Soil water repellency from Mediterranean environments: a brief review of studies by MED_Soil Research Group

FUEGORED
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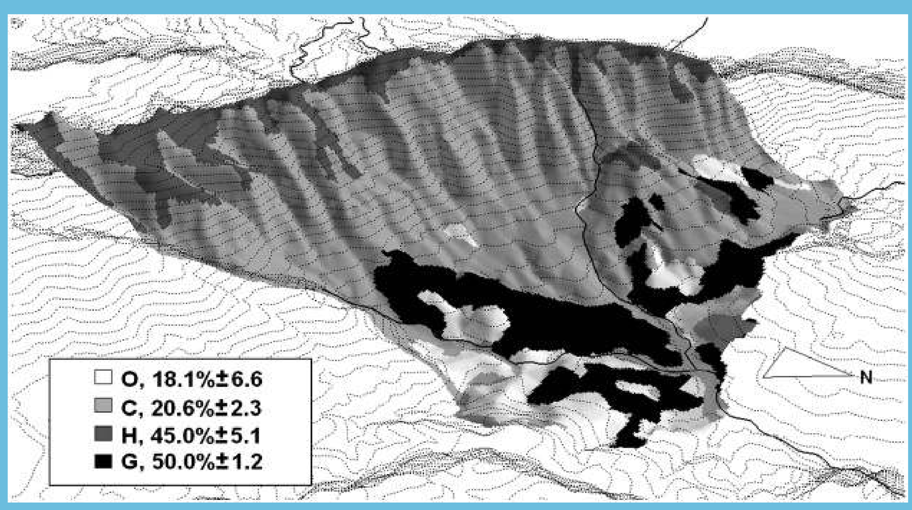
Hydrological and erosional response of fire-affected vegetation types

The hydrological response and erosional response of soils under cork oak woodland, heathland, grassland, and cork oak/olive tree mixed forests in Southern Andalusia has been studied by rainfall simulation studies.

Significant differences in the hydrological behavior of the studied vegetation types were observed after the rainfall simulations. Soils under woodland showed low runoff rates and coefficients, whereas the highest runoff rates were measured on the heathland and grass-covered parts of the hillslope. Soil water repellency clearly contributed to reduce infiltration rates (especially under the heathland), and seems to be the cause of fast ponding and runoff generation during the first stages of rainstorms. The patchy patterns of persistence and intensity of soil water repellency is conditioned by the spatial distribution of the studied land uses, which dictate the intensity and persistence of soil water repellency, and modulated by other environmental factors.

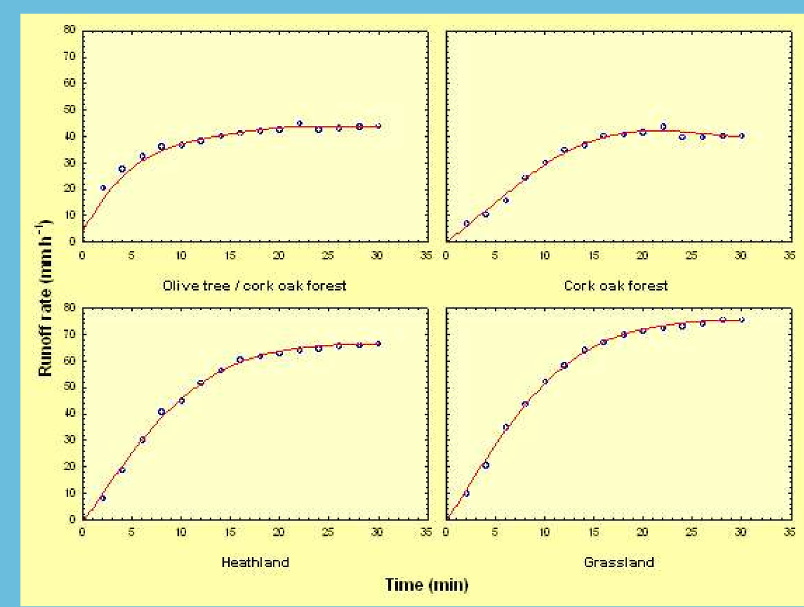
The vegetation effects on soil hydrology should be considered for afforestation work and flooding control.

3D view of the spatial distribution of land cover types and mean runoff coefficients (± standard error). C: plots under cork oaks; H: plots under heathland; G: plots under grassland; O: plots under cork oaks and olive trees.



Soil response to simulated rainfall. Tp: time to ponding; Tr: time to runoff; Pr: amount of precipitation necessary for runoff; SSIR: steady-state infiltration rate; C: plots under cork oaks; H: plots under heathland; G: plots under grassland; O: plots under cork oaks and olive trees. Within a column means followed by the same letter are not significantly different.

Vegetation type		Tp (s)	Tr (s)	Pr (mm)	Runoff rate (mm h^{-1})	Runoff coef. (%)	Infiltration rate (mm h^{-1})	SSIR (mm h^{-1})
Cork oak	Mean	82.90 a	256.70 a	4.01 a	11.64 a	20.60 a	44.96 a	41.34 a
	SD	17.20	20.35	0.32	1.93	3.41	1.93	2.54
Heathland	Mean	27.50 b	79.20 b	1.23 b	25.44 b	44.99 b	31.16 b	21.07 b
	SD	9.06	6.48	0.11	4.56	8.07	4.56	6.37
Grassland	Mean	75.37 a	109.20 b	1.56 b	28.30 b	50.04 b	28.30 b	12.70 c
	SD	22.67	32.69	0.25	5.02	8.88	5.02	7.90
Olive tree / cork oak	Mean	76.90 a	249.90 a	3.92 a	10.26 a	18.14 a	46.34 a	42.57 a
	SD	16.24	42.44	0.65	1.09	1.93	1.09	1.36
ANOVA, p		0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

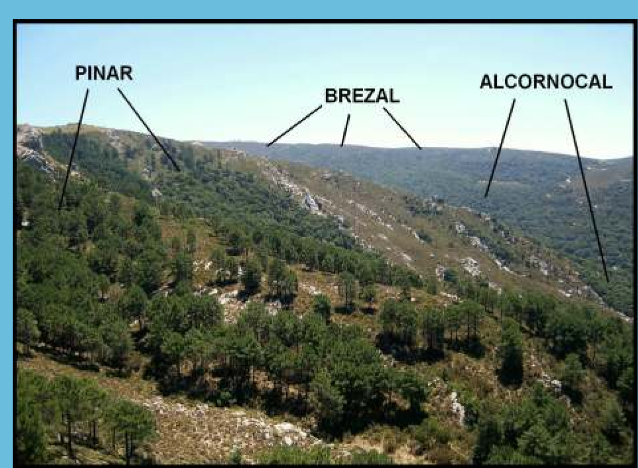


Seasonal variability of soil water repellency in Mediterranean environments

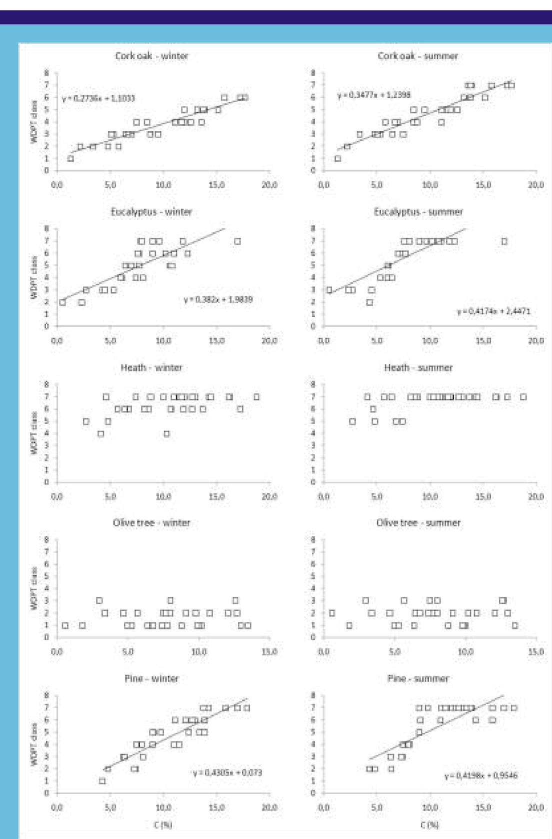
The objectives of this research were to study the persistence and intensity of water repellency in soil samples (0-5 cm deep) collected under different plant species, to analyze the relationships between soil water repellency and environmental factors including soil organic matter content, soil acidity, and texture, and to study the variations of soil water repellency measured on soil samples collected in winter (2007) and summer (2008) in the studied area.

Soil water repellency has been studied in Mediterranean coniferous and eucalyptus forests, particularly after burning, but the number of studies concerning other Mediterranean forest systems is still very low. In this paper, soil water repellency was measured by using the water drop penetration time test and the ethanol percentage test on samples collected during the winter of 2007 and the summer of 2008 under different land uses (pines, cork oaks, eucalyptus, heathland and olive trees) in a Mediterranean subhumid forested area (Los Alcornocales Natural Park, Cádiz and Málaga, Spain).

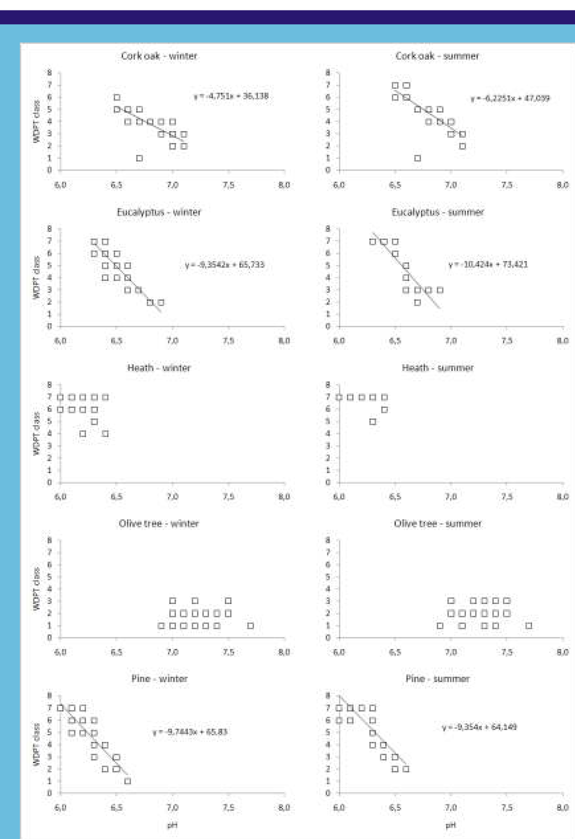
Most of soil samples collected under heathland showed extreme water repellency, whereas soils under olive trees showed low or inexistent water repellency. The organic matter content and acidity were highly correlated with water repellency in soils under pines, cork oaks and eucalyptus, while soils under heathland or olive trees showed poorer correlations. The average soil moisture content of samples collected during winter (2007) was 20.7±7.9 %, and it decreased in samples collected during summer (2008) to 1.1±0.6 %. The persistence and intensity of water repellency varied slightly between samples collected in winter and summer in soils under all species except under heathland. Water repellency persisted in most cases during the wet and dry season, and many soils showed strong water repellency even during winter. The patchy patterns of persistence and intensity of soil water repellency is conditioned by the spatial distribution of the studied land uses, which dictate the intensity and persistence of soil water repellency, and modulated by other environmental factors.



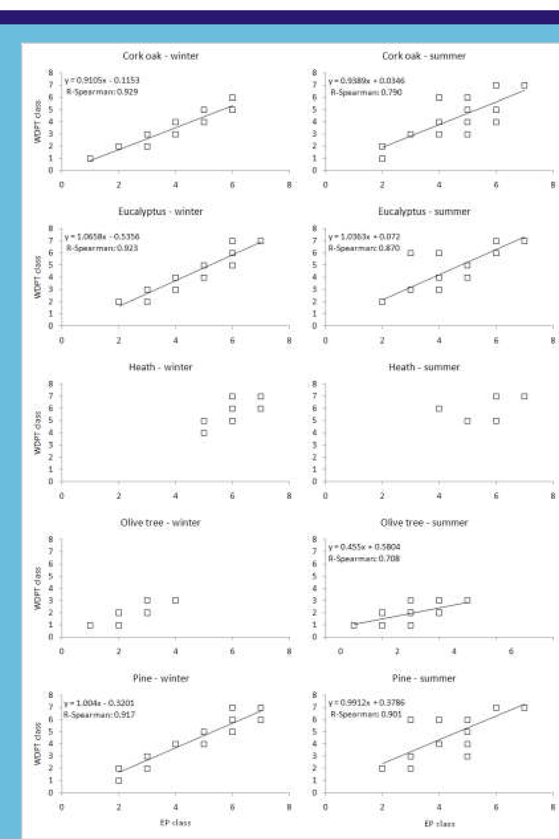
One of the studied sites, showing pine (pinar), cork oak forests (alcornocal), heathland (brezal) and bare soils
(Los Alcornocales Natural Park, Cádiz)



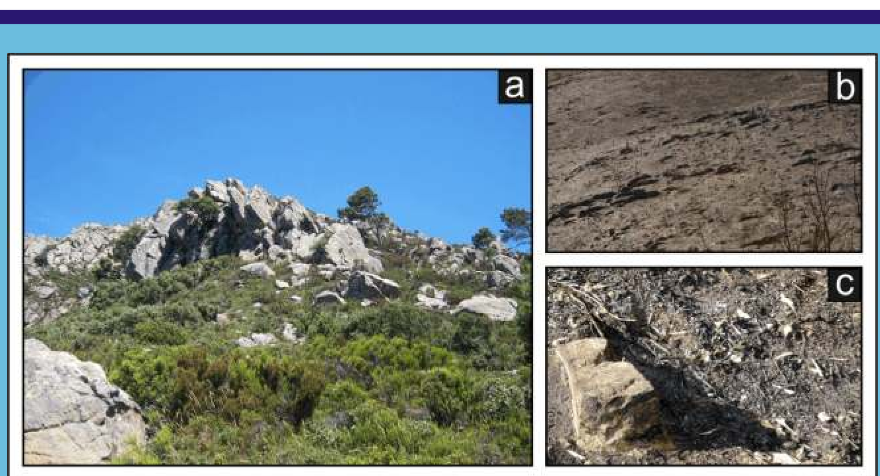
Relationship between water drop pentration time (WDPT) class and organic carbon content during winter and summer under different vegetation types.



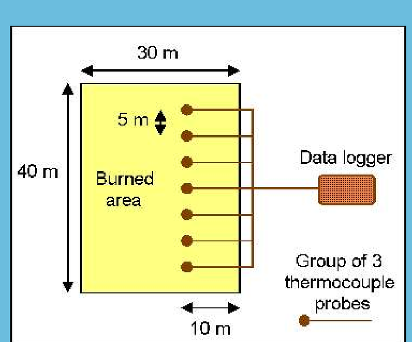
Relationship between water drop pentration time (WDPT) class and pH during winter and summer under different vegetation types



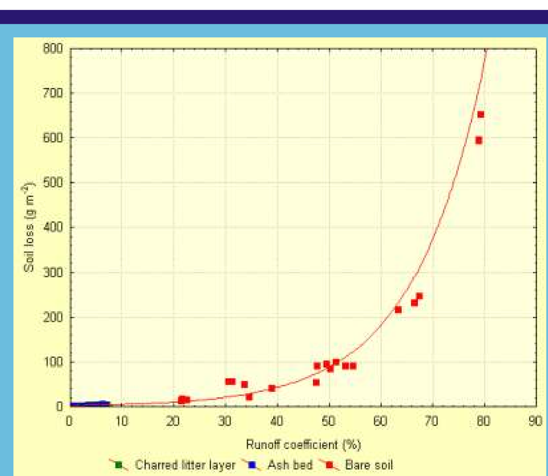
Relationship between water drop pentration time (WDPT) class and ethanol percentage class (EP) during winter and summer under different vegetation types.

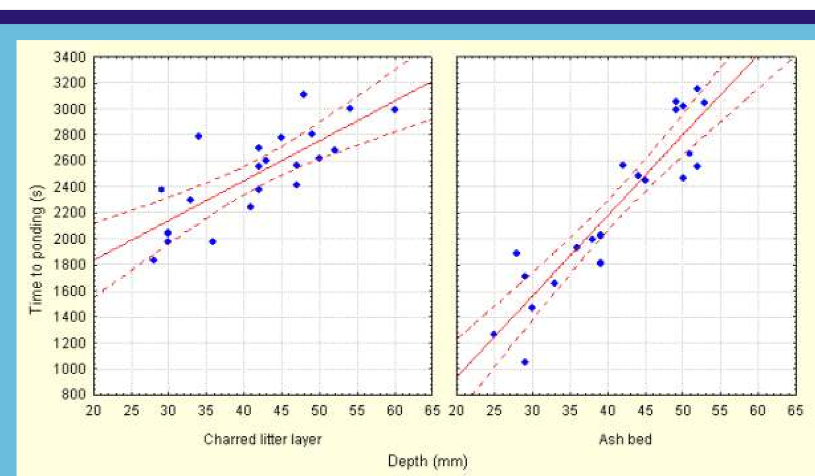


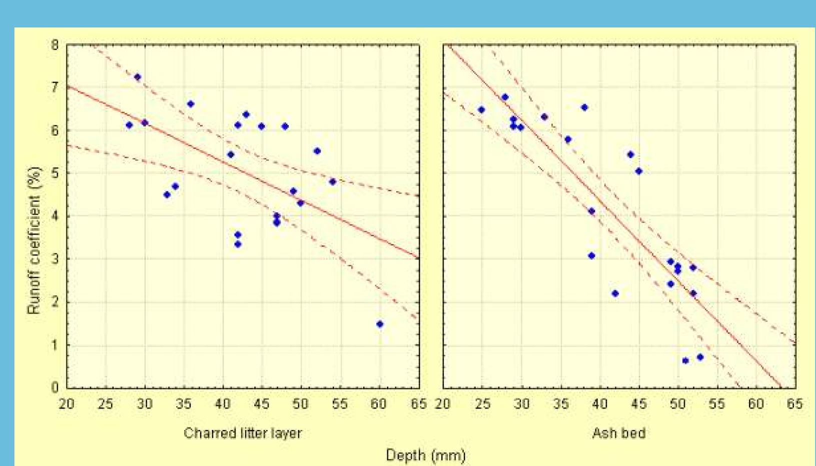
A: view of an unburned control plot; B: burned plot; C: detail of a burned area showing a thick ash layer.

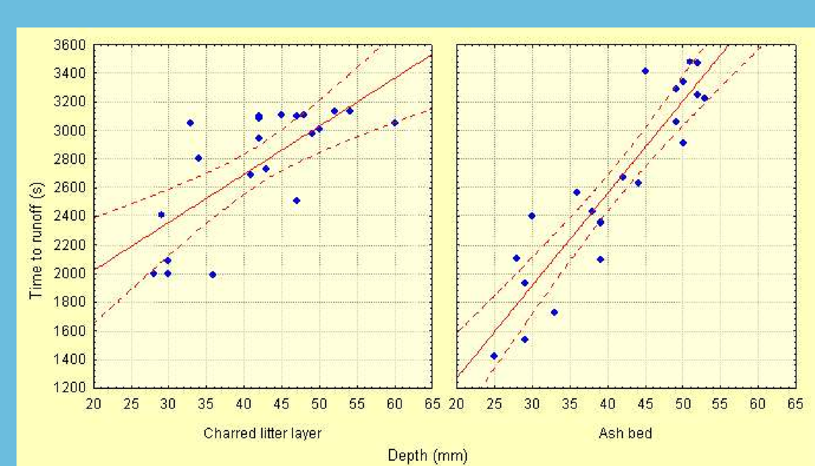


Experimental design.









Intact ash and charred litter reduces susceptibility to rain splash erosion post-wildfire

Soil water repellency and soil hydrological and erosional responses to rainfall at small-plot scale, arising from a prescribed fire were studied immediately following burning and one year later in a Mediterranean heathland in the area of the Strait of Gibraltar (southern Spain).

Very little research has been carried out about the modifications on the ground surface after fire immediately after burning. A prescribed fire was conducted to study short-term changes of the ground surface immediately and 1 year following burning.

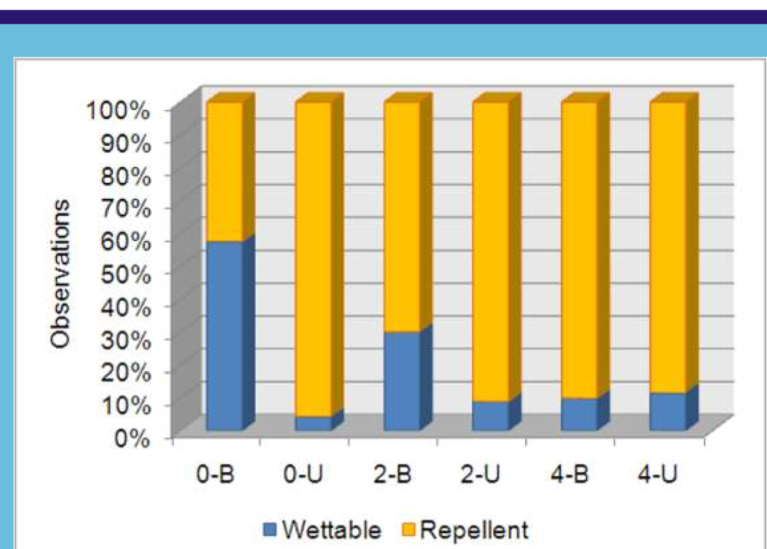
After a prescribed fire, a homogeneous charred litter layer and ash-bed covered the mineral soil surface. This cover stayed stable on the soil surface during a period of seven days, until strong winds redistributed litter and ashes. Water repellency of the exposed surface (litter and ashes) decreased considerably in relation with the litter layer properties before the fire. Ponding, runoff coefficients and soil loss were determined using simulated rainfall over the litter layer, the ash-bed and the bare soil. Significant differences were not detected between pre- and post-fire soil loss rates while a charred litter and thick ash layer were present on the soil surface.

Runoff and erosion rates increased and time to ponding and runoff decreased when the charred litter and ash layers were artificially removed and the bare soil was exposed. Although wildfires will increase soil erodibility, the trends observed in this study suggest that this increased susceptibility to erosion from rainsplash processes may be limited to some degree while an intact ash and charred litter layer is still present.

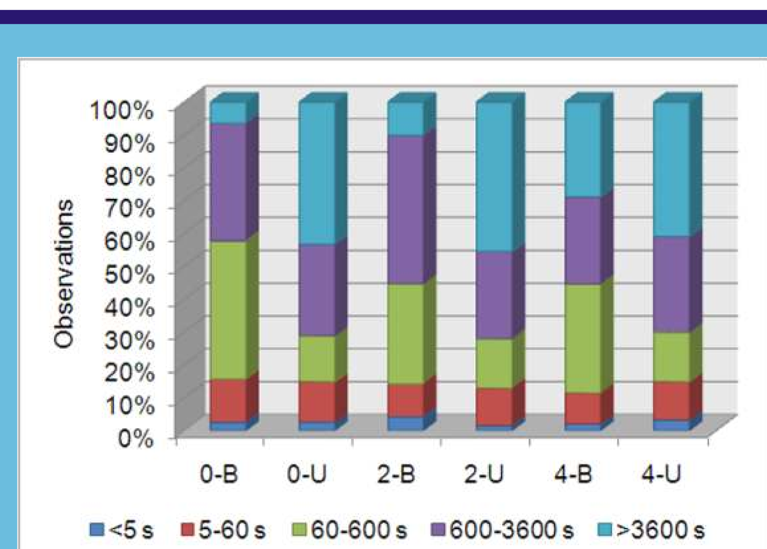
Fire-induced or natural soil water repellency?

Water repellency has been usually considered as a fire-induced characteristic of soils, but an increasing number of works have suggested that a natural background repellency occurs in many soil types.
A prescribed fire was conducted to study changes of the soil surface during the first 18 months following burning. In situ water repellency changes were studied at three soil depths (0, 2 and 4 cm) immediately after burning. Long-term evolution of water repellency under field conditionswas studied and the main hydrological consequences of these changes were outlined.
After field and laboratory analysis, it was found that soil water repellency was partly destroyed after intense burning. Changes were relatively strong at the soil surface, but diminished progressively with depth. Levels of water repellency were practically re-established 18 months after burning. This suggests that water repellency in the studied area is not necessarily a consequence of fire, but can instead be a natural attribute. Finally, although limited in time, destruction of soil water repellency has important consequences for runoff flow generation and soil loss rates, and, indirectly, for water quality.

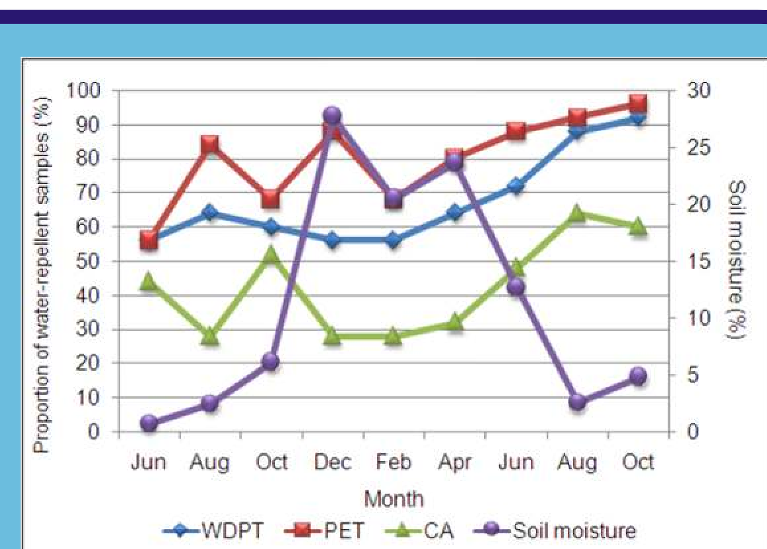
View of a burned area inmediately after fire (a,b) and one year after (c,d).



Proportion of wettable/water repellent field moist samples immediately after fire.



Proportion of soil water repellency classes from samples immediately after fire under laboratory conditions.



Evolution of the proportion of water-repellent samples under field conditions (WDPT, water drop penetration time; PET: ethanol percentage test), average contact angle (CA) and soil moisture.

Different approaches to the analysis of water repellency

A: water drop penetration time.
B: ethanol percentage test.
C: contact angle determination using a pocket goniometer.