






Department of
Primary Industries




Building soil organic carbon – the role of your management

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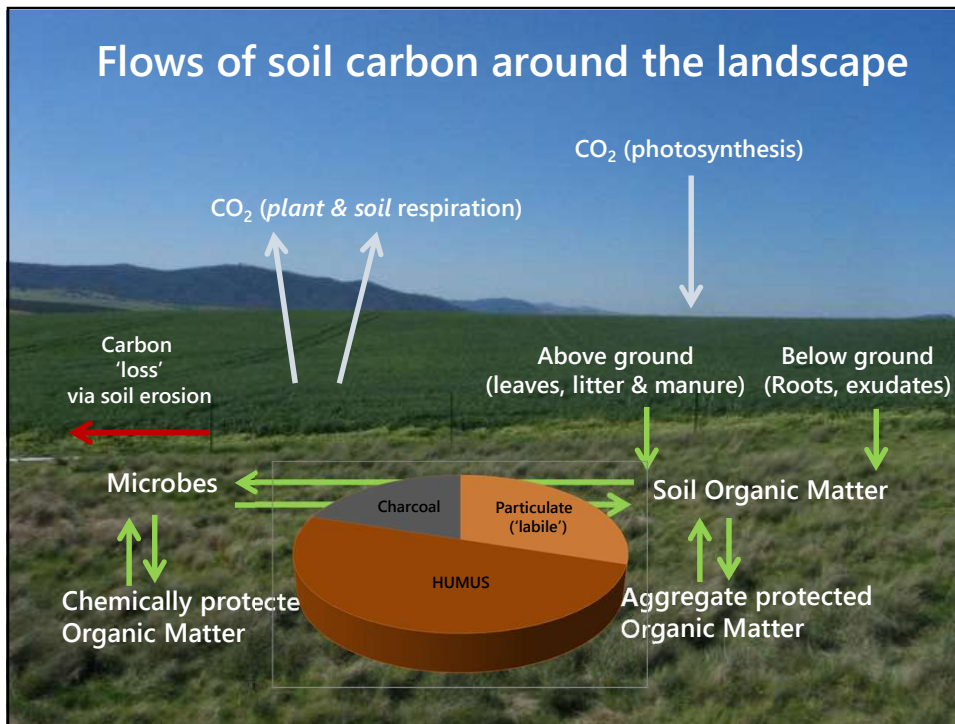
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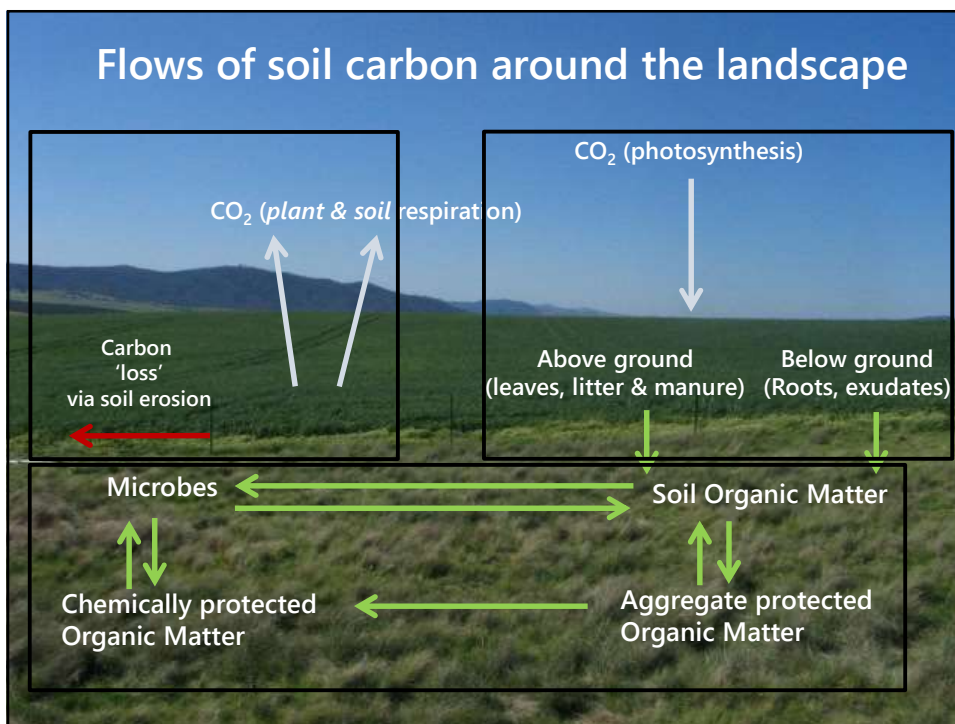
Scenario 3: Soil Organic Carbon

Carbon, it's all that is currently talked about. My kids want me to do something to help the environment and there seems to be lots of **benefits** in improving soil carbon and I don't want to miss out if there is money to be made from **carbon credits** or benefits to be had. But I hear it's **tricky** to change levels and to **tell if you are**, you need to do lots of testing over a **long time** or test **carbon fractions**. I'm not sure that my **carbon levels** are even that bad and that its worth lifting them. How do I even tell and if I do try and improve, what's the **best way to improve soil carbon**? The neighbours are putting on compost and I have heard about special pasture renovators and even biological stimulants to increase soil carbon.

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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%)

S (1 to 1.5%)

and a range of **nutrients and trace elements...**

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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

(Soil C stocks (t C/ha) = SOC g/100g x depth (cm) x BD)

- CO₂-e 1 t of C = 3.66 t CO₂

(Carbon dioxide equivalent)



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Example: calculating Soil Carbon (SOC) stocks

- Soil C stocks (t C/ha) = SOC g/100g x depth (cm) x BD

E.g. SOC = 2.7 g/100g, depth = 10cm, BD = 1.03

Soil C stocks (t/C/ha) = 2.7 x 10 x 1.03 = 27.8

... you need to do lots of testing over a long time or test carbon fractions. I'm not sure that my carbon levels are even that bad and that its worth lifting them.

Monitoring and measuring SOC

- Soil organic carbon (total) – dry combustion test
- 0-10 cm (+) monitoring vs 0-30 cm trading
- Monitor frequently (with other soil testing); set your own benchmarks; GPS the location
- Getting ACCUs (C trading) is a different game; lots of paperwork, planning, mapping, specialised sampling gear & process (work with project managers)



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Why are we interested in soil carbon?

Production benefits

- Nutrient cycling
- Water infiltration and storage
- Plant growth & quality

Soil organisms –
'functional carbon'!

Increased cation exchange capacity (CEC)
SOC = 25 to 90% of CEC
(depends on soil type, management, soil pH, OM type)

Nutrient reservoir
~1% increase in SOC in
0-10cm loam soil =
1080 kg N
228 kg P
168 kg S

Increased water holding capacity
1% increase in SOC = 20-30% extra WHC for sandy loam
10% extra in WHC for clay loam

... there seems to be lots of **benefits** in improving soil carbon and I don't want to miss out if there is money to be made from **carbon credits** or benefits to be had

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Why are we interested in soil carbon?

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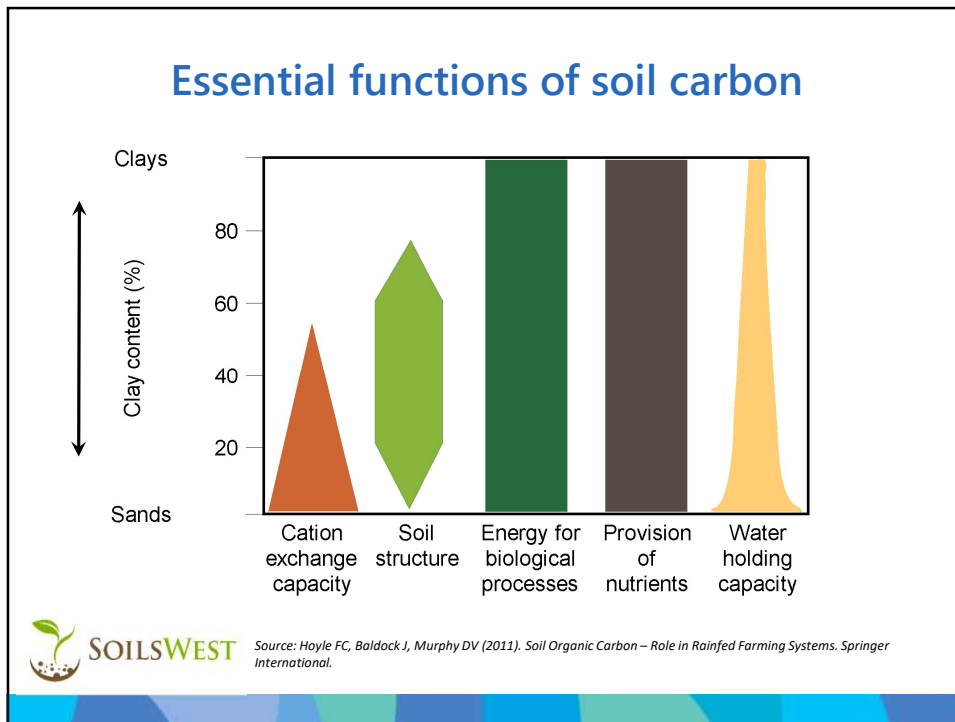
Ecosystem Services

- 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

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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, vegetation and climate factors influence carbon sequestration

- These factors drive productivity
- Some can be changed (plant type, structure)
- Some cannot be changed (clay, soil depth)

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We CAN build soil carbon and continue to produce food and fibre

Supply of organic matter

- Pastures
- Stubble
- Cover crops
- Nutrients
- Manure
- Composts etc

Loss of organic matter

- Decomposition
- Erosion

...But I hear it's **tricky** to change levels...

Increasing biomass through good agronomy, grazing and residue management increases...

- Productivity AND
- Supply of organic matter

Therefore building SOC


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Plant nutrition


Grazing management

Management	Region (NSW)	C seq rate (t C/ha/yr 0-30cm)	Years	Reference
Pastures - NSW				
Liming	Riverina	0.46 to 0.55	18	Chan et al 2011
Nutrient management	Southern Tablelands	0.41	>25	Chan et al 2010; Orgill et al 2014; Orgill et al 2017
Rotational grazing	Southern Tablelands	0.35	>25	Chan et al 2010
Grazing management	Southern Tablelands & Western Division	1.04 to 1.46	> 5	Orgill et al 2016; Orgill et al 2017
Nutrient mgmt & inc stocking rate (*60cm)	Southern Tablelands	0.60*	20	Coonan et al 2019
Organic amendments	Central West	1.09 to 2.47	5	Badgerly et al 2020
Pastures - Australia meta-analysis				
Nutrient management		0.29	dns	Sanderman et al 2010
Irrigation		0.11		Sanderman et al 2010
Introduced perennial pastures		0.50	dns	Gifford et al 1992
Cultivated crop to pasture		0.50 to 0.70	22	Young et al 2009; Chan et al 2011; Conyers et al 2015
Min till crop to pasture		0.78 to 1.33	5	Badgerly et al 2020

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Pastures in rotation



Crop nutrient & residue management

Management	Region (NSW)	C seq rate (t C/ha/yr 0-30cm)	Years	Reference
Crop to pasture - NSW				
Cultivated crop to pasture	North West & Riverina	0.50 to 0.70	22	Young et al 2009; Chan et al 2011; Conyers et al 2015
Min till crop to pasture	Central West	0.78 to 1.33	5	Badgery et al 2020
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				
Pasture rotations				
Pasture rotations	Riverina	0.22 to 0.40	>13	Chan et al 2011; Helyar et al 1997
No till wheat with 2 yr pasture rotation	Riverina	0.26	25	Chan et al 2011
Crop rotation with 2-6 yr pasture rotation	Riverina	0.23	18	Helyar et al 1997
Crop with nutrients - NSW				
Nutrients + stubble & incorp (*160cm)	South West Slopes	1.10*	5	Kirkby et al 2016
Organic amendments + direct drill crop	Central West	0.32 to 0.64	5	Badgery et al 2020

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There are multiple strategies to build SOC

- Pastures**
 - Grazing management is KING! Think time and timing
 - Legumes and nutrients from microbes
- Crops**
 - Changing the crop and pasture sequence
 - Minimising tillage, and in some cases considering strategic tillage (to overcome a soil constraint or plant disease)
 - Retaining stubble
- General**
 - Nutrients for plants and microbes (build humus)
 - Liming to overcome acidic soil constraints
 - Gypsum to overcome sodicity, compaction or surface sealing
 - Changing practice or land use on degraded soils
 - Adding carbon-rich materials (e.g. composts and manures)
 - Mixed species plantings
 - Biostimulants
 - Microbes that store stable carbon






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

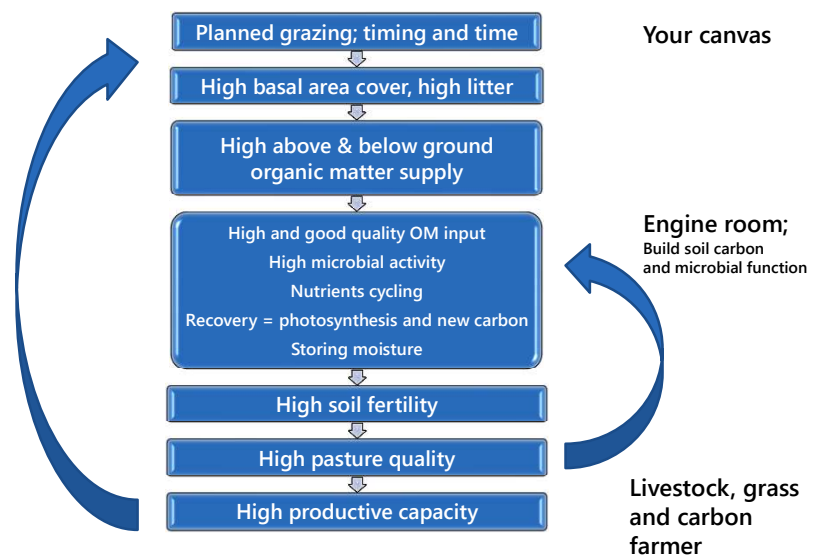


- Large background SOC levels
- Soil type and climate (drivers of production and OM turnover)
- Plant nutrition
- Drought
- Spatial variability

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

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Manage carbon flows, not stocks



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- ✓ It is possible build soil organic carbon and support productivity!
- ✓ SOC% is a cheap and important indicator of soil condition – add this to your soil test and monitor; create your own benchmarks; compare with others
- ✓ 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?
- ✓ The C market is real & maturing; know your canvas, assess your business goals & aspirations and see if it is a good fit for you
- ✓ There may be some soil and climate factors that limit carbon sequestration
- ✓ Benefits beyond trading; improvements to **soil fertility and structure** come from carbon cycling – **microscopic livestock are key!**
- ✓ To increase SOC on your farm consider:

right practice, right place, right time

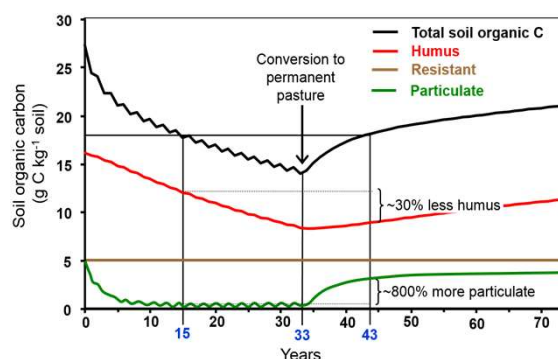
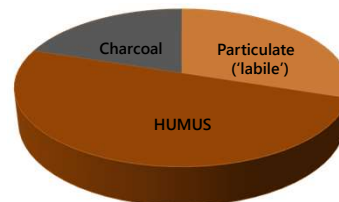
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Permanence – Increase 'stable' carbon or sustain the higher level of carbon input

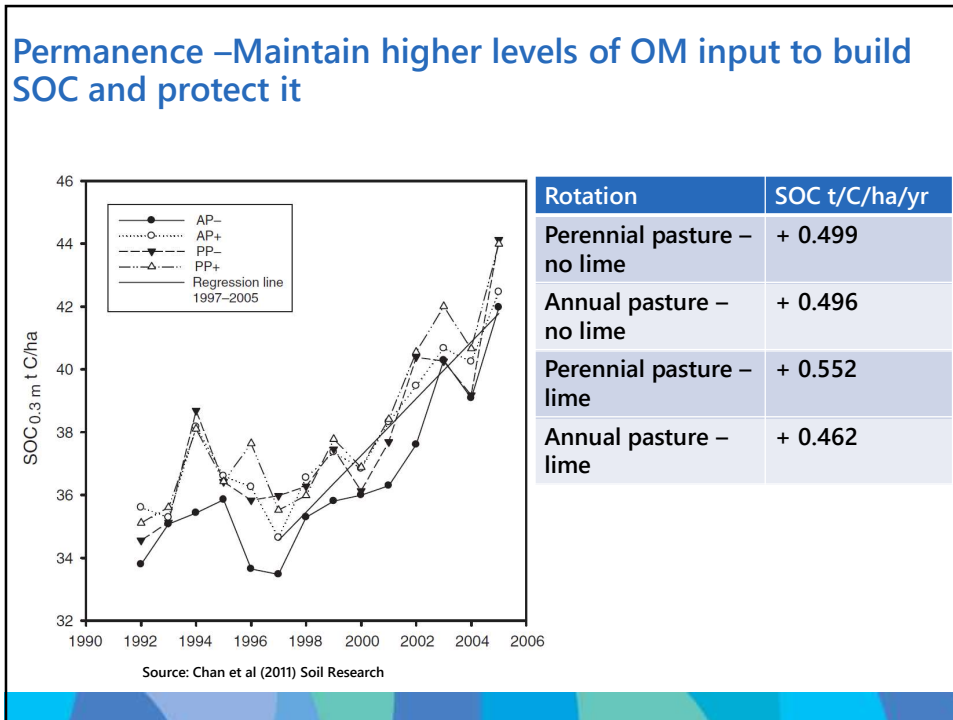
Management influences fractions of SOC

- SOC losses rapid; rebuilding SOC slower and in altered state
- Changing a wheat-fallow rotation to permanent pasture altered SOC fractions over 75yrs (Roth-C simulation)



Source: Jeff Baldock, CSIRO

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