CSIRO PUBLISHING

International Journal of Wildland Fire **2013**, *22*, 696–706
http://dx.doi.org/10.1071/WF12079

Reduction of nutrient losses with eroded sediments by post-fire soil stabilisation techniques

M. X. Gómez-Rey[A,C], *A. Couto-Vázquez*[A], *S. García-Marco*[A], *J. A. Vega*[B] *and S. J. González-Prieto*[A]

[A]Instituto de Investigaciones Agrobiológicas de Galicia (CSIC), Apartado 122, E-15780 Santiago de Compostela, Spain.
[B]Centro de Investigación Forestal de Lourizán, Consellería de Medio Rural e do Mar, Apartado 127, E-36080 Pontevedra, Spain.
[C]Corresponding author. Email: mxgomez@iiag.csic.es

Abstract. After an experimental fire in steep shrubland in a temperate–humid region (north-west Spain), the effects of two post-fire stabilisation treatments (grass seeding and straw mulching) on the chemical properties of eroded sediments, and the amount of nutrients lost with them, were evaluated relative to control burnt soil, over a period of 13 months. Total C and N concentrations, and $\delta^{13}C$, indicated that sediments were mainly contributed by charred plant and litter material. The highest concentrations of extractable base cations in the sediments occurred during the first 3 months following fire, especially for Na and K. As treatments had little or no effect on nutrient concentration in sediments, differences in nutrient losses were due to the 10-fold lower sediment production in mulching compared with other treatments. In control and seeding treatments, the accumulated amounts of nutrients lost with sediments were 989–1028 kg ha^{-1} (C), 77 kg ha^{-1} (N), 1.9–2.4 kg ha^{-1} (Ca), 0.9–1.1 kg ha^{-1} (Mg), 0.48–0.55 kg ha^{-1} (NH_4^+–N), 0.39–0.56 kg ha^{-1} (K), 0.19–0.34 kg ha^{-1} (Na) and $<$0.1 kg ha^{-1} (P and NO_3^-–N). These values accounted for 22–25% (total C and N) and 5–12% (NH_4^+–N, Ca, P and Mg) of available nutrients in ash, and 1.0–2.4% of those in ash+topsoil. As nutrient and sediment losses were strongly correlated, the reduction of the latter by mulching application leads to an effective decrease of post-fire nutrient losses.

Additional keywords: burnt area emergency response, $\delta^{13}C$, $\delta^{15}N$, experimental fire, mulching, seeding, shrubland.

Received 21 May 2012, accepted 13 November 2012, published online 15 February 2013

Introduction

Wildfires destroy the vegetation cover and can greatly accelerate the processes of soil degradation (physical, chemical and biological) and nutrient losses through volatilisation, leaching and erosion (Certini 2005). Soil erosion rates typically increase after a wildfire due to reduced ground cover (Diaz-Fierros *et al.* 1987; Robichaud and Brown 1999) and changes in soil physical characteristics (Martin and Moody 2001; Cerdà and Lasanta 2005). After fire, the highly available nutrients accumulated in the ash and the upper soil layer are vulnerable to losses by leaching, wind and runoff (DeBano *et al.* 1998). Despite universal recognition of erosion as a prevalent post-fire process, most studies have focussed on nutrient losses in solution, with less emphasis on the importance of nutrients attached to sediments and, therefore, little is known concerning nutrient losses associated with the eroded material (de Koff *et al.* 2006). Shortly after a fire, compared with soil surface, debris leaving a burnt area is enriched in organic matter, P, mineral N and exchangeable cations (Carreira and Niell 1995; Andreu *et al.* 1996; Thomas *et al.* 1999) and, consequently, nutrient losses with sediments can substantially exceed those lost in solution (Debano and Conrad 1978; Gimeno-Garcia *et al.* 2000; Smith *et al.* 2011). The increase in nutrients in eroded sediments has been related to fire intensity (Andreu *et al.* 1996; Gimeno-Garcia *et al.* 2000), but it was also observed after low intensity prescribed fires (de Koff *et al.* 2006).

Although post-fire erosion effects on downstream water quality and sedimentation (Smith *et al.* 2011) are recognised, several authors consider that nutrient losses in eroded sediments are unlikely to affect long-term site productivity (Helvey *et al.* 1985; Emmerich 1999; Robichaud *et al.* 2006) taking into account the small amounts of nutrients in sediments compared with those lost from burning, or accumulated in soils and the post-fire ash-layer (Grier 1975; Feller 1988; Means *et al.* 1992; Busse 1994; Baird *et al.* 1999). By contrast, other authors consider that soil quality might well be seriously affected through preferential loss of fines and organic matter, both of which contain more nutrients than does the remainder of the soil (Thomas *et al.* 1999; Shakesby *et al.* 2002). Moreover, the fate of eroded C (e.g. sequestration or oxidation) could affect the global C budget, and N and P delivery to waterbodies can lead to eutrophication (Gabet *et al.* 2005).

Post-fire erosion rates are highly variable (reported values range from 1 to 240 Mg ha^{-1}; Robichaud *et al.* 2006; Moody and

