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One part of the Monaro region soil carbon story...

*Soil Carbon Monitoring Project
(Southern Rivers CMA) and
Monaro Farming Systems Action on
The Ground Project*



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Can we increase carbon in soil?

Yes we can!

Sort of.

a bit.....

■ **The challenge is**

- **Pasture systems already have high carbon**
- **OM supply (or biomass grown) is often limited by climate and soil nutrients**
- **Soils have an upper limit**

To increase soil carbon:
Inputs > Losses

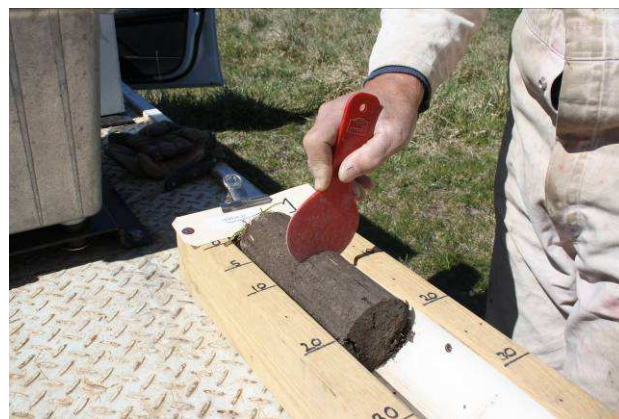
That is, OM supply either grown on site or grown elsewhere and brought to the paddock needs to be more than losses via decomposition and erosion.

Outline

- Part 1
 - Soil carbon survey across the Monaro Region (2009)... what we now know

- Part 2
 - And then it rained...
 - 2012 sampling for the SR CMA and MFS Project

Soil sampling... an example of what protocols in a 'methodology' may look like...



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What we don't measure!

- “Organic matter” (measure **carbon**)
- Litter on the soil surface
- Organic matter (roots) > 2mm



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Carbon stock

Carbon units: Total Carbon (LECO); g/100g

Carbon stock (t/C/ha) =

Carbon concentration (g/100g) x bulk density (g/cm³) x
sample depth (cm) x gravel correction factor



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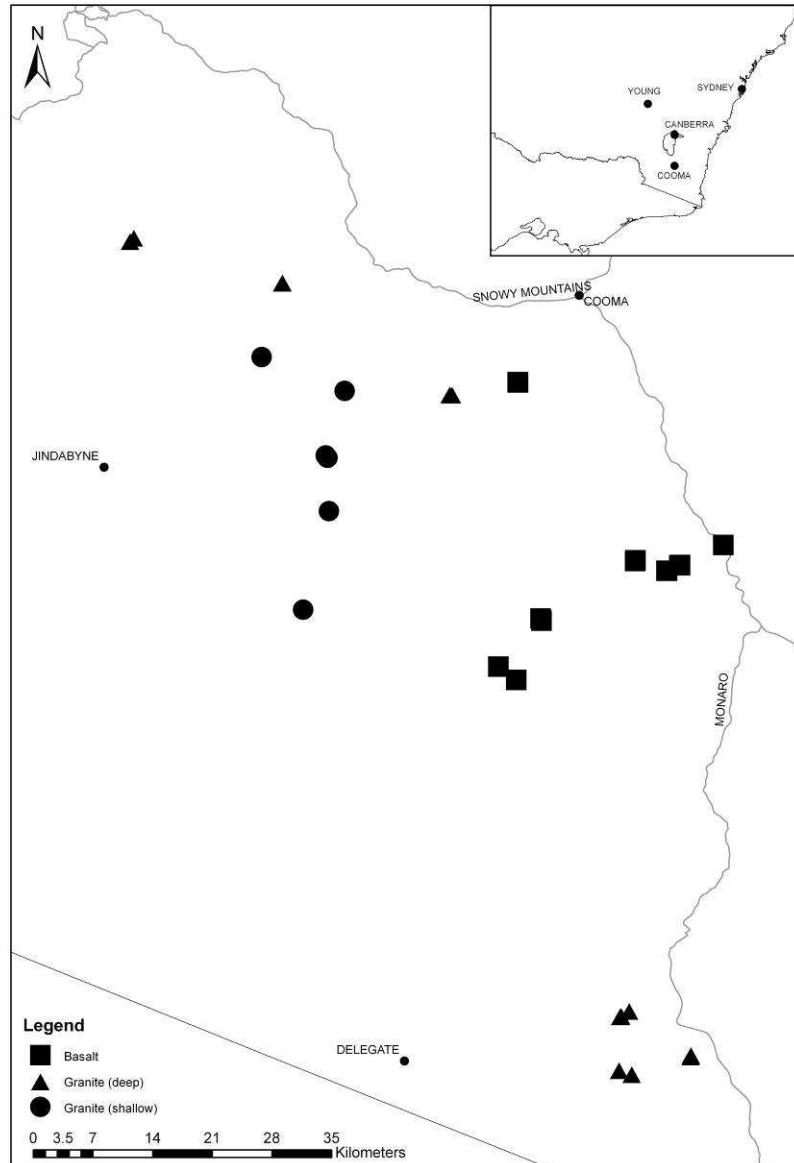
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Role of perennial pastures in maximising carbon stocks

- Does **parent material** influence soil carbon sequestration?
- Does **climate** influence soil carbon sequestration?
- Do **introduced perennial pastures** sequester more carbon than native pastures?
- Can **management** influence pastures to sequester carbon?



SR CMA Soil Carbon Benchmarking Project



- 32 sites
- Sampled in 2009 and 2012
- Deep granite derived soil: 6 pairs native and introduced pastures
- Basalt derived soil: 6 pairs native and introduced pastures
- Shallow granite derived soil: 6 (5 in 2012) native pastures

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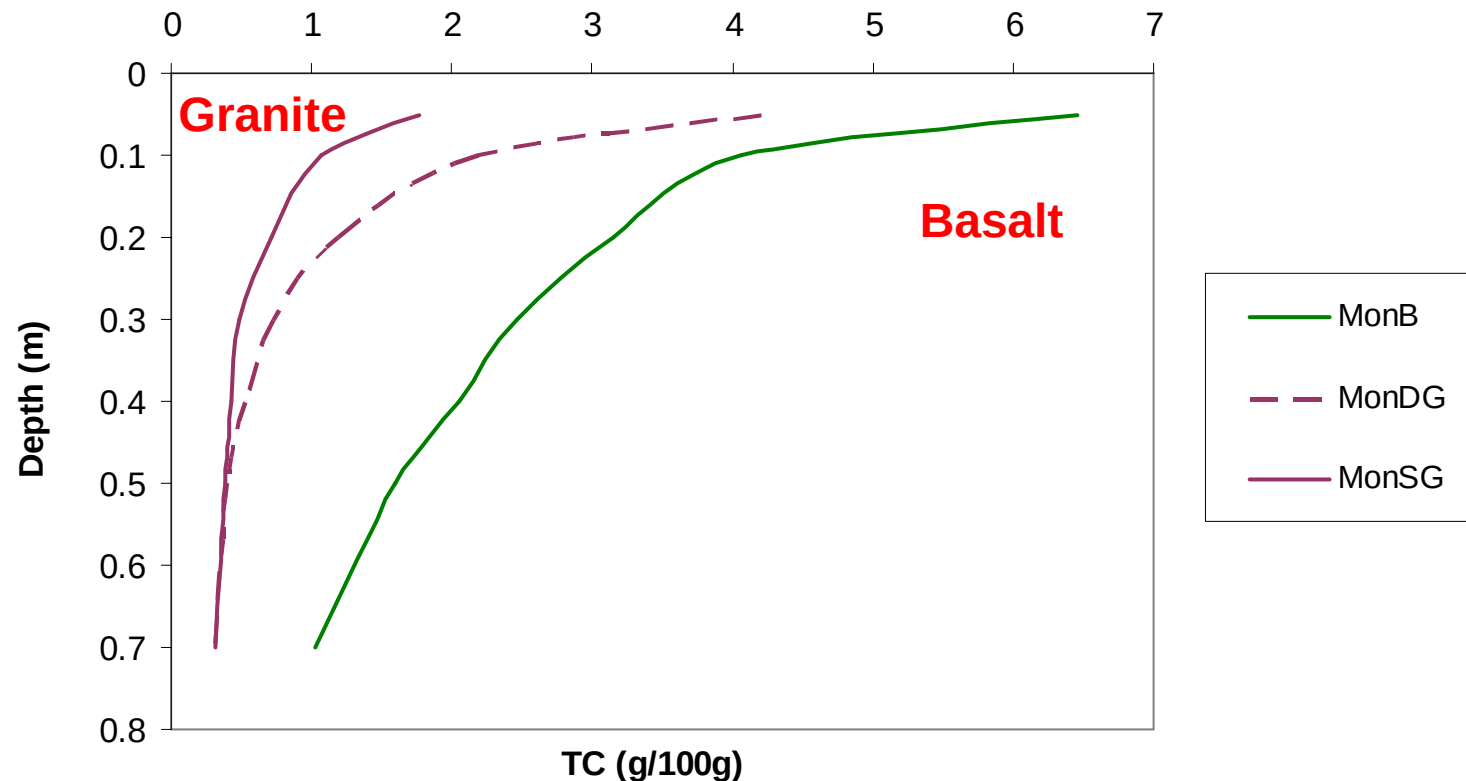
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Soil C profiles

Does **parent material** influence the ability of soil to accumulate carbon?

YES!

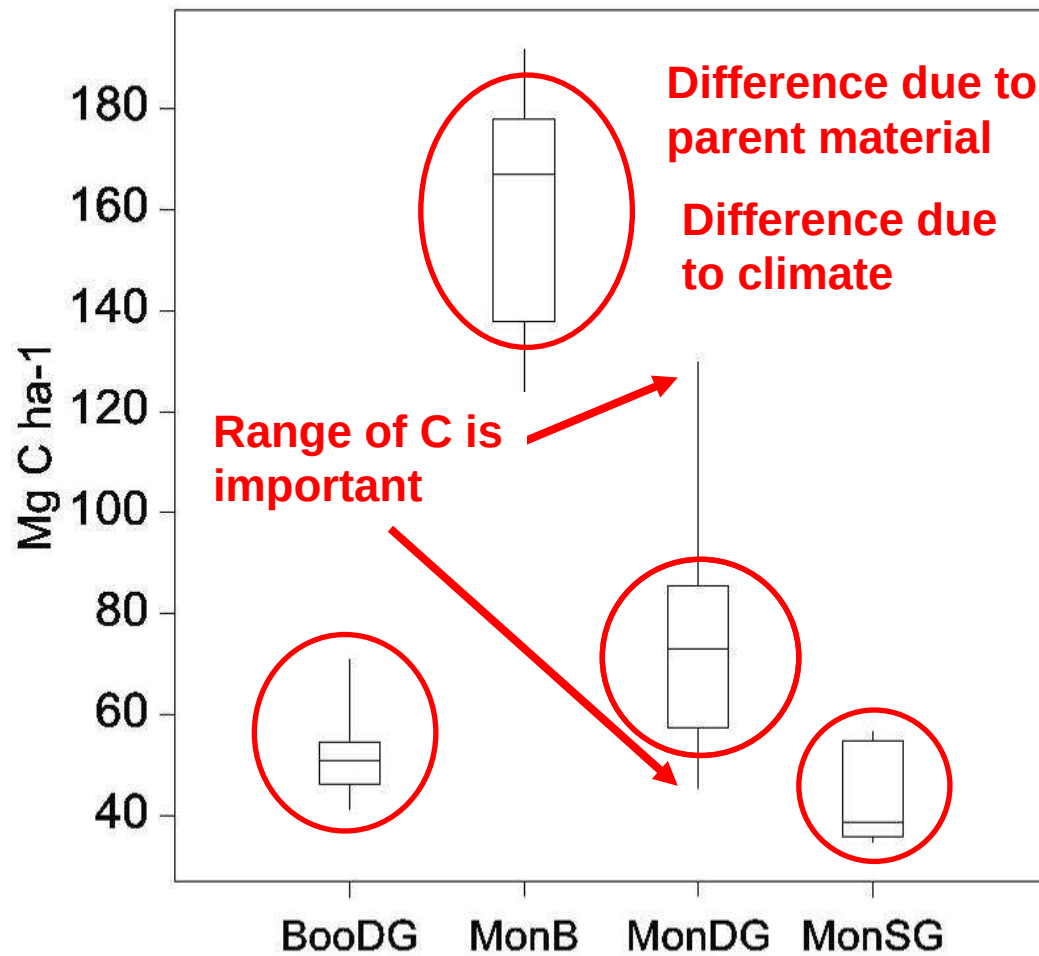
2009 results



More evidence for parent material ... and introducing 'climate' as a factor

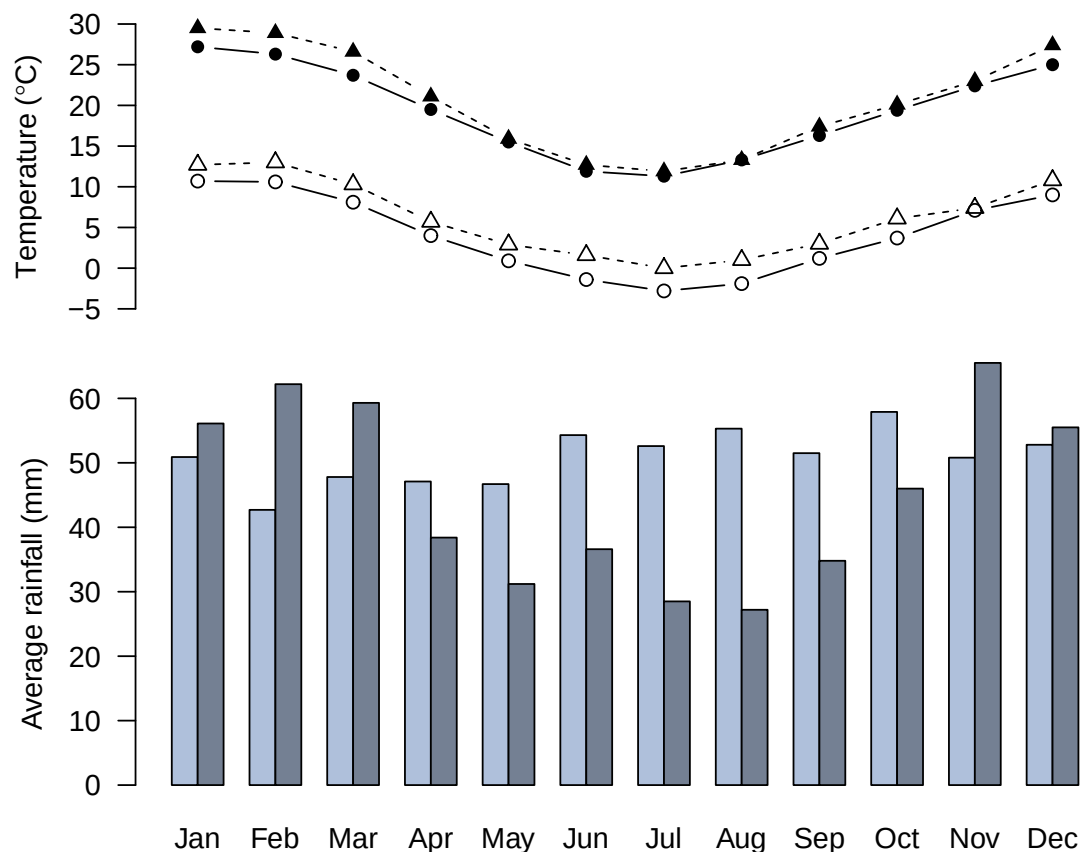
Does **climate** influence the ability of soil to accumulate carbon?

YES!



2009 results

A little more on subtle climate differences...



- Temperature and rainfall also influence OM supply and decomposition
- That is, how much can be grown and the rate of decomposition
- Monaro has Min Temp <5°C for more than one month longer and more variable rainfall

Dark grey bars – Monaro
Light grey – Boorowa

● – Monaro

▲ – Boorowa

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Introduced vs Native Pastures

Do introduced perennial pastures sequester more carbon than native pastures?

NO, not in these regions

Region	Parent material	Vegetation	Carbon density (Mg C/ha)	
			0-0.70 (m)	s.e.
<i>Monaro</i>	Basalt	Introduced	160.38	n.s. 10.8
	Basalt	Native	156.86	10.1
	Basalt	Remnant	116.29	unreplicated
	Deep granite	Introduced	77.99	n.s. 11.4
	Deep granite	Native	75.00	11.1
	Deep granite	Remnant	44.58	unreplicated
	Shallow granite	Native	43.29	3.4
<i>Boorowa</i>	Deep granite	Introduced	52.35	n.s. 2.8
	Deep granite	Native	51.25	2.8
	Deep granite	Remnant	49.24	unreplicated

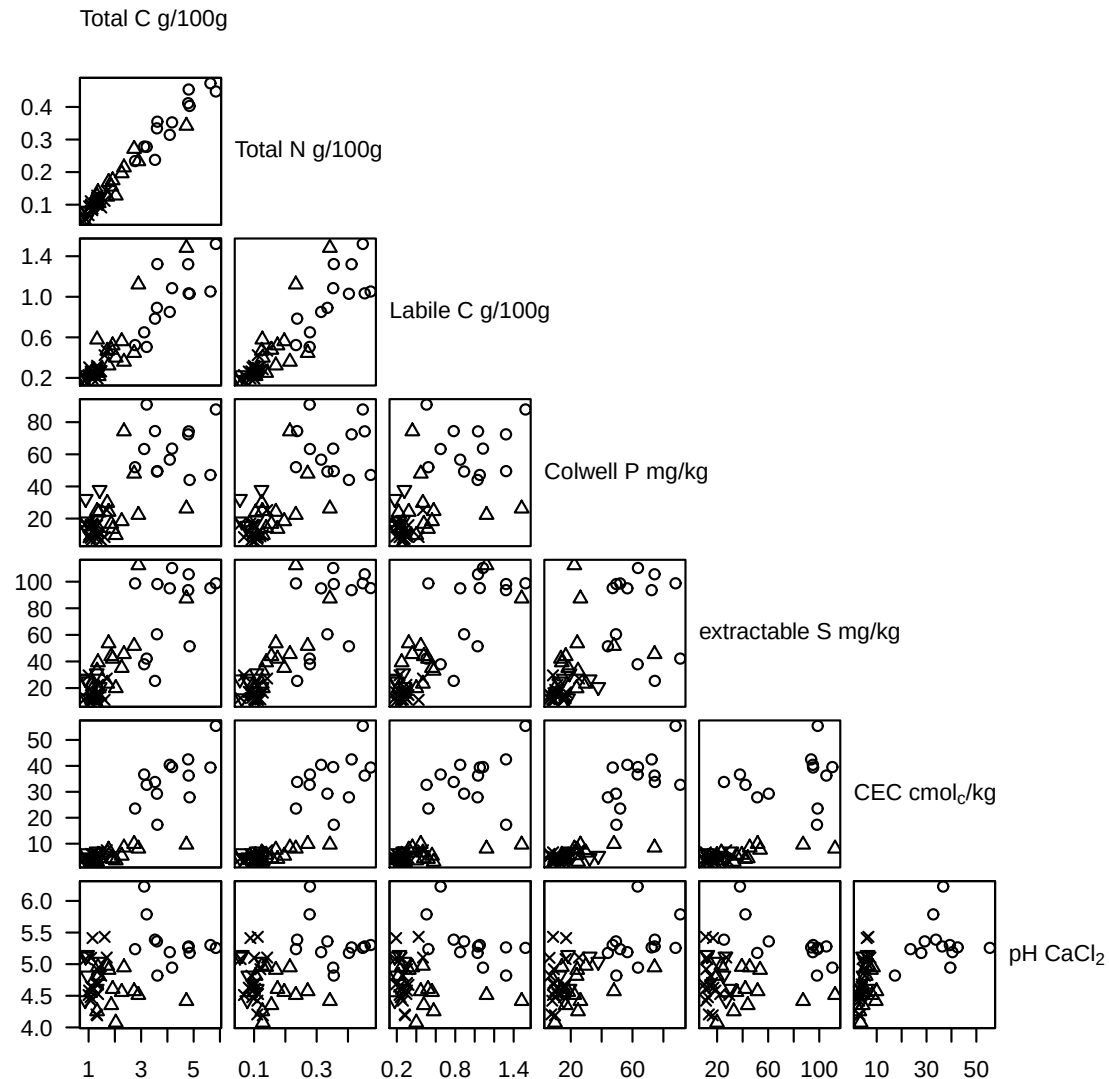
2009 results

Nutrient management

Can **management** influence pastures to sequester carbon?

YES! But it may come at a cost

2009 results



Correlations between carbon and soil nutrients

	Total C (g/100g)	Total N (g/100g)	Labile C (g/100g)	Colwell P (mg/kg)	Extractable S (mg/kg)	CEC (cmol _c /kg)	pH (CaCl ₂)
Total C	1						
Total N	0.80**	1					
Labile C	0.85**	0.74**	1				
Colwell P	0.19	0.02	-0.06	1			
Extractable S	0.52**	0.31*	0.60**	-0.09	1		
CEC	0.51**	0.21	0.26	0.49**	0.22	1	
pH	-0.06	0.29*	-0.08	0.31*	-0.29*	0.21	1

Carbon is significantly and positively correlated with:

- Total N
- Labile C
- Extractable S
- CEC

Correlation between selected soil chemical traits conditional on parent material and vegetation class transformed from a multivariate linear model. Significant values are indicted (* $P < 0.05$; ** $P < 0.01$). 2009 data.

Importance of soil fertility

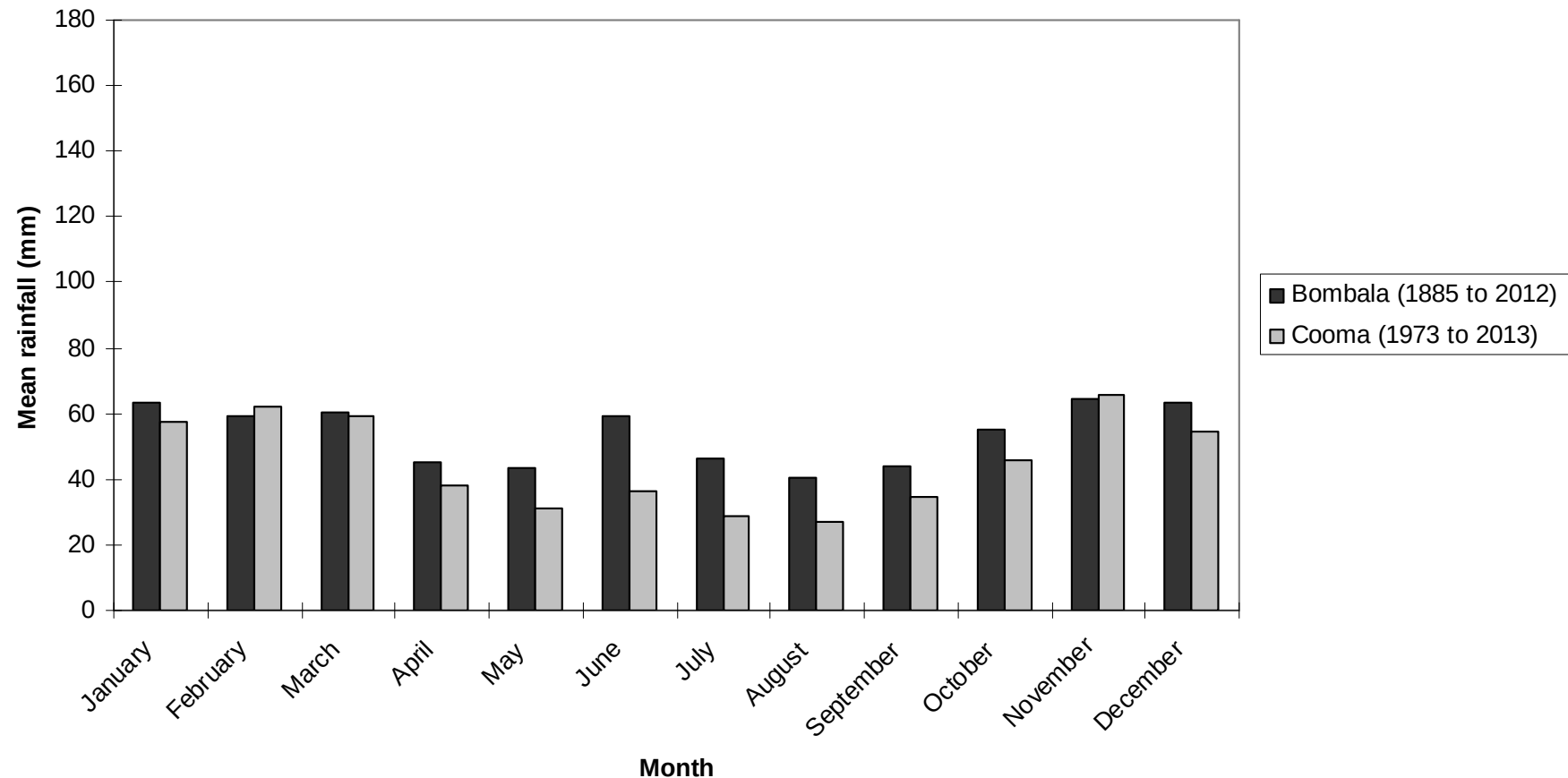
- C sequestration is strongly related to soil fertility
- We can influence available P and S to maximise biomass production and therefore OM supply to soil
- Nitrogen primarily from legumes
- Phosphorus and sulfur are commonly applied as mineral fertilisers to increase legume production, function and nodulation (thereby N fixation)
- We cant change parent material or climate, but we can influence soil fertility
- The range in carbon stocks under pastures may indicate potential to sequester more carbon in some soils

Part 2 And then it rained...



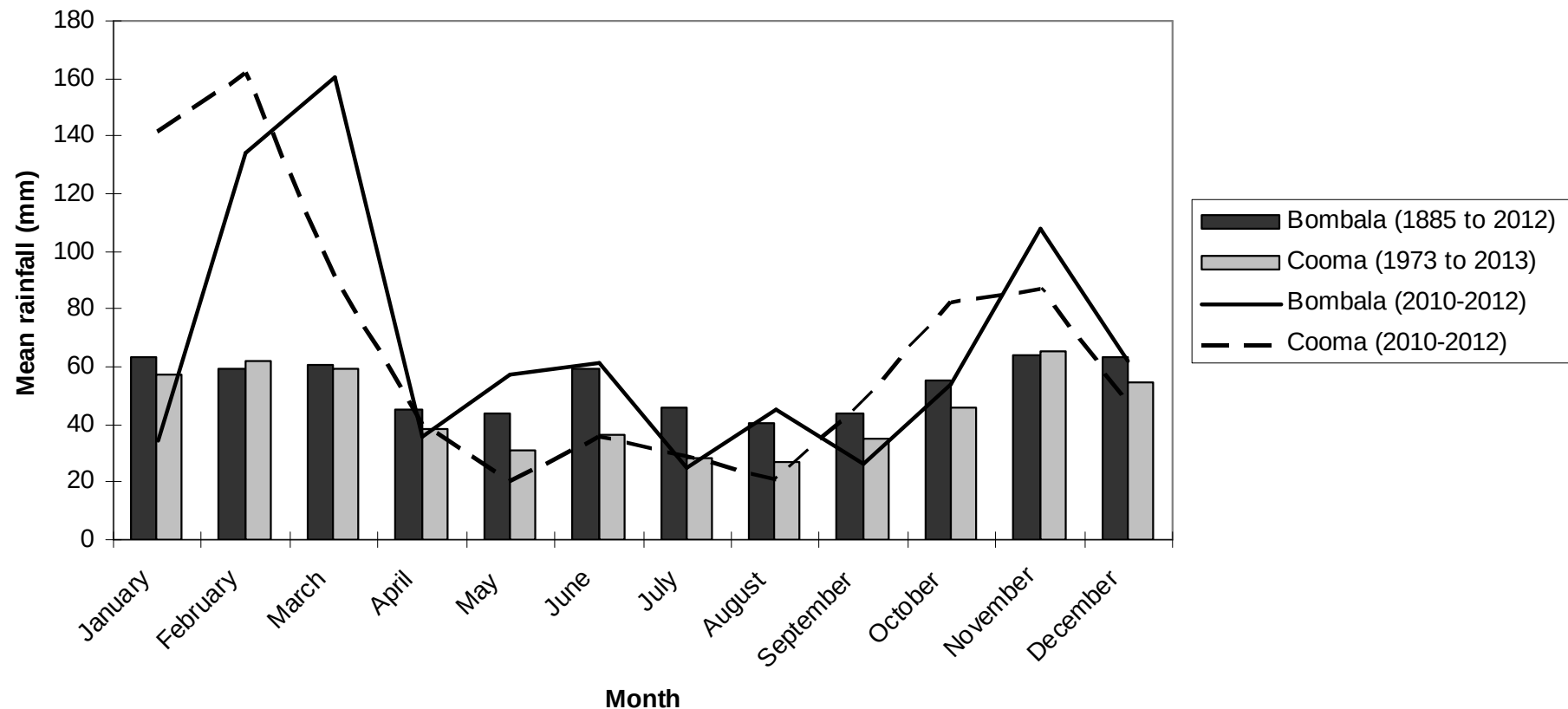
Part 2 And then it rained...

Long-term average monthly rainfall for Cooma and Bombala



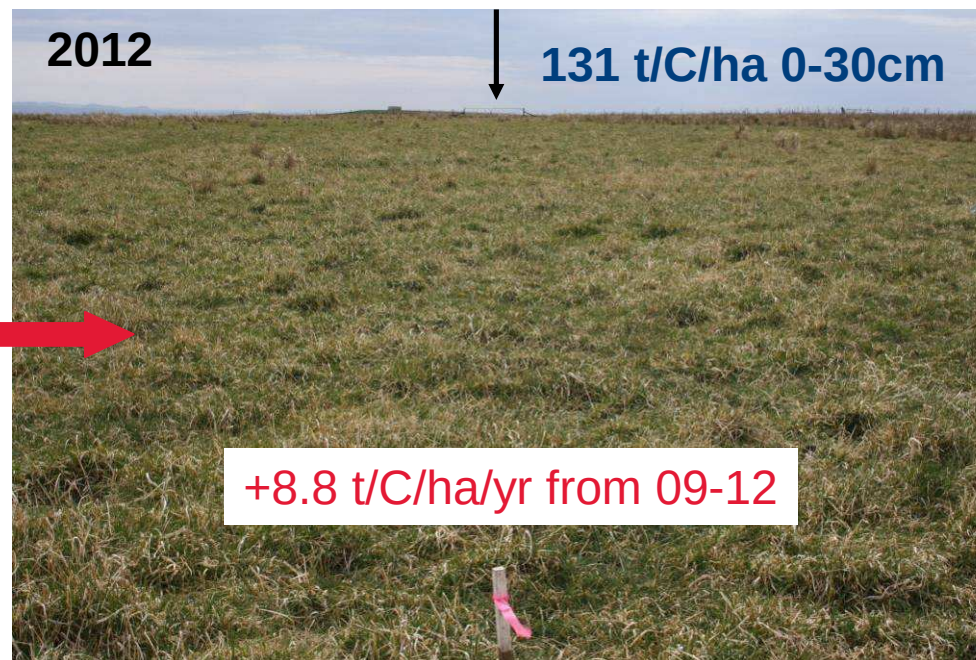
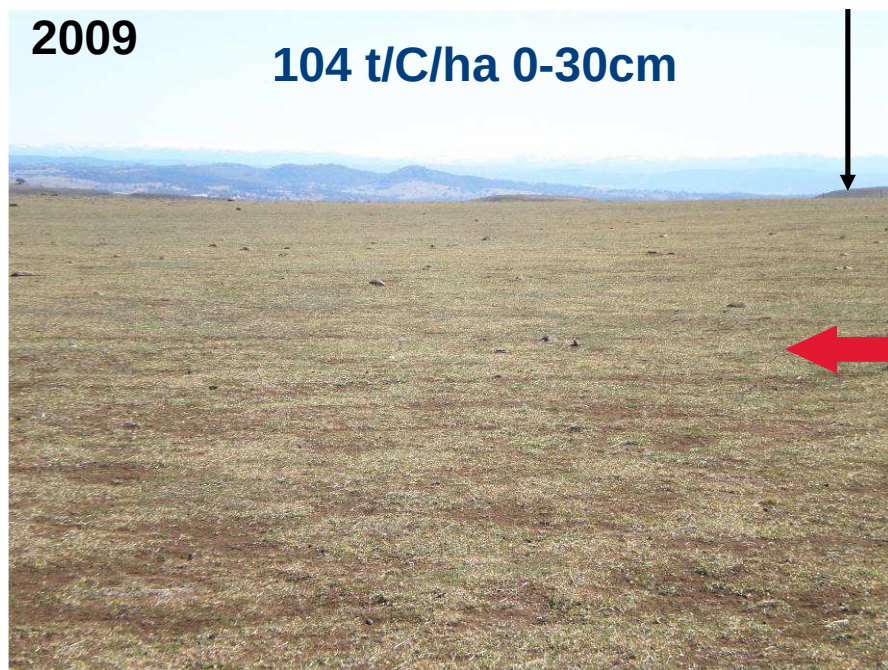
2009-2012 monthly rainfall averages

Opportunity to look at the influence of climate within region



Influence of drought, rain and seasons...

Basalt derived soil

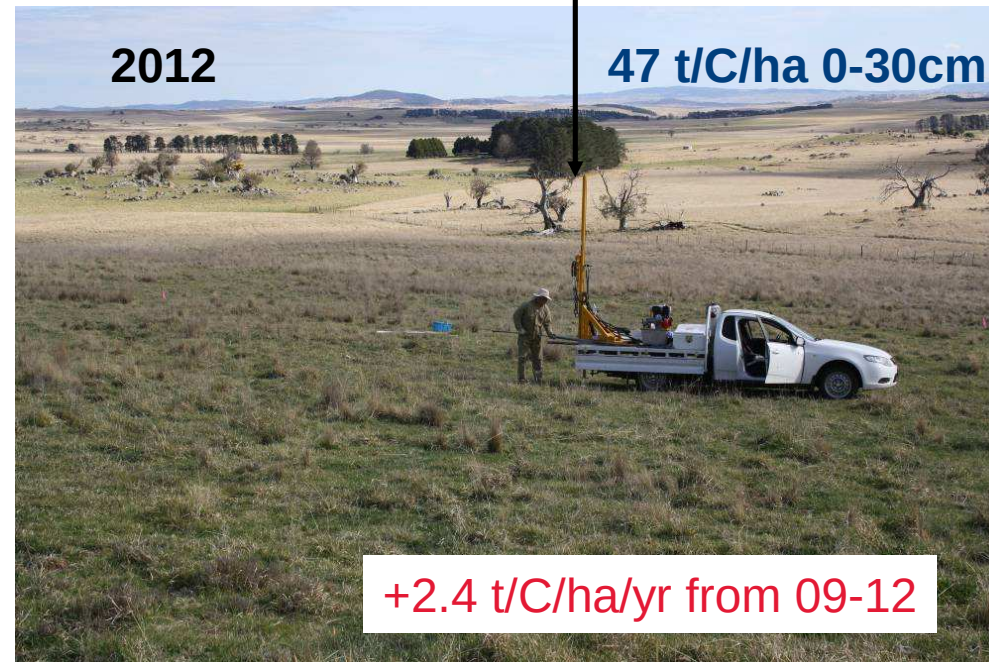
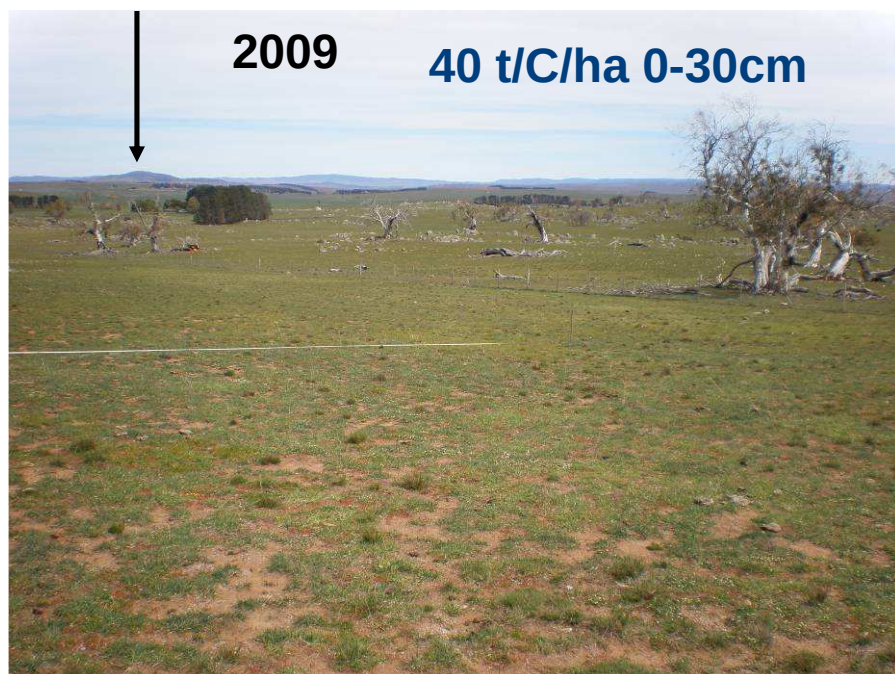


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Granite derived soil



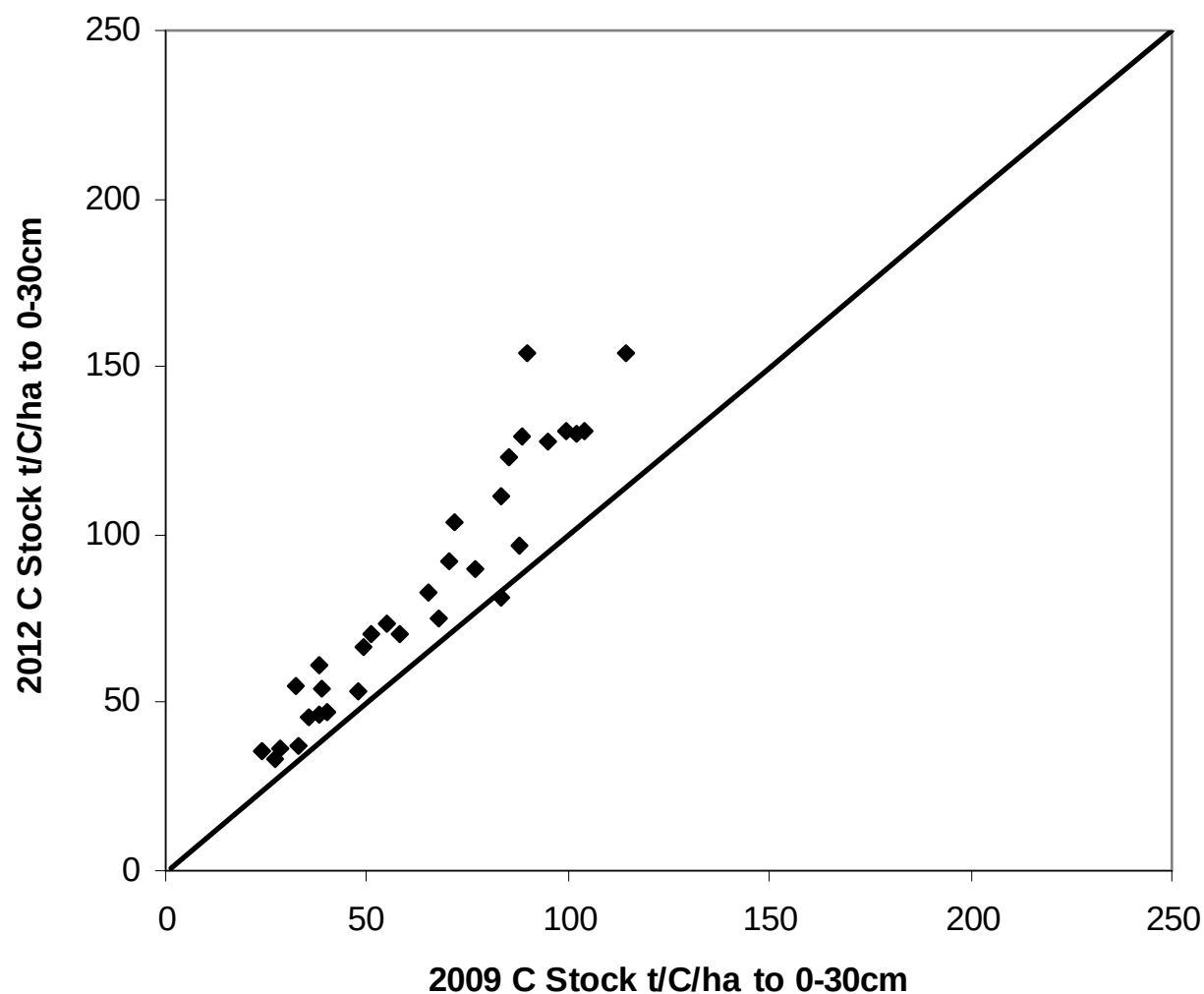
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C stock to 30cm – **quick calculation!

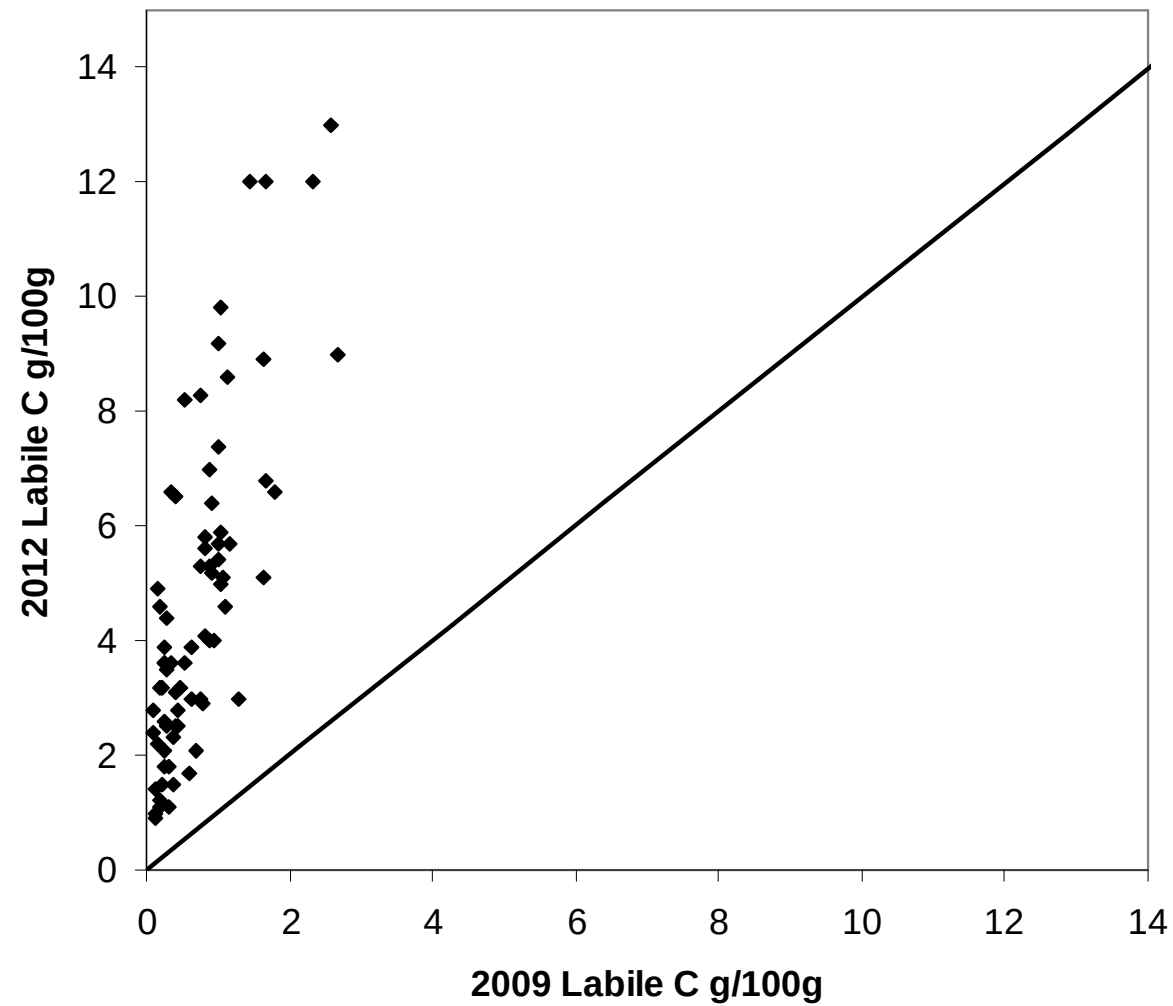
2009 vs 2012



Monaro Soil Carbon

Labile C

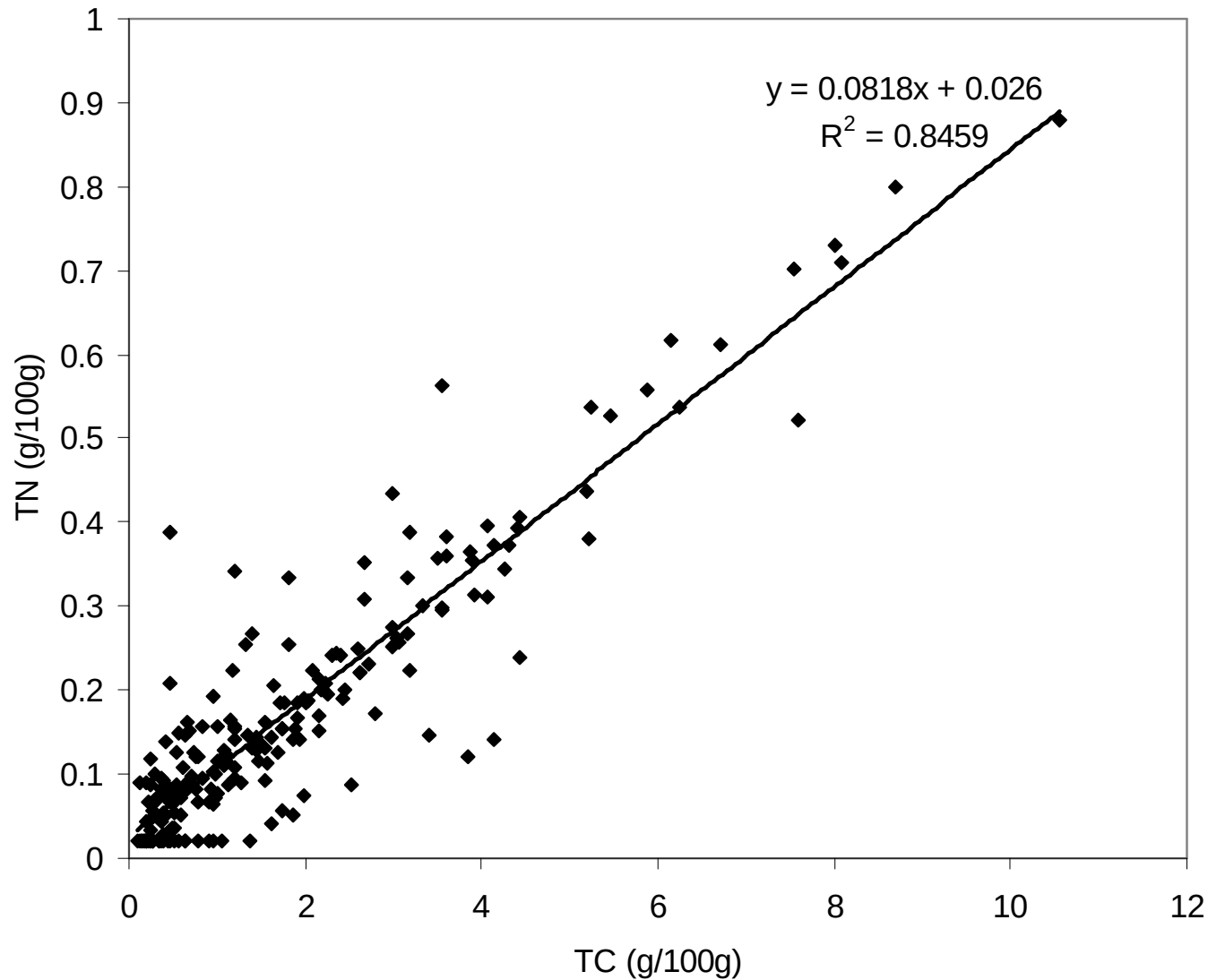
2009 vs 2012



Monaro Soil Carbon

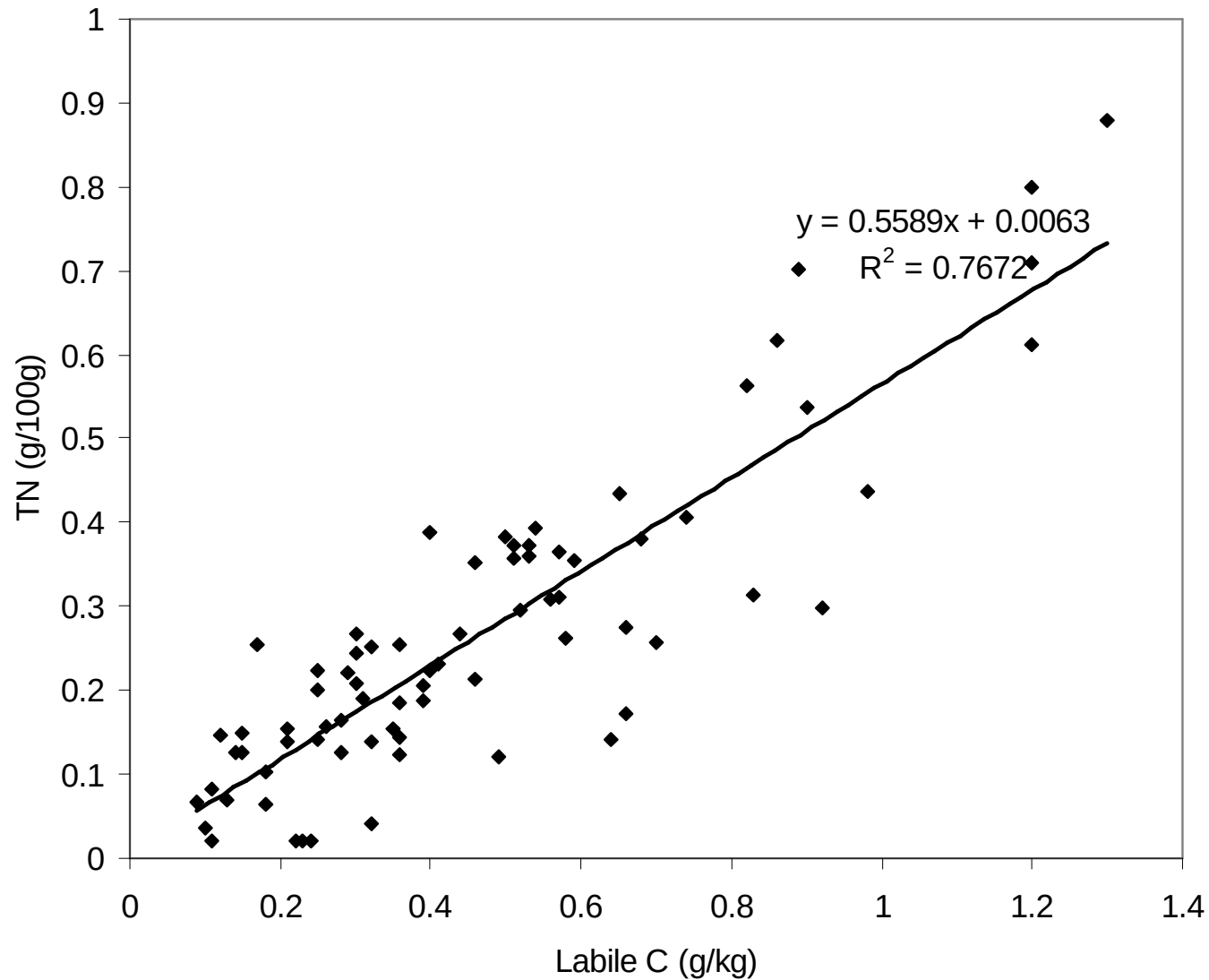
Carbon and Nitrogen are correlated

Total C and Total N 2012



Labile Carbon and Nitrogen are correlated

Labile C and Total N 2012



Preliminary results

- Most of the increase in carbon is labile – i.e. not permanent and high in N
- This could stimulate decomposition of native soil carbon
- Most of the increase was in the surface soil layers
- Strong correlation between carbon: nitrogen and sulfur
- Some sites didn't increase much
- Such big increases due to season could mask management differences

Monaro Farming Systems AOTG Project

- Demonstrations, not replicated
- Comparisons selected to be same soil type, landscape position, within close proximity
- Sampled according to national protocols
- Sampled to 50cm in 10cm layers
- Demonstrations based on local management and current literature
 - Liming
 - Aspect
 - Cropping
 - Pasture type
 - Pasture age
 - P concentration



Preliminary results – a first glance

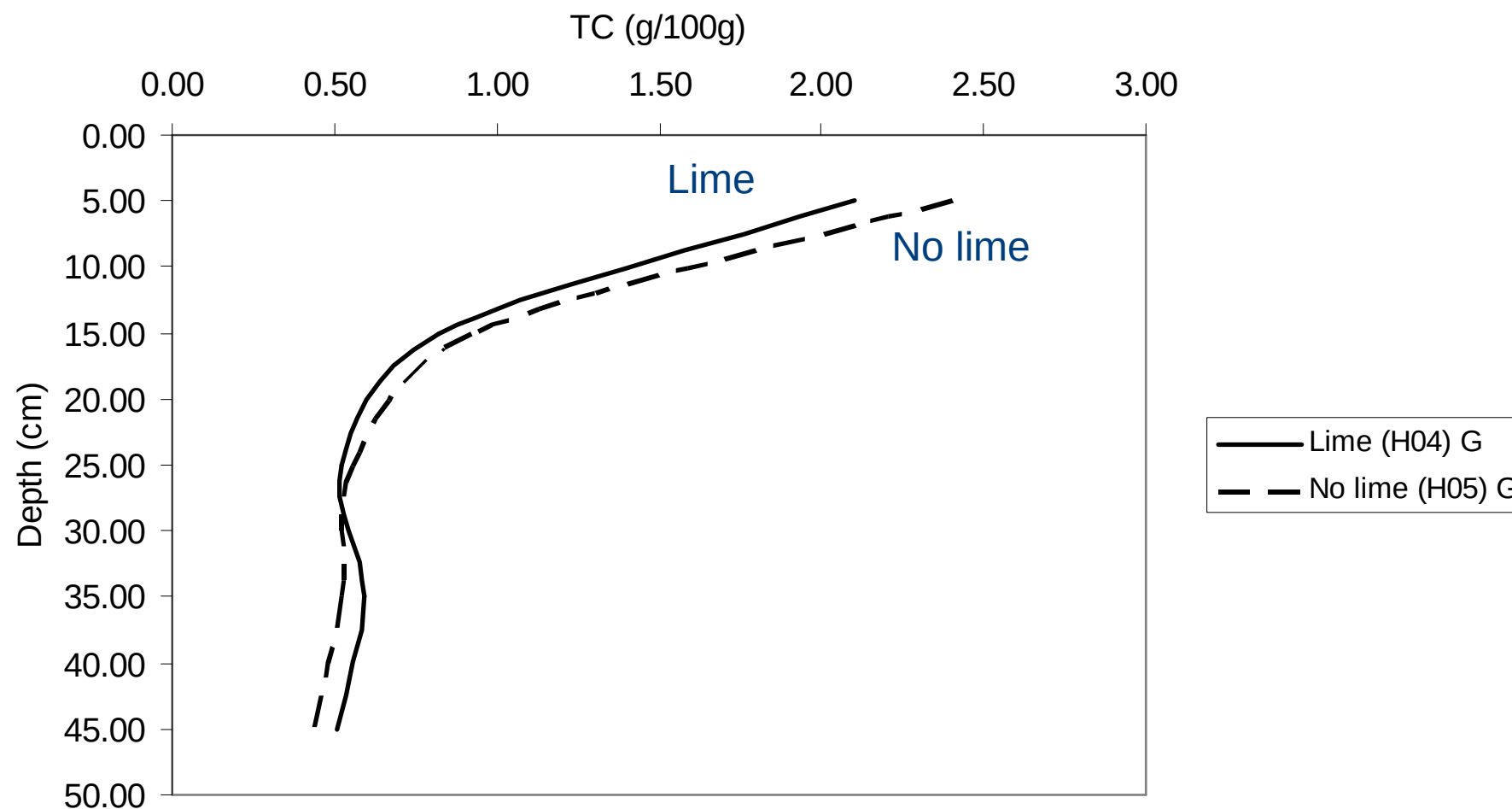


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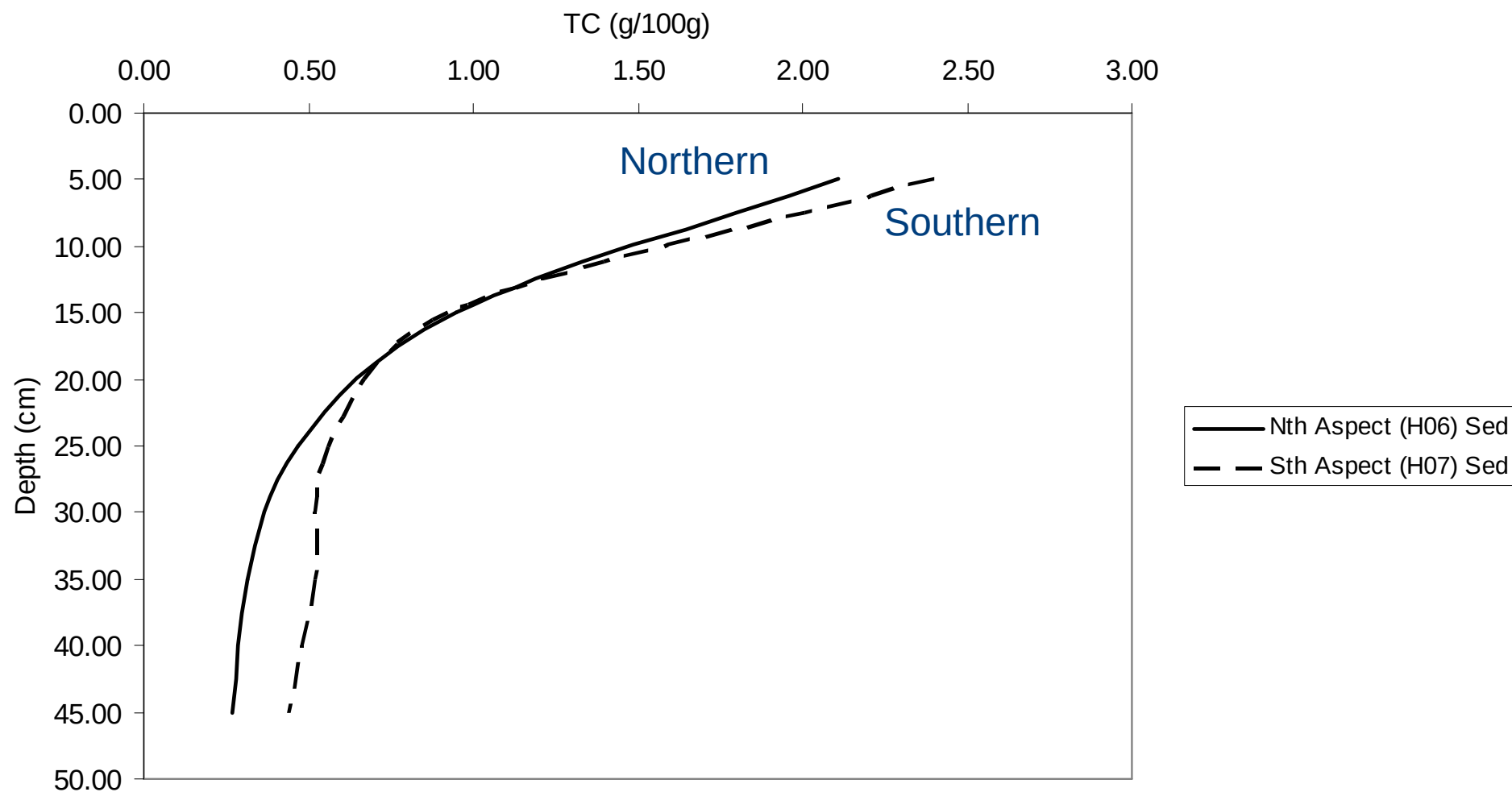


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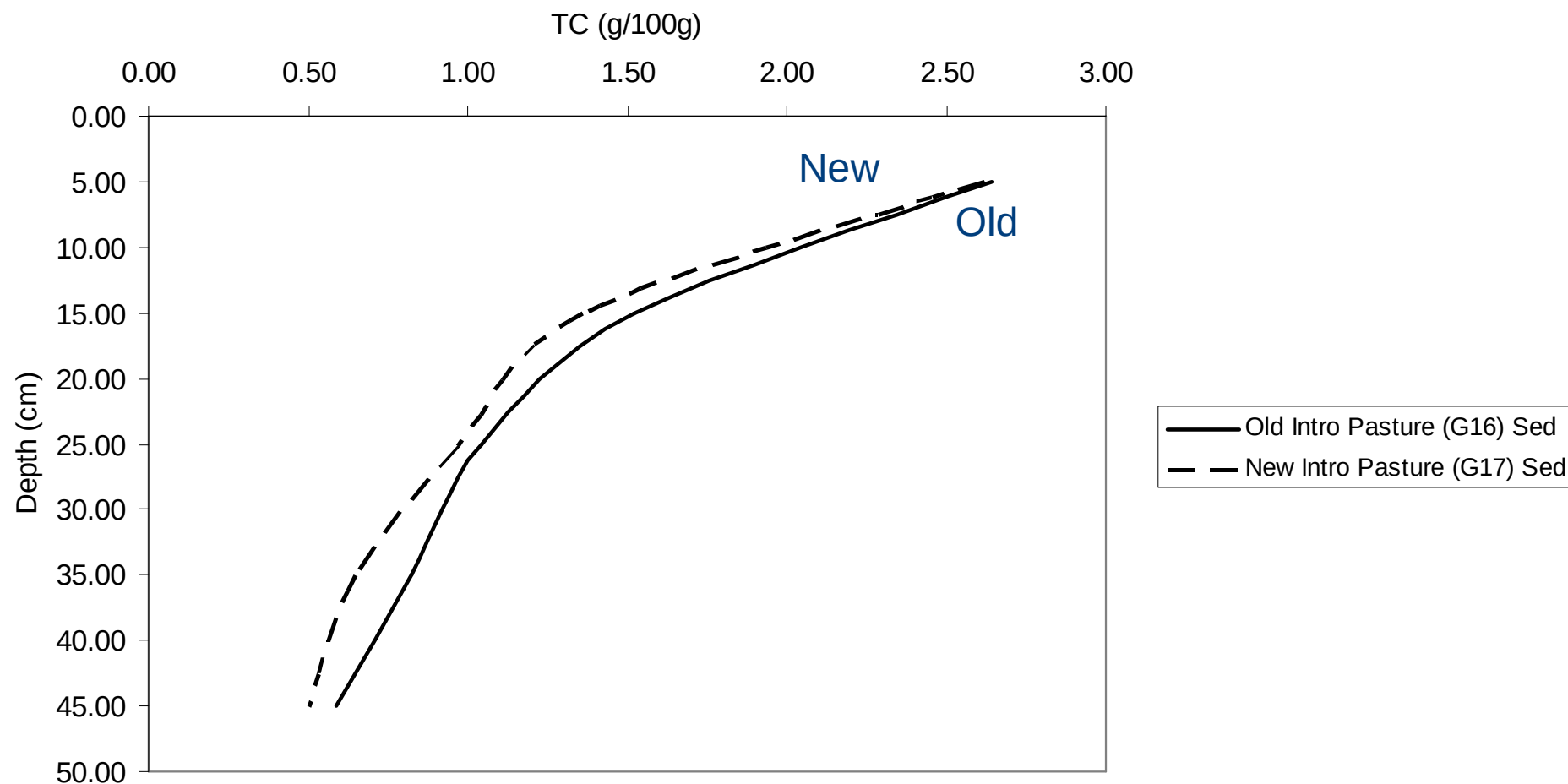
Soil carbon profiles (TC g/100g)



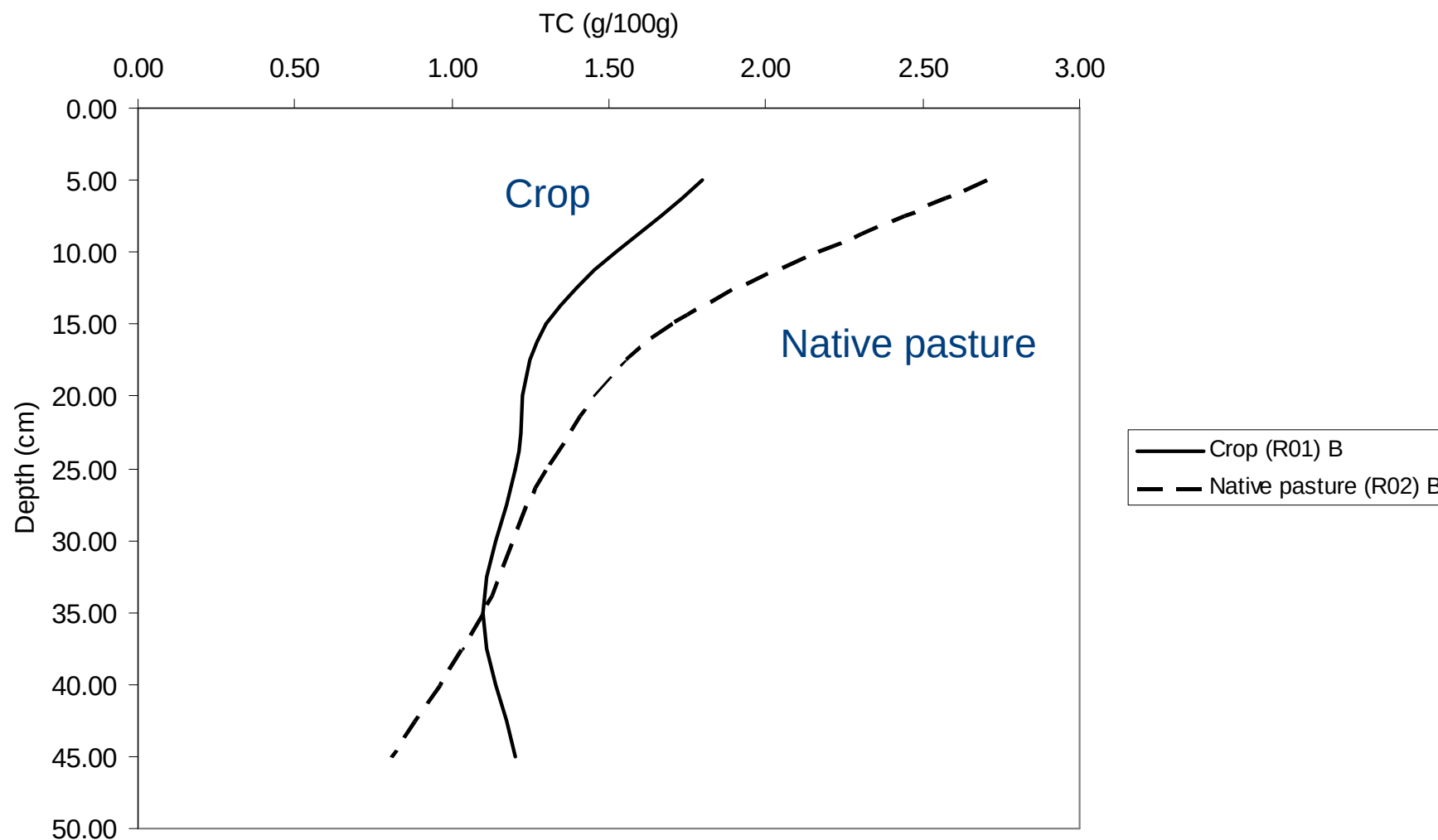
Soil carbon profiles (TC g/100g)



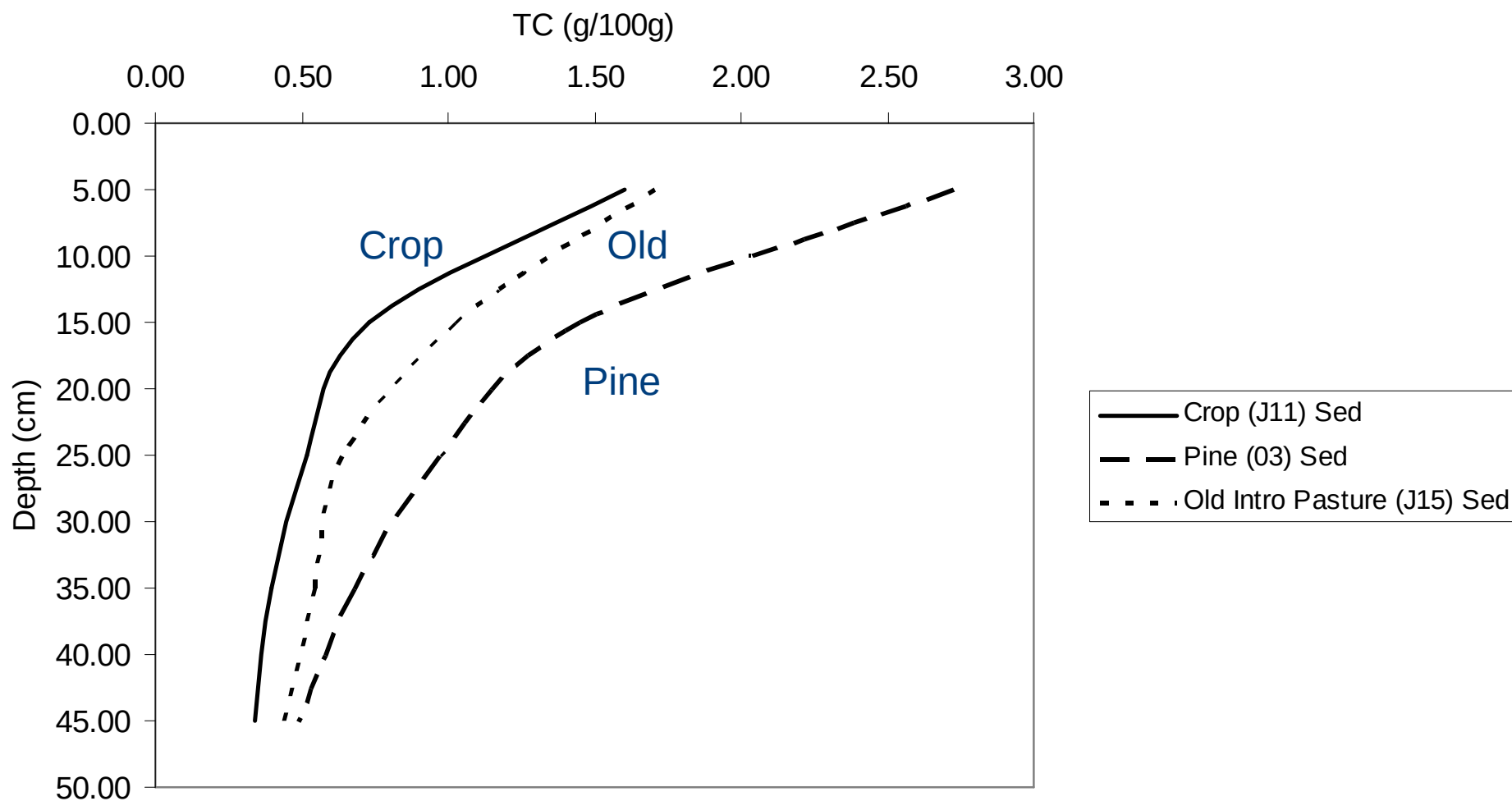
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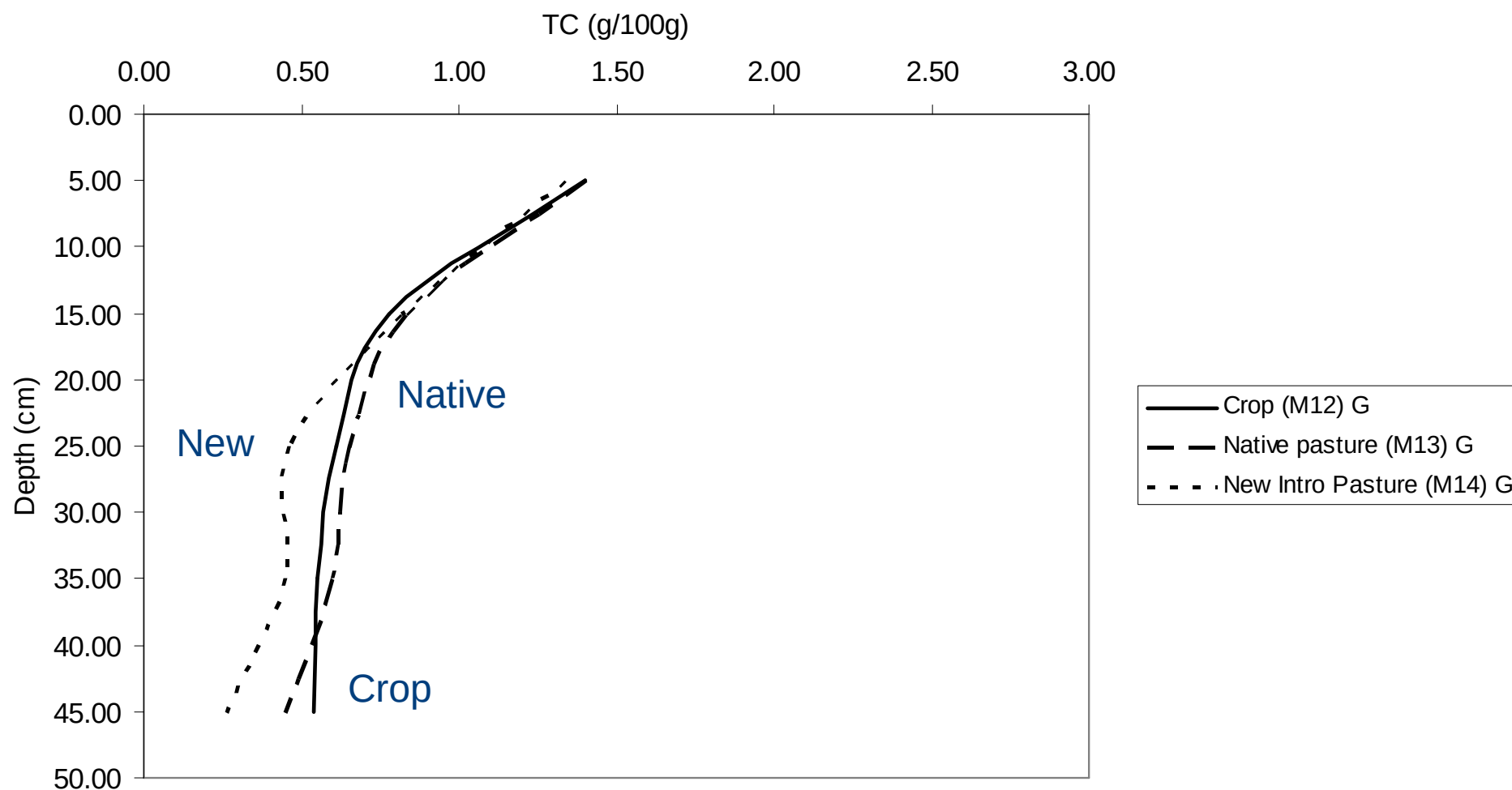


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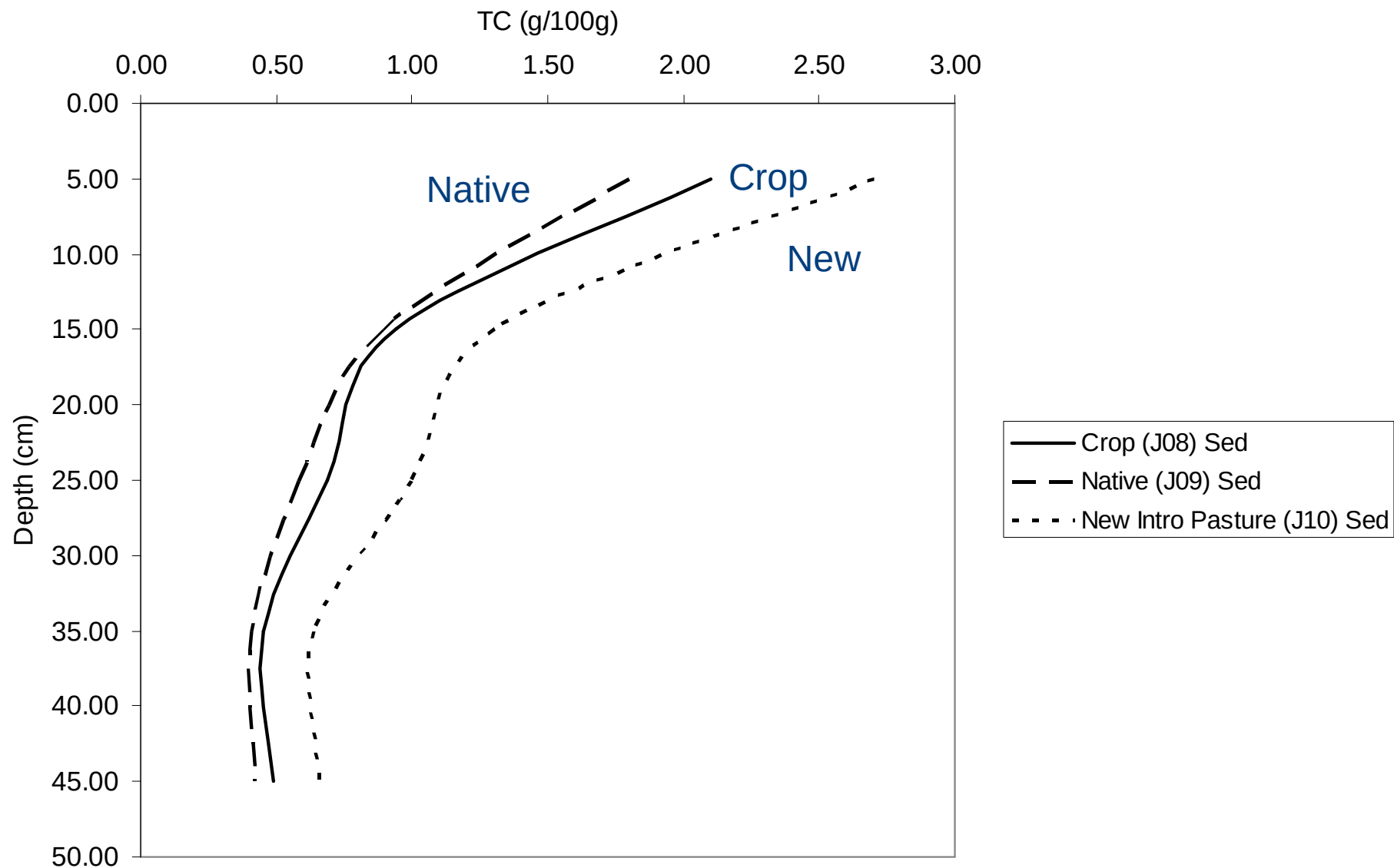


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Soil carbon profiles (TC g/100g)

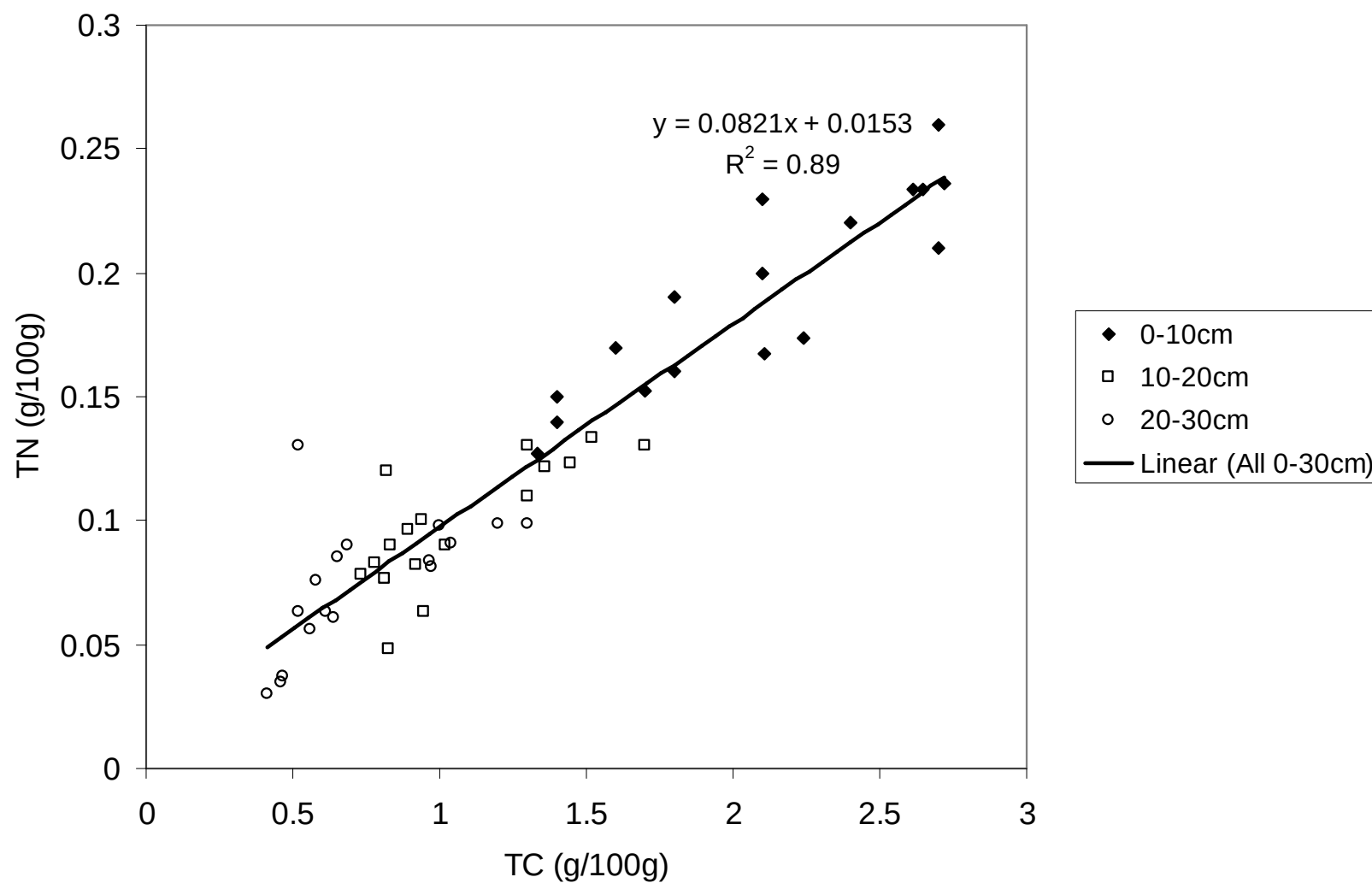


Soil carbon profiles (TC g/100g)

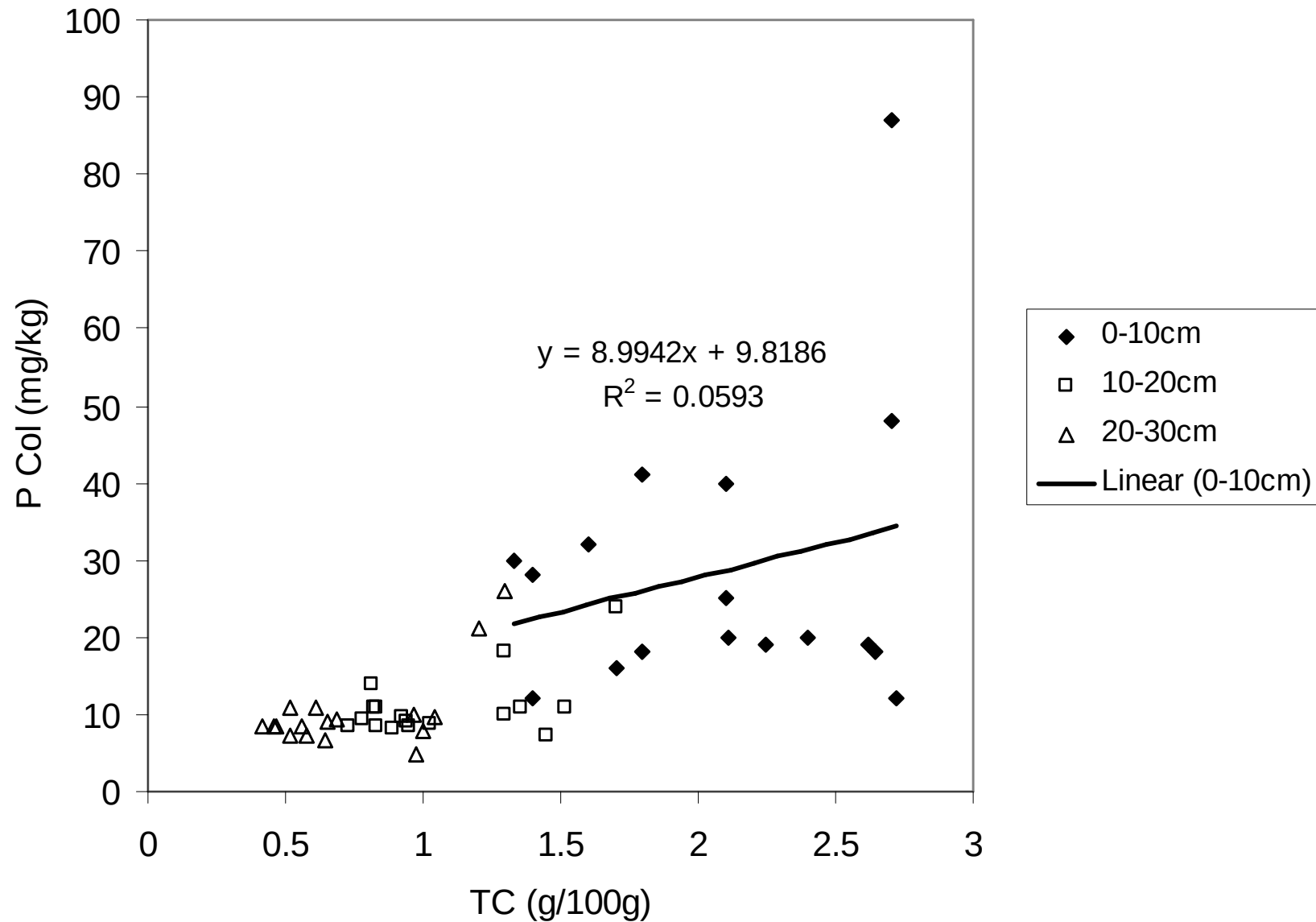


Site ID	C stock (t/ha to 30cm)	C stock (t/ha to 50cm)	Comparison 0- 30cm	Comparison 0- 50cm
Lime (H04) G	46.9	62.8	Lime	
No lime (H05) G	52.8	66.7	(-) 5.9	(-) 3.9
Nth Aspect (H06) Sed	47.3	56.4	North	
Sth Aspect (H07) Sed	45.7	55.6	(+) 1.6	(+) 0.8
Old Intro Pasture (G16) Sed	73.6	96.6	New	
New Intro Pasture (G17) Sed	75.2	92.7	(+) 1.5	(-) 3.9
Crop (R01) B	46.8	72.4	Crop	
Native pasture (R02) B	61.3	82.5	(-) 14.5	(-) 10.1
Crop (J11) Sed	42.7	54.6	Pine Crop	Pine Crop
Pine (03) Sed	67.2	85.7	(+) 22.0 (-) 2.5	(+) 25.4 (-) 5.6
Old Intro Pasture (J15) Sed	45.2	60.2		
Crop (M12) G	41.4	58.1	Crop New	Crop New
Native pasture (M13) G	41.4	58.5	0.0 (-) 1.9	(-) 0 (-) 7.0
New Intro Pasture (M14) G	39.5	51.5		
Crop (J08) Sed	52.1	68.0	Crop New	Crop New
Native (J09) Sed	46.5	60.6	(+) 5.7 (+) 23.8	(+) 7.4 (+) 29.5
New Intro Pasture (J10) Sed	70.3	90.1		

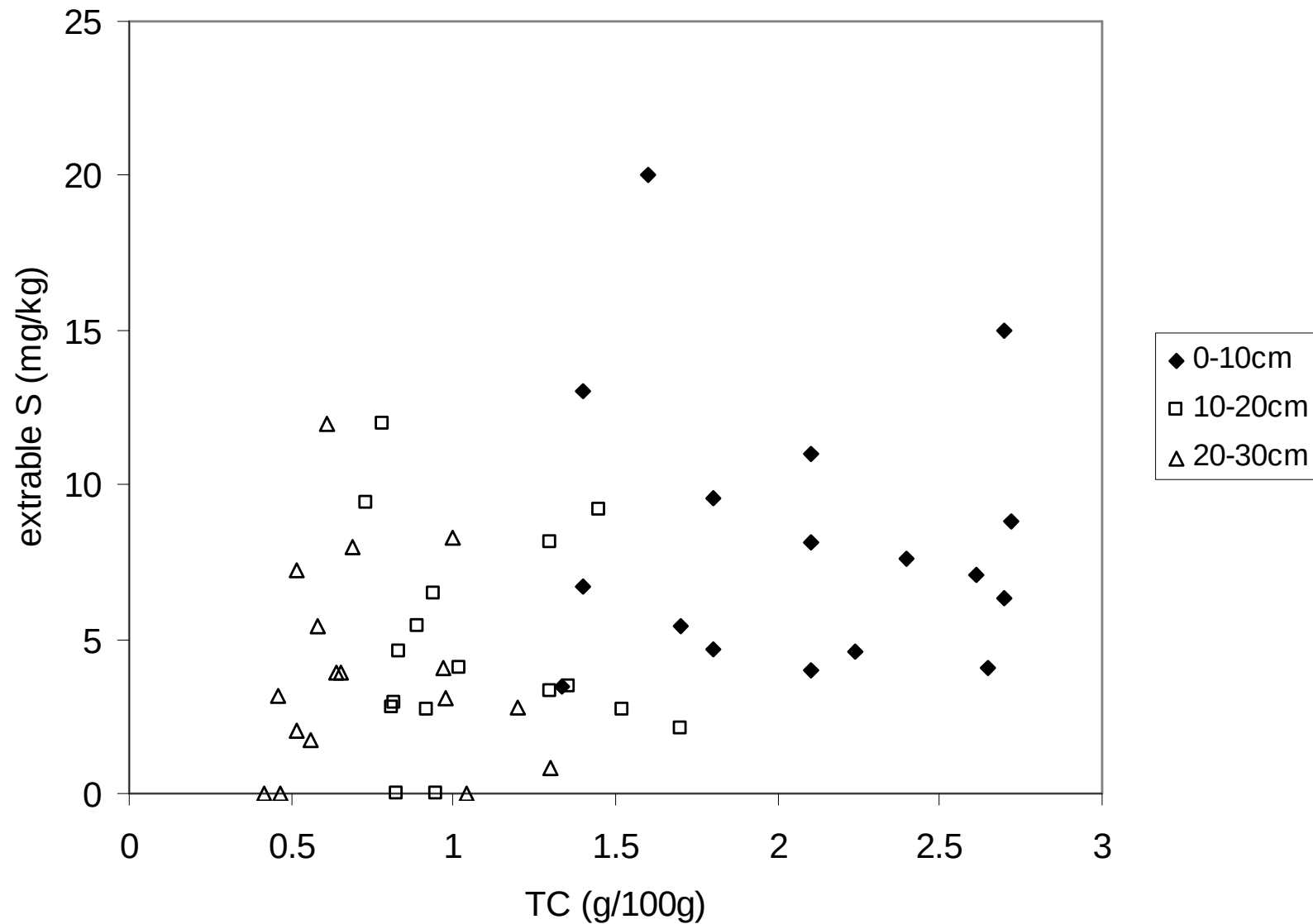
Total carbon and total nitrogen



Total carbon and phosphorus (Colwell)



Total carbon and extractable sulfur (KCl₄₀)



Preliminary findings for the MFS AOTG

- Strong positive correlation between C and N at all sites and depths and to some extent with P and S (within some parent material classes)
- Majority of the variation in carbon concentration and stock in the surface 20cm
- Little difference with aspect, lime and pasture age
- Highest carbon stocks for perennials (pastures and the pines)
- Good seasons preceding sampling may be masking treatment comparisons
- Need to remember that this is a point in time sampling, T2 results will help with comparisons

Take home messages

- What we cant manage:
 - Parent material and climate major drivers of carbon
- What we can manage
 - Soil nutrients, specifically N and S. But, this may come at a substantial cost...
 - Grazing to maximise plant growth, groundcover and organic matter supply
- Any rapid gains in carbon can generally be lost just as rapidly
- There are on-farm productivity and environmental benefits of organic matter in soil

Acknowledgements

- Participating landholders
- Southern Rivers CMA
- Monaro Farming Systems and the Australian Government through the Action On The Ground funding
- Robert Smith (NSW DPI) for technical assistance with field and laboratory components of all Monaro (and State wide) soil carbon work over the past 5 years