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Changes of the Wetland landscape and the Consequent Impacts on the Waterbirds in Western Songnen Plain

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Abstract

Wetland have been shrinking rapidly in area and degrading in functioning. These all hold back the sustainable development of human communities and caused globe changes. Taken Western Songnen Plain as a case study, a series of landscape pattern metrics were selectively used to quantify the wetland changes. The correlation between the acreage losses of wetland and the number of waterbirds was studied based on the statistical data of waterbirds. The results showed that the wetlands had undergone substantial loss in area and fragmented during the nearly 50 years in the study area. The changes of the wetlands exerted impacts on the waterbirds which depend on the wetlands. The waterbirds changed in two ways: Waterbirds dropped rapidly in number at the first stage, then come down gently. Secondly, waterbirds declined gently in number at the first time period, then dropped rapidly. From the study, we concluded that wetlands had been shrinking in area and fragmented and partly accounted for decline and even extinctions of waterbirds during the nearly 50 years during the study period.

Keywords: wetland, biodiversity, landscape indices, fragmentation waterbird, waterfoul.

Introduction

The wetland system has been critical to the development and survival of human communities[1,2,3]. It is not only among the most important environments for human beings' survival but also among the important ecological landscapes which serve as the most diversified habitats for living things[4,5]. Wetlands perform functions which other systems cannot supplant such as attenuating floods, regulating surface runoff, storing freshwater and preventing drought, adjusting climate, controlling soil erosion, beautifying the environment, etc.[6].This simply reflects the key role that wetlands have played in human life, and small wonder that there is worldwide focus on wetlands and their services to us.

However, wetlands have been suffering huge areal losses and functional degradation. And this has lead to changes in land use/cover, while land use/cover changes are central to environment management through their impacts on biodiversity, water and carbon cycling. Moreover, it is believed that dynamics of land use/cover pattern would be one of the main driving forces of environmental changes superimposed on the natural changes at regional scale. Therefore we need to know the impacts of the dynamic of land use/cover

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on environment for environmental management and land use planning and the driving forces. There are mainly two reasons for loss of wetlands, one is changes of the natural factors (e.g., climate change), the other is disturbances of anthropogenic activities. Changes of wetlands result in land use/cover change at regional scale and have an impact on global change at the same time[7]. Wetlands have been one of the hotspots in global change research owing to its unique ecological functionality. And the protection of wetlands is a significant concern to administration [8]

Site Description

The Western Songnen Plain, a key area for biodiversity(especially for waterbirds) and famous for hosting many kinds of rare waterfowls such as red-crown cranes(*Grus japonensis)*, Siberian Crane(*Grus leucogeranus*), White-naped Crane(*Grus vipio*), etc., is located between 43°59′～47°52′ E，121°38′～125°45′N, with the area of about 6.71×104 km^2 (Fig. 1). The main soil types are black soil, clay, arenaceous clay, and saline soil. The elevation ranges from 130m to 155m a. s. l. The climate belongs to the transitional zone from dry in the western part to semi-humid type in the eastern part， with the precipitation from 360-480mm. The geomorphology is low-flat，making the discharge of surface water difficult, and then wetlands are widespread in this area. Due to the reclamation of wetland, grassland and forestland on a large scale in traditional agricultural practices (terracing, overgrazing, woodcutting, cultivating fields, etc.), land use/cover had changed dramatically and the regional eco-environment had been rapidly deteriorating. And wetlands had undergone functional degradation as well as acreage loss. Therefore, several natural reserves were established in the 1980s to conserve remnant semi-natural wetland habitats. Among the natural reserves, Zhalong wetlands, Xianghai wetlands and Momoge wetlands are national natural reserves (NNR), which are famous at home and abroad.

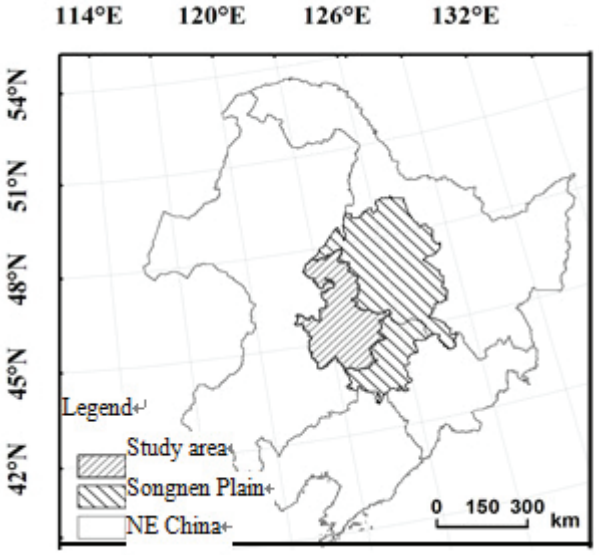

Fig. 1, The location of the study area

Material and Methods

Data Source. n consideration of the studying purpose, on the basis of the information reflected by the TM images and the topographic map, referring to IGBP and LUCC classification system advanced by Food

and Agricultural Organization, a classification system had been established for the wetlands of the study area after synthesized the various types and in combination with field investigations,. Specifically, the classification includes the following LUCC types: forest land, grassland, water body, wetland, residential land and cultivated land (paddy and dry farmland).

Data Processing. The time scale was about 50 years which was divided into 3 periods of time, prior to 1954, 1954-11986 and 1986-2007. Because the data sources in different periods of time are different, the different method was applied to process different data. The topographic maps in 1954 were selected as the data source and the scale of the map is 1:100,000. From 1986 to 2007, TM's satellite remote sensing images with the 30-meters spatial resolution were selected, and the wave band is 4, 3 and 2. Land Sat TM (or ETM) data and were used. Image-to-map registration (with Ardas imagine 8.6) was conducted using "affine" resampling procedure. The total standard error was less than 0.5 pixel (15m*15 m). Taken the data in 2007 as the reference to correct the image in 1986, the images in 1986 were compared with the images in 2007 and the patches which had changes were extracted, and the data of the dynamics of land use/cover in the studying area from 1986 to 2007 were obtained. Finally the land use/cover data in 1954, 1986, 2007 and the data about the dynamics of LUCC in the study area were acquired and stored in geodatabase in coverage format.

Methods of Landscape Pattern Analysis. In order to conduct landscape analysis, vector format grids were converted into a raster format at 30m×30m, and a suite of non-redundant landscape pattern metrics was selected and applied to calculate the value of the indices for each of the grids. Landscape composition was quantified by means of the area covered by each class. Transition matrices, based on cells occupied by classes over the 3 time periods, were generated to quantify the total increase and decrease of the area for different landscape classes. We used a series of landscape pattern metrics to quantify change in the landscape. Such metrics have been widely applied in similar studies, and allow objective description of the temporal pattern of landscape change and comparison of this landscape with other similar landscape. The following landscape metrics were selected to assess landscape structure: Total Area(TA), Patch Density (PD), Shape_MN Index and the Division Index. The formula and explanation of these metrics are given by WU[9].

The division index of patches is to calculate

$$DIVISION = \left[1 - \sum_{j=1}^{n} \left(\frac{a_{ij}}{A}\right)^2\right] \quad , \quad 0 \le DIVISION < 1 \qquad (1)$$

a_{ij} is the area of the patches, and A is the total area of the study region.

With the help of FRAGSTATS software, the above landscape indices of landscape pattern were calculated.

Results and Analyses

Landscape Changes Analyses. Landscape pattern can be used to quantify and monitor the changes of landscape in time[9]. TA and PN indices of wetlands landscape had been declining and it indicated the wetlands had been undergone continuous fragmentation during the study time period. The increases of PD (Patch Density) reflected that the fragmentation and division between wetland habitats increased greatly over time; the notable increases of Shape_MN Index(Shape Mean Index) showed the increases of complexity of wetland patches with the land use changes.

Table 1 changes of wetlands landscape indices for in Songnen plain

Year	Total area(TA) （km^2）	Patch number(PN)	Patch Density(PD)	Shape_MN Index （hm^2）	division index(DI)
1954	11 983.33	2216	0.1849	540.76	0.524
1986	5 312.33	1 792	0.3373	296.29	0.873
2007	4 488.13	1 387	0.309	324.59	0.987

Fragmentation. The division index for the periods of time is 0.524, 0.873 and 0.987 respectively. The jack-up of the division index indicated that the patches of the other land use type grew, and the trend of segmentation became more and more obvious. The gap between the wetland patches grew more and wider. The change of the landscape pattern revealed that wetland became more and more fragmentized.

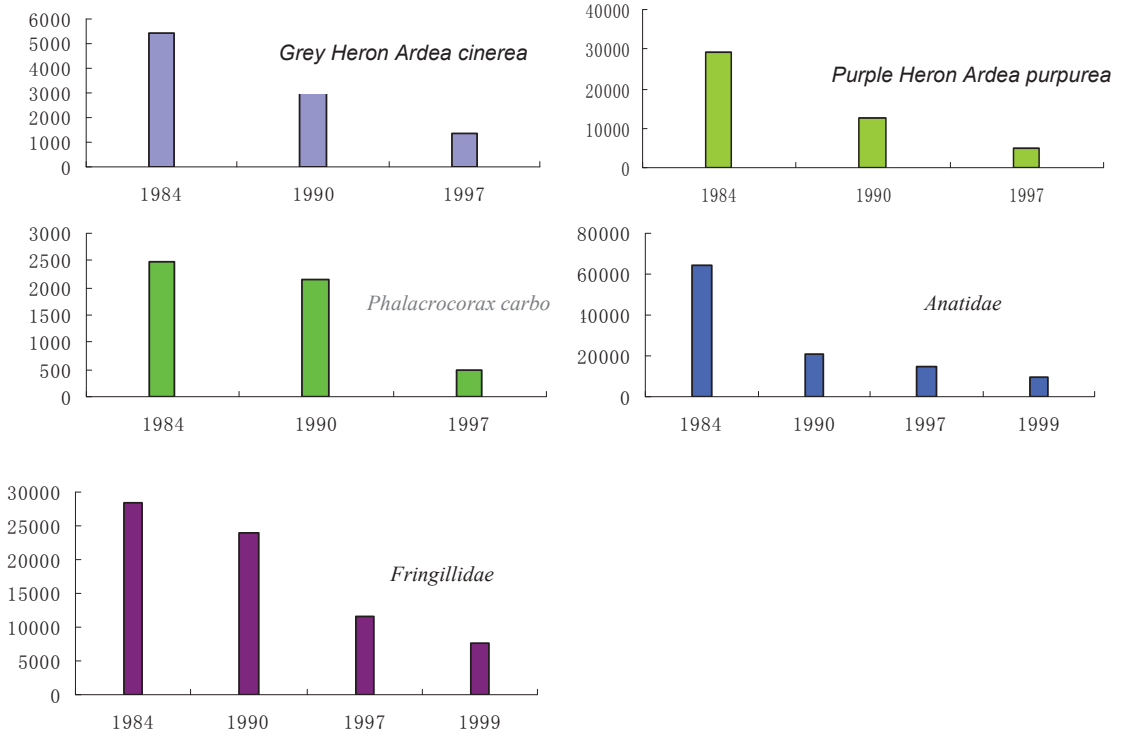

Fig. 3 The changes of waterbirds since 1984

The Impacts of Wetland Changes on Waterbirds

The Changes of Waterbirds population in number. Studies showed wetlands were widespread and there existed hundreds of thousands of waterbirds in the study area. The number dropped down rapidly for every kind waterbird since the statistic year (1984) with the losses and fragmentation of the wetlands and the conversion into arable land in magnitude. And it indicated there is a positive relationship between the acreage loss of wetlands and the decline of waterbirds.

The Correlation Model Between Waterbirds and Wetlands. Seen from the Fig. 4. The study showed each kind of waterbird might have its own change law while wetlands changed in area. However, they could fall into two categories: (1) waterbirds dropped rapidly in number at the first stage, then come down slowly .(2) Contrarily, waterbirds came down slowly in number at the first time period, then dropped rapidly.

Conclusions

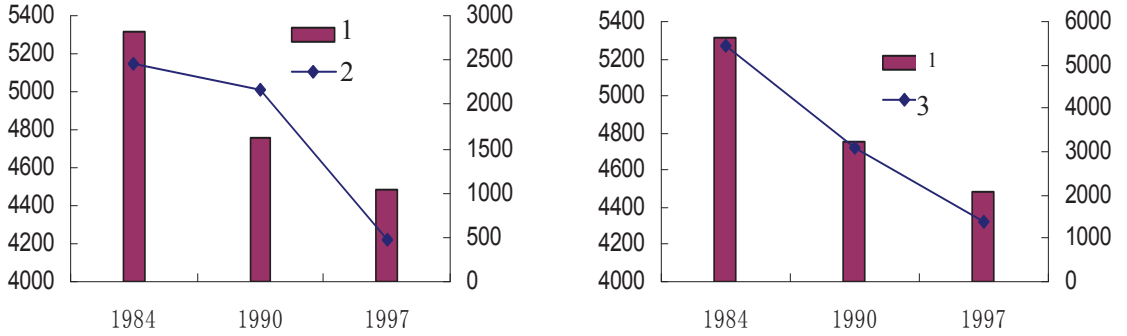

Fig. 4 The correlation between the decline of waterbirds and areal loss of wetlands

(1: Marsh; 2: Grey Heron Ardea cinerea; 3: Phalacrocorax carbo)

From the above analysis, the wetlands had been shrinking in area and fragmented during the nearly 50 years during the study period. The changes of the wetlands exerted impacts on the waterbirds which depend on the wetlands. The population of every kind of waterbird dropped dramatically in number.

Despite a widespread acceptance of the value of wetland ecosystems to society, few land planners (landscape architects, architects, planners, engineers, etc.) involved with planning cultural landscapes have integrated wetlands into community plans resulting in a long-term decline of population density in spite of extraordinary efforts to be made to protect these areas from development. Wetland protection needs to be expanded beyond protecting the area from dredge and fill to an effort that seeks to integrate wetland habitats into the planned landscapes.

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