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Short-term effects of a wildfire on soil properties in Fragas do Eume Natural Park (Galicia, NW Spain)

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Abstract

The impact of a wildfire on some selected physicochemical, biochemical and microbiological properties was assessed in an ecosystem located in the Fragas do Eume Natural Park (NW Spain). Soil samples were collected from the topsoil (0-2.5 and 2.5-5 cm) of the unburnt and burnt soil under the autochthonous (Quercus) and non autochthonous (Eucalyptus) vegetation. The results indicated that, independently of the vegetation considered, a short-term impact of the wildfire on most soil properties analyzed was detected; the effect being more pronounced for the biochemical properties than for the physical and chemical ones. As expected soil properties varied with soil depth, and the fire effect was more noticeable in the 0-2.5 cm layer than in the 2.5-5 cm layer.

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1 INTRODUCTION

Galicia (NW Spain) and the North of Portugal are the areas of Europe most affected by forest wildfires, and worldwide they are amongst the areas with the greatest number of fires per hectare and inhabitant (Carballas et al., 2009; Catry et al., 2010). Approximately half of the wildfires in Spain occur in Galicia; the number of fires is around 9,000 per year on average, and the area burned was on average about 40,000 ha in each of the last ten years (Ministerio de Medio Ambiente, 2010). Thus, since forest fires are common events in Galicia causing the destruction of vegetation and soil degradation as well as enormous losses of soil and nutrients due to runoff and erosion processes, there is a need to determine their effects on terrestrial ecosystems, particularly when fires occurs in environmental sensitive areas, natural areas and areas set aside for wildfire. The aim of the present study was to evaluate the short-term impact of a wildfire occurred in 2012 in the Fragas do Eume Natural Park (Galicia, NW Spain) on the soil quality (physicochemical, biochemical and microbiological properties).

2 METHODS

2.1 STUDY AREA

The study was performed in one of the six natural parks located in Galicia, the Fragas do Eume Natural Park (A Coruña, NW Spain), which extends along the valley of the river Eume within the Ferrolterra municipalities of Pontedeume, Cabanas, A Capela, Monfero, Pontedeume and As Pontes de García Rodríguez. The park is an example of a temperate rainforest recognized by the European

Union as Site of Community Importance in which the autochthonous vegetation is dominated by "Fragas", a natural woodland with a mixture of species such as Quercus robur, Corylus avellana, Castanea sativa, Betula alba, Laurus nobilis, Ulmus glabra, Salix atrocinerea, Fraxinus excelsior, Fraxinus angustifolia and Alnus glutinosa. However, the protected area also included vegetation dominated by non autochthonous species such as Eucalyptus globulus and, in a less extent, Pinus radiata. On March 2012 a wildfire destroyed during 3 days the heart of the park and approximately 1000 ha of the Natural Park were affected, 750 ha dominated by non autochthonous vegetation, mainly E. globulus, and 350 ha dominated by autochthonous vegetation, mainly Quercus robur. In order to evaluate the impact of this wildfire, unburned and burned plots with different species composition, named according to the dominating specie, and representative of these two types of vegetation (Quercus, autochthonous vegetation; Eucalyptus, non autochthonous vegetation) were selected. Thus, a total of 16 plots (4 unburt Quercus, 4 burnt Quercus, 4 unburnt Eucalyptus, 4 burnt Eucalyptus), each plot covering a surface of about 1 ha, were established for the field experimental design. The soil is developed over granite and the slope of the plots is 30-70%.

2.2 LABORATORY ANALYSES

Soil samples from the top 0-5 cm (0-2.5 cm, 2.5-5 cm) of the A horizon were collected 3 months after the wildfire from both the burnt and the unburnt plots and the following soil properties were monitored in the fraction < 2 mm: moisture content and water retention capacity, pH (in water and KCl), electric conductivity, free Fe and Al oxides, total C, extractable C, microbial biomass, soil respiration, bacterial activity and soil enzymes related with C, N and P cycles. The methods described by Guitián-Ojea and Carballas (1976) were used to determine most properties analyzed. The microbial biomass C was determined using the fumigation-extraction method (Díaz-Raviña et al., 1992) and soil respiration by measurement of the CO2 evolved during 10 days (Díaz-Raviña et al., 1988). The ß-glucosidase and urease activities were assayed as reported by Eivazi and Tabatabai (1988) and Kandeler and Geber (1988), respectively, and the phosphatase activity following the method described by Trasar et al. (1985). The bacterial activity was also determined by means of the incorporation of labelled leucine into bacteria, extracted after homogenization-centrifugation (Bååth et al., 2001). In order to evaluate the effect of the wildfire on the soil under two representative park vegetation types (autochthonous vegetation and non autochthonous vegetation), 4 plots with the same vegetation type were averaged (mean±SD). The data were analyzed by a standard analysis of variance (ANOVA1) and, in the cases of significant F statistics, the Tukey´s minimum significant difference test was used to separate the means.

3 RESULTS AND DISCUSSION

The soil properties obtained in the 0-2.5 and 2.5-5 cm layers of the different soil samples under different vegetation 3 months after the wildfire are shown in Table 1. A similar effect of the wildfire was observed in the soil under Quercus and Eucalythus vegetation, although more pronounced and significant effects were detected for the latter. The values showed that most parameters analyzed experienced short-term fire induced changes, but the magnitude of the effect depended on the soil property studied. Commonly, the fire tended to slightly increase the pH and to decrease the soil properties related with the organic matter content (total C, water retention, extractable C) but fire induced changes were not significant due to high spatial variability among the different unburned and burned field replicates. Likewise, most biochemical properties determined differed between the burnt samples and the corresponding unburnt ones; however, a different response was observed depending on the parameter analyzed. Thus, whereas a negative influence for microbial biomass C, respiration and urease, glucosidase and phosphatase activity was observed, there was a positive effect on the bacterial activity. For the same vegetation, a clear significant effect of the soil depth on most soil properties analyzed ($p<0.05$, data not showed) was also detected and except for soil pH and free Al and Fe oxides the values tended to decrease along the soil profile. The results also showed that the two factors considered, soil depth and wildfire, showed a more intense effect on the biochemical properties than that detected on the physicochemical and chemical properties. These data are coincident with those reported in previous studies performed in the same area showing that the biochemical parameters exhibited a higher sensitivity to asses the impact of wildfires or prescribed fires on soil ecosystems than that observed for the physicochemical properties (Díaz-Raviña et al., 2012; Fontúrbel et al., 2012).

4 CONCLUSIONS

The results clearly showed that the overall soil quality

Table 1. Soil properties analyzed in the unburnt and burnt soil samples under Quercus and Eucalyptus. For the same depth, different letters denote significant differences (p<0.05).

		Quercus				*Eucalyptus*			
	Depth (cm)	**Unburnt**		**Burnt**		**Unburnt**		**Burnt**	
Moisture (%)	0-2.5	49.2±6.1	b	42.3±6.9	b	41.4±.,5	b	29.4±4.6	a
	2.5-5	41.4±49	b	37.6±6.4	ab	35.7±3.1	ab	29.4±3.9	a
pH H_2O	0-2.5	3.5±0.1	a	4.1±0.3	bc	3.7±0.1	ab	4.4±0.4	c
	2.5-5	3.7±0.1	a	4.1±0.2	ab	3.9±0.1	ab	4.2±0.2	b
pH KCl	0-2.5	2.7±0.2	a	3.2±0.3	ab	2.8±0.2	ab	3.3±0.3	b
	2.5-5	3.0±0.3	a	3.3±0.2	a	3.1±0.1	a	3.3±0.3	a
Electric conductivity ($\mu S\ cm^{-1}$)	0-2.5	156±18	a	123±27	a	134±35	a	101±28	a
	2.5-5	136±28	a	115±30	a	108±31	a	95±15	a
Water retention at field capacity (g water kg^{-1})	0-2.5	1191±304	b	962±213	ab	880±101	ab	592±128	a
	2.5-5	905±165	b	783±120	ab	712±48	ab	619±122	a
Al_2O_3 ($g\ kg^{-1}$)	0-2.5	9±3	a	11±2	a	10±1	a	9±3	a
	2.5-5	11±3	a	13±2	a	12±2	a	12±4	a
Fe_2O_3 ($g\ kg^{-1}$)	0-2.5	35±13	a	34±17	a	44±12	a	31±13	a
	2.5-5	46±9	a	39±16	a	51±15	a	39±19	a
Total C ($g\ kg^{-1}$)	0-2.5	263±107	a	210±47	a	200±63	a	169±58	a
	2.5-5	175±66	a	137±19	a	119±34	a	112±34	a
Extractable C ($mg\ kg^{-1}$)	0-2.5	43±11	b	18±5	a	33±5	b	17±5	a
	2.5-5	33±10	b	17±3	a	38±5	b	18±6	a
Microbial C ($mg\ kg^{-1}$)	0-2.5	2367±779	b	815±386	a	2558±607	b	656±345	a
	2.5-5	1719±125	b	782±265	a	1773±586	b	607±294	a
Respiration ($mg\ CO_2 kg^{-1} day^{-1}$)	0-2.5	141±79	a	92±38	a	88±40	a	53±12	a
	2.5-5	70±37	a	53±18	a	46±28	a	36±5	a
Bacterial activity (mol leucine10^{-17})	0-2.5	0.78±0.16	a	1.13±0.74	a	0.44±0.13	a	1.02±0.33	a
	2.5-5	0.56±0.22	a	0.93±0.34	a	0.46±0.19	a	0.83±0.24	a
Glucosidase activity (μg p-nitrophenol $g^{-1}\ h^{1}$)	0-2.5	418±147	b	212±107	ab	289±123	ab	107±50	a
	2.5-5	247±111	b	159±54	ab	130±39	ab	94±59	a
Urease activity ($\mu g\ NH_4^+ g^{-1} h^{-1}$)	0-2.5	211±51	b	182±57	ab	186±52	ab	98±50	a
	2.5-5	150±17	ab	172±28	b	129±32	ab	106±37	a
Phosphatase activity (μg p-nitrophenol $g^{-1}\ h^{1}$)	0-2.5	1364±397	b	1033±342	b	818±211	ab	403±239	a
	2.5-5	772±301	a	589±137	a	366±102	a	464±192	a

(physicochemical, biochemical and microbiological properties) of the soils from the Fragas do Eume Natural Park under both autochthonous vegetation (Quercus) and non autochthonous vegetation (Eucalyptus) were affected by the wildfire occurred in march 2012. Since this is a protected area and burnt soils are highly susceptible to suffer soil erosion, the establishment of soil stabilization and rehabilitation treatments should be considered in order to minimize the impact of fire on these ecosystems as well as to preserve the biodiversity of the natural park.

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