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Soil seed bank techniques for restoring wetland vegetation diversity in Yeyahu Wetland, Beijing

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ABSTRACT

In recent years, wetland restoration measures have created extensive concerns globally. The theory and practice of restoring wetland vegetation diversity in wetlands through soil seed banks is discussed in this paper. A comparative study on soil seed bank and species composition in Yeyahu Wetland, Beijing, was conducted in 2007. Species and quantities of seeds from 12 sample sites were counted and measured by the seed-germinating method. After germination, 27 species belonging to 16 families and 23 genera were recorded, with an average of 11.75 species per sample site, and total average density of 24831.0 individuals/m^2. There were significant differences between the soil seed bank and vegetation in spring, summer and autumn, with similarity coefficients of 0.2620 ± 0.0868, 0.2580 ± 0.0778 and 0.1953 ± 0.0452, respectively. Also in 2008, by using the seed bank technique, vegetation diversity was restored in a degraded wetland near Maying River of Yeyahu Wetland through the processes of spot selection, topographic surveying, water level monitoring, and vegetation management. The results showed that in the restored regions, both species and diversity coefficients of vegetation observably increased: 73.68% of the hydrophytic species we discovered were transplanted from provenance regions; germination of seeds in the soil lasted until late September; and many species completed their life history and produced new seeds to renew the seed bank. In addition, the results suggested that seed bank technique not only increased richness and multiplicity of vegetation, but also provided food chains with animal diversity in wetlands.

1. Introduction

Wetland ecosystems provide critical habitat for many animals and plants, as well as a number of valuable ecosystem services, such as water clarification, climate regulation, and flood mitigation (Mitsch and Gosselink, 2000). However, wetland has become one of most endangered ecosystems due to human activities. As we become more and more aware of the significance of the wetland ecosystem, it has gained more and more attention. Its restoration and reconstruction has become the hotspot of our research. Since 1995, wetland restoration activities have begun rapidly in China, mainly in the lakes (Ni et al., 1995; Jin et al., 1999; Tian, 2000; Li, 2008) and swamps (Cui and Liu, 1999; Wang et al., 2004; Tang et al., 2006). In 2005, China has issued *China's Wetland Conservation Regulation (2005–2010)*. Since then more than 10 wetland restoration model projects have started. But it remains to be determined how to design wetland restoration project efficiently so that its structure and function can be recovered.

The theoretics for wetland restoration include self-design and secondary succession. van der Valk, Mitsch and Jorgensen proposed that wetland ecosystem can self-organize and alter its components given enough time (van der Valk, 1999; Mitsch and Jorgensen, 1989). Mitsch and odum corroborated this theory through experiments, and they propose that wetland can self-restore in 15–20 years, and introduction of plants can expedite the recovery process (Mitsch, 1996; Odum, 1998). The theory of secondary succession, however, proposes that as long as the habitat (hydrology in the case of wetland) is restored to the previous conditions, the vegetation (and even the entire biotic community) could develop by its own rules until restored to its original state.

During wetland vegetation restoration, many reintroduction techniques are widely applied, for example, plant seeding, vegetative transplantation (Chen, 2001). However, which species should be introduced to the site, is an important factor in achieving ecologically sound wetland restoration (Jun Nishihiro et al., 2006). One method to facilitate the restoration process is to transfer the surface soil rich in vegetative seeds to the restoration areas is becoming a common re-vegetation technique in wetland restoration (McKinstry and Anderson, 2005; Jun Nishihiro et al., 2006).

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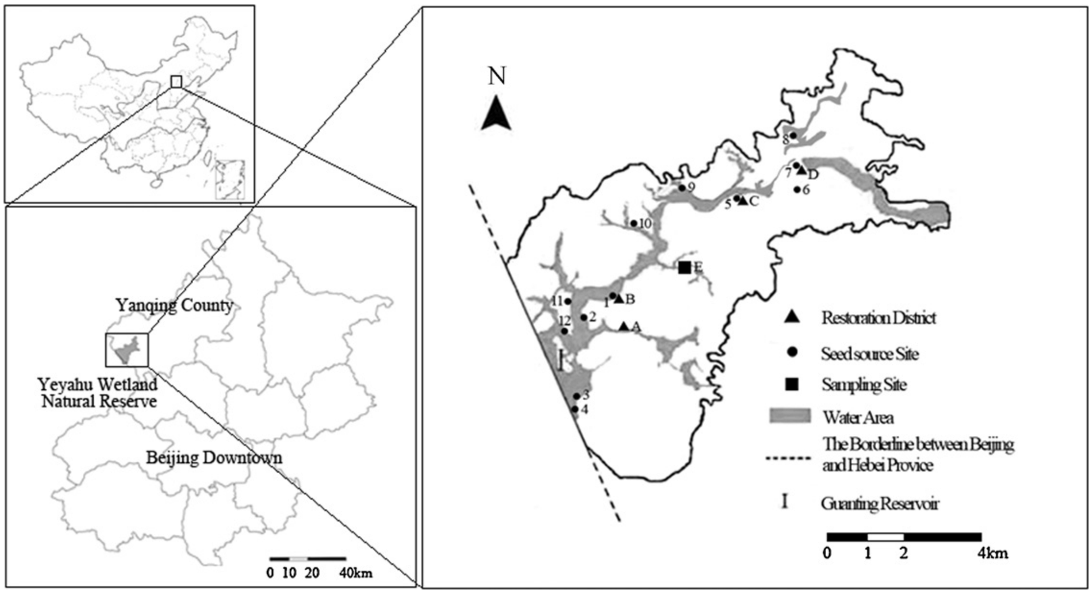

Fig. 1. Location of the sampling sites, the seed source sites and the restoration district in the Yeyahu Wetland Nature Reserve.

Seed banks represent a sum of reproducible structures such as seed, fruit, asexual propagule and other reproducible parts of the plant (Poiani and Johnson, 1989). The study of soil seed banks is indispensable in the fields of botany, ecology and wetland restoration ecology, and has become an active research area (van der Valk and Davis, 1979; van der Valk and Pederson, 1989; McDonald et al., 1996; Li et al., 2002). In the seed bank process, most seeds that fall to the surface of the ground will experience a dormant period, which varies from several days to many years, depending on species and environmental conditions. Therefore, the seed bank in a plant community is an “evolutionary memory” of the past and also an important factor in reflecting the community characteristics of the present and the future (Coffin and Lauenroth, 1989; Li et al., 2002). The seed bank not only plays an important role in the protection and reconstruction of plant community, but also provides a solid foundation for the restoration of vegetation in wetlands (Bakker, 1989). As an indicator, the seed bank is sensitive to land utilization and climate change (Hodgson and Grime, 1990); and it functions as a seed storage to decrease the possibility of extinction of plant species (MacDonald and Watkinson, 1981; Kalisz and McPeek, 1993). As a seed bank contains alleles produced in different periods by land surface species, it can decelerate or accelerate the velocity of evolution, changing the genetic structure of population (Templeton and Levin, 1979; Hairston and De Stasio, 1988; McCue and Holtsford, 1998). Previous research shows that full utilization of the seed bank preserved by the primary wetland and restoration of vegetation through transplantation (Liu et al., 2004) will be more favorable to the restoration of species and genetic diversity in wetlands.

More recently, research on wetland seed banks has occurred mainly in North America, Europe and Oceania. Most of the research has focused on scales, distributions of the seed banks, seed banks and vegetation dynamics, and seed bank function (Li et al., 2002; B.J. Wang et al., 2005; Y. Wang et al., 2005; Zhang et al., 2003). However, the only example is in the second largest lake in Japan, the Kasumigaura, where seed banks were adopted to recover the lakeside swamps and were shown to be feasible and efficient (Jun Nishihiro et al., 2006). There are few reports on applications of wetland seed banks in the practice of restoration. Our experiment intends to: (1) determine what roles the seed bank in wetlands can play in wetland restoration and how plant diversity can be reconstructed effectively in wetlands; (2) test the authenticity and actual implementation effect of the concept of planting seed banks collected from a healthy wetland area at a restoration site in order to facilitate wetland vegetation restoration.

2. Materials and methods

2.1. Site description

The Yeyahu Wetland Natural Reserve is located in the swamp area of Yanqing County, Northwest Beijing (115°47′E∼ 115°54′E, 40°25′N∼ 40°30′N), bordering Huailai County, Hebei Province, with total watershed area of 8700 km^2. According to statistics from 2002, it has a water area of 9.8 km^2 and marsh area of 12 km^2. Its topmost altitude is 485 m, and it has an annual average temperature of 13.1 °C, 2813.2 annual sunlight hours, 196 days of annual no-frost period. Its physiognomy type is floodplain in the basins for mountains, and its surface water system mainly includes the Guishui river and the Caijia river, which belong to the Guanting reservoir. The core area of the Yeyahu Wetland Natural Reserve is located in the influx area of the rivers and the Guanting reservoir. Common cinnamon soil and carbonate cinnamon soil cover the upper areas, while in the lower ones there is moisture soil and aqui-cinnamon soil. The underground water depth of the waterfront is less than 2 m, providing a centered place for moisture soil. In part of the marsh, where the underground water emerges, lie swamp soil. It is estimated that vegetation cover of Yeyahu wetland is of various species and rich biodiversity, of which there are 357 higher plants from 71 families and 213 genera (Fig. 1).

2.2. Soil seed bank and germination

The soil seed bank was sampled in April 2007. Twelve sampling sites along the perpendicular direction of the river were selected, with 3 plots (1 m × 1 m) placed at approximately 20 m intervals at each sampling site. Those 3 plots in every sampling site are controlled in the same habitat type with the same surface vegetation type. Sample Nos. 1, 2, 6, 7, 8, 11 and 12 are waterfront bottomland, which centered by moisture water, with no surface water, the soil is mainly alluvial soil; Sample Nos. 5, 9 and 10 belong to marsh