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RESEARCH ARTICLE

# Assessing the Ecological Success of Restoration by Afforestation on the Chinese Loess Plateau

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## Abstract

**Afforestation has been accepted as a key measure for preventing soil erosion on the Chinese Loess Plateau for 40 years. In this study, we assessed the ecological success of afforestation by comparing afforested with pre-afforested (croplands) and natural recovery sites in a typical watershed on the Loess Plateau. We evaluated the ecosystem response in terms of vegetation structure, plant diversity, and several key ecological processes of soil moisture, soil nutrients, and soil anti-erodibility. Compared with the croplands, we found that the following indexes were significantly enhanced in afforested sites: vegetation structure and species diversity (species richness, Margalef index, Shannon–Wiener index, and Sorensen's similarity index), soil nutrients (organic carbon, total nitrogen, extractable ammonium nitrogen, available potassium, and available phosphorous), and soil anti-erodibility indexes (water-stable soil aggregates, mean weight diameter, and the ratio of soil structure dispersion). Afforestation offered few additional advantages when compared with natural recovery sites. More importantly, afforestation had significant negative effects on soil desiccation, with negative impacts on the long-term sustainability of these ecosystems. In order to develop self-sustaining and functional ecosystems, our results suggest that natural revegetation offers a more adaptive and appropriate method of ecological restoration on the Loess Plateau.**

**Key words: afforestation, plant diversity, soil anti-erodibility, soil desiccation, soil nutrients, vegetation structure.**

## Introduction

Soil erosion ranks as one of the most serious environmental problems in the world because soil erosion from land areas is widespread and adversely affects all natural and human-managed ecosystems, including agriculture and forestry (Pimentel & Kounang 1998). China is one of the most seriously soil erosion-affected regions of the world, especially the Loess Plateau (Shi & Shao 2000). Soil erosion also causes siltation of rivers and reservoirs off-site (Hessel et al. 2003) increasing the flooding risk along the lower reaches of the Yellow River basin (McVicar et al. 2002). Previous studies have concluded that artificially accelerated soil erosion caused by deforestation is the primary cause (Zheng 2006). Therefore, tree planting and afforestation have been considered a key technique for soil and water conservation to minimize erosion on the Loess Plateau in the past 40 years (Li et al. 2008).

Since 1949, afforestation on the Loess Plateau has been widely implemented. Fast growing tree and shrub species are usually planted for vegetation restoration. These trees and shrubs grow well in the early stages after planting, but their rate of growth often declines once the initial water supply is exhausted, leading to soil desiccation and dried soil layers (Chen et al. 2007; McVicar et al. 2007*a*). Long-term soil water deficit and soil desiccation are increasing threats to the normal growth of afforestation on the Loess Plateau (Cao et al. 2007; Shangguan 2007), together with a decrease of streamflow in different scale catchments (McVicar et al. 2007*a*). Eventually, this threat results in forest degradation, low productive "small but old tree" forests, and tree death in drought years (Chen et al. 2008). As a result, soil erosion is not effectively controlled. To further control soil erosion, the Chinese government implemented the "Grain for Green" project in March 2000. This is a large-scale project that requires farmers to reserve a part of their sloping farmland for trees, shrubs, or grasses (McVicar et al. 2007*a*; Zhou et al. 2009). The government agencies in charge of the project issued a decree that "ecological forests" (i.e. trees for soil and water conservation, e.g. locust and buckthorn) must account for 80% of the restored lands and the rest should be "economic forests" (i.e. horticultural tree crops e.g. apples and dates). In this way, the drive for vegetation recovery on the P1ateau has turned into a single-issue movement of afforestation. However, there are controversies over the appropriateness of afforestation in this area. Based on the historical documents, as relatively dense forests had grown over a vast area of the Loess Plateau before devastation by human activities, some researchers recommend

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