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Review

Natural wetland in China

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As it is known to all, wetland is one of the most crucial ecosystems in the world, with large varieties in China. How to protect wetland in China has become a more serious problem and five typical wetlands were selected in the article to illustrate the condition. Through the comparison between the past and present of wetland, attention should be paid in adjusting the human behavior and the ways of producing and living.

Key words: Wetland, Mangroves, San Jiang Plain, Xilingol Reserve, Qinhai-Tibetan Plateau.

INTRODUCTION

Wetlands are important ecosystem in China, making up 10% of the world's total. Due to their high ecosystem services per unit area, the wetlands (tidal marsh/ mangroves, swamps/floodplains) are the biggest sector of total terrestrial ecosystem services (Costanza et al., 1997). However, due to conversion to farmland and pollution from point and non-point sources, the contribu-tions of wetlands, such as flood mitigation, water quality improvement, habitat biodiversity, and landscape esthetics have been reduced considerably (Liu and Diamond, 2005). According to Cyranoski (2009), nearly 30% of China's natural wetlands vanished between 1990 and 2000, which will seriously impact the survival of both human, birds and biodiversity (Cao and Fox, 2009). Thus, it is time for China to restore the area and functions of natural wetlands (Pan and Bin 2009).

However, before we take any actions, it is necessary to investigate the situation of natural wetlands in China.

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Here, five typical wetlands were selected to show rough pictures of natural wetlands, the utilization and protection of people and government. These wetlands include coastal mangroves, Yancheng National Nature Reserve in middle and lower reaches of the Yangtze River, San Jiang plain in northeast, wetlands in Xilingol Biosphere Reserve and in the Qinghai-Tibetan Plateau.

MANGROVES IN CHINA

Mangroves are the only forests bridging the sea and land in subtropical and tropical coastal regions, and play a vital role in providing habitats for coastal animal and birds as well as in serving as natural defense against disturbance (Kathiresan and Rajendran, 2005; Dalton, 2006; Luo et al., 2007). However, clearing for aquaculture and other land uses has caused sharp decline in mangrove forests worldwide, such that over the past half century, more than one third of mangrove forests vanished mainly due to various human activities (Valiela et al., 2001; Alongi, 2002). In China, more than 70% of mangrove forests

(Figure 1) have disappeared since the 1950s. It is attributed primarily to clearing because of rapid development of urbanization and aquaculture in coastal regions (Lin, 1997). By 2000, there are only about 133.46 km^2 mangroves, most of which are under protection in nature reserves, and are near the rapidly developing cities. The expansion of cities with the increasing population is increasing the threats of chronic pollution from agriculture and industry, and other anthropogenic inputs into mangrove habitats.

In past decades, environmental degradation has led to attempts to rehabilitate and restore mangroves in coastal regions of China. With the economic boom in China, however, this attempt contradicts the strong pressure to increase wealth and living standards of people living in coastal areas. On the other hand, the success of the rehabilitation depends on adequate site selection and proper use of soil preparation and planting techniques. There are already well established general criteria for the rehabilitation of mangrove ecosystems (Field, 1999). First, understanding the reasons for the degradation of mangrove forests; second, creating selection criteria for site and mangrove species according to specific local soil and climate conditions; third, adopting suitable seedling and planting strategies. And lastly, monitoring, assessing and managing the development of the rehabilitated mangrove forests. During the regeneration process of mangrove forest, the dynamics of seedling population have significant influence on community structure; it is needed to pay practical management attention to this developing stage. One of the severe problems that mangrove forests are facing is the loss of biodiversity. It is critical to consider the role of mangrove species in regulating the population dynamics of other plants and animals, such as birds and crabs. The primary objectives of mangrove rehabilitation are silviculture, mitigation, coastal stabilization, ecosystem function and fisheries (Alongi, 2002). In China, the main usages of mangrove forest include cutting for firewood and small-scale aquaculture. Since the reform and opening in 1978, rapid development of economy results in increasing population growth, aquaculture, and industrial and urban development in coastal regions. This led to the dramatic decline of the areas of mangrove forests, the loss of biodiversity in mangrove system, the destruction of mangrove forest structure and functioning (Li and Lee, 1997). As the south coastal regions of China where mangrove forest are distributed are also frequently attacked by typhoon, silviculture, ecosystem function and coastal stabilization might be the prior objectives of the rehabilitation and conservation projects. These projects should be applied according to the degree of the destruction of the local environmental conditions (Luo et al. 2007). It is also needed to deepen the understanding of the responses of mangrove forests to different disturbance, such as human activities and natural influences.

PROTECTION AND MANAGEMENT OF LAKES AND WETLAND IN MIDDLE AND LOWER REACHES OF THE YANGTZE RIVER: A CASE STUDY OF THE YANCHENG NATIONAL NATURE RESERVE FOR COASTAL RARE BIRDS IN JIANGSU PROVINCE, CHINA

The middle and lower reaches of the Yangtze River are economically and ecologically important in 21st century, with the water source of national strategic importance and the last defense for the balance of water supply in China. However, the high-speed development of valley economics and the deep effect by human activities (e.g. large-scale exploitation), a series of negative environmental effects appear. Of them, the most serious problem is the destruction of lakes, especially the large degradation of the ability to adjust ecological environment and self-recovery, which has brought bad ecological result, and has already threatened the ecological balance and sustainable development in the Yangtze River.

There are many rivers, marches and wetlands in the face of the Yangtze River. Wetlands are the typical representative of the silt plain of the coast under the impact of waves and tide of the old Yellow River and Yangtze River. Due to its temperate climate, plenty of rain and level terrain, the wetland ecosystem here is rich in biological resources, especially as a wintering site, breeding site and “transfer station” for rare birds, such as red-crowned cranes. Recently, wetlands are being recognized as important ecosystems for the conservation of biodiversity. To protect terrestrial ecosystem and biodiversity, Chinese Government built Yancheng National Natural Reserve for Coastal Rare Birds with an area of 453,000 ha located at the coastal region of Sheyang, Dafeng, Binhai, Xiangshui and Dongtai Counties, Jiangsu Province. Established as a provincial reserve in 1983, the reserve was classified as a national nature reserve in 1992, and included in the International Man and Biosphere Reserve Network of UNESCO in the same year. The reserve joined the Reserve Network of Northeast Asian Cranes in 1996. As a number of wetlands are of international importance, wetland ecosystems and red-crowned cranes are the main protection targets in the reserve. The reserve is increased by over 900 hectares every year for the Yellow River and the Yangtze River, which flows from here into the East Sea.

Recent statistics show that the reserve has 539 species of plants, 394 species of birds, 34 species of amphibians and reptiles, 285 species of fish and 31 species of mammals (Reserve Station data, 2005). 10 species of them are listed as National Grade-A protected animals including red-crowned crane, white crane, great bustard, golden eagles and Chinese paddle-fish. 65 species of them such as river deer and swan are under the second-grade state protection. In the summer and autumn, nearly 2,000,000 birds fly through Yancheng while 200,000

Figure 1. The comparison of mangroves in China.

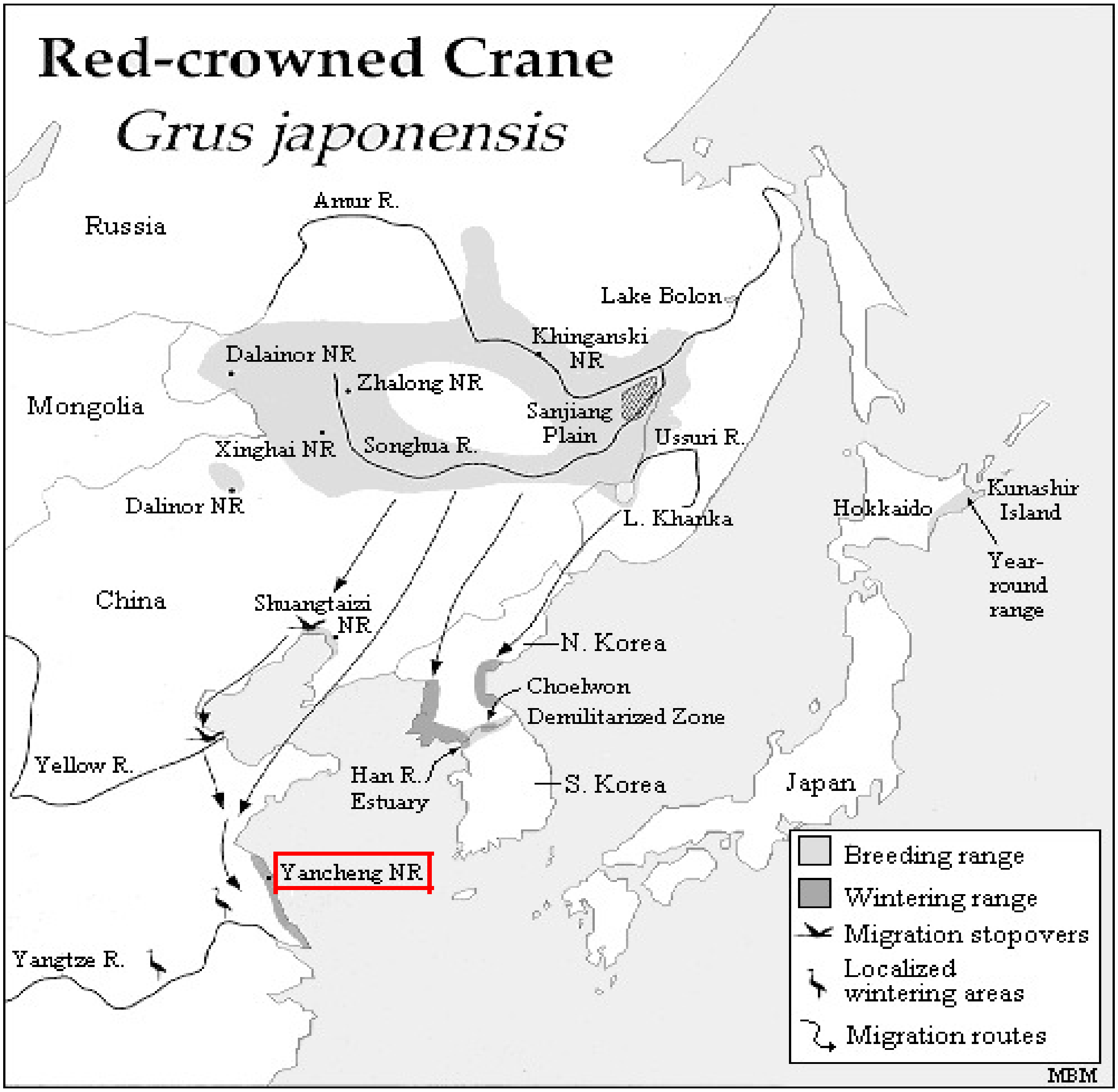

Figure 2. Range, migration and nesting map of Red-crowned crane (from the International Crane Foundation website_ http://www.savingcranes.org/redcrownedcrane.html).

water birds live through winter in the reserve. Among them, the reserve is vital as a localized wintering site for migratory red-crowned cranes (Figure 2, (International Crane Foundation website, 2010), with nearly 50% red-crown cranes in the world as a whole.

The establishment of the Yancheng National Nature Reserve has become an ideal habitat for rare birds. Since the reserve is established, the amount of over wintering red-crowned cranes increases quickly (Figure 3, (Li et al., 2004). However, numbers of red-crowned cranes observed in Yancheng Reserve decline from 2000. Habitat loss and fragmentation are mainly associated with population decrease of endangered species and biodiversity loss. Original wetlands in Yancheng are disappearing at a rapid rate due to exploitation and utilization of the tidal flat resources such as agricultural, residential, and industrial developments (Li et al., 2004).

In 2006, the government enlarged the “core area” (that is, mostly natural landscape and befitting habitat for red-crowned crane) and “buffer zone” (that is, no tourism and commercial activities except for scientific research) and less human activity) of the reserve from 17400 to 20357 ha and from 46700 to 58691 ha, which are 6.88 and 19.83% of the reserve, respectively. However, the total area of the reserve reduces to 296,000 ha, which is caused by the shrinkage of “experimental zone” (that is,

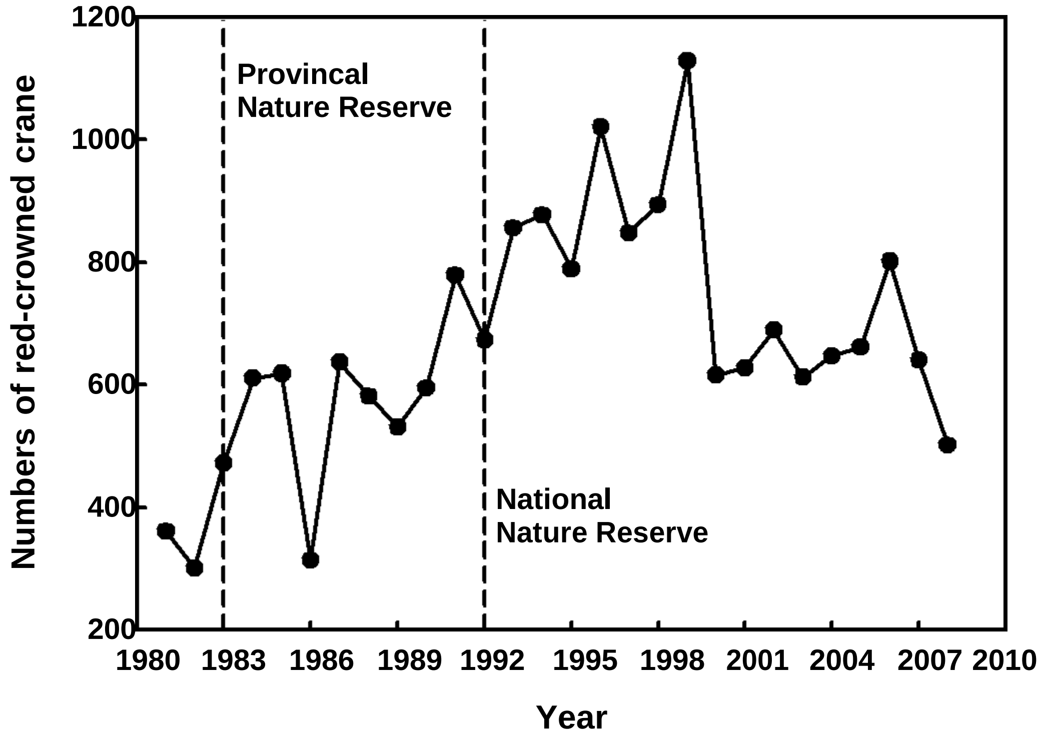

Figure 3. Numbers of overwintering red-crowned crane in Yancheng National Nature Reserve from 1981 to 2008.

Table 1. The changes of land use/cover in Yancheng National Nature Reserve from 1992 to 2006.

Land use/cover type	1992 (km^2)	Rate (%)	Variation	2002 (km^2)	Rate (%)	Variation	2006 (km^2)	Rate (%)
Built-up area	1.61	0.29	3.58	5.19	1	0.75	5.94	1.15
Saltern	42.24	7.71	4.88	47.12	9.06	2.59	49.71	9.65
Dry land	105.09	19.19	-18.09	87	16.74	-5.36	81.64	15.86
Paddy field	10.46	1.91	0.27	19.73	2.06	0.82	11.55	2.24
Breeding aquatics	12.55	2.29	8.85	21.4	4.12	0.95	22.35	4.34
Suaeda salsa shoal	98.07	17.91	-46.88	51.19	9.85	-8.3	42.89	8.33
Reed shoal	55.06	10.05	-9.43	45.63	8.78	2.23	47.86	9.3
Grass shoal	31.38	5.73	-17.23	14.15	2.72	-3.89	10.26	1.99
Spartina alterniflora marsh	3.1	0.57	45.27	48.37	9.3	-10.03	58.4	11.34
Mud	188.07	0.57	1	189.07	36.37	-4.77	184.3	35.79
Total	547.63	100		519.87	100		514.9	100

permit frequent human activities) of the reserve. Although the habitat for red-crowned cranes seems to increase, the land use/cover changes of the reserve vary obviously. Especially, the best habitats for red-crowned crane include Suaeda salsa shoal, reed shoal and grass shoal decrease; while some unsuitable habitats such as *Spartina alterniflora* marsh and saltern increase quickly (Table 1, (An, 2003). Picking clamworm (a favorable food for red-crowned crane) in core area cannot be banned or even be worse than before (An, 2003). The habitat fragmentation and the shortage of food and hidden places are bringing quite a few species of migratory birds to face the danger of extinction. In 2004, a wind power project of 200,000 kw was inaugurated in coastline region located in Dafeng City, which includes most "experimental zone" of the reserve. Since the project has been built in 2006, its risk to birds is not clear. The ecological security of the reserve is not optimistic (Dai, 2007).

Figure 4. San Jiang agricultural reclamation management department in Sep.2003.

SAN JIANG PLAIN

The San Jiang plain is located in temperate wetness and sub-wetness continent season zone; its winter is harsh and cold, while summer is warm, with lots of rain; it lies between 43°49′55″~48°27′40″N and 129°1′20″~135°05′10″E (Yan et al., 2003). It is located at the top of Heilongjiang and Wu Su Li Jiang, in the north of Heilongjiang Province, Northeast China, which is the biggest freshwater swamp in China. Besides Zha Long, Khanka and Hong He, it is another important international everglade (Figure 4).

San Jiang plain's total area is 1 0, 8 90,000 h m, the area of the plain, billabong and swamp are 6,643,000 h m in all, occupying 61% of the whole. In 20C 50S early days, forest, meadow, swamp and rivers are the main outlook: Swamp and swampy meadow are distributed in big acreage series, water system interlace becomes like web, while small lakes can be found everywhere. There are many rare animals and plants, such as country primary protected animal: northeast tiger, sable and spotted deer; protected animal such as red-crowned crane, white marabou, Chinese merganser, golden vulture and erne and more than 1200 drug use, honey, fibre and the like

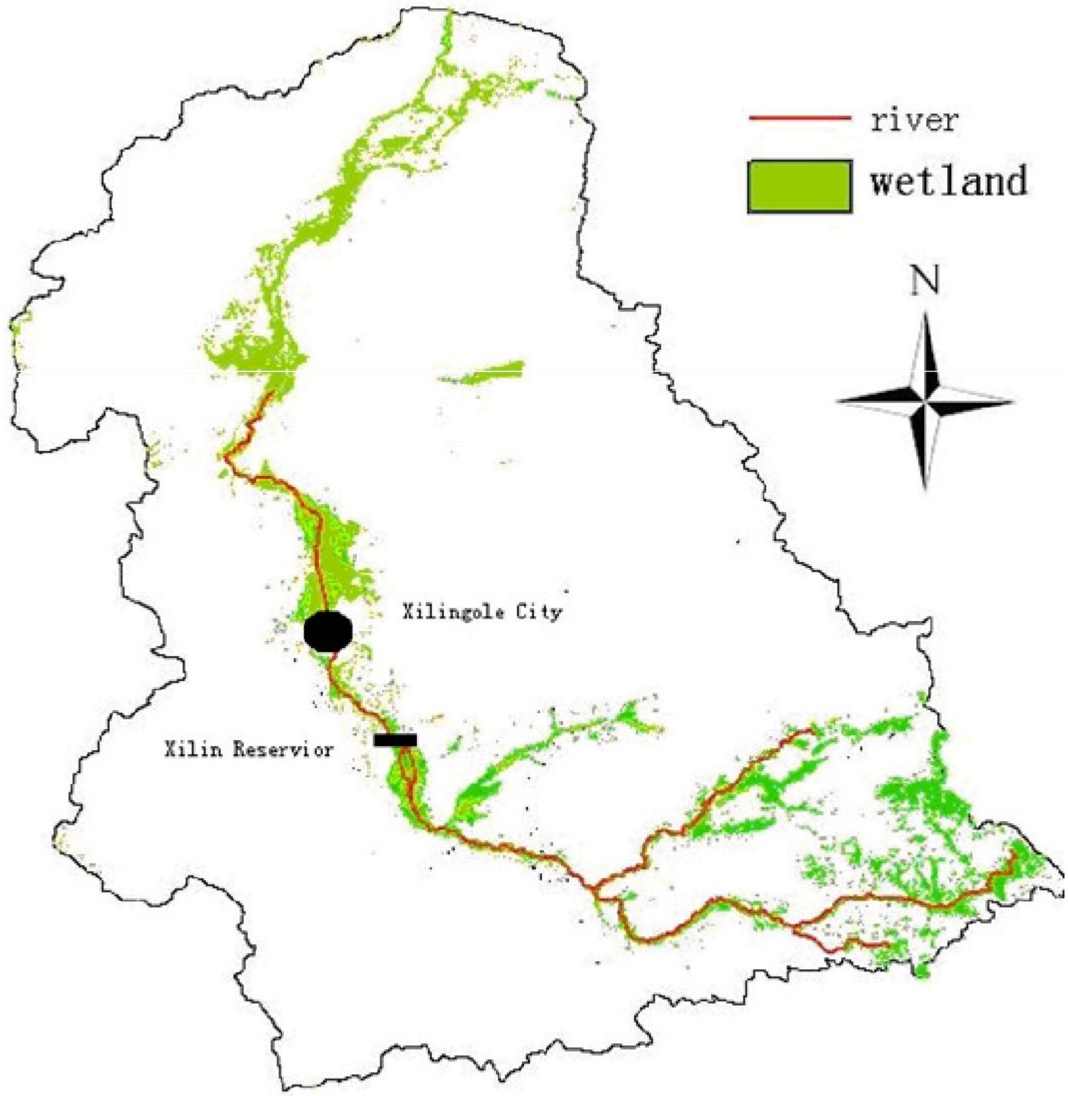

Figure 5. Location of wetland in the Xilin river basin.

abundant economy wilding (Yan, 2006). Owing to its special geographical environment and ecological status, it has significant meaning in ecological construction.

But in the recent 50 years, the landscape of the San Jiang plain has changed sharply due to large scale farming land use reclamation and the exploitation of turfs. In the past, San Jiang plain had been the biggest plain and swamp concentrated place. But now, take the natural bog for example, and according to statistics, its area was 21700 km^2 in 1975, which accounted for 32.5% of the total plain. And then the data dropped to 18300 km^2 in 1983, which occupied 27% of the total plain. Up to 1995, the area of swamp just down to 10400 km^2, account for 16% of the total plain (Brinson and Malvarez, 2002). Besides the agricultural land use, urbanization, road construction and industrial development also made wetlands diminish. Another typical example is the north raoli drainage; the wetland area lost 13675 km^2 from 1950 to 2000, with area proportion declining from 52.49% to 15.71% (Hou et al., 2006).

As a result of its rapid drop, San Jiang plain's ecological function degenerates a lot. It leads to heavy water and soil loss, frequent disaster such as drought and flood and large depressed biological diversity. The deep reasons of this change are irrational and excessive exploitation, behind hand environmental protecting consciousness, and heavy pressure of the increasing population and so on (Yan, 2006).

WETLANDS IN XILINGOL BIOSPHERE RESERVE

The Xilin River is the only inland river in the Xilingol Biosphere Reserve, a typical grassland ecosystem in this basin supported by MAB-China (Han et al., 2002) (Figure 5, (Han et al., 2002). Riparian wetlands developed in the

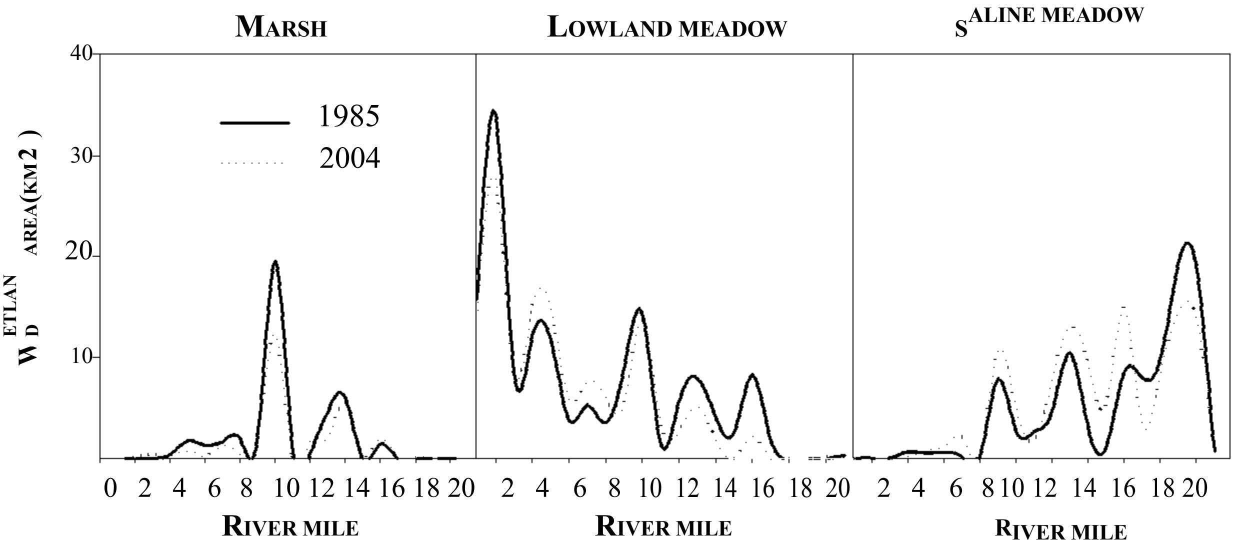

Figure 6. Changes of three wetland from upper to downstream of the river.

mosaics grassland landscape offer higher ecological, economics and cultural values to local people such as high species diversity, water resource protection and tourism (Liu and ZI, 1988; Li et al., 1993; Wang et al., 2006). In some ways, the current status of wetlands here can indicate most grassland wetland in the Inner Mongolia.

Three main wetlands grow in the riparian area, so called *Phragmites australis* marsh, *Achnatherum splendens* saline meadow and lowland meadow with higher species diversity. Since the 1980s, both quantities and patterns of wetlands changed differently from upstream to downstream according to TM survey (Figure 6, (Liu and ZI, 1988; Li et al., 1993; Wang et al., 2006). The high quality wetland, *P. australis* marsh and lowland meadow, decreased generally, while lowland meadow increased in some places of upper stream. At lower quality wetland, *A. splendens* saline meadow increased at the middle stream, but decreased at the end stream due to water shortage. In addition, field surveys showed that wetland species composition changed also and more mesophyte species occurred increasingly, especially in lowland meadow.

Several main factors determine wetland degradation here: 1) Overstock, the main problem in Inner Mogolia, impacted wetlands largely, because the Xilin River is a very important water resource and wetland plants are good food for livestock; 2) the Xilingole City and the Xilin River Reservoir are located at the middle stream of the river. Urbanization and water interception by the city and reservoir played key roles in wetlands; 3) tourism brought a large amount of hotels, yurts and roads without any scientific planning around the wetlands because of the beautiful nature scenes; 4) desertification influenced profoundly wetlands, also.

Although local government and people have taken measures to protect typical grassland landscape in the reserve, wetlands were still ignored for their relative small areas. Therefore, wetlands function to the whole basin should be emphasized and mechanisms of wetland degradation should be studied in detail. Public education should emphasize water-use efficiency of the river and wetland values. The suggestions following aim at the three wetlands: Lowland meadows should be strictly fenced for their high ecological values and functions, especially at the upper stream. Enclosures effect should be studied including plant community, biomass, recovery rate as well as ecosystem function. Tourism activities around lowland meadow should be limited.

P. australis marsh with higher economic values should be utilized rationally. Alternative harvest of this wetland can assure this simple wetland structure and maintain the largest ecosystem function for the basin. It is profoundly necessary to construct artificial *P. australis* marsh in riparian area to compensate the decreasing of the natural marsh. *A. splendens* saline meadow is the most impacted one by the Xilin River reservoir which can store up 18.67 million cubic meters of water (Xilingol Water Conservation Commitment, 1999). Wetlands at the downstream of the reservoir should be inundated several times per year to ensure this meadow developed in saline soil. Further, field survey on the saline meadow should be conducted to indicate species changes under the impacts of long term water inception.

NATURAL WETLAND IN QINHAI-TIBETAN PLATEAU

Known as the third pole of the earth, Qinghai-Tibetan plateau has 1.33×107 ha alpine freshwater wetland,

Figure 7. Inland river wetland in Damxung County, Tibet, China, which supply local domestic animals with most of forage in cold season.

which functions as biological species gene pool, oxygen supply, and a critical factor maintaining the stability of water table and the balance of diverse alpine ecosystems in the Qinghai-Tibetan Plateau. Wetland distributes mainly on three kinds of area in Qinghai-Tibetan Plateau, which are (1) Source area of rivers that flow into sea directly or indirectly, e.g. lake wetland, river wetland and swamp wetland distributed in the source area of Yangtse and Yellow river; (2) the hinterland of the plateau with very high altitude or inland water in basins among mountains, e.g. inland river or lake wetlands in the Northern Tibet Qiang-Tang Plateau, Kekexili and Qinghai Lake; and (3) flat land with lower elevation is represented by Nagqu, Ruergai, chaidamud and permafrost, and backwater areas adjacent to alpine glacier and snow cover, and swampy wetlands exist extensively in regions of this kind in Qinghai-Tibetan Plateau.

Three-river Source Region, which is located in the south of Qinghai Province, is the source of Yangtse, Yellow River and Lancangjiang; therefore, it is called Chinese Water Tower. Plateau wetland ecosystem in Three-river Source Region is the largest with the highest altitude above sea level in the world, the total area of which is 7.33×106 ha. It supplies 25, 49 and 15% of Yangtze and Yellow Rivers and Lancangjiang's total water volume, respectively (Chen et al. 2002). Another famous wetlands distribution area in the Plateau is Ruergai with altitude ranging from 3400 to 3900 m, where the wetland is the largest Plateau peat swamp remaining in China with a total area of 1.6 × 106 ha (Chai et al., 1965). Ruergai wetland ecosystem is a critical water conservation of Yellow River with its runoff amount increasing to 29 and 45% in wet and dry seasons, respectively, when it flows through here (Zhang et al., 2005). Moreover, this area is the concentrated distribution area of plateau swamp vegetation and main breeding habitat of *Grus nigricdlis* which belongs to the national first class protected animal; and its common plant species are *Carex muliensis* and *Clinelymus nutans*.

Diverse wetland ecosystems in Qinghai-Tibetan Plateau have been playing an important role in maintaining that other kinds of ecosystem perform healthily and regulate water resources. Due to natural and human factors, however, typical alpine wetland has degraded extensively with an area shrinkage of 10% in Qinghai-Tibetan Plateau (Wang et al., 2007). In the western and northern part of Three-river Source Region, ecosystem shifting, commonly water ecosystem shifting to bottomland ecosystem and wetland shifting to grassland occurred during 1975 to 2004, and area shrinkage speed of water and wetland became larger and larger gradually in the temporal process (Xu et al., 2007). In Source Region of Yangtse River, swampy wetland shrank by 29 and 17.5% of lochan had dried up. Similarly, 38.9% of total lake dried up from 1985 to 2000 in Ruergai Region, which is 56.13 ha per year (Yong et al., 2003). In terms of landscape ecology, the fragmentation degree and island of wetlands in the source region of the Yellow River and the Ruergai region were accelerated. Degradation of plateau wetlands led to alteration of their hydrological functions: In the source region of the Yangtze River and the Ruergai region, where the wetlands declined more severely, the low water runoff decreased while the frequency of rare larger runoff increased, and the frequency of regular runoff decreased; water regulation capacity of all the wetlands was declined. Considering precipitation increasing and glacier thawing, wetland degradation was the main cause for river runoff decrease (Wang et al., 2007).

Climate change was an important cause of wetland degradation in the Qinghai-Tibetan Plateau. Among the analyzed climatic factors, the increased unevenness of annual precipitation, the prolonged sunshine duration and the increasing air and soil temperature have shown important impact on water loses and the degradation of plateau wetlands (Luo, 2005). Furthermore, changes of the temporal and spatial distribution of key climatic factors on small scale or mesoscale and alteration of local climate characteristics could be the direct cause and driving force for wetland degradation. Meanwhile human activity plays the role as amplifiers and accelerators in wetland degradation processes.

To protect and restore wetlands in the Qinghai-Tibetan Plateau, it is absolutely necessary to reduce and restrict negative effect of human activities in wetland areas. At the same time, putting ecological compensation into practice may boost the positive effect of human activities on the protection of plateau wetland ecosystems. On the other hand, further research on plateau wetland science is urgently needed in Qinghai-Tibetan Plateau, especially on several important aspects as follows:

1. Water balance of wetlands, especially on the evapo-transpiration process and models of plateau wetlands which have close relation to revealing the mechanism of wetland degradation.
2. Key processes and mechanisms of wetland ecosystem biogeochemical cycle, such as greenhouse-gas (GHG) emissions, carbon storage capacity, soil nitrogen mineralization and nitration etc.
3. Wetland biodiversity conversation and ecosystem restoration approach.
4. Response and adaptation of wetland ecosystem to climate changes.
5. Management approaches of plateau wetland in different spatial scales (ecosystem, landscape, or drainage area).

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