Effects of snow cover on CO_2 production and microbial composition in a thin topsoil layer

Dalia López[1,2], Francisco Matus[2,3], Carolina Merino[2,3,4].

[1]Doctorate Program in Science of Natural Resources, La Frontera University, Temuco, Chile
[2]Laboratory of Conservation and Dynamic of Volcanic Soils, Department of Chemical Sciences and Natural Resources, Universidad de La Frontera, Temuco, Chile.
[3]Network for Extreme Environmental Research (NEXER) Universidad de La Frontera, Temuco, Chile.
[4]Center of Plant, Soil Interaction and Natural Resources Biotechnology. Scientific and Technological Bioresource Nucleus (BIOREN), Universidad de la Frontera, Temuco, Chile.

carolina.merino@ufrontera.cl

INTRODUCTION

Temperate rain forest soils (>8000 mm yr-1) of south of Chile are intensively affected by early and fast snow melting due to increasing climate variability in the last 20 years (Weatherspark, 2016). Most of these volcanic forests soils are unpolluted (pristine) and receive seasonal snow-cover, that contains aerosols, nutrients and microorganisms from circumpolar south west winds (Alfonso et al., 2019). We hypothesized that these inputs during the snow melting generate a change on nutrient availability at the shallow layer for soil microbiology and biochemistry processed. This may affect in turn, soil properties and the capacity for soil carbon sequestration. The objectives of the study were to evaluate the impact of snow melting on microbial and chemical properties of a topsoil in a pristine rainforest.

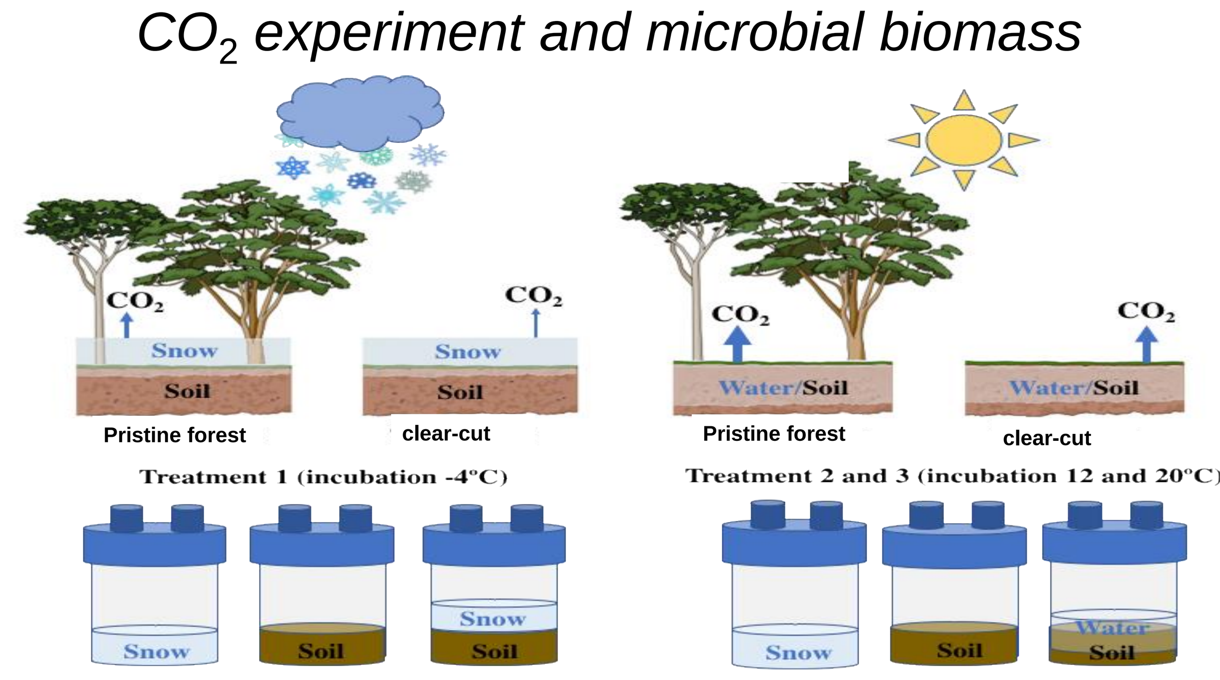
METHODS

Figure 1. Materials and Methods description

Sampling

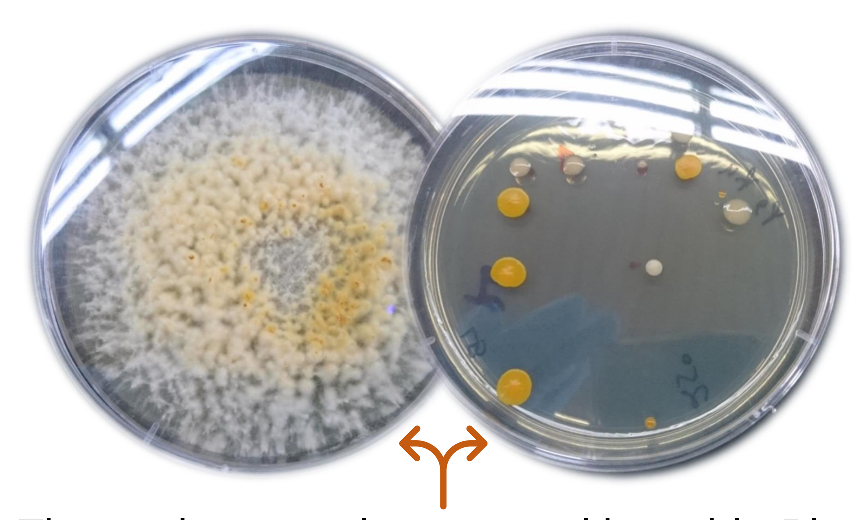
Snow and soil were sampled in Puyehue National Park (40° S) from a pristine forest (PF) and after clear-cut (CC).

CO_2 experiment and microbial biomass



20 g of soil and 10 g of snow separately and combined were incubated to see the release of CO_2. It was measured continuously during 360 h. Each 120 h the temperature was increased (-4 ºC, +12 ºC and +20 ºC). Microbial C biomass were measured before and after 5 days of CO_2 incubation according to Vance et al., (1987).

Microbial analysis



The mother samples were cultivated in Plate Count Agar (PCA) and Potato Dextrose Agar (APD) and were incubated at 27 °C and 4 °C. They were identified by MALDI TOF MS and electronic microscopy SEM equipment, to evaluated the microbial composition from soil and snow of PF and CC.

Data Analysis

We applied ANOVA test at P<0.05. The average values were explored by Tukey comparison test.

RESULTS

Table 1. Soil and snow characteristics measurements.

Analysis	Units	Pristine forest (PF)		Clear-cut (CC)	
		Soil	Snow	Soil	Snow
[1]TOC	%	11.4 ± 0.3	6.1 ± 4.8	4.6 ± 0.5	5.1 ± 3.7
N total	%	0.6 ± 0.03	0.3 ± 0.1	0.22 ± 0.1	0.2 ± 0.02
C:N ratio	Unitless	19.1	15.6	20.1	25.5
pH water	Unitless	5.3 ± 0.2	5.7 ± 0.1	6.5 ± 0.3	5.8 ± 0.05
Redox	MVolt	343.6 ± 2.8	366.7 ± 24.6	332 ± 4.4	336 ± 8.2
Conductivity	us	19.2 ± 7.4	5.4 ± 0.9	5.7± 1.5	10.6 ± 0.2
[2]NO_3^-	mg L^{-1}	3.0 ± 0.0	0.04 ± 0.1	ND	0.1 ± 0.01
NH_4^+	mg L^{-1}	6.6 ± 0.0	0.05 ± 0.0	0.06 ± 0.0	0.11 ± 0.0
Si	%	7.8 ± 2.7	5.7 ± 1.8	26.2 ± 5.1	3.6 ± 2.8
Fe	%	2.3 ± 1.3	0.6 ± 1.6	12.4 ± 6.2	5.7 ± 3.1
[3]Texture		SCL		Sandy	

[1]Total soil organic carbon; [2]ND: Not determined; [1]SCL: sandy clay loam.

Total soil organic carbon (TOC) in pristine forest (PF) soil unlike the clear cut (CC) was 16 times higher, similar for Nitrogen, 0.5 vs 0.08%, (Table 1).

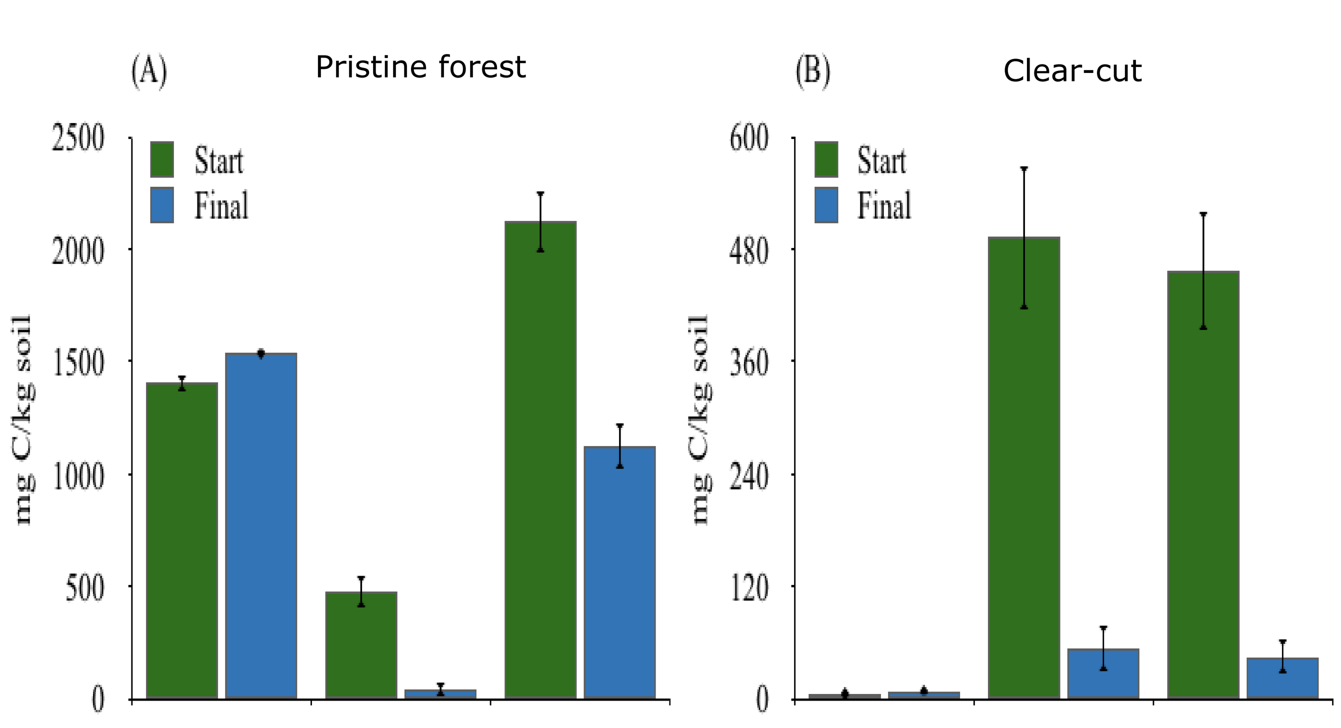


Figure 2. Soil and snow Microbial biomass of PF and CC to start and final of CO_2 experiment.

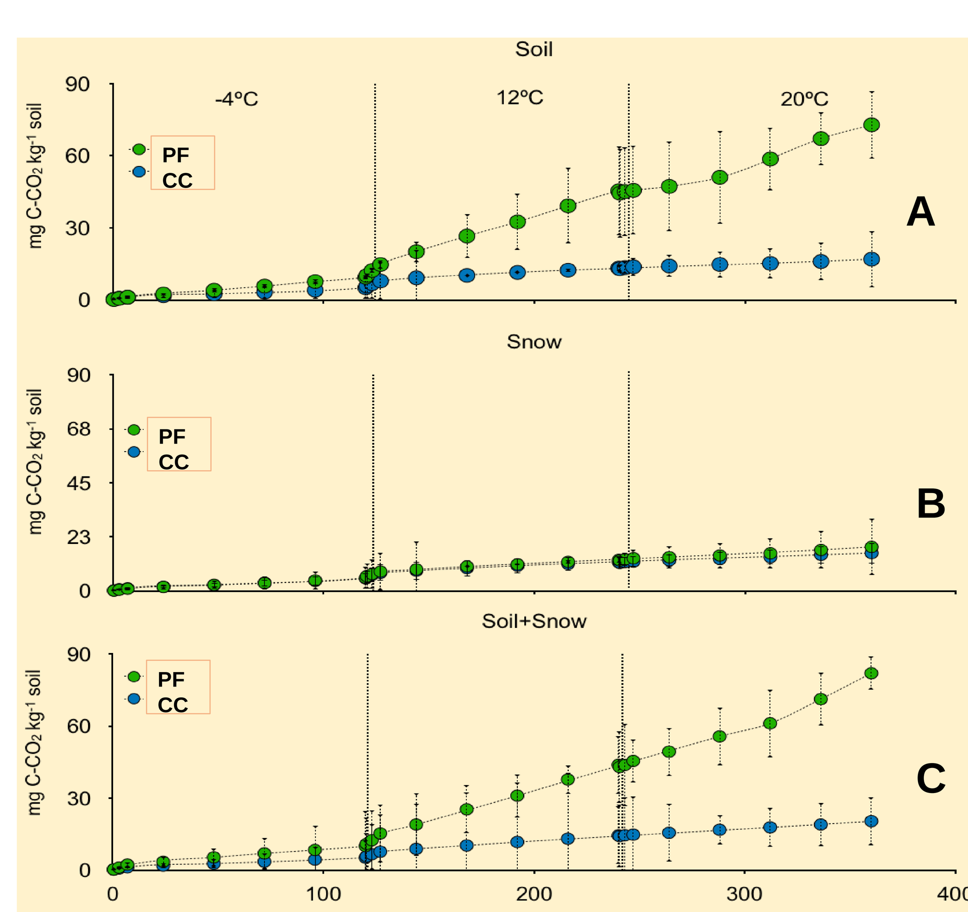


Figure 3. Cumulative CO_2 of (A) soil control (B) snow control (C) soil + snow from Pristine Forest and Clear-Cut.

Microbial biomass in soil+snow showed a marked difference between PF with 2122.8 ± 140.8 mg ml^{-1}against 457.1 ± 63.9 mg ml^{-1} in CC. These results agree with microbial count and the images observed by SEM due to, we found pollen and plant tissues debris that have been reported as source of C available for microbial activity (Freeman et al., 2009).

The temperature rise in soil+snow released more CO_2 in PF 81.9 mg CO_2 kg^{-1} than that after CC 20.5 mg CO_2 kg^{-1}. Soil texture has deeply influence on C release pattern. It means that more developed soils in the forest retain more organic matter and enhance biological soil properties that than in sandy soil.

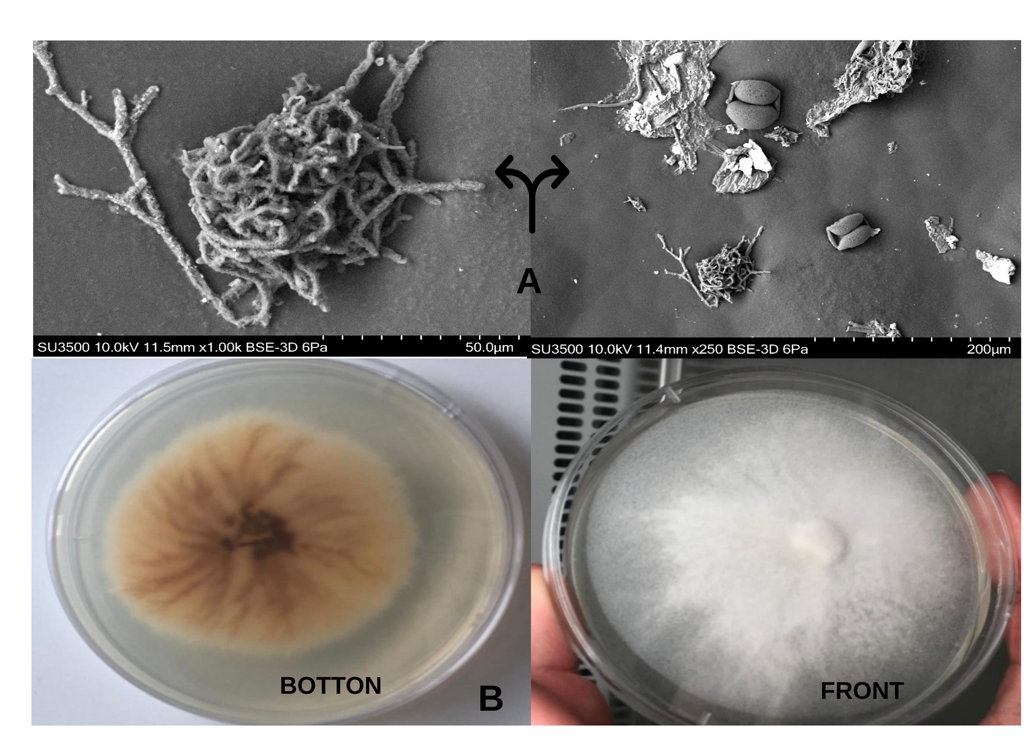


Figure 4. (A) SEM images of snow microbial debries. B) Microbial isolation in plates.

It was observed fungi hyphae and bacteria (A).The identification by MALDI TOF reported for fungi *Thanatephorus* sp. and *Microsporum* sp. and *Fusarium* sp. and for bacterial colonies *Burkholderia* sp. and *Pseudomonas* sp (B).

CONCLUSION

Soil texture and the accumulation of SOM play a crucial role on C mineralization. Gradually increase of soil temperature after freezing reveled that soils with certain amount of available C can maintain microbial population that response to change the temperature,

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References: Weatherspark. 2016. [Online]. Puyehue, Chile. En: https://es.weatherspark.com/y/25116/Clima-promedio-en-Puyehue-Chile-durante-todo-el-a%C3%B1o#Sections-Sources. Consulted on 27 June 2019; Alfonso, J., Cordero, R., Rowe, P. Neshyba, S., Cassasa, g., Carrasco, J., MacDonell, S., Lambert, F., Pizarro, J., Fernandoy, F., Feron, S., Damiani, A., Llanillo, P., Sepulveda, E., Jorquera, J., Garcia, B., Carrera, J., Oyo-la, P. and Min-Kang, C. 2019. Elemental and Mineralogical Composition of the Western Andean Snow (18°S–41°S). Sci Rep 9, 8130; Vance, ED; PC Brookes & DS Jenkinson. 1987. An extraction method for measuring soil microbial biomass. Soil Biol Biochem. 19: 703-707; Freeman K., et al. 2009. Evidence that chytrids dominate fungal communities in high-elevation soils. PNAS 106:18315–18320..