P 1.7 FIRE INTENSITY IN MODERATE DROUGHT CONDITIONS: EFFECT ON TOPSOIL PROPERTIES IN MEDITERRANEAN SHRUBLAND VEGETATION

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1. INTRODUCTION

The effects of fire on soil depend on the temperature and the residence time of the fire as well as the soil moisture content. The degree of change in both the chemical and biological properties of soil are strongly linked with fire intensity (Flinn *et al*., 1984). Exposure of the mineral soil may lead to loss of nutrient (Chesterfield, 1984) and organic matter. Some of these events may be further aggravated by the weather conditions following fire.

Fire intensity depends largely on the time of the year, prevailing weather conditions and the period since the last fire (i.e. the amount of fuel available). The intensity of fire influences the heat per meter of fireline that the soil is subjected to. The values of fireline intensity as well as the other parameters related to fire severity (rate of spread, heat per unit area, reaction intensity, etc.) can be estimated under different weather and fuel scenarios, using fire spread and behaviour prediction models (BEHAVE, FARSITE, etc.). FARSITE is one of the main fire simulation systems developed over recent years. The simulator is based on the physical statistical fire spread model of Rothermel (1972). This simulator allows the user to describe the spatial and temporal spread and behaviour of fire under different terrain, fuels and weather conditions.

The aim of this study is to compare burned and unburned soil in order to evaluate the effect of fire on physical and chemical soil properties of a typical Mediterranean area.

2. MATERIALS AND METHODS

The analysis was carried out in a human caused fire occurred in moderate environmental conditions, during the 2006 summer season. The study area is characterized by the sub-arid Mediterranean climate and mainly covered by the typical shrubland Mediterranean vegetation.

The climate is characterized by a remarkable water deficit occurring from May through September and precipitations mainly concentrated in autumn and winter. The mean annual rainfall is 640 mm and annual air temperature is 16.8 °C.

In order to study the effect of the fire on soil physico-chemical properties, pedological samples were collected in the area of Monte Doglia (40° 36' N; 8° 09°E; 20 m a.s.l.), inside the Regional Natural Park of Porto Conte, North West of Sardinia, Italy.

The soil samples were collected, immediately after fire, from various depths (0-5, 5-15 and 15-25 cm) and from burned and unburned plots where the vegetation cover was composed by different Mediterranean maquis species (*Chamaerops humilis* L., *Pistacia lentiscus* L. and *Calycotome spinosa* L.). Before analysis the samples were sieved at 2 mm and air dried. Soil pH was determined potentiometrically in H_20. The soil organic matter content was determined by the Walkey and Black methods, and the total nitrogen was determined by semimicro Kjeldahl procedure. Cation exchange capacity (CEC) and exchangeable bases (Ca, Mg, Na, K) were determined in Barium chloride and triethanolamine according to Italian Society of Soil Science (Società Italiana della Scienza del Suolo, 2000). The particle size distribution was measured by the pipette method in a sedimentation cylinder (Società Italiana della Scienza del Suolo, 1997).

Information about the severity of fire environment were estimated using FARSITE fire simulator system. The values of fire line intensity, fire heat per unit area, reaction intensity, and rate of spread were calculated with a spatial resolution of 15 m. A GIS was realised in order to acquire and manage the spatial information required to perform FARSITE simulations. A digital elevation model (DEM) was used to produce the maps of slope and aspect. Hourly meteorological data were obtained from weather stations of the Sardinian Agrometeorological Service (SAR) network. Despite the moderate drought conditions, the high values of wind speed affect the rate of spread in the burned area. Fuel and canopy cover maps were produced by supervised classification of pre-fire aerial photographs (1:10,000), field observation of the plant community and use of the 1:25,000 land cover map of Sardinia from the CORINE project (EEA ETC/TE, 2002). The simulations were run using a custom fuel model for the shrubland. The initial values of fuel moisture content (FMC) for the 10-h time lag (TL) dead fuel were determined calculating the relationship between observed FMC and fuel moisture sensor

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measurements (model CS505, Campbell Sci., Logan, UT, USA) which were obtained during days with meteorological conditions similar to those when the fire events occurred. The 1-h and 100-h TL dead fuel moisture content values were obtained from field observations and literature data (Fernandez, 2001; Baeza, *et al*., 2002; De Luis e*t al*., 2004).

3. RESULTS AND DISCUSSION

The results of the physical and chemical analysis of the soil samples are reported in Table 1 and Table 2. With reference to the different Mediterranean maquis species, the soil samples collected in the burned area under *Chamaerops humilis*, showed the highest content in organic matter, in particular in the surface soil horizon (Figure 1). The C/N ratio was higher in burned area under *Chamaerops humilis* followed by *Pistacia lentiscus* and *Calycotome spinosa*. Values of sand content which were found in burned area were lower than in unburned area, whereas the higher values of silt and clay content were detected in burned area. The differences for the other variables resulted less important (Table 1 and Table 2).

Table 1 - Physical and chemical characteristics, mean and standard deviation (n=3) of the burned soil.

Soil property	*Calycotome spinosa*	*Pistacia lentiscus*	*Chamaerops humilis*
Sand (g/kg)	844.3±37.5	843.3±18.6	871.3±9.2
Silt (g/kg)	66.3±6.5	71.7±15.8	66.0±8.2
Clay (g/kg)	89.3±31.9	85.0±7.8	62.7±6.3
pH	6.2±0.3	6.7±0.1	5.2±0.3
C (g/kg)	12.3±13.6	15.3±13.5	46.0±35.4
O.M. (g/kg)	21.0±23.5	26.3±23.1	79.7±61.0
Total N (g/kg)	0.9±0.9	0.9±0.7	1.2±0.7
C/N	11.3±3.1	16.3±2.9	38.7±7.1
Ca (meq/100g)	3.7±1.9	6.9±4.4	3.1±2.5
Mg (meq/100g)	0.8±0.2	1.3±0.8	0.6±0.3
Na (meq/100g)	0.4±0.1	0.6±.01	0.2±0.2
K (meq/100g)	0.9±0.3	1.4±0.4	0.5±0.2
CEC (meq/100g)	7.8±3.8	14.3±4.4	10.3±3.4
Base satur (%)	78±12.1	68.7±14.4	38.7±18.8

Table 2 - Physical and chemical characteristics, mean and standard deviation (n=3) of the unburned soil.

Soil property	*Calycotome spinosa*	*Pistacia lentiscus*	*Chamaerops humilis*
Sand (g/kg)	875.0±15.1	868.7±7.4	883.0±10.4
Silt (g/kg)	58.0±4.3	60.3±5.9	64.3±5.9
Clay (g/kg)	67.0±10.8	71.0±8.7	52.7±8.6
pH	6.3±0.2	6.3±0.2	6.4±0.1
C (g/kg)	15.7±13.6	16.7±8.6	27.7±18.0
O.M. (g/kg)	27.0±23.1	29.0±14.7	47.7±31.0
Total N (g/kg)	1.0±0.9	1.1±0.5	0.8±0.6
C/N	17.0±1.0	15.3±0.6	37.0±6.9
Ca (meq/100g)	6.4±5.0	5.8±2.5	4.1±1.7
Mg (meq/100g)	1.2±0.8	1.1±0.4	0.8±0.4
Na (meq/100g)	0.4±0.2	0.3±0.1	0.6±0.5
K (meq/100g)	0.9±0.4	1.2±0.3	1.5±1.4
CEC (meq/100g)	10.0±5.7	12.6±4.4	7.0±3.5
Base satur (%)	87.7±11.9	67.3±1.26	109.3±34.0

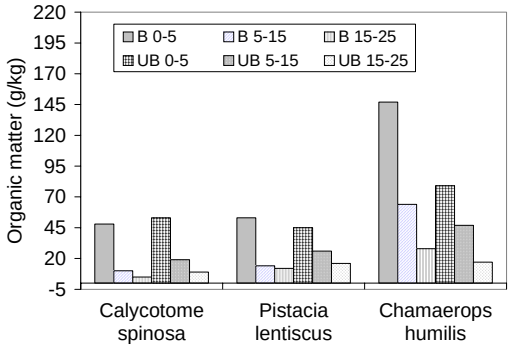

Figure 1 - Organic matter content of soil collected in burned (B) and unburned area (UB) from different depths (0-5, 5-15, and 15-25 cm).

Despite the high values of wind speed (35 m s^{-1}), the fire occurred in moderate environmental conditions due to the high values of fuel moisture content and weather condition (temperature and humidity). Moreover, the FARSITE simulations confirmed that the fire environment was moderate, as showed by low values of fire line intensity (97.6 kW m^{-1}) and fire heat per unit area (3355.5 kJ m^{-2}). The low value of rate of spread (1.53 m min^{-1}) can be explained by both effect of plant height (about 2 m) in reducing the wind speed, and of flat terrain that characterized the surrounding area.

The absence of significant effects of fire on soil physico-chemical properties was explained by the moderate environmental conditions reported by FARSITE simulations; the damage on soil characteristics, as reported also by other authors (Humphreys and Craig, 1981), are related to the severity of fire (i.e. the temperature reached during the event). This seems to be confirmed by a new FARSITE simulation conducted using fuel moisture content values reduced by half. This simulation provided an increase of fire line intensity of 42% and of rate of spread of 27%.

4. CONCLUSIONS

The study showed the low effect on soil properties of a wildland fire occurred in northern Sardinia during moderate environmental conditions, as obtained by FARSITE simulator outputs. The study confirms the low damages on soil properties related to the use of prescribed burning during moderate drought conditions that characterize the late spring and early summer seasons in Mediterranean basin.

5. REFERENCES

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