Final Report

For Project Dongting Lake' 2001

Title: Changes in habitats and population dynamics for waterfowl in Dongting Lake, Central Yangtze, China.

Approved by: BP Conservation program 2001
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1 Introduction

8.81% of Earth's land surface, accounting for 13.2 million km^2 has been established as protected

areas around the world (IUCN, 1998). Protected areas are generally believed to be the cornerstones of biodiversity conservation (Noss, 1996; Pimm and Lawton, 1998; Bruner et al., 2001) and the safest strongholds of wilderness (Soule and Sanjayan, 1998; Armesto et al., 1998). EDLNNR, formerly Junshan Nature Reserve was established in 1982, but the management of the Nature reserve was formally begun after it was protected by the RAMSAR network since 1992 (Chen et al., 1995). Dongting Lake wetland provided critical stopover and wintering grounds for many waterfowls, so EDLNNR has been designated for inclusion in the List of Wetlands of International Importance on July 1992. Based on the Landsat remote sensing imagery data, on-spot investigation data and observing data of waterfowl, this project studied characteristics and dynamics of waterfowl habitats, and structure and dynamics of waterfowl community in EDLNNR between 1989 and 1998. This project report mainly included the following contents: (1) Dynamics of waterfowl habitats in EDLNNR; and (2) Structure and dynamics of waterfowl community, and population dynamics of some endangered waterfowl. In addition, conservation recommendations were proposed to preserve and restore waterfowl community.

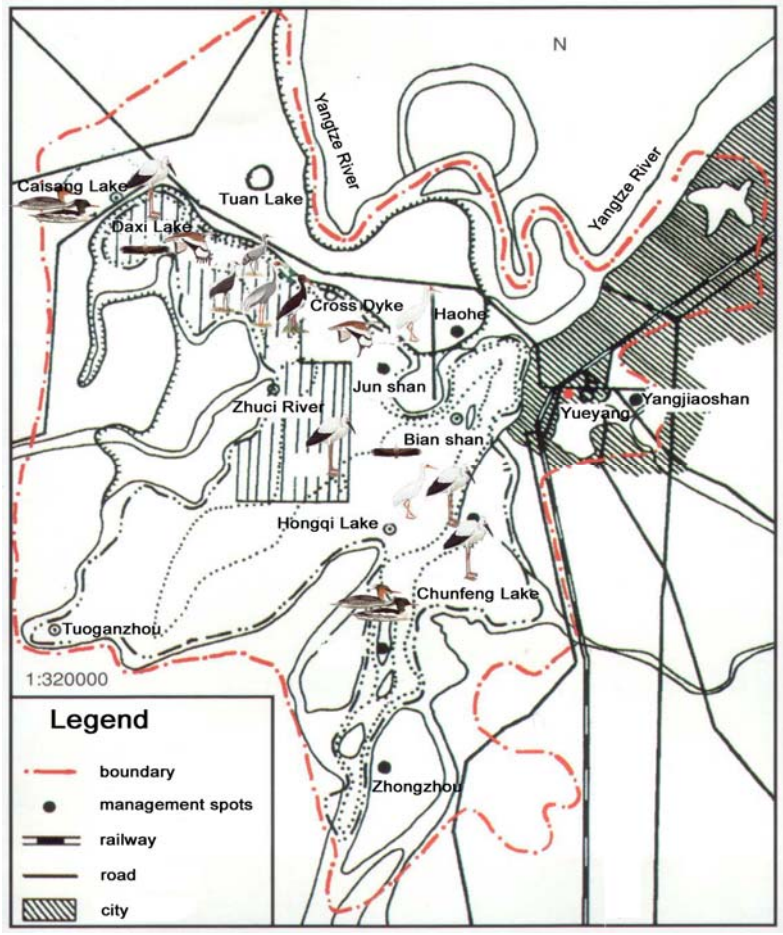

Fig.1 Sketch map of the Eastern Dongting Lake National Nature Reserve

2 Methods

2.1 Study area

There are huge differences in water level between the flooding season and the dry season at the Dongting Lake (Hunan Province, China), with a maximum difference of 18 meters. The lake is therefore called a spillway lake. Normally, the flooding season begins in middle June and ends in late August when the migratory birds return. Such a habitat provides waterfowl good feeding and roosting opportunities. East Dongting Lake is a part of the huge Dongting Lake system, which is a Nature Reserve covering the area of 190,000 ha. EDLNNR is situated at southern part of the Yangtze River's middle reaches, Hunan Province, China, with a latitude of 112°43'-113°15'E, and a longitude of 28°59'-29°38'N (See Fig. 1). It is one of the seven most important international wetland conservation areas in China, and protected by the RAMSAR network (Chen et al., 1995). It's one of conservation priority ecoregions of the Global 200 proposed by WWF (Olson and Dinerstein, 1998), and also one of critical regions of biodiversity conservation in China (The committee of Chinese biodiversity research, 1998).

2.2 Habitats dynamics analysis

The image processing software Erdas Image 8.4 was used to classify the habitat types with a data set of a 3-band RGB combination (Bands 4, 5, and 3) of Landsat Thematic Mapper (TM) imagery in 1989 and 1998. In order to minimize possible interpretation errors, all the images were acquired in dry season of Dongting Lake (December 4, 1989; February 12, 1998, respectively). The images were geo-referenced according to Transverse Mercator (TM) system with known coordinates in 1:50000 topographical maps firstly, then were classified using the maximum likelihood method (Jensen, 1996). An initial field survey was conducted before TM imageries were interpreted. Habitats were grouped into eight types: water body, Mudflat, Sedge meadow, Reed field, Paddy field, Dryland, Forest and Settlement (see Fig.2).

Spatial analysis was carried out to describe patterns of habitat changes over time and to measure the rate of changes. By overlaying the two classified images, the area (%) converted from each of the categories and to any of the other categories was calculated.

Patch characteristics can be used to describe landscape features (Forman, 1995). Thus, we generated and analyzed several patch-related landscape indices across the study area based on classified image data. We exported the classification maps to the Grid Module of ArcInfo GIS program (ArcInfo is the product of ESRI, Inc.), and derived each patch area and its perimeter for all the habitat types of the two classification maps (1989 and 1998). We then computed the patch-related landscape indices listed below using FRAGSTATS algorithms (McGarigal and Marks, 1995).

Mean patch size (MPS) can serve as a habitat fragmentation index at the landscape level, because a patch type with a smaller MPS might be considered more fragmented (Turner, 1990).

$$\text{Mean patch size (MPS)} = \sum_{j=1}^{n} a_{ij} / n_i \,(1/10000)$$

Where *i* is the *i*th habitat type, *j* is the *j*th patch of the *i*th habitat type, a_{ij} is the *j*th patch area (ha) of the *i*th habitat type, n_i is the patch numbers of the *i*th habitat type.

Patch density (PD) as an index has the same basic utility as the number of patches, except that it expresses the number of patch based on a unit area. When total landscape area remains constant, patch density is the index of heterogeneity, because a landscape with a higher patch density shows greater spatial heterogeneity (Hietala-Koivu, 1999).

Patch density (PD) $= n_i / A$

Where n_i is the same as the above-mentioned, and *A* the total area (km^2) of all habitat types.

2.3 Waterfowl census

Ornithological fieldwork was conducted at six sites: DaXiao xi Lake, Caisang Lake, Cross Dyke, Chunfeng Lake, Hongqi Lake and Tiane Duan during October 2000 to March 2001 and October 2001 to March 2002 in EDLNNR. The investigation area in every site was about 6km^2. For each bird observation, the identity of the species, numbers of individuals, flocking and foraging behavior where possible, location and habitat were recorded. As for each site, 2-3 times ornithological count were carried out during each wintering season. The first census was during early October or late September, second count was in December or early January; the late count was about in March. By cooperated with the Nature Reserve, we also carried out the continual monitoring of waterfowl in Core Zone of EDLNNR during 1992-1993 and 2001-2002 wintering periods.

To make abundance comparisons of waterfowl species at different sites, we used the field observations to provide an encounter count per time.

$$\text{Count encounter by per time} = \frac{\text{Total count of some waterfowl}}{\text{observing times}}$$

3 Results and discussion

3.1 Habitat dynamics of waterfowl in EDLNNR between 1989-1998

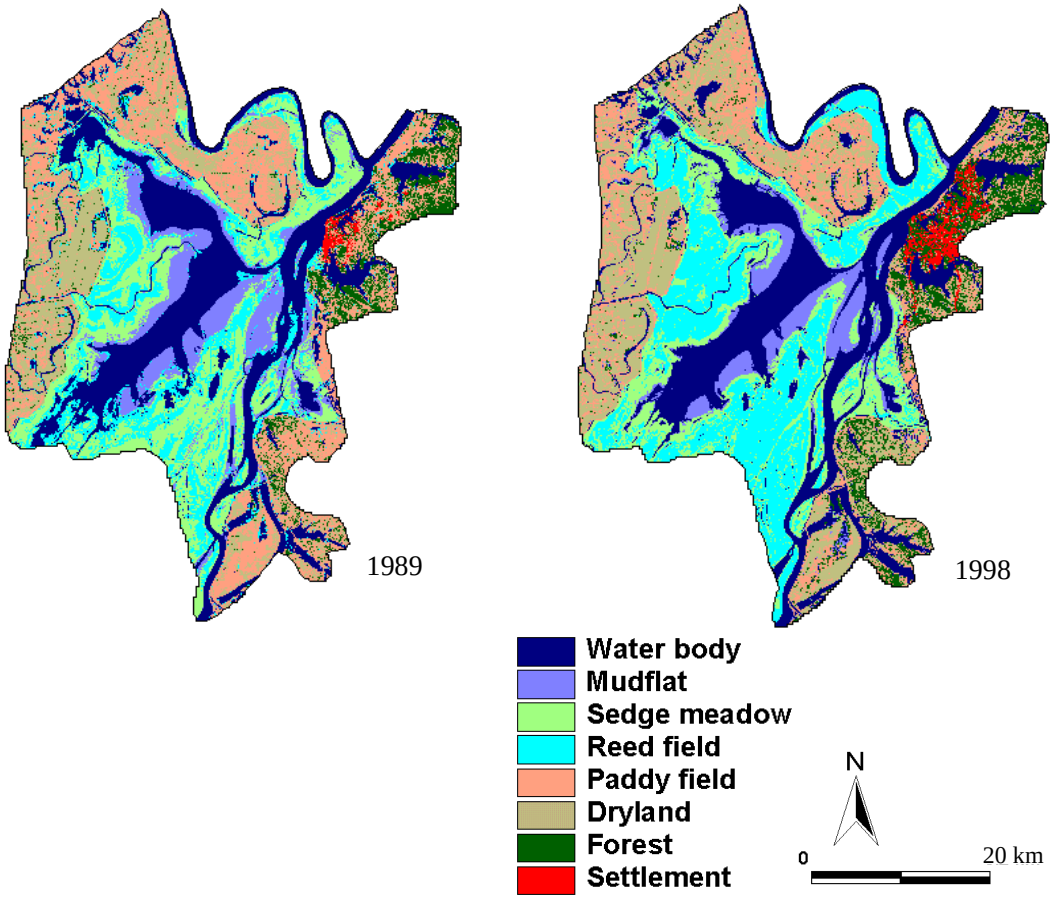

Fig. 2 Classification map of waterfowl habitats of EDLNNR in 1989 and 1998

The size and landscape structure of wetland habitats and their changes are crucial to waterfowl distribution and their dynamics. Our results showed landscape indices and habitat transition between 1989 and 1998 by integrating satellite remote sensing data with landscape analysis.

Table 1 Landscape indices for waterfowl habitats in EDLNNR between 1989-1998

	Area (km^2)	Area percentage (%)	Patch number	Average patch size (ha)	Patch density (number/km^2)
Water body					
1989	444.4	23.3	1206	36.9	0.6
1998	441.1	23.2	1402	31.5	0.7
Mudflat					
1989	152.9	8.0	2541	6.0	1.3
1998	123.2	6.5	7947	1.6	4.2
Sedge meadow					
1989	335.6	17.6	4105	8.2	2.2
1998	269.6	14.2	6878	3.9	3.6
Reed field					
1989	253.7	13.3	9022	2.8	4.7
1998	356.4	18.7	1137	31.4	0.6
Paddy field					
1989	367.5	19.3	5321	6.9	2.8
1998	268.8	14.1	5555	4.8	2.9
Dryland					
1989	244.0	12.8	10971	2.2	5.8
1998	292.1	15.3	3917	7.5	2.1
Forest					
1989	97.9	5.1	4279	2.3	2.3
1998	126.5	6.6	3425	3.7	1.8
Settlement					
1989	9.2	0.5	119	7.8	0.1
1998	27.7	1. 5	285	9.7	0.2

As indicated by the landscape indices (Table 1): The area of water body, mudflat, sedge meadow and paddy field decreased during 1989 and 1998, of which the sedge meadow and paddy field dropped greatly, with an decrease of 66.07 km^2 and 98.74 km^2, respectively. While the area of reed field, dryland, forest and settlement showed the increased trends, the reed field and dryland increased by 102.69 km^2 and 48.13 km^2. The area percentage of these waterfowl habitats showed the same trends as those of area.

Average patch size of water body, mudflat, sedge meadow and paddy field decreased, while the patch number and patch density of these habitats increased in the recent 10 years. Which indicated that these habitats became more fragmented and more heterogeneous. Average patch size, patch number and patch density of other habitats showed the opposite trends.

Water body, mudflat and sedge meadow are the feeding and nesting habitats for most waterfowl wintering in EDLNNR, while the paddy field is the feeding area for the waterfowl that are inclined to corn, such as cranes. Therefore the area decrease and the characteristics change of landscape indices in these habitats maybe cause the negative effects on the waterfowl that habituated on them. These results suggested that the Nature Reserve should pay attention to the habitat management and try to avoid the further degradation of waterfowl habitats.

Table 2 Waterfowl habitat transition proportion (%) in EDLNNR during 1989-1998

	Water body	Mudflat	Sedge meadow	Reed field	Paddy field	Dryland	Forest	Settlement
					1998			
1989								
Water body	83.46	6.74	6.00	1.20	1.51	0.18	0.65	0.26
Mudflat	15.45	44.64	32.41	6.29	0.90	0.22	0.08	0.01
Sedge meadow	1.62	1.63	40.35	54.59	1.13	0.55	0.12	0.01
Reed field	9.25	5.06	25.16	53.86	3.55	1.06	1.74	0.32
Paddy field	3.37	1.50	2.81	0.30	45.37	31.78	11.33	3.54
Dryland	0.94	0.30	0.96	0.24	25.66	63.68	7.09	1.13
Forest	2.23	0.33	1.06	0.12	18.55	14.36	57.64	5.71
Settlement	8.33	1.41	2.34	0	3.61	2.27	15.74	66.30

A transition matrix (Table 2) was calculated to help understand the habitat retention rate and transition rate to other categories between 1989 and 1998. The water body has the highest retention rate, while the retention rate of sedge meadow was the lowest. The highest change rate, 54.59% was for the habitat transition from sedge meadow to reed field. As above-mentioned, sedge meadow is the main habitat for most waterfowl, while the harvest time of reed field was just of the time of waterfowl wintering in EDLNNR, and harvest activities disturbed the waterfowl. Therefore, the waterfowl distributed in the reed field was rare.

The second highest change rate 31.78%, was from paddy field to dryland, which was caused by the reason that cultivating dryland such as vegetable, cotton and sugarcane was profitable than paddy field, so the farmers are willing to change the paddy field to dryland to increase their income. These two dominant habitat transition types indicated that the suitable habitats for waterfowl in EDLNNR were decreased between 1989 and 1998.

3.2 Distribution and community dynamics of Waterfowl in EDLNNR

3.2.1 Waterfowl distribution between 2000-2002 winters

Different waterfowl distributed in different habitats. The waterfowl habitats in EDLNNR can be divided into four types, which are water body+mudflat, sedge meadow, cropland and forest+settlement. Our investigation result showed that water body and mudflat was highly suitable habitat for most species, whether the species composition or individual numbers were higher than other habitats. Sedge meadow was the suitable habitat, while the waterfowl distributed in other two habitats were relatively low (Table 3). Species that distributed in forest and settlement were higher than those in cropland, but the count encountered per time in the former is lower than in the latter, and the latter was the preferable habitat for some endangered species such as wintering cranes.

Table 3 Waterfowl distribution in different habitats of EDLNNR

Habitat type	Species numbers	Count encountered Per time	Dominant species
Water body+mudflat	69	10848	Ducks IBS BS SR
Sedge meadow	31	8756	BG GWFG LWFG Ducks
Cropland	15	245	Cranes NL
Forest+settlement	26	66	RRS EJ WCS

BG=Bean Goose (*Anser fabalis*); GWFG=Greater White-fronted Goose (*A. albifrons*); LWFG=Lesser White-fronted Goose (*A. erythropus*); BS=Baird's Sandpiper (*Calidris alpina*); IBS=Invert-billed Sandpiper (*Recurvirostra avosetta*);

SR=Spoted Redshank (*Tringa erythropus*)NL=Northern Lapwing (*Vanellus vanellus*); RRS=Red-rumped Swallow (*Hirundo daurica*); EJ=Eurasian Jackdaw (*Corvus monedula*); WCS=White-cheeked Starling (*Sturnus cineraceus*).

104 waterfowl species were recorded within two wintering periods during 2000-2002, which were subjected to 12 orders and 26 families, 75 percentages were wintering and on passage birds, and 74 percentages were listed as conservation species.

Owing to the waterfowl inventory table is too huge, so we listed the recorded waterfowl according to groups. Table 4 gave these groups' ultimate count, total count, count encountered per time and their distribution situation in different spots. As showed in Table 4 that geese, ducks, waders and plovers were the dominant wintering group in EDLNNR, the individual numbers of these groups occupied 93.4 percent of all recorded numbers. While stork, cranes and rails were accidental species wintering here, but of which the Oriental White Stork (*Ciconia boyciana*), Siberian Crane (*Grus leucogeranus*) and White-napped crane (G. *vipio*) were ranked the top national conservation list. Hooded crane (G. *monacha*) and Common crane (*G. Grus*) were listed as the second national conservation level. Common coot (*Fulica atra*) was also protected species at province level. The result of table 4 also indicated that the species and individual number distributing in EDLNNR varied with different places. We will analyze that in detail in the following table.

Table 4 Count and distribution of different waterfowl groups in EDLNNR during 2000-2002 winters

Groups	Uitimate count	Total count	Count encountered Per time	Distribution places				
				Core zone	Cross Dyke	Chunfeng Lake	Hongqi Lake	Tiane Duan
Grebes	2~378	1307	59.4	+++	++	++	+	++
Cranes	2~214	478	21.7	+	++		+	+
Rails	2~310	560	25.5	+++		+	+	
Waders	2~43699	121374	5517.0	+++	++	+++	+++	+++
Gulls	1~1757	5414	246.1	+++	++	++	++	+
Cormorants	7~1700	7617	346.2	+++	+++	+	++	
Herons	7~1577	4378	199.0	+++	++	++	++	++
Storks	2~37	182	8.3	++	++	++	+	++
Ibises	9~1500	4551	206.9	+++		+		+++
Geese	129~60409	204844	9311.1	+++	+++	+++	+++	+++
Ducks	33~12580	54643	2483.8	+++	+++	+++	+++	+++

+++ dominant species, ++ frequent species, + accidental species

Community structure and individual numbers of waterfowl distributed varied in different spots. As indicated by Table 5, both the species composition and population size of waterfowl habituated in Daxiao xi Lake were more than those of other spots. Bean Goose, Greater White-fronted Goose, Lesser White-fronted Goose, Ducks, Baird's Sandpiper and Invert-billed Sandpiper were dominant species in Daxiao xi Lake. Daxiao xi Lake, which were belong to the core zone of the Nature Reserve appear as separate lakes in winter, but they unify with Dongting Lake when the water level rise, which provided optimal habitats for most waterfowl.

Caisang Lake was adjacent to Daxiao xi Lake, so it provided important compensate habitat for wintering waterfowl when disturbance level from hunting, fishing activities and sometimes from Water Buffaloes was higher in Daxiaoxi Lake.

Chunfeng Lake is a very important site for waterfowl, especially for geese and ducks in the early

wintering season. This is because the elevation of Chunfeng Lake is relative higher (28-30m) than the other sites (e.g. Da Xiaoxi Lake (25-26 m)), therefore there is food available earlier there than on the other sites.

There are large area of sedge meadow appearing in the Cross dyke in winter. Aquatic animals in sedge meadow and the corn remaining in the adjacent Jianixng farm provided enough available food for wintering waterfowl. Cross dyke was the important habitat for Geese and ducks, but especially for wintering cranes that were inclined to corn.

The dominant species that distributed in Hongqi Lake were geese and ducks, Baird's Sandpiper, Spotted Redshank and Great Cormorant.

Tiane Duan was adjacent to Hongqi Lake, but its water level was deeper than Hongqi Lake, so it was suitable habitat for swan and paddling ducks.

Table 5 Waterfowl distribution in different investigation spots in EDLNNR during 2000-2002 winters

Locality	Area (km^2)	Time	Identified species	Count range encountered Per time (Average count)	Dominant species
Daxiaoxi Lake	6	2000 2001	62	80505~115775 98140	BG GWFG LWFG IBS BS CT
		2001 2002	47	7798~44620 18452	GWFG BG LWFG FD IBS
		Total	68	7798~115775 38374	BG GWFG LWFG IBS BS Ducks
Caisang Lake	6	2000 2001	24	5503 5503	IBS LG CT
		2001 2002			
		Total	24	5503 5503	IBS LG CT
Chunfeng Lake		2000 2001	48	283~22863 9341	BS GWFG SR KP
		2001 2002	11	2737 2737	BG GWFG SBD
		Total	49	283~22863 7690	BG GWFG BS SR
Hongqi Lake	6	2000 2001	42	9285~18928 14106	Goose BS SR Ducks
		2001 2002	6	5517 5517	Goose and Ducks GC
		Total	42	5517~18928 11243	Goose and Ducks BS GC SR
Tiane Duan	6	2000 2001	30	2794~17106 9950	BS Goose ES TS
		2001 2002			
		Total	30	2794~17106 9950	BS Goose ES TS
Cross Dyke	6	2000 2001	21	135~5310 2723	BG GWFG Ducks
		2001 2002	21	1126~1813 1470	GC BG CC
		Total	30	135~5310 2096	BG GWFG GC Ducks

Acronym description: CT=Common Teal (*Anas crecca*); FD=Falcated Duck (*A. falcata*); SBD=Spot-billed Duck (*A. poecilorhyncha*); TS=Tundra Swan (*Cygnus columbianus*); KP=Kentish Plover (*Charadrius alexandrinus*); LG=Little Grebes (*Podiceps ruficollis*); CC=Commom Crane (*Grus grus*); GC=Great Cormorant (*Phalacrocorax carbo*); ES=Eurasian Spoonbill (*Platalea leucorodia*); other acronyms see above-mentioned descriptions.

According to above-mentioned distribution data of waterfowl, we have drawn the distribution map of wintering waterfowl in EDLNNR between 2000-2002 winters (Fig. 3).

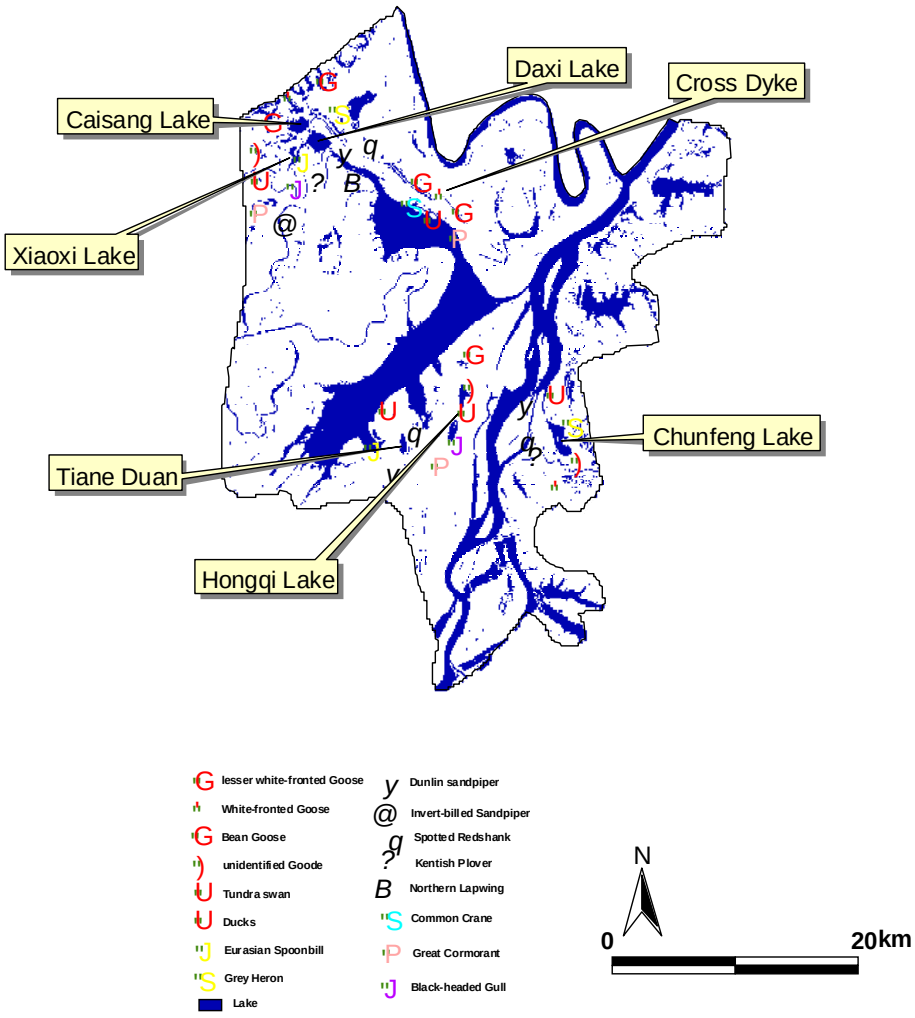

Fig. 3 Distribution map of waterfowl in EDLNNR during 2000-2002

3.2.2 Waterfowl community dynamics between 1992-1993 winter and 2001-2002 winter

We carried out continual waterfowl observing between 2001-2002 winter in core zone, and obtained information on structure and number of waterfowl community. The systematic ornithological fieldwork had ever conducted by the Nature Reserve during 1992-1993 winter. So we could compare the community dynamics of waterfowl in the recent 10 years, and further to understand the relationship between waterfowl distribution and dynamics and their habitats.

Waterfowl diversity and richness showed increased trends in the recent 10 years in the core zone of EDLNNR: waterfowl species number increased from 37 in 1992-1993 to 64 in 2001-2002, and individual numbers encountered each time increased from 9729 to 28000 (as showed in Table 6). The changes in species composition of dominant waterfowl distributing in core zone of EDLNNR were also happened. Excepting the geese and ducks were still the dominant species, Great Cormorant, Invert-billed Sandpiper, Tundra Swan and Black-headed Gull had taken the dominant place of Herons

until 2001-2002 winter. However, We also found that some endangered species such as Whooper Swan (*Cygnus cygnus*) appeared in 1992-1993 winter was not recorded in 2001-2002 winter.

Table 6 Community characteristics comparison of waterfowl between 1992-1993 and 2001-2002

Time	Observing period	Observing times	Identified species	Count encountered per time (Average)	Dominant species
1992-1993	92.11.5-93.3.10	53	37	2028-48586 9729	Ducks Goose ES GH LE
2001-2002	01.11.5-02.3.10	26	64	2852-68461 28354	BG GWFG LWFG Ducks GC IBS TS BHG

LE=Little Egret (*Egretta garzetta*); GH=Grey Heron (Ardea cinerea); BHG=Black-headed Gull (*Larus Ridibundus*); other acronyms see above-mentioned descriptions.

3.3 Population dynamics of some endangered waterfowl in EDLNNR

3.3.1 Population size change of Lesser White-fronted Goose between 1992 and 2002

The Lesser White-fronted Goose (*Anser erythropus*, later LWFG) is a globally threatened species. Current studies show that the world population of LWFG is not more than 25,000-30,000 individuals (Tolvanen et al., 1999), Roughly half of them winter mainly in China. EDLNNR is the most important wintering site known so far, the highest counts being 9,000 in the winter 1989/90 (Liu, 1994); 13,700 in spring 1997 (Iwabuchi et al.1997) and 16,500 in late autumn 1999 of LWFG (Lei, 2000). Integrating our ornithological observation with the historical monitoring data in the Nature Reserve, we analyzed the population size change of EDLNNR and expected to reveal the factors causing threat to LWFG.

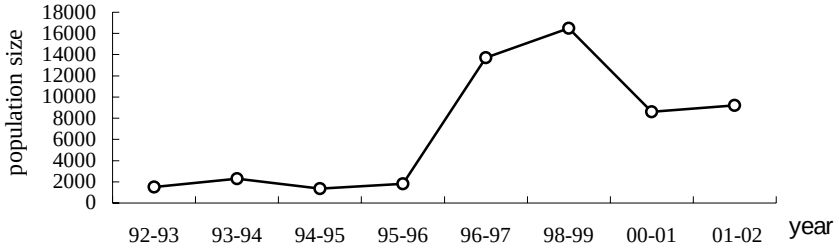

Fig. 4 Wintering population size of LWFG since 1992 in EDLNNR

As showed in Fig.4, the population size in the early of 1990s was 1500. The size remarkably increased to 137,00 during 1996-1997. Wintering population size of Lesser White-fronted Goose kept relatively stable after that, and the population size were 8000-9000 or so at present. This result indicated that after the effective management of the Nature Reserve, EDLNNR provided important habitat for endangered LWFG.

DaXiaoxi Lake was the most suitable habitat for LWFG, but they also preferred the ChunFeng Lake, Cross Dike, especially when the disturbance (fishing) at the Daxiaoxi Lake is high. In early winter, LWFG are usually shy and mixed with White-fronted Geese, but in the late winter LWFG were mainly concentrated at the DaXiaoxi Lake, because the disturbance is relatively low in that period. So it is appropriate time to count the total population size at that time.

Illegal hunting and human disturbance are serious threats for the LWFG conservation in EDLNNR. Poisoning is the most common way of hunting. The poachers usually put the poison on the mudflats and the lakeside, which are used by LWFG. Fishing and reed harvest are the common human disturbances to wintering LWFG.

3.3.2 Population size change of four endangered cranes in the recent 16 years

There are 15 cranes in the world, 9 of which were recorded in China (Ma, 1990; Shu et al., 2000). Siberian Crane (*Grus leucogeranus*), Hooded Crane (*Grus monacha*), White-napped Crane (*G. vipio*) and Common Crane (*G. grus*) had ever recorded to winter in EDLNNR (Zheng et al., 1960), and we recorded all these four cranes in our fieldwork. These four cranes wintering in EDLNNR mainly habituated in fallow paddy field, mudflat and sedge meadow of Cross Dike. We studied the population dynamic of four endangered cranes by using our observing data and related references (indicated by table 7).

Table 7 Population dynamics of four Endangered Crane wintering in EDLNNR in the recent 16 years

Period	Hooded Crane	White-napped Crane	Siberian Crane	Common Crane	Data source
1985 1986	59	6	2	20	Gui, 1990
1986 1987	120	157	16	57	Gui, 1990
1988 1989	110	36	16		Wang, 1998
1989 1990	159	72	57		Wang, 1998
1990 1991	106	32	23		Wang, 1998
1991 1992	28	24	62	420	Wang, 1998
1992 1993	87	103	37	420	Wang, 1998
1993 1994	22	89	22	407	Wang, 1998
1994 1995	53	72	24	198	Wang, 1998
1995 1996	49	48	61		Wang, 1998
2000 2001	14	3	17	214	This fieldwork
2001 2002	9	3	2	153	This fieldwork

Population size of these four cranes wintering in EDLNNR showed decreased trends in the recent 16 years. Hooded Crane decreased from the zenith number, 159 ind. during 1989-1990 to 9 ind. during 2001-2002. White-napped Crane decreased from the highest record of 157 ind. during 1986-1987 to 3 ind. during 2001-2002. The highest recorded of Siberian Crane was 62 ind. during 1991-1992, while in this fieldwork, we only recorded 17 and 2 ind. between 2000-2001 and 2001-2002. Of all these four cranes in EDLNNR, the population size of Common crane was highest. Its size was 420 ind. in the early of 1990s, while the population decreased to 214 and 153 ind. respectively between 2000-2001 and 2001-2002. As showed in waterfowl habitat dynamics, the higher transition from paddy field to dryland was the main reason that led to the decline of population size for cranes in the recent two years.

The study on population dynamics for LWFG and four cranes showed that although waterfowl composition and population size increased in the recent 10 years, some endangered waterfowls that were sensitive to the habitat change declined in the recent two wintering periods, which were mainly resulted from illegal hunting, over-fishing and other human disturbances, such as land cover change.

4 Conservation recommendations

The factors that could affected the waterfowl distributed in the Eastern Dongting Lake Nature

Reserve included: silt deposition process, waterfowl habitat change, water level, human disturbance, the management of the Nature Reserve, climate change, vegetation composition and ecological condition of their breeding area in the north. Of which the silt deposition process, habitat degradation led by the LUCC change and some human disturbance may have the negative effects on the waterfowl distribution; While the suitable management of the Nature Reserve provided the positive conditions for the waterfowl distribution. Our results showed that the waterfowl composition and population size increased in the recent 10 years, which may mean that the suitable management of the Nature Reserve and corresponding habitat restoration project play an important role in the wintering waterfowl species restoration, although waterfowl habitat degraded a little. This maybe also means that the waterfowl species wintering here were much less than those of their carrying capacity. In fact, if the habitat changes were considered in the recent 50 years, we could find that the habitat degradation was mitigated in the recent 10 years (Zhao et al., unpublished). Through integrating consideration of possible factors that affected distribution and community dynamics of waterfowl, possible approaches were proposed to restore waterfowl community (indicated by Fig. 5).

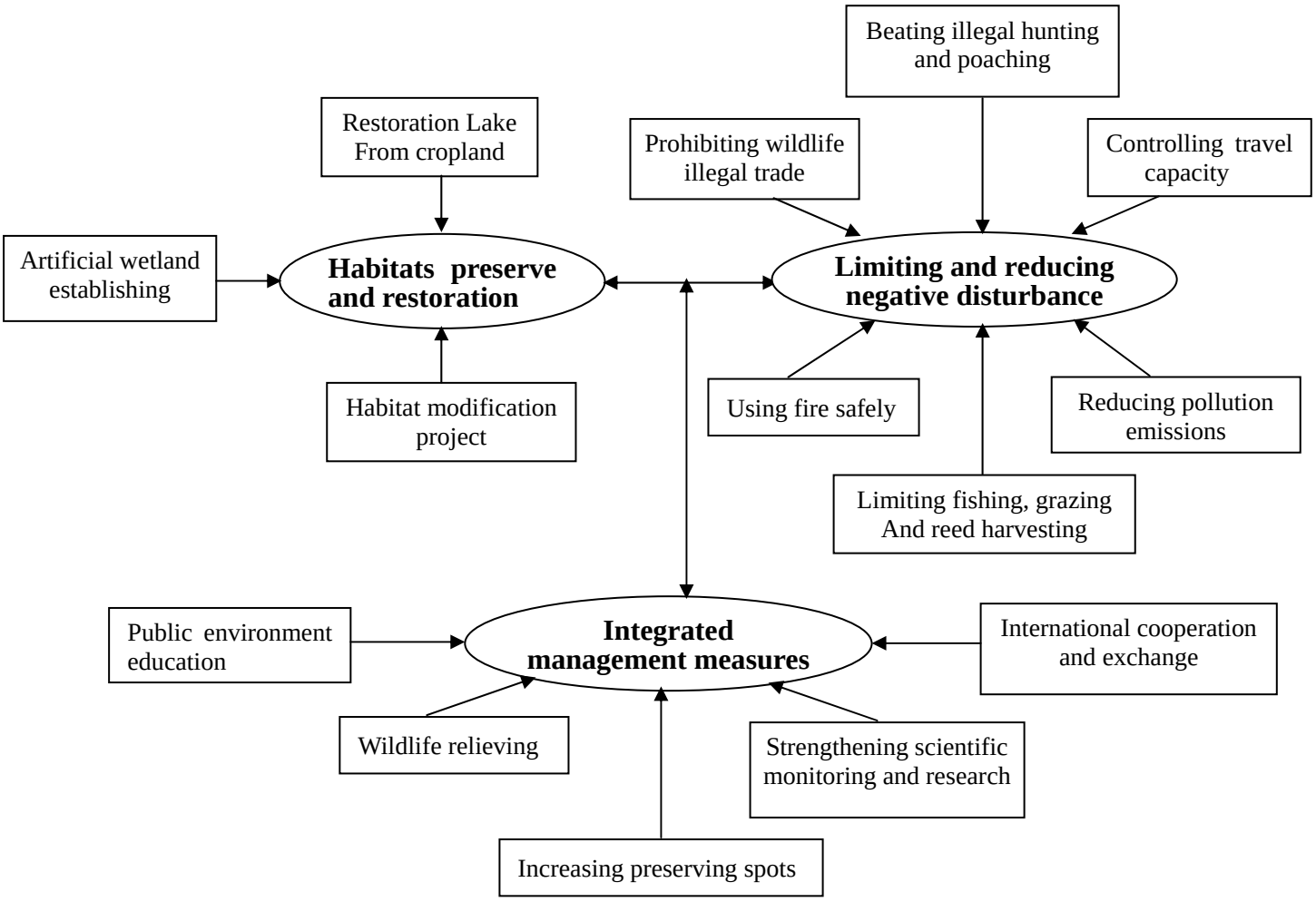

Fig. 5 Approaches to reserve and restore waterfowl

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