NSW GOVERNMENT Department of Primary Industries

Grow more plants, store more carbon

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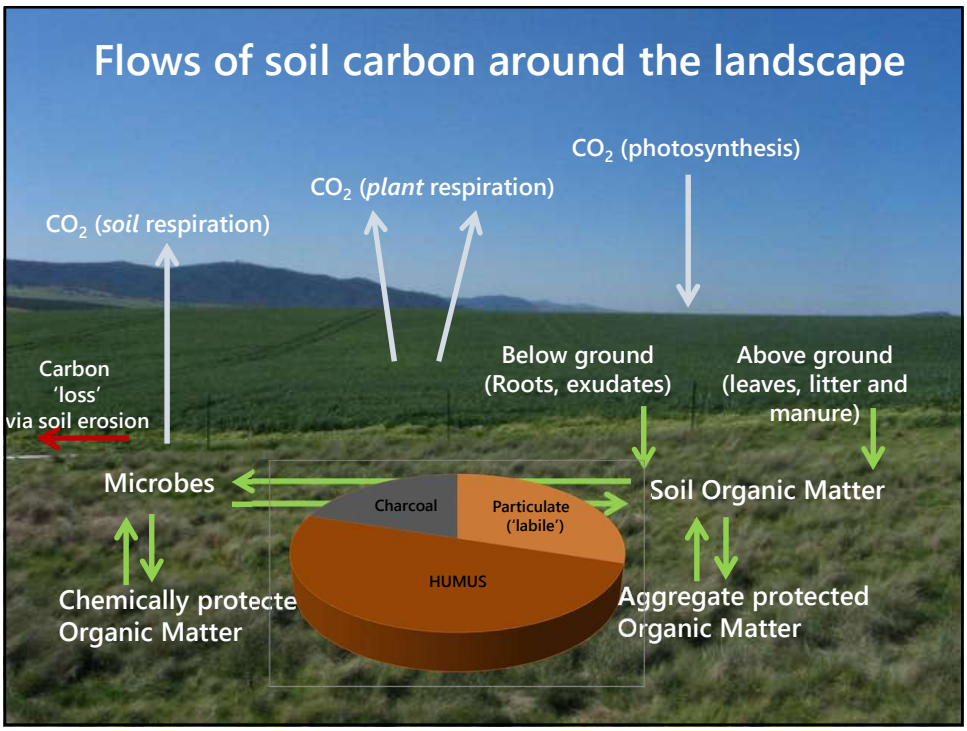
@NSWDPI_Soils www.dpi.nsw.gov.au

Flows of soil carbon around the landscape



Soil Organic Matter (OM) and Soil Organic Carbon (OC)

Soil Organic Matter

- <2mm partially decomposed organic residues
- microbes
- humus
- charcoal

Carbon is what we *measure;* soil organic matter is approx 58% C

The rest is O (10 to ~40%), H (~5%), N (8 to 10%), P (0.5 to 2%), and S (1 to 1.5%) and a range of nutrients and trace elements…

Soil Organic Matter (OM) and Soil Organic Carbon (OC)

- SOC% = total organic carbon in soil, g of C per 100 g soil
- Soil C stocks = t C/ha generally to 0-30cm
- CO_2-e 1 t of C = 3.66 t CO_2

Why are we interested in soil carbon?

Production benefits

- Nutrient cycling
- Water infiltration
- Pasture regeneration & establishment
- Pasture/crop growth & quality

Ecosystem Services

- Soils support food and fibre production
- Regulate climate, store carbon
- Filter and recycle, water, nutrients and waste
- Regulate floods, droughts, heatwaves, frost penetration
- Habitat
- Genetic resource

Opport.

- Increase productivity
- Diversify farm income, access new markets
- Reduce risk, or reverse land degradation
- Improve resilience, lessen impact of climate variability

Soils vary in their capacity to sequester and 'protect' carbon

SOC % is dependant on:

Carbon (OM) supply

Biomass grown or (carbon) amendment added e.g. compost

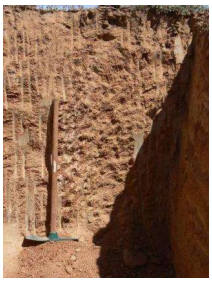
AND

Carbon loss

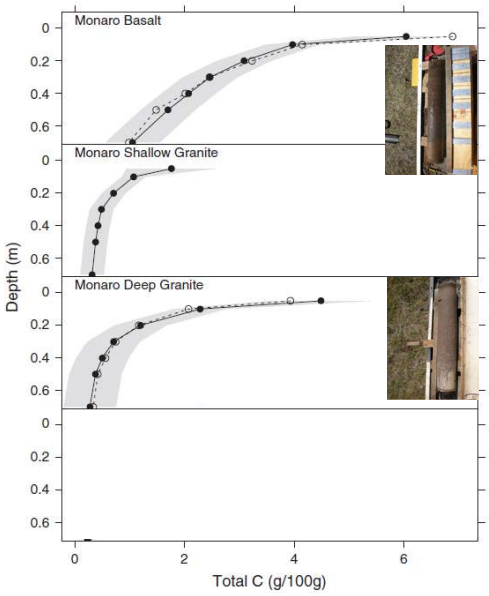
Decomposition and erosion

This is modified by the…

- Type of OM
- Soils capacity to store SOC (clay%, mineralogy, depth, structure)



Soil and climate factors influence carbon sequestration

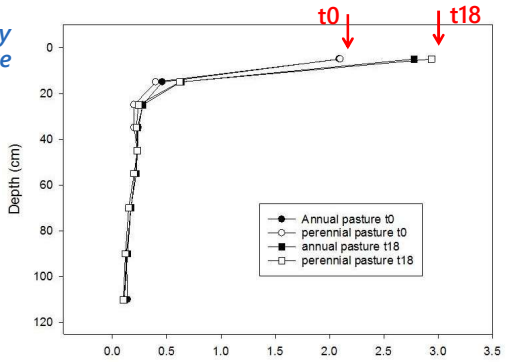


Source: Orgill et al. 2014. *Geoderma*

Management factors	C seq rate (t C/ha/yr 0-30cm)	Years	Reference
Permanent pasture - NSW			
Liming	0.46 to 0.55	18	Chan et al 2011
Pasture rotations	0.22 to 0.40	>13	Chan et al 2011; Helyar et al 1997
Nutrient management	0.41	>25	Chan et al 2010; Orgill et al 2014; Orgill et al 2017
Rotational grazing	0.35	>25	Chan et al 2010
Grazing management (strategic & rotational)	1.04 to 1.46	>5	Orgill et al 2016; Orgill et al 2017
Nutrient mgmt & inc stocking rate (*60cm)	0.60*	20	Coonan et al 2019
Permanent pasture - Australia meta-analysis			
Nutrient management	0.29	dns	Sanderman et al 2010
Irrigation or legumes	0.11		Sanderman et al 2010
Introduced perennial pastures	0.50	dns	Gifford et al 1992
Cultivated crop to pasture - NSW	0. 50 to 0.70	22	Young et al 2009; Chan et al 2011; Conyers et al 2015
Crop to pasture - Australia meta-analysis			
Nutrient mgmt, legumes, irrigation (*30cm+)	0.30 to 0.60	dns	Sanderman et al 2010
Crop with pasture in rotation - NSW			
No till wheat with 2 yr pasture rotation	0.26	25	Chan et al 2011
Crop rotation with 2-6 yr pasture rotation	0.23	18	Helyar et al 1997
Crop - NSW; Nutrients + stubble & incorporated (*160cm)	1.10*	5	Kirkby et al 2016

There are land management options to increase soil carbon BUT this may be slow and unspectacular

Largest gains in soil C stock are typically seen 5 to 10yrs after adoption or practice change

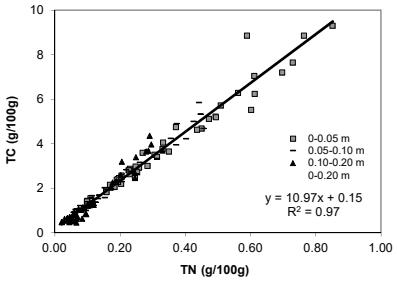


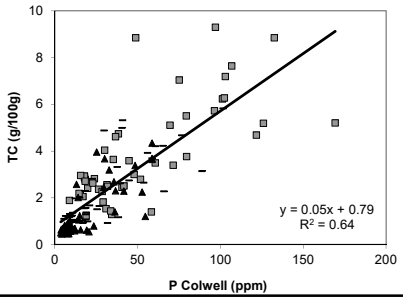
MASTER 18yrs of data 1992-2010

(Managing Acid Soils through Efficient Rotations)

Rotation	*t C/ha/year 0 to 30cm*
Perennial pasture (phalaris & cocksfoot)	+0.50
Annual pasture (rye & sub)	+0.50
Perennials - limed	+0.55
Annuals - limed	+0.46

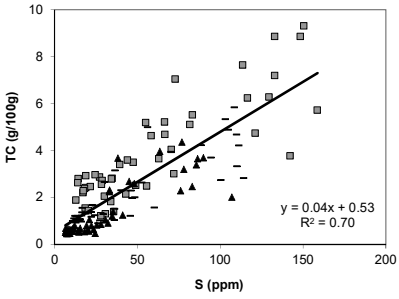
Crop and pasture management that increases plant growth can also increase soil carbon





PART 1 Strong correlations between SOC and nutrients

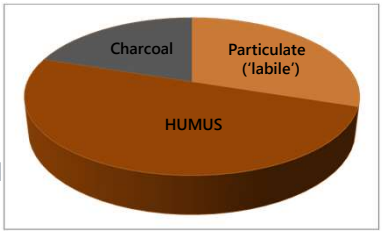
1. More plant growth = greater OM supply
2. Grass dominant pastures rely on N-fix from legumes
3. Legumes require more P and S for nodulation



PART 2

Soil microbes need nitrogen (N), phosphorus (P) and sulphur (S)

1. Humus consists of the remains of bacteria and other microbes that 'break down' OM
2. Plant material consists mainly of carbon
3. To increase humus (stable C) soil microbes use N, P and S



	C	N	P	S
Humus	1000	~90	~19	~14
Wheat	1000	17	2	3
Phalaris (shoot)	1000	71	5	5
Subclover (shoot)	1000	89	10	..

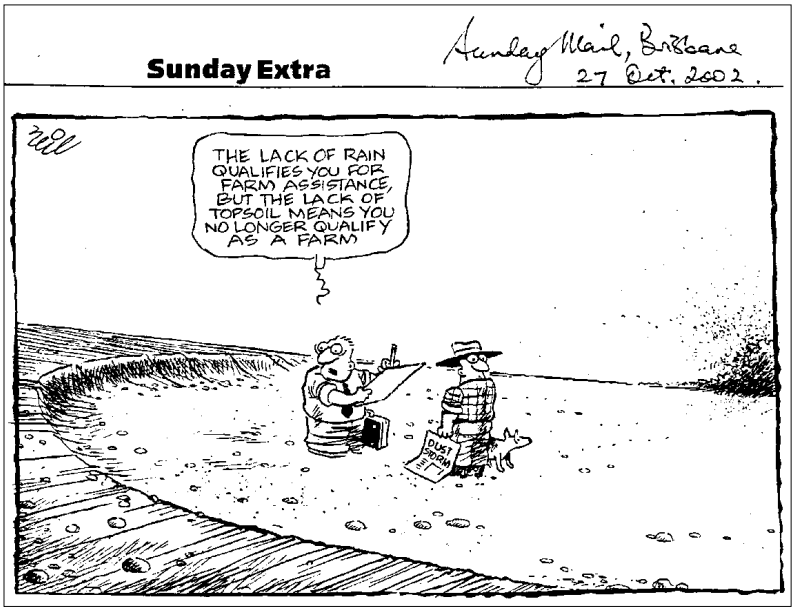
Kirkby et al. (2011) Geoderma, 163:197-208

Nutrients for plants AND for soil microbes?

In some systems, why doesn't SOC increase despite 'best' management?

- Large background SOC levels
- Soil type and climate (drivers of production and OM turnover)
- Poor crop and pasture nutrition
- Drought
- Spatial variability

In some cases, SOC may not be a sensitive measure of the benefits of management…



Adaptive management – future proofing soils (and farming systems)

Resilience on your farm through enabling your soil to

- Store more water
- Cycle more nutrients
- Grow more plants
- Make more soil

- Think about transforming part of the farm or farming system (there are risks with pulling the rug out!)
- Make the transition or changes on parts of the farm as part of a plan
- Identify the inefficiencies (e.g. fertiliser application) and start there
- Think about profitability over time, not just short-term production/yield
- Ask questions of … everyone!

Productivity is linked to soil functions that depend on decomposition of organic matter

Pastures improve soil structure and nutrient (re)cycling, but do not always increase soil carbon

Pasture rotations increase soil nitrogen for the following crop, but not always soil carbon

Grazing management can increase soil carbon (!) but this may not always be detected. Importantly grazing management drives groundcover and soil functions.

SOC and soil N	Grazing treatment (0-30cm)		
(t/ha)	Ungrazed	Tactical	Cell
SOC	25.6[b]	29.5[a]	32.9[a]
Soil N	2.5	2.7[a]	2.7[a]

Orgill et al 2016

Soil carbon – market snapshot

- $13.87/t CO_2-e* (general increase, min ~$10.23/t) (i.e. $13.87 x 3.66 = $50.76/t C)
- Agriculture: 18.2M t abatement contracted so far; 17M t is soil carbon
  - $1.8B already committed

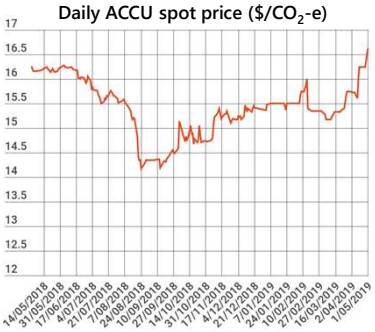
Future purchasing

- Funding includes Climate Solutions Fund to reach Australia's 2030 emissions reduction target (deliver another 100 million tonnes of emissions reductions by 2030)
- Total investment = $4.55B

Voluntary market (~$16.37/t CO_2-e) - demand for ACCUs has doubled, e.g. CN2030/50

- ACCU = Australian Carbon Credit Unit

Daily ACCU spot price ($/$CO_2$-e)



Source: RepuTex Connect, 2019
https://www.reputex.com/blog/insights-what-is-the-current-australian-carbon-spot-price/

Soil carbon methodologies

ACCU's need to be consistent with approved methodologies

Some buyers pay more on the voluntary market (value of co-benefits!)

Soil carbon methods

1. Measurement of soil carbon sequestration in agricultural systems
2. Estimating sequestration of carbon in soil using default values method (model-based soil carbon)

Needs to be additional, new (not business as usual) and permanent (25 or 100yr contracts)

In Summary…

- Carbon is cycling on your farm already
- …. To change it and sequester more SOC you may need to change practice
- So what is your biggest lever?
- Remember that there may be some soil and climate factors that limit carbon sequestration
- To increase SOC on your farm consider:

  right practice, right place, right time

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