Forest Ecology and Management 432 (2019) 741–747

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Survivorship of plant species from soil seedbank after translocation from subtropical natural forests to plantation forests

Qingqiu Zhou[a,b], Feng Li[a,b], Xi-an Cai[a], Xingquan Rao[a], Lixia Zhou[a], Zhanfeng Liu[a], Yongbiao Lin[a], Shenglei Fu[c,a,*]

[a] Key Laboratory of Vegetation Restoration and Management of Degraded Ecosystems, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510650, China
[b] University of Chinese Academy of Sciences, Beijing 100049, China
[c] College of Environment and Planning, Henan University, Kaifeng 475004, China

ARTICLE INFO

Keywords:
Soil seedbank
Natural forest
Plantation forest
Soil translocation
Forest regeneration

ABSTRACT

The enhancement of biodiversity is an important strategy to improve the structure and functioning of monoculture plantations. However, compared with seedling transplanting, there is limited information about the utilization of soil seedbanks in regenerating plantation forests. In the present study, to investigate the potential application of soil seedbanks in plantation forest regeneration, the topsoil (0–10 cm) of natural forests was translocated to different monoculture plantations, namely, *Acacia crassicarpa*, *Castanopsis hystrix* and *Eucalyptus urophylla* monocultures. Seed germination, seedling growth and related environmental conditions of the plantation forests were monitored in the experiment. Although, at the very start, large numbers of seedlings emerged from the soil seedbank, only nine species survived after 2.5 years, including seven tree species and two shrub species. Notably, *Machilus chekiangensis*, a tree species with high economic value, was established in the plantation forests. Except for the common species that emerged in the three plantations, there were some special species that were only associated with a specific plantation. Redundancy analysis revealed that nitrogen from both the natural forest and plantation forest soil had significant effects on seedlings growth. However, environmental conditions such as light (reflected by leaf area index), soil temperature, moisture and pH showed no obvious influence on seedling growth. Our study suggests that soil seedbank translocation from a natural forest to a plantation forest can be a useful approach for plantation forest regeneration because it could introduce valuable plant species and improve the plant biodiversity.

1. Introduction

The intensification of human activities leads to a gradual decrease in species in natural and seminatural forests (Brockerhoff et al., 2008) and an overexploitation of plant and animal resources, which are major causes of the loss of biodiversity (Milner-Gulland and Akçakaya, 2001; Brook et al., 2003; Laurance, 2007). The degraded ecosystems can be regenerated by the restoration of natural vegetation and artificial tree plantation (Jin et al., 2014). However, a long period is necessary for the restoration of natural vegetation. Therefore, developing plantation forests worldwide to act against the trend of decreasing forest cover is an important measure of ecological restoration (Brockerhoff et al., 2008).

Globally, particularly in developing countries, plantation forests have rapidly expanded during the last two decades (Hartley, 2002). The results of The Eighth National Forest Resources Inventory show that China has 69 million hectares of artificial forest, ranking first in the world (SFA, 2014). Although plantations can assist ecosystem restoration, it is incontestable that excessive plantations can extremely easily cause a simultaneous reduction of biodiversity (Friend, 1982; Freedman et al., 1996). In addition, featuring monoculture as a common structure, plantation forests usually have less habitat diversity and complexity, and offer inferior habitats for native plant species than natural forests (Lindenmayer and Hobbs, 2004; De Warnaffe and Deconchat, 2008). Natural ecosystems with high biodiversity are more adaptable to climate change (Cardinale, 2011), while the limited genetic diversity of plantations will make them more vulnerable under the influence of climate change (Pawson et al., 2013). Therefore, the biodiversity enhancement of a plantation can be a major adaptation strategy in response to climate change. To increase the biodiversity and stability of

* Corresponding author.
E-mail address: fsl@henu.edu.cn (S. Fu).

https://doi.org/10.1016/j.foreco.2018.10.013
Received 26 July 2018; Received in revised form 8 September 2018; Accepted 4 October 2018
0378-1127/ © 2018 Elsevier B.V. All rights reserved.

plantations, it is imperative to optimize their community structure.

Soil seedbanks (SSBs) are a reserve of abundant species diversity and conserve genetic information sometimes for decades, which maintains genetic homogeneity and the population viability of forests to adapt to environmental changes (Koch et al., 2003; Satterthwaite et al., 2007). Once exposed to the land surface by either plant roots or human disturbance, seeds buried in the soil can germinate as a seedling bank, which can play a vital role in forest regeneration (Douh et al., 2018). In particular, long-term persistent categories of SSB can assist in the restoration of extinct plant populations (Csontos and Tamás, 2003). There have been many studies about the composition and functions of SSBs in various ecosystems (Miao et al., 2016; Tamura, 2016; Hazelton et al., 2017; Török et al., 2017; Czerwiński et al., 2018).

Numerous investigations have outlined the heterogeneity of the density and species composition of SSBs (Butler and Chazdon, 1998; Perera, 2005; Martins and Engel, 2007). Their species abundance uncertainly depends on the study site, sample size, season of soil collection, treatment of the soil samples and the depth of the sampled soils (Warr et al., 1993). Ecosystems recovery using the methods of seed sowing or seedling planting can be expensive and sometimes unpredictable (Hallinger and Shisler, 2009). Therefore, many managers employ relatively simple restoration methods using existing SSBs, which are less costly and more accessible. As early as 1997, SSBs were used for the recovery of threatened endemic plant species (Aparicio and Guisande, 1997) by replacing the topsoil with soil from forest sites with abundant seeds (Dougall and Dodd, 1997). According to Douh et al. (2018), the soil surface layer (0–10 cm in depth) possesses the highest species richness, accounting for almost 80% of the total. In the present study, the SSB of the topsoil from subtropical natural forests were translocated to plantation forests. We intended to ask the following: (1) Can plant species from natural forests be established in plantation forests through SSB translocation? (2) If they could emerge from the soil seedbanks, how well would the plant species adapt to the new environmental conditions?

2. Materials and methods

2.1. Site description

To investigate the effects of SSBs from natural forests on the regeneration of monoculture plantations, we chose three natural forests with similar conditions in the Yingde Shimentai Natural Reserve (113°15′E, 24°35′N) and three different monoculture plantations in the Heshan National Field Research Station of Forest Ecosystem (112°50′E, 22°34′N), Guangdong Province, China. The mean annual precipitation of the Yingde site is 2365 mm, the mean annual temperature is 20.8 °C, and the average altitude is 800 m (Liu et al., 2016). With an average altitude of 80 m, the mean annual precipitation and temperature of the Heshan site is 1688 mm and 22.3 °C (2005–2012), respectively (Chen et al., 2017). Three monoculture plantations were established in 2005 and were chosen for this experiment, namely, *Acacia crassicarpa* (AC), *Castanopsis hystrix* (CH) and *Eucalyptus urophylla* monocultures (EU). These plantations were used to as pioneers for forest recovery in the past, but their structure are still simple, even nine years after planting.

2.2. Experimental design

In July 2014, three natural forests (N1, N2 and N3) were selected, and a plot of 20 m × 25 m was set up in each forest in the Yingde Shimentai Natural Reserve, Guangdong Province, China. Each plot was divided into 20 subplots of 5 m × 5 m apiece, of which nine suitable subplots were selected for SSB translocation. The size of each SSB excavated was 1 m × 1 m × 0.1 m (length × width × depth) in volume, and the litter layer and visible roots were carefully removed. In total, 27 SSBs were excavated, agitated thoroughly, and then placed into large sacks.

In the three monoculture plantations, the surface soil of the same size as the SSBs (1 m × 1 m × 0.1 m) were removed. Therefore, 27 pits (1 m × 1 m × 0.1 m) were prepared to accommodate these SSBs. All the 27 SSBs were immediately translocated to three monoculture plantations with nine SSBs (three each from N1, N2 and N3) in each plantation forest and randomly installed. These installed SSBs were underlaid with a large mesh nylon net and spaced approximately five meters apart from each other.

2.3. Investigation of seedling emergence and growth

Seedling emergence from the SSBs was monitored continually in the next five months after translocation, where plant species were identified when possible and the seedling density was measured. The systematic species identification of plant species was started in 2016, and only woody plants were considered in this study. However, obvious sprouts from rhizomes and other non-seed burgeons such as ferns and herbage were not included.

2.4. Soil sampling and analysis

Soil samples for the measurements of physicochemical properties and microbial composition were initially collected as background data in June 2014 and then twice a year from 2014 to 2016 in June and December. Both natural forest soil (NS) inside the SSBs and plantation forest soil (PS) outside the SSBs were collected. Five cores (5 cm in diameter and 10 cm in depth) were collected from NS by the five-spot-sampling method and then combined to one composite sample for each SSB. The PS were sampled in a similar way but 10 cm away from the four sides of each SSB. The surface organic materials and visible roots were removed before soil sampling. After sampling, all 54 soil samples were immediately taken to the laboratory for further analysis.

After the removal of visible plant roots and stones, the soil samples were sieved using a mesh of 2 mm and divided into two parts (the fresh part was stored at −80 °C for DNA extraction, and the other part was used for soil chemical analysis). The soil water content (SWC%, g of water per 100 g dry soil) was measured with approximately 10 g of fresh field soil dried by oven at 105 °C for 24 h and the soil pH was determined in 1:2.5 (w/v) soil solutions. A HOBO data logger was used for monitoring the long-term trends of soil temperature. The canopy attributes were characterized by the leaf area index (LAI), calculated through a LAI-2200C Plant Canopy Analyzer (manufactured by LI-COR, America). Phospholipid fatty acids (PLFAs) were analyzed using the method described by Bossio and Scow (1998). The soil organic carbon (SOC, g/kg dry soil) content was determined by the potassium dichromate oxidation method and titration with ferrous ammonium sulfate (Chen et al., 2017). Total nitrogen (TN, mg/kg dry soil) and total phosphorus (TP, mg/kg dry soil) concentrations were determined by the semimicro-Kjeldahl digestion, followed by colorimetry and then treated with an enzymatic-reader at 625 nm and 700 nm. Soil nitrate (NO_3^-, mg/kg fresh soil) and ammonium nitrogen (NH_4^+, mg/kg fresh soil) were measured by extraction with the potassium chloride solution spectrophotometric methods.

2.5. Data analysis

One-way ANOVA was performed in SPSS 19.0 to test the differences of seedling density in three monoculture plantations. Statistical significance was determined at $p < 0.05$ and difference analysis among treatments was examined with LSD.

Richness index of available seedlings in the plot was calculated using the Margalef richness index (d) (Gambi et al., 2008):

$$d = (S-1)/\ln N \quad (1)$$

where S is the number of plant categories and N is the total number of individual of all plant categories.

Download English Version:

https://daneshyari.com/en/article/11028412

Download Persian Version:

https://daneshyari.com/article/11028412

Daneshyari.com