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Efficacy of bark strands and straw mulching after wildfire in NW Spain: Effects on erosion control and vegetation recovery

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ABSTRACT

Slope stabilization treatments like mulching are frequently used to reduce runoff and erosion following high severity wildfires, but they may also affect native vegetation recovery or facilitate exotic species invasion. However, the effectiveness of many treatment options has not been well established, in particular, the use of wood-based mulches.

In this study we assessed the efficacy of different methods of reducing soil erosion and the effects on vegetation recovery after a severe wildfire in Galicia (NW Spain). We compared the following treatments: straw mulch (2.0 Mg ha^{-1}), bark strands mulch (3.5 Mg ha^{-1}) and control (untreated). The straw mulch provided an initial ground cover of 70% and the bark strands mulch, 57%.

During the first year after wildfire the mean sediment yield in the control plots was 5.4 Mg ha^{-1}. In this period, the mean sediment yields in the treated plots were significantly lower than in the control plots (0.7 Mg ha^{-1} in the bark strands mulched plots and 0.5 Mg ha^{-1} in the straw-mulched plots). The bark strands mulch decayed very rapidly, so that six months after its application the mean cover had decreased to about 27%. Straw mulch persisted longer, and the mean cover was more than 40% at the end of the first year after fire.

Soil erosion decreased sharply during the second year after wildfire with low and similar erosion yields in all cases.

Straw mulching favoured vegetation cover recovery. Mulching did not have a significant effect on seedling emergence. Vegetation regrowth was very rapid and the total vegetation cover was about 70% at the end of the study.

Mulching did not affect species composition, and there was also no evidence of the presence of any exotic species.

The results indicate the feasibility of mulching with straw to reduce soil erosion after fire. The efficacy of bark strands mulch in controlling soil erosion losses during the first year after fire was probably due to the fact that most rainfall occurred when the cover provided by the mulch was maximal (i.e. before it decayed). This may indicate a limitation for soil protection the first year after fire when the erosion risk is highest.

1. Introduction

Soil erosion rates usually increase after wildfire because vegetation cover and ground cover are reduced or eliminated, thus exposing the mineral soil to raindrop impact and reducing its infiltration capacity, enhancing soil water repellency and also altering other soil physical properties (De Bano et al., 1998; Benavides-Solorio and MacDonald, 2001; Keizer et al., 2008; Ubeda and Outeiro, 2009).

The application of emergency post-fire rehabilitation treatments such as mulching and seeding are often recommended in severely burned areas to minimize overland flow and erosion risk (Napper, 2006; Robichaud et al., 2010). Mulching protects the soil directly by providing cover that reduces raindrop impact, prevents soil sealing, promotes infiltration and slows runoff. The most popular material for mulching is agricultural straw, which has been shown to be effective in reducing soil erosion after fire (Bautista et al., 1996; Wagenbrenner et al., 2006; Groen and Woods, 2008; Fernández et al., 2011; Díaz-Raviña et al., 2012; Robichaud et al., 2013). However, straw mulch is easily transported by wind, leaving slopes exposed in some areas (Robichaud et al., 2010).

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Mulches made from forest residues are potential alternatives to agricultural straw. These wood-based materials are more expensive to produce and apply, but are less likely to be blown away by the wind and also persist longer than straw mulch (Foltz, 2012). Wood-based mulches have been shown to be effective for erosion and runoff mitigation in laboratory studies (Foltz and Dooley, 2003; Yanosek et al., 2006; Foltz and Copeland, 2009). However, the results of field studies are inconclusive, and wood-based mulches have been reported to be effective (Foltz, 2012; Prats et al., 2012; Robichaud et al., 2013) and ineffective (Fernández et al., 2011) for erosion control, depending on the type of material (particularly particle size) and application rate, amongst other factors.

Information about how mulching affects vegetation recovery and community composition is scarce and is mainly derived from studies carried out in the United States in relation to straw mulching. The results obtained to date are inconclusive: some studies suggest that mulching, particularly in deep piles of mulch, inhibits plant growth (Beyers, 2004; Kruse et al., 2004; Dodson and Peterson, 2010), while others suggest that mulch can also promote vegetation establishment and growth by retaining soil moisture, particularly in dry sites (Bautista et al., 1996, 2009; Badía and Marti, 2000; Peterson et al., 2009). Information about the effectiveness of forest residues and their possible effect on vegetation recovery is particularly scarce. For example, Fernández et al. (2011), Foltz (2012) and Robichaud et al. (2013) did not find any effect on post-fire plant cover recovery after mulching with wood chips or wood strands.

Wildfires have a particularly strong impact on the establishment of exotic species (Hunter et al., 2006) and the use of agricultural mulching can also facilitate exotic plant introduction or the establishment of locally present non-native species (Kruse et al., 2004). On the other hand, wood chips that commonly provide a thick mulch cover may increase the risk of inhibiting seed germination, slowing post-fire vegetation recovery (Beyers et al., 2006). However, ecological effects of these alternative wood mulches remain to be studied (Foltz, 2012) and the present study is the first attempt to evaluate the recovery of plant communities following the simultaneous application of straw and wood-based mulches.

In the period 2001–2010, about 8000 fires occurred per year in Galicia, representing 46% of wildfires in Spain (MMA, 2010). Wildfire frequency and the size of burned areas are expected to increase under the probable future climate scenarios in NW Spain (Vega et al., 2009). Planning for post-wildfire soil stabilization is critical because of the large number of fires that occur annually, the high potential of rainfall erosivity (MMA, 2005) and the large population living in the urban-wildland area in this region. Soil stabilization treatments are expensive, and it is therefore important to assess their effectiveness by considering both erosion control efficacy and potential ecological effects. In the present study, we evaluate the effects of straw and bark strands mulching in the first two years after fire in a severely burned shrubland area in Galicia. We addressed the following points:

(a) Whether the mulching treatments were effective in reducing soil erosion relative to an untreated control.
(b) How mulch cover affected native vegetation cover recovery.
(c) Whether treatments affected the plant community composition and particularly if they enhance the presence of exotic species.

Secondary objectives were to classify soil burn severity in the experimental area and to study the persistence of two different mulch materials.

2. Materials and methods

2.1. Study site

The study was carried out on the Fial das Corzas hillslopes (42°11′49.70″ N–7°22′51.34″ W; 1550 m a.s.l.) in the *Macizo Central* (Ourense, NW Spain). A recently burned shrubland area on a relatively homogeneous slope of 60% was selected for study in the summer of 2010.

The shrubland was a heathland dominated by *Erica australis* L. and *Pterospartum tridentatum* (L.) Willk, *Halimium lasianthum* ssp. *alyssoides* (Lam.) Greuter was also present. The climate in the area is Mediterranean with a continental influence. The average rainfall is about 1100 mm year^{-1}, with a three-month dry period in summer and the mean annual temperature is 9 °C. The soil, developed on schist, was classified as Alumi-umbric Regosol (FAO, 1998), and the mean soil depth is 0.33 m.

2.2. Experimental design

Immediately after the wildfire, twelve experimental plots (50 m × 10 m each) were established with their longest dimension along the maximum slope. Soil burn severity was assessed by use of a 20 cm × 20 cm quadrat at thirty systematically selected points along two transects parallel to the plot longest dimension in each plot. Each quadrat was classified by the soil severity index proposed by Vega et al. (2013): (1) Burnt litter (Oi) but limited duff (Oe + Oa) consumption. (2) Oa layer totally charred and covering mineral soil, possibly some ash. (3) Forest floor (Oi + Oe + Oa layers) completely consumed (bare soil) but soil organic matter not consumed and surface soil intact. (4) Forest floor completely consumed and soil organic matter in Ah horizon also consumed, a thick layer of ash deposited and soil structure altered. (5) As 3 and colour altered (reddish). The percentage of stoniness was also visually estimated in each quadrat.

The plots were delimited by a geotextile fabric fixed to posts. Uphill borders of the plots were trenched to avoid external inputs from runoff or erosion. Sediment fences, made from a geotextile fabric similar to that described by Robichaud and Brown (2002), were located in the downhill portion of the plots and were used for periodic collection of sediments. Three different treatments were assigned at random: straw mulch, bark strands mulch, and control (untreated burned soils). The bark strands are a by-product of eucalyptus (*Eucalyptus globulus* Labill.) processing from a paper mill placed in the region. Four replicates of each treatment were established. Wheat straw and bark strands were spread manually at a rate of 2.0 Mg ha^{-1} and 3.5 Mg ha^{-1}, respectively.

Eroded soil was collected between October 2010 and October 2012 in function of rainfall events. Samples of eroded soil were oven dried (105 °C) for 24 h to determine dry sediment mass.

Rainfall amount and intensity were measured by two recording raingauges positioned adjacent to the experimental site, at 1.20 m above ground level. Total precipitation, maximum rainfall intensity in 10 (I10) and 30 min (I30), and the rainfall erosivity factor (Wischmeier and Smith, 1978) were determined.

Twenty 1 m × 1 m quadrats were placed at random in each plot. In each quadrat, all plant species were identified, and the number of individuals or sprouts from each species was counted. Exotic species were defined according to Castroviejo (1986–2012) and Sanz et al. (2004). Vegetation cover and mulch cover were also measured and the height of the dominant shrub species was recorded. Sampling was repeated every four months between October 2010 and October 2012.