Short-term effects of litter extraction on soil respiration, soil temperature and soil water content in a Sclerophyll forest of Central Chile

Juan-Pablo Fuentes[A], Horacio Bown[A], Daniela Gatica[A] and Jorge Pérez[B]

[A]Faculty of Forestry Sciences and Nature Conservation, University of Chile, Santiago, Email jufuente@uchile.cl
[B]Faculty of Agronomic Sciences, University of Chile, Santiago.

Abstract
Litter extraction is a common practice in sclerophyll forests of Central Chile. This process has caused a long-term depletion of C substrates, thereby affecting biogeochemical balances, soil microbial populations, and plant germination. Evaluation of the effects of litter removal on biophysical parameters such as soil respiration, soil temperature and soil water content do not exist for this type of forest ecosystems. The aim of this study was to evaluate the short-term effect, caused by the extraction of soil organic layers in a peumo-boldo-litre forest ecosystem, in these biophysical parameters. Soil respiration, soil water content and soil temperatures at different depths were measured in a 24-days period. Immediate extraction of soil litter layers did not cause significant differences in soil respiration. In the consecutive sampling days, litter extraction caused significant decreases in soil respiration. Overall, the extraction of organic layers caused a decrease of about 33% in soil respiration. The extraction of soil organic layers, particularly the Oe+Oa layers might be responsible of the decrease in soil respiration. These layers contain considerable amounts of readily decomposable sources of C as well as microbial populations that could contribute to soil respiration. The decreased soil water content impeded a good correlation between soil T and soil respiration.

Key Words
Soil respiration, litter removal, sclerophyll forest, Chile.

Introduction
In the last decades, soil respiration has been considered one of the main fluxes of carbon in terrestrial ecosystems. Approximately 70% of CO_2 exchange between the forest ecosystem and the atmosphere comes from the soil (Raich and Schlesinger 1992; Granier *et al.* 2000). The soil respiration rate is controlled by the decomposition of soil organic matter (SOM), the inputs of plant debris, root respiration (Raich 1998), and soil environmental factors such as soil temperature and soil water content. Since an important fraction of soil respiration depends on litter decomposition, plant litter removal can reduce soil respiration up to 25% (Luo and Zhou 2006). In sclerophyll forests of Central Chile, litter removal is a common practice which has contributed to the degradation of these ecosystems, causing soil nutrient and SOM depletion, soil erosion and germination problems of tree seeds. Effects of litter removal on biophysical parameters have not been determined for this type of forest ecosystem. The aim of this study was to evaluate the short-term effects (i.e. first 20 days) of litter extraction on soil respiration, temperature, and soil water content in a sclerophyll forest of Central Chile. We also elevated the effect of temperature and soil water content on soil respiration. We hypothesize that litter extraction will made the declination of soil respiration as a consequence of changes in environmental factors and the depletion of SOC substrate.

Materials and methods
Study area and site description
The study area was located in Central Chile (34°7'36"S, 71°11'18"W; 247m above sea level) near the city of Santiago (Figure 1). The climate type of the zone is Mediterranean with a mean annual precipitation of 503 mm, and maximum and minimum annual air temperatures of 29 and 3°C, respectively (CONAF 2008). The study site was located in a toe-slope position and represents a typical example of the natural vegetation of the region. However, the site has less anthropogenic disturbances compared with similar ecosystems of the region (i.e. harvesting and forest fires occurred around 50 years ago). The natural flora of the site is composed by peumo (*Cryptocarya alba* (Molina) Looser), boldo (*Peumus boldus Molina*), and litre (*Lithraea caustica* (Molina) H. et A.). The soil has developed from alluvial granitic deposits, with the particle-size distribution dominated by the silt fraction. It has well-developed organic layers (Oi, Oe, and Oa) on the surface and an A horizon rich in humified SOM.

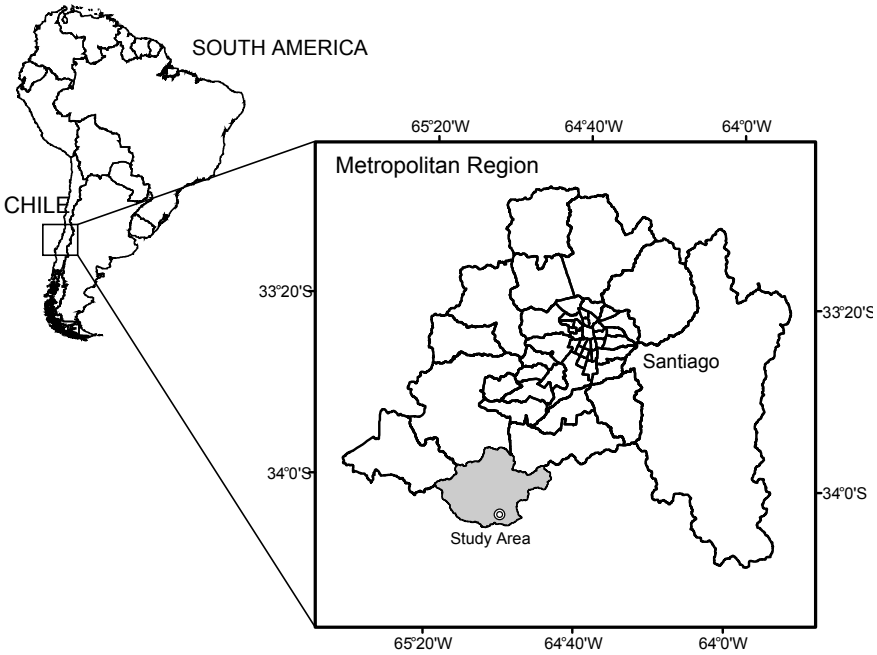

Figure 1. Location of the study area in the Metropolitan Region of Chile.

Experimental setup

A total of three plots of 10 x 10 m were selected. At each plot, 12 cylinders (polyvinyl chloride, 10 cm internal diameter, 8 cm length) were randomly installed. Cylinders were inserted manually, avoiding major soil and organic layers disturbances. One week after the insertion of the collars, soil litter layers (Oi and Oe+Oa) were extracted from six cylinders per plot. The litter extraction treatment (LE) represented the manual cleaning of an area of 0.56 m^2. The litter extracted was equivalent to 14.4 and 9.2 Mg/ha of the Oi and Oe+Oa layers, respectively. Cylinders with no litter extraction were considered as the control treatment (NLE).

Measurement of biophysical parameters

Soil respiration (R), volumetric soil water content (θ), and soil temperature (T) were measured immediately after the extraction of the organic layers and then, every four days for a total period of 24 days. Soil respiration ($gCO_2/m^2/h$) was measured with a portable infrared gas analyzer (Model EGM-4, environmental Gas Monitor System, PP Systems, USA). Volumetric soil water content in the top six-cm of soil, was determined with a time domain reflectometer connected to a datalogger (WET Sensor model WET-2, HH2 moisture meter, Delta-T Devices, UK). This sensor also includes a temperature sensor that allowed soil temperature determination at 6-cm soil depth. Soil temperature at 10.5- cm depth was measured using a digital thermometer (Checktemp 1, Hanna Instruments, USA). Surface soil temperature was also measured with an infrared thermometer (IR Wide Range Non-Contact Thermometer, Extech Instruments, USA) inside each cylinder, and immediately after the measurement of soil respiration.

Data analysis

Analysis of variance (ANOVA) was used to test for differences in R, θ, and T between treatments, and during the different days of measurements. The ANOVA model considered a complete randomized block design with one way treatment structure. Additionally, a correlation analysis was performed between T,θ, and R as the response variable.

Results

Immediate extraction of soil litter layers did not cause significant differences (p=0,437) in soil respiration. At day 4 however, and in the consecutive sampling days, litter extraction caused significant ($p<0.001$)) decreases in soil respiration. Comparing the means of all sampling days, the extraction of organic layers caused a decrease in about 33% as compared with the NLE treatment (Figure 2). This decrease is consistent with other studies that found similar effects under conifer forests (Ma *et al.* 2005). Temporal variation of soil respiration was not significantly correlated with θ or T. Soil water content was low during the trial (i.e. <0.25 m^3/m^3); thus the potential correlation between soil respiration and temperature was particularly weak. Rey *et al.* (2002) evaluating seasonal changes in soil respiration concluded that volumetric water contents lower

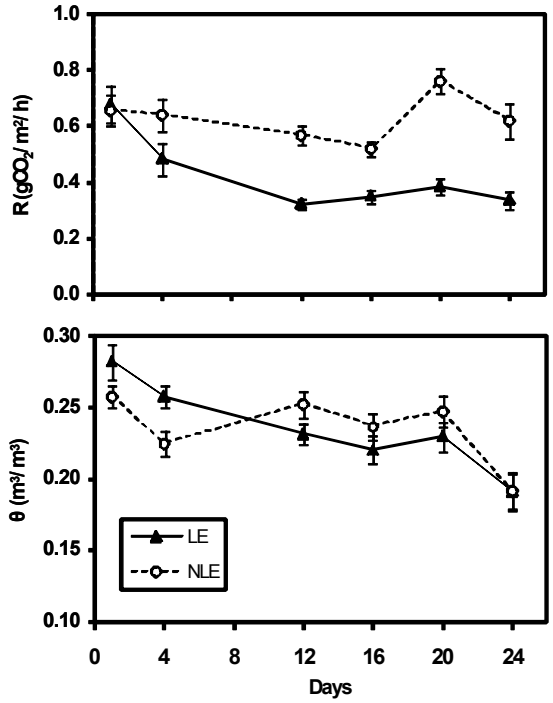

Figure 2. Temporal variation of soil respiration and volumetric water content in the top 6.5-cm depth in the litter extracted (LE) and no litter extracted (NLE) treatments. Differences between LE and NLE at days 1 and 4 are caused by a sampling artifact related to sampling depth. Error bars indicate ± one standard error of the mean.

than 0.20 m^3/m^3, can distort the relationship between R and T. The extraction of organic layers caused a significant increase in soil surface temperature (from 15.1 to 20.4 ^oC), which can be attributed to changes in surface albedo. At lower depths, soil temperature was not significantly affected by the extraction of the organic layers (Figure 3).

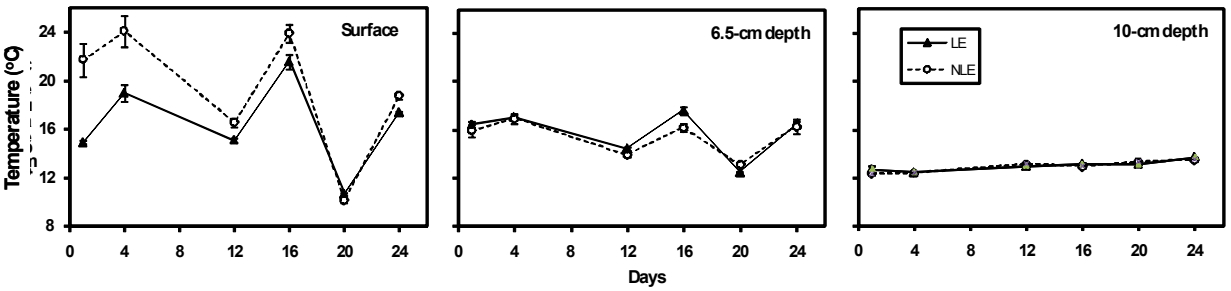

Figure 3. Temporal variation of soil temperature, at different depths, in the litter extracted (LE) and no-litter extracted (NLE) treatments. Error bars indicate ± one standard error of the mean.

Conclusions

The sclerophyll forest of Central Chile is characterized by an intensive use, particularly in terms of cattle activities and the extraction of forest litter. The later process has caused the degradation of the soil and the perturbation of the C balance. The results of this study showed that soil respiration decreased in the first days after the removal of organic layers. The main factor responsible for this variation seems to be related to the depletion of the organic substrate rather than changes in temperature and soil water content. Particularly, the removal of the more humified layers (Oe+ Oa) possibly created a lack of readily-available C sources and the extraction of a substantial population of the microorganisms responsible of C degradation.

Acknowledgements

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