

SPECIES REVIEW:
BLACK-NECKED CRANE (*Grus nigricollis*)

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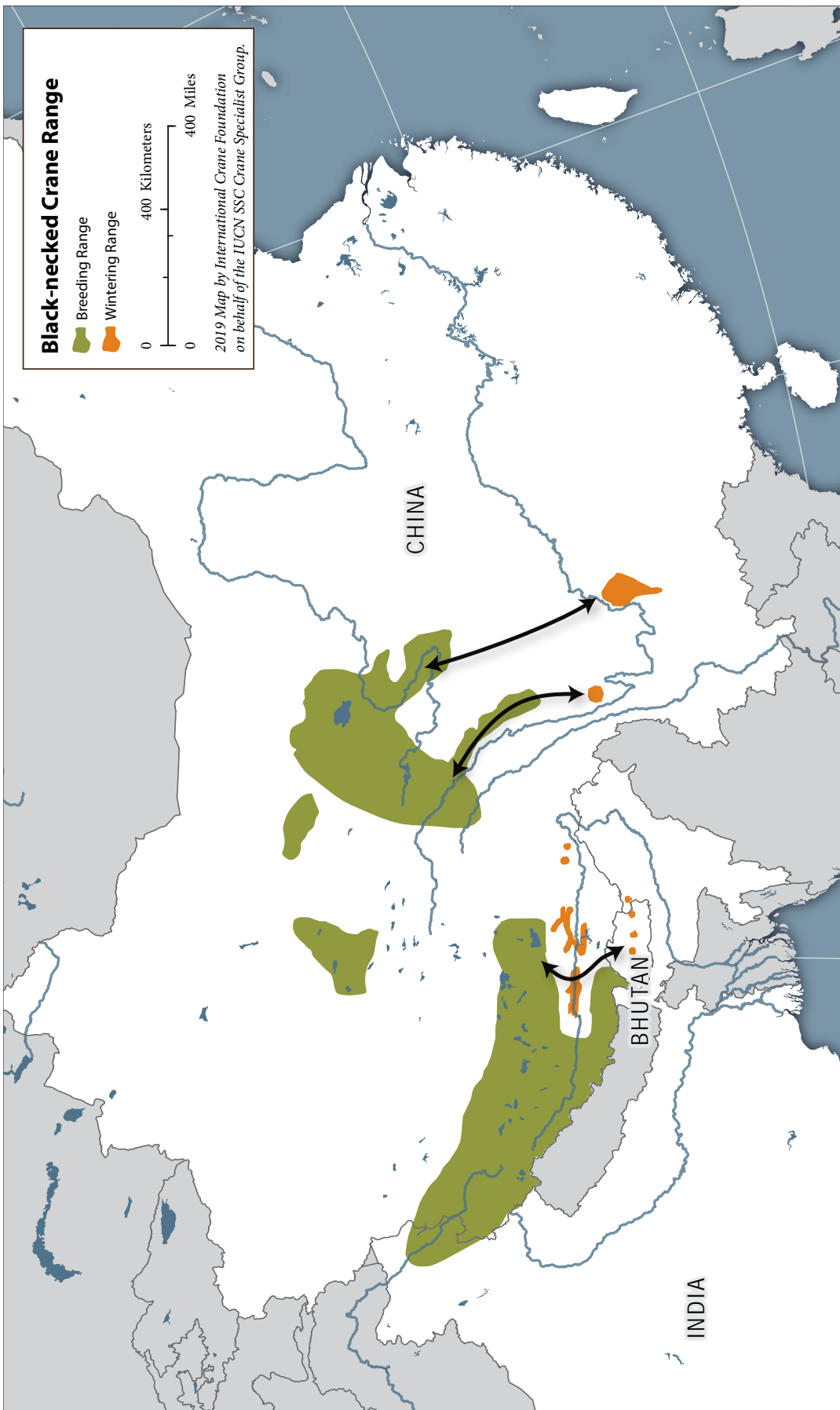
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Black-necked Crane pair nesting at Yanchiwan, China, with melting glacier in the background (Photographer: Yongjun Se, Yanchiwan National Nature Reserve)

Red List Category: Vulnerable
Population Size: 10,000–10,200
Population Trend: Increasing
Distribution: Central Asia



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

DISTRIBUTION AND STATUS OF KEY SITES

The Black-necked Crane breeding range includes much of the Qinghai-Tibetan Plateau in western China, with a small breeding population occurring in adjacent Ladakh in India. Wintering grounds include lower elevations of the Qinghai-Tibet and Yunnan-Guizhou Plateaus in China, with several hundred occurring in Bhutan and few birds in Arunachal Pradesh in northeast India. There are approximately 10,000–10,200 Black-necked Cranes remaining in the wild (Li 2014).

Subspecies/Populations

The Black-necked Crane is a monotypic species. No genetic study has been done on sub-populations or subspecies. The summer breeding range of this crane stretches throughout mostly continuous plateaus. There are three isolated wintering populations.

Breeding Grounds

The Ruoergai marshes, located on the north-eastern edge of the Qinghai-Tibet Plateau, have the largest population estimated at about 2,500 Black-necked Cranes (Liu et al. 2009). The marshes include two national, one provincial, and two county reserves (Ministry of Environmental Protection of People's Republic of China 2010), with Ruoergai National Nature Reserve (NNR) designated as a Ramsar site.

Celin Cuo Black-necked Crane NNR probably has the largest concentration of Black-necked Cranes in Tibet. Although no counts have been done for the entire reserve, a survey at Shenzha, located in the southern part of the reserve, recorded a total of 16 nests in 1991 (Dwyer et al. 1992). Surveys in the same region in 2000 revealed a minimum of 30 breeding pairs, suggesting an increase of the population on the breeding grounds (Archibald 2005). From July–August 2008, the National Bird Banding Center and the Wildlife Conservation Society (WCS) jointly conducted a breeding population survey of this species in Changtang region of Tibet, covering Anduo, Bange, Shenzha, and Nima of Naqu prefecture; Cuoqin, Gaize, Geji, Gaer, Ritu, Zhada, and Pulan of Ali Prefecture; and Zhongba and Saga of Shigaze Prefecture.

A total of 514 Black-necked Cranes were recorded including 38 chicks, mostly concentrating in Cuo Lake, Shibu Cuo, Mujiu Zangbu, Mujiu Cuo, Rebanggou Wetland, and Mapangyong Cuo (Zhang et al. 2015).

There are more Black-necked Cranes than previously thought in Xinjiang, with an estimated 220 breeding or summering, and an additional 137 birds recorded at the Altun NNR during the migration period (Ma et al. 2011). There were potentially six areas with Black-necked Cranes in central Xinjiang, as well as locations adjacent to Tajikistan, Kazakhstan, and Mongolia (Ma et al. 2011).

The number of resident Black-necked Cranes at Longbaotan in Qinghai Province was about 100–125 cranes in the summer of 2011. The highest count (of 16 counts) was 216 in April 2011. Thirty breeding pairs were present in 2011. Minimum count of 16 counts was 81 in 2011. Peak count (of two counts) in 2012 was 178 (Farrington and Zhang 2013).

A newly rediscovered place is a plateau along Shaluli Mountains, including Daocheng, Xinlong, Litang, and Baiyu (Liu et al. 2010, Zhu et al. 2009, Liu et al. 2012). This species was seen to be abundant in migration in Litang over 70 years ago by Dolan (1939). During summer surveys in Daocheng alone in 2007 and 2008, 29 Black-necked Cranes were recorded, including seven pairs (Zhu et al. 2009).

Ladakh is the only breeding area for Black-necked Cranes in India, with a total of 64 birds including 51 adults and 13 chicks in 2004 (Chandan et al. 2005). The population increased to 15 breeding pairs and a total of 81 cranes in 2008. During a count conducted by the World Wildlife Fund (WWF)-India

team in Ladakh in October 2012, the Black-necked Crane population in Ladakh had further increased to 139 birds. This count included 128 adults and 11 juveniles, the highest number of birds ever recorded in Ladakh (Chandan et al. 2014).

Where old data are available, for three widely separated locations, the numbers of breeding pairs have been increasing: Shenzha (see earlier paragraph), Longbaotan (only six pairs in 1988; Farrington and Zhang 2013), and Ladakh only (12 breeding pairs in 1998; Pfister 1998).

Wintering Grounds

Black-necked Cranes spend the winters mainly in three populations:

Eastern population (northeastern Yunnan and northwestern Guizhou Provinces): Three national nature reserves on the Yunnan-Guizhou Plateau in this flyway (Dashanbao, Cao Hai and Huize) have a total of 2,469 Black-necked Cranes (2004 data), accounting for 69% of the total population in this flyway (Li and Yang 2005). Satellite tracking data of eight birds and two color-banded cranes show birds from Dashanbao and Cao Hai migrate to Ruorgai for breeding (Qian et al. 2009, Wu et al. 1993).

Central population (northwestern Yunnan): Napahai Provincial NR has a stable population of 270 Black-necked Cranes, an increase from less than 100 in the 1980s and before 1997 (Zhao and Yu 2005, Wang et al. 2009). Napahai is the winter home for >90% of Black-necked Cranes in the central flyway.

Western population (south-central Tibet and Bhutan): Along the Lower and Middle Reaches of the Yarlung Tsangpo (Brahmaputra) River Basin, the Middle Yarlung Tsangpo Black-necked Crane NNR hosts the majority of wintering Black-necked Cranes in Tibet. This reserve, established in 1993 (Ministry of Environmental Protection of People's Republic of China 2010), covers almost all wintering areas in Tibet, although there has been virtually no active management.

Black-necked Cranes are recorded in four wintering sites in Bhutan at Phobjikha, Bumdeling, Khotokha, and Bumthang. Among the four sites, 437 birds were counted at Phobjikha and Bumdeling combined, accounting for 95% of the total population in Bhutan (Royal Society of Protection of Nature 2012). In the winter of 2014–15, there were 544 birds in Bhutan (Royal Society of Protection of Nature 2015).

ECOLOGY

The Black-necked Crane is the only exclusively alpine species among the 15 species of cranes in the world, with breeding grounds ranging from 2,600–4,800 m above sea level and wintering grounds at 2,000–3,800 m above sea level (Wu et al. 1991, Dwyer et al. 1992). Black-necked Cranes roost in shallow water on lakes, river banks, or small ponds. Throughout the year they forage in agricultural fields, shallow wetlands, and grasslands. However, in many breeding areas at high altitudes where crops cannot be grown, they forage mainly in wetlands and heavily grazed pastures. By nesting at high altitudes Black-necked Cranes, in contrast to other migratory cranes, have relatively short migration routes, with the longest ~700 km (Wu et al. 1993, Gao et al. 2007, Qian et al. 2009), while the shortest extends 200 km or less (Wangmo 2007, Liu et al. 2010). The cranes migrate both altitudinally and along north–south routes. The migration route from the wintering area in Bhutan to the breeding area in China is 120 km (Sherub, personal comm. 2014).

NUMBERS AND TRENDS

Numbers of Black-necked Cranes have been monitored annually over many years in representative wintering sites practically across the entire range of the species. The world population of Black-necked Cranes grew from about 5,000–6,000 in the early 1990s (Meine and Archibald 1996) to about 11,000

a decade later (Bishop and Tsamchu 2007). While the higher numbers may be due in part to more complete counts, significant growth also seems to have occurred. The current world population of Black-necked Cranes is estimated at 10,000–10,200, based on most recent counts of 3,687 (eastern population; Yang and Zhang 2014), 232–300 (northwest Yunnan; Yang and Zhang 2014; Qiang Liu, personal comm. 2014), 5,558 (Tibet; Zhang et al. 2014), 550 (Bhutan; Phuntsho and Tshering 2014), and ~10 (India; Chandan et al. 2014).

Over a ten-year period of 2000–2010, the population is believed to have been stable, based on close monitoring of this species at several key wintering sites. In the western population, counts in Bhutan averaged 458 from 11 counts (ranging from 425–509) (Royal Society of Protection of Nature 2012). In Shigaze, where ~3,600 cranes overwinter, their numbers were relatively consistent during 2006–2010 (Bishop et al. 2012). In the central population, counts from 2001–2007 recorded an average of 290, ranging from 263 to 320, although this population might be experiencing a slight decline since the juvenile recruitment was 8.4% in winter of 2009 (Qiang Liu, personal comm. 2014), compared to 11.84% in 2002 (Li and Yang 2005). In the eastern population, Cao Hai and Dashanbao have recorded about 1,000 birds each.

THREATS

This conservation success may be partly attributed to improvement of natural breeding habitats through glacier melting, as well as to lower mortality throughout the year due to warm temperatures and the enforced protection of cranes, especially in China, where hunting of cranes by Han Chinese in Tibet was perhaps widespread from 1960–1990. It stands in marked contrast to significant population declines for most waterbirds in Asia over the same period. Still, this species faces significant threats. In India, due to sustained conservation efforts during the past two decades, the population is showing increasing trends. Threats to the nesting birds, however, are still very serious and the recruitment rate is very low compared to the overall population (Pankaj Chandan, personal comm. 2014).

Overall Range

Climate change is already having significant impact on high-altitude regions of central Asia, with changing rainfall patterns and rapid glacial melt. Climate models indicate that the Tibetan Plateau will undergo even more drastic changes in coming decades, with loss of glaciers leading to water shortages and extensive loss of wetlands that will threaten breeding waterbirds of the region including Black-necked Cranes. Open water area at Seling Lake is increasing while Longbao and Ruorgai are drying up. Lakes are getting bigger at present from glacier melt and increased rainfall, but many shallow wetlands used by cranes are believed to be disappearing due to permafrost degradation (Farrington 2009, Ma et al. 2009, Qiu 2012). Similarly, in Ladakh in India, Lake Tsomoriri (a closed basin) showed a rise in water between 2000 to 2006 and then suddenly the water level started decreasing, whereas Tsokar Basin is regularly shrinking (Pankaj Chandan, personal comm. 2014).

Developmental activities have been dramatic in the range of the Black-necked Crane in the past decade, specifically:

- Growing human populations with increasing water demands that negatively impact the availability and quality of water in the marshes;
- Development of tourism, resulting in disturbance from road construction, vehicles, and disposal of waste;
- Changes in wetlands due to natural and man-made causes;

- Wetland reclamation for agriculture, and changes in agricultural practices (e.g., traditional crops replaced by higher yield crops, and land plowing in the fall instead of spring) in farmlands used by cranes; and
- Power lines and wind turbines installed to meet the rapid economic development.

Breeding Grounds

- Overgrazing and destruction of habitat by domestic yaks (*Bos grunniens*), cows (*Bos taurus*), sheep (*Ovis aries*), and goats (*Capra hircus*) within the marshes and surrounding habitats, fencing of wetlands throughout the breeding range, and—especially threatening—livestock spend more time grazing on wetlands due to deterioration of less resilient upland dry pastures;
- Disturbance and predation of eggs and chicks by feral dogs (*Canis lupus familiaris*) in Ladakh and China;
- Overgrazing at Ruoergai, which leads to vegetation degradation, desertification in local areas, and increasing populations of rodents;
- Chemical applications to control rodents, one of the food items of Black-necked Cranes at Ruoergai (Dejun Kong, personal comm. 2014);
- In some cases, as in Hanle in Ladakh, development of tree plantations in high-altitude wetlands have severely impacted the breeding habitat of Black-necked Cranes; and
- Wetland reclamation for agriculture and construction activities.

Wintering Grounds

- Plantations of willows (*Salix*) and poplars (*Populus*), especially in and near roost sites in Tibet, and tree plantations on grassland/farmlands on which cranes forage in Yunnan (Kong et al. 2011);
- Increased mortality due to collision with power lines, especially in winter areas in Tibet and the Yunnan-Guizhou Plateau (Li et al. 2011). Rapid development of wind farms has been proposed in many areas across the species' range, and could become a problem;
- Mortality from poisoning due to farmers mixing seeds with chemicals, mainly for rodent and insect control, in China;
- Change from traditional to modern crops, methods, and tools in Tibet (e.g., barley [*Hordeum vulgare*] to winter wheat [*Triticum aestivum*], fall plowing, conversion of barley fields to greenhouse agriculture);
- Water pollution within wetlands from nearby cities on the Yunnan-Guizhou Plateau, degrading/damaging wetland ecosystems; and
- Regular floods in the wintering habitat at Bomdeling in Bhutan and at Sangti in India have washed away major wintering habitat in both areas.

Along the Flyway

Very little has been done for study or conservation of habitats along the flyways because there are no major staging areas and Black-necked Cranes make many short stops (Li et al. 2007, Qian et al. 2009). Individually, these small wetlands may not have additional wildlife values. However, they are crucial to the survival of this species. Lack of knowledge prevents identification of threats or effective

conservation responses, or assessment of significance of individual wetlands or groups of wetlands. Little is known about Black-necked Crane flyways west of Sichuan.

CONSERVATION AND RESEARCH EFFORTS UNDERWAY

Regionally

- A Black-necked Crane Conservation Network was formed in China in 2006, and has held meetings every 12–18 months at key crane sites;
- Regional coordinated winter counts, at different scales of coverage by varying methods, were conducted several times in the past and should be repeated with coordination of timing and methods every five years;
- WWF-India and the Royal Society for the Protection of Nature have been taking a leading role in coordinating conservation work for Black-necked Cranes respectively in India and Bhutan;
- Long-term cooperation among partners, such as Kunming Institute of Zoology of the Chinese Academy of Sciences, the Tibet Plateau Institute of Biology, the National Bird Banding Center of China, and ICF;
- A network of protected areas for Black-necked Cranes has been established in China, covering a total of 89,073 km², including 10 national-level, eight provincial-level, and four county-level reserves by the end of 2009 (Ministry of Environmental Protection of People's Republic of China 2010); and
- Much information on Black-necked Cranes has been reported in China Crane News, including a special issue on the species, published in 2015 (China Crane and Waterbird Specialist Group 2015).

Locally and at Sites

- Kunming Institute of Zoology of the Chinese Academy of Sciences has conducted research on the ecology of Black-necked Cranes in Sichuan, Yunnan, and Guizhou Provinces since 2004;
- Cao Hai and Dashanbao NNRs were designated under the Northeast Asia Crane Site Network (they are now part of the East Asian – Australasian Waterbird Site Network);
- The Tibet Plateau Institute of Biology has worked on winter surveys and breeding and winter ecology of the crane for over two decades in Tibet;
- The Royal Society for Protection of Nature (Bhutan) has conducted monitoring and education in wintering areas of this species in Bhutan for many years;
- At Cao Hai, multiple domestic and international organizations have targeted a wide range of issues, and implemented activities including research, conservation, education and community development for the past two decades;
- At Ruoergai, long-term monitoring of wetland habitats in relation with climate and human activities has been conducted by ICF working with local universities in Sichuan and Gansu Provinces;
- A waterbird survey was conducted in Tibet, including Black-necked Cranes, by the National Bird Banding Center of China and Wildlife Conservation Society in Tibet in summer of 2008;
- Longbao population study was conducted by WWF in 2011; and
- In Ladakh and Arunachal Pradesh in India, WWF-India is taking the lead role in coordinating various conservation and research activities on the species.

CHANGES SINCE 1996

Over the past 15 years, China's economic growth has been over 8% annually, resulting in pressure on land and water resources as well as other development related pressures, including tourism. Although regions in western China and other countries with Black-necked Cranes have been developing more slowly due to harsh physical conditions, changes in habitats have been dramatic. For example, in Napahai, the primary wintering area for the central population, an airport was constructed close by the wetland, with direct impacts as well as increasing the inflow of tourists. At present, an airport is in the planning phase for Ruoergai, the most important breeding area for the eastern population of this species. Unplanned developmental activities, plantations in wetlands, drainage of wetlands to create more cropland, increasing population of feral dogs, and disturbances from tourists threaten the welfare of cranes in Ladakh, India. And in eastern Bhutan, warmer winter facilitates winter crops on fields that formerly in winter were harvested rice fields with gleanings for cranes.

In terms of protection status, five out of 22 Black-necked Crane nature reserves in China have been established since 1996. Among 10 national reserves, eight have been upgraded from either the provincial or county level since 1996. Increasing the number of protected areas and upgrading reserve levels do not necessarily mean these areas have been secured, rather it indicates how urgently these areas are under environmental and economic pressure.

Research on Black-necked Cranes has improved knowledge dramatically for habitat selection, response to power lines, foraging and other behaviors, migration, and breeding distribution. Studies using satellite telemetry have greatly improved our understanding of migration of this species, with a total of 18 satellite transmitters deployed in China and Bhutan; among them, 17 were actually tracked for a full migration or more. The Black-necked Crane has been a focal species of the bird group at the Kunming Institute of Zoology of the Chinese Academy of Sciences since 2002; mainly due to its Black-necked Crane work, the Bird Group was re-established at the Kunming Institute of Zoology in 2011. The National Bird Banding Center, as a coordinating agency in crane conservation in China, has played an important role in establishment of Black-necked Crane Conservation Network and regional coordination in the species' conservation and management. WWF-India has conducted a long-term research on the breeding biology of the species in Ladakh. At regional level, WWF-India has linked conservationists and managers from the range states to enhance regional cooperation for the species. And in Bhutan, where cranes are revered, the Black-necked Crane is the symbol of a leading political party, as well as of the Royal Society for the Protection of Nature.

PRIORITY RESEARCH AND CONSERVATION ACTIONS

Recently, discussions to undertake potential downgrading of the status of Black-necked Cranes have been initiated. Any actions taken on Black-necked Cranes, especially down-listing, should be taken with great caution. The stability and growth of the population of this species, in part due to successful conservation interventions, stands in marked contrast to significant population declines for most waterbirds in Asia over the past two to three decades. The increase in Black-necked Cranes may be also due in part to improved survival in both summer and winter due to global warming. Climate models indicate that the Tibetan Plateau will undergo even more drastic changes in coming decades, however, with loss of glaciers leading to water shortages and extensive loss of wetlands that will threaten breeding waterbirds of the region, including Black-necked Cranes. Also, the melting of the permafrost will result in the disappearance of "perched" wetlands where cranes breed. Furthermore, the Black-necked Crane is an important flagship species in the high-altitude wetlands. Almost all wetland nature reserves, especially national wetland nature reserves on the Western China plateau, were established almost exclusively because of Black-necked Cranes. In the state of Jammu & Kashmir

in India, the Changthang Cold Desert Wildlife Sanctuary and many wetland conservation reserves have been established only because of the presence of Black-necked Cranes (Pankaj Chandan, personal comm. 2014). The bird is also the State Bird of Jammu & Kashmir State of India. Downscaling the conservation status of Black-necked Cranes would mean less intensive management and less enforcement for these plateau wetlands, which are already very fragile, and could jeopardize the future for Black-necked Cranes and other species that depend on these habitats.

The priority actions are as follows:

- Conduct long-term monitoring of cranes and wetlands in breeding areas with focus on climate change, including at least one area not affected by glaciers (e.g. Ruoergai) and one area likely to be directly impacted by glacial melt and then by glacial shrinking (e.g., Shenzha);
- Conduct study and assessment of the impact of tourists on crane habitat in China;
- Conduct coordinated, range-wide counts in winter every five years;
- Strengthen networking among range countries and key sites to share information on threats and conservation responses;
- Promote strategies for using this flagship species to preserve fragile high-altitude wetland ecosystems and other biodiversity;
- Build capacity for resource managers, especially nature reserve staff;
- Conduct genetic study within and among different populations, especially wintering populations which are separate on wintering grounds;
- Establish baseline information on chemical contaminants, including heavy metals and pesticides, to assess the impact of these factors on cranes, if any;
- Educate locals around crane wintering and breeding sites about threats to cranes;
- Educate livestock herders about methods they can use to reduce disturbance to cranes and crane habitat;
- Regular coordination and sharing of information among various stakeholders in the crane habitats; and
- Ensure coordination among developmental and conservation agencies in the crane landscapes.

REFERENCES

- Archibald G. 2005. Observations of Black-necked Cranes. In: Wang Q, Li F, editors. Crane research in Yunnan. Kunming, China: Education Publishing House. p 19–25.
- Bishop MA, Tsamchu D. 2007. Tibet Autonomous Region January 2007 survey for Black-necked Crane, Common Crane, and Bar-headed Goose. China Crane News 11(1):24–26.
- Bishop MA, Tsamchu D, Li F. 2012. Number and distribution of Black-necked Cranes wintering in Zhigatse Prefecture, Tibet. Chinese Birds 3(3):191–198.
- Chandan P, Chatterjee A, Gautam P, Seth CM, Takpa J, Haq S, Tashi P, Vidya S. 2005. Black-necked Crane – status, breeding productivity and conservation in Ladakh, India 2000-2004. New Delhi and Srinagar, India: WWF-India and Department of Wildlife Protection, Government of Jammu and Kashmir. 64 p.

- Chandan P, Khan A, Takpa J, Hussain SA, Mehdi K, Jamwal PS, Rattan R, Khatoon N, Rigzin T, Anand A, Dutta PK, Ahmad T, Ghose PS, Shrestha P, Theengh LT. 2014. Status and distribution of Black-necked Crane (*Grus nigricollis*) in India. *Zoological Research* 35(S1):39–50.
- China Crane and Waterbird Specialist Group. 2015. China Crane News – a special issue on Black-necked Cranes. Beijing, China: China Ornithological Society. 57 p.
- Dolan B. 1939. Zoological results of the second Dolan expedition to western China and eastern Tibet, 1934-36. Part I. *Proceedings of Academy of Natural Science Philadelphia (USA)* 90:159–185.
- Dwyer N, Bishop MA, Harkness J, Zhang YZ. 1992. Black-necked Cranes nesting in Tibet Autonomous Region, China. In: Stahlecker DW, editor. *Proceedings of the 6th North American Crane Workshop*, 3–5 October 1991, Regina, Saskatchewan. Grand Island, Nebraska, USA: North American Crane Working Group. p 76–80.
- Farrington JD. 2009. Impacts of climate change on the Yangtze Source Region and adjacent areas. Beijing, China: WWF and the China Meteorological Press. p 61–96.
- Farrington JD, Zhang X. 2013. The Black-necked Cranes of the Longbao National Nature Reserve, Qinghai, China. *Mountain Research and Development* 33(3):305–313.
- Gao L, Qian F, Yang X, Wu H, Li F. 2007. Satellite tracking on the migratory routes of wintering Black-necked Cranes at Dashanbao in Yunnan. *Zoological Research* 28(4):352–361.
- Kong D, Yang X, Liu Q, Zhong X, Yang J. 2011. Winter habitat selection of vulnerable Black-necked Cranes *Grus nigricollis*: implications for determining effective conservation actions. *Oryx* 45(2):258–264.
- Li F. 2014. IUCN Black-necked Crane (*Grus nigricollis*) conservation plan. *Zoological Research* 35(S1):3–9.
- Li F, Bishop MA, Tsamchu D. 2011. Power line strikes by Black-necked Cranes and Bar-headed Geese in Tibet Autonomous Region. *Chinese Birds* 2(4):1–7.
- Li F, Qian F, Zhang H, Gao L, Yang X, Wu H. 2007. Habitat survey to stop-over sites of Black-necked Cranes in Hanyuan and Meigu of Sichuan. *Chinese Journal of Zoology* 42(5):83–89.
- Li F, Yang F. 2005. Distribution and population of Black-necked Cranes on the Yunnan-Guizhou Plateau. In: Wang Q, Li F, editors. *Crane research in China*. Kunming, China: Yunnan Education Publishing House. p 29–43.
- Liu Q, Li F, Buzzard P, Qian F, Zhang F, Zhao J, Yang J, Yang X. 2012. Migration routes and new breeding areas of Black-necked Cranes. *Wilson Journal of Ornithology* 124(4):702–710.
- Liu Q, Wang K, Yang X, Li F. 2010. Report on satellite tracking of Black-necked Cranes at Napahai Nature Reserve of Yunnan, China (2007.10 – 2010.7). China Exploration and Research Society (Hong Kong), International Crane Foundation, National Bird Banding Center of China, Napahai Nature Reserve, and Shangri-la County Forestry Bureau Kunming Institute of Zoology of Chinese Academy of Sciences. Baraboo, Wisconsin, USA: International Crane Foundation.
- Liu Q, Yang X, Li F, Wang K, Kong D, Gu H. 2009. Report on Black-necked Crane survey at Ruoergai, China. *China Crane News* 13(2):10–11.
- Ma M, Li W, Zhang H, Zhang X, Yuan G, Chen Y, Yuan L, Ding P, Zhang Y, Cheng Y, Sagen G. 2011. Distribution and population state of Black-necked Crane *Grus nigricollis* in Lop Nur and Kunlun Mts., Southern Xinjiang. *Chinese Journal of Zoology* 46(3):64–68.
- Ma Z, Li F, Li F, Xiao J. 2009. The dynamic change research of ecological environment in Longbao region of Yushu state in Qinghai. *Pratacultural Science* 26(7):6–11. (In Chinese with English abstract.) Available at http://cykx.lzu.edu.cn/EN/volumn/volumn_1163.shtml (accessed 1 December 2016).

- Meine CD, Archibald GW, compilers. 1996. The Cranes: Status survey and conservation action plan. Gland, Switzerland: International Union for the Conservation of Nature and Natural Resources. 282 p.
- Ministry of Environmental Protection of Peoples Republic of China. 2010. List of China Nature Reserves (up to end of 2009). Available at http://sts.mep.gov.cn/zrbhq/zrbhq/index_1.htm (accessed 1 December 2016). (In Chinese.)
- Pfister O. 1998. The breeding ecology and conservation of the Black-necked Crane (*Grus nigricollis*) in Ladakh, India. Kingston upon Hull, UK: University of Hull. 124 p.
- Phuntsho T, Tshering J. 2014. Black-necked Cranes (*Grus nigricollis*) in Bhutan: current population status and conservation initiatives. *Zoological Research* 35(S1):10–19.
- Qian F, Wu H, Gao L, Zhang H, Li F, Zhong X, Yang X, Zheng G. 2009. Migration routes and stopover sites of Black-necked Cranes determined by satellite tracking. *Journal of Field Ornithology* 80:19–26.
- Qiu J. 2012. Thawing permafrost reduces river runoff: China's Yangtze River is receiving less water as climate warms. *Nature, News*, January 6, 2012. Available at http://www.nature.com/news/thawing-permafrost-reduces-river-runoff-1.9749?WT.ec_id=NEWS-20120110 (accessed 1 December 2016).
- Royal Society for Protection of Nature. 2012. Crane count in Bhutan from 1992–1993 to 2011–2012 winter. Available at <http://www.rspnbhutan.org/news/crane-count-in-bhutan-from-1992-1993-to-2011-2012-winter> (accessed 1 December 2016).
- Royal Society for Protection of Nature. 2015. Species Conservation. Thimphu, Bhutan: Royal Society for Protection of Nature Bhutan. Available at <http://www.rspnbhutan.org/annual-report-2015/> (accessed 3 January 2019).
- Wang K, Yang X, Zhao J, Yu H, Min L. 2009. Relations of daily activity patterns to age and flock of wintering Black-necked Crane (*Grus nigricollis*) at Napa Lake, Shangri-La in Yunnan. *Zoological Research* 30(1):74–82.
- Wangmo R. 2007. Research initiated by the Royal Society for Protection of Nature (RSPN) of Bhutan has revealed new insights into the migration of the Black-necked Crane. *China Crane News* 11(1):7–9.
- Wu Z, Li Z, Wang Y, Jiang Y, Li R. 1993. Migration of Black-necked Cranes in China. *Acta Zoologica Sinica* 39(1):105–106.
- Wu Z, Wang Y, Jiang Y, Li Z, Li R, Li D, Zhou Z. 1991. Distribution and abundance of Black-necked Cranes (*Grus nigricollis Przewalski*) in China. *Acta Biologica Plateau Sinica* 10:108–116.
- Yang F, Zhang YQ. 2014. Quantities and distributions of the Black-necked Crane (*Grus nigricollis*) and other large waterfowls on the Yunnan and Guizhou Plateau. *Zoological Research* 35(S1):80–85.
- Zhang G, Liu D, Jiang H, Zhang K, Zhao H, Kang A, Liang H, Qian F. 2015. Abundance and conservation of waterbirds breeding on the Changtang Plateau, Tibet Autonomous Region, China. *Waterbirds* 38(1):19–29.
- Zhang G, Liu D, Li F, Qian F, Ma T, Dan D, Lu J. 2014. Wintering waterbirds community at Yarlung Zangbo River of Tibet, China. *Zoological Research* 35(S1):92–98.
- Zhao J, Yu H. 2005. Study of Black-necked Cranes wintering at Napahai Nature Reserve, Shangri-la County. In: Li F, Yang X, Yang F, editors. Status and conservation of Black-necked Cranes on the Yunnan and Guizhou Plateau, People's Republic of China. Kunming, China: Yunnan Nationalities Publishing House. p 149–155.
- Zhu P, Qu S, Wang N. 2009. Survey of the breeding population of Black-necked Crane Daocheng County, Sichuan Province. *China Crane News* 13(1):13–14.

