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Changes in Plant Cover Induced by Grazing Affect the Soluble Fraction of Soil Organic Carbon – But Not the Total Pool Size in the Arid Rangelands of Patagonian Monte, Argentina

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Introduction

Soil is the largest organic C (SOC) pool in the biosphere (Lal, 2004). The size of this pool depends on the primary production and SOC residence time which are controlled by biome type, climatic conditions and land management (Lal, 2004). In arid ecosystems, these controls are strongly related to the amount and seasonal distribution of precipitation (Sala et al., 1988). However, the low plant cover (< 40 %), the spatial heterogeneity of plants, and the selectivity of grazing by domestic livestock may also influence SOC dynamics and stability. Most changes in plant communities induced by grazing are not reversible after removal of this disturbance agent (Briske et al., 2003). Accordingly, our ability to predict and mitigate consequences of grazing disturbance on ecosystem function and global change depends, in part, on a better understanding of the effects of vegetation changes on the size and composition of SOC pools. The objectives of this study were (i) to analyze whether the effects of grazing pressure on plant canopy are reflected in the size and composition of the SOC pool, and (ii) to identify easily measurable variables related to SOC that could be used as indicators of changes in organic C pools in grazed rangelands.

Materials and Methods

The study area is representative of the Patagonian Monte, Argentina (42º 12´ S, 64º 58´ W). Mean annual temperature is 13° C and mean annual precipitation is 188 mm (15 years series). Soils are a complex of Typic Petrocalcids-Typic Haplocalcids. Vegetation community is dominated by *Larrea divaricata* Cav. and *Stipa* spp. arranged in randomly distributed patches on a matrix of bare soil. This area has been grazed by sheep since the beginning of the past century with a mean stoking rate of 0.13 sheep ha^{-1}. Based on the sheep faeces density (i.e. indicator of grazing pressure), we selected six sites with increasing signs of grazing disturbance. Total plant cover was assessed at four randomly located transects using the line intercept method.

Sampling was carried out in winter and summer in two consecutive years (2011 and 2012) (4 sampling dates). At each sampling date, we randomly selected the four most representative plant patches per site and we collected a soil sample (0-30 cm depth) under the patch canopy and another in the middle of the nearest bare soil area. Roots were separated from each soil sample and soil was air-dried (c.a. 20º C), sieved to 2 mm mesh and weighed. We assessed the concentration of total soil organic C, organic C in humic substances and water soluble C (Page et al., 1982). These C fractions differ in the residence time (C in humic substances > water soluble C). Then, we calculated the size of total SOC pool as the product of soil mass and the organic C concentration. SOC composition was calculated as the product of (i) the soil mass and the concentration of C in humic substances, and (ii) the soil mass and the concentration of water soluble C.

The relationships among total plant cover, grazing pressure, total SOC pool size, and SOC composition were assessed by regression analysis using the mean values of each variable per site. Statistical analyzes were performed using SPSS software. The significance level used throughout this study was $p \leq 0.05$.

Results

Total plant cover responded negatively to grazing pressure ($y=-8.69*\ln(x) + 53.24$, $r^2= 0.76$, $p= 0.02$, $n= 6$). Perennial grasses were the most negatively affected by grazing pressure (data not shown). Total plant cover did not predict total SOC pool size (Fig. 1a) or C content in humic substances (Fig. 1b). However, total plant cover was significantly related to the content of water soluble C (Fig. 1c).

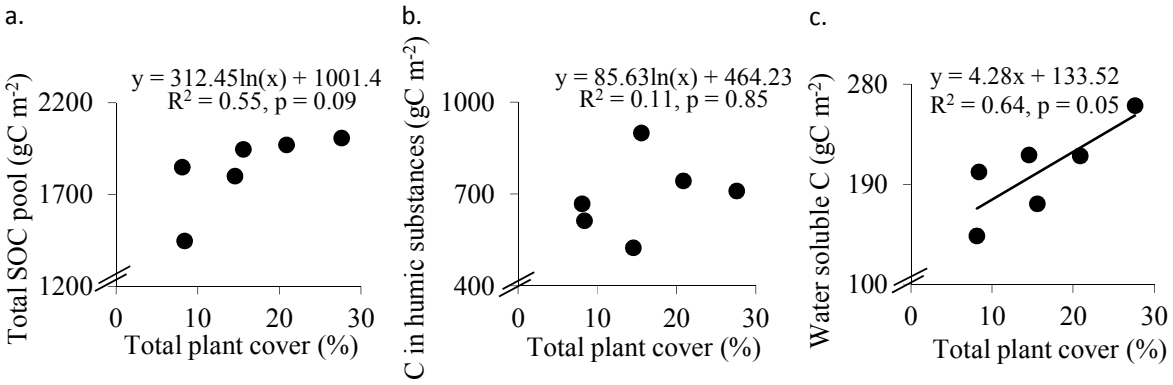

Figure 1. Relationship between total plant cover and a. the size of the total SOC pool, b. the content of C in humic substances, and c. the content of water soluble C.

Discussion

Although increased grazing pressure had a negative effect on total plant cover, the size of the total SOC pool did not change. However, the reduction in plant cover induced by grazing disturbance negatively affected the content of water soluble C. This could be related to changes in litter chemistry and stability induced by species shifting in grazed disturbed areas (mainly replacements of perennial grasses by long-lived evergreen woody plants). Litter in degraded areas, dominated by shrubs, has lower concentration of chemically labile compounds and higher concentration of complex C compounds (i.e. lignin) than litter from sites with low grazing disturbance (Follet 2001). In contrast, C content in humic substances (recalcitrant fraction) was not reduced with grazing disturbance. This could be associated with high litter recalcitrance to decomposition inducing high SOC residence time as found in other studies (Follet 2001). Based on these results, the periodic estimations of plant cover and/or the monitoring of changes in soil water soluble C could be used as indicators for early detection of degradation processes involving C losses in the ecosystem.

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