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Combined effects of anthropogenic fires and land-use change on soil properties and processes in Patagonia, Chile

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ABSTRACT

Fire and land-use change are two major types of disturbances that strongly affect the structure and function of forest ecosystems around the world, although their impacts can be difficult to quantify due to concomitant changes in climate or other land-use change factors. In this study we examined how fire and subsequent land-use conversion impacted soil properties (i.e. organic matter (OM), total available pools of carbon (C), nitrogen (N), and phosphorous (P)), and processes (i.e. N cycling inferred through $\delta^{15}N$) in each of six different land cover types, including old- and second-growth native *Nothofagus pumilio*, ~50 year old exotic conifer plantations, and grassland pastures. We selected six land cover types, including unburned old-growth (MF), and post-fire second-growth (SG) forests of *N. pumilio*, post-fire afforestations of *Pinus contorta* (PC), *P. ponderosa* (PP) and *P. sylvestris* (PS), and post-fire grassland (GR), in three watersheds in the Aysén Region, Chilean Patagonia. In one growing season, at each of 5–7 sampling locations within each site, two 10 cm deep soil cores were removed using a 12.4 cm diameter PVC soil-corer. From each soil core, organic matter content, total C and N concentrations, availability of NH_4^+, NO_3^-, and PO_4^-, and $\delta^{15}N$ were determined. Additionally, we collected foliage of *Osmorhiza chilensis*, a forb that was present in every tree-cover condition, for $\delta^{15}N$ determination. Unburned old-growth *Nothofagus* forests showed significantly higher stocks of OM, C, N and P than the *P. contorta* and *P. sylvestris* afforestations but not higher than *Nothofagus* second-growth forests and *P. ponderosa* afforestations. Conifer afforestations showed significantly lower NH_4^+ values than unburned *Nothofagus* forests, whereas no differences in NO_3^- were found among the land cover types. Contrary to expectations, conifer afforestations showed significantly higher plant and soil $\delta^{15}N$ values than the unburned *Nothofagus* forests. Although most land cover types resulted in significant alteration of soil properties and processes relative to the mature, unburned *N. pumilio* forests, we highlight that *P. ponderosa* afforestations generated the most similar characteristics, suggesting a utility of this species to restore some ecosystem properties.

1. Introduction

Fire is the dominant type of natural disturbance in many forest ecosystems around the world. In many cases they occur at large scales, and have a strong control on forest dynamics by burning existing forests and initiating a new regeneration cycle (Veblen et al., 2011). Many early-successional tree species are able to persist only because of large-scale fires, and are dependent on the post-fire regeneration environment. One well known way that fire influences forest ecosystem dynamics is through its effects on soil properties and processes (Neary et al., 1999). Fire can strongly influence soil structure and nutrient availability, as well as ecosystem nutrient and carbon (C) budgets (Neary et al., 1999; Chapin et al., 2002; MacKenzie and DeLuca, 2006), with magnitude of change depending on the intensity, frequency or evenness of fire (Gundale et al., 2006; Bond-Lamberty et al., 2007). For example, nitrogen (N) availability can sharply increase following fire due to the conversion of organic to inorganic N, as well as enhanced mineralization and nitrification rates (e.g. Covington and Sackett, 1992; Davidson et al., 1992; Gundale et al., 2005). Although, in other cases, N availability has proved to decrease with time since fire (e.g. DeLuca et al., 2002; MacKenzie et al., 2004). While much is known about the short-term impact of fire in systems where fires commonly occur, relatively little is known about the long term impact of fire in forest systems where fire is uncommon, and is accompanied by land-use change.

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