



SHORT COMMUNICATION

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Effect of fuel treatments and backfiring on the recovery of an obligate seeder-dominated heathland

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Abstract

Aim of the study: To evaluate how a plant community responded to a backfire that occurred four years after application of different types of fuel-reduction treatments.

Area of study: *Erica umbellata* Loe. (L.)-dominated heathland in Galicia (NW Spain).

Materials and Methods: Shrub cover surveys in 16 experimental plots from 2006 to 2014. Fuel reduction treatments (prescribed burning, clearing and mastication) were applied in the spring of 2006 and the area was burned by a wildfire in the summer of 2010.

Main results: Shrub total cover recovered quickly after the backfire in both the treated and untreated areas, and the pre-treatment values were reached four years after the fire. Post-wildfire resprouting species cover recovery was not affected by fuel treatments. As a contrast, *Erica umbellata* cover reached levels similar to those in the untreated plots only in the areas treated by prescribed burning. After the wildfire, grasses cover recovery was greater in the treated than in the untreated areas and the effect lasted until the end of the study.

Research highlights: Prescribed fire and backfire was favourable for *Erica umbellata* regeneration compared to clearing and mastication.

Keywords: prescribed burning; clearing; mechanical shredding; *Erica*; wildfire.

Citation: Fernández, C., Vega, J.A. (2016). Effect of fuel treatments and backfiring on the recovery of an obligate seeder-dominated heathland. Forest Systems, Volume 25, Issue 3, eSC12. <http://dx.doi.org/10.5424/fs/2016253-09119>.

Received: 10 Dec 2015. **Accepted:** 14 Jul 2016.

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Funding: The study was funded by the National Institute of Agricultural Research of Spain (INIA) through projects RTA 2005-00244-C02-01 and RTA2011-00065-C02-01, cofounded by FEDER. Financial support from the Plan de Mejora e Innovación Forestal de Galicia (2010-2020) and INDITEX is also gratefully acknowledged.

Competing interests: The authors have declared that no competing interests exist.

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Introduction

Shrub communities are valuable ecosystems that are protected under the Spanish Natura 2000 network, being the conservation and maintenance of these ecosystems strongly linked to a particular degree of management (Muñoz *et al.*, 2012b, 2014). In Galicia (NW Spain), fuel reduction treatments are used in those communities to reduce the risk of high-severity wildfire and to meet other ecological and socio-economic objectives (Vega *et al.*, 2001). In the particular case of heathland communities, they are considered to be endangered by both atmospheric nutrient deposition and natural succession and that a high-intensity management is necessary for their conservation.

Although research on the effects of fuel treatments on shrubland communities has increased in recent years (e.g. Calvo *et al.*, 2005; Fernández & Vega, 2014, 2016; Fernández *et al.*, 2015), still remains the uncertainty on how a wildfire combined with fuel treatment could affect the regeneration of an obligate seeder species.

In the present study, we investigated how a plant community dominated by *Erica umbellata* Loe. (L.) responded to a backfire that occurred four years after application of different types of fuel-reduction treatments. The aim of the study was to detect any differences in shrub recovery in relation to fuel treatment (i.e. differences between treated and untreated areas or between types of treatment).

Material and methods

Study site and experimental design

The study was carried out on a northwest-facing slope (42°34'56"N; 8° 6' 4"W; 600 m a.s.l.) in the Seixas hillslopes (Pontevedra, NW Spain) where sixteen plots (each 35 m x 25 m) were installed. The shrub community in the study area is an Atlantic mixed heathland dominated by *Erica umbellata* Loebl. (L.). at the beginning of the experiment, the area had not been burned for fifteen years.

Four different treatments were assigned at random: prescribed burning, clearing and mastication and control (no treatment). Fuel reduction treatments were carried out in the spring of 2006. Plots were burned by a strip head fire. Mastication was performed by a steel-track tractor with a rear mounted rotating toothed drum, which shredded above-ground biomass into a fairly uniform layer of small diameter woody debris that was left on the soil surface. In the shrub clearing treatment, shrubs were cut at the base of the plants with a trimmer and the cut material was removed from the plots. In August 2010, a wildfire burned close to the experimental area, a backfiring technique was used to suppress the wildfire affecting the plots of this study. As a result,

fuel consumption was very high and soil burn severity was classified as very high due the complete loss of soil organic cover and the loss of particle cohesion in the mineral soil surface according to the classification by Vega *et al.* (2013).

Field measurements

Shrub cover was measured using the line intercept method in four line transects (25 m) in each experimental plot. Surveys were carried out before fuel reduction treatments (2006) and each year thereafter (2007-2010) and also during the first four years after the 2010 fire (2011-2014). The monitoring was carried out in spring of each year.

Data analysis

A linear generalized mixed-effects model was used to examine the effects of the treatments on shrub cover. Treatments, date and their interactions were included as fixed categorical variables in the models. Plots were considered as random effects to account for positive correlations between repeated measurements of the

Table 1. Results of mixed-model analysis of fuel reduction treatments on vegetation-related variables. Treatment: Numerator degrees of freedom = 1; Denominator degrees of freedom = 3. Date: Numerator degrees of freedom = 1; Denominator degrees of freedom = 144. Significant effects are indicated in bold type

Variable	Fixed effect	F	P
Total vegetation cover	Treatment	3.652	0.0560
	Date	3.527	< 0.0001
	Treatment x Date	8.046	0.0179
<i>Erica umbellata</i> cover	Treatment	8.067	0.0045
	Date	0.002	0.9950
	Treatment x Date	16.029	0.0003
<i>Pterospartum tridentatum</i> cover	Treatment	0.012	0.9140
	Date	4.446	< 0.0001
	Treatment x Date	0.399	0.8192
<i>Ulex gallii</i> cover	Treatment	2.076	0.1497
	Date	107.570	< 0.0001
	Treatment x Date	7.044	0.0295
<i>Halimium lasianthum</i> ssp. <i>alyssoides</i> cover	Treatment	5.382	0.0203
	Date	34.020	< 0.0001
	Treatment x Date	7.281	0.0262
Grass cover	Treatment	12.618	0.0004
	Date	58.178	< 0.0001
	Treatment x Date	14.402	0.0007
Forbs cover	Treatment	1.828	0.1763
	Date	7.945	< 0.0001
	Treatment x Date	3.829	0.1474

plots within each model. Statistical analyses were carried out with the R statistical package (Core Team Development, 2014).

Results

The treatment factor had no effect on total vegetation cover (Table 1). Before the wildfire, four years after fuel reduction treatments, the mean vegetation cover in the area treated by prescribed fire was 108.5%, compared with 107.6% in the areas treated by clearing and 105.9% in the areas treated by mastication, respectively (Fig. 1). Four years after the wildfire, the values ranged from 152% in the areas treated by prescribed burning or clearing to 129% in the area treated by mastication. The total vegetation cover was, on average, 153% in the control areas.

Separate analysis of each shrub species showed that the response differed depending on the species (Table 1). Treatment had no effect on the recovery of *P. tridentatum* or *U. gallii* (Table 1; Fig. 2). The treatment factor was significant for the *E. umbellata* and *H. lasianthum* cover (Table 1). For *E. umbellata* cover, clearing and mastication differed from the control ($p < 0.0001$ in both cases). For *H. lasianthum* cover, the three fuel treatments differed from the control ($p < 0.05$). Treatment affected grass cover, mainly resprouting of *P. longifolium* and *A. curtissii* (Table 1), with the responses differing significantly between all treated areas and the control ($p < 0.01$). However, there were no differences in grass cover in the three fuel

treatments. No treatment effect was observed for forbs cover (Table 1).

Discussion

In the treated areas, the backfire did not affect the recovery of the resprouting species (i.e. *P. tridentatum* and *U. gallii*), as also observed after an experimental fire in this area (Fernández & Vega, 2014) and supports previous research that demonstrated the high resprouting capacity of those species after perturbations (Reyes *et al.*, 2009; Muñoz *et al.*, 2012b) along with a possible increase in heat-stimulated seed germination (Rivas *et al.*, 2006).

The lower *E. umbellata* cover in the areas treated by clearing and mechanical shredding compared with prescribed burning and control may be related to higher soil burn severity, as dead woody material may accumulate after mechanical treatments, but not after prescribed burning treatment (Fernández *et al.*, 2013a). Fuel reduction may have favoured a higher heat penetration in the soil, thus promoting a reduction in the soil seed bank (Schimmel & Granstrom, 1996). Nonetheless, *E. umbellata* cover recovery was faster than observed by Fernández & Vega (2014) in a previous study after fuel treatments and a low severity experimental fire (4 %, on average 3 years after the experimental fire). The rapid recovery also contrasts with previously observed low rates of germination of this species after fire (Reyes & Casal, 2008), probably of lower severity of that of this study.

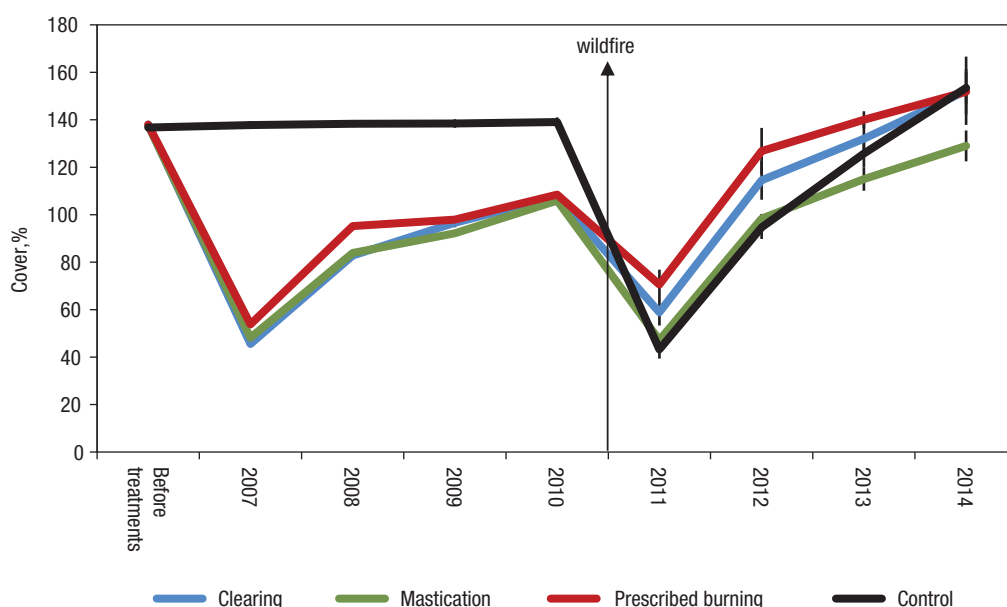


Figure 1. Mean percentage of ground covered by vegetation throughout the study period. Vertical bars represent the standard error.

The greater presence of *H. lasianthum*, a minor species in the community, in the treated than in control plots after the wildfire may be due to stimulation of germination by heat (Fernández *et al.*, 2013b). The observed increase in grass cover is consistent with previously observed increases in the abundance of herbaceous graminoids and non-graminoids with the frequency of perturbation (Vilà-Cabrera *et al.*, 2008).

As observed in other heathlands in the region, some kind of management is necessary to preserve those eco-

systems (Muñoz *et al.*, 2012 a and b, 2014). In the community under study, dominated by an obligate-seeder species, it seems that a severe fire that substantially reduces the soil organic layer can be necessary for a successful regeneration. A similar response was documented in some South-African fynbos species (van Wilgen, 2013). Consequently, mechanical treatments seemed to be less appropriated for the management of these communities. This result could be extended to other similar systems although more research is necessary to confirm this.

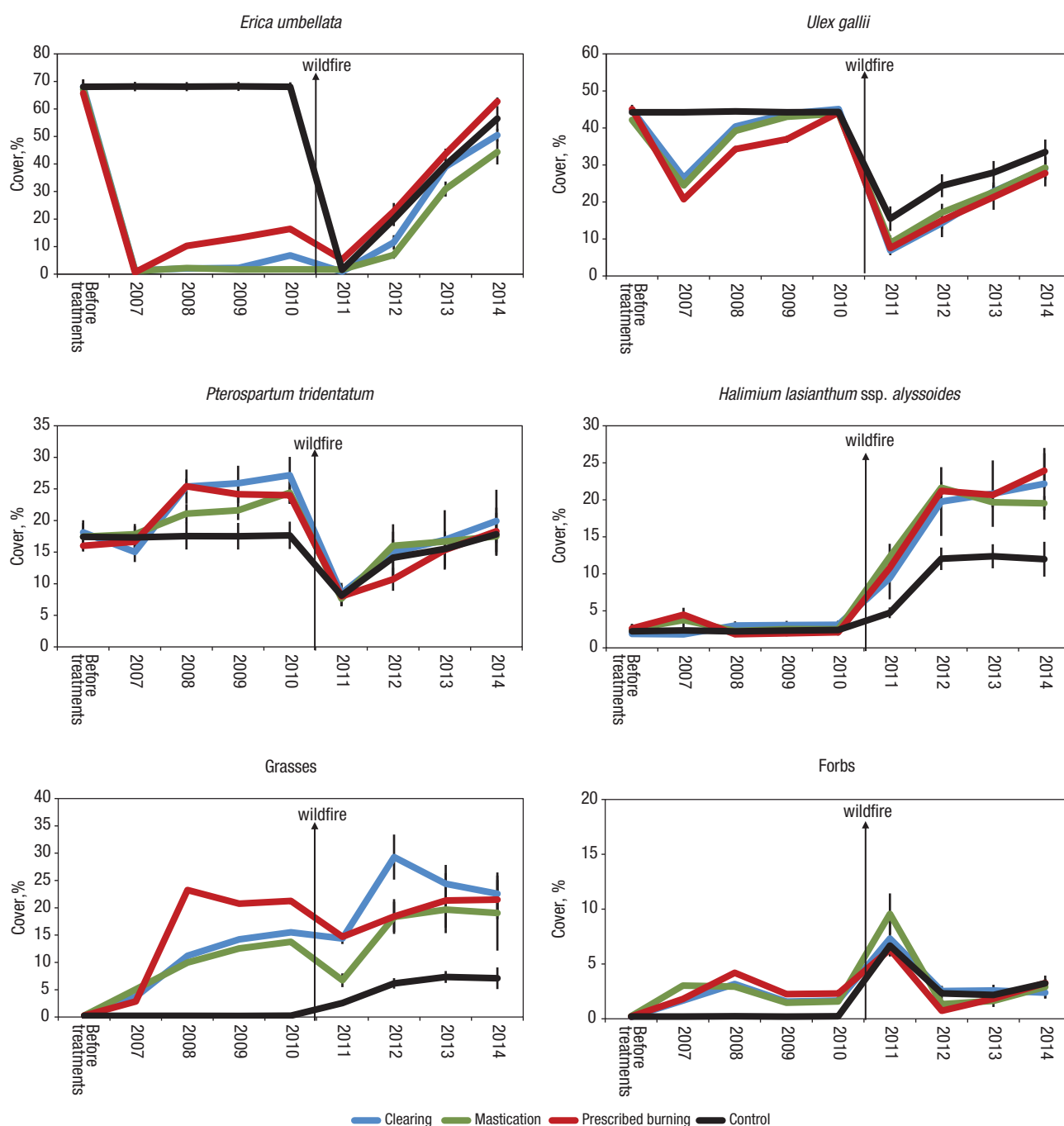


Figure 2. Mean percentage of ground covered by the main plant species or group of species throughout the study period. Vertical bars represent the standard error.

Fuel treatments, particularly prescribed burning, were favourable for the *E. umbellata* regeneration, in the community under study that was senescent at the beginning of the study. Similarly, prescribed fire is used for *Calluna vulgaris* heathlands preservation (Davies *et al.*, 2008).

Conclusions

From a management point of view, the fuel treatments considered did not have different effects on the recovery of heathland burned by a backfire. Shrub cover recovered quickly after fire in both in the treated and untreated areas.

Prescribed burning seems to be the most favourable treatment for enhancing regeneration of *E. umbellata* although other possible consequences of this treatment must also be considered (e.g. increased erosion risk and nutrient losses).

Acknowledgements

We thank Antonio Arellano for valuable field assistance at all stages of the experimental work. We also thank all those who helped with fieldwork, particularly José Ramón González, Jesús Pardo, José Gómez and Alba Martínez.

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