Types of ash resultant from burning different vegetation and from varied combustion processes

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Summary: *Some of the physical and chemical properties of ash produced from* Pinus halepensis *collected after a wildfire and* Eucalyptus radiata *burned by a prescribed fire and under laboratory controlled conditions were determined and compared. The ash was found to be different, depending on the combustion characteristics and vegetation type. The different properties of ash will affect the recovery of the ecosystem after fire.*

Key words: *ash, ash properties, fire type, temperature of combustion*

INTRODUCTION

The intensity of a forest fire and the resulting burn severity can be complex and varied. This variability is a function of fuel load, weather, vegetation type, vegetation and soil moisture, slope, fire climate, topography, time since last burned and area burned (Neary *et al*., 1999).

Products of forest fire such as soot, charcoal and ash reflect the characteristics of a fire. Ash, in the broad sense is a solid residue of various sizes that can include both organic and inorganic material. As combustion ceases it is deposited and blankets the soil (Scott, 2010; Moody *et al*., 2009). Depending on the characteristics of the forest fire, ash may have a different colour, organic carbon content, particle size or chemical composition. Therefore ash is an indicator of fire characteristics.

The objective of this work is to compare some physical and chemical properties of different types of ash produced from burning different vegetation and from varied combustion processes.

METHODOLOGY

Four different types of ash were used for the experiment: (i) ash collected after a prescribed fire in a dry Eucalypt forest in Australia, (ii) ash produced by a controlled fire that simulated a low intensity bushfire in dry Eucalypt forest (iii) ash produced by a controlled fire that simulated a high intensity bushfire in dry Eucalypt forest, (iv) ash collected after a low intensity fire in a Spanish Mediterranean forest of *Pinus halepensis*.

In the simulated low intensity fire, mostly fine leaves and branches were used, the leaves had moisture content of 14.5 %. The fire was circular and was ignited from one edge and allowed to spread by wind until all the fuel was burned (Fig. 1a). Three thermocouples connected to a data logger were used to measure the temperature (average = 300 ºC, maximum = 600 ºC). Leaves (3 % moisture content), branches and logs were used to simulate the high intensity fire. The fire was ignited in a barrel (Fig. 1b) and was allowed to burn for a longer period of time than in the previous fire, again temperatures were measured using thermocouples (average temperature = 500 ºC, maximum = 1234 ºC).

The four types of ash were kept in plastic bags and analysed for bulk density, particle density, particle size, water repellency, pH and cation content (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}).

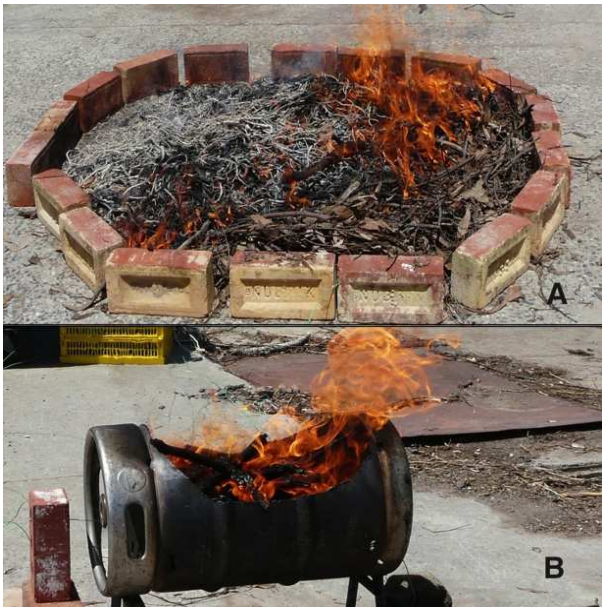

FIGURE 1. Ash produced under controlled conditions a) low intensity fire b) high intensity fire.

RESULTS AND DISCUSSION

The *Eucalyptus radiata* ash collected after the prescribed fire and made by simulating a low severity fire had similar appearance and properties (Table 1). Temperatures of the fire during these two treatments are thought to have been similar. At lower burn temperatures organic material is semi-combusted resulting in the presence of large particles of charcoal. The water repellency of this ash was found to be extreme due to the high content of organic particles (Bodí *et al*., 2011). The ash produced from the more intense controlled fire had a higher particle density, porosity and pH, the particle size of the material was smaller, which is consistent with the findings of Woods and Balfour (2011), and was hydrophilic. At higher temperatures organic material is fully combusted.

Pinus halepensis ash from a low intensity wildfire in the Mediterranean forest is similar to the ash from *Eucalyptus radiata* collected after a prescribed fire in terms of particle size and particle density, probably due to the similar combustion temperature. However, *Pinus halepensis* ash had higher porosity and therefore a lower bulk density and did not exhibit water repellency. The cation content and pH was also higher in the Mediterranean ash possibly due to the difference in species and the underlying basic nature of the lithology in the *Pinus halepensis* burned area (Úbeda *et al*., 2009).

CONCLUSION

Ash produced during a forest fire is different depending on the burn characteristics and the vegetation. These different properties will influence the water quality, soil hydrology, air quality, nutrient cycling and the recovery of an ecosystem after a fire.

Ash properties can provide evidence of fire intensity and the type of vegetation burned. Therefore the study of ash may be a great help in assessing wildfire severity.

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Ash properties	*Ash from Australian dry Eucalyptus forest (Eucalyptus radiata)*			*Ash from low severity fire in a Mediterranean forest of Pinus halepensis*
	Prescribed fire	*Produced in the laboratory simulating a low severity fire*	*Produced in the laboratory simulating a high severity fire*	
Bulk density (g cm^{-3})	*0.52*	*0.38*	*0.35*	*0.29*
Particle density (g cm^{-3})	*1.42*	*1.35*	*2.04*	*1.47*
Porosity (%)	*0.63*	*0.72*	*0.82*	*0.80*
Particle size (%, 2-0.05 mm; 0.05-0.002 mm; <0.002 mm)	*60, 38, 2*	*53, 45, 2*	*32, 64, 4*	*73, 26.5, 0.50*
Particles > 2 mm (%)	*48.24*	*36.34*	*43.87*	*13.64*
Water repellency (WDPT -seconds)	*3600*	*3600*	*<5*	*<5*
pH	*7.53*	*8.87*	*9.24*	*9.42*
Cation content (mg L^{-1}): Ca^{2+}	*24.67*	*45.04*	*24.29*	*58.4*
Mg^{2+}	*9.68*	*14.12*	*1.97*	*12.2*
Na^{+}	*6.60*	*7.5*	*8.30*	*28*
K^{+}	*5.81*	*5.81*	*20.42*	*9.6*

TABLE 1. Ash properties.