International Journal of Applied Earth Observation and Geoinformation 56 (2017) 36–43

Contents lists available at ScienceDirect

International Journal of Applied Earth Observation and Geoinformation

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

# Responses of landscape pattern of China's two largest freshwater lakes to early dry season after the impoundment of Three-Gorges Dam

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ARTICLE INFO

*Article history:*
Received 15 July 2016
Received in revised form
24 September 2016
Accepted 14 November 2016

*Keywords:*
Early dry season
Dongting lake
Poyang lake
Three-Gorges dam
Vegetation distribution
Landscape pattern

ABSTRACT

The effects of hydrologic cycle change (caused by human activity and global climate change) on ecosystems attract the increasing attention around the world. As a result of impounding of the Three Gorges Dam (TGD), climate change and sand mining, the dry season of Poyang Lake and Dongting Lake (China's two largest freshwater lakes) came early after the TGD impoundment. It was the primary cause of the increasing need for sluice/dam construction to store water in the Lakes and attracted increasing attention. In this paper, we compared the landscape pattern between three hydrologic years with early dry season (EY) and three normal hydrologic years (NY) of each lake by remote sensing technology, to reveal the effect of early dry season on landscape pattern. The results showed that early dry season caused expanding of *Phalaris* to mudflat zone in Poyang Lake, while caused expanding of *Carex* to *Phalaris* zone and expanding of *Phalaris* to mudflat zone in Dongting Lake. In landscape level, there was no significant difference in landscape grain size, landscape grain shape, habitat connectivity and landscape diversity between EY and NY in the two lakes. While in habitat class level, there were significant changes in area of mudflat and *Phalaris* and grain size of mudflat in Poyang Lake, and in area of *Carex*, grain size of *Phalaris* and grain shape of *Carex* and *Phalaris* in Dongting Lake. These changes will impact migrating birds of East Asian and migratory fishes of Yangtze River.



## 1. Introduction

The damming of rivers has a global impact on river flow regimes and natural wetlands (Kellogg and Zhou, 2014; Wu et al., 2013; Zhao et al., 2012). Besides, climate change also caused further changes in the hydrologic cycle over the next 100 years (De Jager et al., 2012; Milly et al., 2002; Wu et al., 2015). The Three-Gorges Dam (TGD, in China) on the Yangtze River (Changjiang River) is the largest hydroelectric project in the world (Wu et al., 2013). The project began in 1993, and then commissioning started in 2003 and was completed in 2009. This project has played a key role in controlling frequent catastrophic floods downstream, generating hydropower (with an installed capacity of 18,200 MW), and improving navigation at the upper reaches of the Yangtze (CWRC, 1997). However, the project has caused environmental and ecological problems that have attracted the attention of environmental activists, researchers and communities around the world (Feng et al., 2013; Stone, 2008; Wu et al., 2015, 2003).

As a result of impounding of the TGD (Feng et al., 2013; Liang et al., 2012; Wang et al., 2013), climate change (Feng et al., 2014; Liang et al., 2012) and sand mining (Lai et al., 2014), the dry season of Poyang Lake and Dongting Lake (the downstream wetlands of the TGD, and the two largest freshwater lakes in China) came early after commissioning of the TGD. An early dry season in the two largest freshwater lakes in China is one of the important effects of the TGD and is the primary cause of the increasing need for sluice/dam construction to store water in the wetlands of Poyang Lake and Dongting Lake wetland (Li, 2009; Wu et al., 2015). It also attracted increasing attention from many people around the world. There was an obvious trend of early starting dates for the dry season of the Poyang Lake wetland ($-7.35$ days year$^{-1}$) and the Dongting Lake wetland ($-3.42$ days year$^{-1}$) from 2000 to 2009 (Feng et al., 2013). Zou et al. (2000) predicted that the average starting date of the dry season for the Dongting Lake wetland arrived 2, 7 and 35 days early in a high-flow year, a median-water year and a

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http://dx.doi.org/10.1016/j.jag.2016.11.006
0303-2434/

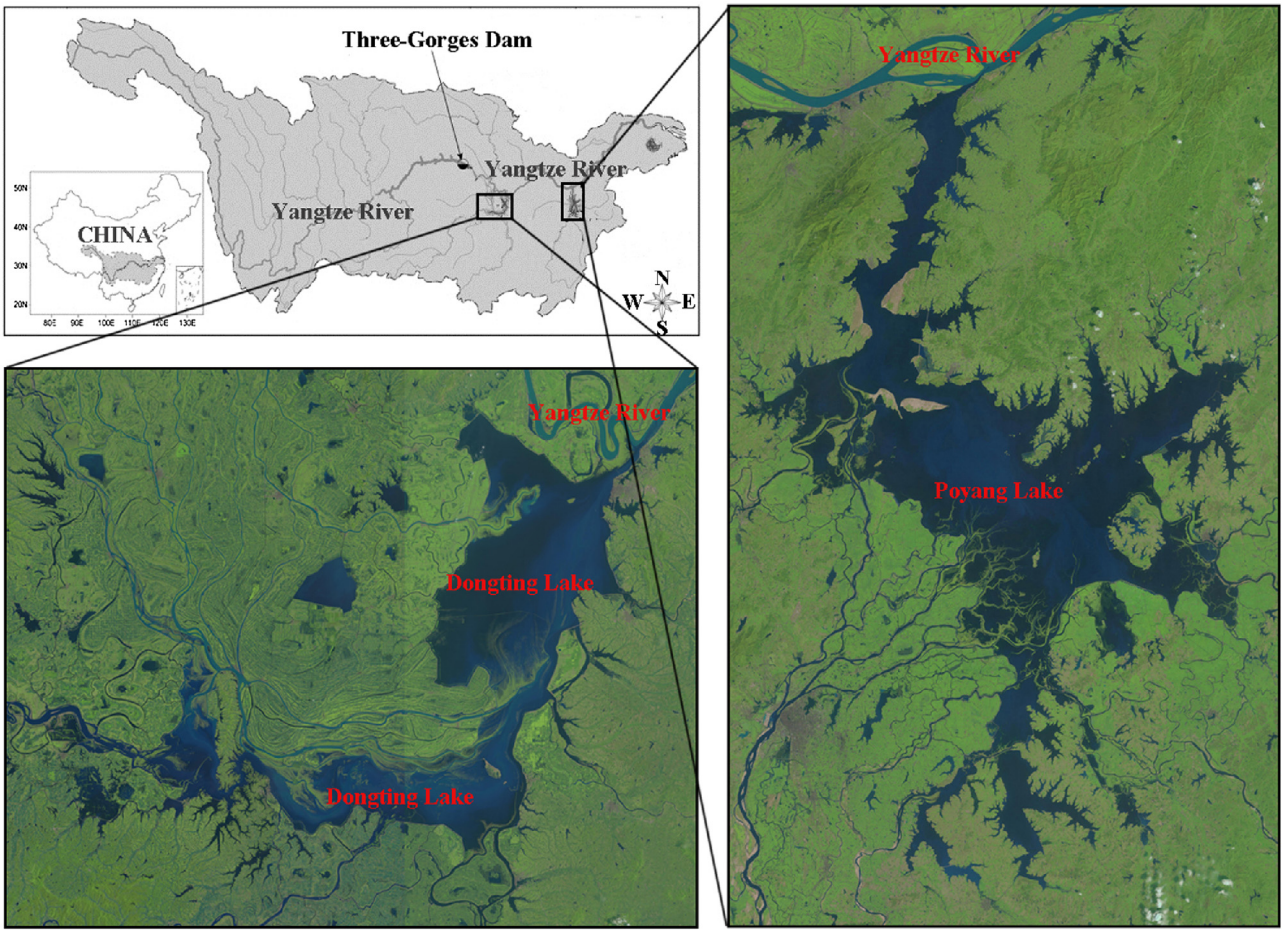


**Fig. 1.** Locations of Poyang Lake, Dongting Lake and Three-Gorges Dam (TGD).

low-flow year, respectively, during the early stages of the TGD construction and that this increase in lead time would continue for 50 years after impoundment of the TGD was constructed. Liang et al. (2012) found that the average starting date of the dry season for the Dongting Lake wetland in the post-TGD period (2003–2010) was 18 days earlier than that for the pre-TGD period (1981–2002).

Several studies have been conducted on the early dry season, but have primarily been focused on the prediction, verification and analysis of the early starting dates (Wu et al., 2015; Huang et al., 2008). However, little is known about the effect of the early dry season on landscape pattern (or vegetation). Landscape pattern is sensitive to local changes in the environmental conditions (Hoorn et al., 2010; Zeng et al., 2013b), biology (Gurnell, 2012; Zhang et al., 2016) and anthropogenic activity (Wright and Wimberly, 2013; Zeng et al., 2013a), and affects ecological progresses (Fahrig et al., 2011; Heffernan et al., 2014) and services of ecosystems (Gong et al., 2009; Lawler et al., 2014), biology population (Fischer and Lindenmayer, 2007; Xu et al., 2012) and biodiversity (Fahrig et al., 2011; Lawler et al., 2014). The change of hydrologic cycle could affect landscape pattern of wetland (De Jager et al., 2012; McClain et al., 2003; Tang et al., 2008). Therefore, the early dry season will impact landscape pattern (or vegetation) of the two largest freshwater lake wetlands in China (Wu et al., 2015). And the changes of landscape pattern of the two wetlands will impact migrating birds of East Asian and migratory fishes of Yangtze River.

In this study, we used TM/ETM data to investigate the landscape pattern of the Poyang Lake and Dongting Lake in hydrologic year which had an early dry season (EY) and which had normal dry season (NY), and analysis the effect of early dry season on landscape pattern. The dry season, had an obvious earlier starting day than the mean starting day before TGD, was EY. The dry season, had a starting day close to the mean starting day before TGD, was NY. The objectives of this study were as follows: (1) to analyze the responses of landscape pattern of the two largest freshwater lakes in China to the early dry season after impoundment of the TGD; and (2) to provides the basis for studies of the effect of early dry season on biology (especially migrating birds and migratory fishes).

## 2. Materials and methods

### 2.1. Study area

The Yangtze River (Changjiang River) is one of the major rivers on earth and plays a critical role in the global water cycle, sediment cycle, energy balance, climate change and ecological development (Dai et al., 2016; Wu et al., 2015). The river exhibits seasonal variability in the water level and area from monsoon-driven precipitation, such that there is a high water level and area in the wet season from May to October and a low water level and area in the dry season from November to the following April (Li et al., 2011; Zhang et al., 2007). The TGD is located 44 km upstream of Yichang station (the control point of the upper Yangtze River basin) (Hu et al., 2011; Wu et al., 2015). Many lakes are located downstream of the TGD. Among these lakes, Poyang Lake (28°11′–29°51′ N, 115°31′–117°06′ E) and Dongting Lake (28°30′–29°38′ N, 112°18′–113°15′ E) (Fig. 1) are the two largest freshwater lakes in China (Feng et al., 2013; Wu et al., 2015). In normal water periods, areas of Poyang Lake and Dongting Lake