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Short communication

Effects of the Three Gorges Dam on preupland and preriparian drawdown zones vegetation in the upper watershed of the Yangtze River, P.R. China

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ABSTRACT

After the construction of the Three Gorges Dam (TGD) on Yangtze River, the preupland region and preriparian zone were submerged as a result of a substantial increase in the water level. To assess the overall effects of the Three Gorges Reservoir (TGR) impoundment on the drawdown zone vegetation, we compared the preupland drawdown zone (PU-DZ) vegetation with its adjacent upland and the preriparian drawdown zone (PR-DZ) vegetation with the natural riparian zone (NRZ) of the Yangtze River. Twelve sites were surveyed in each of these four habitats in September 2009. The results showed that the TGR impoundment had different effects on the PU-DZ and PR-DZ vegetation. The species composition of the PU-DZ vegetation changed substantially after the impoundment. The species number per 100 m^2 increased significantly in the PU-DZ compared with the adjacent upland. Most of the species were forbs and ferns, especially annual and biennial species. However, the total cover in the PU-DZ was lower than that of the adjacent upland due to the destruction of tree and shrub communities. In contrast, the total cover and species composition of the PR-DZ did not change as seriously as the PU-DZ vegetation for the existing tolerant perennials. Significantly fewer species were found per 100 m^2 in the PR-DZ than in the NRZ. Moreover, the species numbers per 100 m^2 for trees and shrubs, forbs and ferns and graminoids decreased significantly, but the proportions of cover for these groups were unchanged, except for trees and shrubs decreased significantly. This result indicated that all species groups were extensively suppressed in the PR-DZ.

1. Introduction

The Three Gorges Dam (TGD) built on the Yangtze River is the largest dam ever built in China (Wu et al., 2004). After the construction of the TGD, the water level of Yangtze River at Zigui City (where the TGD is located) rose from 68 m above sea level (asl) to 175 m asl. Thus, the portion of the Yangtze River Basin between Jiangjin and Zigui City, with a distance of approximately 660 km, has come into be the Three Gorges Reservoir Region (TGRR; 106°–111°50′ E, 29°16′–31°25′, Fig. 1). According to the water level management, the impoundment of the Three Gorges Reservoir (TGR) starts from 145 m asl in September to 175 m asl in November. The water level is maintained for three months and then returned to 145 m asl again in May (Fig. 2a). This whole cycle is repeated annually. Before the construction of the dam, the average water level of Yangtze River at Fuling and Jiangjin City is about 145 m asl and 175 m asl, respectively (Fig. 1). Therefore, the backwater area of the TGR reaches Fuling City when the impoundment water level is at 145 m asl and reaches Jiangjin City when the water level is at 175 m asl. Consequently, two types of drawdown zone appear along the TGR banks: (1) Preupland drawdown zone (PU-DZ) distributed in the reservoir region between Fuling City and the dam, where the former natural riparian zone of the Yangtze River is submerged forever since it is lower than 145 m asl. The former upland vegetation is inevitably submerged by the impoundment from September to May (Fig. 2a). (2) Preriparian drawdown zone (PR-DZ). The former riparian zone is higher than 145 m asl in the reservoir region between Fuling and Jiangjin City and overlaps with the impoundment drawdown zone (Fig. 1). Thus, it is affected by the summer flooding from July to September as well as by the impoundment from September to May (Fig. 2b and c).

Nilsson et al. (1997) claimed that one of the most important factors affecting plant communities at the onset of river regulation is whether the river margin is located within, above or below the pre-regulation riparian zone. Furthermore, plant communities along river margins respond differently to different water level regimes (Jansson et al., 2000). We may therefore assume that the TGR impoundment is likely to have different effects on the PU-DZ and

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PR-DZ vegetation. Although some studies had focused on different effects of river regulation on preupland and preriparian vegetations (Sundborg, 1977; Nilsson et al., 1991, 1997), very few studies on how preupland and preriparian vegetations within a reservoir region are affected by reservoir regulation have been reported. In addition, flood timing and duration were considered as important factors affecting species distribution (Noble and Murphy, 1975; Nilsson and Keddy, 1988). The floods in these studies mostly took place in spring or summer, and the durations were normally less than 3 months (Nilsson and Keddy, 1988; Nilsson et al., 1997; Jansson et al., 2000). However, the study on the extremely long submergence of the TGR (4–8 months), which occurs in late autumn, winter and early spring, is scarce. To date, however, little is known about the effects of the TGR impoundment on its drawdown zone vegetation.

One the other hand, such long-term impoundment of the TGR inevitably erodes the soil and decreases the stability of the drawdown zone and a number of studies have already paid close attentions to the restoration of it (e.g. Wang et al., 2005; Fan et al., 2006). Understanding the overall effects of the TGR impoundment on the drawdown zone vegetation is essential for the implementation of restoration.

The aims of our study were therefore (1) to test whether the TGR impoundment has different effects on the PU-DZ and PR-DZ vegetation and (2) to provide some advices on vegetation conservation of the TGR drawdown zone.

2. Materials and methods

2.1. Study area

The TGRR has a humid subtropical monsoon climate, with a mean annual temperature of 15–19 °C, mean annual precipitation of 1250 mm and relative humidity of 76%. The current land cover of the TGRR is dominated by secondary vegetation and agricultural fields as a result of long-term human activity (Wu et al., 2004).

2.2. Field investigation

To assess the effects of the TGR impoundment on the PU-DZ and PR-DZ vegetation, we compared them with vegetations which were similar to their initial ones because of the lack of detail in pre-regulation data. Before the construction of the TGD, the PU-DZ and its adjacent upland had similar vegetation because they were both secondary vegetation which has little variation with increasing elevation. The PR-DZ and the natural riparian zone (NRZ) also have similar vegetation since they were both riparian zones of the Yangtze River. The NRZ is located in the upstream of Jiangjin City (Fig. 1), which experiences natural flow regimes supporting the characteristic natural riparian vegetation (Mallik and Richardson, 2009). In this study we therefore compared the vegetation of the PU-DZ with its adjacent upland and the vegetation of the PR-DZ with the NRZ.

A field survey of the study area was performed in September 2009 before the impoundment. Twelve sites were selected throughout these four habitats respectively and were chosen to represent typical communities and environmental conditions found in the above habitats (Fig. 1). The distances between adjacent sites ranged from 10 km to 90 km. Each site encompassed about a 130-m-long stretch of drawdown zone, spanning the entire area between the low and high water levels. For the PU-DZ, this was identical to the area between 145 m asl and 175 m asl. The area in the NRZ located between winter low-water ("0 m", the mean of many years' winter low-water levels) and summer high-water levels (12–15 m, relative to the "0 m"). In the PR-DZ, the area was equivalent to the portion of drawdown zone submerged by the impoundment as well as summer flooding. The upper limits for

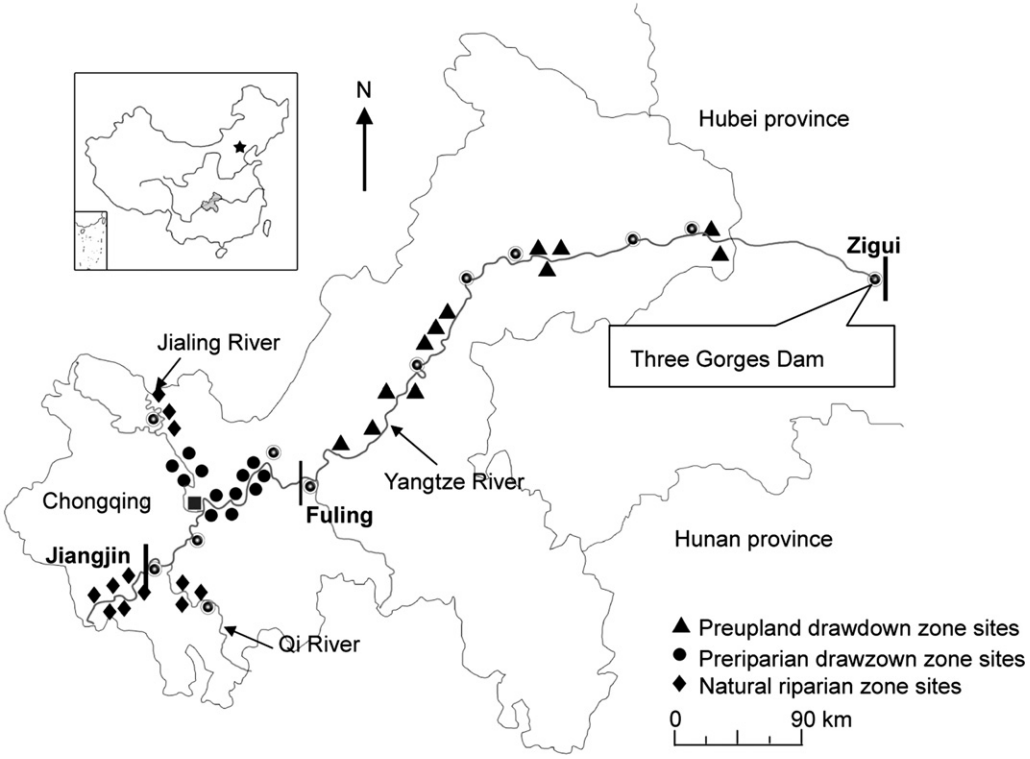

Fig. 1. The spatial extent of the Three Gorges Reservoir and the location of the sampling sites.