From Forest Nursery Notes, Winter 2009

86. © Effectiveness of aerial seeding and straw mulch for reducing post-wildfire erosion, north-western Montana, USA. Groen, A. H. and Woods, S. W. International Journal of Wildland Fire 17:559-571. 2008.

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International Journal of Wildland Fire **2008**, *17*, 559–571

Effectiveness of aerial seeding and straw mulch for reducing post-wildfire erosion, north-western Montana, USA

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Abstract. Various methods are available to reduce post-wildfire erosion, but there is limited quantitative information on the relative effectiveness of these techniques. We used rainfall simulations to compare the erosion and runoff rates from adjacent 0.5-m^2 plots treated with aerial grass seeding and straw mulch with untreated control plots following the July 2002 Fox Creek Fire in north-west Montana. In the first summer after the fire, plots seeded at a rate of 9 kg ha^{-1} had a mean of less than 5% ground cover and the seeding treatment had no effect on the rainsplash erosion rate. In contrast, straw mulch application at a rate of 2.24 Mg ha^{-1} resulted in ~100% ground cover and an 87% reduction in rainsplash erosion relative to the control ($P = 0.001$). Measurements on a subset of the plots in the second summer after the fire indicated that ground cover in the treatments and the control averaged 39%, and neither treatment provided a significant increase in ground cover or reduction in erosion relative to the control. These results add to the growing weight of evidence that straw mulch application is highly effective in reducing erosion in the first year after fire, whereas grass seeding is often ineffective because of the limited increase in ground cover that it produces.

Additional keywords: burned area emergency response, erosion control, grass seeding, overland flow, post-fire rehabilitation, restoration, runoff.

Introduction

Soil erosion rates in undisturbed forested watersheds are typically very low (Biswell and Schultz 1965; DeByle and Packer 1972). However, increases in erosion of two or more orders of magnitude have been observed after forest fires due to the reduced ground cover, increased sediment availability, and changes in the soil physical characteristics that reduce the infiltration rate and increase the frequency and magnitude of Hortonian overland flow events (Helvey 1980; Morris and Moses 1987; Robichaud and Brown 1999; Benavides-Solorio and MacDonald 2001, 2005; Moody and Martin 2001; Shakesby and Doerr 2006; Spigel and Robichaud 2007). Increases in erosion after fire are a concern owing to the potential for loss of life and property associated with debris flows and other catastrophic erosion events (Helvey 1980; Moody and Martin 2001; Neary *et al.* 2005), and the impacts of increased sedimentation on downstream water quality, aquatic habitat and reservoir storage (Ewing 1996; Gresswell 1999; Moody and Martin 2001; Kershner *et al.* 2003; Legleiter *et al.* 2003; Libohova 2004). Various erosion control techniques are used to reduce the impact of post-fire erosion, including hillslope treatments such as grass seed, straw mulch, contour logs and straw wattles, in-stream treatments such as straw bales and log check dams and road rehabilitation treatments such as upgrading of culverts and ditches. Hillslope treatments are considered the most beneficial because they are expected to control erosion nearer to the point of origin, thus reducing the probability that eroded soil will reach downstream water bodies. A majority of fire managers consider hillslope treatments such as grass seeding and mulching to be effective in achieving the goal of reducing post-fire erosion. However, there is limited quantitative information on the effectiveness of even the most commonly used post-fire erosion control treatments (Robichaud *et al.* 2000; US General Accounting Office 2003).

Aerial grass seeding is widely used as a post-fire hillslope erosion control treatment owing to its relatively low cost and ease of application (Beyers 2004). The effectiveness of aerial grass seeding is dependent on the additional ground cover that it produces, which depends primarily on the seed density (Krammes and Hill 1963; Keeley 2004) and the amount and timing of rainfall in the period following seed application (Amaranthus 1989; Robichaud *et al.* 2006; Wagenbrenner *et al.* 2006). Lower ground cover values tend to occur when seed is applied in arid areas, or when application is followed either by drier than normal conditions that limit germination or by high-intensity rainfall that washes the seed off the hillslope (Robichaud *et al.* 2000). A low germination rate in winter wheat seed applied following the North 25 Fire in north-central Washington was apparently caused by below-average precipitation in the spring after seeding (Robichaud *et al.* 2006). An intense summer thunderstorm washed aerially applied seed from hillslopes in the area burned by the 2000 Bobcat Fire, resulting in significantly lower seed densities compared with areas that were seeded after the storm (Wagenbrenner *et al.* 2006). Despite their widespread use, there is evidence that many post-fire grass seeding treatments are ineffective because they fail to produce enough ground cover to affect the erosion rate, particularly in the first year after fire when burned hillslopes are most vulnerable. Only one of eight post-fire

10.1071/WF07062 1049-8001/08/050559