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Priority sites and conservation gaps of wintering waterbirds in the Yangtze River floodplain

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Abstract: The Yangtze River floodplain is critical for migratory waterbirds along the East Asian-Australasian Flyway (EAAF). Greater awareness of its global importance is urgently needed to ensure waterbird populations remain in favourable conservation status, as well as the enhancement of wider wetland biodiversity within this region. The designation of protected wetland areas and building a green ecological corridor in the Yangtze floodplain is now becoming a critical issue of interest to the Chinese government. Priority sites in this area were identified based on the criteria used to identify sites that qualify as Wetlands of International Importance (Ramsar Sites) and Important Bird and Biodiversity Areas (IBAs) by using multi-source data. The results show that 140 of the sites surveyed are priority sites. The Importance Index (*I*) for the whole floodplain decreased slightly from 2001–2005 and an unbalanced distribution pattern is evident with Jiangxi and Hunan provinces significantly higher than the other provinces in the floodplain. Although more than 60% of the priority sites are currently located outside protected areas, the average Conservation Effectiveness Index (*C*) of the whole floodplain is 75.6%, which suggests the coverage of protected areas for most wintering waterbird population is reasonable. Conservation of the Yangtze River floodplain needs to be further strengthened due to declining waterbird abundances and the mismatch between the distribution of protected areas and their importance for wintering waterbirds. A comprehensive system for priority site identification and protection and scientific review is needed. Multi-sourced data from regular, systematic and coordinated monitoring of waterbird distribution and abundance across the EAAF, as well as national scale citizen science programmes are also critically important.

Keywords: wintering waterbirds; Yangtze River floodplain; priority site; feeding guild

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1 Introduction

Habitat loss and degradation are the most pertinent causal factors driving rapid biodiversity decline globally (Rodrigues *et al*., 2004; Hoekstra *et al*., 2005). Today, biodiversity conservation action has shifted focus from specific species protection to habitat protection (Hoekstra *et al*., 2005). The protected area approach is one of the most effective measures currently available to minimize habitat loss and degradation (Chape *et al*., 2005). A strategically designed nature conservation plan requires a site prioritization system to be in place, so that the limited resources available to maintain ecosystem functions and biodiversity can be deployed to the maximum effect (Bonn and Gaston, 2005; Freudenberger *et al*., 2013). Such nature conservation plans can also connect science and decision-making concerning ecosystem conservation and management (Vohland *et al*., 2011; Fu *et al*., 2017).

Migratory waterbirds include some of the most threatened bird populations in the world, and the identification and protection of key sites and habitats along their flyways has attracted worldwide attention (Kirby *et al*., 2008; Runge *et al*., 2015). To effectively maintain waterbird populations, the protected site network should include a complimentary suite of sites that provide for all aspects of the life cycle and daily needs of the species it aspires to protect, e.g. sufficient and available food resources at safe feeding sites and safe shelter (Iwamura *et al*., 2013; Murray and Fuller, 2015). The Yangtze River floodplain is a globally important region on the East Asian-Australasian Flyway (EAAF) and is estimated to support more than 900,000 wintering waterbirds annually, especially herbivorous Anatidae (Barter *et al*., 2005). However, the floodplain is under intensive economic and urbanization development pressure (Gao and Zhang, 2010; Gu *et al*., 2011), resulting in serious conflicts between development and ecological conservation (Cao and Fox, 2009). Habitat degradation, and consequent decreased food availability for waterbirds that feed on tubers and grasses, caused by hydrological regime alterations is also a major issue in this region (Fox *et al*., 2011; Zhao *et al*., 2012). The need to balance both conservation and sustainable economic development in the floodplain is urgent. Drawing ecological ‘redlines’ and planning protected site networks for biodiversity has become an essential part of national strategies related to the Ecological Environmental Protection Plan in the Yangtze River (Yao *et al*., 2015).

In order to formulate an “ecological redline” for China based on waterbird survey data, a handful of studies have presented the broad situation of waterbirds with relevant information (Cui *et al*., 2014; Zhang *et al*., 2017), however it is still necessary to give a comprehensive assessment in this region in order to promote the establishment of a protection network and the wise use of wetlands in a holistic flyway manner which is urgently needed (Margules and Pressey, 2000).

Sufficient species distribution and abundance data are essential for the effective identification of key habitats, yet the lack of such data is a long-standing barrier to the setting up of conservation plans globally (Tantipisanuh and Gale, 2018). In recent decades, citizen science data have filled some of the data gaps and now play an increasingly important role in biodiversity assessments and conservation, especially data from birdwatchers. ‘Big data’, such as eBird (www.ebird.org.cn) (Sullivan *et al*., 2009; Snall *et al*., 2011) and Birdwatching in China (Li *et al*., 2013; Hu *et al*., 2017), have made valuable contributions to avian conservation studies. Contemporary methods used to assess and design protected area networks depend on data availability at appropriate spatial scales. MARXAN (Heiner *et al*.,

2011) and C-plan (Cowling *et al*., 2003) are more suited to large-scale assessments and heavily rely on occurrence data rather than species abundance data (Manel *et al*., 2001). Biodiversity mapping using Geographic Information Systems (GIS) has also been used at local and regional scales (Stralberg *et al*., 2011; Kordi and O'Leary, 2016) and both species richness and occurrence data play important roles when scoring and setting priorities (Bonn and Gaston 2005; Ambal *et al*., 2012). The latter may provide scientific information to conserve target species, e.g. such data were used to determine the key regions for biodiversity conservation in the Yellow Sea (Mackinnon *et al*., 2012) and along China's coast (Xia *et al*., 2017a). In addition, waterbirds in the same 'feeding guild' usually possess similar habitat preferences and exhibit similar feeding characteristics (Kear, 2005). For example, grass eaters typically prefer wet meadow and relatively short swards (Guan *et al*., 2016), while many shorebirds and dabbling ducks prefer shallow water (Ma *et al*., 2010). Different guilds may respond differently to changes in habitat variables, such as ecological and anthropogenic factors (Tavares *et al*., 2015; Zhang *et al*., 2018). Using 'feeding guild' as a unit to identify core habitats and plan protected areas may be a cost effective approach for policy makers.

In this study, waterbird survey data from coordinated surveys and birdwatchers' records in the Yangtze River floodplain were used to identify priority sites for conservation based on a standardized framework. The importance of individual priority sites is quantified and a spatio-temporal distribution of waterbird importance is mapped. This study supports the provision of a scientific foundation for waterbird conservation and strategic planning in the Yangtze River floodplain.

2 Data and methodology

2.1 Study area

The Middle and Lower Yangtze floodplain (MLY), with a wetland area of 7.7×10^6 ha, accounts for 17% of the gross wetland area in China (SFA, 2014). It is one of the most densely distributed lake clusters in China, stretching over 1,000 km inland from the Yangtze estuary at Shanghai and spanning five other provinces, namely, Jiangsu, Anhui, Jiangxi, Hubei and Hunan. The floodplain wetlands primarily consist of shallow lakes, and include globally important waterbodies such as Poyang Lake and Dongting Lake. In total, there are more than 600 lakes with areas greater than 1 km^2, representing 37.2% of the total area of freshwater lakes in China (Wang and Dou, 1998). At present, the total area of provincial and national nature reserves intended to protect wetlands and waterbirds in the Yangtze River floodplain is 2.07×10^6 ha, which accounts for 26.1% of the total wetland area (7.7×10^6 ha; SFA, 2014) of the region. Sixteen National Nature Reserves make up 39.1% of the total protected area. There are also 38 Provincial Nature Reserves, accounting for a further 42.4% of the total protected area, and 57 other nature reserves, making up 18.5% of the total protected area (China's Nature Reserve specimen resource sharing platform, http://www.papc.cn/). These protected areas include ten Ramsar Sites which are designated to protect waterbirds and their habitats: (1) East, (2) South and (3) West Dongting Lake in Hunan, (4) Poyang Lake National Nature Reverse and (5) Nanji Wetland National Nature Reverse in Jiangxi, (6) Chongming Dongtan in Shanghai, (7) Honghu Lake, (8) Chenhu Lake and (9) Wanghu Lake in Hubei and (10) Shengjin Lake in Anhui (RCS, 2010; https://www.ramsar.org/wetland/

china). It is also a priority region of the East Asian-Australasian Flyway Partnership (EAAFP) (Cao *et al*., 2009) (Figure 1).

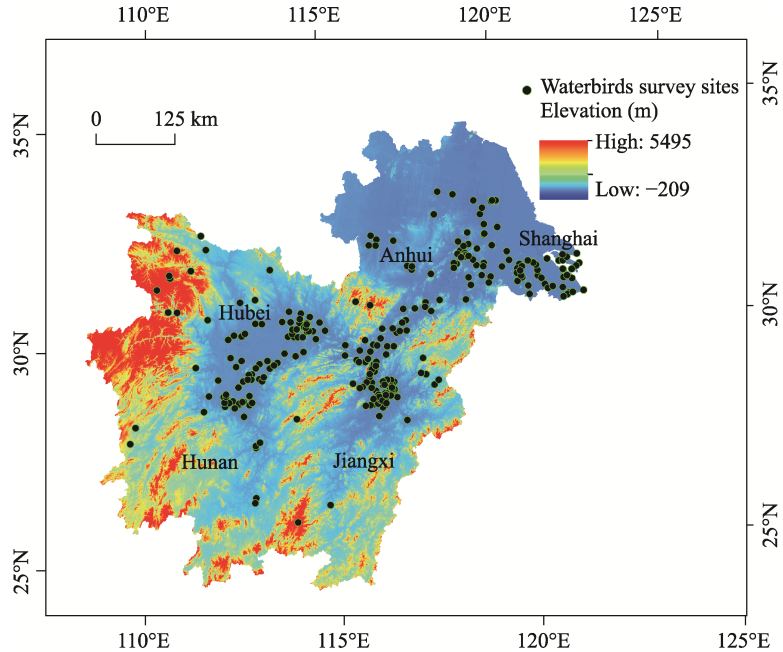

Figure 1 The location of waterbird survey sites in the Yangtze River floodplain

2.2 Data collection and processing

Most data used in this study are sourced from coordinated waterbird surveys undertaken in the MLY floodplain in 2004 (Barter *et al*., 2005), 2005 (Barter *et al*., 2006), 2011 (Lei *et al*., 2011) and 2015 (Tao *et al*., 2015). In addition, in order to comprehensively map species distributions over different decades, we combined waterbird data collected before the 2000s, which were mostly obtained from the literature and site surveys, such as waterbird research in China (Waterbird Specialist Group of Chinese Ornithological Association, 1994) and the Status of Waterbirds in Asia 1987–2007 (Li *et al*., 2009). Citizen science data, such as the annual China Bird Report (2003–2007) and bird survey records from the China Bird Watching Network website (2008–2015; http:// www.chinabirdnet.org/) were also combined in this study. Wintering waterbirds typically start arriving at the MLY in October and do not depart until the following March, thus waterbird records during this period were used in this study. The dataset includes waterbird species, site name, site location (latitude and longitude), number of individuals and the survey date. Coordinated waterbird surveys in some large areas are usually divided into different counting units according to, e.g., a physical geographic boundary or a specific survey boundary. At Poyang Lake, sub-lakes such as Hanchi Lake and Zhuhu Lake which are separated from Poyang Lake in winter and the Ramsar site, Poyang Lake National Nature Reserve were treated as individual survey units (or sites). Thus, some large areas were divided into several sites and survey data were analysed at the survey unit scale to compare between sites. The dataset contains 15,700 records of 89 species from 309 sites. The waterbird survey sites were located by latitude and longitude using ArcGIS 10.5 and then mapped. Information on protected areas within the MLY floodplain, including location data, was collected from China's Nature Reserve specimen resource sharing platform (http://www.papc.cn/).

Identifying priority sites using feeding guild as a determinant, rather than single species, may provide more meaningful information for policy makers and managers to promote conservation activities (Zhang *et al*., 2018). Therefore in this study, we have classified the waterbird species in the MLY floodplain into five such guilds according to their main foraging habitats and diets (Wang *et al*., 2013; Appendix A provides a complete species list). The five guilds were: (i) tuber eaters (seven species, including cranes and swans that inhabit shallow water and wet mudflats), (ii) short grass foragers (six geese species that inhabit wet meadows), (iii) seed and aquatic vegetation eaters (18 species, mainly dabbling ducks that inhabit shallow water), (iv) invertebrate eaters (33 species, mainly shorebirds that inhabit muddy areas and the shallowest water), and (v) fish eaters (25 species including storks, egrets and herons).

2.3 Criteria and thresholds for identifying priority sites and the conservation status of the Middle and Lower Yangtze floodplain for waterbirds

The criteria and population thresholds used to identify priority sites in the MLY floodplain are shown in Table 1, which refers to the identification criteria for Ramsar Sites (RCS, 2010), and Important Bird and Biodiversity Areas (IBA, Fishpool and Evans, 2001). Sites which met at least one Ramsar or IBA identification criteria were considered as priority sites (criterion listed in Table 1).

Table 1 Criteria and thresholds for identifying priority sites of the Yangtze River floodplain for the conservation of wintering waterbirds

Criteria	Source	Thresholds for identifying priority sites
Criterion 1 Sites in which a globally threatened species occurs in significant numbers	Criterion 2 for identifying Ramsar sites (Ramsar Convention Secretariat, 2010); Criterion A1 to determine Important Bird Area (Fishpool and Evans, 2001)	Regular presence of a single individual for Critically Endangered (CR) and Endangered (EN) species; presence of 30 individuals for Vulnerable species (VU) according to IUCN Red List category
Criterion 2 Sites that hold a significant proportion of the flyway population	Criterion 6 for identifying Ramsar sites (Ramsar Convention Secretariat, 2010); Criterion A4 to determine Important Bird Area (Fishpool and Evans, 2001)	Population exceeds 1% of flyway population (hereafter Ramsar 1% criterion)
Criterion 3 Sites that support a significant aggregation of individual waterbirds	Criterion 5 for identifying Ramsar sites (Ramsar Convention Secretariat, 2010)	Supports 20,000 or more waterbirds

Note: The value of Criterion 2 means the percentage of the global or EAAF population published in Waterbird Population Estimates Fifth Edition (Ramsar Convention Secretariat, 2010; WPE5; Wetlands International, 2015; http://wpe.wetlands.org/).

The Importance Index (*I*) (Xia *et al*., 2017a) was used to quantify the relative priority of sites (Equation 1). It can also indicate a site's importance and conservation value. A higher value of I represents a higher priority of a site for conservation:

$$I = \sum_{i=1}^{s} n_i / N \qquad (1)$$

where n_i denotes the population of the *ith* waterbird species at the survey site, N denotes the flyway population of the ith species, according to Waterbird Population Estimates Fifth Edition (WPE5) (Wetlands International, 2015), and s denotes the number of species at the site.

We also established a Conservation Effectiveness Index (*C*) to quantify the relative degree of protected area coverage, which was the proportion of the Importance Index under protection, calculated as Equation 2:

$$C = C_p / C_t$$

$$C_p = \sum_{i=1}^{s} I_p ; C_t = \sum_{i=1}^{n} I_t$$

where C_p denotes the sum of the importance indices of the sites under protection by provincial and national nature reserves in the MLY floodplain or specific provinces. C_t denotes the sum of the importance indices of all the sites in the MLY floodplain or specific provinces. Higher *C* index indicates the main waterbirds or their habitats were under protection.

2.4 Data processing, priority setting and gap analysis

Globally threatened species were identified according to the International Union for Conservation of Nature and Natural Resources (IUCN) Red List (http://www.iucnredlist.org/). The peak counts of each species per site were used to identify whether or not a species met the Ramsar 1% criterion. The average total count of waterbirds during the 2011–2015 period at each site was used to determine the sites' waterbird abundance. The importance of each site was quantified using the Importance Index, determined from Equation 1. The peak count of each species in different provinces/regions (Jiangxi, Hunan, Hubei, Anhui, Jiangsu and Shanghai) or time periods (1980–2000, 2001–2005, 2006–2010 and 2011–2015) was used when we calculate their Importance Index. This was then summarized according to province or time period as the total Importance Index, which may indicate the overall waterbird abundance. A list of protected areas in the MLY floodplain and their locations was collected from the China's Nature Reserve specimen resource sharing platform (http://www.papc.cn/). Most vector files of the boundaries of the protected areas were sourced from Resource and Environment Data Cloud Platform, Chinese Academy of Sciences (http://www.resdc.cn/data.aspx?DATAID=272), while others were vectorized manually. Individual priority sites were then overlain with the protected areas distribution map. Sites outside the protected areas were network recognized as gap areas.

3 Results

3.1 Priority sites in the Middle and Lower Yangtze floodplain

Waterbird data from 309 sites throughout the MLY floodplain were analyzed. Overall, 140 sites (45% of the total) were identified as priorities, 120 of which (39% of the total) supported at least one species listed as globally threatened on IUCN's Red List). In total, 13 globally threatened species were recorded (Table 2), including two Critically Endangered species (CR), three Endangered species (EN), and eight Vulnerable species (VU).

One hundred and fifteen sites (37% of the total) met the Ramsar 1% criterion, and eight of these sites (namely Poyang Lake NNR, Nanji wetland NNR, Duchang PNR, Zhuhu Lake and Dalianzi Lake in Jiangxi; East Dongting Lake NNR in Hunan, Shengjin Lake NNR in Anhui, Chenhu Lake in Hubei) had more than 15 species which met the 1% criterion. Twenty-seven sites (8% of the total) supported 5000 or more waterbirds and seven sites supported 20,000 or more waterbirds (criterion 3).

Table 2 Globally threatened waterbirds in the Yangtze River floodplain

English name	Scientific name	IUCN category	Number of sites where the species was present during the wintering season
Baer's Pochard	*Aythya baeri*	CR	38
Siberian Crane	*Grus leucogeranus*	CR	49
Far Eastern Curlew	*Numenius madagascariensis*	EN	13
Oriental Stork	*Ciconia boyciana*	EN	71
Scaly-sided Merganser	*Mergus squamatus*	EN	9
Common Pochard	*Aythya ferina*	VU	48
Dalmatian Pelican	*Pelecanus crispus*	VU	9
Hooded Crane	*Grus monacha*	VU	31
Horned Grebe	*Podiceps auritus*	VU	7
Lesser White-fronted Goose	*Anser erythropus*	VU	33
Saunders's Gull	*Larus saundersi*	VU	28
Swan Goose	*Anser cygnoides*	VU	73
White-naped Crane	*Grus vipio*	VU	28

In total, 140 sites met either the Ramsar criteria or IBA criteria, while only 10 of these sites of them are currently designated as Ramsar sites and 54 are identified as or included in IBAs (Appendix B). The spatial distribution of these sites is shown in Figure 2. Eight sites have an Importance Index of more than 200, namely Poyang Lake NNR, Duchang PNR, East Dongting Lake NNR, Nanji wetland NNR, Zhuhu Lake, Shengjin Lake, Longgan Lake and Hanchi Lake, while 12 sites with an Importance Index between 100 to 200, and seven

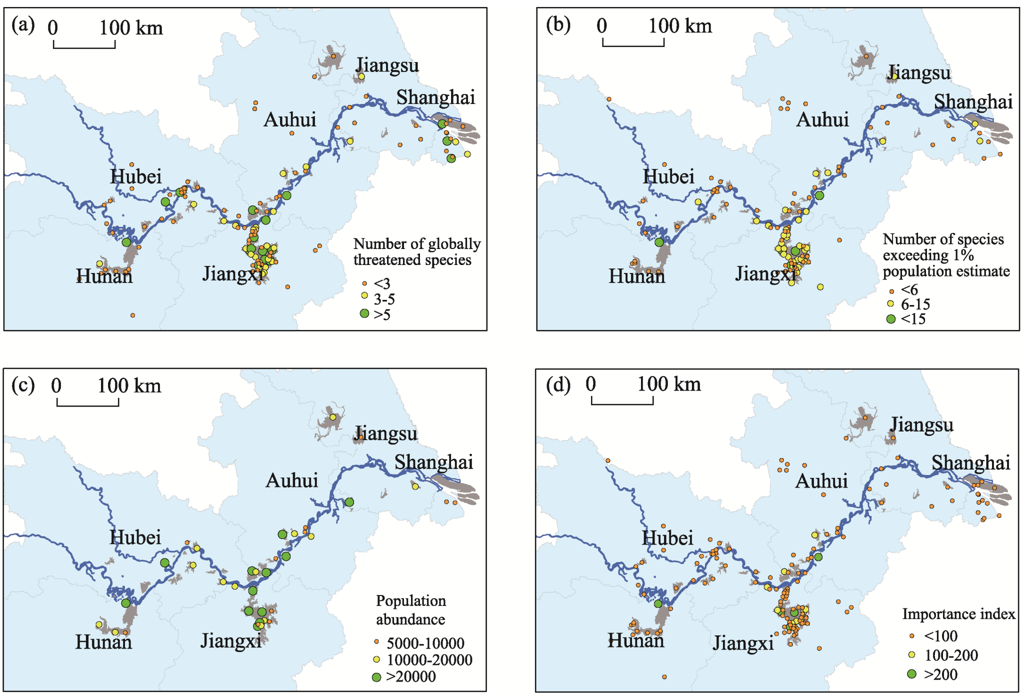

Figure 2 Sites with (a) globally threatened species, (b) species meeting the Ramsar 1% criterion, (c) high total waterbird abundance, and (d) high Importance Index

sites between 50 to 100. The sites are listed according to their Importance Index value in Appendix B.

3.2 Spatio-temporal variation of waterbird conservation values in the Yangtze River floodplain

The total Importance Index values from various time periods (1980–2000, 2001–2005, 2006–2010 and 2011–2015) were calculated to present waterbirds abundance changes, as well as waterbirds spatial patterns in the MLY floodplain (Figure 3). The results showed that the Importance Index of the whole floodplain decreased slightly from 2001–2005 to 2011–2015, which is suggestive of a decrease in total waterbird abundance during this period. The Importance Index was also low before 2000, however this is likely to be an underestimate due to data limitations. The overall spatial pattern is asymmetric. Jiangxi Province, with 62 priority sites, stands out as the most prominent region for waterbird conservation. Its Importance Index is twice the sum of the other regions, which collectively hold 78 priority sites.

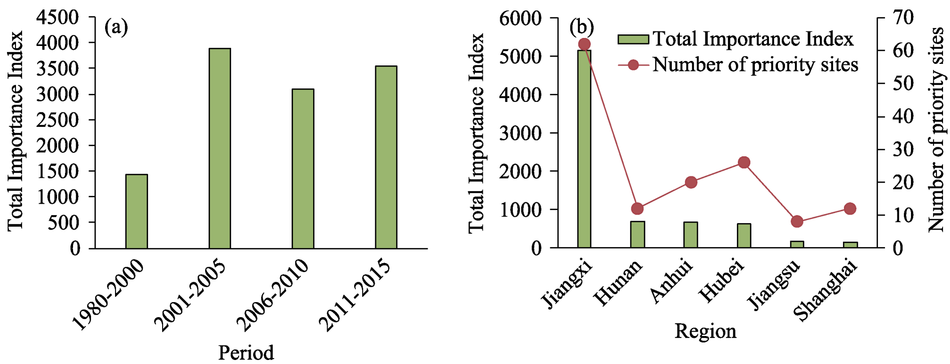

Figure 3 Spatio-temporal variations of Importance Index in the Yangtze River floodplain

3.3 Importance Index for different waterbird feeding guilds in the Yangtze River floodplain

We also analyzed the spatial patterns of the Importance Index for various feeding guilds. The results of this analysis show that waterbirds are most dependent on wetland habitats in Jiangxi Province, which had the highest Importance Index for all five feeding guilds (Figure 4). Notably, it accounted for more than 50% of the total Importance Index for tuber eaters and invertebrate eaters, and more than 40% for seed eaters and fish eaters. Hunan and Anhui accounted for 38% and 15%, respectively, for grass eaters. Hunan and Shanghai accounted for nearly 20% of seed eaters.

3.4 Conservation Effectiveness Index and gaps in the Yangtze River floodplain

The total protected areas in MLY floodplain is 2.07×10^6 ha, which account for 26.1% of the total wetland areas in this region; most are natural wetlands. After comparative analysis with the distribution of protected areas, we found that 87 of the 140 priority sites (62.1%) identified in this study are located outside of the current protected area network in the MLY.

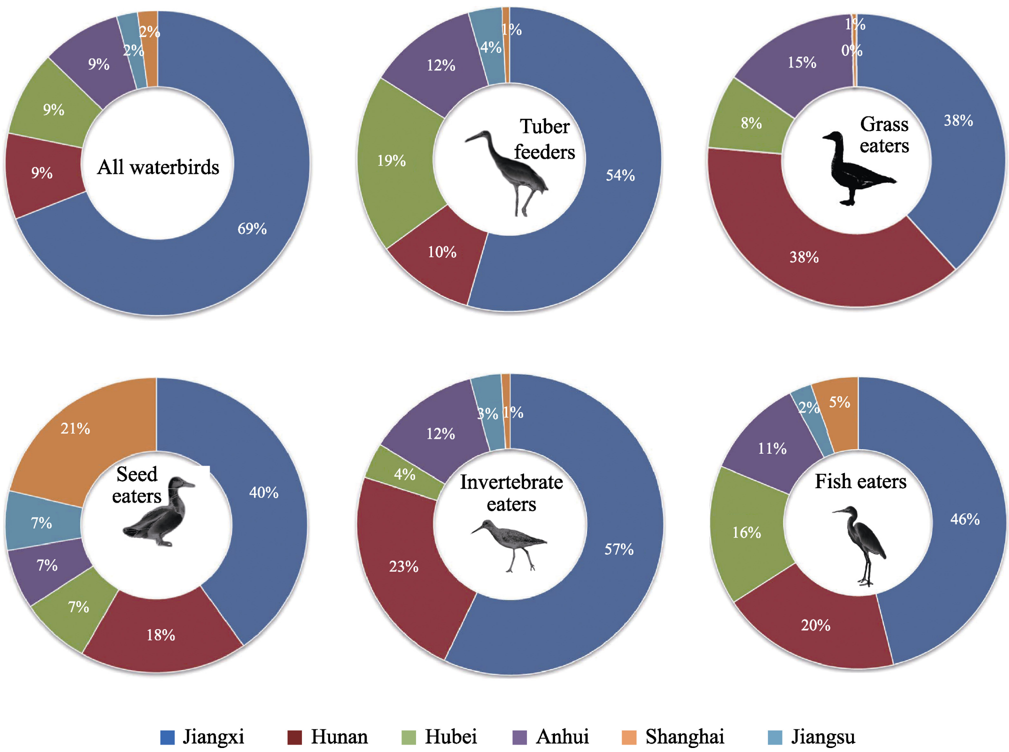

Figure 4 The proportion of the Importance Index in different provinces for five feeding guilds

The status of protected area coverage, along with the size of the protected areas in each region of the MLY, is shown in Table 3. Overall, we found a relatively high *C* index in the MLY with an average value of 75.6%. Anhui and Hunan had the highest *C* index values (98.3% and 97.5%, respectively), meaning most of the important waterbird sites in those provinces are legally protected. Hubei and Jiangsu, with *C* indices of about 80% (Hubei 84.6% and Jiangsu 79.1%), also have relatively high levels of legal protection. Jiangxi, however, has a relatively low *C* index (69.1%) despite its high Importance Index (twice the total sum of all other provinces). Shanghai had the lowest *C* index (56.9%). We can build new protected areas or expand the land areas of existing protected areas to cover all priorities sites to fill conservation gaps, this may however be unrealistic to implement.

Table 3 Protected areas and conservation effectiveness indices in the Yangtze River floodplain

Items (Regions)	Anhui	Hubei	Hunan	Jiangsu	Jiangxi	Shanghai	MLY
Number of suevey sites	32	71	43	64	78	21	309
Total Importance Index	672.44	610.66	677.87	154.27	5142.45	152.19	7409.88
Importance Index of sites being protected	661.22	516.69	660.72	121.98	3557.17	86.66	5604.44
Protected area (10^3 ha)	328.51	289.44	485.64	533.47	341.94	93.88	2072.88
Proportion of protected area to wetland area (%)	31.5	20.0	47.6	18.9	34.6	20.2	26.90
Conservation gap rate (%)	30.0	52.0	58.3	62.5	75.8	75.0	62.10
Conservation Effectiveness Index (%)	98.3	84.6	97.5	79.1	69.1	56.9	75.63

To strengthen the protected area network in the MLY, we suggest enhancing the conservation effectiveness by increasing the total Importance Index value for protection and assigning a greater priority to sites with high individual importance values. After further analysis, six sites are proposed as the best for increasing the *C index* in the whole MLY to more than 85% (Figure 5). The analysis showed that this could be achieved solely by selecting six sites in Jiangxi, namely Dalianzi Lake, Linchong Lake, Qihu Lake, Chihu Lake, Chengjiachi and Dawu Lake suggesting Jiangxi Province should be the focus when developing a blueprint for a stronger protected area network in the MLY.

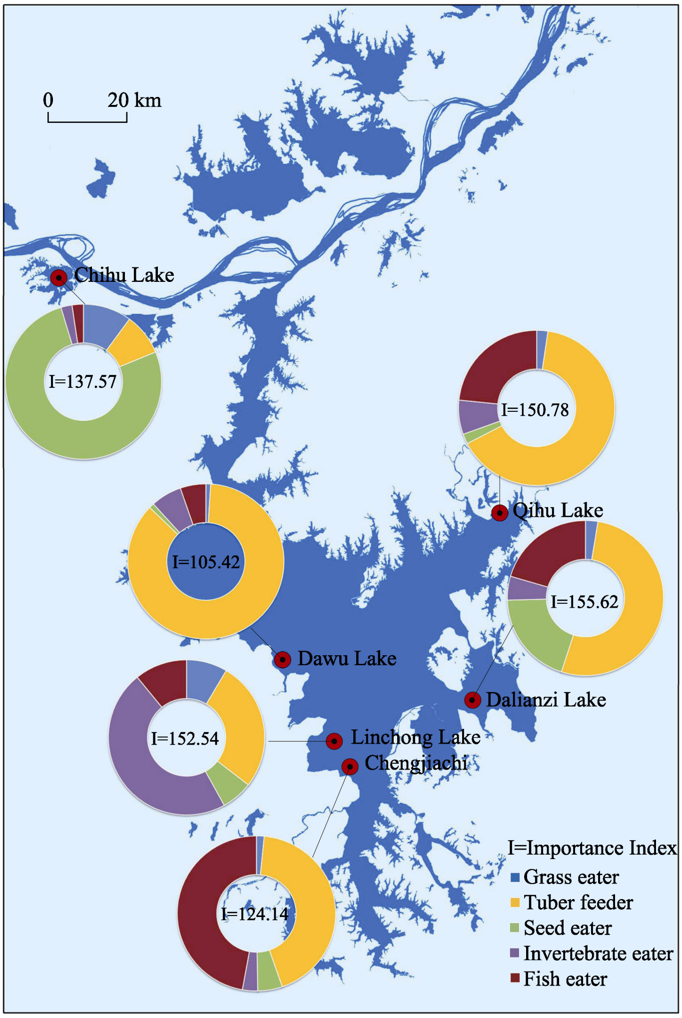

Figure 5 Priority sites proposed for the establishment of new protected areas in Jiangxi Province

4 Discussion

4.1 Conservation assessment methods in this study

A spatial prioritization method was applied in this study, and wetland priorities, as well as the *C* index in the Yangtze River floodplain were determined from waterbird survey data obtained from multiple sources. Internationally accepted criteria and standards were used to identify sites qualified as Important Bird and Biodiversity Areas (IBA; Fishpool and Evans, 2001) or wetlands of international importance (RCS, 2010). We referred to the assessment framework and data processing procedures in Xia *et al*. (2017a). *C* index is an important indicator for the most effective and efficient design of protected area networks. In previous studies, the extent of site protection is usually measured through conservation gap rates, that is the ratio of unprotected sites (numbers or areas) to the total sites (numbers or areas) (Xia *et al*., 2017a). However, when calculated in this way, it may not fully represent the rationale of why protected areas are needed and, therefore, may not be an appropriate guide for the planning of protected area networks. To investigate ways to improve on this, we evaluated the conservation efforts using a slightly different approach which gives a more ecologically meaningful result. We calculated the *C* index as the ratio of the sum of the Importance Index of sites covered by protected areas to the total Importance Index in the region. A higher *C* index means that a greater proportion of all waterbirds in a region occur at protected sites. We introduced the concept of 'feeding guild' into the identification of priority sites, rather than only focusing on individual species. The dynamics of feeding guilds inherently implies there is variation in habitat types in these areas. Feeding guilds can also help guide future management options within protected areas by recognizing that habitat 'ownership' based on clarifying the requirements of specific feeding guilds, promotes habitat conservation activities through a cost-effective way (Zhang *et al*., 2018).

Citizen science data and coordinated waterbird survey data were compiled in this study to maximize the accuracy and comprehensiveness of the results. Coordinated waterbird survey data are only available after 2004 in the MLY River and such waterbird survey data, supported by WWF and WWT, from 2004, 2005, 2011 and 2015 were the main data source in this study. Citizen science data (e.g. China Birdwatching Association, CBA) were particularly useful for identifying occurrences of globally threatened species. In the future, we anticipate that a large quantity of data will be generated through citizen-science approaches and rigorous data validation processes will be required during data collation and any follow-up studies (Cohn, 2008). The criteria for Ramsar Sites and Important Bird and Biodiversity Areas state that the site should 'regularly' support more than 1% of the population or 20,000 or more individuals. We used the average number of individuals in 2011 and 2015 when assessing the population abundance for individual sites, since no other recent synchronously collected data were available. For some species, the peak count from a single survey was used to calculate the Importance Index. These peak count values were verified by bird experts or local investigators to ensure reliable results. The observed increase in conservation values from 1980–2000 to 2001–2005 should be treated with a degree of caution, since systematic and insufficient data before 2000 may lead to underestimation. In addition, we focus on wintering waterbirds, particularly Anatidae, along the EAAF and most of the data are sourced from coordinated surveys during mid-winter. The Yangtze Estuary, e.g. Chongming Dongtan in Shanghai, is an important stop over site for shorebirds on migration in spring and autumn, hence its conservation value may be an underestimated by this study. Furthermore, we suggest that future coordinated surveys in MLY should be expanded to include migration periods (spring and autumn) so that the importance of each site for stop over migratory waterbirds is better understood, which in turn can ensure a more comprehensive and better managed protected area network is developed.

4.2 Policy implication on waterbirds and their habitats conservation

Waterbirds along the EAAF faithfully utilize a number of traditional wintering sites and studies have shown that the MLY floodplain has been a long-standing wintering habitat for waterbirds along the flyway since at least the 1960s (Cao *et al*., 2009). Our study suggested that the total Importance Index in the MLY floodplain declined after 2001–2005, which implies that waterbird abundance is decreasing in this region due to declines in some waterbird populations in the EAAF. However, what cannot be ignored is that as habitat degradation occurs elsewhere in China, the MLY floodplain becomes more and more critical for wintering waterbirds if they cannot find alternative habitats.

Meanwhile, the study also showed that there are 140 sites met either Ramsar or IBA criteria or both, while only ten of them are designated as Ramsar sites and 54 of them identified as or included in current IBAs, which indicates that the value of the MLY floodplain is currently underestimated.

Furthermore, this study also highlighted the unbalanced distribution pattern in the MLY. Jiangxi and Hunan account for almost 60% of the Importance Index for all five feeding guilds. For tuber eaters and invertebrate eaters, they account for in excess of 70% (Figure 4). The spatial distribution of these waterbirds, which was wide in historical periods, is beginning to show a more concentrated pattern, partly because of reduced seasonal inundation as a result of dams affecting hydrological regimes (Wang *et al*., 2017; Xia *et al*., 2017b). Moreover, a mismatch between the locations of protected areas and the provincial conservation values cannot be ignored; Jiangxi Province, which has the highest conservation value, has a relatively low C index (Table 3) in turn can ensure a more comprehensive and better managed protected area network is developed. Nevertheless, wetland conservation across the whole floodplain still needs to be further strengthened along with its important role in the flyway and potential habitat degradation in the MLY floodplain.

Scientific conservation planning coupled with effective governance is essential to achieve successful waterbird conservation (Brooks *et al*., 2006; Amano *et al*., 2018). Currently, protection of the Yangtze River floodplain has the attention of the Chinese central government who advocated 'the integrated conservation of the Yangtze River' in early 2016. How to allocate protected wetland areas and build a green ecological corridor is now becoming a critical issue. The approach to identify priority sites for waterbirds provides a useful example. For successful conservation planning, a comprehensive system for key habitat identification including regular review and adaptation is necessary (William *et al*., 2016). Waterbird habitats in the MLY floodplain have undergone dramatic changes due to factors such as climate change, habitat loss/degradation and operation of the Three Gorges Dam. The formulation of a comprehensive basin-scale conservation plan should consider the above factors, whilst having a regular review process in the future. For example, we suggest enhancing conservation and management on some sub-lakes in Poyang Lake and Dongting Lake, which have hydrological interactions with the Yangtze River during the wet season and are independent systems in the dry season. Some of these sub-lakes are already identified as important sites for waterbirds, and it is therefore easier to undertake habitat management and restoration action. However, we acknowledge that this method is based on protection at the site level, and building a protected network of wetlands flyway-wide is more important. Therefore, we should connect waterbird conservation efforts in the MLY floodplain with that of the EAAF network. Firstly, it is necessary to undertake regular systematic and coordinated monitoring at the flyway and national level. In addition, whilst flyway waterbird population estimates directly affect the evaluation of a site's importance, the accuracy of these population estimates varies considerably from species to species. For some species, e.g. Siberian Crane *Grus leucogeranus*, the population estimate is quite accurate, whereas the estimated population size or population trend of Common Coot *Fulica atra* is quite coarse or even non-existent. Therefore, organizing internationally coordinated monitoring for all waterbird species to understand population trends, support flyway population estimates and facilitate the setting of the population 1% criterion should be urgently strengthened. Furthermore, the value and use of data collected outside of coordinated surveys (e.g. citizen science data) should also be enhanced. For example, collect as much information as possible about species distribution, as well as population trend through citizen science data to complete the protected area networks especially for the identification of important waterbird sites at all periods of the annual life cycle. To improve the overall quality and accuracy of related studies, it is vital to strengthen capacity on data integration, setting standards for multi-source data collection, collation and quality control. Furthermore, economic factors rather than conservation values tend to influence local governments when setting the location and boundaries of protected areas, which has had an adverse impact on biodiversity (Zhao *et al*., 2013; Ma *et al*., 2019). Although the situation in MLY floodplain is acceptable, there is an unbalanced pattern with low conservation indices in Jiangxi and Shanghai. Therefore, we propose that conservation planning and the process of setting areas and boundaries for protected areas should be led by central government with local government involvement. This would optimize the allocation of conservation resources, improve the efficacy of protection and circumnavigate local government desire for economic development.

5 Conclusions

This paper establishes a framework and roadmap for biodiversity assessment based on conservation priority by using wintering waterbirds as an indicator. We proposed the use of Conservation Effectiveness Index (C) rather than protected rate to generate more meaningful information.

The main findings of this study are as follows:

The Importance Index of the entire Yangtze River floodplain has decreased slightly from 2001–2005 which implies a decline in overall waterbird abundance, while the spatial pattern of Importance Index in the region is unbalanced; more than 60% of the priority sites are currently located outside protected areas; we therefore recommend further strengthening of the protected area network to better protect declining and internationally important waterbird populations; six sites are the priority for protected status, namely Dalianzi Lake, Linchong Lake, Qihu Lake, Chihu Lake, Chengjiachi and Dawu Lake as their designation increase the total Importance Index (*I*) be protected in the MLY to 85%.

This study provides support to the implementation and planning of the ecological 'redline' along the Yangtze River, as well as the construction of the Yangtze River Ecological Corridor.

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Appendix A Feeding guilds and 1% population thresholds for waterbird species in the Yangtze River floodplain
Note: waterbird species population retrieved from Waterbird Population Estimates Fifth edition (Wetland International 2018, wpe.wetlands.org). null= no data

Feeding guilds	English name	Scientific name	IUCN category	1% threshold
Grass eaters	Bar-headed Goose	*Anser indicus*	LC	560
Grass eaters	Bean Goose	*Anser fabalis*	LC	1100
Grass eaters	Greater White-fronted Goose	*Anser albifrons*	LC	1800
Grass eaters	Greylag Goose	*Anser anser*	LC	710
Grass eaters	Lesser White-fronted Goose	*Anser erythropus*	VU	260
Grass eaters	Snow Goose	*Chen caerulescens*	LC	1
Tuber eaters	Common Crane	*Grus grus*	LC	160
Tuber eaters	Hooded Crane	*Grus monacha*	VU	10
Tuber eaters	Siberian Crane	*Grus leucogeranus*	CR	35
Tuber eaters	Swan Goose	*Anser cygnoides*	VU	680
Tuber eaters	Tundra Swan	*Cygnus columbianus*	LC	1000
Tuber eaters	White-naped Crane	*Grus vipio*	VU	10
Tuber eaters	Whooper Swan	*Cygnus cygnus*	LC	600
Seed / aquatic vegetation	Baikal Teal	*Anas formosa*	LC	7100
Seed / aquatic vegetation	Common Coot	*Fulica atra*	LC	20,000
Seed / aquatic vegetation	Common Moorhen	*Gallinula chloropus*	LC	10,000
Seed / aquatic vegetation	Common Pochard	*Aythya ferina*	VU	3000
Seed / aquatic vegetation	Common Teal	*Anas crecca*	LC	7700
Seed / aquatic vegetation	Eurasian Wigeon	*Anas penelope*	LC	7100
Seed / aquatic vegetation	Falcated Teal	*Anas falcata*	NT	830
Seed / aquatic vegetation	Ferruginous Duck	*Aythya nyroca*	NT	1000
Seed / aquatic vegetation	Gadwall	*Anas strepera*	LC	7100
Seed / aquatic vegetation	Garganey	*Anas querquedula*	LC	1400
Seed / aquatic vegetation	Greater Scaup	*Aythya marila*	LC	2400
Seed / aquatic vegetation	Mallard	*Anas platyrhynchos*	LC	15,000
Seed / aquatic vegetation	Mandarin Duck	*Aix galericulata*	LC	400
Seed / aquatic vegetation	Northern Pintail	*Anas acuta*	LC	2400
e	Purple Swamphen	*Porphyrio porphyrio*	LC	250
Seed / aquatic vegetation	Ruddy Shelduck	*Tadorna ferruginea*	LC	710
Seed / aquatic vegetation	Spot-billed Duck	*Anas poecilorhyncha*	LC	1000
Seed / aquatic vegetation	Tufted Duck	*Aythya fuligula*	LC	2400
Invertebrate eaters	Water Rail	*Rallus aquaticus*	LC	10,000
Invertebrate eaters	Baer's Pochard	*Aythya baeri*	CR	5
Invertebrate eaters	Common Shelduck	*Tadorna tadorna*	LC	1200
Invertebrate eaters	Black-tailed Godwit	*Limosa limosa*	NT	1500
Invertebrate eaters	Black-winged Stilt	*Himantopus himantopus*	LC	1000

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(***Continued***)

Feeding guilds	English name	Scientific name	IUCN category	1% threshold
Invertebrate eaters	Common Goldeneye	*Bucephala clangula*	LC	10,000
Invertebrate eaters	Common Greenshank	*Tringa nebularia*	LC	1000
Invertebrate eaters	Common Redshank	*Tringa totanus*	LC	1000
Invertebrate eaters	Common Sandpiper	*Actitis hypoleucos*	LC	500
Invertebrate eaters	Common Snipe	*Gallinago gallinago*	LC	10,000
Invertebrate eaters	Dunlin	*Calidris alpina*	LC	1000
Invertebrate eaters	Eurasian Curlew	*Numenius arquata*	NT	1000
Invertebrate eaters	Eurasian Spoonbill	*Platalea leucorodia*	LC	100
Invertebrate eaters	Far Eastern Curlew	*Numenius madagascariensis*	EN	320
Invertebrate eaters	Green Sandpiper	*Tringa ochropus*	LC	1000
Invertebrate eaters	Grey Plover	*Pluvialis squatarola*	LC	1000
Invertebrate eaters	Grey-headed Lapwing	*Vanellus cinereus*	LC	1000
Invertebrate eaters	Kentish Plover	*Charadrius alexandrinus*	LC	1000
Invertebrate eaters	Little Ringed Plover	*Charadrius dubius*	LC	250
Invertebrate eaters	Long-billed Plover	*Charadrius placidus*	LC	250
Invertebrate eaters	Marsh Sandpiper	*Tringa stagnatilis*	LC	10,000
Invertebrate eaters	Northern Lapwing	*Vanellus vanellus*	LC	10,000
Invertebrate eaters	Northern Shoveler	*Anas clypeata*	LC	5000
Invertebrate eaters	Pacific Golden Plover	*Pluvialis fulva*	LC	1000
Invertebrate eaters	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	LC	1200
Invertebrate eaters	Pied Avocet	*Recurvirostra avosetta*	LC	1000
Invertebrate eaters	Pintail Snipe	*Gallinago stenura*	LC	10,000
Invertebrate eaters	Red-necked Stint	*Calidis ruficollis*	LC	3200
Invertebrate eaters	Spotted Redshank	*Tringa erythropus*	LC	250
Invertebrate eaters	Swinhoe's Snipe	*Gallinago megala*	LC	1,000
Invertebrate eaters	Temminck's Stint	*Calidris temminckii*	LC	1,000
Invertebrate eaters	Wood Sandpiper	*Tringa glareola*	LC	1,000
Fish eaters	Black Stork	*Ciconia nigra*	LC	1
Fish eaters	Black-crowned Night Heron	*Nycticorax nycticorax*	LC	1,000
Fish eaters	Black-headed Gull	*Larus ridibundus*	LC	20,000
Fish eaters	Black-necked Grebe	*Podiceps nigricollis*	LC	1000
Fish eaters	Black-tailed Gull	*Larus crassirostris*	LC	10,500
Fish eaters	Cattle Egret	*Bubulcus ibis*	LC	10,000
Fish eaters	Chinese Pond-Heron	*Ardeola bacchus*	LC	10,000
Fish eaters	Common Merganser	*Mergus merganser*	LC	710
Fish eaters	Common Tern	*Sterna hirundo*	LC	9800
Fish eaters	Dalmatian Pelican	*Pelecanus crispus*	VU	1
Fish eaters	Eurasian Bittern	*Botaurus stellaris*	LC	1000

(*To be continued on the next page*)

(*Continued*)

Feeding guilds	English name	Scientific name	IUCN category	1% threshold
Fish eaters	Great Cormorant	*Phalacrocorax carbo*	LC	1000
Fish eaters	Great Crested Grebe	*Podiceps cristatus*	LC	350
Fish eaters	Great Egret	*Egretta alba*	LC	1000
Fish eaters	Grey Heron	*Ardea cinerea*	LC	10,000
Fish eaters	Horned Grebe	*Podiceps auritus*	VU	250
Fish eaters	Intermediate Egret	*Ardea intermedia*	LC	1000
Fish eaters	Little Egret	*Egretta garzetta*	LC	10,000
Fish eaters	Little Grebe	*Tachybptus ruficollis*	LC	1000
Fish eaters	Mew Gull	*Larus canus*	LC	2900
Fish eaters	Oriental Stork	*Ciconia boyciana*	EN	30
Fish eaters	Red-necked Grebe	*Podiceps grisegena*	LC	450
Fish eaters	Saunders's Gull	*Larus saundersi*	VU	85
Fish eaters	Scaly-sided Merganser	*Mergus squamatus*	EN	50
Fish eaters	Smew	*Mergellus albellus*	LC	250

Appendix B Identified priority sites for waterbird conservation in the Yangtze River floodplain

Note: NNR=National Nature Reserve, PNR=Provincial Nature Reserve, NR=Other Nature Reserve, WP= Wetland Park, UN-unprotected. *=Ramsar site and #=included in Important Bird Areas

No.	Region	Site name	Latitude	Longitude	Protected area status	Importance Index	Feeding guilds: Tuber eaters	Grass eaters	Seed and aquatic vegetation eaters	Invertebrate eaters	Fish eaters
1	Jiangxi	Poyang Lake NNR*#	29.18	116.01	NNR	1235.50	465.97	168.91	99.57	314.15	186.90
2	Jiangxi	Duchang PNR#	29.14	116.35	PNR	522.31	170.50	90.47	109.79	104.68	46.87
3	Hunan	East Dongting Lake NNR*#	29.48	112.80	NNR	515.02	95.78	167.35	87.94	130.54	33.41
4	Jiangxi	Nanji wetland NNR*#	28.83	116.22	NNR	443.89	126.58	47.55	56.28	170.78	42.70
5	Jiangxi	Zhuhu Lake#	29.15	116.60	UN	356.14	123.89	8.05	86.41	26.24	111.55
6	Anhui	Shengjin Lake*#	30.35	117.08	NNR	280.10	103.25	58.73	28.12	43.56	46.44
7	Hubei/ Anhui	Longgan Lake#	30.08	116.15	PNR	249.25	170.67	19.99	3.89	4.98	49.72
8	Jiangxi	Hanchi Lake#	28.95	116.39	UN	234.42	161.89	9.12	3.24	18.46	41.71
9	Jiangxi	Dalianzi Lake#	28.91	116.53	UN	155.62	81.55	4.00	30.50	7.74	31.83
10	Jiangxi	Baishazhou#	29.20	116.65	NR	153.87	95.33	7.54	13.40	23.62	13.98
11	Jiangxi	Sanhu Lake#	28.91	116.27	NR	153.35	23.47	4.03	1.85	80.61	43.39
12	Jiangxi	Linchong Lake#	28.83	116.29	UN	152.54	41.21	12.93	9.92	71.90	16.58
13	Jiangxi	Qihu Lake#	28.77	116.40	UN	150.79	98.15	3.48	3.14	10.73	35.29
14	Jiangxi	Chihu Lake#	29.75	115.68	UN	137.57	11.98	13.81	105.27	3.29	3.22
15	Jiangxi	Nanhu Lake (in Gongqing)#	29.22	115.91	NR	135.20	103.88	0.06	0.56	16.24	14.46
16	Jiangxi	Chengjiachi#	28.81	116.33	UN	124.14	53.57	1.95	6.25	3.84	58.53
17	Jiangxi	Saicheng Lake	29.46	116.14	NR	122.25	52.92	10.53	48.85	3.96	5.99

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(*Continued*)

No.	Region	Site name	Lati-tude	Feeding guilds							
				Longi-tude	Pro-tected area status	Impor-tance Index	Tuber eaters	Grass eaters	Seed and aquatic vegetation eaters	Inver-tebrate eaters	Fish eaters
18	Anhui	Caizi Lake#	30.85	117.03	PNR	115.04	52.26	7.70	5.09	38.58	11.41
19	Jiangsu	Gaoyou Lake#	32.86	119.35	NR	106.36	1.62	2.42	95.80	3.37	3.15
20	Jiangxi	Dawu Lake#	29.02	116.15	UN	105.43	90.93	1.05	1.10	6.76	5.59
21	Hubei	Chenhu Lake*#	30.36	113.86	PNR	98.90	4.19	19.49	24.49	18.81	31.92
22	Hunan	West Dongting Lake*#	29.02	112.08	PNR	93.05	1.40	1.08	9.00	4.02	77.55
23	Jiangxi	Nanjiang Lake#	28.95	116.48	UN	86.02	50.46	4.95	0.80	1.89	27.92
24	Jiangxi	Zhouxi Lake#	29.21	116.05	UN	83.72	42.75	24.37	10.00	6.08	0.52
25	Shanghai	Chongming Dongtan*#	31.23	121.47	NNR	80.06	32.91	0.12	25.07	15.37	6.59
26	Jiangxi	Kangshan Lake#	28.89	116.58	NR	79.15	45.12	1.99	0.41	8.05	23.58
27	Hubei	Wang Lake*	29.87	115.38	PNR	60.55	4.55	3.28	22.95	8.45	21.32
28	Jiangxi	Jinxi Lake#	28.66	116.35	UN	43.48	36.51	0.69	2.95	3.00	0.33
29	Jiangsu/ Anhui	Shijiu Lake#	31.45	118.88	PNR	41.23	7.07	12.97	2.39	17.00	1.80
30	Anhui	Huanghu Lake	30.02	116.52	PNR	41.09	5.24	29.50	1.63	0.14	4.58
31	Jiangxi	Qinglan Lake	28.43	116.20	NR	40.80	7.77	2.53	26.14	2.27	2.09
32	Jiangxi	Chenjia Lake#	28.66	116.35	UN	40.55	26.87	0.25	5.55	5.66	2.22
33	Hubei	Hannan Lake	30.63	114.38	UN	40.55	0.31	1.49	28.11	0.28	10.36
34	Jiangxi	Nanbeigang Lake#	29.68	116.21	UN	40.19	0.93	0.92	1.60	15.35	21.39
35	Anhui	Bohu Lake	30.21	116.36	PNR	39.35	0.23	2.30	0.52	18.31	17.99
36	Anhui	Wuchang Lake	30.32	116.80	PNR	38.67	10.60	23.80	1.53	0.30	2.44
37	Jiangxi	Yugan Nanhu Lake	28.80	116.26	UN	35.35	26.61	0.97	2.75	3.15	1.87
38	Jiangxi	Yugan Donghu Lake	28.30	116.93	UN	35.08	28.37	0.55	0.83	4.09	1.24
39	Jiangxi	Boyang Lake	29.63	116.20	UN	34.54	2.44	1.50	1.24	23.73	5.63
40	Hubei	Dongxi Lake	30.56	114.26	UN	30.91	0.67	6.06	2.16	6.30	15.72
41	Jiangxi	Luojiao Lake#	29.09	116.04	UN	30.54	17.81	6.76	2.26	0.64	3.07
42	Hunan	Hengling Lake	28.82	112.76	PNR	29.86	0.14	1.14	12.31	6.44	9.83
43	Anhui	Fengsha Lake	30.96	117.65	PNR	29.36	18.16	0.33	8.05	1.21	1.61
44	Jiangxi	Duchang Xi Lake#	29.25	116.47	UN	29.21	5.67	3.12	3.82	15.40	1.20
45	Jiangxi	Fanghu Lake#	29.83	116.48	NR	29.10	11.00	7.65	5.20	3.01	2.24
46	Anhui	Baidang Lake	30.84	117.34	PNR	28.90	11.39	4.11	2.06	10.99	0.35
47	Jiangxi	Junshan Lake#	28.63	116.30	UN	27.53	15.59	0.72	5.34	0.57	5.31
48	Jiangxi	Xieshan Lake#	29.63	116.14	UN	26.40	3.49	10.84	0.20	4.79	7.08
49	Jiangxi	Qili Lake	29.69	115.91	UN	25.77	1.57	1.58	3.87	0.57	18.18
50	Jiangxi	Taibo Lake	30.01	116.70	NR	25.61	5.56	4.19	9.42	4.68	1.76
51	Jiangxi	Liaohuachi	29.34	116.00	NR	25.43	8.81	0.92	4.52	3.97	7.21
52	Jiangxi	Gaoqiang Lake	29.53	116.17	UN	25.13	1.27	6.67	13.86	3.19	0.14
53	Hubei	Liangzi Lake	30.28	114.61	PNR	25.04	3.28	0.15	13.50	1.55	6.56

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No.	Region	Site name	Latitude	Feeding guilds							
				Longitude	Protected area status	Importance Index	Tuber eaters	Grass eaters	Seed and aquatic vegetation eaters	Invertebrate eaters	Fish eaters
54	Jiangxi	Wuxing-kenzhichang	28.72	116.18	UN	20.86	20.86				
55	Jiangsu	Shang Lake	31.65	120.68	UN	20.78			3.67	0.18	16.93
56	Jiangxi	Yufeng	28.87	116.23	UN	20.00					20.00
57	Shanghai	Hengsha Dongtan	31.63	121.39	UN	19.57		0.01	5.14	10.27	4.15
58	Jiangxi	Zaohu Lake#	29.59	116.19	UN	18.69	1.03	1.30	1.37	8.58	6.41
59	Jiangxi	Meixi Lake#	29.51	116.07	UN	17.52	11.16	1.35	0.98	2.10	1.93
60	Hunan	South Dongting Lake*#	28.83	112.50	PNR	17.11	1.51	0.79	10.30	1.59	2.92
61	Anhui	Daguan Lake	30.05	116.25	PNR	16.42	2.47	7.04	1.56	1.02	4.33
62	Hubei	Chong Lake	29.91	112.29	UN	15.17			13.86	1.18	0.13
63	Jiangxi	Embankment in Shuanggang Town	29.03	116.59	UN	15.08	0.01			0.06	15.01
64	Shanghai	Nanhui Dongtan#	30.88	121.97	UN	14.78	0.03	0.01	3.83	8.93	1.98
65	Jiangsu	Hongze Lake#	33.37	118.63	PNR	14.25	5.56		8.62		0.07
66	Hubei	Donghu Lake	30.56	114.37	UN	13.34	6.82		0.03	0.09	6.40
67	Jiangxi	Nanshan Lake#	31.78	118.58	UN	12.38	8.30	0.27	0.67	0.20	2.94
68	Hubei	Shishoutian’e zhou#	29.70	112.43	NNR	11.80	0.12	0.08	0.56	2.91	8.13
69	Hubei	Zhangdu Lake	30.65	114.73	NR	11.38	0.04	0.56	5.58	1.78	3.42
70	Jiangxi	Liufang Lake#	28.93	116.21	UN	10.59			0.02		10.57
71	Anhui	Shibasuo	30.76	117.78	PNR	10.52	0.40	0.60	2.59	0.02	6.91
72	Jiangxi	Caowan Lake#	28.84	116.30	UN	10.51	0.15	9.93	0.41	0.01	0.01
73	Hubei	Honghu Lake*#	29.82	113.28	PNR	10.05		2.16	4.38	0.85	2.66
74	Anhui	Tangduo Lake	32.47	116.42	PNR	9.40	9.40				
75	Hunan	Qingtanyuan	28.87	112.84	UN	8.93	0.01	0.04	0.11	0.42	8.35
76	Shanghai	Baogangshuiku	31.41	121.49	UN	8.55			5.08	3.13	0.34
77	Jiangxi	Jiujiang Lake#	29.70	115.74	UN	8.28	6.01	1.09	0.19		0.99
78	Anhui	Chenyao Lake	30.86	117.63	PNR	7.83	1.12	5.87	0.54	0.09	0.21
79	Jiangxi	Gushan Lake#	29.60	116.11	UN	7.81	0.18	0.02	6.23	0.45	0.93
80	Shanghai	Chongming north lake	31.68	121.62	UN	7.73			1.44	0.34	5.95
81	Jiangxi	Zhangong Lake#	28.88	116.67	UN	7.26	7.16		0.04	0.01	0.05
82	Jiangxi	Yaohu Lake	28.71	116.06	UN	7.21	1.52	0.47	4.39	0.45	0.38
83	Hubei	Futou Lake	29.99	114.26	UN	7.17	0.15	3.64	0.41	1.33	1.64
84	Hubei	Wuhu Lake	30.79	114.47	NR	7.09	0.21	1.26	2.98	0.96	1.68
85	Shanghai	Haiwan coast	30.83	121.52	UN	6.94			0.83	4.65	1.46
86	Jiangxi	Dahu Lake#	28.74	116.35	UN	6.54	4.76	1.78			
87	Jiangxi	Shili Lake	29.41	116.01	UN	6.11	1.76	0.97	0.78	2.51	0.09
88	Hubei	Baiji Dolphin Reserve	29.83	112.58	UN	6.00					6.00

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No.	Region	Site name	Latitude	Longitude	Protected area status	Importance Index	Feeding guilds				
							Tuber eaters	Grass eaters	Seed and aquatic vegetation eaters	Invertebrate eaters	Fish eaters
89	Shanghai	Jiuduansha	31.19	121.69	NNR	5.89	0.25		3.16	1.32	1.16
90	Hunan	Muping Lake	28.88	112.23	PNR	5.68	0.15	0.41		0.01	5.11
91	Jiangxi	Daming Lake#	29.02	116.52	UN	4.91	0.84	3.94	0.04	0.01	0.08
92	Hunan	Zhongzhou	29.02	112.15	UN	4.89			4.81		0.08
93	Hubei	Shangshe Lake	30.61	114.29	NR	4.74	0.02	3.06	1.07	0.34	0.25
94	Jiangsu	Longpao	32.20	118.95	UN	4.54	0.03		1.09	0.18	3.24
95	Jiangxi	Fanhu Lake	28.83	116.07	UN	4.53					4.53
96	Anhui	Chengdong Lake	32.33	116.38	UN	3.91		1.31	1.60		1.00
97	Jiangsu	Yangcheng Lake	31.46	120.78	UN	3.46			2.74	0.06	0.66
98	Hubei	Changhu Lake	30.42	112.40	NR	3.37			2.37	0.09	0.91
99	Hubei	Chidong Lake	30.10	115.40	UN	3.17			1.28	0.52	1.37
100	Shanghai	Chongming north coast	31.42	121.47	UN	2.97			2.22	0.12	0.63
101	Anhui	Shitang Lake	30.43	116.42	UN	2.96			0.04	0.01	2.91
102	Anhui	Pogang Lake	30.54	116.97	PNR	2.52	1.60	0.08	0.01	0.64	0.19
103	Hubei	Huangpo-huanghualao	30.55	114.30	UN	2.47			0.83	0.59	1.05
104	Jiangxi	Nanxi Lake#	29.22	116.33	UN	2.33	1.87	0.10		0.35	0.01
105	Anhui	Chengxi Lake	32.35	116.20	UN	2.19		0.99			1.20
106	Jiangxi	Yugan Xi Lake	28.87	116.22	UN	2.16	2.08			0.08	
107	Hubei	Huangmei Taibai Lake	29.96	115.78	UN	2.17		0.02	0.77	0.95	0.43
108	Hubei	Tongjia Lake	29.93	116.06	UN	2.03		0.04	1.36	0.31	0.32
109	Jiangxi	Fenghuangzhou	28.69	115.85	UN	2.02			0.04	1.84	0.14
110	Hubei	Houguan Lake	30.51	113.99	UN	1.95			0.79	0.31	0.85
111	Jiangxi	Dahukou	28.89	116.54	UN	1.92				0.03	1.89
112	Jiangxi	Yuanyang Lake	29.32	117.52	UN	1.90			1.82		0.08
113	Jiangsu	Chishan Lake	31.84	119.05	UN	1.88			0.51	0.98	0.39
114	Jiangxi	Wangluo Lake#	28.78	116.30	UN	1.70	1.61				0.09
115	Jiangxi	Chouchi Lake#	29.24	116.57	UN	1.67		1.67			
116	Jiangsu	Yanweigang	34.47	119.78	UN	1.61				0.88	0.73
117	Shanghai	Changxing Island	31.62	121.50	UN	1.53			0.63	0.64	0.26
118	Jiangxi	Jiucai Lake#	29.00	116.65	UN	1.51			0.21	1.29	0.01
119	Shanghai	Minhang binjiang park	31.01	121.42	UN	1.49				0.05	1.44
120	Hunan	Hanshou Taibai Lake	29.07	112.15	UN	1.45			1.45		
121	Shanghai	Xinghuo Farm	30.87	121.56	UN	1.44			0.04	0.79	0.61
122	Jiangxi	Qingshan Lake#	29.02	116.65	UN	1.41		1.02	0.04	0.29	0.06
123	Jiangsu	Dafeng Nature Reserve	33.20	120.46	NNR	1.34		0.04	0.06	0.81	0.43

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							Tuber eaters	Grass eaters	Seed and aquatic vegetation eaters	Invertebrate eaters	Fish eaters
124	Hubei	Xiliang Lake	29.90	114.04	UN	1.29			0.26	0.26	0.77
125	Anhui	Wabu Lake	32.42	116.88	UN	1.10				1.10	
126	Anhui	Yicheng	31.73	117.34	UN	0.98	0.05	0.02	0.48	0.31	0.12
127	Hubei	Tanhu Lake	30.45	114.39	UN	0.91			0.06	0.45	0.40
128	Hunan	Xiangjiang Sides	29.36	113.12	UN	0.82	0.06		0.05	0.64	0.07
129	Anhui	Nvshan Lake	32.95	118.07	PNR	0.82			0.82		
130	Hubei	Panlongcheng	30.64	114.38	UN	0.73			0.05	0.42	0.26
131	Hunan	Changshaxing-cheng Town	28.68	111.55	UN	0.69			0.47	0.19	0.03
132	Jiangxi	Xingjiang River	29.17	117.84	UN	0.67					0.67
133	Hubei	Jueshui River	30.68	112.98	UN	0.43			0.04	0.18	0.21
134	Hunan	Yujiaqiao	28.80	112.12	UN	0.26			0.08	0.03	0.15
135	Hubei	Qianjiang	30.33	112.24	UN	0.23			0.20	0.01	0.02
136	Shanghai	Wusongpaotai Wetland	31.27	121.57	UN	0.19			0.07	0.05	0.07
137	Jiangxi	Le'an River	29.07	117.72	UN	0.15				0.02	0.13
138	Hunan	Liyu Lake	29.98	113.74	UN	0.13					0.13
139	Jiangxi	Dalei Lake	29.10	116.56	UN	0.13				0.09	0.04
140	Anhui	Zhanghu Town	30.35	116.89	UN	0.10		0.04		0.02	0.04