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Understanding environmental drivers in the regulation of soil respiration dynamics after fire in semi-arid ecosystems

Miriam Muñoz-Rojas (1,2,3), Wolfgang Lewandrowski (1,2), Todd E. Erickson (1,2), Kingsley W. Dixon (1,2,3), David J. Merritt (1,2)

(1) University of Western Australia, School of Plant Biology, Crawley, 6009, WA (miriam.munoz-rojas@uwa.edu.au), (2) Kings Park and Botanic Garden, Kings Park, Perth 6005, WA, (3) Curtin University, Department of Environment and Agriculture, 6845 Perth, WA, Australia

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Introduction

Soil respiration (Rs) has become a major research focus given the increase in atmospheric CO_2 emissions and the large contribution of these CO_2 fluxes from soils (Van Groenigen et al., 2014). In addition to its importance in the global C cycle, Rs is a fundamental indicator of soil health and quality that reflects the level of microbial activity and provides an indication of the ability of soils to support plant growth (Oyonarte et al., 2012; Munoz-Rojas et al., 2015). Wildfires can have a significant impact on Rs rates, with the scale of the impact depending on environmental factors such as temperature and moisture, and organic C content in the soil. Vegetation cover can have a significant effect on regulating organic C contents; and while advances are made into understanding the effects of fire on organic C contents and CO_2 fluxes (Granged et al., 2011; Willaarts et al., 2015; Muñoz-Rojas et al., 2016), there is limited knowledge of the variability of Rs across ecosystem types, vegetation communities, and responses to fire. In this research we aimed to assess the impacts of a wildfire on the soil CO_2 fluxes and soil respiration in a semi-arid ecosystem of Western Australia (Pilbara biogeographical region), and to understand the main environmental drivers controlling these fluxes in different vegetation types. The study has application for other arid and semi-arid regions of the world.

Methods

The study area was selected following a wildfire that affected 25 ha in February 2014. Twelve plots were established in the burnt site (B) within a 400 m2 area, and 12 plots in an adjacent unburnt control site. At each site, three plots were installed below the canopy of each of the most representative vegetation types of the areas: Eucalyptus trees, Acacia shrubs and Triodia grasses, and three on bare soil. Soil sampling and measurement of soil CO_2 efflux, temperature and moisture were carried out one week after wildfire in the summer-wet season (February 2014) and repeated six months (in July 2014, during the winter-dry season) and twelve months after the wildfire (in February 2015, during the following summer-wet season). Soil physicochemical analyses were undertaken according to standard methods. Rs was measured with a 6400-09 portable soil CO_2 flux chamber attached to a LI-COR 6400. Soil temperature was measured with a thermometer attached to the LI-COR and soil moisture with a portable Moisture Probe MP406. Both temperature and moisture were measured directly adjacent to the collars and simultaneously with Rs at a depth of 5 cm.

Results and discussion

Larger rates of Rs were found in the burnt areas compared to those unburnt. However, Rs showed a large variation among vegetation types in both burnt and unburnt areas for each time period following fire and Rs and soil organic C were consistently higher under Eucalyptus trees. Environmental factors (temperature and moisture) could explain a large fraction of Rs variability and therefore the roles of both water availability and temperature are critical to explain the CO_2 fluxes in these environments. Yet, these relations are variable and change across vegetation types, indicating that specific models need to be used to accurately estimate Rs rates. This study demonstrates the importance of assessing CO_2 fluxes following fire considering both environmental factors and vegetation types. This is particularly important in heterogeneous semi-arid areas that are characterized by patchy vegetation distribution where CO_2 fluxes can be largely underestimated.

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