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# Soil organic carbon sequestration potential of artificial and natural vegetation in the hilly regions of Loess Plateau

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ABSTRACT

The objectives of this study were (i) to determine the stock and distribution of soil organic carbon (SOC) and the quantity and quality of fine root; and (ii) the correlation between SOC stock and fine root quantity and quality in soils of artificial and natural vegetation in the Loess Plateau. Three vegetation types (grassland, shrubland and woodland) and two restoration approaches (artificially and naturally restored from cropland) were investigated in the Yangou watershed of the Loess Plateau. SOC stock, fine root biomass and root C/N ratio at the 0–20, 20–40, 40–60, 60–80, and 80–100 cm depths were determined. The mean SOC stock of natural vegetation at the 0–100 cm depth was significantly greater than that of artificial vegetation, with an increase of 100% for woodland, 15% for shrubland, and 23% for grassland. Natural vegetation restoration led to a significantly greater SOC stock up to a depth of 100 cm for woodland, 40 cm for shrubland, and 40 cm for grassland. The fine root biomass of natural vegetation at the 0–100 cm depth was also significantly greater than that of artificial vegetation, with an increase of 170% for woodland, 140% for shrubland, and 20% for grassland. Natural vegetation restoration led to a significantly greater fine root biomass up to a depth of 100 cm for woodland, 60 cm for shrubland, and only 20 cm for grassland. There was a significant linear correlation between SOC stock and fine root biomass. Thus, natural vegetation restoration could lead to a significantly greater SOC stock, fine root biomass, and fine root C/N ratio than the artificial vegetation restoration. Fine root was an important factor influencing the differences in the SOC stock between artificial and natural vegetation.


## 1. Introduction

Soil organic carbon (SOC) is a major component of the terrestrial carbon (C) pool that contains twice as much C as the atmosphere (Schlesinger, 1997; Post, 2000), and changes in the SOC pool can have a considerable effect on the atmospheric $CO_2$ concentration (Marin-Spiotta et al., 2009; Dou et al., 2013). Vegetation restoration from cropland into woodland, shrubland, and grassland has been recognized as an effective strategy for SOC stock and distribution (Bárcena et al., 2014; Deng et al., 2014; Zhu et al., 2014; Wang et al., 2014). However, natural vegetation restoration is distinctly different from the artificial approach in terms of management (Del Galdo et al., 2003; Six et al., 2000), microclimate (temperature and moisture) (Laganière et al., 2010), species composition (Shi et al., 2013), soil properties (Xu et al., 2014), and fine root quantity and quality (Solly et al., 2014), thus resulting in significantly different SOC stock and distribution (Jin et al., 2014). This highlights the need for a better understanding of the effects of artificial and natural vegetation restoration on the SOC stock and distribution, which is helpful for the selection of appropriate restoration measures.

The Loess Plateau that covers an area of approximately $58 \times 10^4$ km$^2$ in China is known for its long agricultural history and serious soil erosion. It is a long-term and arduous task to control soil erosion and establish a healthy ecosystem. Since the establishment of China, great importance has been attached to the restoration of vegetation in this region (Zhou et al., 2012), and artificial vegetation restoration, such as afforestation and plantation of grasses and shrubs (Yang et al., 2014), and natural vegetation restoration (Li and Shao, 2006; Zhu et al., 2010) have been conducted in this region. Although it is generally agreed that both approaches contribute to SOC accumulation in this region,

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considerable controversy remains regarding their relative efficiency. Guo and Gifford (2002) showed that the conversion of cropland to native and artificial woodland resulted in an increase of SOC by 53% and 18% about 50 years, respectively. In addition, natural vegetation had a greater litter productivity all the year round and better SOC sequestration than artificial vegetation (Jin et al., 2014; Wei et al., 2012). However, some others argued that artificial vegetation had a greater C sequestration capacity due to superior growth rate and stand structure (Gong et al., 2006; Jia et al., 2012). Vesterdal et al. (2002) found the redistribution of SOC along the soil profile rather than an obvious increase after 30 years of forestation. However, factors contributing to these conflicting results are largely understudied, and thus further investigations on the effect of artificial and native vegetation on SOC sequestration are warranted.

Fine root quantity and quality have a profound and lasting effect on the dynamics and distribution of SOC stock (Liao et al., 2014; Sucre and Fox, 2009; Wang et al., 2013; Jessy et al., 2013; Zhang et al., 2015). However, it differs significantly among vegetation types. For instance, Beech (*Fagus sylvatica* L.) has a higher fine root biomass than spruce (*Picea abies* L. Karst.) and Scotspine (*Pinus sylvestris* L.) in Norway (Finér et al., 2007); deciduous tree has a higher fine root biomass than conifer tree in the temperate zone (Jackson et al., 1996; Vogt et al., 1986); and tree fine root biomass is higher in the temperate than in the boreal zone (Vogt et al., 1986, 1995; Christoph and Hertel, 2003). Naturally restored grassland

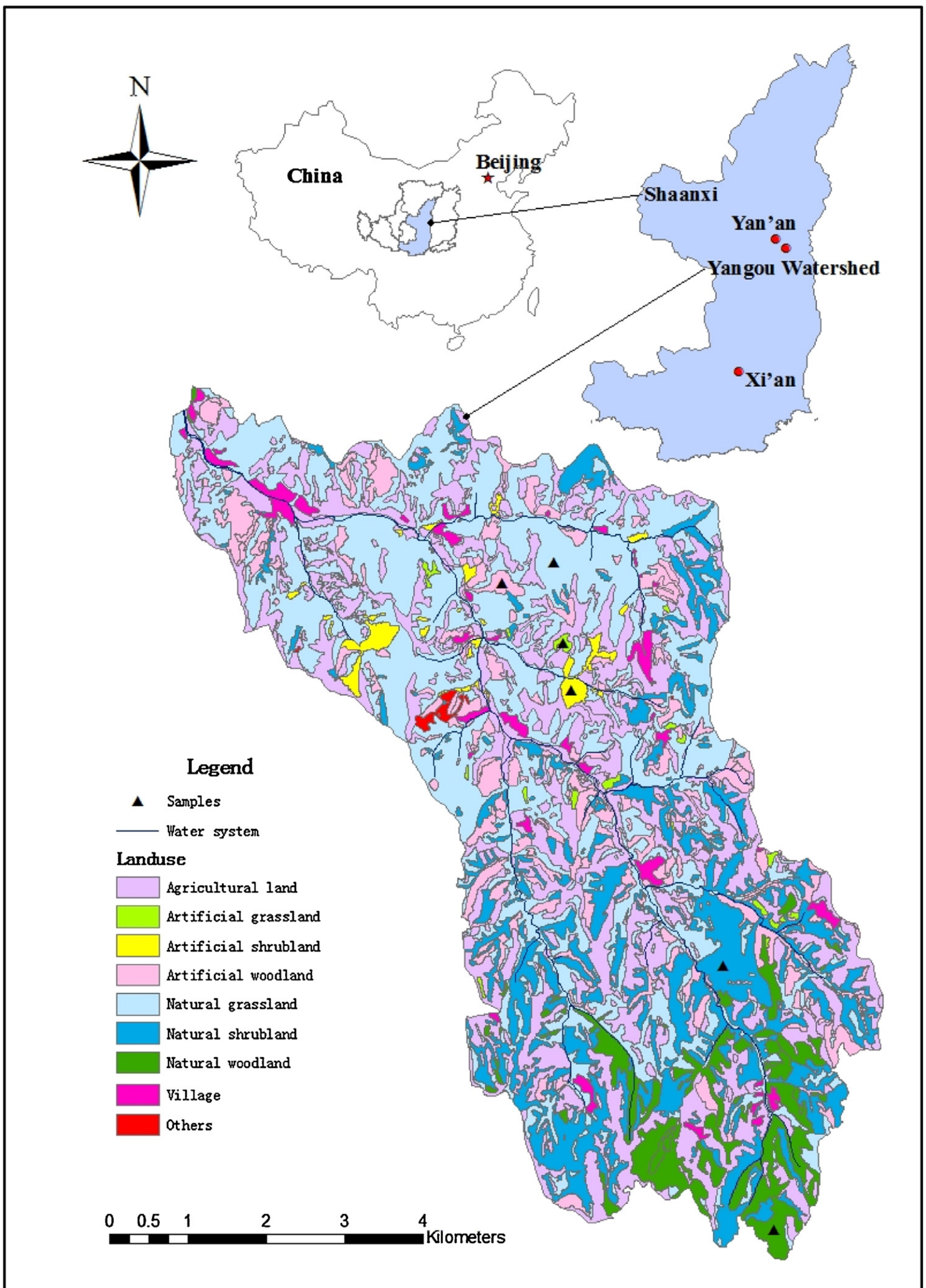


**Fig. 1.** Soil sampling sites and land-use map of the study watershed.