We thank Professor Cerdà for his comments and suggestions. We are grateful for interesting suggestions allowing for manuscript improvement.

Professor Cerdà Comment

Dear author, I found your paper a good contribution to understand the post-fire soil erosion processes, and to contribution to a better understanding of the fire affected land.
Your paper show us that after forest fire there are some chances to control the soil losses. My comment focus on the idea that rehabilitation and restoration strategies are not always necessary. Most of our ecosystems are adapted to the fires and the recovery is done by nature. I expect that your paper will help policy makers to understand this. And also they must understand that some mitigation strategies can damage the natural recovery. We are plenty of examples in the Mediterranean for the last 60 years.
Also, I would like to suggest to make references to the long time measurements that help us to understand the effect of fires at long-time periods. This can be seen in our paper Cerda, A. & Doerr, S.H. (2005) Influence of vegetation recovery on soil hydrology and erodibility following fire: an eleven-year investigation. International Journal of Wildland Fire, 14(4), 423-437. This paper show that the recovery of the Mediterranean Lands can be done without any human interference. Another interesting question I wish to comment is the impact of ash on the immediately post-fire erosion as they can control and mitigate the soil losses. We found that ash (specially when covered with needles) can protect the soil, and this is a natural mitigation strategy that use to be avoided. Researches in this topic can be found in Cerdà, A. y Doerr, S.H. 2008. The effect of ash and needle cover on surface runoff and erosion in the immediate post-fire period. Catena, 74 , 256- 263. doi:10.1016/S0341-8162(02)00027-9. This means that immediately after fire the soil losses can be low as we measured in the field. And this is still not understood by the post-fire management strategies. Many thanks for showing the importance of fire and their effects on the Earth System Congratulations for your excellent contribution.

Authors:
The authors thank professor Cerdà for his suggestions that improve the manuscript. In the introduction a paragraph has been added discussing the post fire natural recovery in the Mediterranean areas.

1. Introduction
Forest fires in Mediterranean area are natural processes due to the mutual interactions between climate and vegetation, forging the biodiversity typical of this ecosystem (e.g.Ursino and Rulli, 2011; Pausas and Paula, 2012). During the last decades the number, extent and severity of forest fires in the Mediterranean countries increased as a result of abandonment of agricultural lands, inadequate forest management, long seasonal droughts, environmental disturbances, human activities (e.g. Soulis et al., 2010; Rulli et al., 2006; Shakesby, 2011) leading to the alteration of natural fire regime. Consequently, areas usually experiencing frequent low severity fires are now hit by less frequent high severity fires, and other areas, adapted to high severity fire, are now subjected to an increase in fire frequency (Fulé et al., 2008). As a result, the mediterranean ecosystem is reducing its resilience to fire. Appropriate mitigation strategies can reduce the negative consequences of fire through a deep comprehension of fire effects and sustainable coexistence with forest fires, in terms of both human security and ecological processes (Pausas and Verdù, 2008).
Fire effects consist on direct damage of vegetation and alteration of physical and chemical soil properties, which in turn affect the hydrological response and sediment erosion and transport (e.g. Moody et al., 2008; Andreu et al., 2001). In particular, both runoff and even more erosion in the first year after fire occurrence often increas by several times compared to natural conditions (Rulli and Rosso, 2005). Measurements taken in the Sila Massif in Calabria (Italy) showed an 87% increase in runoff on areas recently burned compared to non burned areas (Terranova et al., 2009), and rainfall simulations in Liguria (Italy) showed post-fire overland flow and sediment yield respectively one and two orders of magnitude higher in a recently burnt site than in a long unburned site (Rulli et al., 2006).
Although the association among wildfire, flooding, increase in erosion and sedimentation has been observed all over the world (e.g. Benavides-Solorio and Mac Donald, 2005; Cerdà, 1998;

Emmerich and Cox, 1994; Shakesby, 2011; Terranova et al. 2009), post wildfire research, especially regarding fire induced erosion enhancement, has a relatively brief history in the Mediterranean, starting from about the early 1980s (corresponding to the dramatic increase in fire activity) (Shakesby, 2011).

Burn severity has been identified as one of the most important variables affecting post fire changes in runoff response and soil losses (e.g. Fox et al., 2008). From low to high burn severity, the effect on erosion may vary from more than two orders of magnitude to only sevenfold, or no difference (Shakesby, 2011). Besides burn severity, many other factors concur in controlling post-fire runoff and erosion. Among these are loss of organic matter (e.g. Soto and Diaz-Ferros, 1998), increase of bulk density (Neary et al., 2005), reduction of soil porosity and infiltration capacity (Robichaud et al., 2010), increase of soil water repellency (e.g. De Bano, 2000; Doerr et al., 2009). Other important factors are rainfall intensity, slope and aspect, antecedent soil moisture (Wischmeyer and Smith, 1978), soil aggregate stability (Fox et al., 2008), grade of soil water repellency (Keizer et al., 2008), and the time interval between the fire episode and the occurrence of rainfall (Rulli et al., 2006). Univariate analysis conduced on sediment yields in Colorado Front Range burned hillslopes showed that about 77% of the variability in post fire erosion rates is explained by five main factors: fire severity, bare soil percent cover, rainfall erosivity, soil water repellency and texture. Among these, bare soil percentage and rainfall erosivity alone explained 66% of variability in soil loss measurements (Benavides-Solorio and Mac Donald, 2005).

Strategies for watershed post fire rehabilitation are mainly aimed to restore soil cover and infiltration capacity and to reduce sediment detachment and downslope sediment transport (e.g. Fernàndez et al., 2010; Myronidis et al.,2010; Neary et al., 2005; Robichaud et al. 2010; Wohlgemuth et al., 2009) therefore acting mostly on soil characteristics like soil vegetation cover, erodibility, permeability or infiltration capacity.

There are many different mitigation strategies, which are suitable for diverse situations, and whose results depend on when, how and where they are applied (Wohlgemuth et al., 2009). Most of ecosystems are adapted to the fires and the recovery is done by nature. Cerdà and Doerr (2005) show how the recovery of the Mediterranean lands can be done without any human interference, observing during their 11 years field campaigns a time of 2-4 years for the recovery. Moreover, on the immediately post-fire the presence of ash, especially when covered with needles, can control and mitigate the soil losses protecting the soil from rainfall erosivity (Cerdà and Doerr (2008). Nevertheless, the rainfall regime characterized by heavy intensity rainfall occurring right after the fires season in some of the Mediterranean areas (e.g. Liguria, Tuscany, Sicily, etc.), the high spatial and temporal variability of rainfall and its associate hydrogeomorphological response and the occurrence of the fires at the rural-urban interface can require prompt post fire erosion reduction treatments.

Post fire treatments may be applied to hillslopes, channels and roadways.

Treatments used on hillslopes can be divided in three main types: mulch treatments, erosion barriers and chemical treatments (Neary et al., 2005; Robichaud and Elliot, 2006). Hillslope treatments are designed to avoid sediment delivery to downstream water bodies and they are considered to be the most useful (Robichaud 2010). Wagenbrenner et al. (2006) observed ground cover greatly influencing sediment production, meaning that the better performing treatments will be those immediately increasing the amount of ground cover and facilitating vegetative regrowth. Among these, mulch treatment is considered as one of the most effective watershed rehabilitation treatment, consisting in spreading mulch on burned slopes, to provide soil surface cover prior of vegetation regrowth. It produces soil protection from rain splash detachment and soil stabilization (Robichaud, 2007b; Wohlgemuth et al., 2009). For this purpose, several materials can be used: dry straw or wood-based mulches, wet mulches (hydromulch) mixed with water to form a slurry (Neary et al., 2005). Post-fire mulching needs to provide 60-80% ground cover to reduce hillslope erosion (Robichaud et al., 2010). Some problems can arise by using this technique consisting in mulches

slopes slipping down, aerially spread mulches residual vegetation interception, so reducing the actual ground cover and potential effectiveness (Neary et al., 2005; Robichaud et al., 2010).
Erosion barriers are commonly placed in a way to capture sediments and interrupt long flow paths, so decreasing downslope shear stress soil erosion and sediment transport on hillslopes and into streams. Erosion barriers can be contour-felled logs, straw wattles, contour trenches, straw bales (Neary et al., 2005). A barrier treatment performance can be defined as the ratio of dry weight of sediment stored by the barrier and dry weight of collected sediment below the barrier. Erosion barriers present some weakness reducing runoff and soil loss for low intensity rain events, but do not achieve significant results for high intensity events. In addition, the capacity of barriers can be overtopped soon after the first rain events, so determining the uselessness of not cleaned off barriers (Robichaud et al., 2010).
Rehabilitation treatments like ploughing or tilling on croplands burned areas are usually used to decrease soil aggregation and to break up the fire-induced water repellent soil layer to restore drainage capacity (Keizer et al., 2008).

Channel rehabilitation after fire is primarily done by cleaning channel beds and preventing obstruction of streams. The main treatments for these purposes are check dams or debris basins, debris clearing and streambank armoring (Neary et al., 2005).
Even if fire does not directly affect the road drainage system, the increased overland flow can overwhelm its capacity. Mitigation measures as waterbars and bypasses, culvert improvements, ditch cleaning and armouring can enhance road drainage system functionality.
Despite the observation of large post fire increase in soil losses in the Mediterranean area (e.g. Shakesby, 2011 and the references herein) analysis of the efficiency of post-fire erosion mitigation strategies are very scarce. Field studies assessing the effectiveness of mulching and barriers were carried out in Spain (e.g. Badia and Martì, 2000; Bautista et al., 2009; Fernàndez et al., 2011) and in Portugal (Ferreira et al., 2009), but a systematic analysis at basin scale for the Mediterranean area is still lacking.
Given the complexity of fire-related issues, and the importance of fire effects on watershed response and erosion dynamics, accurate predictions of post-fire runoff and sediment yields are needed to guide management decisions, mitigate post-fire soil loss and land degradation and for post-fire rehabilitation planning (Fernàndez et al., 2010). Land use changes impact on soil losses prediction has been carried out by using different kind of modeling depending on study area extent, data availability and output degree of accuracy required. The Water Erosion Prediction Project (WEPP) model (Flanagan and Nearing, 1995) and the disturbed-WEPP (Elliot et al., 2001) are process-based erosion prediction models evaluating mean erosion rate in natural and disturbed condition. ERMiT (Robichaud *et al*., 2007a) is a probability-based erosion prediction model using multiple runs of WEPP model and developed to predict surface erosion from postfire hillslopes, and to evaluate the potential effectiveness of various erosion mitigation practices. Empirical models based on the Revised Universal Soil Loss Equation (RUSLE) were used by several authors (e.g. Terranova et al.2009, Fernández et al. 2010 and Ranzi et al., 2012) to account for forest fire and land use changes effect on erosion in large scale basins. A fully distributed hydro-geomorphological model was developed by Rulli and Rosso (2005; 2007) for analyzing both the hydrological and erosion and deposition process dynamics for both natural and disturbed basin condition, focusing in particular on post fire erosion process in Mediterranean ecosystem.

This paper investigates first year post fire erosion mitigation strategies effectiveness through a distributed model based on the Revised Universal Soil Loss Equation properly parameterized and validated, by using field measurements and literature data, for a Mediterranean basin located in Sardinia, Italy. Soil losses corresponding to six different scenarios are analyzed through appropriate RUSLE parameters changes so describing the particular soil treatment to which the study area is subjected. In detail, the amount and spatial distribution of soil losses under natural condition, burned, after tilling/ploughing treatment, after mulching treatment, with barriers and after a combination of the all treatments are examined.