Soil carbon in the Monaro region: a report from 'Action on the ground'

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Key findings

» Seasonal conditions and soil type have a greater effect on carbon than management.

» Providing necessary nutrients and pH for optimum pasture production will potentially increase soil carbon.

» Cropping in a good season might not decrease soil carbon stocks. Opportunities could exist for Monaro landholders to diversify their enterprises when the conditions are right without depleting their soil carbon.

» A rapid increase of soil carbon can easily be followed by a rapid decrease.

» For more information please see our eBook: *Soil carbon in the Monaro region* (https://itunes.apple.com/au/book/id1035198100 or http://tinyurl.com/zrr9mht).

nutrition & soil

Introduction

This project identified and demonstrated farm management practices that could increase soil organic carbon (C) in the Monaro region in southern New South Wales. Members of the Monaro Farming Systems group identified the management practices to be monitored, including:

» liming

» nutrient management

» introduced perennial pastures

» minimum disturbance cropping.

A group of technical specialists identified 19 sites on commercial farms eligible for the project, based on the land-system comparison, parent material, vegetation and management class, as well as landholder cooperation and agreement. All sites were sampled to a depth of 50 cm in late spring in 2012 and 2014. Analysis included soil C (total organic carbon and organic carbon fractions: POC, ROC and HUM) and major soil chemical properties. This report presents the C stock (t C/ha) data for 2012 and 2014.

Site details and treatments

The Monaro region is located 800 m above sea level with an average annual rainfall of 645 mm. Nineteen sites were sampled as paired or triplet study sites where the desired comparison site was within 500 m and where the site had an existing history of the management practice. Paired sites had the same parent material (granite, sedimentary or basalt) and similar soil and landscape attributes. Site comparisons were selected by the Monaro Farming Systems landholder group to demonstrate the influence of management practices on soil C (Table 1). Management practices compared were:

» Cropping vs native perennial pasture

» Low fertiliser input vs high fertiliser input – native perennial pasture

» Northerly aspect vs easterly aspect – introduced perennial pasture

» Crop vs old introduced perennial pasture vs pine plantation

» Crop vs native perennial pasture vs new introduced perennial pasture

» Unlimed vs limed – introduced perennial pasture

» Old introduced vs new introduced perennial pasture

» Crop vs native perennial pasture vs new introduced perennial pasture.

Sites with native perennial pastures (NPP) had never been cultivated and were typically wallaby grasses (*Rytidosperma* spp.), speargrasses (*Austrostipa* spp.) and snowgrass (*Poa sieberiana*). Introduced perennial pastures (IPP) were typically phalaris (*Phalaris aquatica* L.) and cocksfoot (*Dactylis glomerata* L.). Both native and introduced perennial pastures included exotic annual species such as subterranean clover (*Trifolium subterraneum*).

Table 1. Summary of the comparison with parent material class (IPP: introduced perennial pasture, NPP: native perennial pasture). All pasture paddocks were grazed.

Comparison	Treatment
Basalt	
Crop vs NPP	Short-term cropping (since 2012, previously NPP) paddock (barley in 2012) compared with a native perennial pasture.
Low fertiliser vs high fertiliser	Low compared with high Phosphorus, Sulfur input (since 2005) on a native perennial pasture.
Low grade metamorphics	
IPP: Aspect north vs east	Northerly aspect compared with easterly aspect within the same paddock under an introduced perennial pasture (sown 1989).
Crop vs >35-year-old IPP vs pine plantation	Long-term cropping (since 1998) paddock (oats 2012) compared with an old introduced perennial pasture (sown 1960) and commercial pine plantation (established 2002).
Crop vs NPP vs <5 yr old IPP	Short-term cropping (since 2009, previously native perennial pasture) paddock (wheat 2012) compared with a native perennial pasture and a new introduced perennial pasture (sown 2010, previously crop since 2004).
Granite	
IPP: Unlimed vs limed	Unlimed compared with limed paddock (2.5 t/ha lime broadcast in 2002) under introduced perennial pasture (sown 1970).
IPP: >35 yr old vs <10 yr old	Old (sown 1974) compared with new (sown 2003) introduced perennial pasture.
Crop vs NPP vs <5 yr old IPP	Short-term cropping (since 2011, previously introduced perennial pasture) paddock (wheat 2012) compared with a native perennial pasture and new introduced perennial pasture (sown 2012, previously crop since 2009).

Sites were sampled within a 25 × 25 m quadrat according to the Soil Carbon and Research Project protocols (Sanderman et al. 2011). Soil samples for total organic carbon (TOC) were oven-dried at 40 °C, passed through a 2 mm sieve and analysed on a LECO combustion furnace (LECO 1995) (Rayment & Lyons 2011; Method 6B2b). Results were reported as TOC g/100g on an oven-dry basis. Bulk density was determined on each core with samples dried at 105 °C (Dane & Topp 2002). Results were calculated as bulk density (BD) in g/cm^3 on an oven-dry basis.

Carbon stock was calculated using the equivalent soil mass (ESM) method within a specified soil layer. Carbon stock was calculated in 10 cm increments to 30 cm or 50 cm. For each site, the C stock was first calculated to a depth standard (DS) as; DS C stock (g/100 cm^2) = C concentration (g/100 g) × BD (g/cm^3) × depth (cm) × gravel correction factor (1 − proportion gravel >2 mm), where C stock (g/100 cm^2) = C stock (t C/ha). Carbon stock using the ESM was then calculated. For changes within a site between 2012 and 2014, the 2012 soil mass was used as the reference soil mass. So in 2012, C stocks were calculated to a depth standard (as a starting reference soil mass) and 2014 C stocks for the same site were calculated based on a soil mass equivalent to 2012. Carbon stock in the ESM of the soil layer (e.g. 0–30 cm) t C/ha = DS C stock (to 20 cm) + (DS C stock 20–30 cm × (ESM for the total soil layer/actual soil mass for the total soil layer)).

Summary

Overall, C stocks were influenced by landscape attributes, including:

- parent material
- soil depth
- clay content
- aspect
- topography and relief
- soil nutrients such as nitrogen, phosphorus and sulfur.

The soil C stocks for each treatment comparison and sampling time are summarised in Table 2.

Liming

There were no consistent results indicating an increase or decline in C stocks with liming an introduced perennial pasture. In 2012, there was 1.4 t C/ha/30 cm more under the limed treatment, while in 2014, there was 4.9 t C/ha/30 cm less under the limed treatment.

Correcting soil acidity with lime can have both an immediate and long-term influence on soil C stocks. If soil pH was limiting plant growth, then liming to increase soil pH (and thereby reducing aluminium toxicity) can increase pasture growth and organic matter (OM) supply. However, liming can also increase microbial activity and, therefore, there may be a short-term decrease in C stocks associated with increased decomposition of labile OM. Liming can also influence the pasture composition, in particular the leguminous component of the pasture, which supplies N to the grass component, and again can be responsible for increasing biomass production and OM supply to the soil. Based on the 2012 and 2014 soil survey, there are several sites in this study that have soil pH values at or below the critical value of 4.6. These sites might achieve increases in soil C stocks with liming if responsive plant species are present.

Pasture composition

It is hypothesised that newly established pastures will increase soil C rapidly in the first five to 10 years and then plateau with steady increases in soil C continuing for up to 30 years. The new pasture in this study was sown in 2003, and had a greater existing stock of C potentially representing this rapid increase. However, this increase is surprisingly high given that the Monaro region experienced drought conditions for the first six years following pasture establishment. Based on these soil survey results, from 2012 to 2014 there was a 10 t C/ha/30 cm decrease in C stock. If this is a true representation of what occurred during this period, a possible explanation could be an increase in the rate of decomposition, or a decrease in pasture production associated with soil nutrient limitations under the new introduced pasture. However, given the magnitude of the decrease, it would seem this is more likely due to spatial variability in soil C within the sampling quadrat and not solely due to management effects.

Table 2. Carbon stocks (t C/ha) for each treatment and sampling time (2012 and 2014) comparison. The 2012 C stocks are calculated to a depth standard and the 2014 C stocks were calculated based on an equivalent soil mass (with the 2012 soil as the reference soil mass).

	2012	2014	Difference	2012	2014	Difference
Basalt derived soil						
Crop	46.39	50.12	3.74	71.72	77.09	5.37
Native pasture	59.98	64.94	4.97	80.80	87.10	6.30
Δ Native pasture – crop	13.59	14.82	1.23	9.08	10.01	0.93
Low fertiliser	61.38	77.10	15.72	75.87	101.45	25.58
High fertiliser	78.82	73.48	-5.34	108.65	101.11	-7.54
Δ High – low	17.44	-3.62	-21.06	32.78	-0.34	-33.12
Low grade metamorphics						
Northerly aspect IPP	46.97	49.38	2.41	55.69	58.09	2.40
Easterly aspect IPP	42.37	48.09	5.72	52.29	69.96	17.67
Δ North–east aspect	4.60	1.29	-3.31	3.40	-11.87	-15.27
Crop	47.65	45.36	-2.29	55.69	52.43	-3.26
Native pasture	45.15	55.91	10.76	56.76	70.34	13.59
New IPP	68.96	69.91	0.95	84.76	86.73	1.97
Δ Native pasture – new IPP	-23.81	-13.99	9.81	-28.00	-16.38	11.62
Δ Native pasture – crop	-2.50	10.55	13.05	1.07	17.91	16.84
Pine	66.83	93.87	27.04	85.06	125.14	40.07
Crop	42.37	46.53	4.16	53.82	57.72	3.90
Old intro. pasture	44.93	43.63	-1.30	59.33	55.80	-3.53
Δ Old IPP – crop	2.56	-2.90	-5.46	5.51	-1.92	-7.43
Δ Old IPP – pine	-21.90	-50.24	-28.34	-25.73	-69.34	-43.61
Granite derived soil						
Unlimed IPP	45.87	52.29	6.42	58.85	67.43	8.57
Lime IPP	47.30	47.43	0.13	60.04	63.61	3.57
Δ Lime – unlimed IPP	1.43	-4.86	-6.29	1.19	-3.82	-5.00
Crop	40.21	53.19	12.98	54.92	67.26	12.34
Native pasture	39.94	46.80	6.86	54.88	62.45	7.57
New IPP	36.66	42.79	6.13	47.64	54.69	7.05
Δ Native pasture – new IPP	3.28	4.01	0.73	7.23	7.76	0.52
Δ Native pasture – crop	-0.27	-6.39	-6.12	-0.04	-4.81	-4.77
Old IPP	46.66	44.99	-1.67	66.27	61.29	-4.98
New IPP	50.80	40.79	-10.02	65.91	54.62	-11.29
Δ Old IPP – new IPP	-4.15	4.20	8.35	0.35	6.67	6.31

Cropping

The cropping comparisons in this field study highlighted opportunities for cropping in this region on a range of soil types to at least maintain C stocks that are comparable with introduced pastures. We suggest that soil nutrient management programs associated with cropping and favourable climate years immediately before, and during this project, would have contributed to comparable C stocks. Under drier conditions, the C stocks could decline more under the crop compared with a perennial pasture.

References

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