Comparison of soil water repellency and sorptivity between an *Acacia caven* (highly-perturbed) and *Cryptocarya alba* (slightly-perturbed) dominated ecosystem

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Abstract
Schlerophyll ecosystems are the predominant vegetation type in Central Chile having a long history of degradation by fire, cultivation, firewood extraction and grazing, among others. In order to test soil organic carbon (SOC) mediated reductions in water repellency from a slightly-disturbed *Cryptocarya alba* to a highly-disturbed *Acacia caven* site, we compared intact soil aggregates and sieved soil samples from both situations using a micro-infiltrometer. We found a significantly greater concentration of SOC and repellency index (R) under the slightly-disturbed *C. alba* compared to the highly-disturbed *A. caven* site. We also found a significant correlation between these two parameters for intact soil aggregates. It seems that SOC rather than disturbance per se, could be the main factor mediating water repellency. Water repellency did not significantly decrease in sieved- compared to intact-samples, suggesting that water repellency is independent of soil structure.

Key Words
Water repellency, sorptivity, disturbance, schlerophyll ecosystems.

Introduction
Schlerophyll ecosystems cover around 345 thousands (2.6%) of the 13.4 million ha of native forests in Chile, being the predominant vegetation type in Central Chile where, the greatest proportion of the population lives, emphasizing the need for its conservation. The development of the rural settlements has had a negative effect on Mediterranean ecosystems, as a result of using fire before cropping, firewood extraction and overgrazing practices. These practices have resulted in soil erosion and soil degradation. Protection of previously over-exploited areas has permitted the recovery of some vegetation and soil processes. Here arises the question whether or not soil recovery is taking place and at what extent. The aim of this study was to compare water repellency and sorptivity (S) from intact and sieved soil samples from an *Acacia caven* (highly-perturbed) and *Cryptocarya alba* (slightly-perturbed) dominated ecosystem. We hypothesize that soil repellency is driven by soil organic carbon, so that, the slightly-perturbed site would exhibit greater repellency than the highly-perturbed site for both intact and sieved soil samples.

Material
The study was carried out in the National Reserve "Roblería del Cobre de Loncha", located in Alhué, Central Chile (Figure 1). The climate is calid-template (Cs) with a prolonged dry season from 6 to 8 months according to the classification of Koeppen and Fuenzalida (U. de Chile 2007). Rainfall is concentrated during the winter months (June to August) with an annual average of 503 mm (Santibañez and Uribe 1993). Two sites were selected, representing two conditions with contrasting disturbance levels:

Abandoned agriculture: these sites are characterized by historical extraction of firewood followed by agricultural crops (mainly wheat). After disturbance ending around thirty years ago, a perennial cover of around 10% was gradually established with the legume tree *Acacia caven* and some schlerophyll species such as *Quillaja Saponaria* and *Lithraea caustica*. Common annual grasses from the genus *Melica*, *Nasella* and *Bromus* sp, among others, are the dominant cover during winter, and dying by the end of spring.

Slightly-disturbed schlerophyll forest: These sites are dominated by the schlerophyll species *Cryptocarya alba* (Peumo), *Lithraea caustica* (Litre), *Quillaja saponaria* (Quillay), and *Peumus boldus* (Boldo). These are second growth-coppices brought about by fire and firewood extraction 30 o more years ago. Nowadays these are slightly disturbed by occasional cattle grazing.

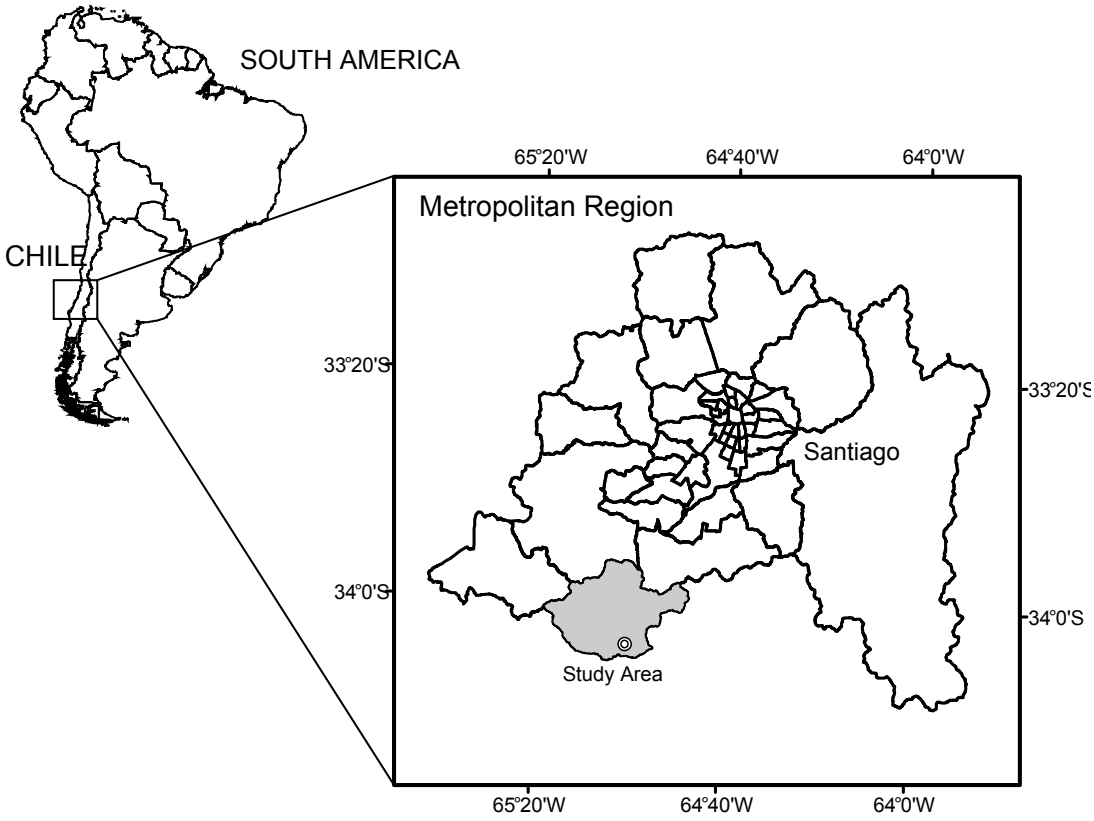

Figure 1. Location of the National Reserve "Roblería del Cobre de Loncha", Alhue, Central Chile.

Methods

In each of the two sites, soil samples of about 700 g were randomly extracted from five points, at soil depths of 0-10 and 10-20 cm. Samples were air-dried and kept in HD polyethylene boxes until water repellency measurements were taken. Repellency was measured following Hallet and Young (1999), over soil aggregates and sieved soil samples. Basically, water repellency and sorptivity are determined by the Leeds-Harrison *et al*. (1994) infiltrometer, which compares curves of infiltration versus time for water and ethanol. Soil organic C was determined by wet combustion and colorimetry. Bulk density of soil aggregates was determined by volume displacement of previously sealed aggregates. Soil porosity was calculated as a function of soil bulk density and assuming a particle density of 2.65 g cm^3.

All analyses were undertaken at the three level using the R language (R Foundation for Statistical Computing, Vienna, Austria). Variables were tested for normality and homogeneity of variance and transformations were made as necessary to meet the underlying statistical assumptions of the models used. The main effects of disturbance on soil repellency and sorptivity variables were examined by analysis of variance. Tukey's least significant difference test was used to distinguish among individual means where applicable with a confidence level of $P \leq 0.05$. Differences in the slopes and the intercepts in the relationships between soil repellency and SOC were tested for significance between *A. caven* (highly-disturbed) and *C. alba* (slightly disturbed) using analysis of covariance.

Results

Highly-disturbed (*Acacia caven*) and slightly-disturbed (*Cryptocarya alba*) sites were compared for soil porosity, soil organic carbon, water sorptivity, ethanol sorptivity, and the repellency index (Table 1). Porosity, organic carbon, ethanol sorptivity, and the repellency index significantly decreased from the slightly- to the highly-disturbed site ($P < 0.05$). In other words disturbance brought about drastic reductions in all these characteristics. Water sorptivity was not significantly different between the highly-disturbed and the slightly-disturbed sites except for the sieved samples taken from 10-20 cm depth. Soil porosity and SOC consistently decreased with soil depth for both intact and sieved samples. The same trend was observed for the repellency index. Water and ethanol sorptivity were much greater for the sieved than for the intact soil samples.

Table 1. Comparison of physical and chemical properties between an *Acacia caven* (highly-disturbed) and *Cryptocarya alba* (slightly-disturbed) dominated ecosystem. Different lower-case letters indicate significant differences at $P < 0.05$ between the highly- and the slightly-disturbed site.

	Soil depth (cm)		Porosity		Organic carbon (%)		Water sorptivity ($mm/s^{1/2}$)		Ethanol sorptivity ($mm/s^{1/2}$)		Repellency index, R	
Soil aggregates	0-10	*C. alba*	0.57	±0.02 a	6,80	±0,71 a	0,96	±0,31 a	1,67	±0,06 a	4,48	±1,18 a
		A. caven	0.38	±0.03 b	1,76	±0,25 b	1,25	±0,50 a	0,78	±0,17 b	1,61	±0,46 b
	10-20	*C. alba*	0.53	±0.04 a	3,90	±0,76 a	1,26	±0,18 a	1,70	±0,13 a	2,73	±0,27 a
		A. caven	0.34	±0.03 b	0,91	±0,06 b	1,03	±0,37 a	0,65	±0,12 b	1,42	±0,15 b
Sieved soil samples	0-10	C. alba	0.68	±0.01 a	6,80	±0,71 a	1,80	±0,19 a	2,58	±0,14 a	2,86	±0,22 a
		A. caven	0.60	±0.01 b	1,76	±0,25 b	2,06	±0,09 a	1,58	±0,13 b	1,50	±0,12 b
	10-20	C. alba	0.63	±0.01 a	3,90	±0,76 a	2,76	±0,09 a	2,48	±0,05 a	1,77	±0,08 a
		A. caven	0.58	±0.01 b	0,91	±0,06 b	1,69	±0,16 b	1,85	±0,15 b	2,24	±0,34 a

We found a significant linear correlation between R and SOC ($P < 0.001$) for intact samples but not for sieved samples ($P = 0.11$) (Figure 2). Slopes and intercepts of these linear relationships for intact samples were not influenced by disturbance, suggesting that differences in repellency between the *A. caven* and *C. alba* sites were well explained by their differences in soil organic C for intact soil aggregates.

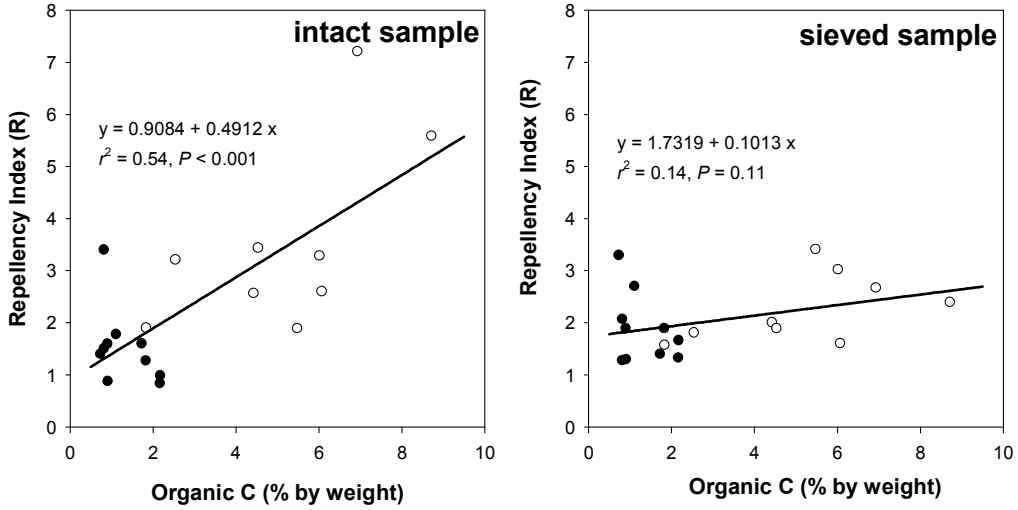

Figure 2. Relationship between measured soil organic C and repellency index for intact and sieved samples.

Conclusions

Water sorptivity did not exhibit significant differences between the *A. caven* (highly-disturbed) and the *C. alba* (slightly-disturbed) sites, although differences were found for ethanol sorptivity. Such difference suggests that there is a limiting factor to water infiltration in the slightly-disturbed site of *C. alba*. Sieved samples showed greater sorptivity which might be explained by the greater porosity in the sieved- compared to the intact-sample.

We found a significantly greater concentration of soil organic carbon and repellency index in the slightly-disturbed (*C. alba*) compared to the highly-disturbed (*A. caven*) site. We also found a significant correlation between these two variables for intact samples (but not for sieved samples). Therefore soil organic carbon, rather than disturbance *per se*, may be the main factor mediating water repellency.
Water repellency did not significantly decrease in sieved- compared to intact-samples, suggesting that water repellency is independent of soil structure.

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