



Soil erosion after forest fires: evaluation of mitigation measures applied to drainage channels in the northwest of Portugal

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Abstract

The development and implementation of measures which promote the reduction of the impacts of forest fires on soils is imperative and should be part of any strategy for forest and soil preservation and recovery, especially considering the actual scenario of continuous growth in the number of fires and burnt area. Consequently, with the dendrocaustologic reality that has characterized the Portuguese mainland in recent decades, a research project promoted by the Center for the Study of Geography and Spatial Planning (CEGOT) was implemented with the objective of applying several erosion mitigation measures in a burned area of the Peneda-Geres National Park in NW Portugal. This paper therefore seeks to present the measures applied in the study area within the project Soil Protec, relating to triggered channel processes and the results of preliminary observations concerning the evaluation of the effectiveness of erosion mitigation measures implemented, as well as their cost/benefit ratio.

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1 INTRODUCTION

The intervention in forest recovery after wildfires has been implemented for a long time, especially in Mediterranean climate areas, where fire has been a natural and fundamental factor influencing landscape evolution through time (Naveh, 1975; Pausas et al., 2008; Pausas e Keeley, 2009; Pyne, 1982). There is a diverse set of intervention measures implemented after the fires that are generally grouped into three categories (US General Accounting Office, 2006; Robichaud, 2009), distinct from

each other both in terms of implementation strategies as well as in terms of implementation deadlines. The generalization of these techniques in the past decades has, however, revealed a great variability in the effectiveness of each measure. In fact, in recent years, the evaluation of the effectiveness of the different measures of soil protection has occupied researchers, who are trying to solve some unanswered questions (Fontúrbel et al., 2010; Robichaud et al., 2000; Robichaud, 2005; Robichaud et al., 2005; Wagenbrenner et al., 2006). Although the implementation of early post-fire mitigation management

promotes, undoubtedly, protection against soil erosion and helps recover vegetation, in some areas it is preferable not to apply any treatment whatsoever in the burned areas (Bautista et al., 2009; Robichaud, 2009). Moreover, their effectiveness should be further evaluated, as well as their short and long term impacts, on soil, water and plants (Bento-Gonçalves et al., 2012; Kruse et al., 2004; Robichaud, 2009; Neary, 2009).

2 METHODS

2.1 STUDY AREA

Following the two fires that broke out on 8 and 10 August 2010, in the municipality of Terras do Bouro (Figure 1), in the heart of the Peneda-Geres National Park (NW Portugal), a continuous burnt area of 1466 ha, subject to different fire intensities and severity, was registered. It is a large area, occupied by scrublands and stands of *Pinus pinaster*. The lithology is mainly granite, and the soils (cambisols) are generally thin and stony. The land cover in the last 50 years has been essentially composed of woodlands, favored by the climate which is characterized by high amounts of precipitation.

2.2 OBJECTIVES AND METHODOLOGY

Most soil protection measures after fires are relatively expensive and difficult to apply. Accordingly, the project Soil Protec (emergency measures for the protection of soils after wildfires) aims to test low-cost solutions to reduce soil erosion immediately after forest fires of low / medium level severity in stands of *Pinus pinaster* in Northwest Portugal (Bento-Gonçalves et al., 2011, Vieira et al., 2012). In the context of this study, our aim is to test a set of measures in channels where there is a concentration of runoff in order to reduce the gully processes and the removal and transport of soil by implementing structures, materials, and techniques which favor the retention of sediments and the possible consolidation of ridges and pre-existing gullies. The measures will be assessed in terms of their effectiveness in mitigating erosion (especially throughout time), as well as their cost / benefit. In pursuing these objectives, we proceeded to identify a suitable area (*Pinus pinaster* area where the fire reached a medium level of severity), in which critical points were defined and where structural measures in channels were established with the objective of promoting the mitigation of erosion. It is noted that this area was also selected because there was a significant post-fire disturbance,

triggered by the logging of burnt wood using heavy machinery. The measures selected for this purpose were applied specifically in the channels corresponding to the drainage lines (ephemeral or low order), and aimed at changing the flow of water and sediments in order to decrease the amount of soil swept into the watercourses downstream and the subsequent destruction of infrastructure or human cultures. The implemented techniques were log check dams, straw bale barriers, and pine needle remains and pine rot barriers (Vieira et al., 2012). The first (log check dams) forced the use of mechanical means for its implementation (chainsaws and tractors), constituting a more demanding technique in terms of costs. Its implementation is also more labor-intensive. The areas intervened were monitored using GPS and Total Station.

3 RESULTS AND DISCUSSION

The rainfall after the installation of the measures produced a significant erosive action on the slopes of the drainage basin intervened (the average annual rainfall in this region is about 2500mm), leading to an intense evacuation of sediments towards the channels in which the water lines which have been intervened circulate. From the observed sediments accumulations, it was possible to confirm the efficiency of these techniques. The results also show that all the techniques have an important sediment retention capacity. The two installed log check dams, one worked effectively as a buffer for the water flow and allowed the accumulation of sediments upstream (Figure 1a). With regard to the straw bale barrier, its role in sediment retention was also very positive (Figure 1b). The effectiveness of this technique seems to be quite significant because has the advantage of allowing a suitable water flow which prevents ruptures in the structure resulting from large volumes of water. However, this type of structure is less robust than the log check dams and has a limited lifetime (probably no more than a year). The barriers composed of pine rot and pine needle remains obtained the most significant results. In fact, despite the simplicity and low level of development of this technique, its effectiveness in retaining the sediment is high. In all such barriers implemented sediment retention occurred in large amounts, taking into consideration the type of structure (Figure 1c).

4 CONCLUSIONS

In summary, the analysis of the results of the research

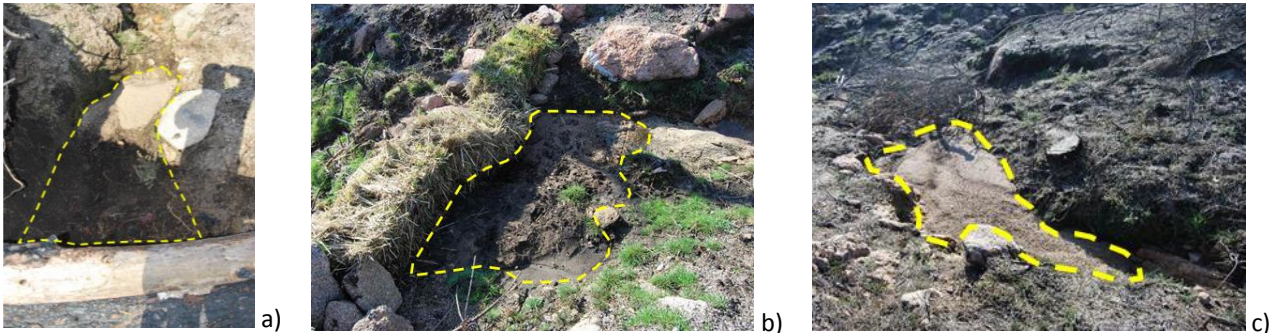


Figure 1. Photos illustrating the results of the various measures implemented: a) log check dams; b) straw bale barriers; c) pine needle remains and pine rot barriers.

allows us to conclude that the techniques applied have a significant degree of effectiveness in trapping sediments carried by drainage channels of the water overflow, contributing to the creation of sediment "pools" that could act as locations for the recovery of vegetation. Indeed, it is imperative to create conditions in these mountainous areas so that the little soil that there still remains is maintained, while simultaneously avoiding its transport and deposit in unwanted areas, namely downstream where the human settlements are located and where there is a dam and other human infrastructures. Moreover, these preliminary results already suggest some differentiation of techniques regarding the cost / benefit ratio. More precisely, the barriers made from the cut debris and pine rot and needles reveal satisfactory erosion mitigation capacity at relatively low costs.

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