zhang S, Jiang H, Wang H. 2009. Spatiotemporal dynamics and landscape pattern of alien species *Spartina alterniflora* in Yancheng coastal wetlands of Jiangsu Province, China. China Journal of Applied Ecology 20:901–908. (In Chinese.)

Liu H, Lu X, Zhang S, Yan Q. 2005. Fragmentation process of wetland landscape in watersheds of Sanjiang Plain, China. China Journal of Applied Ecology 2:298–305. (In Chinese.)

Luo J, Ye Y, Gao Z, Wang W, Hartup BK. 2016. Lead in the Red-Crowned Cranes (*Grus japonensis*) in Zhalong Wetland, Northeastern China: A Report. Bulletin of Environmental Contamination & Toxicology 97(2):177–183.

Ma Z, Melville DS, Liu J, Chen Y, Yang H, Ren W, Zhang Z, Piersma T, Li B. 2014. Rethinking China's new great wall, massive seawall construction in coastal wetlands threatens biodiversity. Science 346(6212):912–914.

MacKinnon JR, Murray N, Verkuil Y. 2012. IUCN situation analysis on East and Southeast Asian intertidal habitats, with particular reference to the Yellow Sea (including Bohai Sea). Bangkok, Thailand: IUCN Species Survival Commission. 76 p.

Masatomi H. 1991. Population dynamics of Red-crowned Cranes in Hokkaido since the 1950s. In: Harris J, editor. Proceedings 1987 International Crane Workshop. Baraboo, Wisconsin, USA: International Crane Foundation. p 297–299.

Masatomi Y. 2008. A simple population viability analysis for the Tancho in Hokkado. In: Koga K, Hu D, Momose K, editors. The current status and issues of the Red-crowned Crane. Proceedings of the Meeting, "Establishment of a Feasible International Project for Protection of the Tancho *Grus japonensis* in 2007." Kushiro, Hokkaido, Japan: Tancho Protection Group. p 27–38.

Masatomi Y. 2013. PTT attached individual. Tancho (18):8. (In Japanese.)

Meine CD, Archibald GW, compilers. 1996. The cranes: Status survey and conservation action plan. Gland, Switzerland: International Union for Conservation of Nature and Natural Resources 282 p.

Momose YS, Qian F, Momose K, Lee K. 2013. The International Winter Census of the Red-crowned Crane in 2011/2012 and 2012/2013. In: Ilyashenko E, editor. Newsletter of Crane Working Group of Eurasia 12:64.

Muratshina KG. 2015. Russia – China: risks of cooperation in usage of transboundary wetlands. In: Muratshina KG, editor. Oriental studies in Ural Region: International Almanac, 6. Ekaterinburg, Russia: Ural University. p 85–95.

Nikitina IA, Svetlakov AN, Surmach SG. 2006. Aerial surveys of rare bird species of the Bolon Reserve and adjacent territories of the Middle Amur lowlands. In: Scientific Study of Natural Systems of the Middle Amur lowlands. Khabarovsk, Russia. p 87–93 (In Russian.)

Parilov MP, Parilova TA. 2013. Experience of early spring preventive burns: the first results (Khingansky Nature Reserve). In: Proceedings of Far-eastern Conference on Nature Protection. Blagoveshchensk, Amur Region, Russia: Blagoveshchensk State Pedagogical University. p 245–249. (In Russian.)

Qian F. Jiang H, Yu G, Yu Y, Yang J, Pang S, Piao R. 2012. Survey of breeding populations of the Red-crowned Crane (*Grus japonensis*) in the Songnen Plain, northeastern China. Chinese Birds 3(3):217–224.

Shibaev YV. 1982. Distribution and population size of Red-crowned Crane at the east of its range. In: Litvinenko NM, Neufeldt IA, editors. Cranes of East Asia. Vladivostok, USSR: Far East Science Centre, USSR Academy of Science. p 213–214. (In Russian with English abstract.)

Shibaev YV, Glushchenko YN. 1982. Modern status and problems of conservation of Japanese Crane on Khanka Plain. In: Litvinenko NM, Neufeldt IA, editors. Cranes of East Asia. Vladivostok, USSR: Far East Science Centre, USSR Academy of Science. p 35–43. (In Russian with English abstract.)

Smirenski S. 2015. Memorandum of Understanding about Hooded Cranes. ZHURAVL: A Newsletter of the Friends of Muraviovka Park. February 2015:20.

Smirenski SM, Danner G, Harris JT. 2018. Agriculture program of Muraviovka Park: integrating wetland conservation with farming. In: Austin JE, Morrison K, Harris JT, editors. Cranes and Agriculture: A Global Guide for Sharing the Landscape. Baraboo, Wisconsin, USA: International Crane Foundation. p 243–258. Available at https://www.savingcranes.org/wp-content/uploads/2018/10/cranes_and_agriculture_web_2018.pdf (accessed 10 May 2019).

Smirenski SM, Kitagawa T, Nosachenko GV. 2012. Importance of agriculture fields for cranes in the south of the Amur Region (abstract). In: Harris J, editor, Cranes, agriculture, and climate change. Proceedings of a workshop organized by the International Crane Foundation and Muraviovka Park for Sustainable Land Use. Baraboo, Wisconsin, USA: International Crane Foundation. p 150.

Smirenski SM, Roslyakov GE. 1982. Status of breeding grounds of cranes in Priamurie. In: Litvinenko NM, Neufeldt IA, editors. Cranes of East Asia. Vladivostok, USSR: Far East Science Centre, USSR Academy of Science. p 12–17. (In Russian.)

Smirenski SM, Smirenski EM. 2009. Protection Status of the Red-crowned Crane in the Amur Region of Russia: practical measures to offset the threats. In: Cranes and People: Prologue to a New Approach for Conservation of the Red-crowned Crane. Proceedings of the International Workshop "Establishment of a Feasible International Project for Protection of the Tancho *Grus japonensis*," 21–26 October 2009." Kushiro, Hokkaido, Japan: Tancho Protection Group. p 21–31.

Smirenski SM, Smirenski EM. 2012. Current conservation challenges in the lowlands of the Middle Amur Basin and possible solutions. In: Harris J, editor. Cranes, agriculture and climate change. Proceedings of a workshop organized by the International Crane Foundation, Muraviovka Park for Sustainable Land Use, Russia, 28 May–3 June 2010. International Crane Foundation: Baraboo, Wisconsin, USA. p 152.

Smirenski SM, Smirenski EM. 2014. The year of the flood. ZHURAVL: A Newsletter of the Friends of Muraviovka Park. February 2014. p 1, 10–13.

Smirenski SM, Smirenski EM. 2015a. Twenty years and counting. ZHURAVL: A Newsletter of the Friends of Muraviovka Park. February 2015. p 1, 10–14.

Smirenski SM, Smirenski EM. 2015b. Current status and top priorities for crane conservation in far-eastern Russia. In: Proceedings of the International Conference on Endangered Cranes, Suncheon Eco-Park, South Korea. Seoul, South Korea: Korean Federation for Environmental Movement.

Smirenski SM, Smirenski EM, Surmach SG, Masatomi Y, Kunikazu Momose K. 2018. Ecology and Conservation of Red-crowned Cranes in Russia. In: F. Nakamura F, editor. Biodiversity Conservation Using Umbrella Species. Chapter 6. Ecological Research Monographs. Republic of Singapore: Springer Nature Singapore Pte Ltd. p 107–128.

Smirenski SM, Thompson B, Smirenski EM. 2011. Language-environmental schools – the way students begin to speak English and become aware of nature. Proceedings of XI International Scientific & Practical Conference. Nizhniy Novgorod, Russia: Nizhniy Novgorod University. p. 207–209.

Su L. 1993. Comparative feeding ecology of the Red-crowned and White-naped Cranes. M.S. Thesis. Columbia, Missouri, USA: University of Missouri.

Su L. 2008. Challenges for Red-crowned Crane conservation in China. In: Koga K, Hu D, Momose K editors. The current status and issues of the Red-crowned Crane. Proceedings of the Meeting "Establishment of a Feasible International Project for Protection of the Tancho *Grus japonensis* in 2007." Kushiro, Hokkaido, Japan: Tancho Protection Group.

Su L, Zou H. 2012. Status, threats and conservation needs for the continental population of the Red-crowned Crane. Chinese Birds 3(3):147–164.

Teraoka H. 2008. Heavy-metal contamination status of the Tancho in Japan – extensive mercury pollution. In: Koga K, Hu D, Momose K, editors. The current status and issues of the Red-crowned Cranes. Kushiro, Hokkaido, Japan: Tancho Protection Group. p 21–26.

Wang H, Wang Q, Chu G, Jiang H, Qian F. 2005. Distribution and population number of Red-crowned crane wintering in Yancheng Nature Reserve, in China. In: Wang Q, Li F, editors. Crane research in China. Kunming, China: Yunnan Education Publishing House. p 49–57. (In Chinese.)

Zhang S, Na X, Kong B, Wang Z, Jiang H, Yu H, Zhao Z, Li X, Liu C, Dale PE. 2009. Identifying wetland change in China's Sanjiang Plain using remote sensing. Wetlands 29(1):302–313.

Zhou D, Xia X, Xu W, Zhang H, Qian Z, Gao J, Wang Z, Jiang M. 2016. A growing captive population erodes the wild Red-crowned Cranes (*Grus japonensis*) in China. Avian Research 7(1):22. DOI 10.1186/s40657-016-0056-z.