Ecological Engineering 86 (2016) 162–173

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Landscape and avifauna changes as an indicator of Yellow River Delta Wetland restoration

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ARTICLE INFO

Article history:
Received 15 November 2014
Received in revised form 8 October 2015
Accepted 10 November 2015
Available online 23 November 2015

Keywords:
Avifauna survey
Landscape metrics
Wetland restoration
Yellow River

ABSTRACT

Wetlands are important habitats on biodiversity protection. In this study, the relationship between wetland and avifauna changes in the Yellow River Delta Wetland was studied. Remote sensing and geographic information system provided an advanced platform for the research. After the avifauna survey was performed from 2012 to 2013, the birds' variation and driving factors were analyzed. The results showed that the flow into the wetland increased continuously from 2000, and the increased of artificial wetland prevented the wetland degradation, although at the same time the total wetland area decreased. Medium grassland, tidal flat and pond are the three main landscapes which are beneficial for the habitation of birds. The migrating numbers of red-crowned crane increased significantly from 2005, and the overwintering numbers increased from 2009. The study results show that the key land use types for protecting endangered species of birds are medium grassland, tidal flat and pond landscapes. Wetland changes are sensitive to the birds and significantly affected by the flow. We suggest that the artificial wetland project should enhance the three land use type area to ensure the wetland restoration.

1. Introduction

River delta wetland played an important role in water conservation, biological diversity, environmental purification and food production. Over the past 20 years, the structure and function of wetland system have been studied thoroughly (Waletzko and Mitsch, 2013), a bibliometric approach to quantitatively evaluate global scientific constructed wetlands research, and statistically assess current trends, and future directions using the Science Citation Index Expanded (SCI-EXPANDED) database from 1991 to 2011 were explored (Zhi and Ji, 2012). Wetland health connects natural ecological security to the development of human society, and has been the core study area of the International Geosphere-Biosphere Programme (IGBP) and International Programme of Biodiversity Science (DIVERSITAS). Moreover, in China, wetland health research has been the main key fields and priority support direction of the "Long-term Scientific and Technological Development". The ability of wetlands to adapt to climate change and function as natural filtering areas is reduced by anthropogenic disturbances. Apart from climate change, loss of wetland warrants a serious concern for the long term survival of birds which solely depend on different habitats (Prabhadevi and Reddy, 2012). Despite being known as critical delivery media of ecosystem service, wetlands are suffering great transformations and land use change is a major driving force of wetland degradation (Zorrilla-Miras et al., 2014).

Wetland restoration requires complete functions and structure. Achieving goals of wetland restoration requires new models and indicators of gathering and analyzing information (Ji et al., 2012; Sakalauskas, 2010; Zhi and Ji, 2014). Clear understanding of the links between wetland and biodiversity is needed to assess and predict the true environmental consequences of human activities. Hydrology is one of the most critical factors influencing the function of wetlands especially in drought seasons, as long-term flood or drought can threaten the plants (Yang et al., 2013). Traditional evaluation methods attempt to place monetary figures on use values, and wetland evaluation methods often apply monetary driven approaches which may undermine intrinsic ecosystem values (McDonough et al., 2014). And there has been little discussion of how and when to integrate avifauna into wetland restoration (Gawlik, 2006). Over the past several decades, the remote sensing (RS) and geographical information system (GIS) with high resolution satellite data has been used for wetland degradation research (Ikiel et al., 2013; Sui et al., 2015). The use of RS and GIS creates a powerful tool for landscape as it is a cost-efficient tool for

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http://dx.doi.org/10.1016/j.ecoleng.2015.11.017
0925-8574/

Table 1
List of satellite images used in this study.

Year	Satellite	ID	Path	Row	Acquire date	Resolution (m)
1990	Landsat 5 TM	p121r03419891003	121	34	03/10/1989	30
1995	Landsat 5 TM	p121r03419950918	121	34	18/09/1995	30
2000	Landsat 5 TM	p121r03420000502	121	34	02/05/2000	30
2005	Landsat 5 TM	p121r03420050508	121	34	08/05/2005	30
2010	Landsat 5 TM	p121r03420100911	121	34	11/09/2010	30

identifying and monitoring wetland on a large scale (Piniewski et al., 2012; Prabhadevi and Reddy, 2012). Therefore it is possible to give suggestions for the management plans. Land use changes can be used to identify both the direct and indirect processes of wetland degradation. Mismanagement of wetland lead to land use change and severe environmental problems, which is mainly due to the fact that available data could be used for large-scale management (Ikiel et al., 2013). Analyzing the changes in landscape patterns helps identifying some of the most critical implications of complex interactions between natural environmental changes and anthropogenic activities (YuhaiBao et al., 2011). Combined with birds' investigation, the relationship between hydrological changes, land use changes and birds' changes could be established (Hinojosa-Huerta et al., 2013).

In this paper, we take the Yellow River Delta Wetlands National Reserve (YRDWNR) as a case study and assess the relationship between avifauna and landscape changes. The YRDWNR is one of the most highly representative wetlands in the world, it plays a particularly prominent role in water conservation, bird migration and local biodiversity maintenance (Liu et al., 2014; Peng et al., 2014). It has been 12 years since the implementation of a wetland restoration project in the YRDWNR in 2002. Based on GIS technology and using remote sensing images as the data source, this paper quantitatively analyzes the land use and landscape pattern change characteristics between 1990 and 2010 and their impacts on the habitat.

2. Materials and methods

2.1. Study area

The YRDWNR (118°33′ E–119°20′ E, 37°35′–38°12′ N) is located in northern Shandong Province, on the southern coast of the Bohai Bay. Due to the rich sediment in its water, the delta channel of the Yellow River changed nine times, and the YRDWNR has been divided into two parts (Yu et al., 2013). There are many forms of protected areas in China. Based on their relative importance, each type of protected area can be further graded into two to three levels such as national level, provincial level and prefectural/county level.[1] As a National Nature Reserve built in 1990, national level key protected areas, YRDWNR was a wetland for bird migration, overwintering and breeding. It occupies a very important position in China's biodiversity conservation. Due to the annual decreased runoff of the Yellow River, freshwater diverted to wetlands decreased between 1990 and 2000.

There are currently 296 species of birds in the YRDWNR, 154 of which were listed in the "Agreement between the Government of Japan and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment", and 53 were listed in the "Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment". Passeriformes are the most common at 103 species at 34.8% of all species (Fig. 1).

2.2. Data and analysis

2.2.1. Data processing

In this study we focused on the land use changes using remote sensing methods and techniques. For this purpose, a multi-temporal set of remote sensed data and Landsat 5 TM satellite imagery were analyzed. The study period was from 1990 to 2010 with one image taken every five years (Table 1). Landsat images were downloaded from the USGS GLOVIS website. Specifically, the images selected were mostly acquired from May to November with minimal cloud cover when the vegetation cover in the study area would be dense, and the summer season (June–August) is in the middle of the period. In one exceptional case, we considered the image acquired in 1989 as that of the year 1990.

Data processing was performed using ERDAS Imagine 2010 and land use interpretation was performed under ArcGIS 10.1 with standard false color RGB432. The satellite imagery underwent geometric correction in order to reduce any displacement errors, the total number of Ground Control Points (GCP) was 32 per image while the correction method was the quadratic polynomial model with the bilinear interpolation method, and the images were also atmospherically corrected in order to remove atmospheric effects.

Supervised classification was performed for land use extraction. The maximum likelihood classification algorithm was chosen due to its successful use in previous studies for detecting land use changes. 27 classes have been defined according to the 2nd "Current Land Use Condition Classification (GBT/21010-2007)", each classes was selected by a group of representative pixels (Table 2), 14 classes were identified and the others were processed according to the China's Land Use Map (1:250,000).

2.2.2. Landscape metrics

We revealed the landscape dynamic changes by analyzing spatial variations of different types of wetland landscape and landscape pattern index variations (YuhaiBao et al., 2011). Considering the actual situation of the research area and landscape type classification system, and analyzing from the landscape type level and landscape pattern level, this paper select six types of index: Area Index, Shape Index, Edge Index, Density Index, Diversity Index and Contagion/Interspersion Index (Table 3). The landscape metrics were calculated with the most popular analysis software designed for this purpose, FRAGSTAS 4.2 (Mcgarigal, 2000).

2.2.3. Avifauna survey

Engineering is sometimes described as the study and practice of solving problems with technological designs, some techniques of ecological engineering that are now widely applied. The common use techniques are avifauna survey, ecological engineering of biodiversity, wetlands ecosystems for receiving wastewaters, wetlands ecosystems for receiving wastewaters, etc. (Odum and Odum, 2003). The functions of ecological engineering methods are to improve the revival ability of ecosystem, improve the protective ability of ecosystem, improve the recoverability of ecosystem, and improve the functions of streams (Wu and Feng, 2006). This research developed avifauna surveys for data collection.

[1] https://en.wikipedia.org/wiki/List_of_protected_areas_of_China.