Grazing and soil carbon, rooting around for an effect

Helen P King

Australian National University, Fenner School of Environment and Society, ACT, Australia 0200
Contact email: helen.king@anu.edu.au

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Introduction

There is considerable scientific and policy interest in the effect of different grazing methods on soil organic carbon (SOC) and general acceptance that increasing SOC by changing grazing management is possible. While overgrazing is recognised as a cause of land degradation and historical loss of SOC, a review and modelling by Conant and Paustian (2002) showed that ceasing overgrazing and stocking at appropriate levels can also increase SOC. Other reviews showed no difference in animal or pasture productivity between continuous (CG) and rotational (RG) grazing (Briske *et al.* 2008); and increases, decreases or no change in SOC with high, medium, low or no grazing (Piniero *et al.* 2010). The variation and sometimes conflicting results of grazing and SOC research is due to the interplay of climate, edaphic factors including current SOC levels (the main drivers of SOC), and management variability; making it difficult to identify a grazing effect.

While there have been decades of research on continuous grazing (CG), where stock have ongoing access to pasture, although it may be rested occasionally; and rotational grazing (RG), where stock are moved through a series of pastures which are rested between grazing periods, there has been little research into Holistic Management Planned Grazing (PG). PG mimics large migratory herds using high stock numbers for short grazing periods (days) with long recovery time (months) before a pasture is grazed again.

There is strong anecdotal evidence that PG can restore degraded land, increase primary production (NPP) and raise soil carbon levels, primarily by shifting from annual to perennial dominated pastures. This is consistent with research showing that perennial grasses with greater root biomass and roots deeper in the soil profile increase SOC (Conant *et al.* 2001).

Root-derived SOC (biomass and exudates) also contributes more to SOC than above ground inputs and is more stable due to its chemical composition and role in soil aggregation (Rasse *et al.* 2005). While Briske *et al.* (2008) did not find a difference in grazing method, he found that frequent defoliation that reduced a plant's photosynthetic capacity beyond that needed to support and produce roots decreased NPP, while grazing at appropriate levels and frequency increased above and below ground NPP. I hypothesized that grazing leading to deep-rooted perennial pasture will improve soil properties and result in higher SOC.

Methods

This paper reports the preliminary results for SOC and root biomass from a fence-line study on the southern tablelands of NSW, Australia (mean rainfall 613 mm, mean temperature 14.5°C, Chromosol soil). Grazing methods studied are PG and CG, representing either end of a continuum of grazing management. The grazing methods have been consistently used since before 1999. Natural variability (climate and edaphic factors) was minimised by use of a fence-line contrast. Soil pits (1 each PG and CG reported here) were sited for similar pasture composition and heterogeneity (patchiness), proximity, slope, position and aspect. Equal volumes of soil were collected from 0-5, 5-10, 10-20, 20-30, 30-40, 40-50 and 55-65 cm depth increments at 10 locations in each pit (5 directly below a perennial grass and 5 between perennials (annual grasses, forbs and litter).

Soil was air dried, sieved (2mm) and visible roots removed. The soil was fine-ground (<0.1 mm) and analysed for SOC concentration with a Sercon isotope ratio mass spectrometer, coupled to a Eurovector elemental analyser (Micromass Isoprime-Eurovector EA 3000), and analysed against a known set of standards. Bulk density (g/cm^3) was calculated and the SOC stock (t C/ha) determined. Root biomass from 0-5, 20-30, 30-40 and 55-65 cm was measured from a subset of samples. Roots were removed from the soil, washed, oven dried at 60°C for 48 hours and weighed.

Results and Discussion

SOC and root biomass was higher in the PG than CG treatment and not significantly different under or between perennials within each grazing method. Higher root biomass was significantly associated with higher SOC under both PG and CG. SOC was higher for PG at all levels (significant) except 0-5 cm (not significant) where CG was higher. PG v CG was 35.6 ± 1.05 v 27.8 ± 1.05 t C/ha, P = 0.0001 for 0-30 cm, and 49.0 ± 1.05 v 35.7 ± 1.05 t C/ha, P = 0.0001 for 0-60 cm, a difference of 7.8 (28%) and 13.3 (37%) t C/ha respectively. Although the preliminary SOC results are significant, it is premature to attribute the difference to grazing method until results from further sites have been included in the analysis. Higher root biomass was significantly associated with higher SOC (Spearman's rho = 0.83, P<0.0001) and root biomass explained 44% (P< 0.0005) of the variation in SOC. Under perennials, the relationship was weaker (Spearman's rho = 0.71, P<0.05) with root biomass explaining 59% (P<0.001) of the varia-

tion in SOC; while the relationship was stronger between perennials (0.98, $P<0.0001$) with 85% ($P<0.001$) of the variation in SOC explained by root biomass. The statistical difference reflects greater variability in root biomass for PG than CG, which should reduce when more samples are analysed. It may also be due to changes in pasture heterogeneity (patchiness and perenniality) and greater complexity of the soil ecosystem under perennials. However, the root biomass and SOC relationship is significant under both CG and PG, indicating that increasing pasture productivity and greater root production is likely to increase SOC regardless of grazing method.

Conclusion

The complex interaction of grazing, pasture and soil make it difficult to identify an effect of grazing on SOC. However, grazing affects pasture composition and above and below ground NPP, so indirectly affects SOC. While it is not possible to attribute the difference in SOC to grazing method on a single study, the magnitude of difference warrants further research. The significant relationship between root biomass and SOC for both PG and CG suggests that, regardless of grazing method, managing grazing to increase pasture production and root biomass should lead to higher SOC.

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