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Original article

Effects of soil enrichment, watering and seedling age on establishment of Mediterranean woody species

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ABSTRACT

Vegetation restoration in strongly degraded lands has inherent limitations. Among the most relevant limitations in Mediterranean Mountains are severe drought and stressful levels of irradiance during summer. Thus, it is common that seedlings planted in open ground incur high rates of early mortality. In the context of a project of restoration of a burned area in Southern Spain, we evaluate the efficiency of watering and enrichment with native soil, and the influence of seedling age on survival and growth of 9 late-successional tall shrubs and trees planted in open ground. We also explore how small-scale variation in environmental variables relates to establishment success. Our results show an overall positive effect of watering on the survival of planted seedlings, while the effects of enrichment with native soil and age of planted seedlings were species-specific. Seedling establishment varied markedly with the presence of ravines, which duplicated seedling survival. This suggests that ravines may be more easily restored, improving their role as corridors in landscape designs of restoration. Independently of the treatment applied, *Rosa* sp. and *Crataegus monogyna*, both fleshy-fruited species, had the highest rates of establishment. In conclusion, this study shows the viability of low aggressive restoration techniques to assist vegetation recovery in fire-degraded environments. Specifically, watering and planting in ravines should be considered where restoration practices are applied in areas lacking vegetation cover. Some species highly attractive for animal dispersers and of easy establishment (*Rosa* sp. and *Crataegus* sp.) could be used to enhance spontaneous regeneration within and beyond corridors through increasing seed attraction and dissemination.

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1. Introduction

The prevailing paradigm in restoration ecology involves returning a degraded system to some desired state by reinitiating succession (Hobbs and Norton, 1996). This would allow recovering the diversity and, more importantly, the dynamics of the community. Thus, knowledge of successional dynamics and the processes driving them must be used to implement restoration techniques for degraded areas. Mediterranean-type vegetation is dominated by fire-tolerant species which are able to resprout or which show enhanced germination after fire (Pausas et al., 2004). These fire-tolerant plants are key in the development of successional processes since, through nurse effects (Maestre et al., 2003; Castro et al., 2004; Gómez-Aparicio et al., 2004), they catalyze the

expansion of late-successional shrubs and trees which will eventually dominate the mature community (Siles et al., 2008). Accordingly, many studies propose the use the nurse plants in the restoration of Mediterranean vegetation (Gómez-Aparicio et al., 2004; Rey et al., 2009).

Unfortunately, a high recurrence of fire (or a long history of land degradation before fire) may overwhelm the capacity of fire-tolerant plants (Pausas, 2004), resulting in a rare spontaneous recovery of the vegetation. Under these circumstances, the availability of spontaneous nurse plants may be too scarce to be of any use for restoration. Restoration in such cases requires the establishment of nurse plants as a first step in restarting the successional dynamics. However, successful establishment of shrubs in the absence of nurse plants can be limited by the altered balance of nutrients in degraded soils (Gimeno-García et al., 2000) and the lowered capacity of soil water retention, and elimination or reduction of fungi and other components of the soil biota after fire (Allen, 1991; De Roman and De Miguel, 2002; Requena et al., 2001). Techniques for increasing the survival and growth of planted seedlings of these species are thus needed in degraded ecosystems.

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