Soil Carbon

Soils, Carbon and Productivity Workshop

Keith, 29 October 2021

Amanda Schapel

PIRSA

Amanda.Schapel@sa.gov.au

Government of South Australia

Department of Primary Industries and Regions

Outline

Carbon in your farm business

- Carbon footprint, emission reduction and sequestration

Soil carbon in our landscape. Can we build it?

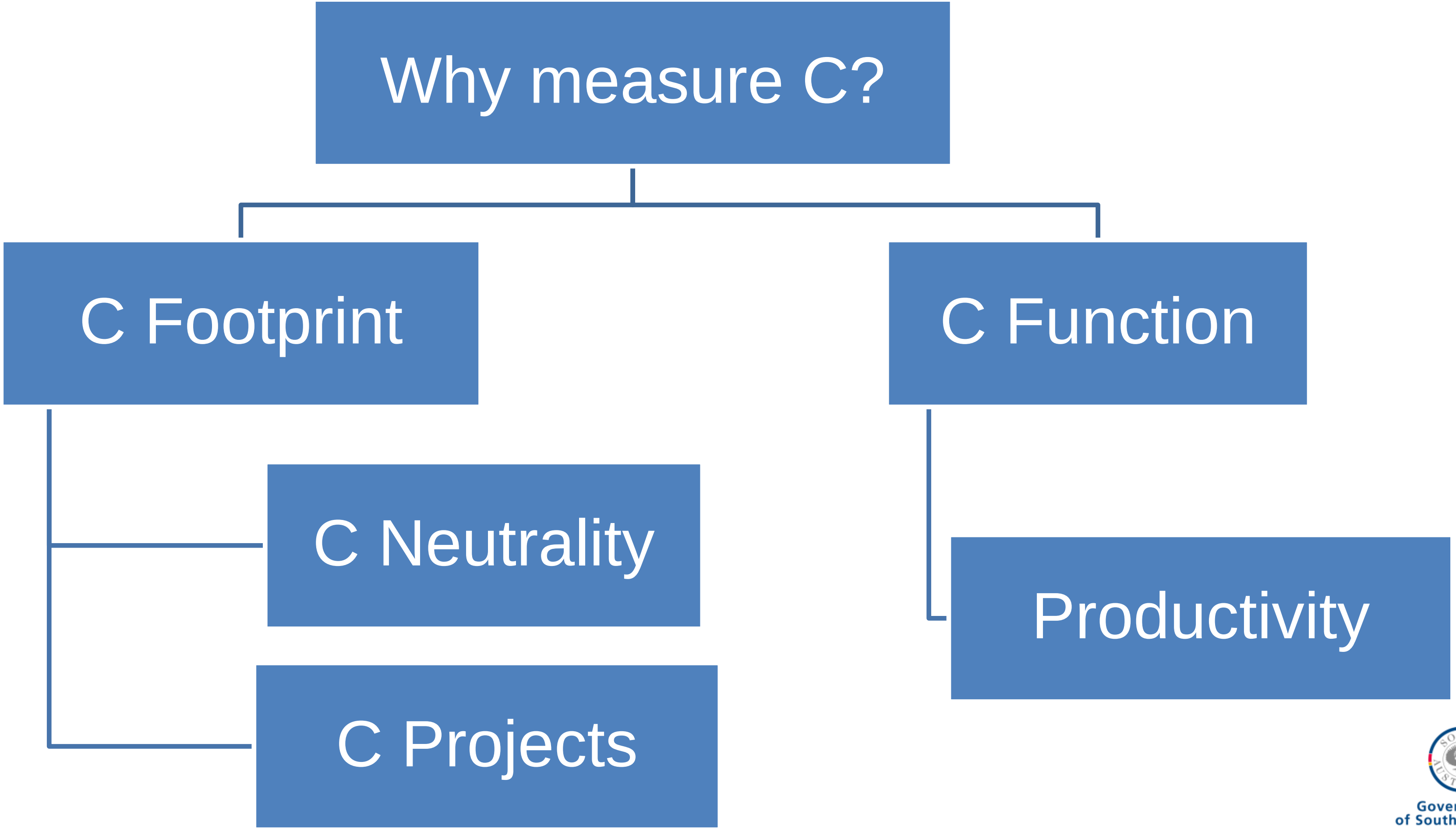
- What is soil organic carbon and why is it important?
- Soil carbon tests – what you need to know
- What we know about soil C in South Australian agricultural soils
- Lessons learnt

Government of South Australia
Department of Primary Industries and Regions

Carbon in your farm business

Government
of South Australia

Department of Primary
Industries and Regions



Government
of South Australia

Department of Primary
Industries and Regions

Carbon Neutrality

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)

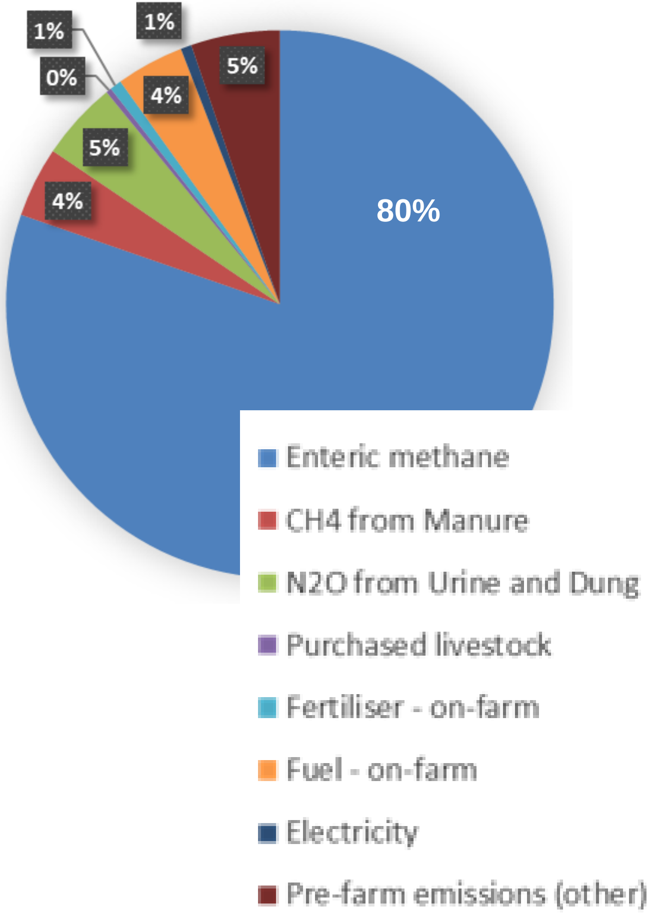
To do this:

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

Carbon Footprint – Turretfield Research Centre

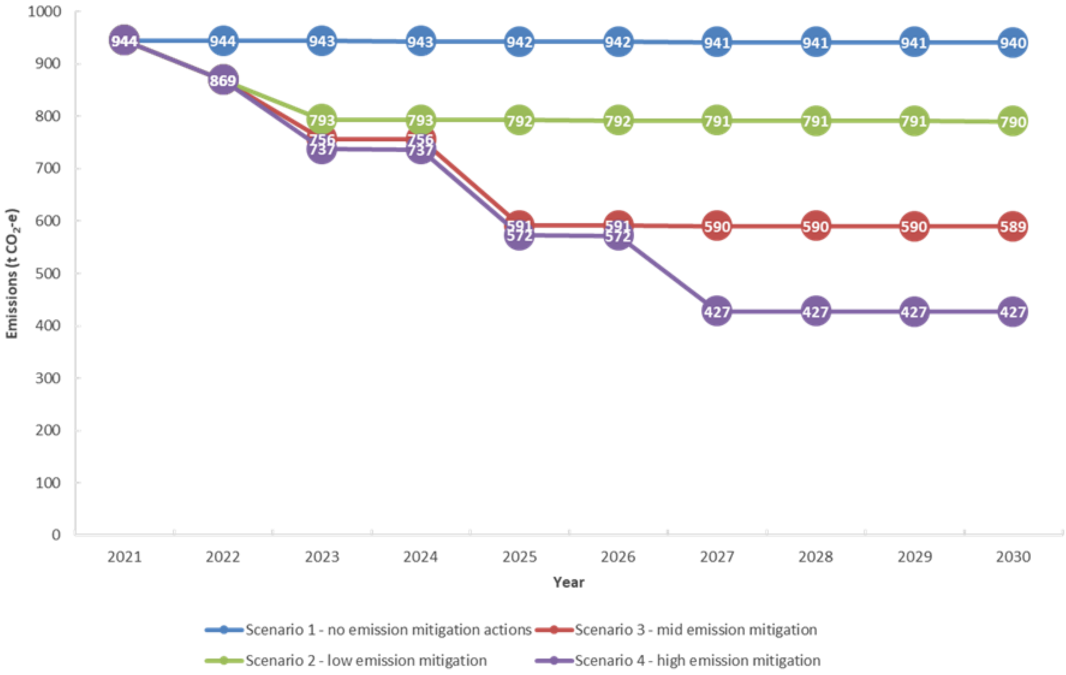
Gross Emissions	(t CO_2-e)	% of emissions
Scope 1	885	94%
Scope 2	6	0.5%
Scope 3	53	5.5%
Total Emissions	**944**	**100%**
Methane – CH_4	799	84%
Nitrous oxide – N_2O	54	6%
Carbon dioxide – CO_2	91	10%

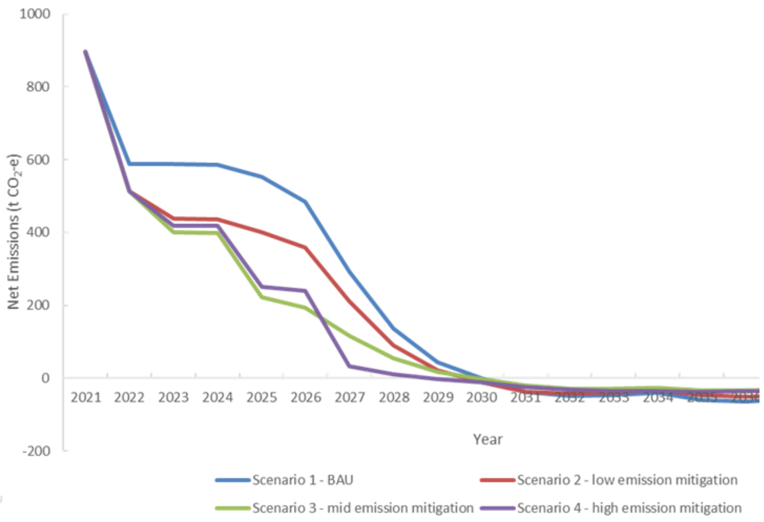
SCOPE 1	Direct GHG emissions from sources owned or controlled by the company (e.g. diesel use in tractors, livestock emissions)
SCOPE 2	GHG emissions from generation of electricity consumed on the location by the company
SCOPE 3	GHG emissions from sources not owned or controlled by the company (eg extraction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



Extracted from Integrity Ag & Environment Report for PIRSA, 2021

CO_2-e Reduction Strategies – Turretfield





Mitigation – emission reduction

Sequestration – storing C

Extracted from Integrity Ag & Environment Report for PIRSA, 2021

Carbon Projects - ERF

Emissions Reduction Fund (ERF) projects

- 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

To do this:

1. Do your homework
2. Enter into an ERF project

SOUTH AUSTRALIA
AGRICULTURE

HIDE

Projects	15
ACCUs Issued ?	6,168

14 soil C, 1 Biogas
ACCUs for Brinkley Biogas Flaring Project

Government of South Australia
Department of Primary Industries and Regions

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

Soil Carbon ERF Projects

Project needs to be registered before soil baselining or activity is applied

Definitions	**Crediting period - 25 years** **Permanence obligation period - 100 years** **Baseline period – 10 years prior to project start**
Soil Carbon project	A project is eligible if the land has soil carbon sequestration potential and has met the land management requirement over the 10 year baseline period A project requires at least one eligible management activity to be carried out or maintained on all land included in a carbon estimation area (CEA), until the end of the permanence obligation period
Additionality	The eligible management activity is new or materially different from the equivalent management activity carried out in the baseline period

Soil Carbon Projects - ERF

How much is change worth?

Spot price Sep 21 AUD **$18** for 1 tCO_2e/ha

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

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
tC to tCO_2e x 3.67
C broker fee between 15-25%

<u>**Discounts**</u> (minus from original value)

5% for uncertainty = **7.32 tCO_2e/ha $132**

25% for 25 year contract = **5.49 tCO_2e/ha $99**

GHG emissions for 5 year sampling period – **not calculated**

20% C broker fee = **4.39 tCO_2e/ha $79**

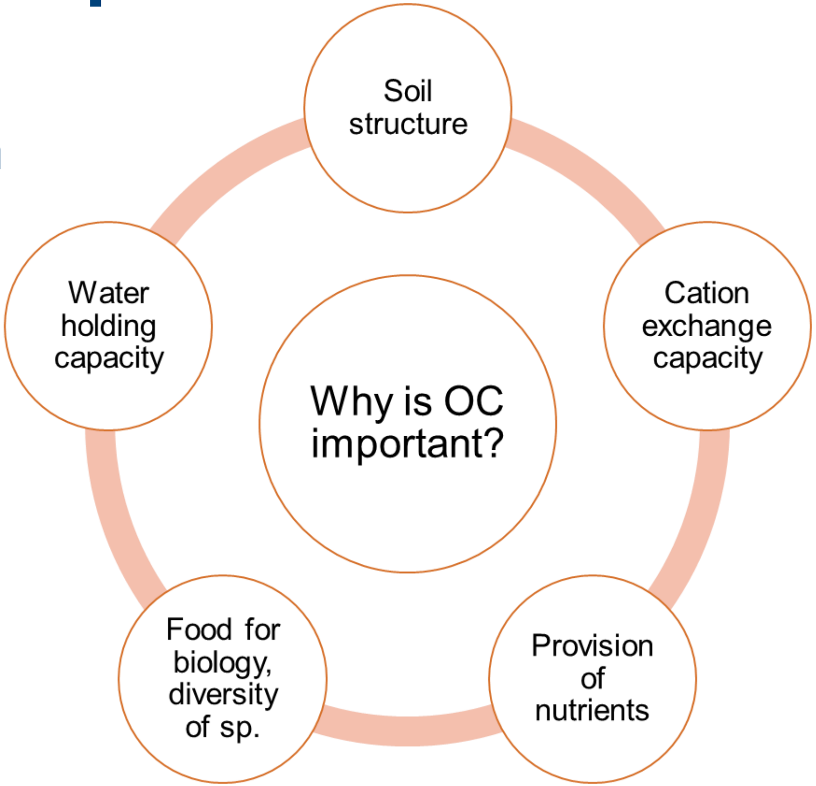
Start $139/ha **After discounts $79/ha**

Government of South Australia
Department of Primary Industries and Regions

Soil C in our landscape

Why is soil C important?

- Soil health / function
- Plant productivity
- Resilience
- Offsetting greenhouse gases



OC is a part of organic matter (OM)

What is soil C?

TC = OC + IC

Inorganic (IC) and organic (OC) forms

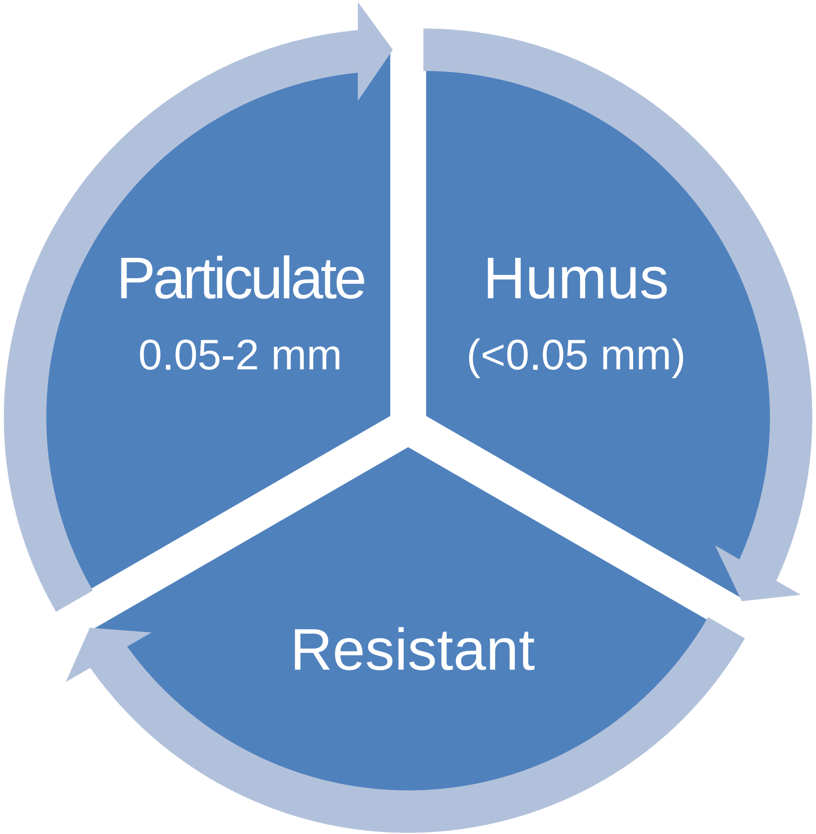
- IC (carbonate) is mineral based and not influenced by land management practices (except liming)

- OC is living or decomposing organic compounds of plants, animal and microbial origin
  - makes up ~ 40-60% of the mass of soil OM
  - influenced by land management practices

Government of South Australia
Department of Primary Industries and Regions

OC is made up of different fractions / pools

Soil biology is critical for OC turnover and nutrient release



<u>OC turnover</u>

POC = years

HOC = decades

ROC = centuries

Turnover is dynamic

Human impact can turn soil into net CO_2 source or sink

What factors influence soil OC?

OC input + OC loss = OC in soil

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

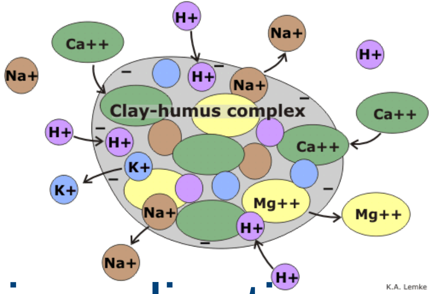
How does OC get into the soil?

- 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)
- Manure and urine from livestock
- Soil biology can make up 1-5% of OC
- Fire – pyrogenic carbon

Decomposition losses are between 70-90% of C inputs

Government of South Australia
Department of Primary Industries and Regions

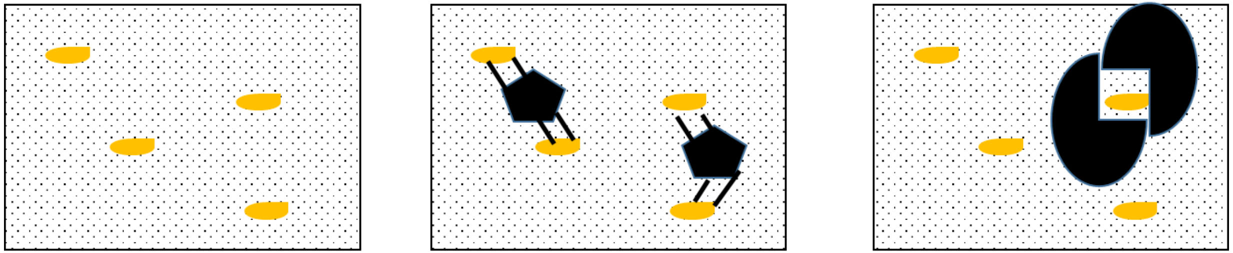
Soils capacity to stabilise OC



Soil has a finite capacity to protect OC from mineralisation

= capacity to bond OC

Free	Bound	Occluded

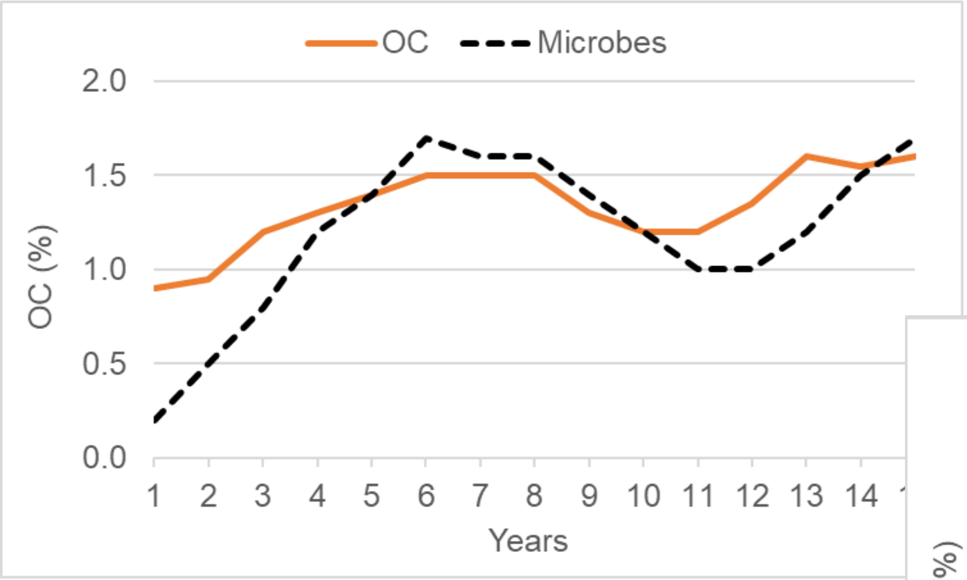


Decomposition risk = high	Decomposition risk = low	Decomposition risk = low

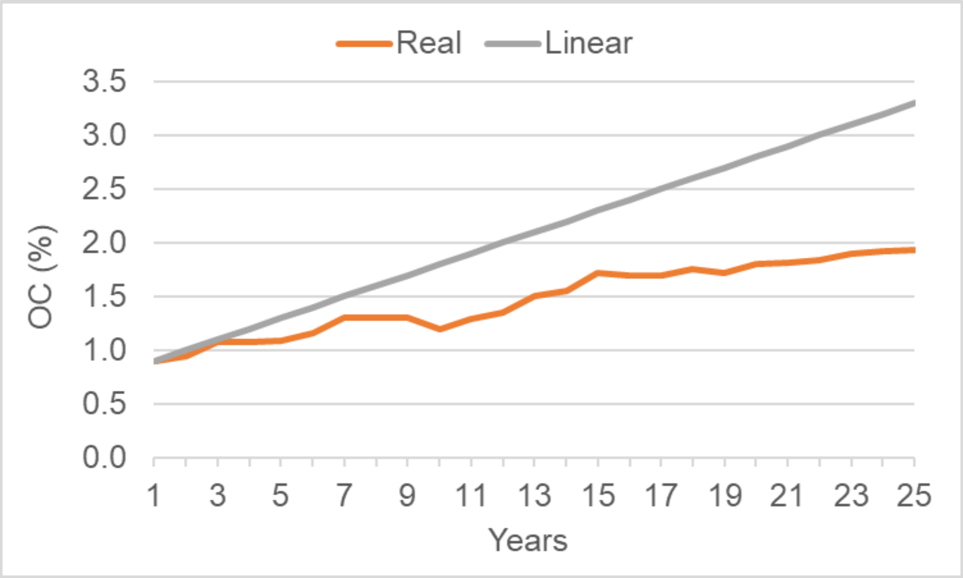
STABILISED with clay minerals and aggregates

Government of South Australia
Department of Primary Industries and Regions

Soils capacity to stabilise OC



OC increase is not linear



OC can be decomposed if not stabilised in soil

Soil Carbon tests

What you need to know

Government of South Australia
Department of Primary Industries and Regions

Soil C tests

CO_3 = carbonate

Test	Method	Measures	Benefits/Limitations
Organic C	Wet oxidation (Walkley Black method)	OC	Incomplete reaction – measures 75-90% of Total OC. Doesn't measure CO_3 which can be a benefit.
Total Organic C	Wet oxidation (Heanes method)	OC	Total OC test by wet oxidation due to an external heating step. Does not measure CO_3.
Total C	High temperature combustion (Dumas)	OC & IC	Measures Total OC in acid or neutral soils. In soils with CO_3 and charcoal can be difficult to measure change in OC
Total Organic C	Acid pre-treatment then high temperature combustion	OC	Preferred method for soils with CO_3 present. Need to ensure that have complete removal of CO_3 before combustion or results will be incorrect.
Inorganic C	Calcium CO_3 Equivalent	IC	Measures the CO_3 by reaction to dilute HCl acid. Can be an inexact test.
Mid Infrared	Spectroscopy	OC and fractions	Quick and relatively cheap, not as accurate as other methods until calibrated. Sensitive to CO_3 and requires acid pretreatment. Not commercially available in high pH soil.

Soil C tests

- If C accounting is being considered Total OC needs to be measured
- OC_{wb} represents 75-90% of the Total OC result
- where soil **pH_{water} is < 7.5**, with no fizz: Total C = Total OC method
- where soil **pH_{water} is 7.5-8.5**, with low to medium fizz: Total OC by calcium carbonate adjustment or acid pre-treatment is required for soils
- where soil **pH_{water} is > 8.5**, with high to very high fizz: carbonate needs to be fully removed by acid pre-treatment. OC_{wb} test can provide a guide.
- Analytical machines can't detect TOC values below 0.2% with confidence. This is **problematic in sandy soils** where values below this are common deeper than 10 cm. OC_{wb} test can provide a guide.

Government of South Australia
Department of Primary Industries and Regions

What we know about soil C

South Australian agricultural soils

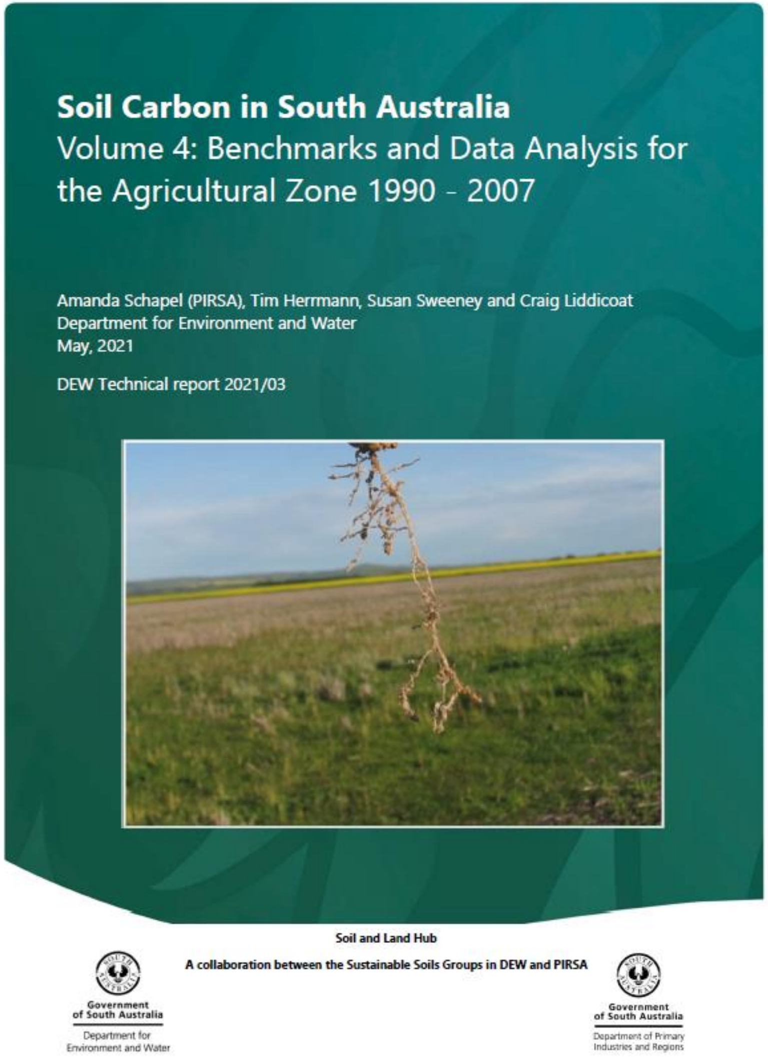
Government of South Australia

Department of Primary Industries and Regions

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 in South Australia
Volume 4: Benchmarks and Data Analysis for the Agricultural Zone 1990 - 2007

Amanda Schapel (PIRSA), Tim Herrmann, Susan Sweeney and Craig Liddicoat
Department for Environment and Water
May, 2021

DEW Technical report 2021/03

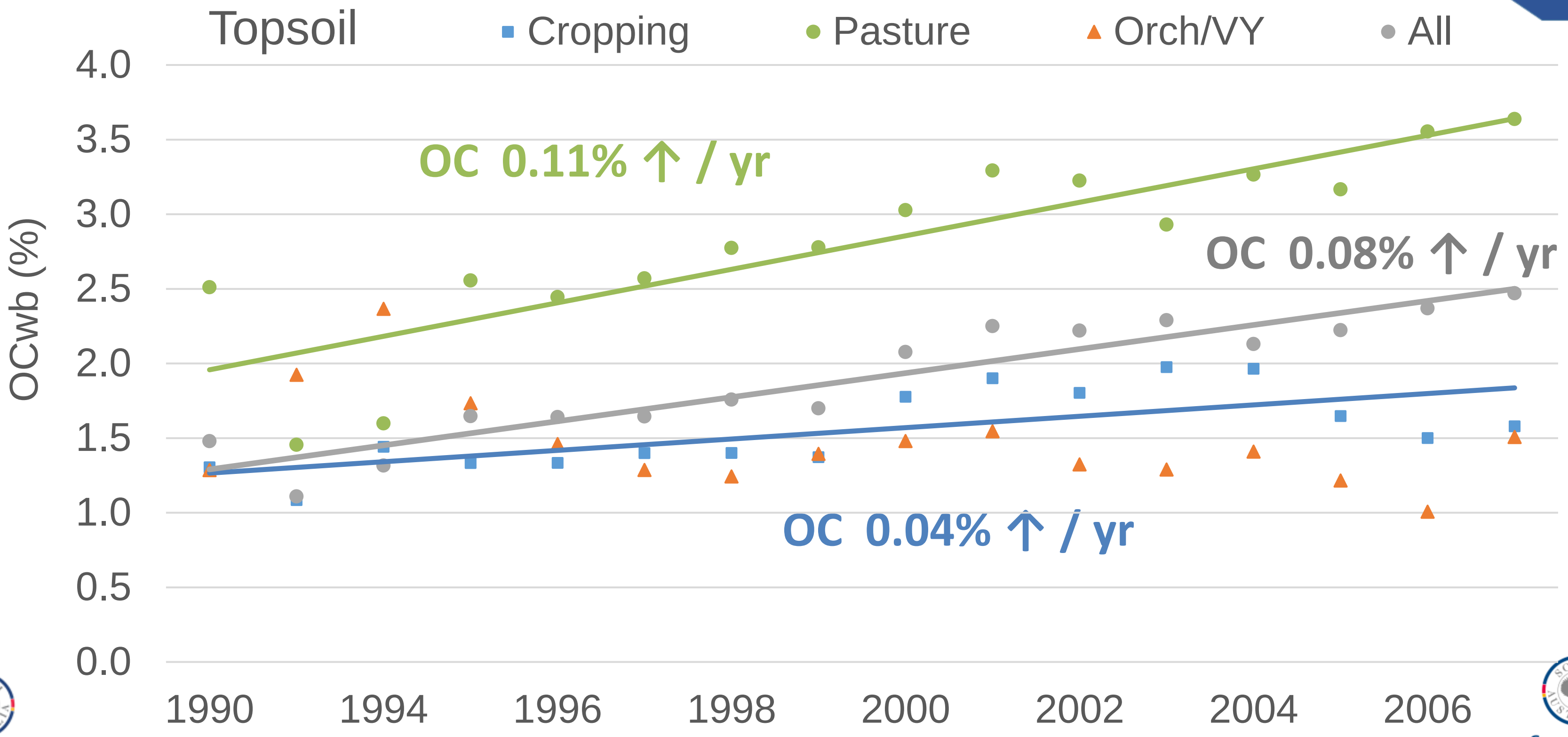
Soil and Land Hub
A collaboration between the Sustainable Soils Groups in DEW and PIRSA

Government of South Australia
Department for Environment and Water

Government of South Australia
Department of Primary Industries and Regions

Soil Carbon 1990-2007

0-10 cm

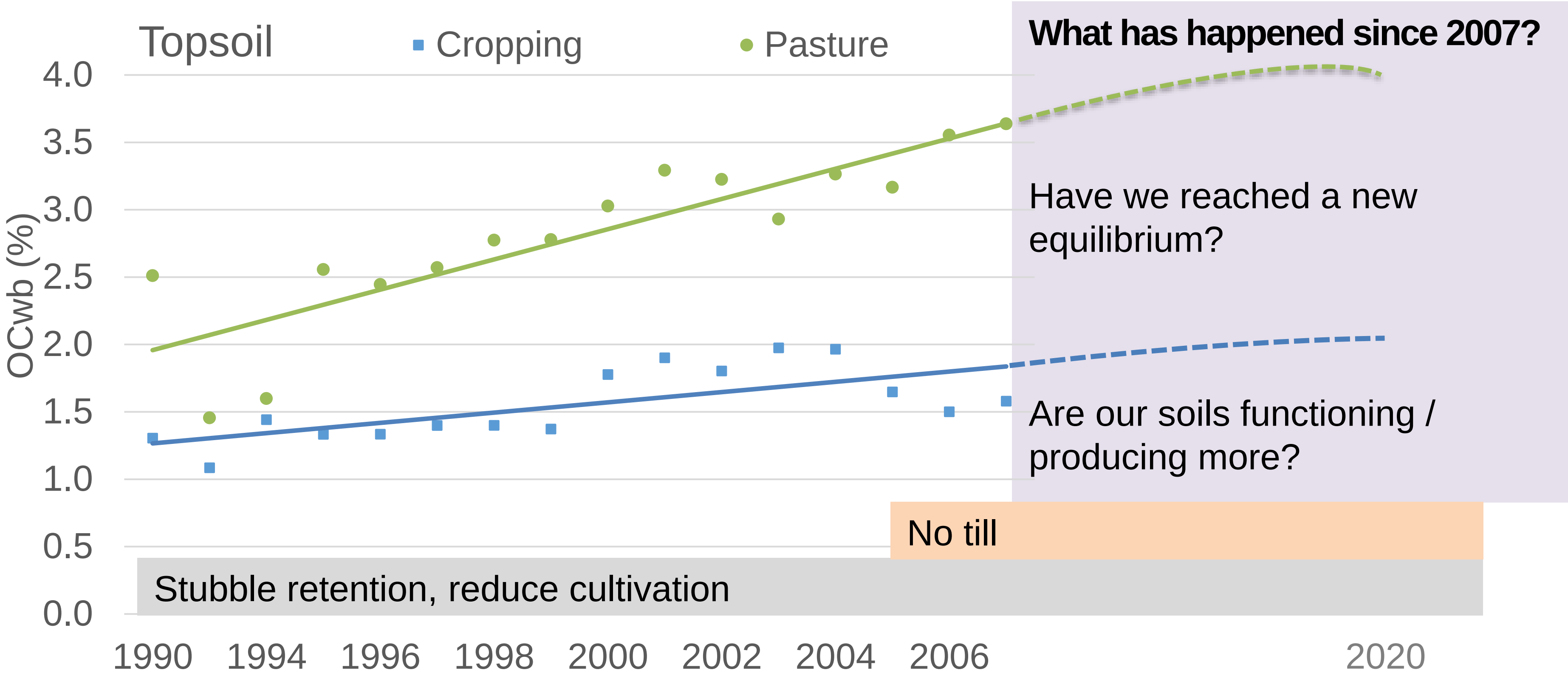


Government of South Australia
Department for Environment and Water

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

Government of South Australia
Department of Primary Industries and Regions

Soil Carbon 1990-2007

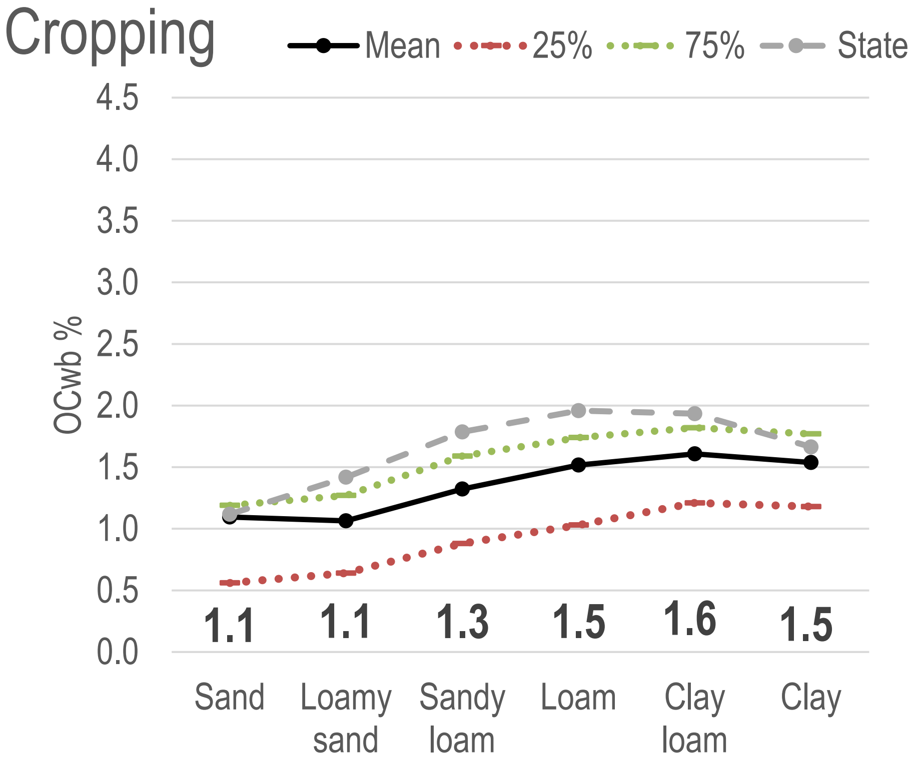


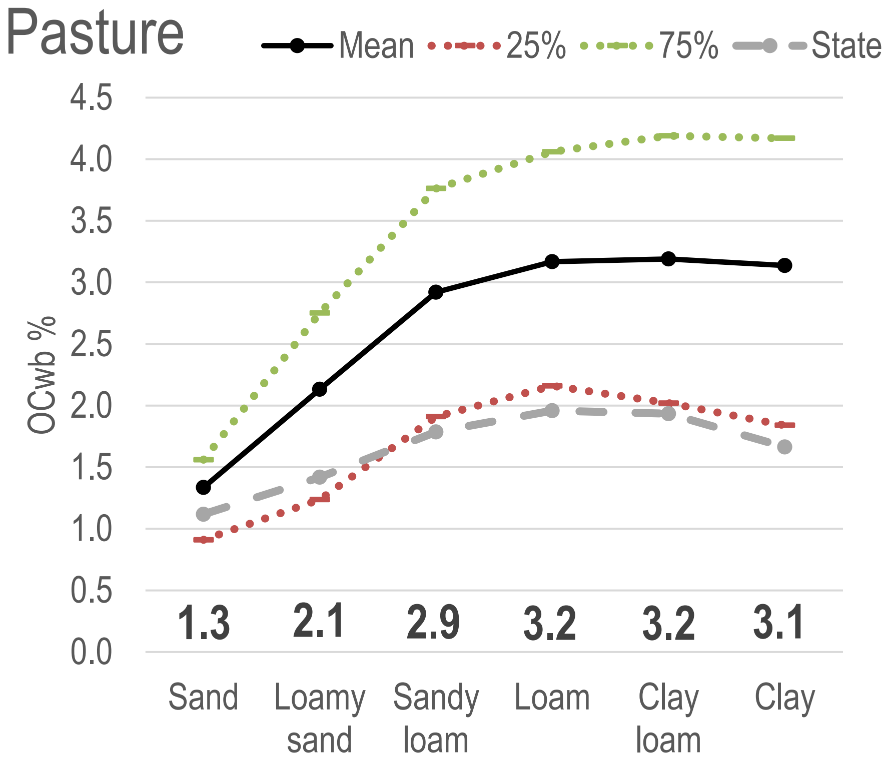
Soil and Land Hub – Collaboration between Sustainable Soils groups in DEW and PIRSA

Topsoil OC benchmarks by texture for key land uses

	Pasture			Cropping			Orchard / Vineyard		
	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
Sand	<0.9	0.9 - 1.6	>1.6	<0.6	0.6 – 1.1	>1.1	<0.6	0.6 - 1.5	>1.5
Loamy sand	<1.2	1.2 – 2.8	>2.8	<0.6	0.6 - 1.3	>1.3	<0.5	0.5 - 1.1	>1.1
Sandy loam	<1.9	1.9 – 3.8	**>3.8**	<0.9	0.9 - 1.3	**>1.3**	<0.6	0.6 – 1.5	**>1.5**
Loam	<2.2	2.2 – 4.1	>4.1	<1.0	1.0 – 1.7	>1.7	<0.7	0.7 – 1.8	>1.8
Clay loam	<2.0	2.0 – 4.2	>4.2	<1.2	1.2 – 1.8	>1.8	<0.8	0.8 - 2.0	>2.0
Clay	<1.8	1.1 – 4.2	>4.2	<1.2	1.2 - 1.7	>1.7	<0.8	0.8 – 2.0	>2.0
All textures	<1.7	1.7 – 3.8	>3.8	<1.0	1.0 – 1.7	>1.7	<0.7	0.7 – 1.8	>1.8

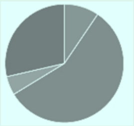
Soil texture x land use





Upper South East OC 1990-2007

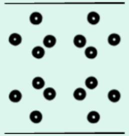
Key Land Use



Cropping: 54%

Pasture: 31%

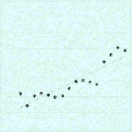
Mean OC Conc



Ag District: 1.45%

Ag Zone: 1.77%

Annual change OC

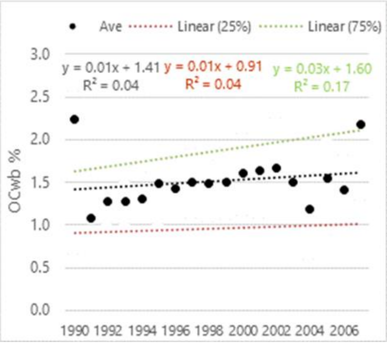


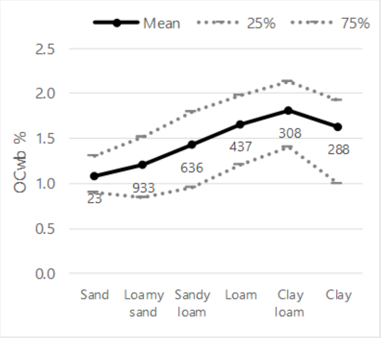
Mean: 0.0103% ↔

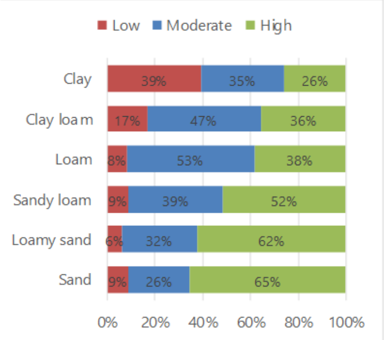
25th: 0.01% 75th: 0.03%

	Ag Zone	Ag District Benchmarks						
Texture	*Mean*	Count	Mean	25%	40%	50%	60%	75%
Sand	*1.12*	23	1.08	0.90	1.05	1.12	1.19	1.31
Loamy sand	*1.42*	933	1.21	0.85	1.01	1.10	1.24	1.51
Sandy loam	*1.79*	636	1.43	0.96	1.20	1.35	1.50	1.80
Loam	*1.96*	437	1.66	1.20	1.40	1.50	1.70	1.97
Clay loam	*1.93*	308	1.81	1.40	1.59	1.74	1.87	2.13
Clay	*1.66*	288	1.63	1.00	1.26	1.40	1.60	1.92
Weighted Mean (all texture)	*1.77*	2625	1.45	1.02	1.22	1.33	1.49	1.77

	Benchmark OC Concentration					District Prop
Land use	**Count**	**Mean**	**25%**	**50%**	**75%**	**(%)**
Orchard / Vineyard	235	0.98	0.58	0.87	1.30	12
Cropping	1084	1.50	1.06	1.43	1.86	54
Irrigated Pasture	20	1.54	1.10	1.41	1.86	1
Pasture	620	1.55	1.00	1.36	1.91	31
Vegetable	37	1.67	1.10	1.51	2.24	2



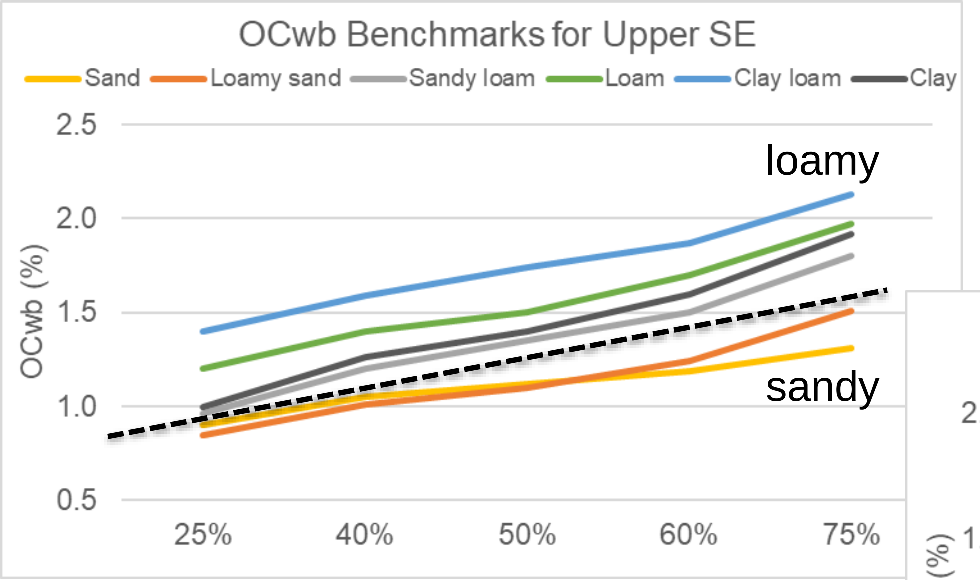




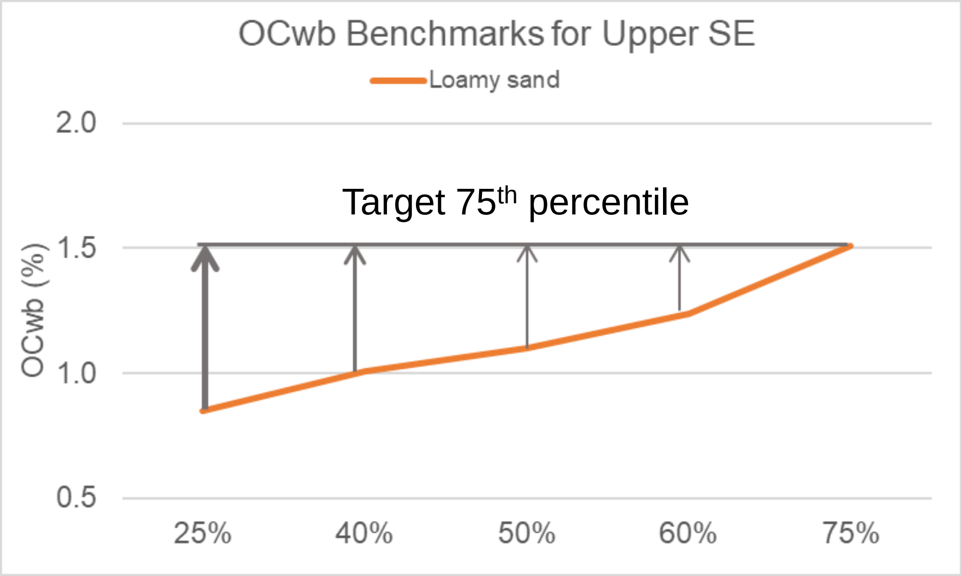
Government of South Australia

Department of Primary Industries and Regions

Opportunity to store soil OC

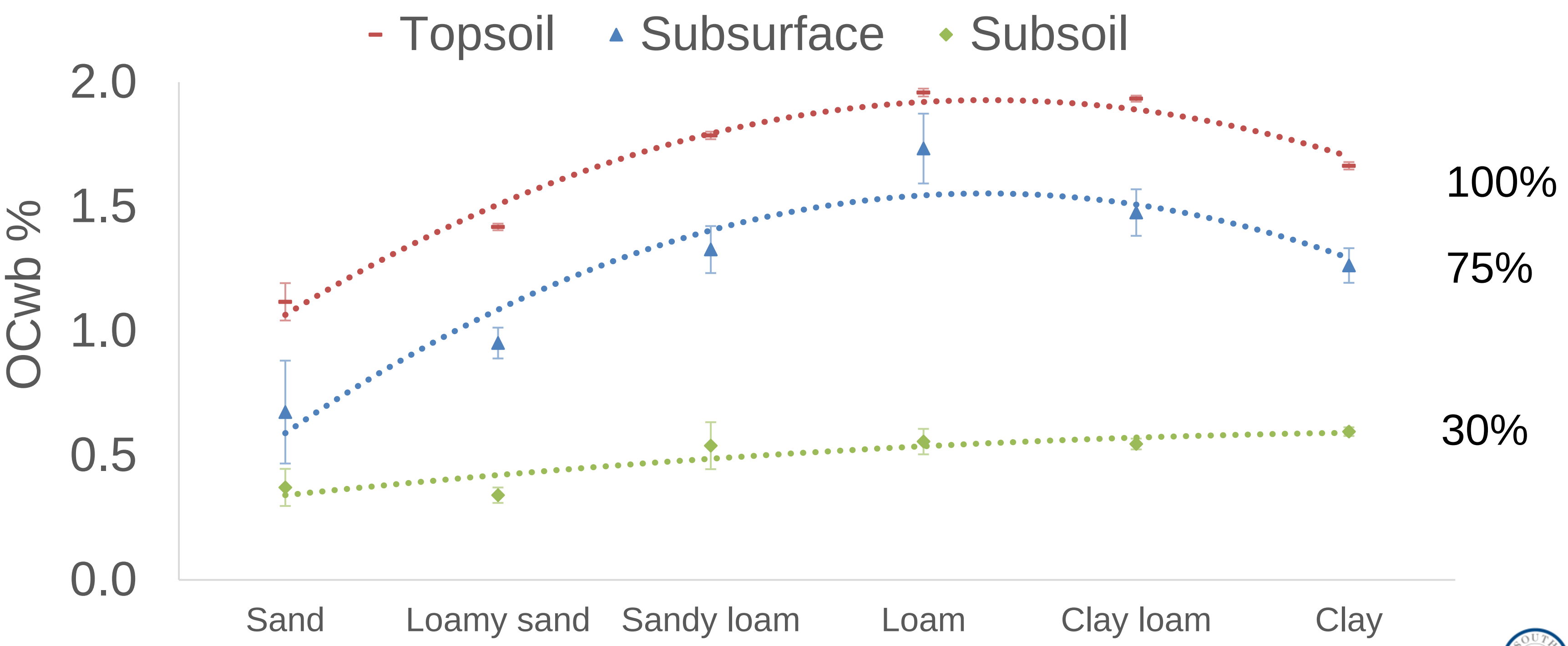


OC storage potential higher at lower OC concentration



OC storage potential lower in 'sandy' than 'loamy' soil

OC concentration down the soil profile

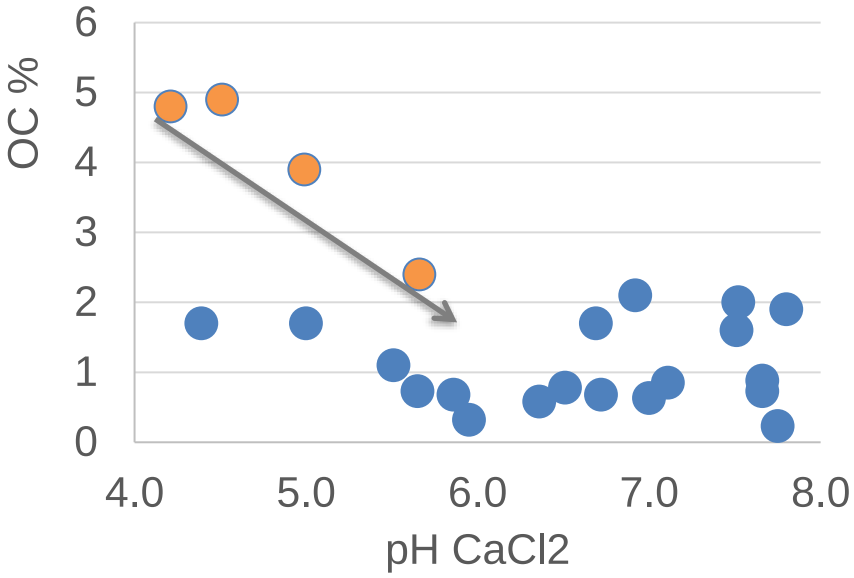


Government of South Australia
Department of Primary Industries and Regions

Lessons learnt from SA soils

Government of South Australia
Department of Primary Industries and Regions

Adverse conditions can increase OC



But = a non functioning soil affect on biological activity

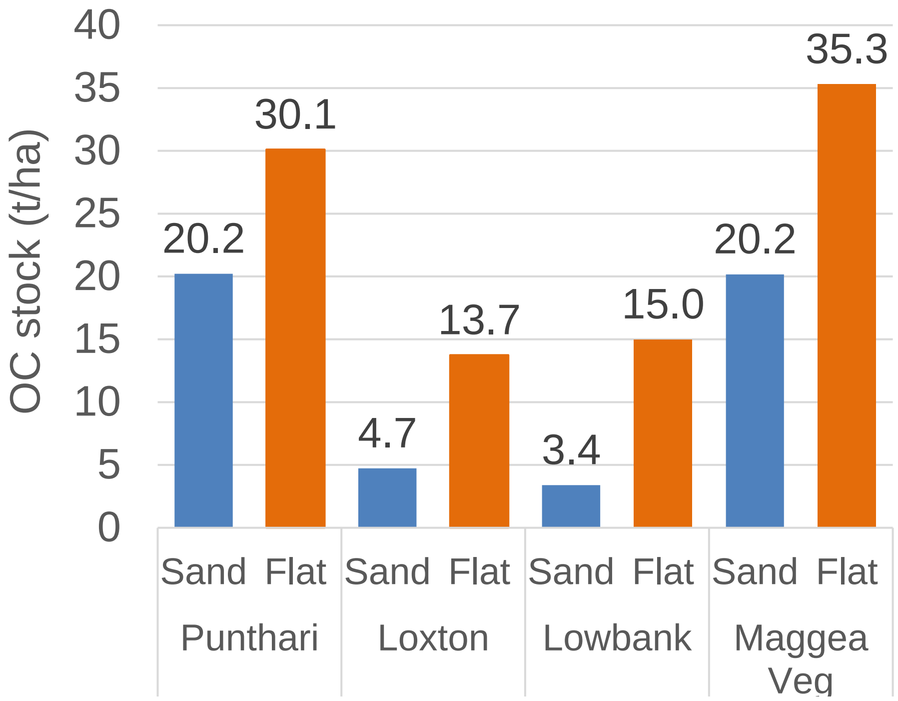
Saline black clay over calcrete

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

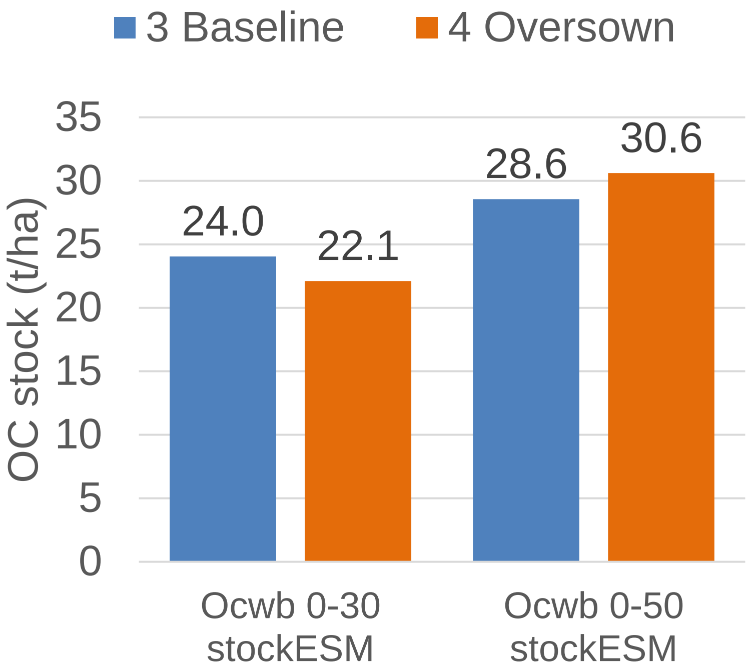
Depth (cm)	pH H_2O	pH $CaCl_2$	NO3 mg/kg	EC 1:5 dS/m	ECe	OC %
0-10	8.1	7.5	12	0.14	2	1.02
10-19	9.0	8.3	1.4	0.094	1	0.16
19-32	9.6	9.0	1.8	0.83	7	0.35
32-48	9.4	8.9	3	2.1	32	0.37

Soil texture



Soil texture in the same paddock strongly affects OC stock

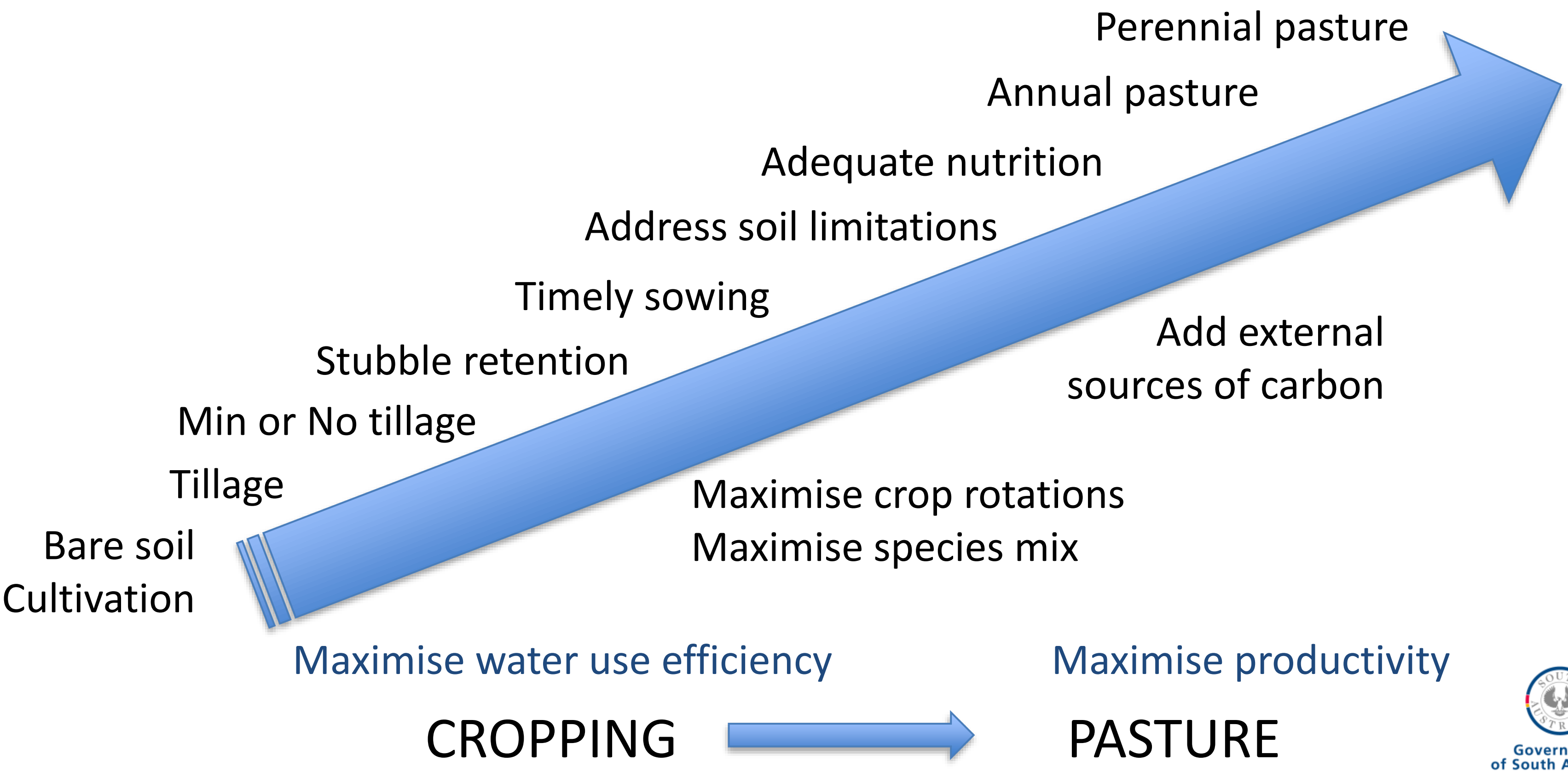
Soil depth



Management practice can change OC stock at depth

LANDSCAPE SOUTH AUSTRALIA MURRAYLANDS AND RIVERLAND

The theory of OC increase by management



Government of South Australia
Department of Primary Industries and Regions

C stock by management practice

Management practices had variable effect on soil C

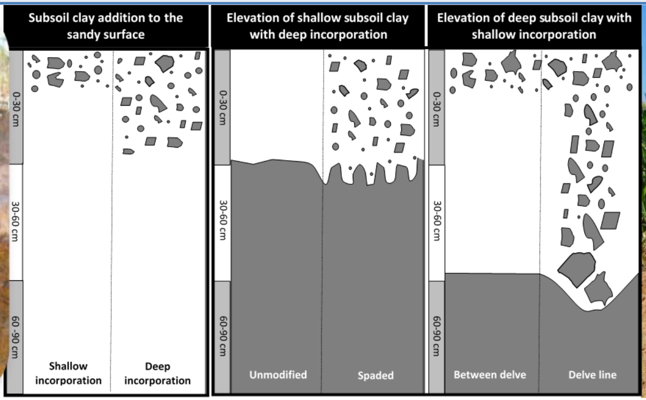
Abbreviations: P = Pasture, A = Annual, K = Kikuyu, C = Crop (no till, stubble retention).

Soil carbon in clay modified soils – Goyder/DEW

Clay modification increased OC stock average 4.9 tha^{-1} (range -1.0 to 8.2 tha^{-1})

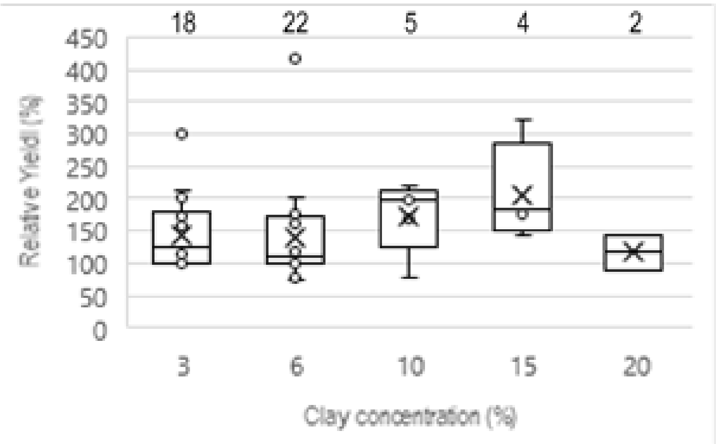
	350-400 mm	400-450 mm	450-500 mm	> 500 mm
Clay concentration		✓	✓	
Water storage	✓	✓	✓	
Nutrition			✓	✓

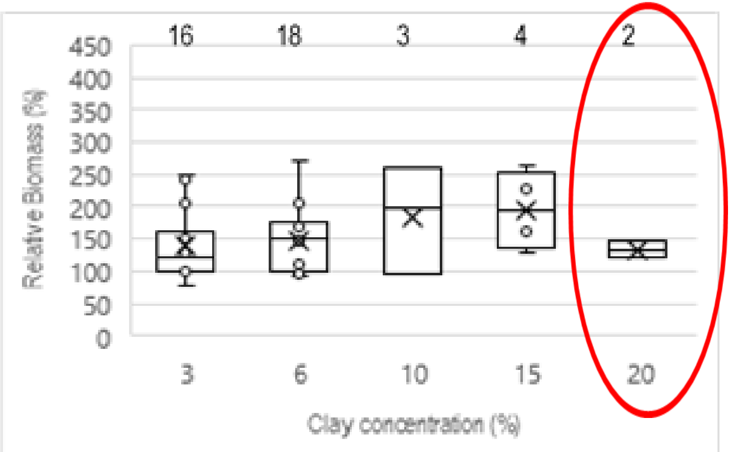
Nutrients
Kirkby ratio
To create 1 T humus need
80 kg N
20 kg P
14 kg S



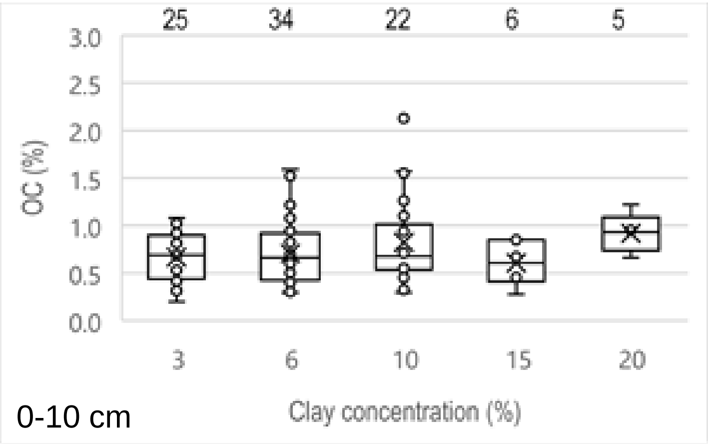
Soil CRC Sandy Soil Project – Clay Concentration

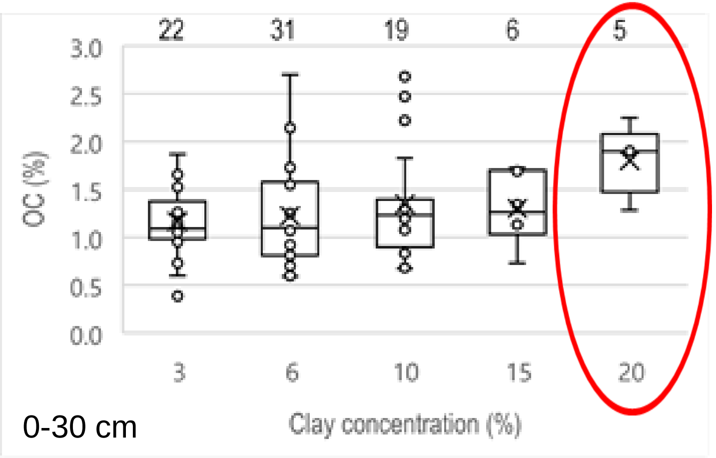
Productivity





OC Conc





SOIL CRC
Performance through collaboration

Amanda Schapel

Senior Soil and Land Management Consultant

0411 137 258

amanda.schapel@sa.gov.au

Government of South Australia

Department of Primary Industries and Regions