Impact of vegetation species on soil pore system and soil hydraulic properties in the high Andes

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Introduction

Soils play a key role in the provision of vital ecosystem services. The soil pore system can be affected by different biological feedbacks. Vegetation has the potential to alter the soil pore system through changes in pore size distribution and porosity, causing differences in soil hydraulic properties as well as soil-water processes.

We explore the diverse vegetation of a high altitude (>4100m) páramo ecosystem in the tropical Andes, located within an old farm with a history of centennial grazing, now part of the Antisana´s water conservation area in the north of Ecuador (Figure 1), by studying its soil hydraulic properties and soil pore system in eight soil profiles at contrasting dominant vegetation.

Figure 1: Western slopes of the Antisana Volcano within Water Conservation Area.

The dominant vegetation species, a cushion forming-plant *Azorella pedunculata* (CU) and a tussock grass *Calamagrostis intermedia* (TU), grow on young vitric Andosol around ~800 y B.P. (A horizon). A buried Andosol (2A horizon) lies between A and a less developed 2BC horizon. Soil profiles have been developed under similar forming factors (volcanic ash deposition, climate, time and topography). The vegetation being the possible different forming factor.

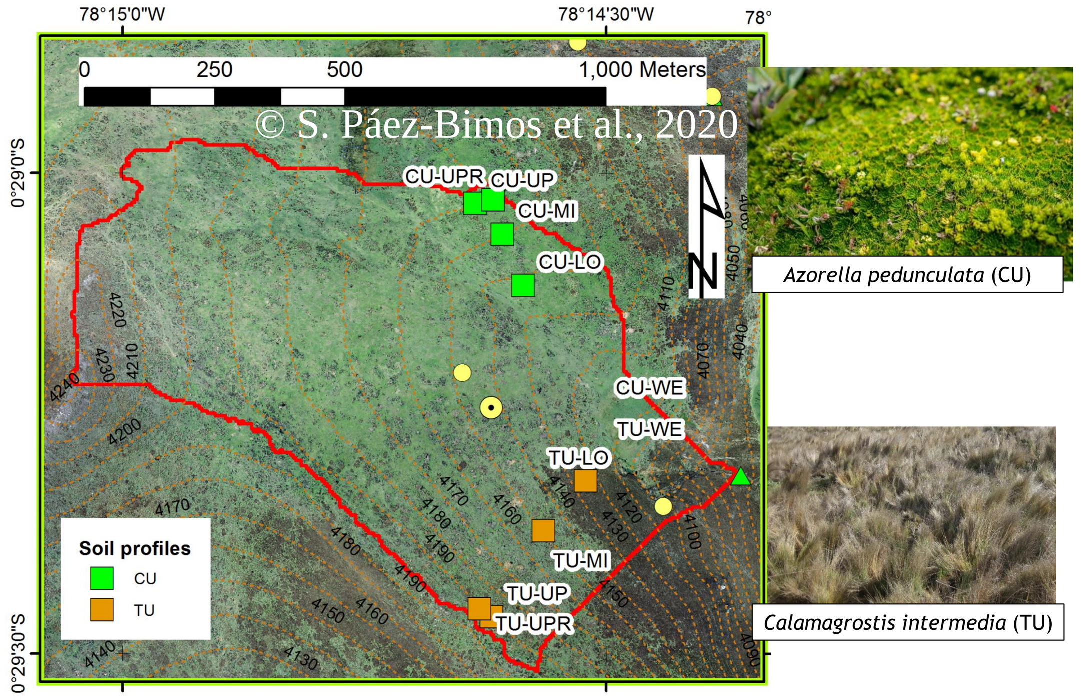

Figure 2: Study area, soil profiles and vegetation species

Hypothesis

We hypothesize that CU and TU vegetation species can drive distinct effects on soil pore system and soil hydraulic properties at different horizons. These effects may be related to other soil's physical properties and root traits.

Figure 3: Soil horizons under (above) TU (below) CU.

Methods

Soil hydraulic properties (SHP) were determined on the basis of field measured saturated hydraulic conductivity by the Inverse Auger Hole (IAH) and Guelph Permeameter (GP) methods as well as based on water retention contents at saturation (h=0bar), field capacity (h=0.10bar) and permanent wilting point (h=15bar) measured in the laboratory by the multi-step outflow method and the porous membrane pressure cell. Furthermore, water retention curves (WRC) were fitted to measured data (0, 0.03, 0.06, 0.10, 0.24, 0.46, 1, 3, 15 bar) using the bimodal van Genuchten model. Based on these fittings the pore size distribution (PSD) was determined as the first derivative of the WRC. Further, modal equivalent pore diameters were derived from the soil water tension head via the capillary rise equation. Statistical analysis to determine significant mean differences was carried out by the Mann-Whitney U test. Relationships between SHP and PSD with other soil physical properties and root traits have been analyzed using Pearson Correlation at 95% confidence level.

Results

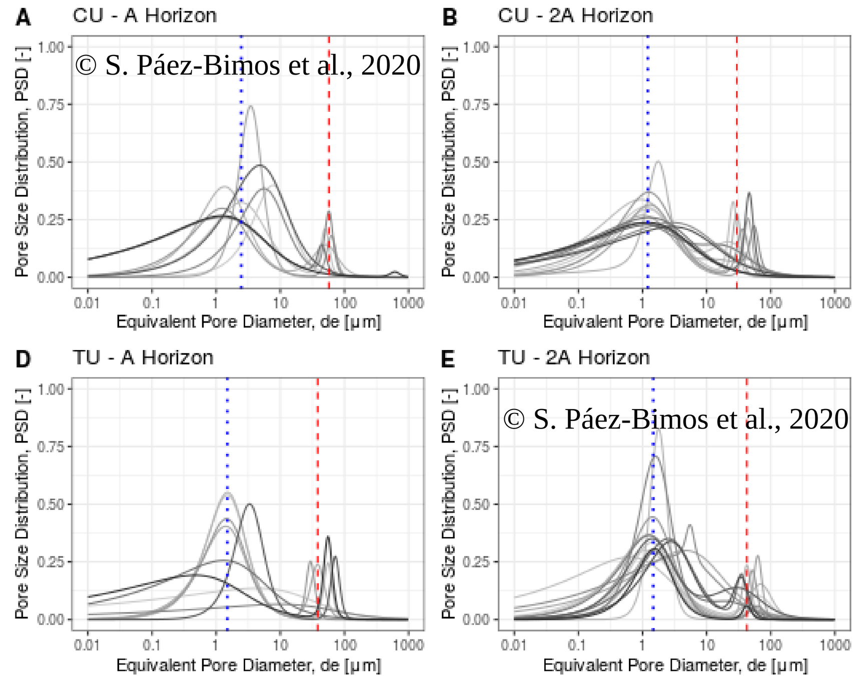

Figure 4: PSD in contrasting vegetation CU and TU and horizons A, and 2A. Median modal equivalent pore diameter from matrix domain (blue) and structural domain (red).

Variables	*Azorella pedunculata* (CU)	*Calamagrostis intermedia* (TU)
θ_{SAT}	**BD (strong -), TOC (strong +)** Alp/Alo (weak +), Root diameter (weak +)	**BD (strong -)**
θ_{FC}	**BD (strong -), TOC (strong +) Alp/Alo (strong +) Root diameter (strong +)** Alp (weak +), Clay (weak +) Root abundance (weak +)	**BD (strong -)** TOC (weak +)
Ksat IAH	TOC (weak +), Structural (weak +) Root abundance (weak +)	
Matrix	TOC (weak +), Clay (weak +), Root abundance (weak +)	
Structural	Clay (weak +), Ksat IAH (weak +)	

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Table 1: Pearson Correlation between SHP and modal equivalent pore diameters to soil physical properties and root traits by vegetation. R>0.84 (strong) and 0.75<R≤0.84 (weak). Plus or minus sign indicates positive or negative correlation, respectively. (95% confidence level). TOC: Total organic carbon, BD: Bulk density, Alo: Amorphous mineral Al, and Alp: Organically complexed Al.

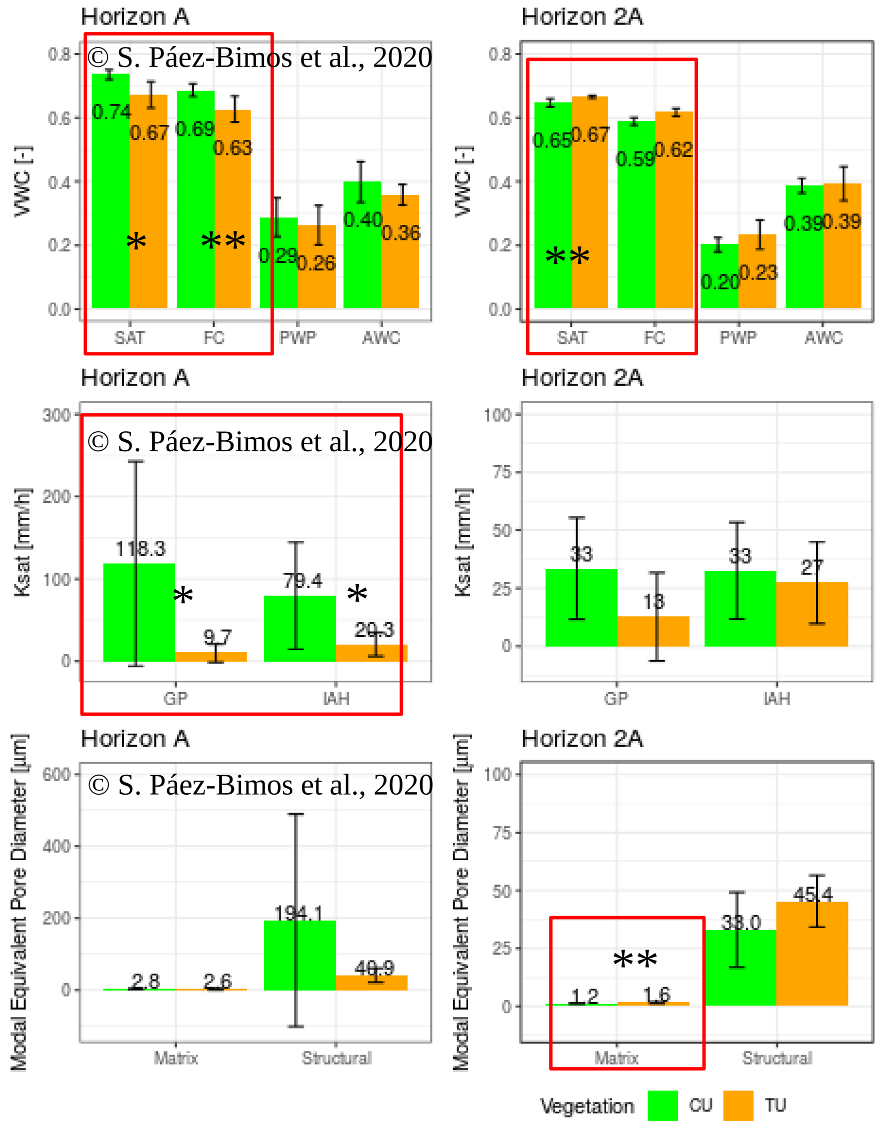

Figure 5: Soil hydraulic properties and median modal equivalent pore diameters for contrasting vegetation species CU and TU. Significant differences with the Mann-Whitney U test are indicated as follows: *p-value < 0.05 and **p-value 0.06.

Discussion

- The results show that significant differences in soil hydraulic properties and soil pore system between vegetation species are found at the upper soil horizons, while they become negligible with soil depth.
- In the A horizon, TU shows lower water retention (0.67,0.63) and saturated hydraulic conductivity (9.7-20.3mm/h) than comparable sites with undisturbed tussock grasslands (0.71,0.66; 50-60mm/h). Typical positive correlation of water retention with TOC is not observed.
- In the upper horizon, CU shows higher water retention (0.74, 0.69) and Ksat (118.3-79.4mm/h) than TU. Water retention under CU is strongly correlated to TOC and BD. High Ksat under CU is partially explained by TOC, root abundance and structural porosity.
- PSD shows bimodal distributions with matrix and structural domains.
- We conclude that, in this long time grazed ecosystem, vegetation species have significant effect on the soil pore system and soil hydraulics properties at the upper soil horizon potentially leading to changes in soil water fluxes.

Acknowledgments

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