

FLAMMA, 5 (2), 83-85, 2014

ISSN 2171 - 665X

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Insignificant impact of prescribed fire on surface soil in a *Pinus pinaster* plantation, northern Portugal

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Keywords

Pinus pinaster forest
Prescribed fire
Soil disturbance

Abstract

Following a prescribed fire in a *Pinus pinaster* forest site located in the north-west Portugal, monitoring of any changes in selected soil characteristics and soil hydrology was undertaken to assess the effects of burning on the following: pH, electrical conductivity, water content, organic carbon and porosity. Thirty plots were established on a regular grid. At each sample plot before and after the fire, samples were collected (disturbed samples from depths of 0-1cm and 1-5cm; undisturbed core samples from 0-5cm). The results indicate that there was no measurable impact on the properties of the soil following this carefully conducted prescribed fire. The fire only affected the litter layer, as intended. Confirmation of this minimal impact on the soil was provided by regrowth of grasses and herbs already occurring two months after the fire. The implication is, therefore, that provided this wildfire-risk reduction strategy is carried out under existing strict guidelines, any impact on soil quality will be minimal.

Received: 1 June 2012 | Accepted: 29 May 2013

1 INTRODUCTION

Prescribed fire is a commonly-used wildfire-risk reduction technique in Portugal by public bodies and private landowners aimed to reduce fuel load. Since 2006, legislation has existed in Portugal to encourage prescribed burning. This technique is less labour-intensive, and therefore more popular, than fuel load control by cutting, which would be expected to have relatively little environmental impact. However, it is unclear whether prescribed fire use has any other important environmental impacts. For *Pinus pinaster* forests in particular, there have been some studies arguing that here is no impact on soil fertility or tree growth (Rego *et al.*, 1987), but others have suggested that there is some impact (Carter and Foster, 2004; Fernandes and Botelho, 2004). It has also been

stated that conclusive general statements concerning the hazard-reduction potential of prescribed fire are difficult to make, and ultimately the impact depends on the overall efficiency of the entire fire management process (Fernandes and Botelho, 2003; Fernandes *et al.*, 2008). Since little is known about the impact of prescribed fires on soils and about the rate of recovery after prescribed fire in Portuguese *Pinus pinaster* forests, and given that Portuguese legislation now actively promotes the use of prescribed fire, insight into the effects of such fires is urgently needed.

Following a prescribed fire in spring 2011 in a forested site in north-west Portugal, monitoring of any changes in soil properties and soil hydrology was undertaken to assess the effects of burning on the following soil characteristics: pH,

Table 1. Means and standard deviations of pH, electrical conductivity, organic matter, soil moisture and particle size distribution at two soil depth class before and after the fire. Bulk density, porosity and litter/ash weight are also shown. Sample size (N) is shown in the last column.

		Before the fire	After the fire	N
pH	0-1cm	4.5 ± 0.4	4.6 ± 0.3	17
	1-5cm	4.8 ± 0.3	4.8 ± 0.3	17
Electrical conductivity (mS cm ⁻¹)	0-1cm	41.7 ± 12.5	24.5 ± 5.6	17
	1-5cm	24.0 ± 3.4	24.4 ± 3.6	17
Organic matter (%)	0-1cm	10.0 ± 2.4	9.7 ± 1.5	17
	1-5cm	6.9 ± 1.8	7.4 ± 1.4	17
Soil moisture (<i>in situ</i>) (%)	0-5cm	11.7 ± 3.8	11.2 ± 4.3	16
Particle size distribution (%)	Clay	1.8 ± 0.3	1.5 ± 0.3	6
	Silt	30.5 ± 4.8	26.4 ± 2.6	6
	Sand	67.7 ± 5.1	72.1 ± 2.8	6
Bulk density (g cm ⁻³)	0-5cm	1.4 ± 0.2	1.4 ± 0.1	17
Total Porosity (%)	0-5cm	44.5 ± 5.5	47.8 ± 11.2	17
Litter / ash (g)		300.7 ± 72.2	12.9 ± 7.5	8

electrical conductivity, water content, organic carbon and porosity. The main aim of this study was to determine whether prescribed fire had a detectable impact on the soil.

2 MATERIALS AND METHODS

2.1 STUDY AREA

The present research was carried out in association with a management burn planned by the Portuguese Forestry Authority (AFN) for the Tresminas area in Vila Pouca de Aguiar municipality, northern Portugal, during February and March 2011. The soil type in the Tresminas study area is an Umbric Chromic Cambisol (Buxx₂) (Agroconsutores, 1991). The site was located at 800 m altitude on a relatively low-angled slope (9°). The study area is covered by a pine forest (*Pinus pinaster*) at least 20 years old. Prior to the prescribed fire, the understorey comprised an herbaceous layer with herbs and short grasses and a shrub layer with semi-deciduous shrubs.

2.2 THE PRESCRIBED FIRE

The prescribed fire was carefully controlled as regards its propagation speed, the size of the flame front and the intensity of energy emitted per unit area. It was started in the early morning when the air humidity was still high, the plants relatively moist and the air temperature low. Burning progressed at the rate of ten to fifteen metres per

hour and when the burning conditions increased this speed, the fire patrol personnel doused the vegetation with water to slow down the rate of fire spread. The burning process used was guided by the meteorological conditions and took a long time to complete because there was almost no wind. This had the benefit, however, of enabling more complete burning of the vegetation and litter, and allowed the use of more fire propagation lines (Fernandes *et al.*, 2003).

2.3 SOIL SAMPLING

The soils were sampled at points on a grid to ensure a good coverage of the study area before and after the fire. Thirty plots (1 x 1 m²) were established at grid points. On each plot, before and after the fire, samples were collected of the O and A horizons (disturbed samples from the depths of 0-1cm and 1-5cm; undisturbed samples from the 0-5 cm depth). The sampling procedure was carried out according to the international standards ISO 10381-1 and ISO 10381).

The main objectives of the sampling design were to identify whether there was an impact of controlled fire on selected soil physical and chemical parameters in *Pinus pinaster* forest plantations: namely, soil pH, electrical conductivity, content of organic matter, clay, silt and sand content and bulk density. As this study focuses on results before and immediately after the prescribed fire, meteorological factors are not considered in explaining

any differences.

At each sampling point, the following samples were collected and measurements made: i) the litter was collected from 25 cm x 25 cm plots to determine the potential fuel load; ii) 5 x 5 cm soil cores were collected for laboratory measurements of bulk density and total porosity; and iii) *in situ* soil moisture contents were obtained using an electromagnetic probe (Thetaprobe ML2X). In the laboratory, pH and electrical conductivity were determined according to the procedures described by Benton Jones (2001), organic matter and particle size distribution were determined for the pre- and post-fire soil samples.

3 RESULTS

A summary of the main findings is given in Table 1. None of the variables measured indicated any significant change as a result of the passage of the fire. This is most probably attributable to the probably low near-surface peak temperatures reached during the fire, which we estimate were nowhere more than 100°C and more likely restricted to 50-80°C.

4 CONCLUDING REMARKS

The controlled fire in our study was conducted in an area that had not been burned for two decades, so that a 5-cm (minimum) thick layer of litter had accumulated. The timing of the fire was based not only on the favourable meteorological conditions needed to conduct the fire, but also on the moisture content of the fuel, which was sufficiently low to enable combustion, but high enough to prevent major heat penetration into the soil. The results indicate that there was no measurable impact of this carefully conducted prescribed fire on the properties of the soil. The fire only affected the litter layer, as intended before the controlled fire applied. Confirmation of this tenuous impact on the soil was provided by regrowth of grasses and herbs already occurring two months after the fire.

The implication is, therefore, that provided this fire prevention strategy is carried out under existing strict guidelines, any impact on the soil physical and chemical features considered in this study will be minimal.

ACKNOWLEDGEMENTS

Eng^o António Vivas and Eng^o Eduardo Carvalho from

Autoridade Florestal Nacional (AFN) (now called the *Instituto da Conservação da Natureza e das Florestas (ICNF)*) are especially thanked for their enormous support and collaboration in fieldwork. The financial support of the British Council and CIGAR funds is gratefully acknowledged.

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