A recent history of Mediterranean wildfires and its influence on soil erosion

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1. Abstract

Wildfires are one of the most threatening environmental hazards in Mediterranean areas, which -apart from the threat to human welfare and lives- produce a general deterioration of ecosystems affecting directly to landscapes patterns and structures, the hydrological cycle and the alteration of the soils erosivity.

In order to assess the impact of wildfires on soils, a spatio-temporal analysis of recent wildfires history, between 1993 and 2005, is undertaken using Geographical Information Systems techniques. Data used consisted on map inventories of burned areas for each year of the time series; a reference moment of land use-cover distribution (based on aerial photogram interpretation for the year 1991) and maps of actual and potential erosion (simulating an scenario of loss of vegetation cover) following USLE methodology.

Combination of different thematic layers have been undertaken in order to assess (1) the spatio-temporal dynamics of burned areas, (2) their comparison with the land cover map to estimate the type of cover that has been lost through time and (3) the calculation of soil erosion losses assuming the pre wildfire conditions and the potential scenario with cover losses.

The methodology has been applied to the Autonomous Region of Valencia (Spain), a territory of 2.3 M hectares. Results show that in the 13 year period almost 10% of the region has been burned, and that only less than 2% of the total area has experienced a second fire recurrence, being negligible the zones with a third fire burst. In terms of soil covers, most fires have occurred on natural areas (91%). Of those, 40% can be understood as natural climax autochthonous vegetation formations.

Soil erosion rates also show an important increase from the USLE estimation for land covers shown in the map of 1991 and those simulated after the wildfire history with no cover conditions. Although these should be taken as preliminary results, the dramatic increment of the erosion rates suggests the need of further detailed research taking into account the pre and post-fire scenarios.

2. Introduction

One of the most important perturbations on the Mediterranean forest ecosystems is fire, both by natural or anthropogenic causes. In the last two decades forest fires in European Mediterranean countries (Portugal, Spain, France, Italy and Greece) have increased in number and frequency (European Communities, 2002). This fact leads to decrease the necessary recovery time of the affected ecosystems.

Forest fires not only reduce plant cover, leaving soil surfaces unprotected against raindrop impact, but also have important consequences for soil hydrology and soil losses thorough erosion and subsequent soil degradation and accelerating the risk desertification. There are reports about the increase in runoff and consequent erosion (Rubio et al., 1997; Inbar et al., 1998; Moody and Martin, 2001), about decrease in the water infiltration capacity (Cerdá, 1998; Martin and Moody, 2001) and about increase in soil hydrophobicity (DeBano, 2000; Robichaud and Hungerford, 2000), which can affect several hydrologic processes like raindrop splash, rill formation and total watershed responses (DeBano, 2000).

In consequence, forest fires act as a triggering factor that initiate changes in Mediterranean ecosystems that finally affect the soil and water resources, as well as the composition, structure and patterns of vegetation that are critical to their overall functions and processes. After wildfire, the soil disturbance produced promotes the reduction of vegetation cover and the alteration of soil hydrology, intensifying the erosive processes and accelerating desertification. The consequential damage, which may result in high erosion rates after them, shows the need to asses the spatial and temporal dynamics of burned areas considering the changes on the vegetation cover.

The objective of this work is to develop a methodology to assess the spatial and temporal dimensions of wildfire targeting (1) the patterns and trends of wildfires, (2) the impact on vegetation cover types and (3) the impact on soils by means of erosion estimations.

The methodology has been applied to the Region of Valencia (Eastern Spain) with a surface of 2.3 M hectares. The region is a western Mediterranean space with a socio-economic history that it is well reflected in the actual land cover. The territory has experienced an increase of forest land due to the historic policy of reforestation and the colonisation of marginal rainfed agriculture lands with natural vegetation. Natural areas

expanded to 50% of the total land of the region, according to the information provided by CORINE LAND COVER inventory in 1991. On the contrary fire risk has been incremented while a new forest use culture is also developed. In some years, more than 80% of forest are due to human reasons (Suárez Torres, 2000).

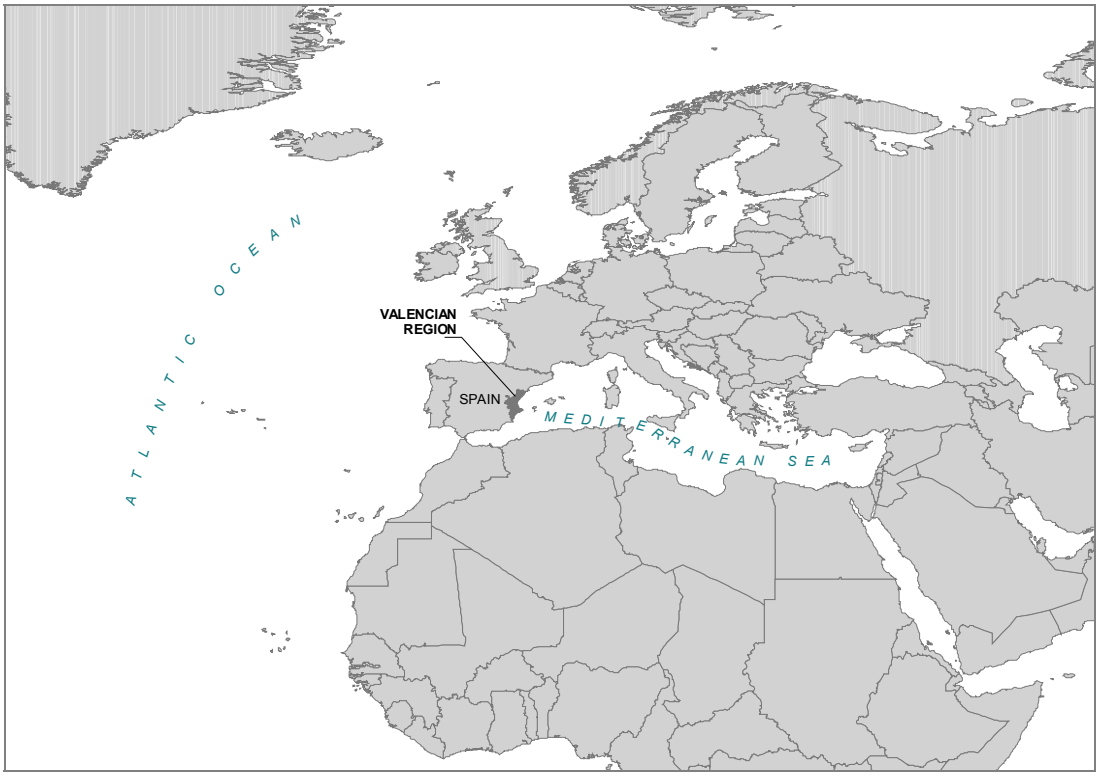

Figure 1 Location of the study area

3. Methods

To assess the impact of wildfires on soils, a spatio-temporal approach using Geographical Information Systems (GIS) (Burrough and McDonnell, 1998) have been developed. Data used consisted on existing vector thematic maps of three types: (1) a serie of digital documents with geometrical entities (polygons) representing the extension, year by year, of wildfires since 1993 to 2005, provided by regional authorities; (2) a digital environmental units map (Antolin, 1998) which contains, among other edaphic and topographic properties, information on erosion estimations according to USLE procedures, and (3) a non published land use-cover map with detailed information for the year 1991 on vegetation types, either agricultural or natural, also provided by regional authorities.

All thematic maps were further treated and incorporated into the same GIS environment to facilitate cartographic overlays and subsequent analysis. Finally, cartographic analysis has been obtained based on three premises: (1) the spatial and temporal incidence on the territory of forest fires in terms of total burnt area and recurrence; (2) the type of vegetation consumption differencing between agriculture and natural vegetation, and within this last category among plant composition, and (3)wildfire impact on the edaphic system, assuming further runoff and erosion modifications. In that last, the calculation of soil erosion losses assumes two scenarios: the pre-wildfire conditions represented by the vegetation cover in 1991 and the potential scenario without vegetation cover.

4. Results

The analysis of cumulative incidences during the 13 year period demonstrate the territorial importance of wildfires (Table 1). According to the results obtained, almost 10% of the region have been burned. In such a short term, the recurrence, presented here as the incidence on the same place of another fire, is not a relevant

feature of the fire occurrence because only less than 2 percent of the total area have experienced a second fire recurrence, being negligible zones with a third fire burst.

Table 1 Wildfire recurrence between 1993 and 2005

Fire Recurrence (1993-2005)	Hectares	% related to the total burnt area	% related to the region area
Land burnt three times	19.0	0.01	0.00
Land burnt twice	3754.8	1.70	0.16
Land burnt Once	217067.7	98.29	9.33
Total Burnt area	220841.5	100.0	9.49
Total Region area	2326192.0	------	100.00

Table 2 highlights the environmental importance of fire occurrence. In terms of soil covers, most fires have occurred on natural areas (91%). Of those, 40% can be understood as natural climax autochthonous vegetation formations. The affected artificial surfaces and agriculture land may be seen as extension of the wildfires from natural spaces to traditional settlement edges, isolated housing and marginal rainfed agriculture fields.

It we redefined the total territorial extension of fires with the information provided in table 2, and assuming that fires have only occurred in the natural lands (50% of the regions surface), we can then adjust the previous extent of burnt areas to the 9.49% of the total Regions area shown in Table 1. In fact the fire recurrence is confined to the natural o semi-natural vegetacion spaces and, in that case, we can also state that wildfires have covered almost 20% of the natural and semi-natural lands.

Table 2 Wildfire occurrence related to vegetation cover type

Type of land cover	Hectares	% out of the total burnt area	% out of Natural covers surface	
Artificial surfaces	717.9	0.33	----	
Agriculture Land	19845.5	8.99	----	
Natural covers	200278.1	90.69	----	
Tree covers	70913.2	32.11		35.41
Maquia and Matorral	125968.7	57.04		62.90
Others	3396.2	1.54		1.70
Total Burnt Area	220841.5	100.00		

Soil erosion rates also show an important increase from the USLE estimation for existing vegetation covers in the pre-fire scenario to the estimation calculated in the post-fire conditions without vegetation cover. Although differences can be observed in the lower classes with less erosion rates, the effect of fires are particularly incident in the upper range, with erosion rates above 40 Tm/ha/year.

Table 3 Actual an Potential erosion estimation considering pre and post-wildfire conditions

	ACTUAL EROSION		POTENTIAL EROSION	
Erosion class	**Hectares**	**% Out of the Total Burnt Area**	**Hectares**	**% Out of the Total Burnt Area**
1. 0-1 Tm/ha/year	1064.0	0.48	1064.0	0.48
2. 1-7 Tm/ha/year	5417.5	2.45	397.2	0.18
3. 7-15 Tm/ha/year	11277.6	5.11	3005.7	1.36
4. 15-40 Tm/ha/year	56972.8	25.80	3497.3	1.58
5. 40-100 Tm/ha/year	93911.2	42.52	10195.7	4.62
6. 100 Tm/ha/year	33311.8	15.08	183794.9	83.22
7. Bare rock with no soil	18886.6	8.55	18886.6	8.55
Total Burnt Area	220841.5			

The recent wildfire history of the Valencia Region put in evidence their importance in two ways, in the extension of the territorial occurrence in a shuch a short period of time and in their environmental consequences in both the loss of natural vegetation and in the increment of erosion and subsequent soil degradation.

Although these should be taken as preliminary results, the dramatic increment of the erosion rates suggest the need of further detailed research, taking into account the pre an post-fire scenarios.

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