Ecological Engineering 96 (2016) 45–54

Contents lists available at ScienceDirect

Ecological Engineering

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

The relationship between standing vegetation and the soil seed bank along the shores of Lake Taihu, China

Lijuan Cui[a,b], Wei Li[a,b,*], Xinsheng Zhao[a,b], Manyin Zhang[a,b], Yinru Lei[a,b], Yan Zhang[a,b], Changjun Gao[a,b], Xiaoming Kang[a,b], Baodi Sun[a,b], Yaqiong Zhang[a,b]

[a] Institute of Wetland Research, Chinese Academy of Forestry, Beijing 100091, China
[b] Beijing Key Laboratory of Wetland Services and Restoration, Beijing 100091, China

ARTICLE INFO

Article history:
Received 13 April 2015
Received in revised form 21 March 2016
Accepted 22 March 2016
Available online 29 March 2016

Keywords:
Lakeshore
Lake Taihu
Similarity
Soil seed bank
Standing vegetation

ABSTRACT

Understanding the basic characteristics of wetland seed banks and the distribution of those seeds is fundamental to providing a theoretical basis for vegetation restoration and wetland management. This study explored the relationship between standing vegetation and the soil seed bank representing four vegetation cover types on the shoreline of Lake Taihu (China) using a seed germination method. The vegetation cover types consisted of the fleabane lakeshore zone (Zone A), bush and grass lakeshore zone (Zone B), crop lakeshore zone (Zone C), and natural reed lakeshore zone (Zone D). The viability of the seeds of all species found during a survey of standing vegetation in the summer of 2010 was assessed using greenhouse germination trials. The fleabane, bush and grass, crop, and natural reed lakeshore zones had 4, 16, 8, and 6 species from the seed bank, respectively. Sorensen similarity coefficients resulting from comparisons of the species found in the seed bank and in the standing vegetation of those same four habitats were 0.250, 0.333, 0.143, and 0.154, respectively. Low similarity levels between standing vegetation and the seed banks indicate that we should increase work on wetland protection and management because of its potentially low recovery ability. Seed density was significantly lower in Zone B (4933 ± 1683 number/m^2) than in the other zones (Zone A: 1160 ± 502 number/m^2; Zone C: 1360 ± 587 number/m^2; and Zone D: 1200 ± 961 number/m^2. The vertical distribution of seeds in the seed bank at the four zones showed a significant decreasing trend with increasing soil depth. The reserves of seeds in the topsoil seed bank accounted for 64.10%, 60.00%, 56.86%, and 68.89% of the entire seed bank in Zones A, B, C, and D, respectively. This research can promote to instruct and inform management practices in wetland protection, wetland management, and restoration and reconstruction in damaged wetlands.

1. Introduction

The seed bank serves as an important component of the dynamics of wetland plant communities (Fenner, 1991; Vivian-Smith and Handel, 1996; Wardle et al., 2004). Seed availability strongly influences the composition of the standing vegetation in wetlands, because different species have different degrees of dependence on seeds in the creation of their part of a plant community (Grelsson and Nilsson, 1991; Middleton, 2000; Wetzel et al., 2001; Leck, 2003; Amiaud and Touzard, 2004). The production of seeds from past and current vegetation along with seed longevity determines the nature of the seed bank (Harper, 1977; Van Der Valk et al., 1992; Wang et al., 2015). The soil seed bank plays an important role in the composition of different plant communities and especially in their conservation (Grandin and Rydin, 1998; Stromberg et al., 2008; Baldwin et al., 2001). Seed banks and their relationships to vegetation have received much attention in the field of seed back studies (Rossell et al., 1999; Amiaud and Touzard, 2004; Takagawa et al., 2006). Understanding the potential of a seed bank to influence the composition of wetland plant communities, and its potential for restoring species-rich ecosystems and maintaining floristic diversity is essential (Bakker et al., 2002) Restoration of salt marshes in the Netherlands. Hydrobiologia, 478(1-3): 29-51.). The soil seed bank has historically been shown to be of great significance to the propagation of individual species (Roberts, 1981; Middleton, 2003; Li et al., 2008; Lu et al., 2010). It has also been found to be an important determinant of plant species diversity and population dynamics (Bossuyt and Honnay, 2009). Seed banks maintain the material basis for vegetation succession. They can also help land

* Corresponding author at: Institute of Wetland Research, Chinese Academy of Forestry, Haidian District, Beijing 100091, China.
E-mail address: wetlands207@163.com (W. Li).

http://dx.doi.org/10.1016/j.ecoleng.2016.03.040
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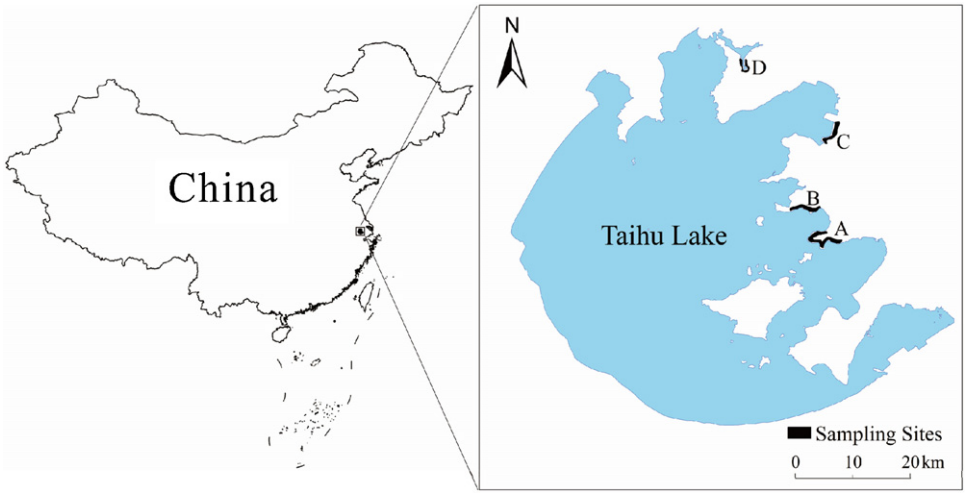

Fig. 1. Lake Taihu study area and locations of the four zones (Zone A: fleabane lakeshore; Zone B: bush and grass lakeshore; Zone C: crop lakeshore; and Zone D: natural reed lakeshore).

managers in mitigating the effects of anthropogenic disruption and disturbance to plant communities, and reduce the probability of population extirpation, and in some cases even extinction (Vecrin et al., 2007; Ma et al., 2011). A number of previous studies have investigated the relationship between standing vegetation and the soil seed bank in different regions (Guardia et al., 2000; Zobel et al., 2007). Soil seed bank and vegetation in mixed coniferous forests stands with different disturbance regimes. However, very little consideration has been given to the relationship between the soil seed bank and the standing vegetation of the Taihu lakeshore region in China.

Wetland soil is critical to the survival of soil organisms and serves as the bridge between above- and below-ground biological interactions, particularly in tidal freshwater marshes (Thompson and Grime, 1979). The shoreline of Lake Taihu had been constantly used in a flood control project since the 1990s, which has led to the degradation of the lakeshore. This study analyzed our different types of lakeshore habitat to investigate the basic characteristics and distribution of the soil seed bank, and to understand the relationship between the seed bank and standing vegetation. The results of this study provide scientific support for wetland restoration. Using soil seed bank research can not only allow the evaluation of the quality and/or degradation of wetland systems, it may allow the prediction of the ongoing vegetation dynamics as well as provide a theoretical basis for species selection during re-vegetation.

2. Materials and methods

2.1. Study area

Lake Taihu is located in the city of Shanghai, China, on the border of Jiangsu and Zhejiang Provinces (Fig. 1). It is the third largest lake in China, and covers an area of 36,900 km^2 (Xu et al., 2012; Xu et al., 2010). The mean annual temperature in this area is around 15 °C and the mean annual rainfall falls between 1000 and 1500 mm. Lake Taihu plays an important role in supplying water for domestic, industrial, and agricultural production and related uses (Wang et al., 2010). However, Lake Taihu has suffered from increasing water and soil pollution caused by industrial, agricultural, and urban waste as a result of being located in one of the most developed regions of China. In May 2007, nearly 4 million people in Wuxi, an industrial city located along Lake Taihu, lost access to drinking water for nearly a week when a carpet of algae and scum as well as an unhealthy agglomeration of biological origin made the local lake water unusable (Li et al., 2014). In addition, the aquatic and terrestrial biological transition has been seriously disturbed by the construction of dams and embankments, which has led to significant effects on the lakeshore soil.

The study area, located on the eastern shores of Lake Taihu, averages 4 m in elevation. The dominant species of standing vegetation include *Phragmites australis*, *Arundo donax*, *Typha orientalis*, *Alternanthera philoxeroides, Polygonum hydropiper*, *Humulus scandens*,and *Rumex acetosa*. The four vegetatation cover types analysed in the study consisted of the fleabane lakeshore zone (Zone A), bush and grass lakeshore zone (Zone B), crop lakeshore zone (Zone C), and natural reed lakeshore zone (Zone D)(Fig. 1). The fleabane lakeshore zone is located near Taihu Lake Wetland Park and is dominated by *Erigeron ace*, *R. acetosa*, *H. scandens*, *Echinochloa crusgalli*, *Setaria viridis*, *Glycine soja*, *P. australis*, *Chenopodium album*, *Plantago major*, and *Polygonum lapathifolium*. The bush and grass lakeshore zone is dominated by*Tamarix chinensis*, *Salix babylonica*, *A. philoxeroides*, *P. australis*, *P. hydropiper*, *Zizania latifolia*, *T. orientalis*, *Leersia japonica*, *Ixeris polycephala*, *Acalypha australis*, *P. lapathifolium*, *E. crusgalli*, and *Cuscuta chinensis*. The crop lakeshore zone is cultivated by local residents, and is dominated by *Ipomoea batatas* and *Sesamum indicum*, and associated species such as *H. scandens* and *Chenopodium glaucum*.In comparison, the natural reed lakeshore zone is dominated by *P. australis* and *A. philoxeroides*, as well as *A.*

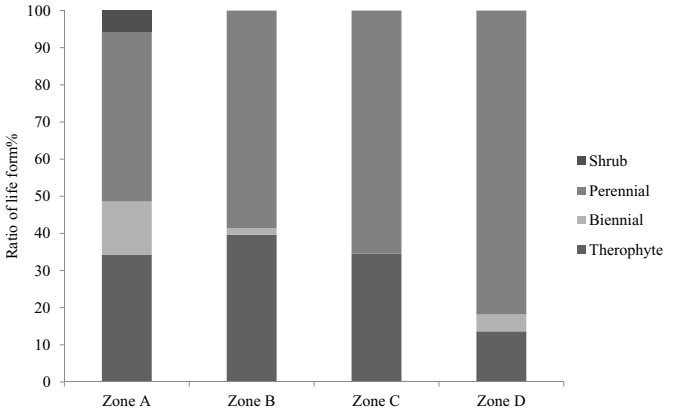

Fig. 2. Life forms of the standing vegetation in each zone (Zone A: fleabane lakeshore; Zone B: bush and grass lakeshore; Zone C: crop lakeshore; and Zone D: natural reed lakeshore).