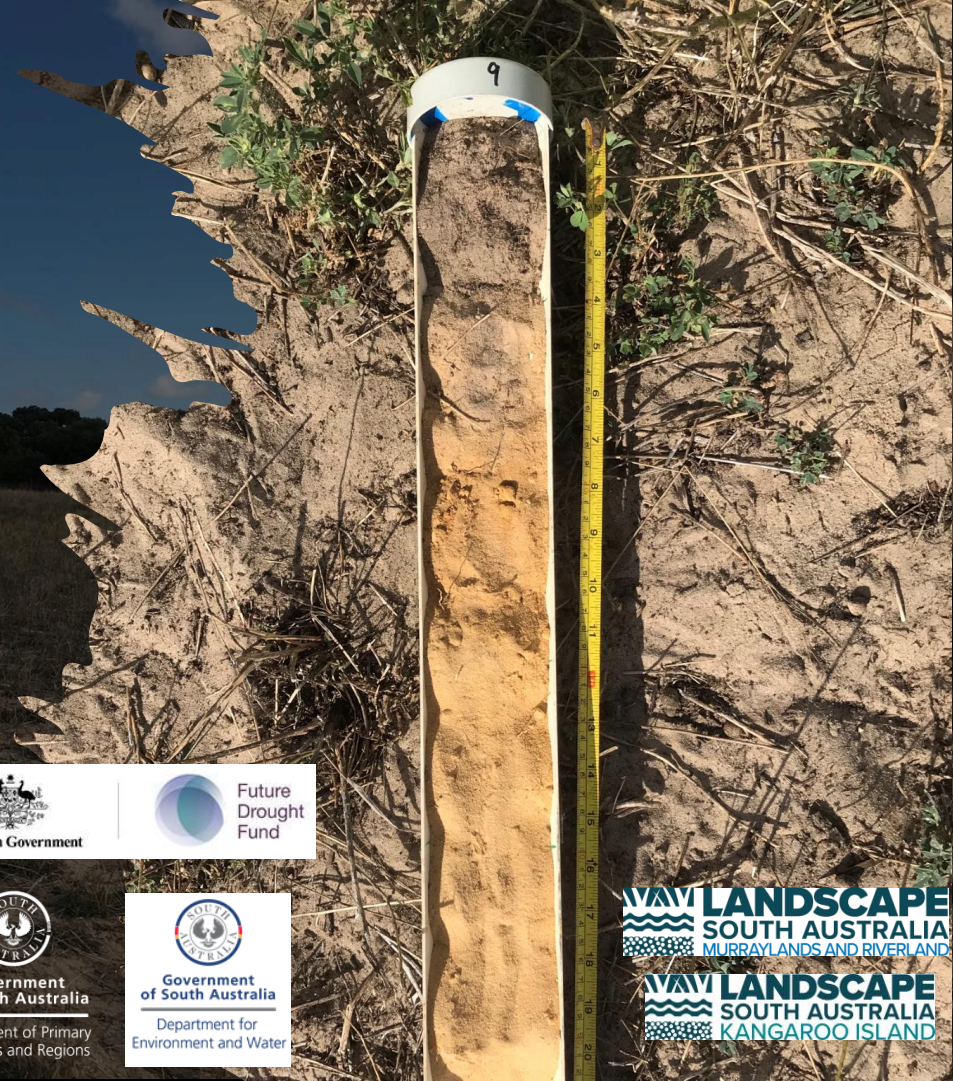
Soil Carbon in SA Soils

Bowhill, 17 February 2022

Carbon and Agriculture

Is it possible to make your farm carbon neutral?



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Australian Government | Future Drought Fund

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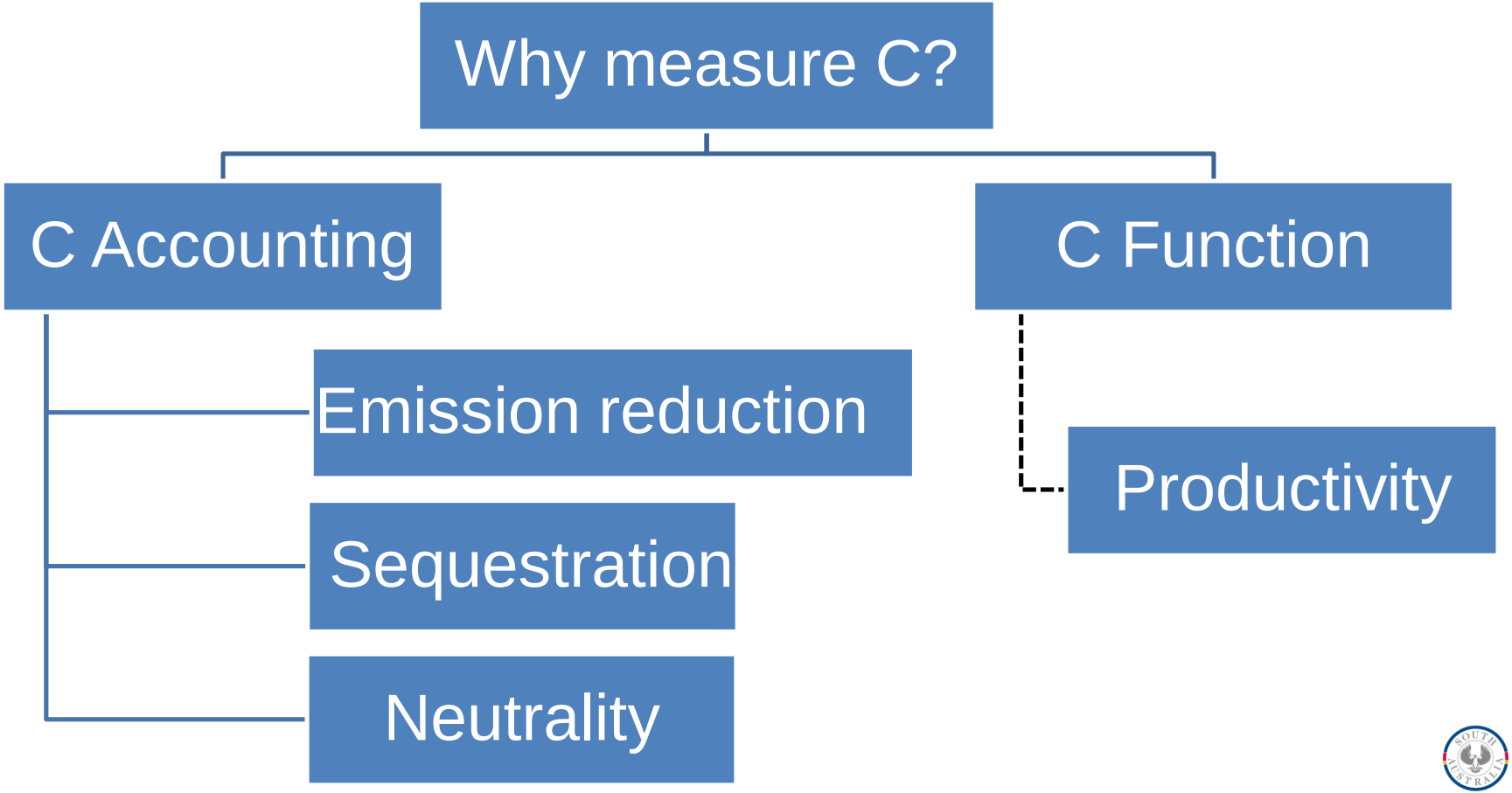
LANDSCAPE SOUTH AUSTRALIA MURRAYLANDS AND RIVERLAND

LANDSCAPE SOUTH AUSTRALIA KANGAROO ISLAND


C Footprint
ACCU
Neutrality
Carbon in your farm business
Sequestration
C Positive
Abatement
GHG emissions
Net zero



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Carbon Neutral

- businesses and organisations are choosing to reduce their climate impact to zero by becoming carbon neutral
- gain certification (e.g. Climate Active, Industry targets)

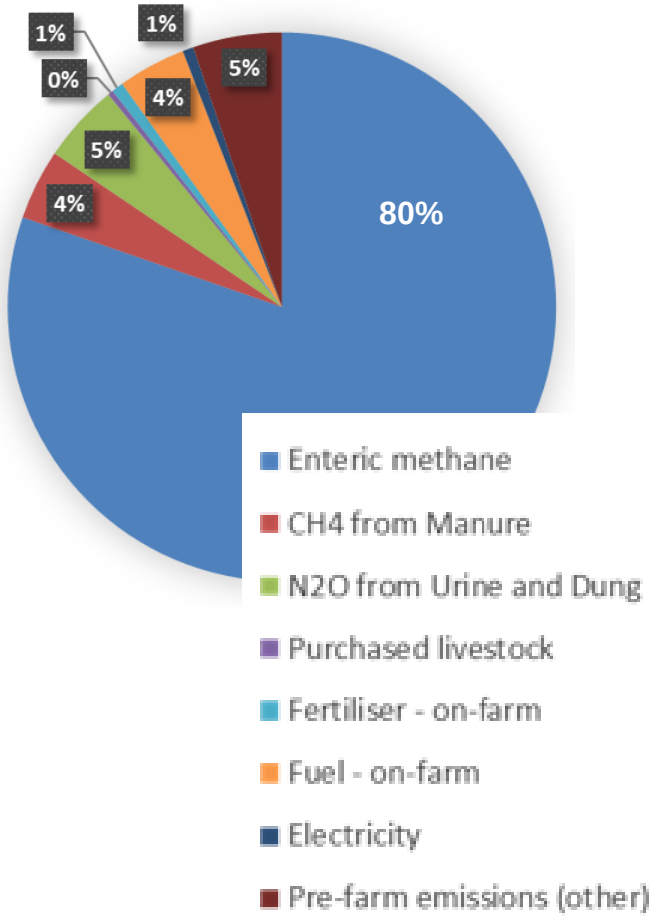
To do this:

1. **calculate** the greenhouse gas emissions – C Footprint
2. **reduce emissions** as much as possible by investing in new technology or changing the way you operate
3. **offset** any remaining emissions by sequestration or purchasing carbon offset units

Carbon Footprint – Turretfield Research Centre

Gross Emissions	(t CO_2-e)	% of emissions
Scope 1	885	94%
Scope 2	6	0.5%
Scope 3	53	5.5%
Total Emissions	**944**	**100%**
Methane – CH_4	799	84%
Nitrous oxide – N_2O	54	6%
Carbon dioxide – CO_2	91	10%

SCOPE 1	Direct GHG emissions from sources owned or controlled by the company (e.g. diesel use in tractors, livestock emissions)
SCOPE 2	GHG emissions from generation of electricity consumed on the location by the company
SCOPE 3	GHG emissions from sources not owned or controlled by the company (eg extraction and production of fertilisers)



Extracted from Integrity Ag & Environment Report for PIRSA, 2021

Carbon Projects – Emission Reduction Fund

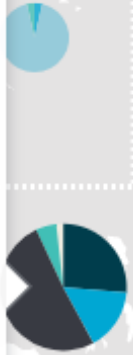
- Earn Australian Carbon Credit Units (ACCUs) by participating in specific activities under emission reduction or sequestration projects
- ACCUs can be sold to generate income either to the government or in a secondary market
- **You can not sell ACCUs and use to become C Neutral**
- Contracts with Clean Energy Regulator (CER)
    - Fixed – obligates seller to deliver an agreed quantity of ACCUs
    - Optional – offers seller the right but not the obligation to sell ACCUs
    - No contract – still provide offset and audit reports and ACCUs issued
        - CER will not purchase without a contract
        - can sell on secondary market or directly to other parties

http://www.cleanenergyregulator.gov.au/ERF/Forms-and-resources/auctions-and-contracts/contracts-frequently-asked-questions#5

All Methods

SOUTH AUSTRALIA

METHOD	PROJECTS	ACCUs ISSUED
Vegetation	15	219,072
Landfill and Waste	9	1,364,496
Agriculture	29	6,168
Savanna Burning	0	0
Energy Efficiency	3	29,632
Transport	1	0
Industrial Fugitives	0	0
Facilities	0	0
Total	57	1,619,368



SOUTH AUSTRALIA CONTRACTED

HIDE

Projects	15
ACCUs Issued	1,308,209

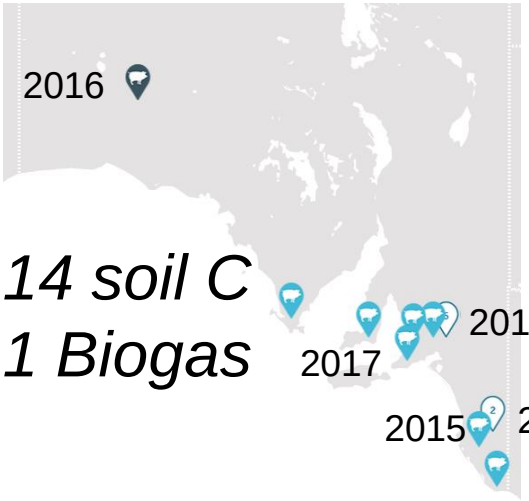
SOUTH AUSTRALIA NON-CONTRACTED

HIDE

Projects	42
ACCUs Issued	311,159

Agriculture methods – 3 out of 29 projects are contracted

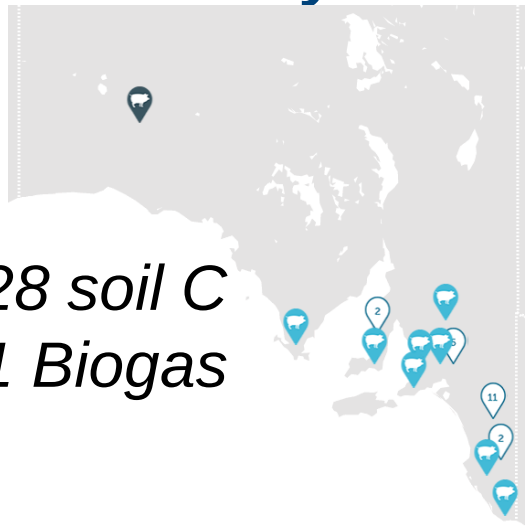
March 2021



14 soil C
1 Biogas

5 years from project start before we see soil ACCUs

February 2022



28 soil C
1 Biogas

SOUTH AUSTRALIA AGRICULTURE — HIDE

Projects	15
ACCUs Issued	6,168

ACCUs for Brinkley Biogas Flaring Project

SOUTH AUSTRALIA AGRICULTURE — HIDE

Projects	29
ACCUs Issued	6,168

ACCUs for Brinkley Biogas Flaring Project

http://www.cleanenergyregulator.gov.au/maps/Pages/erf-projects/index.html

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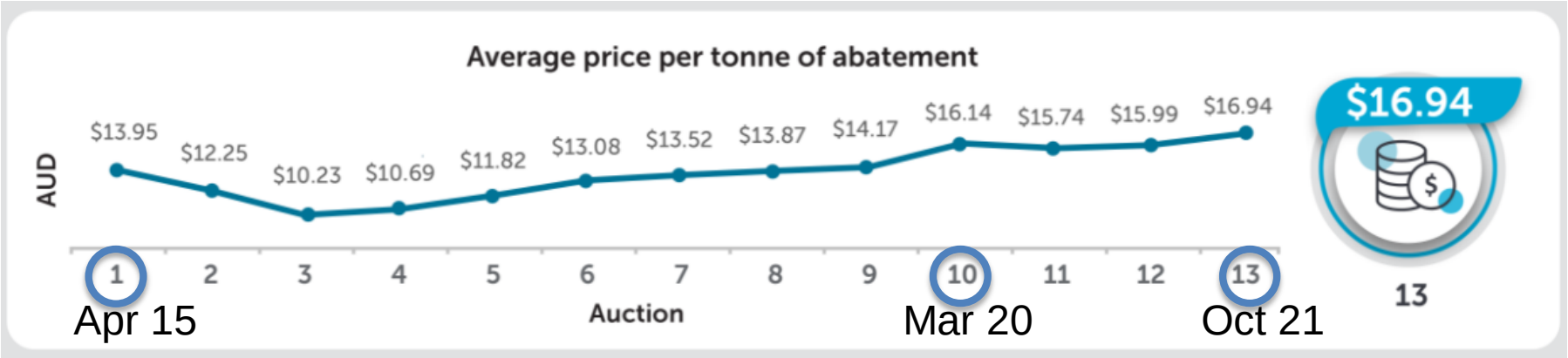
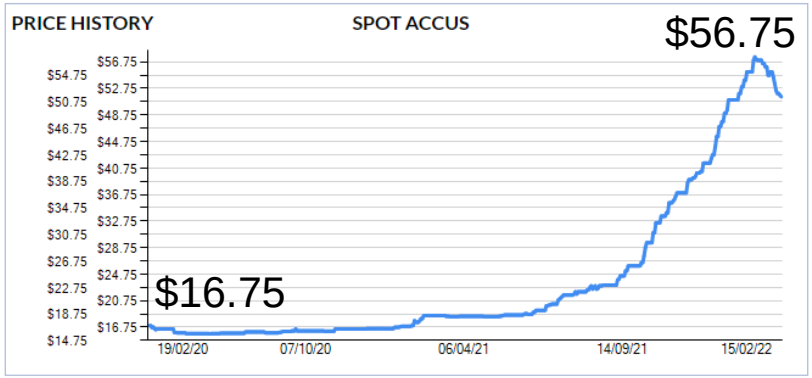
ERF Auction Results – Auction 13 October 2021

http://www.cleanenergyregulator.gov.au/ERF/auctions-results/october-2021





For further details or access to ACCU pricing, please contact Jarden Australia on +61 (2) 8310 7918 or commodities@jardengroup.com.au

Spot Price Australian ACCUs

Feb 2022 $51.50

Source: Jarden Australia as of 16/02/22
https://accus.com.au/

ERF – to think about

- There are many C methods that include emission reduction and sequestration
- At this stage, you can't have a vegetation AND a soil C project on the same piece of land
- Stacked C methods will reduce admin costs and efficiency of data that needs to be entered

Soil C projects

- Project needs to be registered before baselining or activity is applied
- Crediting period - 25 or 100 years
- Permanence obligation period - 100 years
- Baseline period – 5 years prior to project start

Soil Carbon Projects - ERF

How much is change worth?

If soil OC ↑ over 5 years by **0.5%** = **7.70 tCO_2e/ha**

Discounts (minus from original value)	tCO_2e/ha
5% for uncertainty	7.32
25% for 25 year contract	5.49
GHG emissions for 5 year sampling period not calculated	?
20% C broker fee	4.39

$/tCO2e/ha	Before discounts	After discounts
$16.94	$130	$74
$50.00	$385	$220

Assumptions
OC = 0.5 %
Bulk density = 1.4g/cm^3
Soil depth = 30 cm
= 2.1 tC/ha
= 7.7 tCO_2e/ha

Bulk density and gravel remains the same 5 yrs

C broker fee between 15-25%

Still need to pay for soil sampling and independent land management report

Carbon Units

C **Concentration** (%) is the unit used for soil analysis results

C **Stock** is the unit used in carbon accounting and reported as

- t C / ha or CO_2 equivalents
- 1 t C / ha = 3.67 t CO_2e / ha
- Is measured in the top 30 cm of soil

To calculate stock need the soil bulk density (mass of soil / volume of soil) and the gravel content of the soil

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Soil C tests

OC (Walkley Black method) most often used

- OC_{wb} represents 75-90% of the Total OC result

If C accounting - Total OC needs to be measured

- where soil **pH_{water} is < 7.5** with no fizz: Total C = Total OC
- where soil **pH_{water} is >7.5** with low to medium fizz: Total OC by acid pre-treatment
    - where soil **has** high to very high fizz: carbonate needs to be fully removed by acid pre-treatment. OC_{wb} test can provide a guide.

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Question Time

How to accumulate OC in your soils

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What is soil C?

Inorganic (IC) and organic (OC) forms

- IC (carbonate) is mineral based and not influenced by land management practices (except liming)
- OC is living or decomposing organic compounds of plants, animal and microbial origin
  - influenced by land management practices
  - makes up ~ 58% of the mass of soil OM
  - SOM = Total SOC x 1.72

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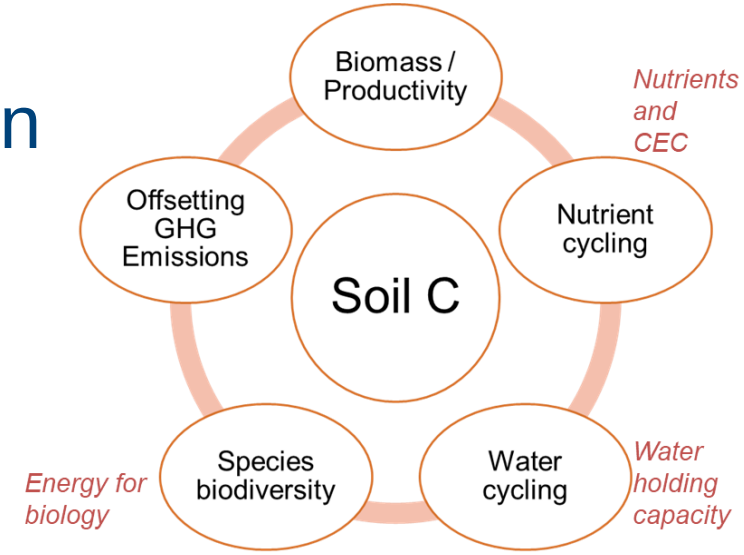
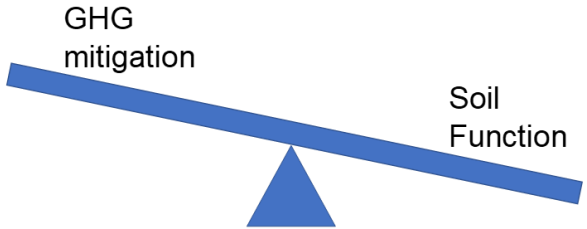
Why is soil C important?

OC is a part of organic matter (OM)

- Soil health/function
- Resilience

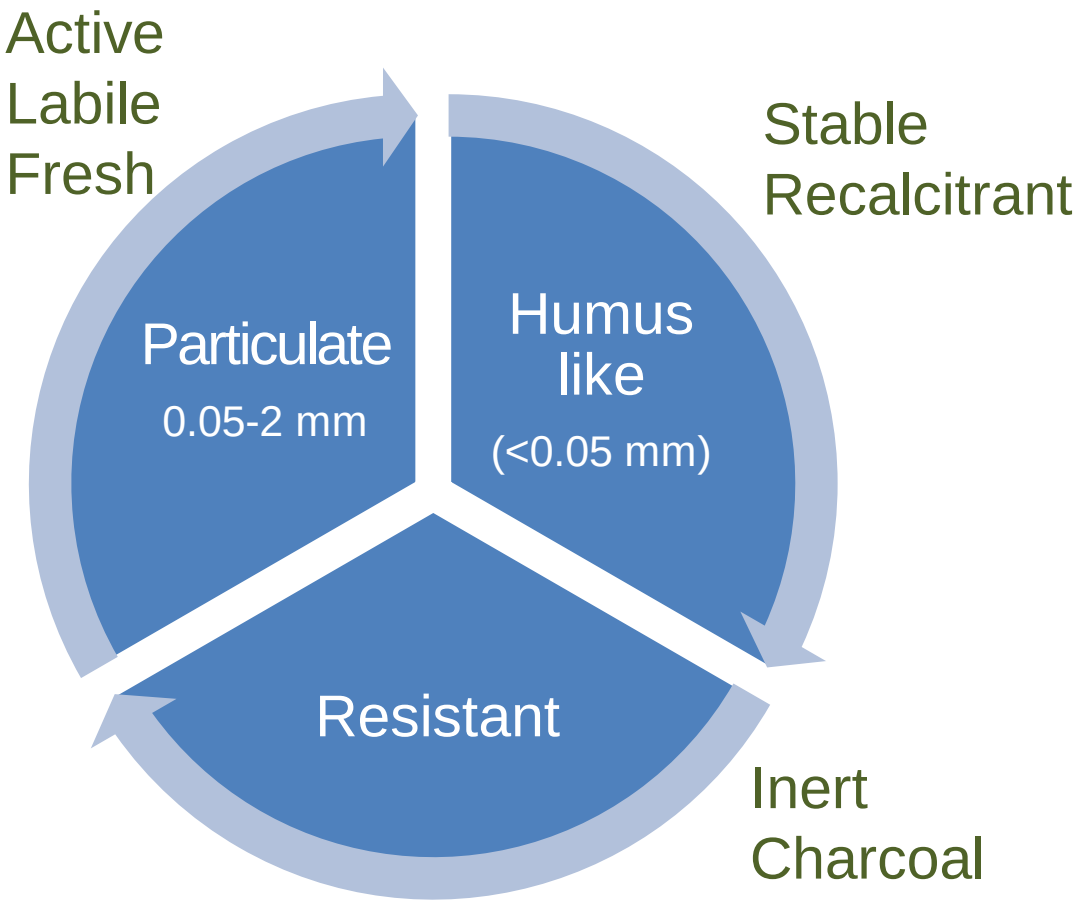


Can we increase soil function and increase OC or is it a balance?



OC is made up of different fractions / pools

Soil biology is critical for OC turnover and nutrient release



OC turnover

POC = years

HOC = decades

ROC = centuries

After J. Baldock

What factors influence soil OC?

Potential SOC

Defining factors

- Soil type Mineralogy, texture, density

Attainable SOC

Limiting factors

- Solar radiation
- Climate

Rainfall, temperature

Actual SOC

Reducing factors

- Management practices

After Ingram and Fernandes 2001

How does OC get into the soil?

- Plant residue (above and below ground)
- Root exudates - plants convert CO_2 via photosynthesis into sugars that are exuded through the roots to support biology (liquid carbon pathway)
- Living soil biology can make up to 1-5% and dead as much as 30-50% of OC
- Manure and urine from livestock
- Fire – pyrogenic carbon

Decomposition losses are between 70-90% of C inputs

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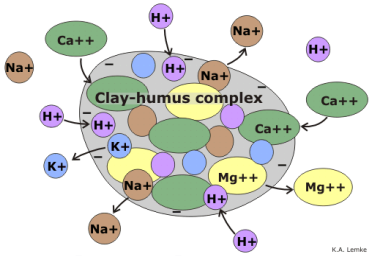
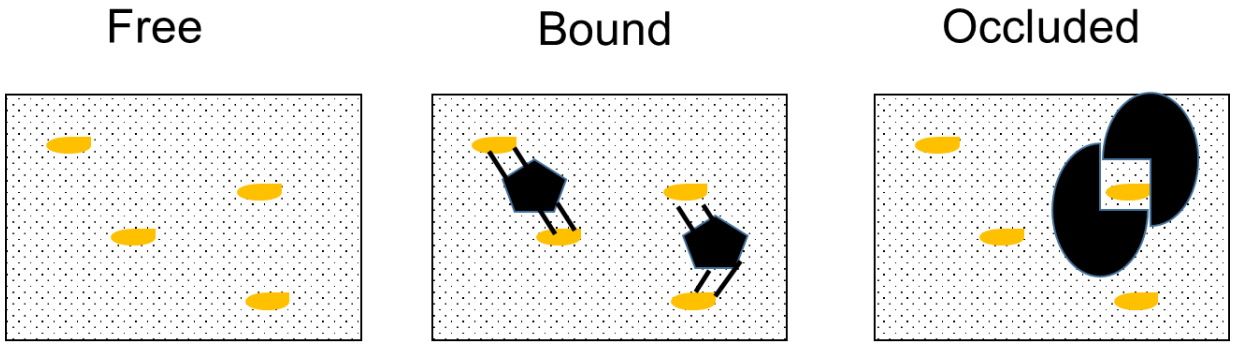
Soils capacity to stabilise OC



Soil has a finite capacity to protect OC from mineralisation

= capacity to bond OC



STABILISED with clay minerals, Fe, Al, Ca and aggregates (MOAM)

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What we know about soil C

South Australian agricultural soils

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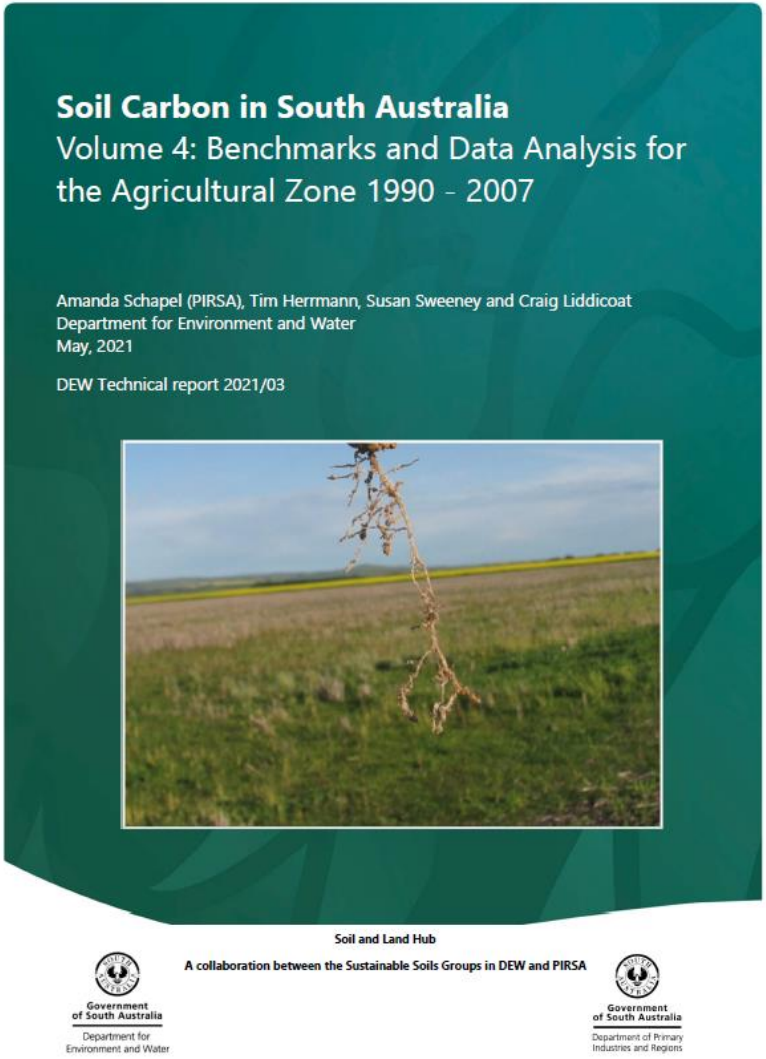
Soil Carbon Benchmarks for the agricultural zone 1990-2007

Soil and Land Hub – Collaboration between Sustainable Soils groups in DEW and PIRSA

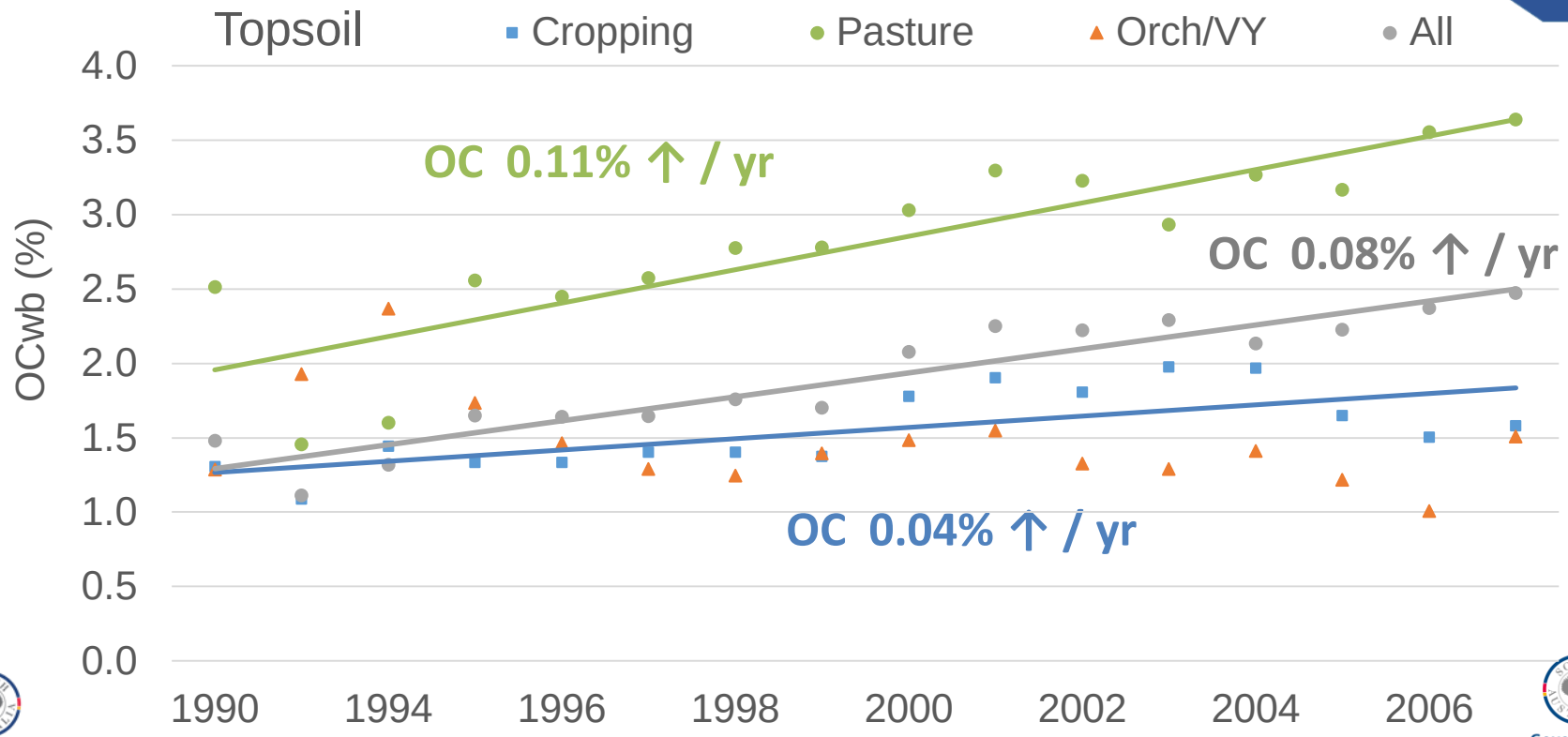
Land Resources Home (environment.sa.gov.au) under All Reports for Soil C in SA Volume 4



Soil Carbon 1990-2007

36,000 soil tests

0-10 cm



Soil and Land Hub – Collaboration between Sustainable Soils groups in DEW and PIRSA

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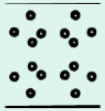
Lower Murray OCwb 1990-2007

0.07% / yr

Key Land Use

Mean SOC Conc



Annual change SOC

Cropping: 56%

Pasture: 28%

Ag District: 1.45 %

SA Ag Zone: 1.77%

Mean: 0.0685% ↑

25th: 0.00% 75th: 0.12%

Texture	Ag Zone Mean	Count	Ag District Benchmarks Mean	25%	40%	50%	60%	75%
Sand	1.12							
Loamy sand	1.42	152	0.94	0.50	0.60	0.71	0.87	1.13
Sandy loam	1.79	172	1.40	0.79	1.03	1.18	1.32	1.80
Loam	1.96	159	1.47	0.89	1.10	1.21	1.40	1.73
Clay loam	1.93	145	1.66	1.10	1.29	1.40	1.56	1.86
Clay	1.66	81	2.10	1.10	1.33	1.51	1.77	2.34
Weighted Mean (all texture)	1.77	709	1.45	0.85	1.04	1.17	1.34	1.71

- No decrease in SOC for clay loam and clay as seen in other agricultural districts – possibly due to irrigation.

Land use	Benchmark SOC Concentration Count	Mean	25%	50%	75%	Pro District Prop (%)
Orchard / Vineyard	48	1.02	0.44	0.88	1.36	9
Cropping	288	1.19	0.80	1.18	1.46	56
Vegetable	26	1.42	0.86	1.52	1.87	5
Pasture	145	2.27	1.34	1.95	2.76	28

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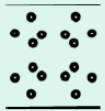
Northern Murray OCwb 1990-2007

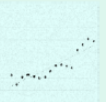
0.01% / yr

Key Land Use

Mean SOC Conc



Annual change SOC



Orchard /Vineyard: 46%

Cropping: 45%

Ag District: 0.60%

SA Ag Zone: 1.77%

Mean: 0.0119% ↔

25th: - 0.00% 75th: 0.01%

Texture	Ag Zone Mean	Count	Ag District Benchmarks Mean	25%	40%	50%	60%	75%
Sand	1.12	13	0.26	0.07	0.12	0.13	0.23	0.47
Loamy sand	1.42	236	0.48	0.34	0.40	0.45	0.48	0.55
Sandy loam	1.79	190	0.52	0.35	0.41	0.46	0.52	0.63
Loam	1.96	100	0.74	0.37	0.54	0.63	0.71	1.00
Clay loam	1.93	82	1.00	0.46	0.65	0.81	1.01	1.33
Clay	1.66	44	0.77	0.18	0.34	0.42	0.66	1.34
Weighted Mean (all texture)	1.77	665	0.60	0.35	0.44	0.51	0.60	0.79

Land use	Benchmark SOC Concentration Count	Mean	25%	50%	75%	Pro District Prop (%)
Cropping	191	0.58	0.40	0.50	0.65	45
Orchard / Vineyard	199	0.56	0.33	0.46	0.67	46
Pasture	34	0.58	0.40	0.50	0.70	8

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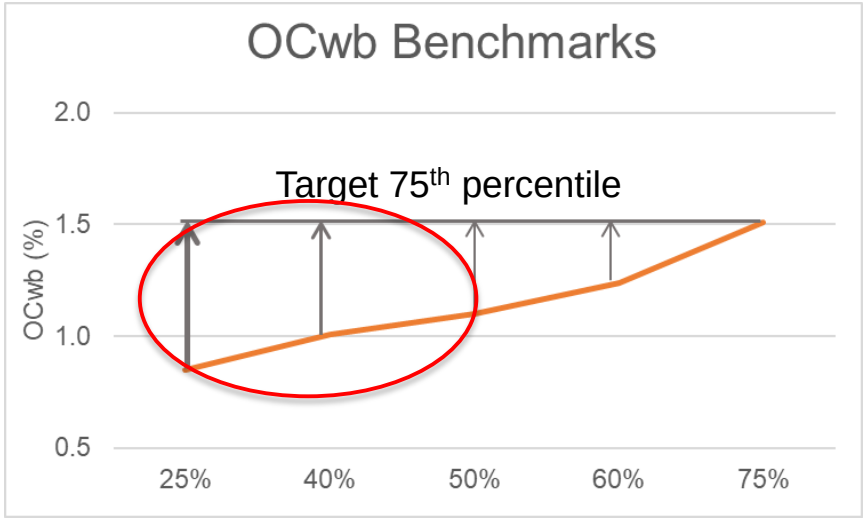
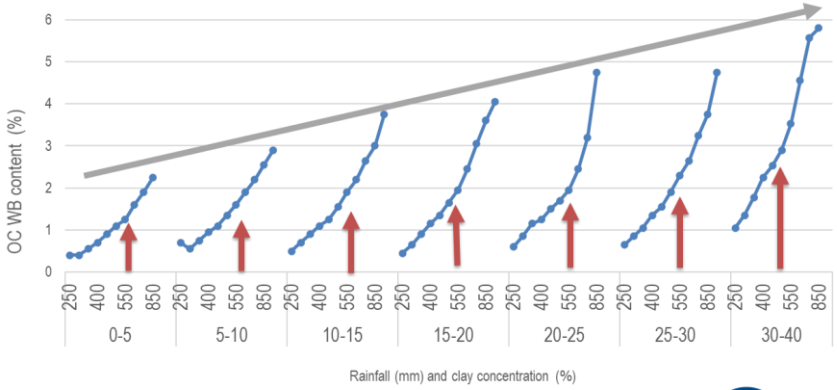
Opportunity to store soil OC

Higher potential for OC storage at lower OC concentration



Rainfall has a huge influence on C storage

sharp increase between 500-550 mm annual rainfall



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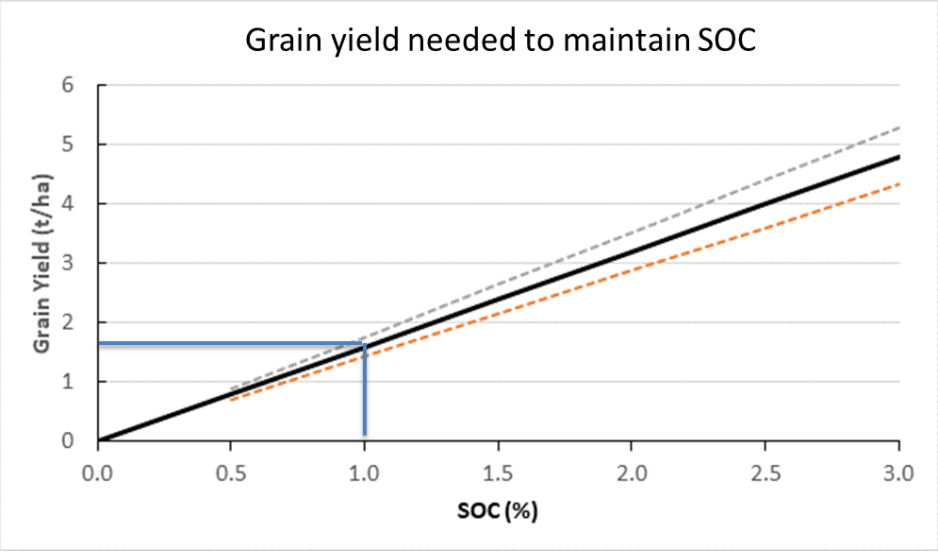
Opportunity to store soil OC

Sufficient OC inputs



To maintain SOC at 1% need to yield 1.5 t/ha

Source: Tim Herrmann from DEW Sustainable Soils

Sufficient nutrients

POC to HOC or Active to Stable

Nutrients required to create 1t humus

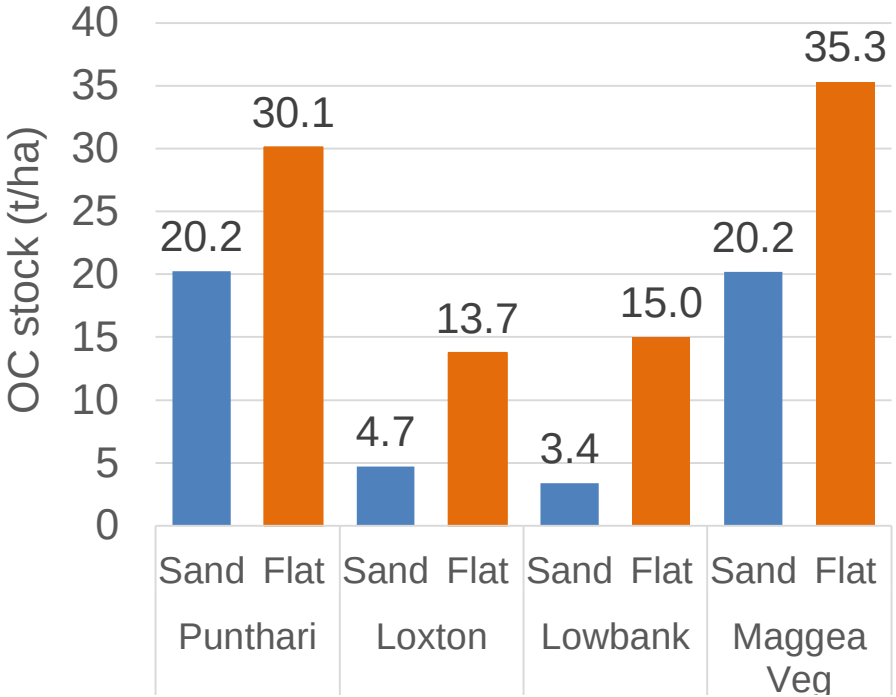
- 80 kg N
- 20 kg P *Clive Kirkby ratio*
- 14 kg S

Estimated cost using synthetic nutrients $300

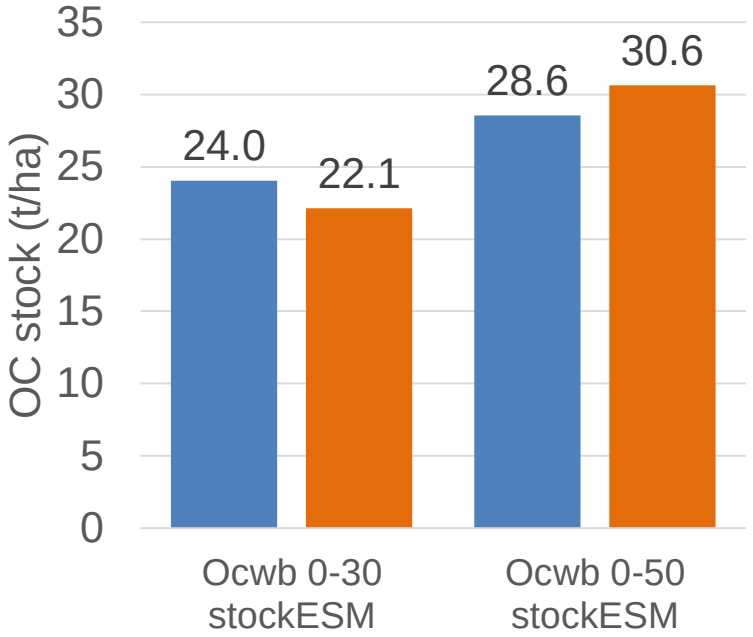
In cereal-based farming systems extra nutrients

- with low (4t/ha) or normal stubble quantities
  X build stable soil C stocks
- where large amounts of stubble (12 t/ha)
  ✓ for enhancing soil carbon

Soil texture



Soil depth

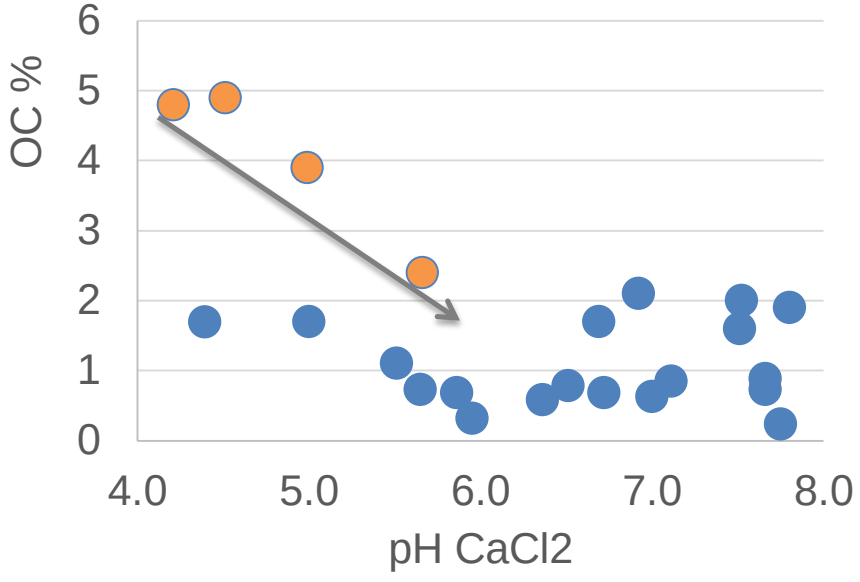


Soil texture in the same paddock strongly affects OC stock

LANDSCAPE SOUTH AUSTRALIA MURRAYLANDS AND RIVERLAND

Management practice can change OC stock at depth

Adverse soil conditions can increase OC



But = a non-functioning soil by affecting biological activity

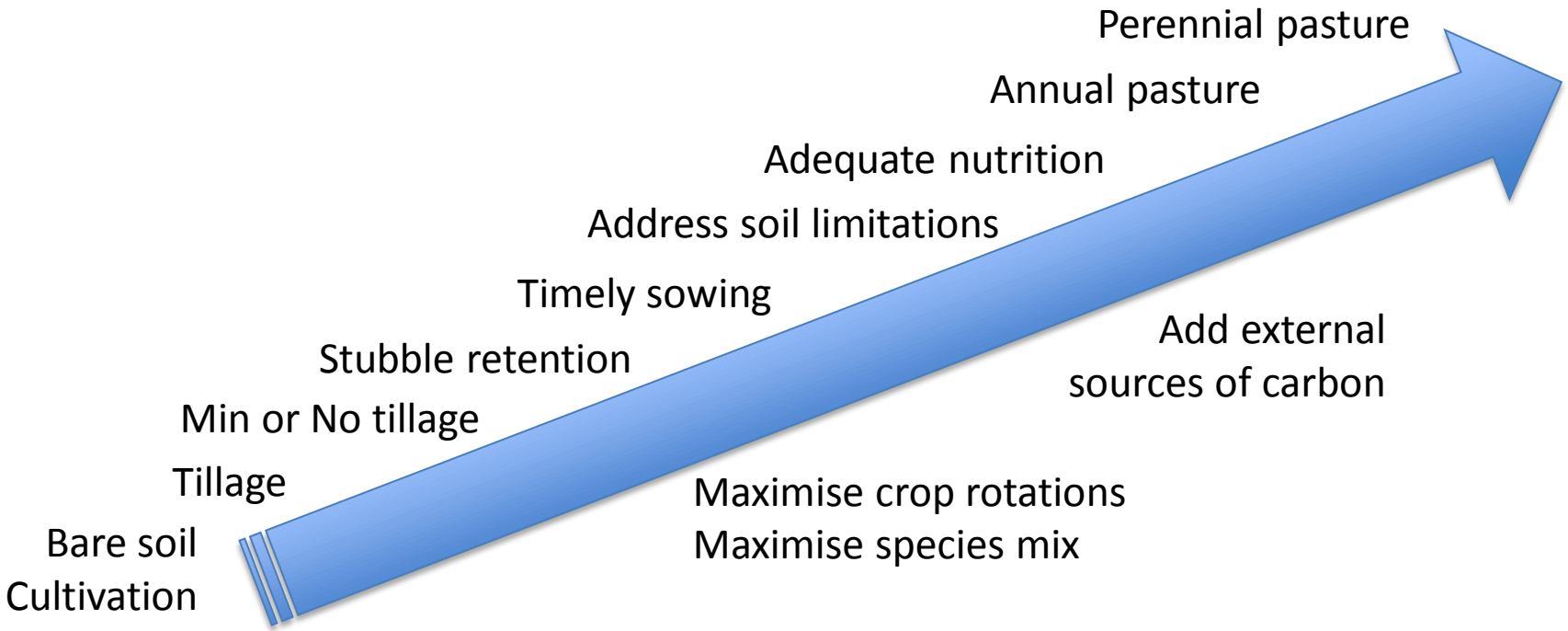
Saline black clay over calcrete

Depth (cm)	pH H_2O	pH $CaCl_2$	NO3 mg/kg	EC 1:5 dS/m	ECe	OC %
0-10	9.2	8.5	5.4	0.82	7	3.99
10-20	9.6	8.7	1.5	0.84	7	1.05
20-28	9.6	8.7	1.3	0.85	13	0.52
28-55	9.7	9.0	<1	0.78	12	0.06

Sand over clay with increasing lime

Depth (cm)	pH H_2O	pH $CaCl_2$	NO3 mg/kg	EC 1:5 dS/m	ECe	OC %
0-10	8.1	7.5	12	0.14	2	1.02
10-19	9.0	8.3	1.4	0.094	1	0.16
19-32	9.6	9.0	1.8	0.83	7	0.35
32-48	9.4	8.9	3	2.1	32	0.37

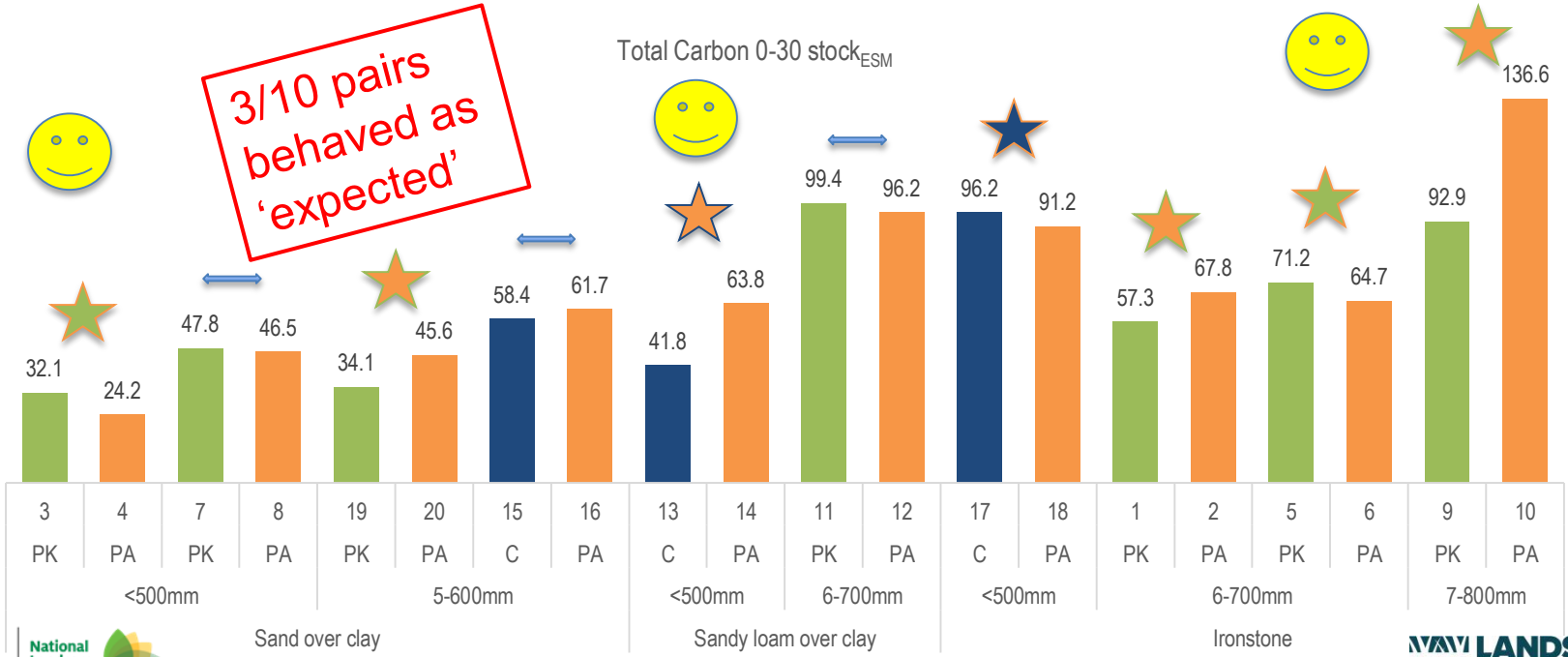
The theory of OC increase by management



C stock by management practice

Management practices had variable effect on soil C

Abbreviations: P = Pasture, A = Annual, K = Kikuyu, C = Crop (no till, stubble retention).

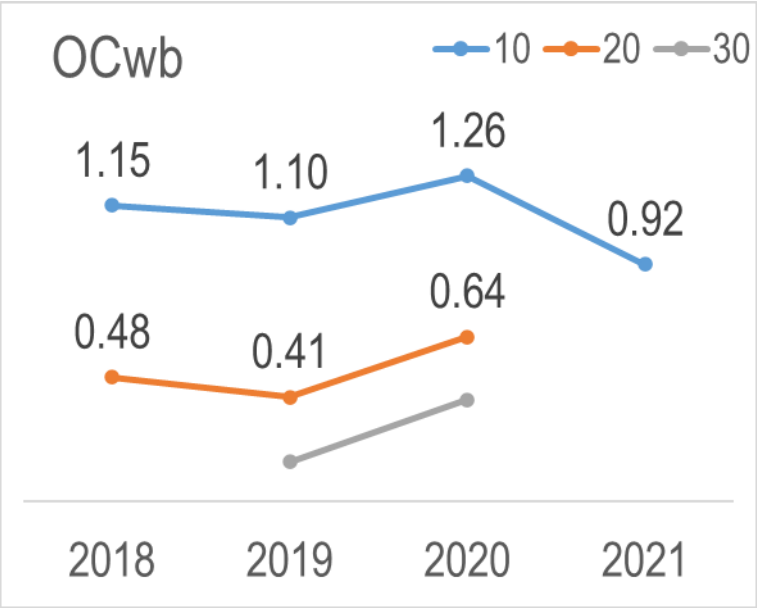


Australian Government | National Landcare Program

LANDSCAPE SOUTH AUSTRALIA KANGAROO ISLAND

Variability OC concentration – time and depth

Making sense of annual changes in OC can be tricky



Change can take 5-10 years to be able to say if change is occurring

OC changes over time and with depth - more stable > 10 cm

Accumulating OC

Opportunity to increase soil OC depends on

- Ability of soil to stabilise OC (texture, mineralogy)
- Capacity of the soil to store more OC (check the benchmarks)
- Ability to grow sufficient biomass
- OC inputs are more than the OC outputs (decomposition / erosion)

  How to make decomposition rates most efficient for what we need

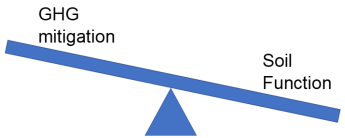
- Possibility to increase and maintain OC inputs
- OC pools in the soil – longevity

  How to convert OC to more stable forms - consider if sufficient nutrition for transformation

Take Home Thoughts

Determine why you want to change OC

- trade-offs for function if focus on GHG



Be realistic about how much you can change OC

- texture, rainfall, inherent limitations, induced limitations, fertility

OC is variable and needs a long time (5-10yrs) to measure change

- at the surface, down the soil profile, over time
- often more stable > 10 cm with less climatic influence
- good depth to think about changing OC with root growth and activity

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Department of Primary Industries and Regions

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