Remote Sensing of Environment xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Remote Sensing of Environment

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

Wetland changes of China's largest freshwater lake and their linkage with the Three Gorges Dam

Xingxing Han[a,c], Lian Feng[b,c,*], Chuanmin Hu[c], Xiaoling Chen[a]

[a] State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, Wuhan 430079, China
[b] School of Environmental Science and Engineering, Southern University of Science and Technology, Shenzhen 518055, China
[c] College of Marine Science, University of South Florida, 140 Seventh Avenue South, St. Petersburg, FL 33701, USA

ARTICLE INFO

Keywords:
Poyang Lake
Wetland
Three Gorges Dam
Water depth
MODIS
Remote sensing

ABSTRACT

The impoundment of the Three Gorges Dam (TGD) has led to significant inundation shrinkage and water level decrease in China's largest freshwater lake, Poyang Lake. However, little is known about the influence on the lake's wetland landscapes. Here, using Moderate Resolution Imaging Spectroradiometer (MODIS) observations and a phenology-based decision tree approach, we present the spatial and temporal changes of the major wetland cover types from 2000 to 2014. Over the 15-year period, both total coverage of vegetation (*Carex* spp., *Triarrhena lutarioriparia* L. - Phragmites, sparse grass, and *Zizania latifolia* communities) and the area of each community (excluding floating aquatic macrophytes community or FAM) showed significantly increasing trends, with vegetation expanded towards the lake center. In contrast, the areas of water and mudflat have decreased significantly since the TGD impoundment, and they were mainly replaced by prominently expanded vegetated areas. The transition maps during 2000–2014 show that the vegetation community transitions occurred mainly from hydrophilic cover types to those adapted to dryer conditions. Despite the significant changes in wetland cover types, the most preferable water depth for each cover type remained stable before and after the TGD. In conclusion, the vegetation compositions are primarily controlled by water depth, indicating that the recent wetland changes can be directly linked to the TGD-induced hydrological regime-shift. These results provide a critical reference for local authorities to assess the potential influence of the newly proposed dam in this lake and to optimize its future operations with respect to modulating water levels.

1. Introduction

The Three Gorges Dam (TGD) is the world's largest hydroelectric dam (Fig. 1). It has received numerous criticisms since its planning stage due to its environmental and societal impacts. In addition to the resettlement of ~1.3 million people and its enormous cost ($26 billion) (Stone, 2011), the ecological and biodiversity consequences have caused significant concerns and controversy. Various studies have demonstrated the TGD-related eco-environmental threats on the local region, downstream in the Yangtze River Basin, and in the East China Sea (Feng et al., 2014; Jiao et al., 2007; Wang et al., 2010; Wu et al., 2004; Xie et al., 2003; Xu and Milliman, 2009; Yan et al., 2008). As a result, the State Council of China released a "Three Gorges follow-up plan" in 2011 to mitigate the impacts. However, better understanding of the potential mechanisms leading to these negative effects is required to support effective measures. Indeed, one of the greatest challenges has been how to differentiate the impacts of climate variability from those of the TGD.

Downstream from the TGD is the Poyang Lake Wetland, which is a productive ecosystem that supports fisheries, tourism and the local economy. The wetlands also serve as an important habitat for most of the winter birds from Siberia (Finlayson et al., 2010). Unfortunately, the landscape of this lake has experienced dramatic changes in recent years, especially after 2003 when the TGD was impounded (Feng et al., 2013; Hu et al., 2010; Zhang et al., 2012; Zhang et al., 2012), threatening its ecological system. The lake's inundation area showed a statistically significant decreasing trend in the past decade, resulting in a prolonged exposure period of the lake's bottom and thus providing favorable conditions for wetland vegetation growth (Feng et al., 2012). Four decades of Landsat observations showed that the vegetation coverage increased by 620.8 km^2 (16.6% of the lake area) during the low water stages from 2001 to 2013 (Feng et al., 2016; Han et al., 2015). However, previous studies either treated all vegetation communities as one single type (Chen et al., 2014; Han et al., 2015) or focused only on a short period (Dronova et al., 2012; Dronova et al., 2011; Wang et al., 2012). Although long-term data have been used in some studies to

* Corresponding author at: School of Environmental Science and Engineering, Southern University of Science and Technology, Shenzhen 518055, China.
E-mail address: fengl@sustc.edu.cn (L. Feng).

http://dx.doi.org/10.1016/j.rse.2017.09.023
Received 15 February 2017; Received in revised form 4 September 2017; Accepted 16 September 2017
0034-4257/ © 2017 Elsevier Inc. All rights reserved.

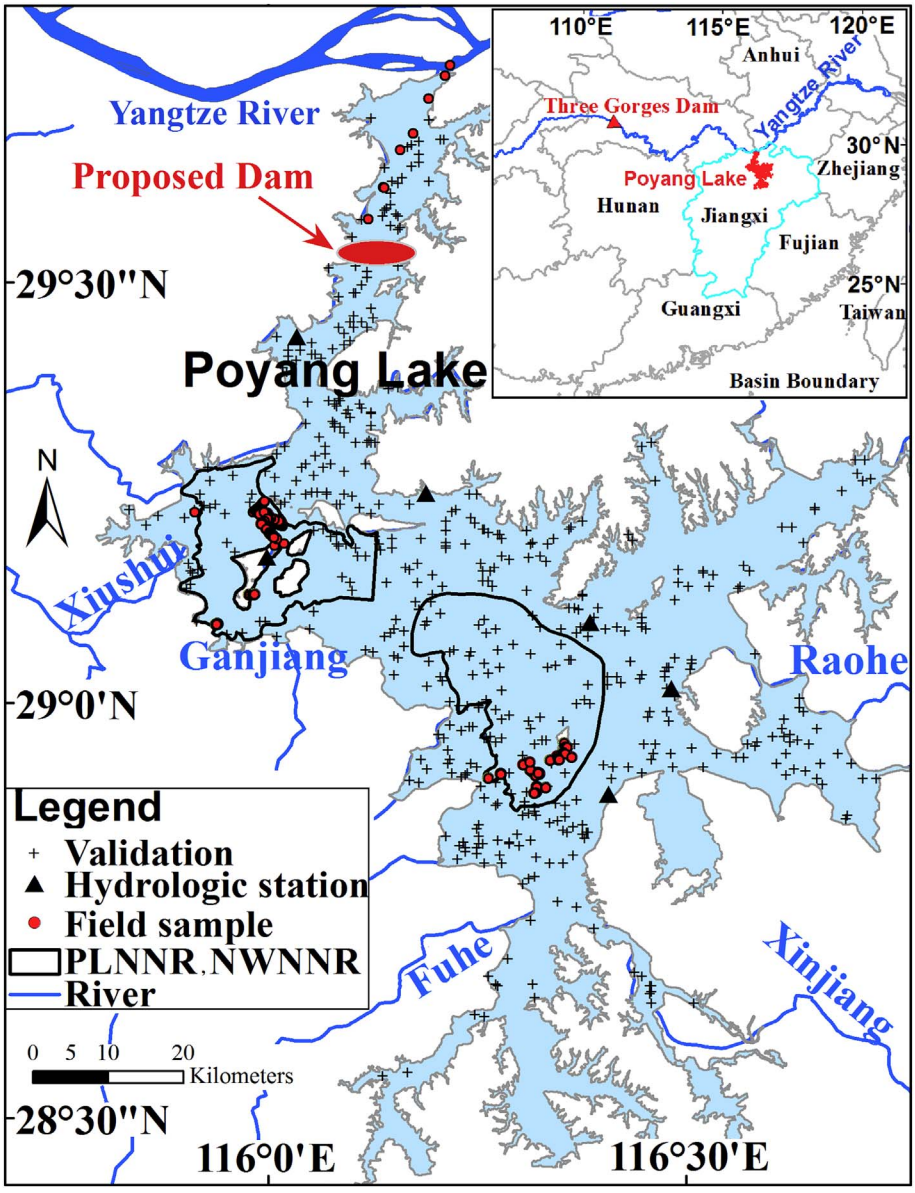

Fig. 1. The locations of Poyang Lake, the Three Gorges Dam (TGD), and the newly-proposed dam in the lake. The black line is the boundary of the Nanjishan Wetland National Nature Reserve (NWNNR) and the Poyang Lake National Nature Reserve (PLNNR). Seven hydrological stations are annotated as black triangles. Field samples annotated as red points were used for classification rules development, and field samples annotated as black crosses were used for validation. The inset figure shows the location of the Poyang Lake, TGD, and the Yangtze River. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

identify different vegetation communities, the phenological disparities between different years that are associated with inter-annual water-level changes were not considered (Chen et al., 2014; Hu et al., 2015; Wu et al., 2017). How the different vegetation communities changed over the years or transitioned among each other has remained largely unknown, as have the causes of these changes.

To protect the lake against rapid inundation shrinkage and aimed at preserving its ecological functions, the local government has proposed to spend ~2 billion U.S. dollars to build another dam (e.g., Poyang Lake hydraulic project, or PLHP) in the northern part of the lake (Jiao, 2009) (see location in Fig. 1). While this proposal has been submitted to the National Development and Reform Commission of China for approval, knowledge of how the TGD-associated hydrological changes could influence the Poyang Lake Wetland is still limited. Previous studies generally focused on the overall vegetation area's variability and tried to establish a mathematical linkage (i.e., through correlation analysis) between water level changes and vegetation increases (Feng et al., 2016). Indeed, in addition to its influence on the germination and establishment of wetland plants, the water level can also impact the competitive interactions between different communities (Keddy and Constabel, 1986; Wilson and Keddy, 1985), which are often more related to wetland ecological functions. Hence, it is critical to assess the transitions between different vegetation communities (i.e., wetland cover type) to understand the potential impacts of the TGD and the currently planned dam.

Here, the difficulty of establishing a long-term time series of various vegetation communities has been overcome by a novel approach using a phenology-based decision tree over a 15-year satellite observation period, with the objectives of deriving long-term changing patterns of each community and determining their potential linkage with the TGD impoundment.

2. Materials and methods

2.1. Study area

Located in the north of Jiangxi Province (28°22′–29°45′N and 11°47′–116°45′E), Poyang Lake is the largest freshwater lake in China (Fig. 1). The inundation area can reach > 3000 km^2 in wet seasons (April to September) and decrease to < 1000 km^2 in dry seasons (October to March of the next year) (Feng et al., 2012). The main water supplies of the lake are precipitation, local rivers (Ganjiang, Fuhe,

Download English Version:

https://daneshyari.com/en/article/8866901

Download Persian Version:

https://daneshyari.com/article/8866901

Daneshyari.com