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Number, Habitats, and Roosting Sites of Wintering Black-necked Cranes in Huize Nature Reserve, Yunnan, China

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*The black-necked crane (*Grus nigricollis*, BNC), a migratory bird classified as vulnerable under the revised IUCN Red List, faces serious threats from human activities and habitat degradation. We measured the changes in the number, habitats, and roosting sites of wintering BNCs in Huize Nature Reserve, northeast Yunnan, China, based on remote sensing images from 1992 and 2006 and field data from 1991 to 2009. The wintering BNCs foraged collectively in muddy bottomlands and cultivated fields. The number of BNCs increased from 320 in 1991 to 738 in 2009, but their roosting sites decreased from 12 between 1990 and 1995 to 6 in 2009. Most BNCs, similar to what is described in other studies, spent nights in the wetlands; but some were forced to roost on dry hill slopes, an unusual roosting site for BNCs. From 1992 to 2006, cultivated fields increased from 17.35 to 34.45%, woodlands decreased from 40.89 to 35.80%, and shrublands decreased from 36.72 to 20.74%. Of the total usable food in BNC habitats, 65.8% was seeds and tubers—potato, turnips, and wild radish—found especially on the soils of muddy bottomlands and cultivated fields. We conclude that abundant food (especially potato residues) available near the surface of soils of traditionally cultivated fields benefits the survival of wintering BNCs and that the wintering BNCs are forced to choose new habitats for the nights when wetland habitats are degraded and human disturbance increases.*

Keywords: Grus nigricollis*; cultivated fields; human disturbance; migratory bird; potato production; China.*

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Introduction

Black-necked cranes (*Grus nigricollis*, BNCs), one of the migratory crane species that inhabit alpine areas, are classified as vulnerable under the revised International Union for Conservation of Nature Red List (IUCN 2011). Their breeding range includes much of the Qinghai-Tibetan Plateau and Gansu in China and the Ladakh District of Jammu and Kashmir in India (Gujja 2005; Chandan et al 2006; Xiang et al 2009; Farrington and Zhang 2013, in this issue). The main wintering grounds are in southern Tibet, western Sichuan, Yunnan, and Guizhou in China (Ran et al 1999; He and Wu 2000; Su et al 2000), the central and northeastern parts of Bhutan, and Arunachal Pradesh in India; in addition there are single records from Nepal and Myanmar (BirdLife International 2001; Chandan et al 2006). The species faces serious threats due to habitat loss and degradation (Chatterjee et al 2010). In Yunnan, for example, due to wetland reclamation and pollution, the number of BNC wintering areas declined from more than 20 in the 1990s (Li 1996) to 12 in 2002 (Li and Yang 2003), and some of the current wintering areas are unstable, with a population of fewer than 10 cranes (Li and Yang 2003; Liu et al 2010). Most of the wintering BNCs crowd into protected areas.

In China, apart from supporting research on the ecology (Yang et al 2007; Liu et al 2010), migration (Hu et al 2002; Qian et al 2009), and conservation of BNCs (Su et al 2000; Li et al 2005), a key action is to establish reserves. So far, of the 18 reserves with a total area of more than 383,000 km^2 to protect BNCs, only six (6560 km^2, or 0.17% of the area) are for the wintering flocks. Thus, the protected wintering areas must support large number of BNCs, causing not only biological competition between BNCs but also conflicts between BNCs and local populations (Bishop et al 2002).

We used Huize Nature Reserve, one of the reserves for wintering BNCs in China, as a case study to assess relations between the changing numbers of wintering BNCs and their habitats in the past decades. We examined changes in the numbers of wintering BNCs, their roosting sites, and foraging habitats based on field investigations. We also examined changes in land cover by analyzing remote sensing images for 1992 and 2006, in order to discuss the effects of land cover on wintering BNCs.

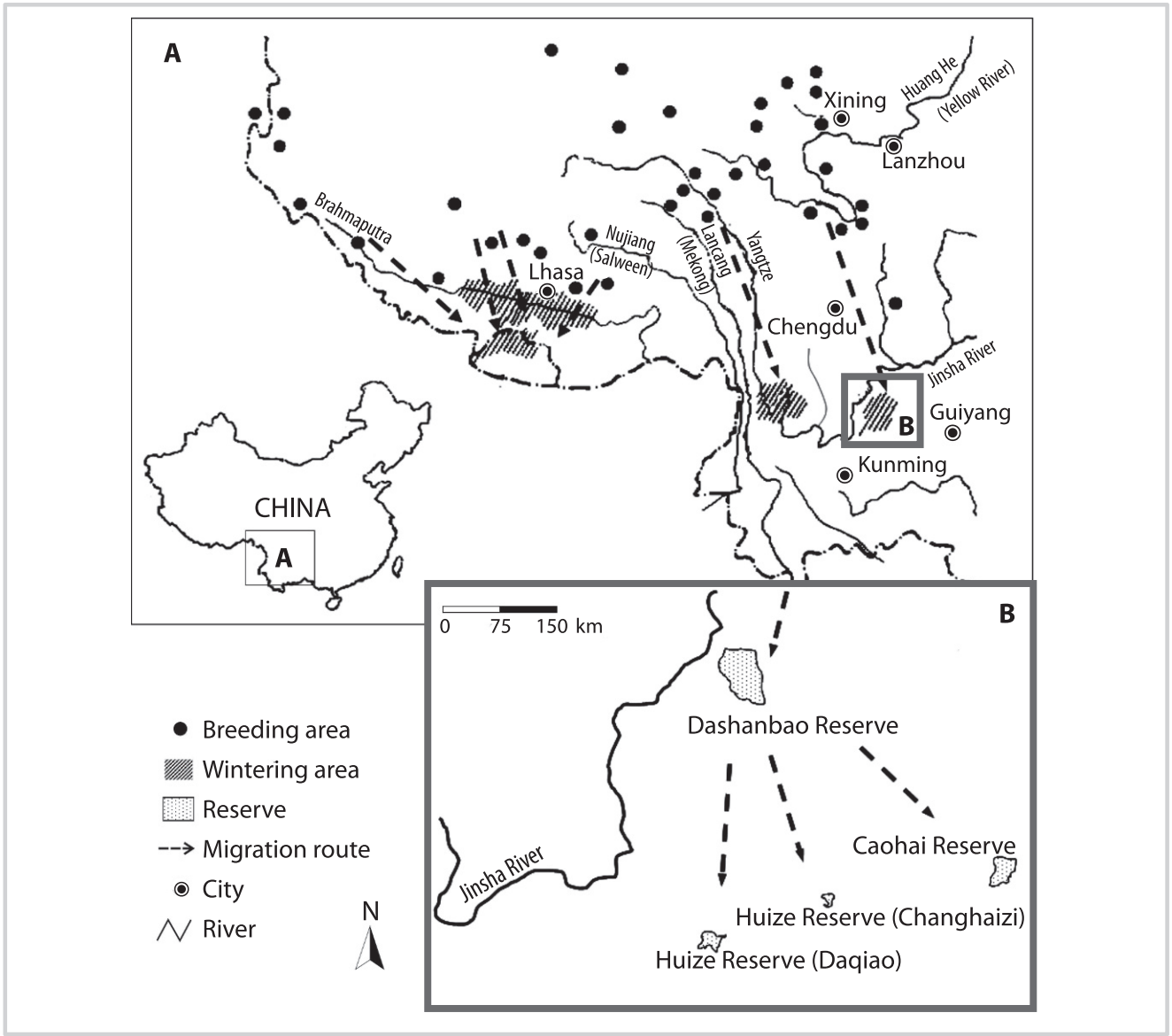
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Study area

Huize Nature Reserve is the southernmost reserve for wintering BNCs in China (Figure 1). According to unpublished documents, the reserve was initially established as a county reserve in 1990 with the main aim of protecting wintering BNCs and was approved as a provincial reserve in 1992 and a national reserve in 2006. The reserve, located in northeast Yunnan Province, consists of two separate subreserves, Daqiao and Changhaizi, with a total area of 14,670.23 ha. The Daqiao subreserve is a wide valley surrounded by mountains with a total area of 10,228.22 ha. It is located at longitude 26°38′00″–26°44′24″N and latitude 103°12′06″–103°22′02″W, with an elevation ranging from 2470 to 3090 m. The Changhaizi subreserve is located in the upper part of mountains, with a total area of 4442.01 ha. It is at longitude 26°34′08″–26°39′36″N and latitude 103°33′36″–103°39′00″W, and its elevation ranges from 2050 to 2800 m (Figure 1).

A conservation organization and facilities were established, and field management has been implemented since 1990 to protect wintering BNCs and their habitats. Unfortunately, the management of the reserve does not own the land. According to data from the Bureau of Huize Nature Reserve, 58 villages with a total population

FIGURE 1 Location of the study area. (Map by Zhaolu Wu)



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of 14,608 people inhabited the reserve in 2010. They live from rain-fed agriculture, cultivating potato, corn, buckwheat, oat, and rape. During our study, the BNCs arrived in the reserve in October and flew away to their breeding areas in April of the following year. During this period of 5 or 6 months, serious conflicts between BNC conservation and agricultural development led to a crisis. Another important factor to be considered is the following: in 1958, 2 reservoirs were built by damming streams running through places where the two subreserves were established in 1990. The reservoirs were rebuilt in 2005–2007.

Methods

Investigating BNC numbers, roosting sites, and foraging habitats

Participatory rural appraisal (PRA) was used to collect data and information on the number of BNCs and possible sites for them to forage during the daytime and stay overnight. PRA has been widely used to analyze and estimate the current situation and development planning of communities, using informal interviews with inhabitants (Yu et al 2009). It has also been used to study changes in species and landscape in rural areas (Wu 1997). Our investigation—aimed at collecting detailed information on wintering BNCs—was carried out in 12 villages in the reserve, from 2 to 8 February 2009. Questions covering 4 points were prepared for interviewees: (1) the places where BNCs foraged in the daytime and stayed overnight, (2) the kind of food BNCs preferred to eat, (3) changes in the number, sites, and food of BNCs in the past years, and (4) views, attitudes, and perceptions of the interviewees concerning BNCs. Following the questioning, using a topographical map (scale: 1:50,000) we talked with 30 interviewees (including reserve staff and local people living in the reserve) and collected views, attitudes, and perceptions from the respondents regarding the questions. Seven local adults aged 70–75 with good memories and from different villages were interviewed in detail about changes in BNC populations and habitats in the past 50 years.

Thirty-four volunteers and researchers from the Kunming Bird Conservation Association and the Bureau of Huize Nature Reserve investigated the number of BNCs and the sites where BNCs foraged during daytime and roosted overnight. Groups of 3–5 volunteers and researchers were then appointed to count the number of BNCs with telescopes at the possible roosting sites, from 6:10 to 8:00 AM, and the possible foraging sites from 12:00 to 16:00 PM. The investigation was implemented from 3 to 7 February 2009. We counted the number of roosting sites rather than their area; indeed, as BNCs roost in tight groups, the size of the sites is less relevant than their number and location.

Land cover change and statistical analysis

GIS ARC/GIS software (version 9.1) and ERDAS IMAGING 8.7 image software were applied to process and analyze the variables. The variable data grid format was used, with a cell size of 60 × 60 m. The variable land cover was generated by using supervised classification of remote sensing images from Landsat, dated 16 August 1992 and 19 May 2006. Field investigations were conducted in February 2009 to check the current land cover types. After comparing the land cover map in 1994 provided by the Bureau of Huize Nature Reserve and the map made in this study, 6 types of land cover were identified in Huize Nature Reserve for 1992–2006.

Estimation of usable diet stored in selected habitats

Based on field experience and information from the reserve staff and local people in the reserve, we chose 49 plots at 8 sites (4 in Daqiao subreserve and 4 in Changhaizi subreserve) in cultivated fields, wetlands, and grasslands to study the usable diet stored in the habitats. Dietary items were chosen according to observations made of birds feeding at different sites. At each site, habitat types were identified in terms of cultivated field, grassland, marshland, muddy bottomland, and barren land. In the chosen habitat, we picked all of the visible plant seeds and fruits as well as insects or other invertebrates in the thickets and on the ground, in 1 m × 1 m sampling plots. We then dug these plots to a depth of 10 cm and picked out all plant seeds, tubers, and insects or other invertebrates. Because of the variable nutrition value of different diets for BNCs, we used individual numbers instead of the biomass of diets.

Results

Number of wintering BNCs

During the field counting on 3 consecutive days, from 6:10 to 8:00 AM at the roosting sites, 3–7 February 2009, 738 BNCs were counted, of which 451 were in Daqiao subreserve (including 175 BNCs in Mashu, north of Huize Nature Reserve) and 287 in Changhaizi subreserve. The local adults remembered that they found BNCs occasionally in the wetlands of the reserve when they were teenagers, but the number of cranes was not as high as it is today, which implies a different dispersal pattern of BNCs in the reserve in the 1950s. Based on data from the literature and from the Forestry Department of Yunnan Province and the Bureau of Huize Nature Reserve, we reckoned that BNCs chose Huize Nature Reserve as one of their wintering areas long ago and that the number of BNCs has increased slightly in the past 20 years (Table 1).

Changes in foraging and roosting sites of wintering black-necked cranes

BNCs were found during daytime foraging in cultivated fields and wetlands and staying occasionally in grasslands but never appearing in woodlands, woodlots, and thick

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TABLE 1 Number of wintering BCNs in Huize Nature Reserve (1986–2009).

Year/month	Number of BNCs counted			Data sources
	Daqiao	Changhaizi	Total	
1986	–	21	21	Huan 1993
1988	–	102	102	Li 1996
1991/December			350	Huan 1993
1993/December	480[a]	270	600	Li and Yang 2002
1994–1995	288	145	433	Li 1996
2001/January	419	95	545	Forestry Department of Yunnan Province
2002/January	402	135	537	Li and Yang 2002
2003/January	213	272	505	Forestry Department of Yunnan Province
2004/January	443[a]	319	762	Wang ZJ et al 2009
2006/January	–	–	558	Forestry Department of Yunnan Province
2009/February	451[b]	287	738	Wang ZJ et al 2009
2011/February	75	310	385	Bureau of Huize Nature Reserve
2012/February	83	256	339	Bureau of Huize Nature Reserve

[a]Including *Grus grus*.
[b]Including 175 BNCs counted in Mashu.

shrublands. The numbers in crane flocks fluctuated from 3 to 145. The birds consumed plant seeds, fruit, tubers, and insects or other invertebrates in the herbage and on the ground; they also searched for food by digging the soil with their claws. We saw a large flock of 145 cranes picking potato and turnips (*Brassica rapa*) out of the earth on cultivated fields (Figure 2). In Changhaizi subreserve, the cranes foraged on harvested potato fields but did not approach the reservoir. In Daqiao subreserve, they foraged on cultivated fields toward the south and southwest sides of the reservoir, where there were few roads for motor vehicles or other sources of noise disturbance. The crane flocks flew to their roosting sites before sunset.

We found 6 BNC roosting sites, 4 in Daqiao subreserve, 1 in Changhaizi subreserve, and 1 in Mashu (10 km north of Huize Nature Reserve). According to the reserve staff and local adults interviewed, the number of BNC roosting sites changed markedly (Figure 3). Of the 8 sites in Daqiao subreserve in 1990–1995, only 4 were used by the cranes; they were muddy bottomlands located in the south and southwest sides of the reservoir. Sites in Lijiawan and Maanshan were used for the whole wintering period, but sites in Yangmieshan and Dideka were used discontinuously. Some cranes flew northwest to Mashu in 2007 and no longer came back for the night. We found a total of 175 BNCs there in the early morning of 2–3 February 2009. These cranes foraged in the surroundings and sometimes flew southeast into Huize Nature Reserve but flew back to Mashu in the evening.

In Changhaizi subreserve, the cranes did not use the shallow water of the reservoir as a roosting site for several years due to dwindling reservoir water and an increase in human activities close to the reservoir. We only found 1 roosting site there; it was on the dry hill slopes far from water and wetlands. But for the period 1990–1995 there were 4 sites in the area, according to the reserve staff and local people interviewed.

Changes in land cover

Changing land use policy brought about a change of land use in this region. The adults interviewed related that some of the villages in the reserve were established 200 years ago when immigrants from eastern China moved in, reclaimed land, and developed farming. The construction of reservoirs in 1958 accelerated agricultural development and brought more people from outside. The reserve became a pilot base for potato production in 2002, and more land was planted with potatoes. Rebuilding of the

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FIGURE 2 Wintering BCNs in Huize Nature Reserve benefit from abundant food stored in traditional cultivated fields; in this area, 145 cranes were seen foraging for potatoes and turnips in the harvested potato fields in 2009. (Photo by Zhaolu Wu)



Daqiao reservoir dam in 2005 elevated the surface of the water and submerged cultivated fields and swamps.

Based on remote sensing images, the areas of different land cover types changed markedly from 1992 to 2006. The area of cultivated fields increased from 17.4% of the total area in 1992 to 34.5% in 2006; woodland and shrubland areas decreased (Table 2; Figure 3).

Transformation of land cover types brought about distinct changes of relevance to BNCs (Table 3). Thus, in Daqiao subreserve, 22.25% of woodlands and 49.45% of shrublands in 1992 became cultivated fields by 2006, while 27.05% of cultivated fields remained in the same category. In Changhaizi subreserve, 30.57% of woodlands and 35.78% of shrublands in 1992 were transformed into cultivated fields by 2006, while 28.39% of cultivated fields remained in the same category.

Usable diet stored in selected habitats

On the 49 plots at 8 sites, a total of 1088 pieces of food were found that cranes could use, of which 324 were invertebrates and 680 were plant seeds and tubers near the surface of soils (ie at a depth of 10 cm), while 84 pieces were invertebrates, plant seeds, and fruits on the ground. In other words, 92.4% of the usable food was stored in soils. Of the total stored usable food, 65.8% was seeds and tubers, consisting of potato, turnips (*Brassica rapa*), and wild radish (*Raphanus raphnistroides*) in soils.

There were significant differences in usable food stored in different habitats. On average, pieces of usable food stored in muddy bottomlands, cultivated fields, and grasslands amounted to 30.2, 22.1, and 19.7 n/m^2, respectively, differing greatly from that stored in swamp wetlands (15 n/m^2) and wastelands (4.7 n/m^2) ($P = 0.05$).

Discussion

Many studies have suggested that human-induced land cover change has caused degradation of habitats and fluctuations in crane populations. For example, the habitat change of red-crowned cranes (*Grus japonensis*) in the Liaohe Delta was found to be due to the development of oil and agricultural exploitation, which reduced the main part of the habitat suitable for red-crowned cranes, that is, natural land cover such as reed and *Suaeda* communities (Wang et al 2003). The continuous loss of suitable habitat also accounted for fluctuations in red-crowned crane populations in the Zhalong National Nature Reserve for 1996–2005 (Yu et al 2001; Wang et al 2009). On agricultural landscapes in the Cheolwon area of the Republic of Korea, red-crowned cranes and white-naped cranes (*Grus vipio*) were observed spending more time foraging on the remaining unplowed rice fields than on the adjacent plowed rice fields, because the unplowed fields contained more food resources for cranes than the plowed fields (Lee et al 2007). Early studies in Caohai, Guizou Province, China, also showed that the foraging habitats most preferred by BNCs were natural sedge meadows, not cultivated fields (Li 1999). Plowing practices buried cereal grain residues in the ground and reduced food availability for BNCs (Bishop and Li 2002; Kong et al 2011).

Our results suggest that BNCs in the Huize Nature Reserve preferred to forage on cultivated fields; BNCs foraging near plowmen on cultivated fields were a

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FIGURE 3 Changes in land cover and roosting sites of BCNs in Huize Nature Reserve. (Map by Kunxun Zhang and Zhaolu Wu)

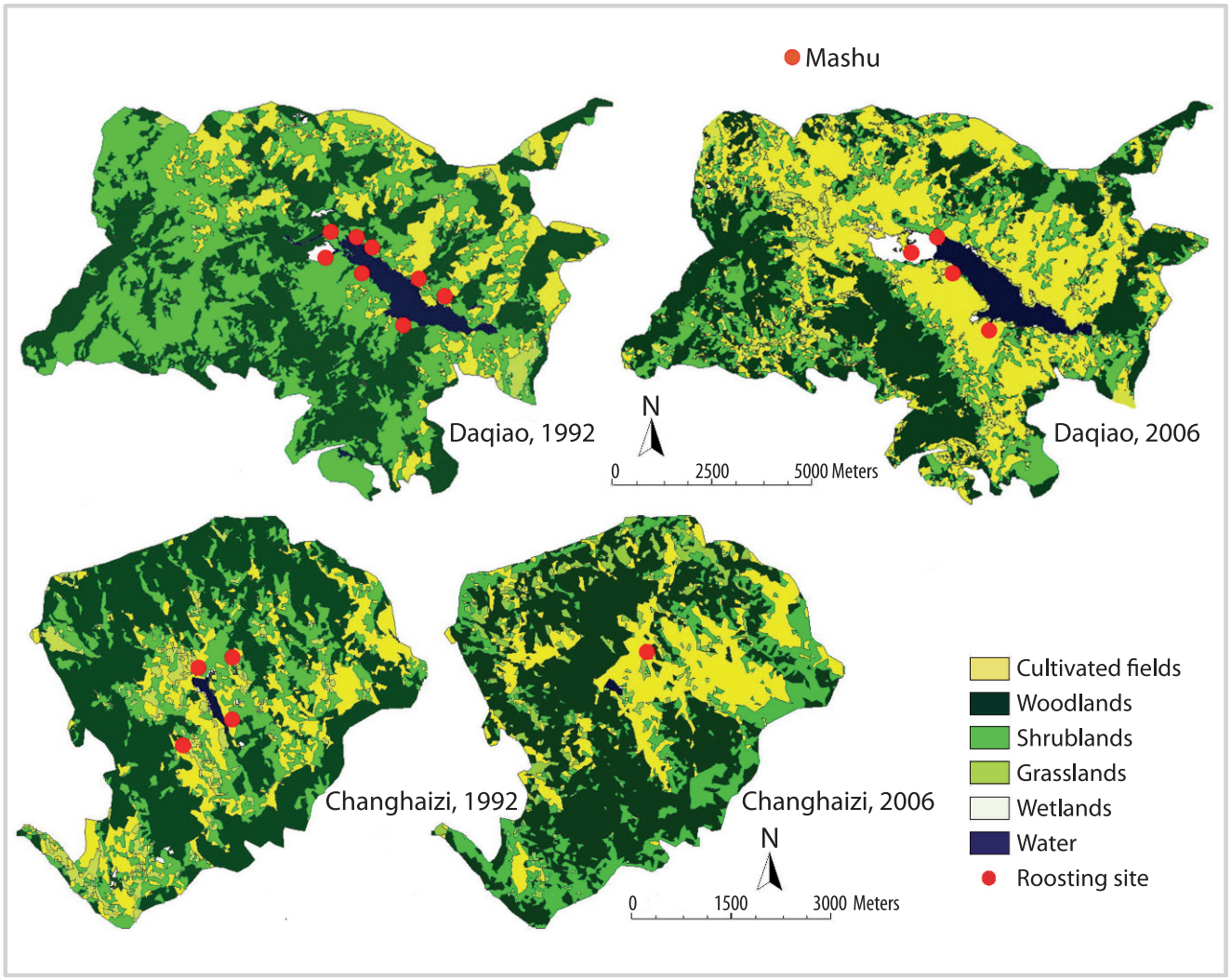


TABLE 2 Changes in land cover types (habitats) in Huize Nature Reserve between 1992 and 2006.

Land cover type	Area in Daqiao in ha (%)		Area in Changhaizi in ha (%)		Total	
	1992	2006	1992	2006	1992	2006
Cultivated fields	1645.6 (16.1)	4033.7 (39.4)	900.2 (20.3)	1020.7 (23.0)	2545.8 (17.4)	5054.4 (34.5)
Woodlands	3759.4 (36.8)	3083.3 (30.2)	2239.5 (50.4)	2168.5 (48.80)	5998.9 (40.9)	5251.8 (35.8)
Shrublands	4365.9 (42.7)	2137.4 (20.9)	1020.5 (23.0)	905.9 (20.4)	5386.4 (36.7)	3043.3 (20.7)
Grasslands	123.0 (1.2)	511.2 (5.0)	248.1 (5.6)	340.0 (7.7)	371.2 (2.5)	851.2 (5.8)
Wetlands	37.4 (0.4)	155.0 (1.5)	11.8 (0.3)	0.4 (0.0)	49.1 (0.3)	155.4 (1.1)
Water	296.9 (2.9)	307.6 (3.0)	21.9 (0.5)	6.5 (0.2)	318.8 (2.2)	314.2 (2.1)
Total	10,228.2 (100.0)		4442.0 (100.0)		14,670.2 (100.0)	

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TABLE 3 Transformation matrix showing percentage change from land cover types in 1992 to other land cover types in 2006.[a] (Table extended below)

Location	Land cover in 1992	Percentage change from other land cover by 2006		
		Cultivated fields	Woodlands	Shrublands
Daqiao	Cultivated fields	**27.05**	4.57	14.53
	Woodlands	22.25	**65.61**	32.33
	Shrublands	49.45	29.13	**49.87**
	Grasslands	0.68	0.60	2.93
	Wetlands	0.21	0.07	0.18
	Water	0.35	0.03	0.16
Changhaizi	Cultivated fields	**28.39**	17.13	21.31
	Woodlands	30.57	**57.64**	50.56
	Shrublands	35.78	19.38	**19.00**
	Grasslands	3.66	5.70	8.57
	Wetlands	0.34	0.14	0.40
	Water	1.27	0.01	0.16

TABLE 3 Extended.

Location	Percentage change from other land cover by 2006		
	Grasslands	Wetlands	Water
Daqiao	14.43	4.45	7.00
	13.75	51.95	0.00
	66.51	19.10	11.02
	3.12	0.00	0.00
	0.02	**14.42**	0.08
	2.16	10.08	**81.91**
Changhaizi	12.87	0.00	25.85
	63.65	0.00	0.31
	19.43	0.00	0.00
	2.94	0.00	0.00
	0.21	**0.00**	15.23
	0.89	100.00	**58.62**

[a]Figures in boldface indicate the percentage of a specific land cover type that remained the same. How to read this table: Of the cultivated field area in Daqiao subreserve in 2006, for example, 27.05% came from the same land cover category (cultivated fields) and 22.25% resulted from a transformation of the 1992 woodlands area to cultivated fields.

common sight in this area. The main reasons could be abundant food and safe habitats in the reserve.

Indeed, cultivated fields stored abundant food for BNCs: of the total stored usable food, 65.8% was seeds and tubers consisting of potato, turnips, and wild radish near the surface of soils. Local people reported abundant potato residues left on the harvested cultivated fields. They collected 150–200 kg/ha^2 potatoes from cultivated fields when they plowed in spring. The potato residue left on cultivated fields (on about 3500 ha^2 of potato fields cultivated in 2009, according to the local administration) was 500–700 tonnes annually. Abundant food (potato)

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stored on cultivated fields was the major factor that determined why wintering BNCs foraged collectively on harvested fields. Consequently, it is easy to understand why the number of BNCs increased in the Huize Nature Reserve (Table 1), despite disturbance from the increase in cultivated fields and agricultural development (Table 2).

Studies in China, Bhutan, and India have indicated that BNCs breeding habitats and wintering grounds consisted of wide wetlands and agricultural lands. In Bhutan, the wintering BNCs chose large U-shaped valleys with wide valley bottoms consisting of undrained mires and agricultural land. In India, BNCs roosted together in secluded bogs, on the shores of reservoirs, along secondary channels of rivers, on sandy riverine beaches, in shallow water or fields, and on paddy fields in a few cases (BirdLife International 2001; Chandan et al 2006). In China, the breeding habitats on the Qinghai-Tibetan Plateau were alpine bog meadows in open valleys, basins, and flatlands that were poorly drained or lacustrine marshes and riverine marshes; the wintering grounds were shallow marsh, wet meadow, farmland, and dry meadow. BNCs were not found in woodlands, thick shrublands, deep water, or villages, or on roads (Hu et al 2002; Xiang et al 2009; Liu et al 2010). We also found that BNCs foraged on cultivated fields and wetlands and stayed occasionally on grasslands but never appeared in woodlands, woodlots, and thick shrublands. According to the knowledgeable reserve staff and local people, some BNCs experienced mortal fear in woodlots and shrublands when they lost their way on foggy days; moreover, wild cats sometimes rushed out of woodlots to attack BNCs that were foraging in cultivated fields.

The changes in land cover in the reserve provided enough safe habitats for BNCs. The area of cultivated fields increased from 2545.8 ha (17.4% of the total area) in 1992 to 5054.4 ha (34.5%) in 2006; woodland and shrubland areas decreased from 5998.9 ha (40.9%) and 5386.4 ha (36.7%) in 1992 to 5251.8 ha (35.8%) and 3043.3 ha (20.7%), respectively, in 2006 (Table 2). Woodlands and shrublands close to the reservoirs were almost replaced by cultivated fields (Figure 3).

On the other hand, responding to human disturbance, the wintering BNCs lost some of their roosting sites and even chose dry hill slopes for the night. According to reserve staff and local people, two important causes led to the loss of roosting sites. One was the increase in human population and activities. More people moved into Daqiao, the seat of Daqiao Township, located on the north side of the Daqiao Reservoir, when the reserve opened pilot bases for potato production in 2002. The reservoir was opened for recreation; tourists drove there and swarmed into the reserve, playing in the water, watching wild birds, and taking photos. An increasing number of small eating establishments and thatched cottages for tourists appeared in areas close to the reservoir when roads around the reservoir were opened in 2010. As a result, BNCs flew to Mashu and no longer returned to the reserve, and the number of BNCs in the Daqiao subreserve declined (Table 1).

Another cause was the change in water areas. In the Daqiao subreserve, the water level continued to rise after the rebuilding of the reservoir dam in 2005, eventually submerging marshes and shallow wetlands previously used by the cranes. Simultaneously, the cultivated fields on the southwest side of the reservoir, approximately 120 ha, were submerged and became muddy bottomlands when the water level dropped between December and March and were used by the cranes for the night. BNCs consequently did not use their roosting sites on the north side of the reservoir; some of them flew away and no longer came back for the night. In the Changhaizi subreserve, following the recent building of houses near the reservoir and the dwindling of water area, BNCs gave up their previous roosting sites and chose the dry hill slopes far from water and wetlands for the night.

Conclusions

Due to habitat loss and degradation in the region, more and more wintering BNCs collected in the Huize Nature Reserve, where increasing potato cultivation simultaneously provides abundant food for them. Thus wintering BNCs benefit from abundant food (potatoes) stored on traditionally cultivated fields. But threats from other human disturbance forced wintering BNCs to retreat to fewer roosting sites, and even to dry hill slopes. Some BNCs flew away from the reserve. We have two proposals for the conservation of BNCs in the future: (1) pay more attention to public education among local people and tourists, focusing on coexistence between humans and BNCs and (2) make partial concessions by eliminating human disturbance from places where wintering BNCs prefer to roost for the night.

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