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Fuel reduction at a Spanish heathland by prescribed fire and mechanical shredding: Effects on seedling emergence

Cristina Fernández*, José A. Vega, Teresa Fonturbel

Centro de Investigación Forestal-Lourizán, Xunta de Galicia, P.O.Box 127, 36080 Pontevedra, Spain

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ABSTRACT

Traditional heathland burning has declined in Spain, leading to fuel accumulation and fuel reduction treatments have become common for severe wildfire hazard reduction. These methods need to maintain the botanical composition of those shrub communities. Prescribed fire has been widely used in the past, but we need to compare mechanical fuel reduction with prescribed fire because it is easier and safer to carry out in a wide range of weather conditions. This information could be particularly useful in flammable ecosystems all over the world where traditional anthropogenic burning has declined. In this study, we compared the effects of prescribed burning and mechanical shredding on the seedling emergence and its relation to the mature vegetation in a fire-prone heathland dominated by *Erica australis* L. and *Pterospartum tridentatum* (L.) Willk., in Galicia (NW Spain). We combined a greenhouse experiment with periodic field inventories of seedling emergence.

In the greenhouse study, the seedling emergence was significantly higher in the soil samples after burning (383 seedlings m^{-2}) than in samples before burning (242 seedlings m^{-2}). In contrast, there was no significant difference in seedling density before and after mechanical shredding (243 compared with 261 seedlings m^{-2}). Also, the number of seedlings that emerged after burning was significantly higher than that emerged after mechanical shredding. The maximum temperatures at the soil organic layer surface during burning were significantly and positively related to the density of *Halimium lasianthum* ssp. *alyssoides* and *P. tridentatum* seedlings.

In the field study, the observed seedling density was very low both after prescribed burning and mechanical shredding. There was a high degree of similarity between emerged seedlings and mature vegetation in both the treated and in the untreated soils, which was probably a consequence of the dominance of resprouting species.

Some consequences for the management of these shrublands are also discussed.

1. Introduction

Shrub communities cover 21% of the land in Galicia (MMAMRyM, 2011). In the period between 2001 and 2010, approximately 8000 fires occurred per year in Galicia, representing 46% of forest fires in Spain (MMA, 2010). In the same period, more than 70% of the wildland area burned annually in Galicia was shrubland (MMA, 2010).

These communities contain a mixture of sprouters and obligate seeders, which have different fire-adaptive traits (Reyes and Casal, 2008). Both fire and grazing regimes can potentially alter the species composition. Successful restoration following such perturbations and human interventions may depend on the size and quality of the viable seed bank (Granström, 1988; Legg et al., 1992; Thompson et al., 1997). More insight into seed bank effects after fuel reduction treatments may provide criteria for choosing the most viable method for restoration. Furthermore, the capability of plant species to produce seeds that persist in the soil for many years allows them to survive unfavourable environmental conditions and await favourable conditions for germination, conserving, thus, genetic variation in the long-term (Bossuyt and Honnay, 2008).

Fuel reduction treatments are commonly used to reduce the risk of severe wildfire and for ecological objectives (Covington et al., 1997; Vega et al., 2000; Davies et al., 2008), particularly fuel management has become a priority at the wildland–urban interface. The Spanish Environmental Ministry is currently implementing a Forest Fire Prevention Programme in different shrubland

* Corresponding author. Tel.: +34 986 805013; fax: +34 986 856420.
E-mail address: cffilgueira@gmail.com (C. Fernández).

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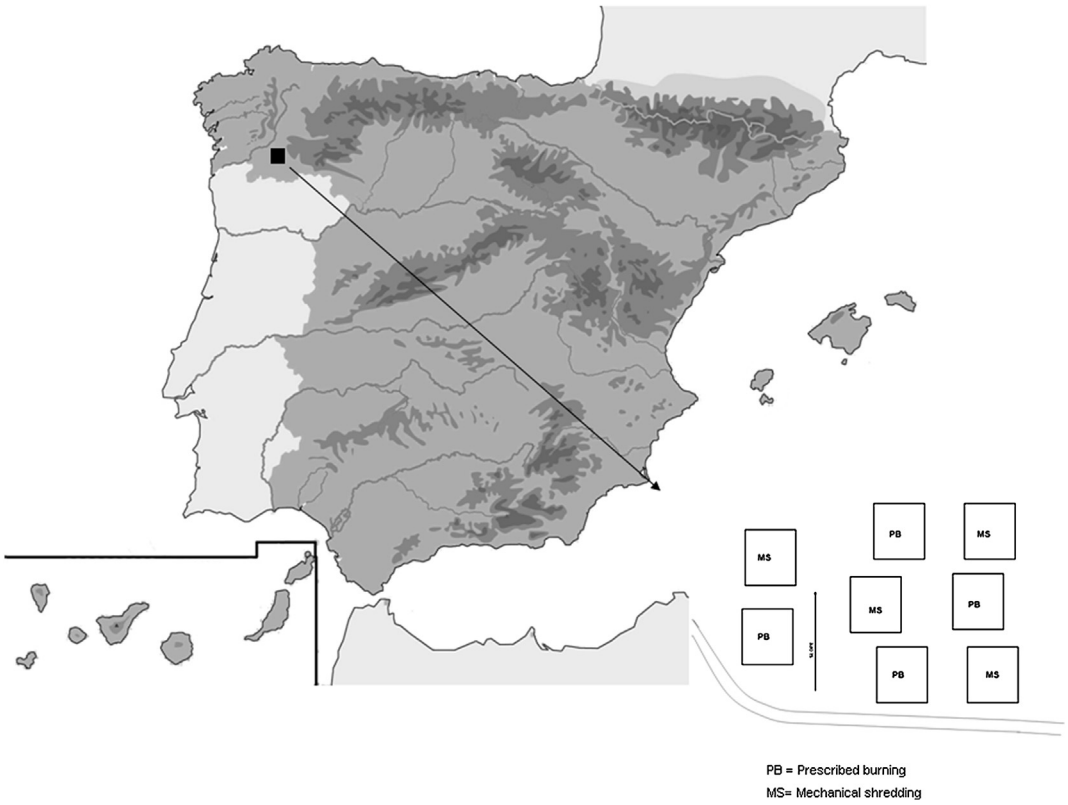

Fig. 1. Location of the study-site in NW Spain.

ecosystems, with the aim of reducing the occurrence of wildfire and restoring the traditional use of fire in rural areas (Vélez, 2010). Prescribed burning is usually the first option because it is an adaptable and relatively inexpensive method of minimizing fuel accumulation. However, other more costly alternatives like mechanical shredding are used for constructing and maintaining fuel breaks and also in the wildland–urban interface, where the use of prescribed burning may be problematic (Potts and Stephens, 2009). There is a good knowledge of the effects of fire on vegetation and post-fire regeneration in heathlands (Gimingham, 1972; Mallik and Gimimgham, 1985; Legg et al., 1992; Måren and Vandvik, 2009; Davies et al., 2010) and for other flammable systems in the world (Bond and van Wilgen, 1996). Little differences in the *Calluna vulgaris* regenerative response have been observed between prescribed burning and shrub cutting (Cotton and Hale, 1994; Calvo et al., 2002; Hancock et al., 2011). It is worthwhile to test if that similar response is also found in other heathland communities after prescribed burning and mechanical shredding.

Theoretically, burning and mechanical treatments may lead to different responses in the seedling emergence. The extent to which a soil seed bank is depleted during a fire depends on chemical and physical germination cues (Paula and Pausas, 2008) as well as on the heat penetration in the soil profile or depth of burn (Legg et al., 1992; Schimmel and Granstrom, 1996). Moreover, burning may affect thermal and moisture soil regimes and light conditions and the heat may destroy allelopathic compounds or their adsorption by charcoal (Wardle et al., 1998), all of which could affect seed germination. Mechanical shredding could increase soil compaction and the depth of the soil organic layer, which has implications for seedling emergence. Forest floor litter could have negative effects on germination and seedling emergence (Facelli and Pickett, 1991; Peterson and Facelli, 1992), as it reduces the amount of sunlight reaching the soil, acts as a physical barrier for seedling emergence and also exerts allelopathic effects (van Andel, 2006). However, a positive effect of forest floor litter on seedling emergence and growth has also been reported through providing suitable microsites for seed germination (Ellsworth et al., 2004).

All the above information is critical for understanding the resilience of heathland ecosystems (Hopfensperger, 2007) to different frequent perturbations and can help managers establish management plans that are compatible with conservation principles and adapted to the possible changes in fire regimes as a consequence of climate change (Davies et al., 2008).

We monitored seedling emergence and recovery of the mature vegetation after mechanical shredding and prescribed burning in a Galician heathland to address the following questions:

a) Do the effects of fuel reduction by mechanical shredding resemble those of prescribed burning, in terms of post-disturbance seedling emergence?
b) Does the thermal regime during burning affect seedling emergence?
c) Do emerged seedlings contribute significantly to the recovery of a heathland after fuel reduction treatment?

2. Material and methods

2.1. Study site

The study was carried out in the Edreiras Mountains (42°8′02″N–7°26′17″W; 1330 m a.s.l.), in the province of Ourense (Galicia, NW Spain; Fig. 1). The mean slope in the study area is 10%. The shrub community is a mixed heathland dominated by *Erica*