From Forest Nursery Notes, Winter 2010

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Restoration Ecology
THE JOURNAL OF THE SOCIETY FOR ECOLOGICAL RESTORATION INTERNATIONAL

RESEARCH ARTICLE

Comparing Direct Abiotic Amelioration and Facilitation as Tools for Restoration of Semiarid Grasslands

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Abstract

Desertification can be an irreversible process due to positive feedback among degraded plant and soil dynamics. The recovery of semiarid degraded ecosystems may need human intervention. In restoration practices, the abiotic conditions often need to be improved to overcome the positive plant–soil feedback loops. Using nurse-plants to improve abiotic conditions for introduced individuals (facilitation) has been suggested as an alternative to direct abiotic amelioration. Here, we compared direct abiotic amelioration and facilitation as tools for restoration of semiarid grasslands in Spain. Seedlings and seeds of *Lygeum spartum* and *Salsola vermiculata* were planted and sown in a stably degraded semiarid area in Northeast Spain. Two levels of direct abiotic amelioration (ploughing and damming) and indirect abiotic amelioration through facilitation by *Suaeda vera* nurse shrubs were compared with a control with no amelioration treatment. The control treatment showed low plant establishment, confirming the practical irreversibility of the degraded state. Plant establishment was significantly higher in the three treatments with interventions than in the control treatment. The best treatment depended on the plant trait considered, but damming was in most cases better than plant facilitation. However, facilitation maintained the nutrient-rich topsoil layer. Given the relative success of facilitation, revegetation using the facilitative effect of nurse-plants would, in principle, be recommended for restoring semiarid grasslands. Direct abiotic amelioration would be needed under extreme degradation or harsh climatic conditions.

Key words: abiotic amelioration, desertification, facilitation, grasslands restoration, Middle Ebro Valley, nurse effect.

Introduction

Desertification is a serious threat for environmental conservation and sustainability of rural populations (UNEP 1994). It has been suggested that desertification can be an irreversible process, when the degraded state becomes stable (Rietkerk & van de Koppel 1997; van de Koppel et al. 1997; Rietkerk et al. 2004). Plant–soil interrelationships cause positive feedback loops (Rietkerk et al. 1997), as occurs when well-preserved vegetation cover maintains soil in good condition, which in turn allows vegetation to establish and survive. This positive plant–soil feedback also implies that reduced vegetation cover can lead to soil degradation, which in turn hampers plant establishment. Events such as overgrazing and drought can promote the shift between the vegetated and the degraded stable states (Rietkerk & van de Koppel 1997; Bestelmeyer et al. 2006; Kéfi et al. 2007) and the positive feedbacks might stabilize the degraded situation (Holmgren & Scheffer 2001). Once a degraded state is reached, initial conditions can often not be recovered without human intervention (Hobbs & Harris 2001). Restoration practices could help the ecosystem to reach the desired vegetated stable state (Hobbs & Harris 2001; Suding et al. 2004; King & Hobbs 2006).

Direct abiotic amelioration is a common reclamation practice for arid and semiarid ecosystems. The practices for abiotic amelioration include treatments that break and roughen the soil surface, create dams and microcatchments, and increase organic matter (Shachak et al. 1998; Suding et al. 2004). These treatments are carried out to increase water infiltration, minimize water and nutrient leakage, and reduce salt content and soil erosion (Shachak et al. 1998; Snyman 2003; van den Berg & Kellner 2005; King & Hobbs 2006). With these practices, soil conditions are improved and the feedback loop that maintains the degraded state stable is reversed, and plant establishment is enhanced. However, these techniques are often expensive, not always successful, and require substantial intervention in the ecosystem (Le Houerou 2000; Snyman 2003; Suding et al. 2004; Byers et al. 2006).

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doi: 10.1111/j.1526-100X.2008.00474.x