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Effectiveness of three post-fire treatments at reducing soil erosion in Galicia (NW Spain)

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Abstract. This study assessed the effectiveness of different methods of reducing soil erosion after a severe wildfire in Galicia (NW Spain). The treatments compared were: straw mulch (2.5 Mg ha^{-1}), wood-chip mulch (4 Mg ha^{-1}), cut-shrub barriers and control. Straw mulch provided an initial ground cover of 80% and the wood chips only 45%. Sediment yields were measured by means of sediment fences in 500-m^2 bordered plots. During the first year after wildfire, mean precipitation was 1520 mm. The mean sediment yield in the control plots was 35 Mg ha^{-1}. During this period, only straw mulch application significantly reduced soil erosion relative to controls (66%). The mean sediment yields in the wood-chip mulch and erosion barrier treatments, 33 and 30 Mg ha^{-1} respectively, were similar to rates in the untreated plots (35 Mg ha^{-1}). Soil erosion decreased sharply during the second year after wildfire when mean precipitation was 1194 mm. Vegetation regrowth was very fast and treatments had no significant effect on the rate of recovery of vegetation cover, which was ~80% at the end of the study. The results obtained showed that ground cover was a key factor in determining post-fire soil loss. Stabilisation treatments such as wood-chip mulch and erosion barriers were not effective in reducing soil loss relative to the untreated control.

Additional keywords: erosion barriers, mulching, sediment yield, stabilisation treatments, wildfire.

Introduction

Soil erosion rates usually increase after wildfire (e.g. Robichaud and Brown 2000; Johansen *et al.* 2001; Martin and Moody 2001; Meyer *et al.* 2001; Benavides-Solorio and MacDonald 2005) owing to the reduction or elimination of vegetation cover and ground cover, which expose the mineral soil to raindrop impact and reduce its infiltration capacity (De Bano *et al.* 1998; Neary *et al.* 2005; Cerdá and Robichaud 2009; Larsen *et al.* 2009). Fire can also alter the soil structure, by affecting bulk density and total porosity, thus reducing infiltration and promoting overland flow (De Bano *et al.* 1998; Neary *et al.* 2005). Fire-induced hydrophobicity (De Bano 1981; De Bano *et al.* 1998; Robichaud 2000; Huffman *et al.* 2001; Keizer *et al.* 2008) can also increase soil losses. Soil shear strength has been related to rill formation risk in disturbed areas (Foster *et al.* 1977; Foster 1982; Toy *et al.* 2002) and also related to increases in soil erosion after wildfire and salvage logging (Fernández *et al.* 2007).

The application of emergency post-fire rehabilitation treatments is generally proposed in severely burned areas (Napper 2006). Hillslope treatments are considered the most beneficial because they are expected to avoid sediment delivery to downstream water bodies (Robichaud 2009). However, rigorous studies determining the efficacy of such treatments are scarce (Robichaud *et al.* 2000).

Straw mulch is applied to immediately increase ground cover and, hence, reduce soil losses after fire (Bautista *et al.* 2009). Reductions between 87 and 95% have been measured in different studies (Bautista *et al.* 1996; Wagenbrenner *et al.* 2006; Groen and Woods 2008) following straw mulch application rates of 2.0–2.4 Mg ha^{-1}.

Erosion barriers are designed to decrease runoff erosive energy, increase infiltration and reduce sedimentation (Robichaud *et al.* 2000; Robichaud 2009). However, the effectiveness of this treatment is highly dependent on the installation quality and decreases with time as the barriers become filled (Robichaud 2009), and their effect on post-fire sediment yields is uncertain (Wagenbrenner *et al.* 2006; Robichaud *et al.* 2008*a*, 2008*b*).

Over the last 11 years, there have been ~9000 fires per year in Galicia. This region represents less than 6% of the Spanish territory, but it suffers 47% of forest fires in Spain (Ministerio Medio Ambiente 2006). Increases in wildfire frequency and burned area are commonly expected under the probable future climate scenarios in NW Spain (Vega *et al.* 2009). However, in this region, advanced planning for post-wildfire rehabilitation is a relatively new concept (Vega 2007), despite the number of fires that occur annually, the high potential of rainfall erosivity (ICONA 1988) and the large population in the urban–wildland area.

Although post-fire soil erosion rates have been assessed in different situations in Galicia, NW Spain (e.g. Díaz-Fierros *et al.* 1982, 1987, 1990; Vega *et al.* 1982, 2005; Vega and Díaz-Fierros 1987; Benito *et al.* 1991; Soto *et al.* 1994; Fernández *et al.* 2006, 2007, 2008), studies of the effectiveness of post-fire rehabilitation treatments are very scarce (Pinaya *et al.* 2000). Cost-effective approaches to mitigate the effects of fire are

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