Use of soil properties for assessing fire severity in fire prone ecosystems

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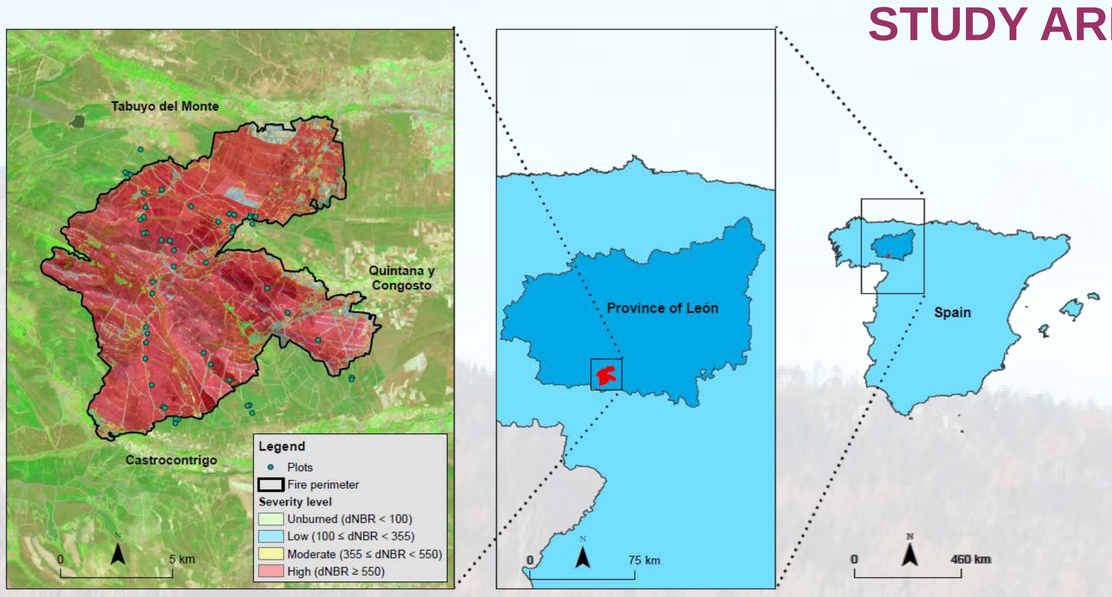
INTRODUCTION

Fire affects physical, chemical, and biological properties of soils depending on their severity. The post-fire recovery of the ecosystems also depends on fire severity. So, to design proper post-fire management strategies it is necessary to develop post-fire severity assessment tools for managers.

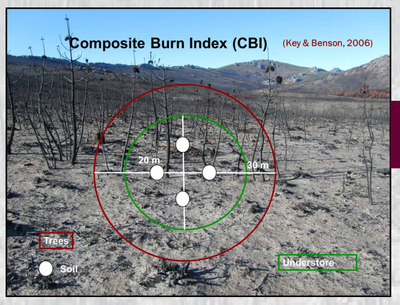
The aim of this work is to assess the suitability of some fire severity indicators to determine soil fire severity in a mega wildfire of a Mediterranean forest ecosystem. We evaluate the potential use of visual indicators and Land Surface Temperature (LST) for identifying fire severity levels.

STUDY AREA



The study site is located in the Sierra del Teleno, in N-W Spain. In August 2012 there was a large fire, which burned 117.75 km^2 for 3 days (August 19th and 21st), of *Pinus pinaster* forest.

SAMPLING METHODS

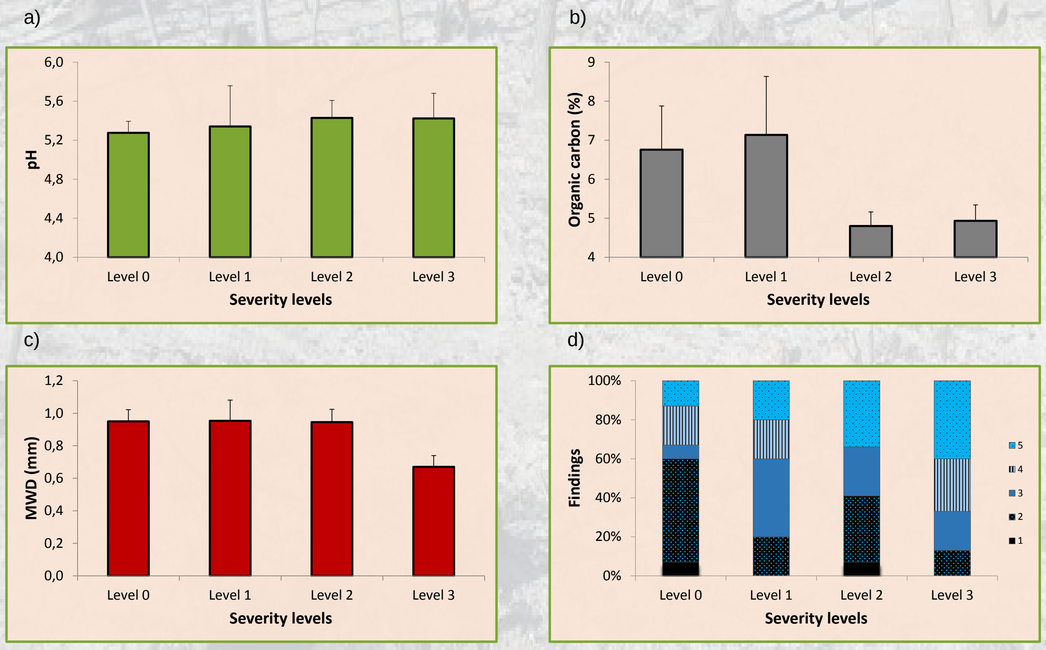


Severity levels	Description
0: unburnt	Undisturbed soil
1: low	Surface organic layers not completely consumed and recognizable. Ground surface is black with charred remains. Soil color unchanged.
2: moderate	Most litter and duff has been consumed but generally incomplete. A layer (1-3 cm) of black and some grey ashes can be observed. Soil colour is darknening.
3: high	Litter and duff totally consumed and medium fuel partially consumed (around 50%). Thick layer (3 to 8 cm) of grey and white ash covers the ground. Soil colour tended to dark gray brown.

Fire severity in the field and soil characteristics were measured in 50 plots, 30-m-diameter circular plot, using CBI values (Key and Benson, 2006). We also collected four soil samples (0-5 cm) and then mixed. Soil properties as a pH, organic carbon, soil water repellence, mean weight diameter (MWD) were analysed. Measurements were carried out one month after the wildfire. Also, some plots were selected in non-burning area.

We use immediately post-fire LST values (21 August 2012) generated from Landsat 7 Enhanced Thematic Mapper (ETM+) data using a single channel algorithm (Quintano et al., 2015). The statistical correlation of potential predictor variables (LST) with the response variable (CBI, soil characteristics) was evaluated using GLM s and LMs.

RESULTS



Mean and standard error: a) pH values, b) organic carbon, c) mean weight diameter, d) distribution of soil water repellency classes in relation to fire severity levels (1: hydrophilic; 2: slight; 3: strong; 4: severe; 5: extreme).

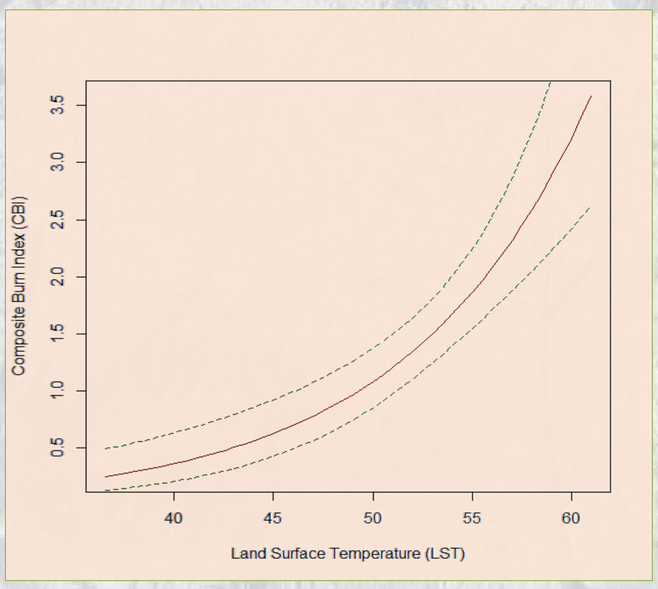
Soil pH did not change significantly (F=0.13; P=0.94) with fire severity. Medium and high fire severity caused a reduction of **organic carbon** content, although it was marginally significant (χ^2 =13.03; P=0.08).

MWD was significantly reduced (F=3.36; P=0.02) with high severity levels, because the most stable aggregates (> 2mm) decreased around 40%. Not changes were observed in low and medium severity.

We did not find significant differences (χ^2 =11.45; P=0.12) in **soil water repellency**. However, in high severity levels a 40% of our findings presented extreme water repellency.

A significant correlation was observed between **fire severity** and **soil water repellency** and **MWD**. No relationship was found with pH and organic carbon levels

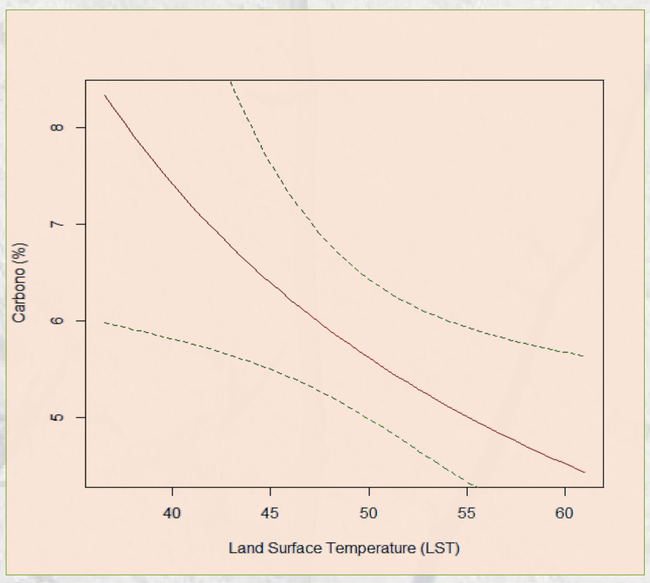
	Fire severity
pH	0.09
Organic carbon	-0.09
MWD	-0.38*
Soil water repellency	0.36*



Predicted values (mean ± 95% confidence intervals) of CBI for LST. Generalized linear model predictions were obtained for the observed range of LST in August 2012.

General linear model between post-fire LST and CBI values explained 43% of the variation in observed CBI. CBI increases significantly with increasing immediately post-fire LST and the predictions of CBI point out that higher LST values than 55 K, are indicating high severity levels.

We only find a significant relationship between soil organic carbon and LST, but not with other soil characteristics. Soil organic carbon decrease with increasing LST values mainly higher than 55 K.



Predicted values of organic carbon (%) (mean ± 95% confidence intervals) for the LST. Generalized linear model predictions were obtained for the observed range of LST in August 2012.

Generalised linear model (GLM) and linear models (LM) results for CBI and soil characteristics

	Df	X^2-value	P-value
CBI	1	40.1	< 0.001
Organic carbon	1	5.82	0.0158
Soil water repellency	1	1.58	0.2076

	Df	F-value	P-value
pH	1	0.25	0.6144
MWD	1	0.56	0.4554

CONCLUSIONS

Both, soil visual severity indicators and LST could be considered very valuable to asses fire severity for large forest fire in Mediterranean ecosystems. However, due to the high intensity and spatial variability of this type of wildfire, it is only possible differentiate between high and low severity levels.

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