Impact of a prescribed fire on soil water repellency in a Banksia woodland (Western Australia)

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Introduction

The Swan Coastal plain of Western Australia (Figure 1) is dominated by fire-prone Banksia woodland (Burrows and McCaw, 1990). In these areas, prescription burning is often used to reduce the risk of wildfires, by reducing available fuels (Boer et al., 2009).
Fire may cause strong modifications of the physical characteristics of soils and landscapes. Fire causes intense decreasement of plant cover and consumption of litter layers. Combustion of soil organic matter results in changes of aggregate stability, texture, pore system, color and other physical and chemical properties. Although most of the heat released is lost upwards, significant changes may be observed in the first centimeters of the soil profile after burning, depending on temperature peaks reached and residence time. Wind, relief, fuel density, soil characteristics and others contribute to a diversity of temperatures and residence times. Consequently, burning is not an homogeneous process.

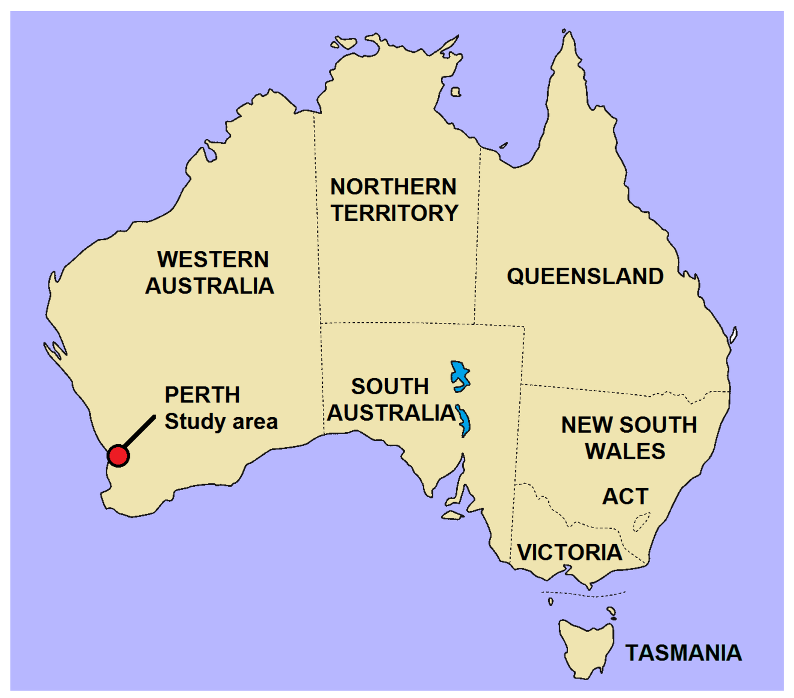

Figure 1. Study area.

Little research has been conducted on the effects of prescription burning on Banksia woodlands, and, in particular, information on the impacts on soil properties and soil water repellency (SWR) is scarce. Here, we have studied the impact of fire on SWR in a banksia woodland and monitored its evolution in the medium-term. It is expected that results are useful for management and restoration of fire-affected Banksia woodlands.

Methods

An experimental fire was conducted on May 7th 2015 in Kings Park, Perth, Western Australia (Figure 2). The fire affected an area of 6 ha of mixed Banksia/Allocasuarina woodland under moderate fire intensity (Figure 3). At the time of ignition, the wind speed below the canopy was 1.2 km/h. During the prescribed burning, air temperatures were on average 20 1 C and relative humidity ranged between 45 and 55% (measured using a Kestrel portable weather station). Fuel moisture averaged 11.8% measured using Wiltronics moisture meter) and soil moisture at 1 cm deep ranged from 0.1% to 8.6% (measured with a PR2 soil profile probe attached to a HH2 data logger). Temperatures greater than 120 ºC were measured 1 cm below the soil surface using iButton temperature sensors. SWR was measured under lab conditions in oven-dry samples (48 h, 105 ºC) with the water drop penetration time (WDPT) test.

Figure 2. Detail of the prescribed burning in Kings Park (Perth, WA).

Figure 3. View of the experimental area after burning.

Soil microbial activity was determined with the 1-day CO_2 test that is based on the measurement of the CO_2 burst produced after moistening dry soil (Muñoz-Rojas et al., 2016).

Figure 4. José Antonio (IRNAS-CSIC, Sevilla, Spain) and Ryan (Kings Park Botanic Gardens, Perth, WA, Australia) collecting soil samples in the experimental area.

Figure 5. Left: view of the unburned area. Right: Detail of one of the transects in the unburned area.

For SWR characterization, soil samples were collected before and one week after burning (Figure 4). At each case, 6 transects (Figure 5) were established at randomly selected points. At each transect, 6 soil samples were collected using sampling cores every 2 m. Soil samples from each transect were gently mixed and homogeneized, resulting in 6 composite samples. A similar sampling design was used in an adjacent unburned control area in the same dates.

SWR was assessed using the Water Drop Penetration Time (WDPT) test (Doerr, 1998). The median value was calculatd for each treatment and date. According to Bisdom et al. (1993), soil was considered wettable (WDPT < 5 s) and SWR was classified as slight (6-60 s), strong (61-600 s), severe (601-3600 s) and extreme (>3600 s).

Results and discussion

SWR was severe in the pre-fire control (median = 2608 s) and pre-fire areas (2722 s) (Figure 6). One week after the prescribed fire, persistence of SWR remained stable in the burned area (2402 s). In contrast, extreme SWR was observed in the unburned area (3750 s).

Increased SWR in the unburned area may be explained by variations in the environmental conditions (eg, decreased soil moisture). Suposedly, these variations also affected the burned area, where no significant changes were observed between pre-fire and post-fire values. Although an increase in SWR was expected in the burned area (as recorded in the control area), similar pre-fire and post-fire values may be a result of a decrease of hydrophobic organic matter content due to combustion, as observed in other cases (Zavala et al., 2009; Jordán et al., 2014).

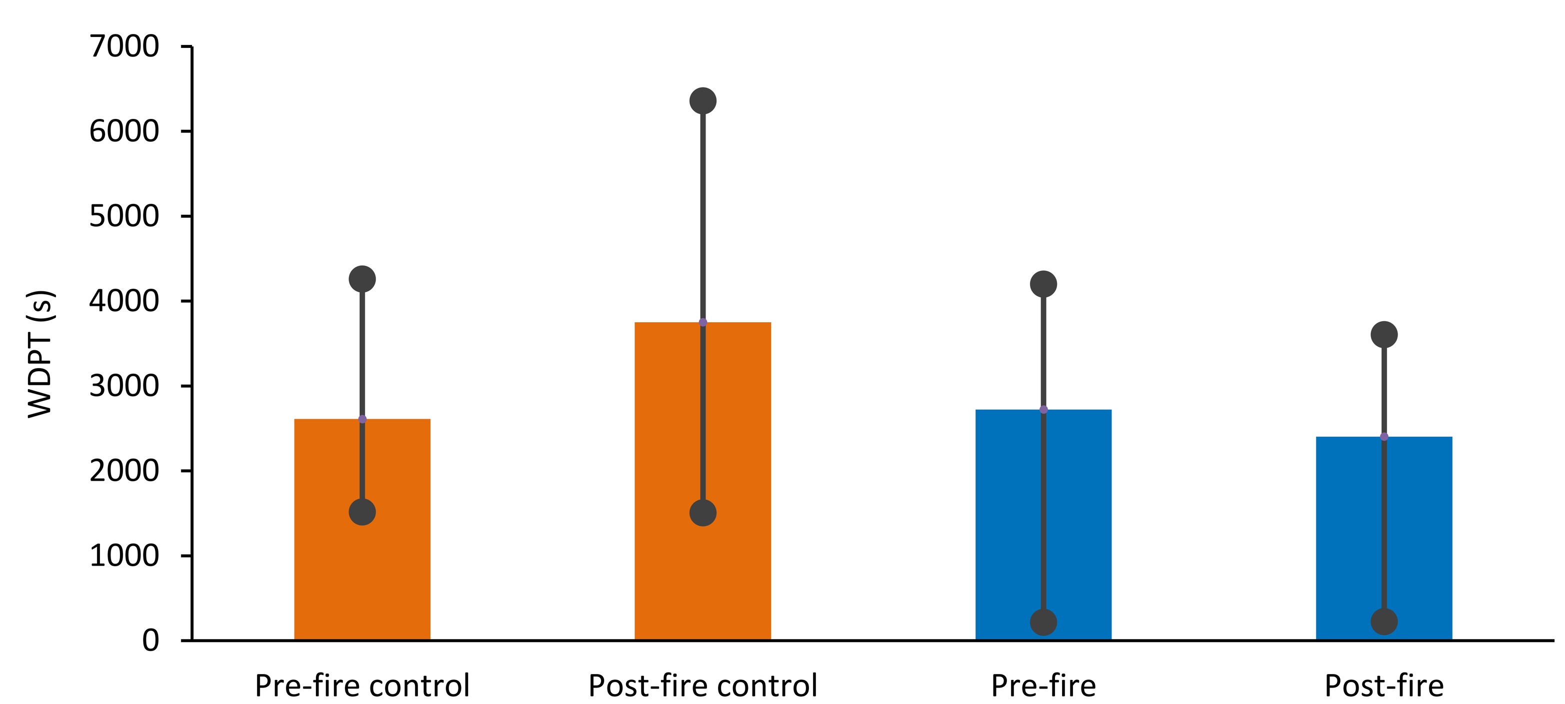

Figure 6. Soil water repellency (median WDPT, s) in control and burned areas immediately before burn (pre-fire) and one week after burn (post-fire). Lines correspond to minimum and maximum values.

Although prescribed burning usually does not produce high-severity fires, evidences of high severity were found, due to prolonged smouldering caused by subsurface Banksia root clusters. In some cases, this led to release of iron oxides, observed as red spots in surface or subsurface points (Figure 7). Prolonged burning at relatively low temperatures contributed to a decrease of hydrophobic organic matter content.

Figure 7. Detailed view of the first few centimeters of the fire-affected soil layer (left) and the release of iron oxides in the surface (center) and subsurface (right) soil layers. In the last case, a thick subsurface layer formed by burned Banksia root clusters are observed.

Fire in Mediterranean and semi-arid environments has a significant effect on microbial biomass and the composition of soil microbial communities during the post-fire period, when soil nutrients become available (Bárcenas-Moreno et al., 2011; Muñoz-Rojas et al., 2016). In our study, microbial activity increased sharply in the burned area (Figure 8) and most likely contributed to a decrease of organic hydrophobic substances in the first centimetres of the soil profile. Bárcenas-Moreno et al. (2011) observed that bacterial activity increases immediately after fire, while fungi decreased and recovered slowly. These processes may contribute to explain differences in SWR following fire, since this soil property may be influenced by fungal activity (Lozano et al., 2013).

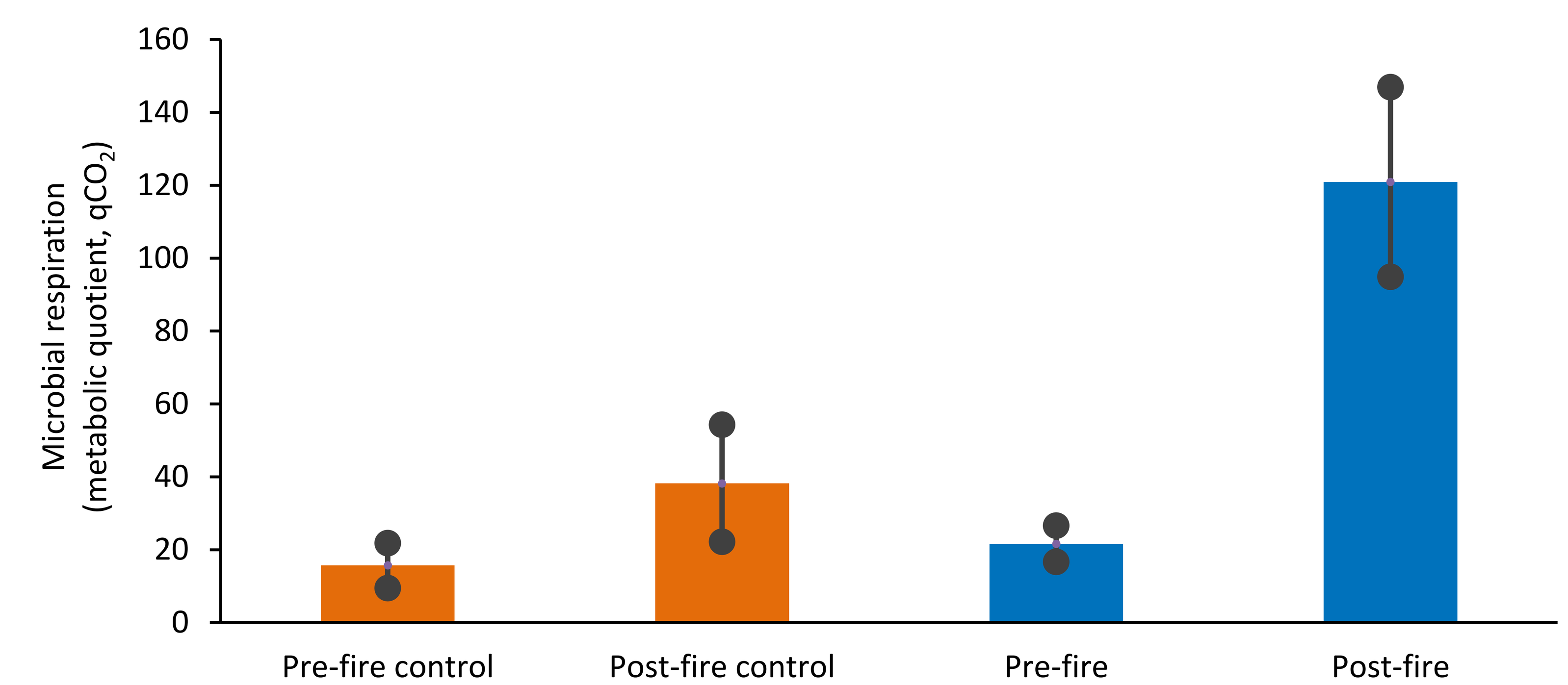

Figure 6. Soil microbial respiration (metabolic quotient, qCO_2) in control and burned areas immediately before burn (pre-fire) and one week after burn (post-fire). Lines correspond to ± standard deviation values.

References. All cited references are included in Muñoz-Rojas et al. 2016. Impact of a prescribed fire on soil water repellency in a Banksia woodland (Western Australia). Geophysical Research Abstracts, Vol. 18, EGU2016-16926-2

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