



# Soil Carbon

## Meningie East – Field Healthy Soils

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# Outline

- Soil Carbon Masterclass – the highlights
- Soil Carbon – tests and sampling
- What we know about soil C in South Australian agricultural soils
- Lessons learnt and practicalities (aka the things to look out for)
- Your soil test results and what they mean

# Soil Carbon Masterclass

## The highlights





# Why is soil C important?

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





# What is soil C?

Inorganic (IC) and organic (OC) forms

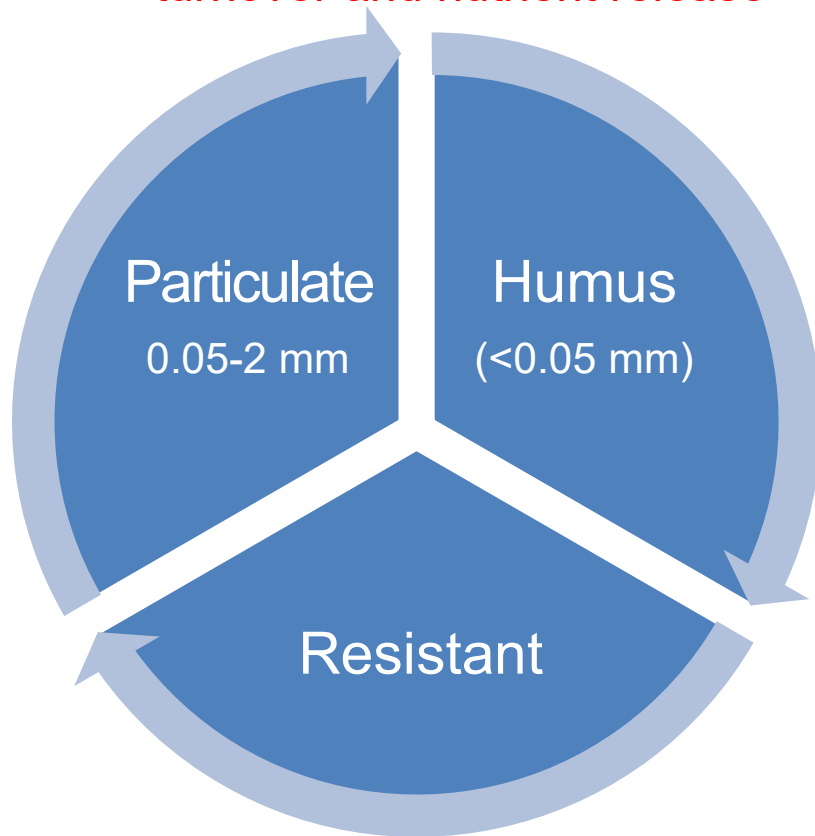
- IC (carbonate) is mineral based and not strongly influenced by land management practices
- OC is associated with organic matter and influenced by land management practices
  - makes up ~ 40-60% of the mass of soil organic matter
  - decomposing organic compounds of plants, animal and microbial origin

# Soil OM affects a wide range of soil properties

Physical	Chemical	Biological
better structural stability (aggregation)	improved cation exchange	increased biological activity
lower bulk density	source of nutrients	increased diversity
rapid infiltration of water	continual release of nutrients	improved suppression of soil borne pathogens
better drainage	sorption and deactivation of contaminants	
better root growth		
less erosion		
improved water holding capacity		

# OC is made up of different fractions / pools

Microbes are critical for OC  
turnover and nutrient release



OC turnover

DOC = minutes to hours

POC = years

HOC = decades

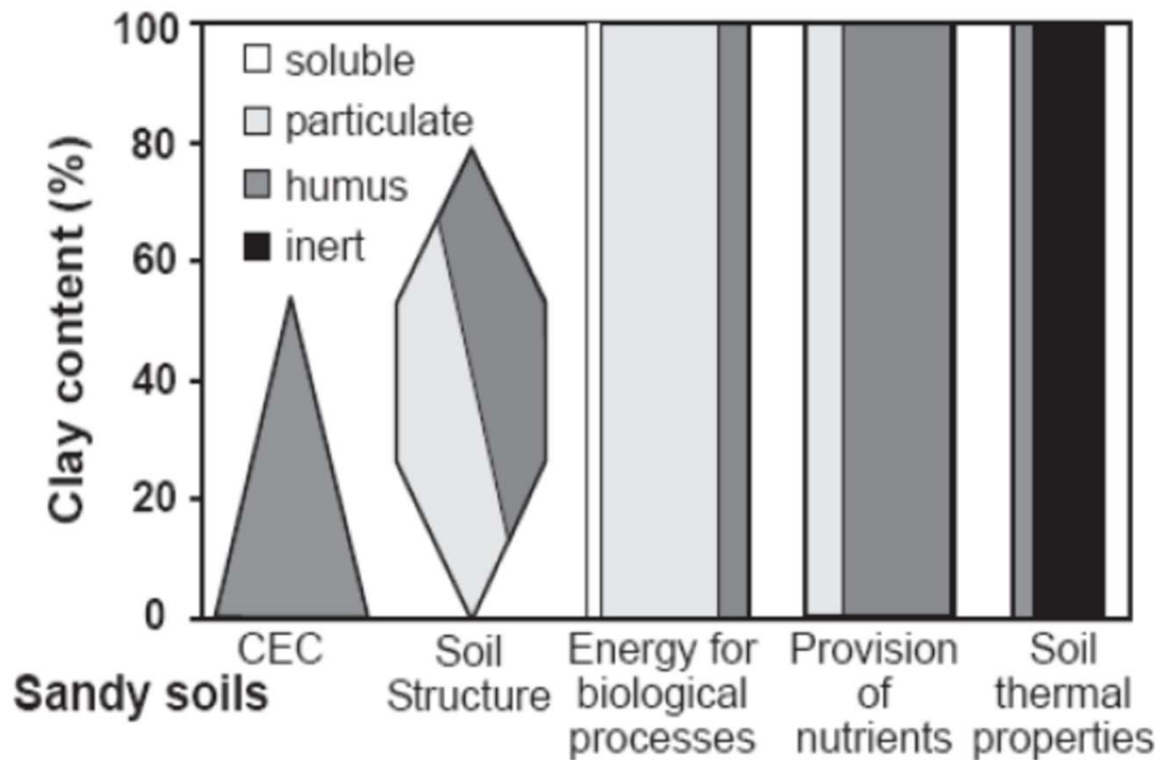
ROC = centuries

*Turnover is dynamic*

*Human impact can turn soil  
into net CO<sub>2</sub> source or sink*

# OC fractions influence soil properties

Clay soils



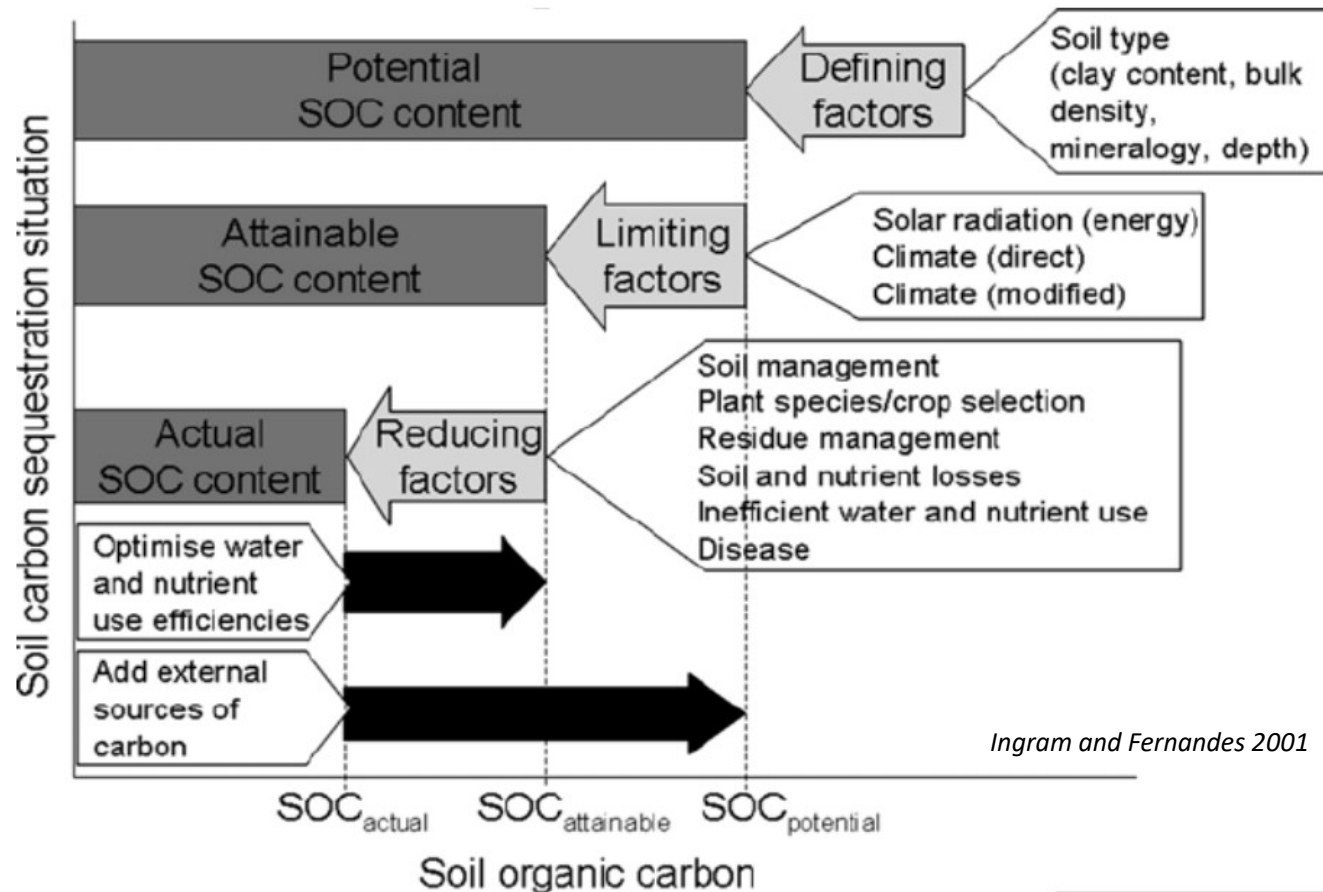
POC – physical  
Stability of macro-aggregates, food for microbes, rapid cycling of nutrients

HOC – chemical  
CEC, pH buffering and availability of nutrients to plants

*from Krull et al. 2004*

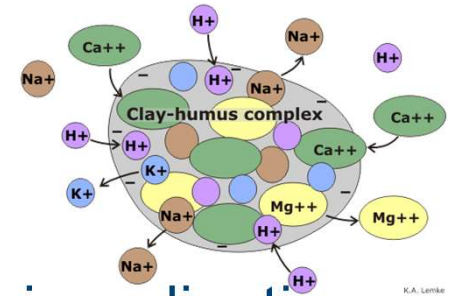


# Factors that influence soil OC

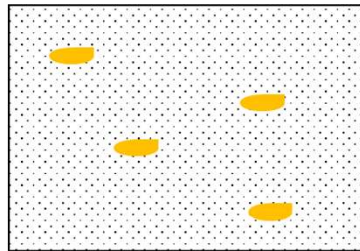


# Soils capacity to stabilise OC

Soil has a finite capacity to protect OC from mineralisation  
= capacity to bond OC

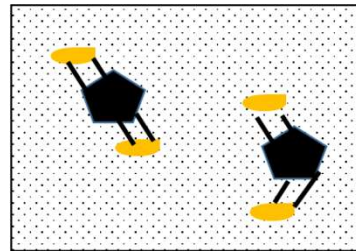


Free



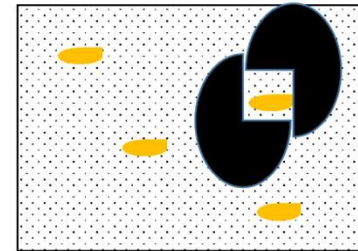
Decomposition  
risk = high

Bound



Decomposition  
risk = low

Occluded



Decomposition  
risk = low

MAOM STABILISED with clay minerals and aggregates

# Soil Carbon tests and sampling

## Soil C tests

Carbon type	Method	Measures	Pros / Cons
<b>Total C</b>	High temperature combustion (Leco or Dumas)	OC and IC	In soils with carbonate can be difficult to measure change in organic C
<b>Organic C</b>	Wet oxidation (Walkley Black method)	OC	Incomplete test – measures only 55-80% of total OC but doesn't measure IC
<b>Inorganic C</b>	Calcium carbonate equivalent	IC	Can be an inexact test.
<b>Total Organic C</b>	Wet oxidation (Heanes method)	OC	Complete test
<b>Total Organic C</b>	Pretreatment then High temperature combustion (Leco or Dumas)	OC	Need to ensure that have complete removal of inorganic C before combustion or results will be incorrect
<b>Mid Infrared</b>	Spectroscopy	OC and fractions	Quick and relatively cheap, not as accurate as other methods until calibrated





# Carbon Stock

Stock is the unit used in soil carbon accounting

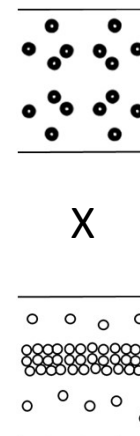
Soil OC stock is reported as

- t C / ha (same as Mg C / ha)
- or CO<sub>2</sub> equivalents 1 t C / ha = 3.67 t CO<sub>2</sub>e
- generally 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

**OC stock (t/ha) =**

**OC (%) x bulk density (g/cm<sup>3</sup>) x depth (cm) x (100 - gravel %)**



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# What we know about soil C

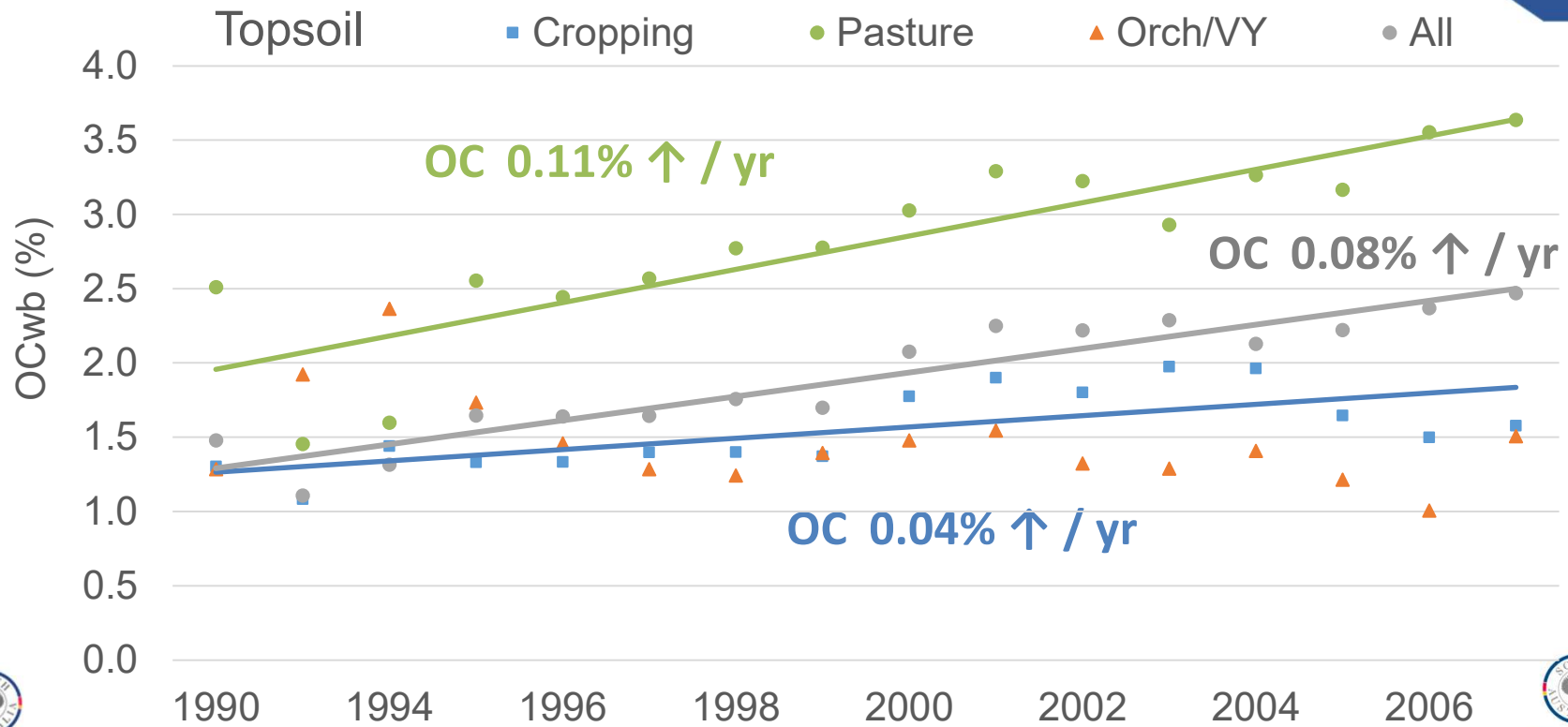
## South Australian agricultural soils

*Work presented is collated from projects predominantly from the Soil and Land Hub (collaboration between Sustainable Soils groups in DEW and PIRSA) but also includes data from the Cooperative Research Centre for High Performance Soils (Soil CRC) and Landscape SA (Murraylands and Riverland, Kangaroo Island)*



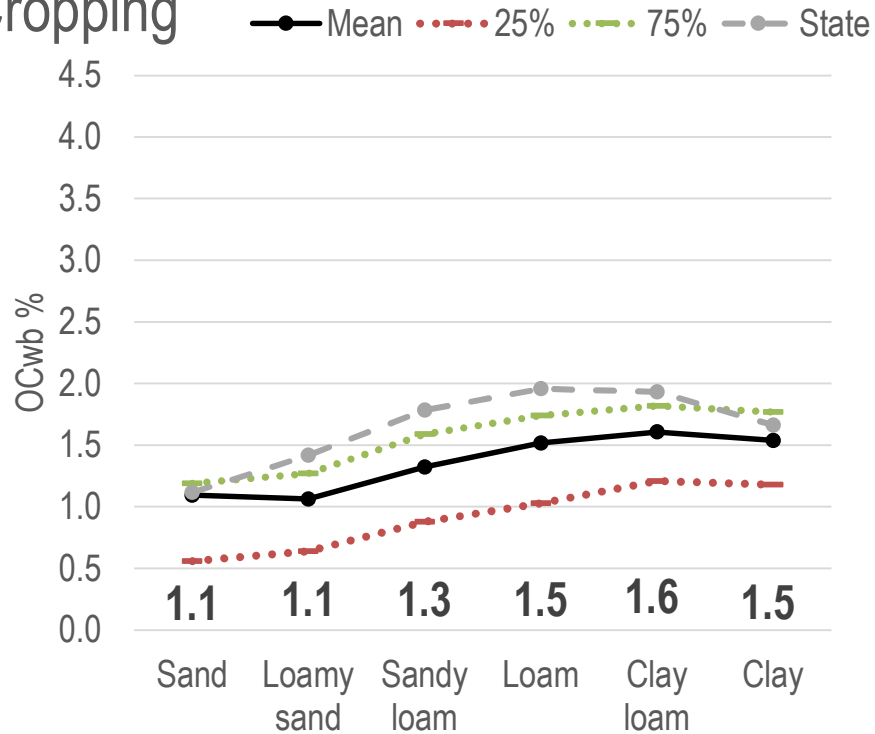
# Soil Carbon 1990-2007

36,000  
soil tests

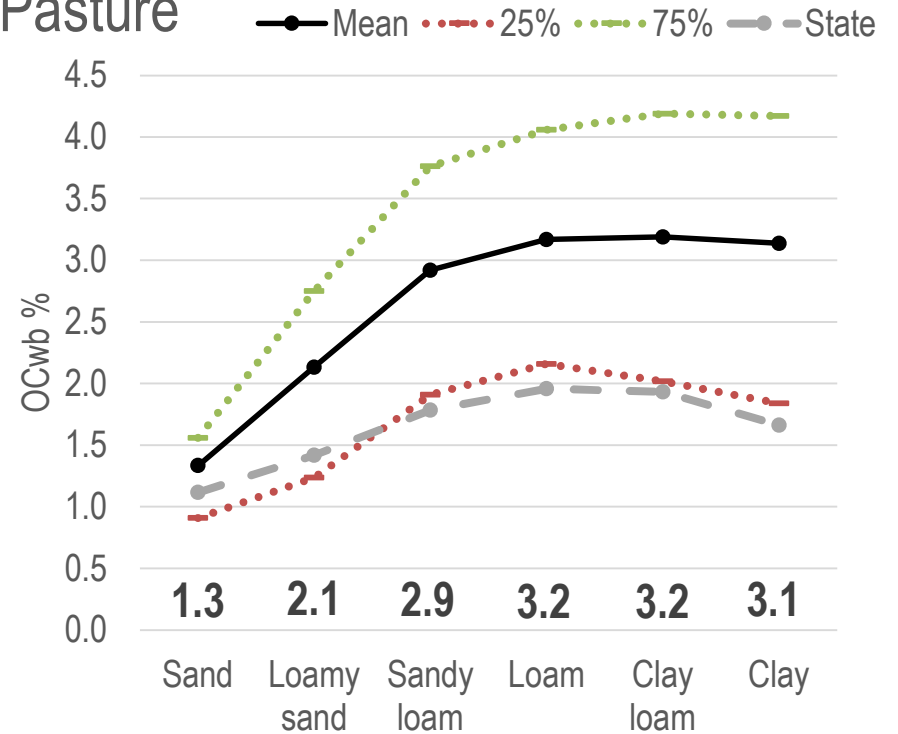


# Soil texture x land use

Cropping

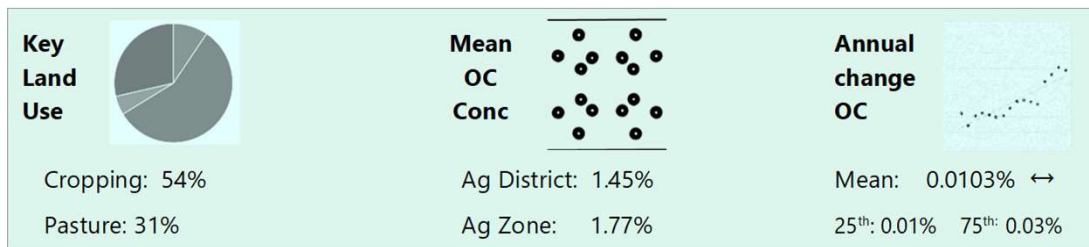


Pasture



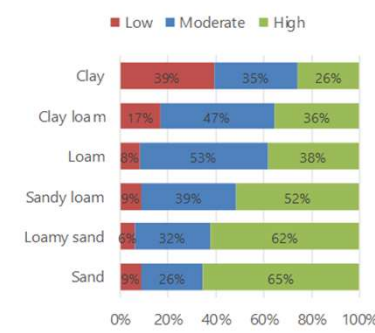
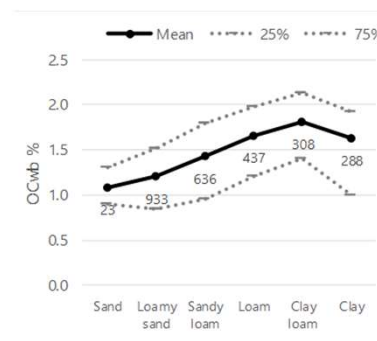
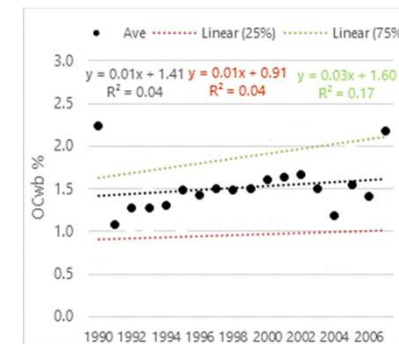


# Upper South East OC 1990-2007

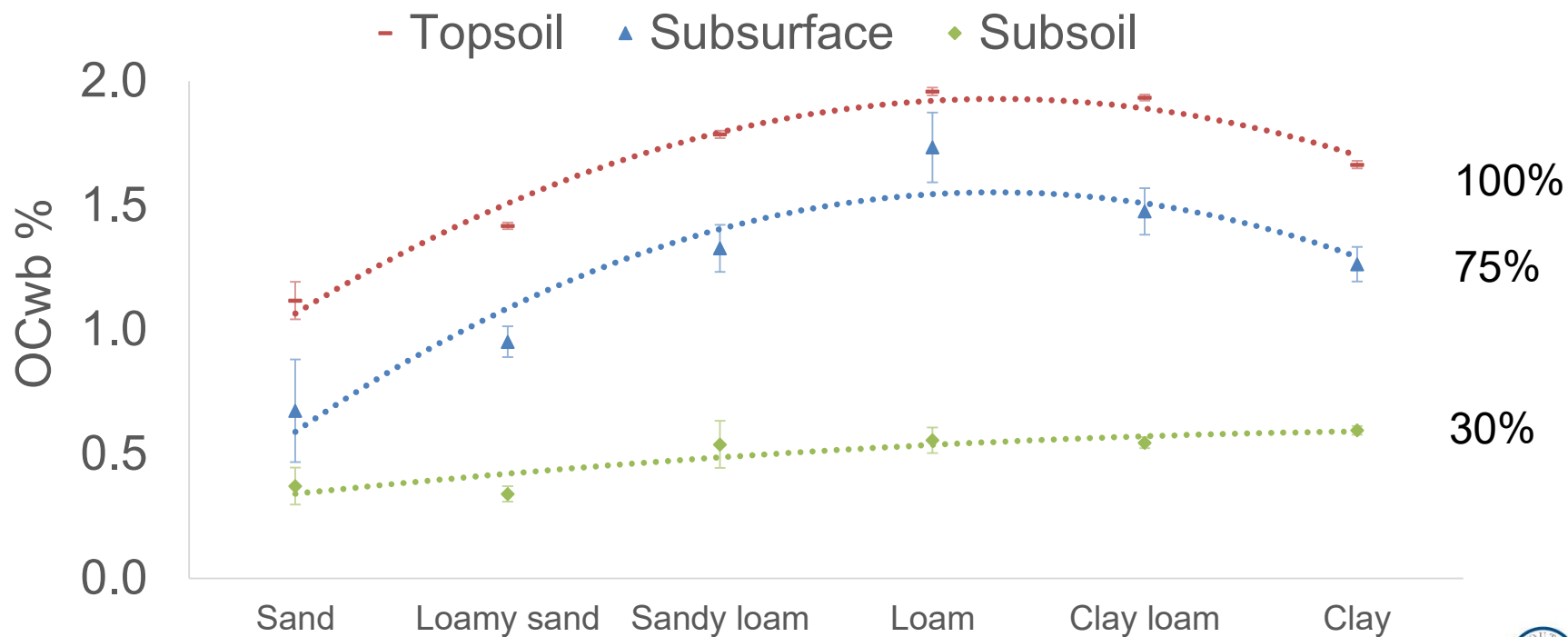


	Ag Zone	Ag District Benchmarks						
Texture	Mean	Count	Mean	25%	40%	50%	60%	75%
Sand	1.12	23	1.08	0.90	1.05	1.12	1.19	1.31
Loamy sand	1.42	933	1.21	0.85	1.01	1.10	1.24	1.51
Sandy loam	1.79	636	1.43	0.96	1.20	1.35	1.50	1.80
Loam	1.96	437	1.66	1.20	1.40	1.50	1.70	1.97
Clay loam	1.93	308	1.81	1.40	1.59	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

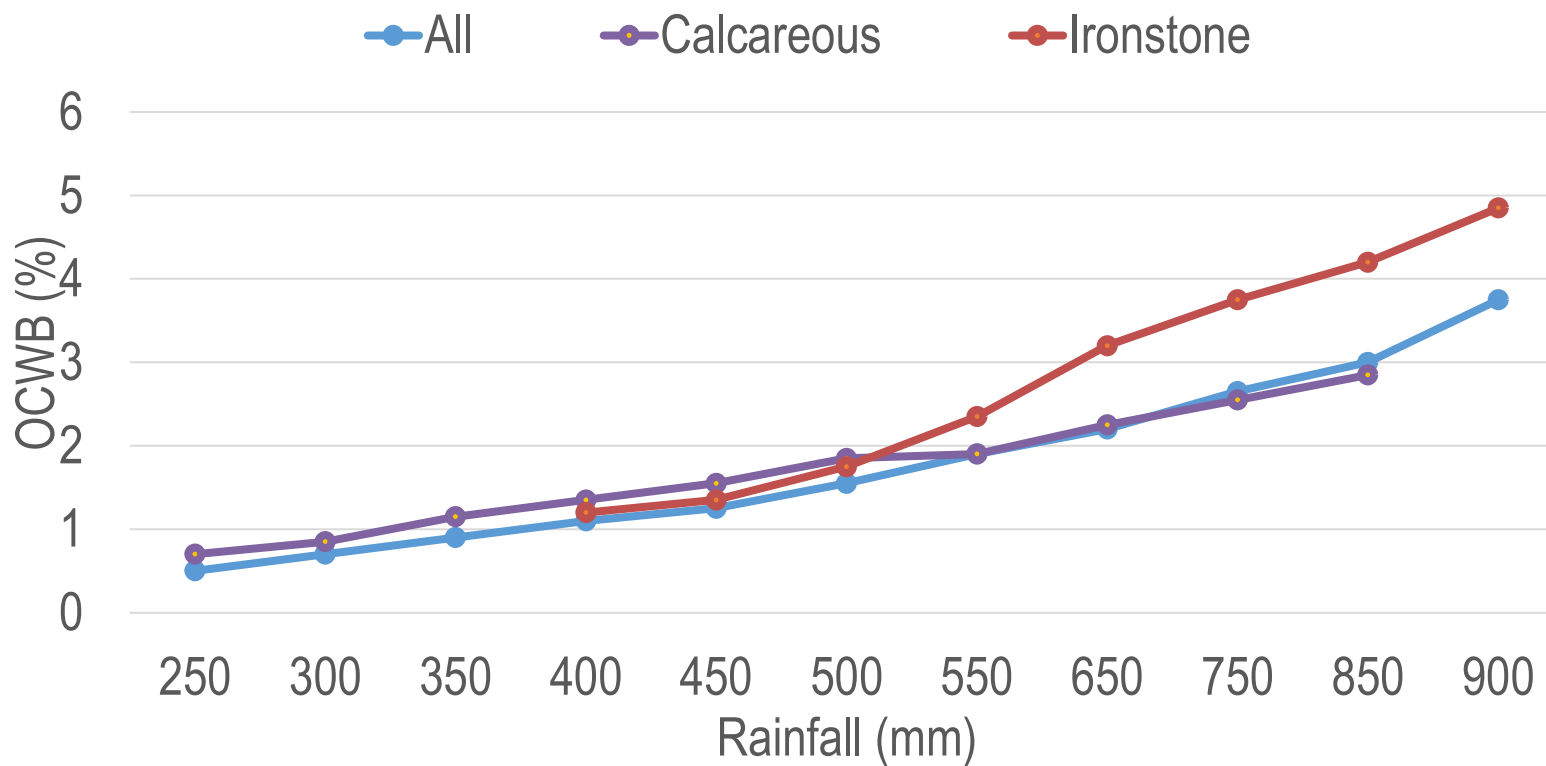


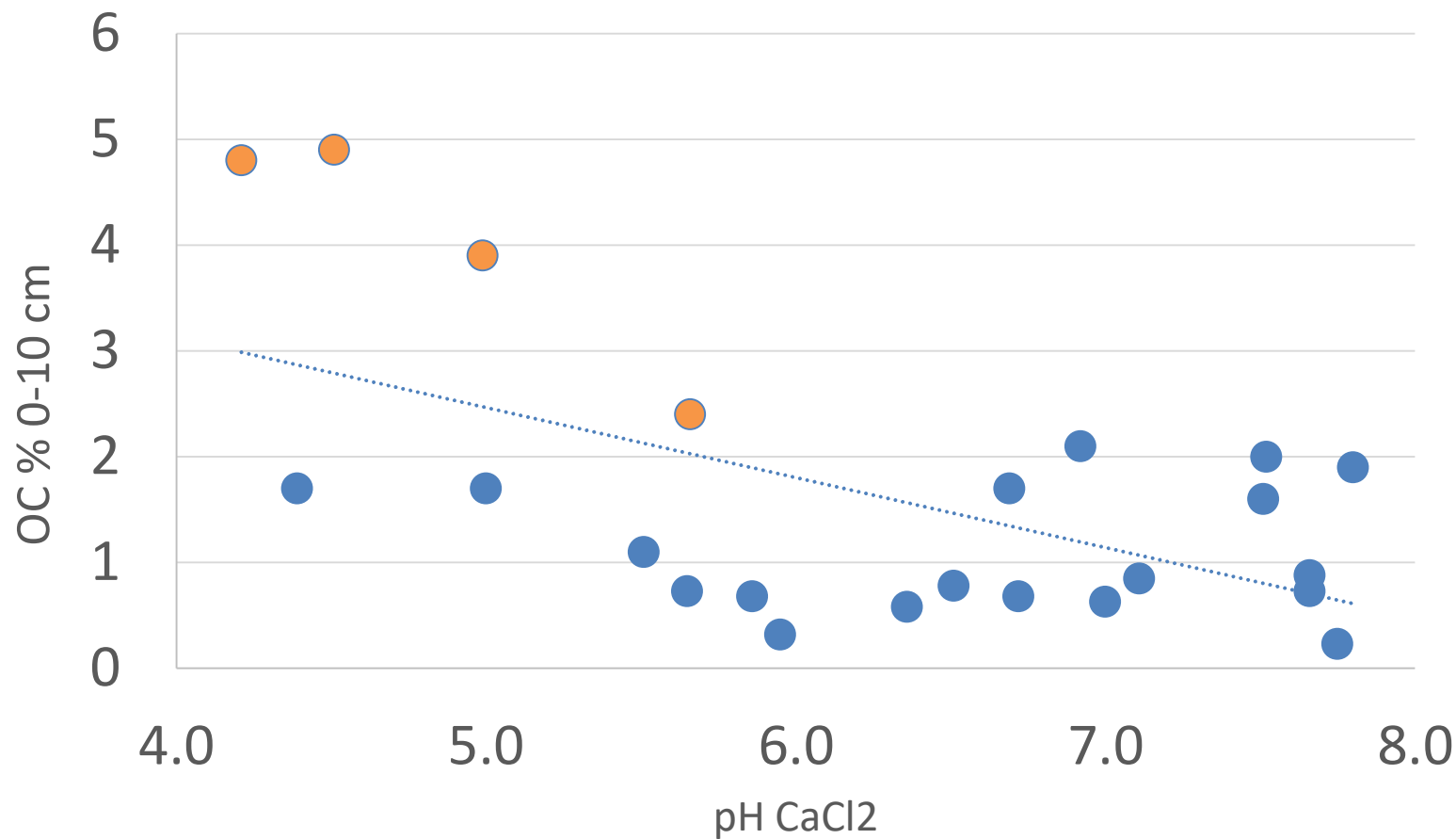
# OC concentration down the soil profile



## State Soil Land Information Framework – rainfall x clay conc

Clay concentration 10-15 %



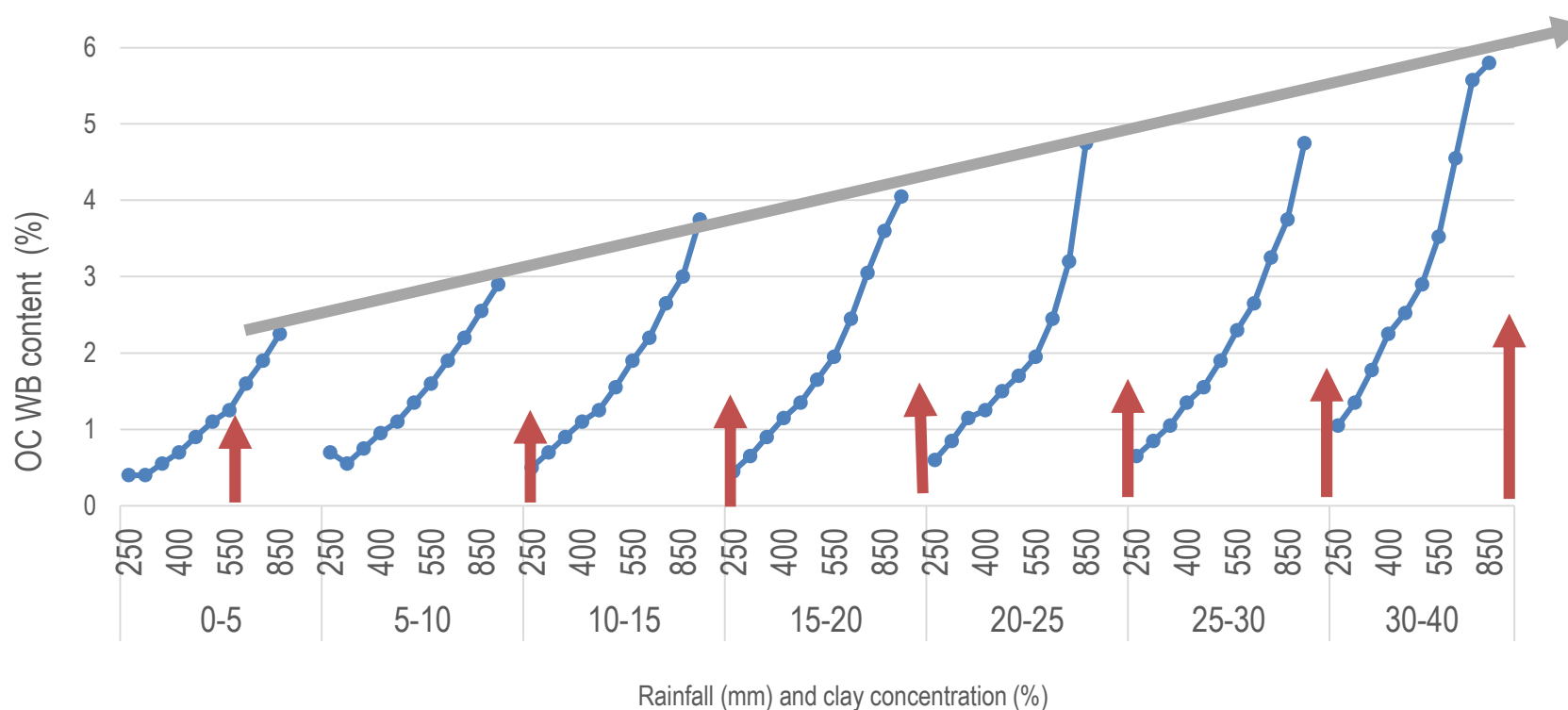


The highest OC concentrations can be due to other factors such as pH. Any factors that affect biological activity can influence OC

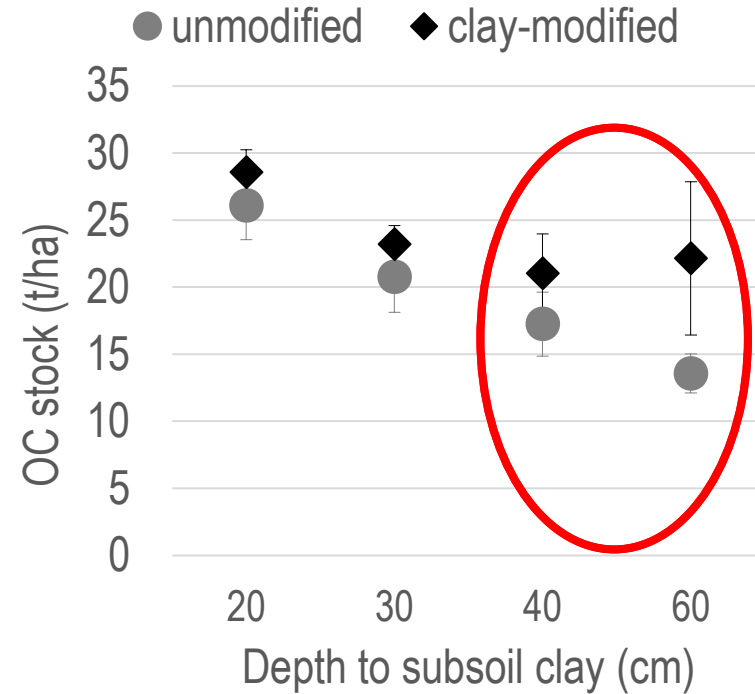
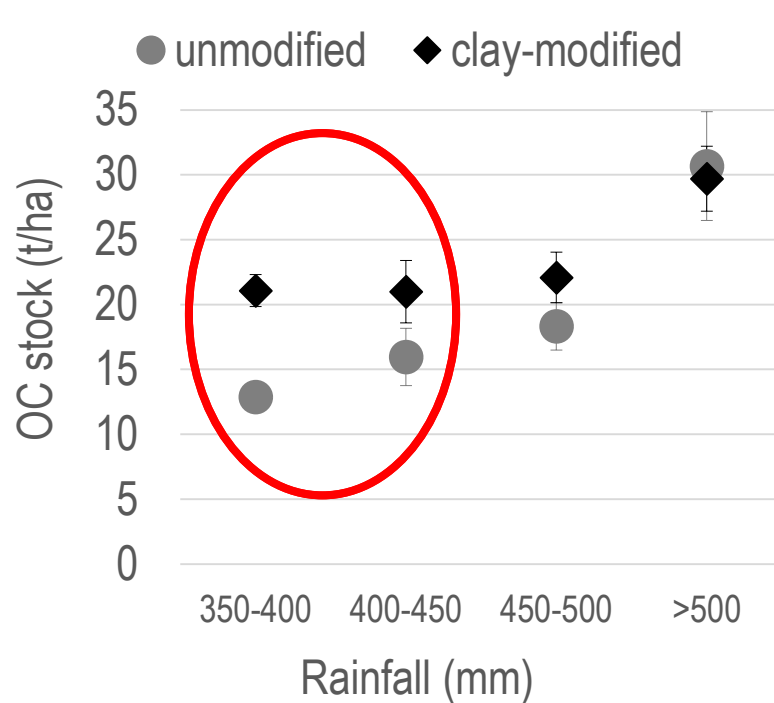


## Effect of climate on soil OC in SA

Rainfall – sharp increase in OC between 500-550 mm for all clay contents



## Clay addition on OC stocks



- Highest OC stock at > 500 mm but unmodified also high

*Greatest OC opportunity rainfall < 500 mm*

*For greatest OC opportunity  
subsoil clay should be > 30 cm*

## Soil carbon in clay modified soils – Goyder/DEW/PIRSA

- Addition of subsoil clay to sands increased OC stock 4.9 t/ha (range -1.0 to 8.2 t/ha)

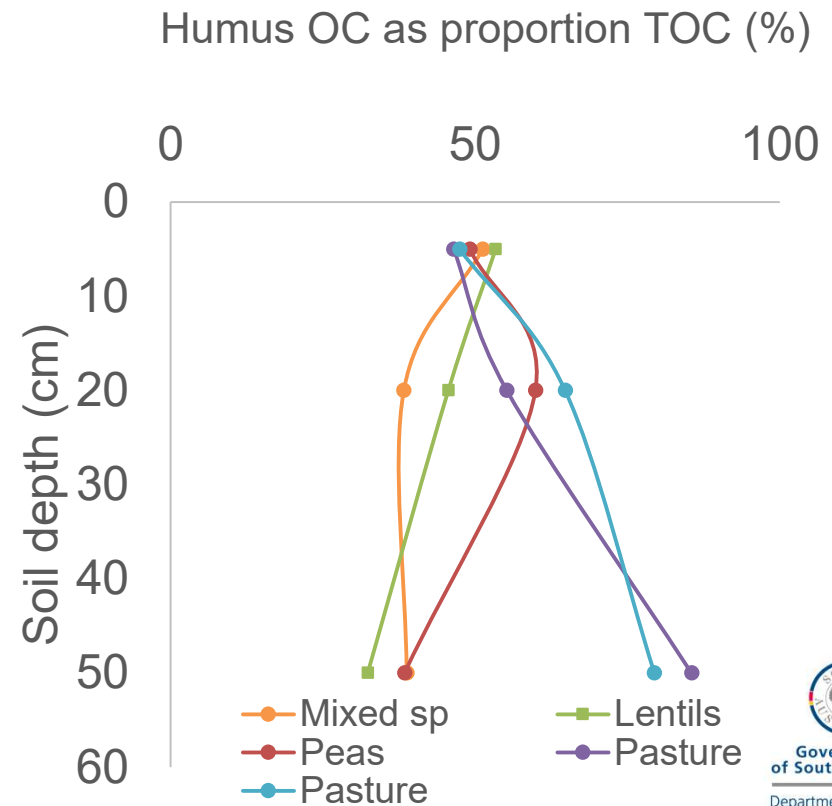
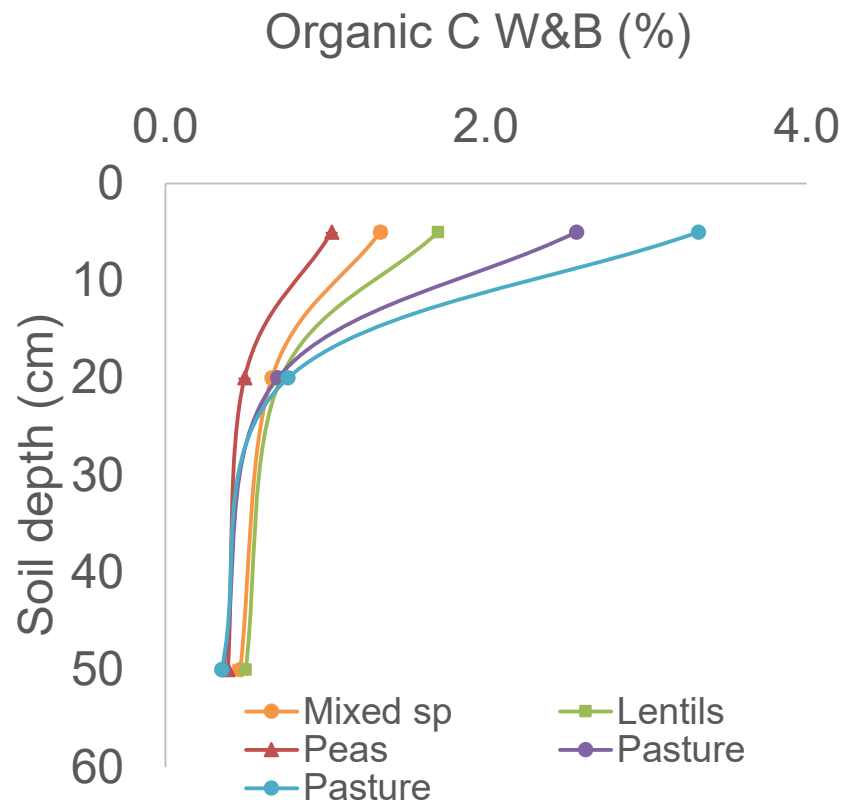


		350-400 mm	400-450 mm	450-500 mm	> 500 mm
<b>Clay concentration</b>			✓	✓	
<b>Water storage</b>		✓	✓	✓	
<b>Nutrition</b>				✓	✓
<b>Subsoil clay addition to the sandy surface</b> 		<b>Elevation of shallow subsoil clay with deep incorporation</b> 		<b>Elevation of deep subsoil clay with shallow incorporation</b> 	
Shallow incorporation Deep incorporation		Unmodified Spaded		Between delve Delve line	



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

# Mid North and Eyre Peninsula 2020

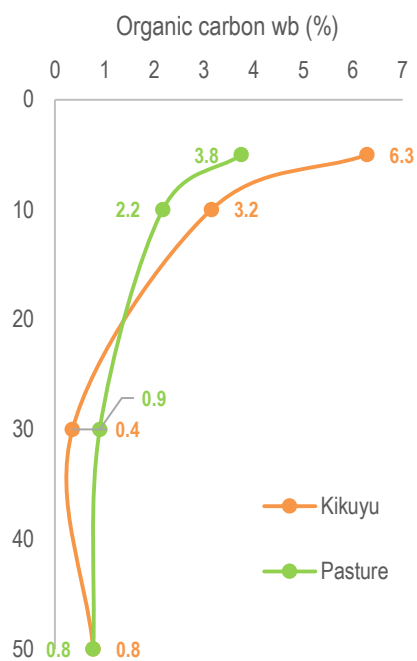




# Kangaroo Island 2021

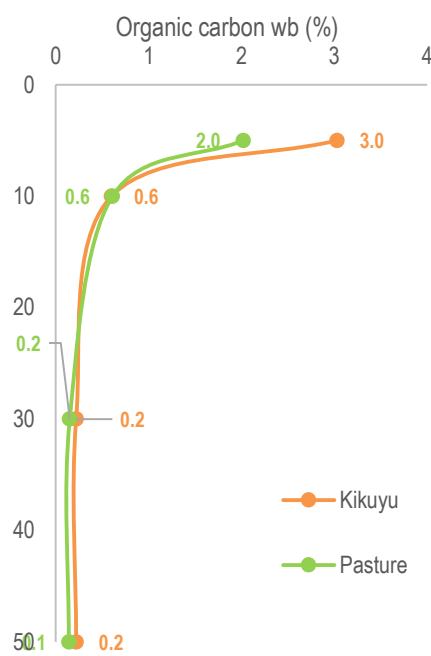
## Ironstone

Annual vs Kike Pasture



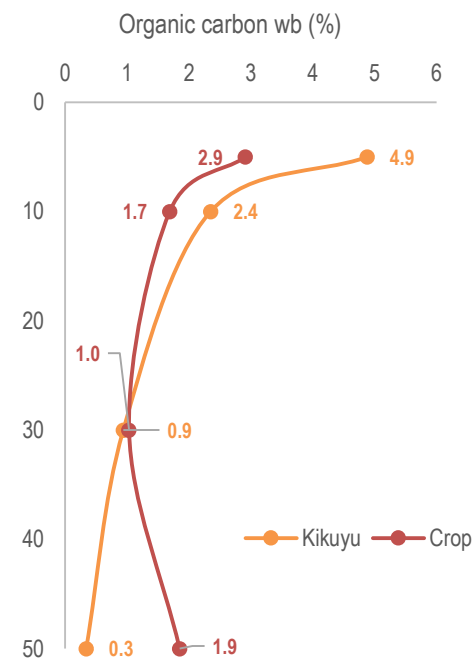
## Deep sand

Annual vs Kike

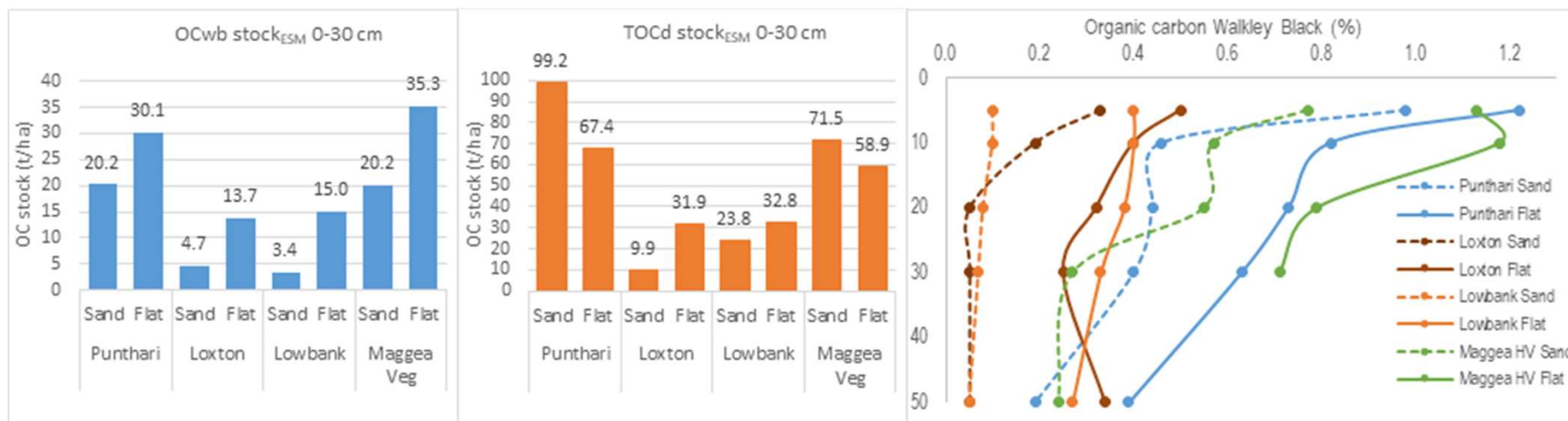


## Sand over clay

Kike Pasture vs Crop



# Landscape SA Murraylands and Riverland 2020

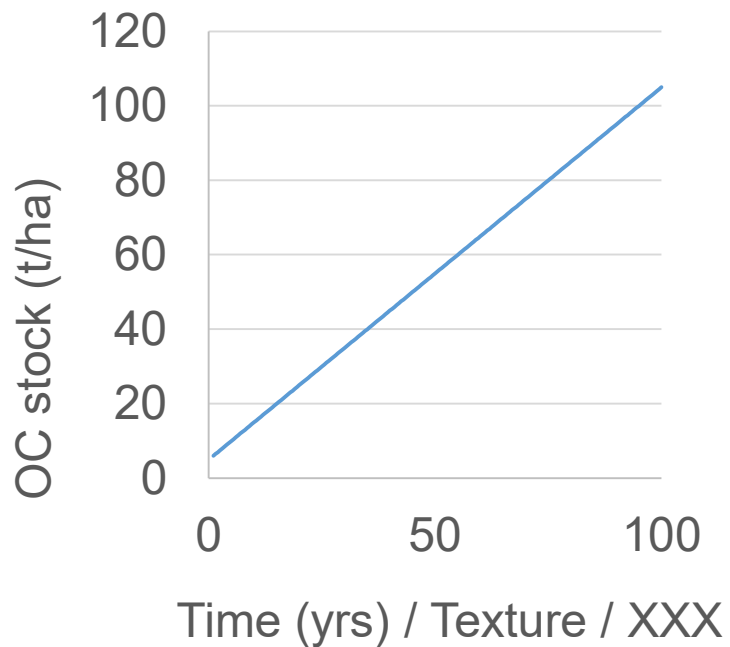


# Lessons learnt and practicalities

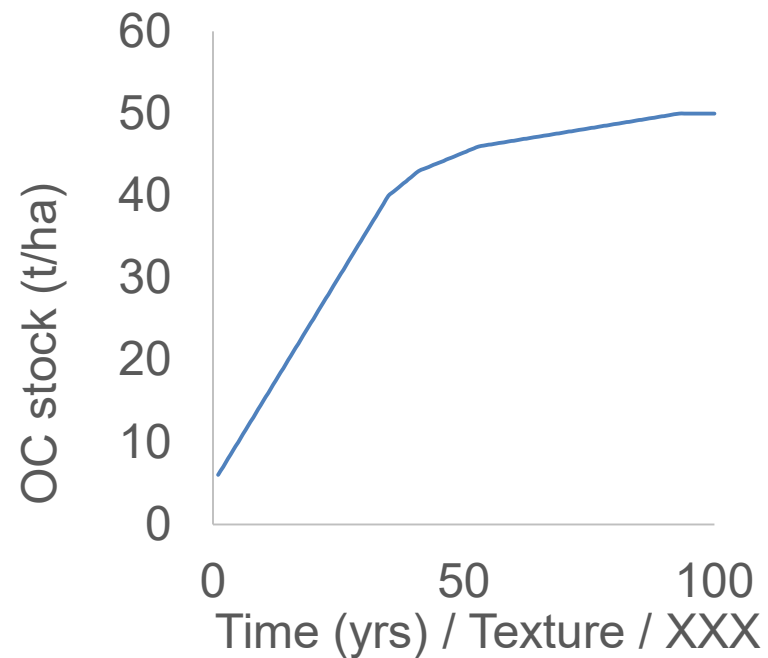
## The things to look out for

# OC increase is

Not linear

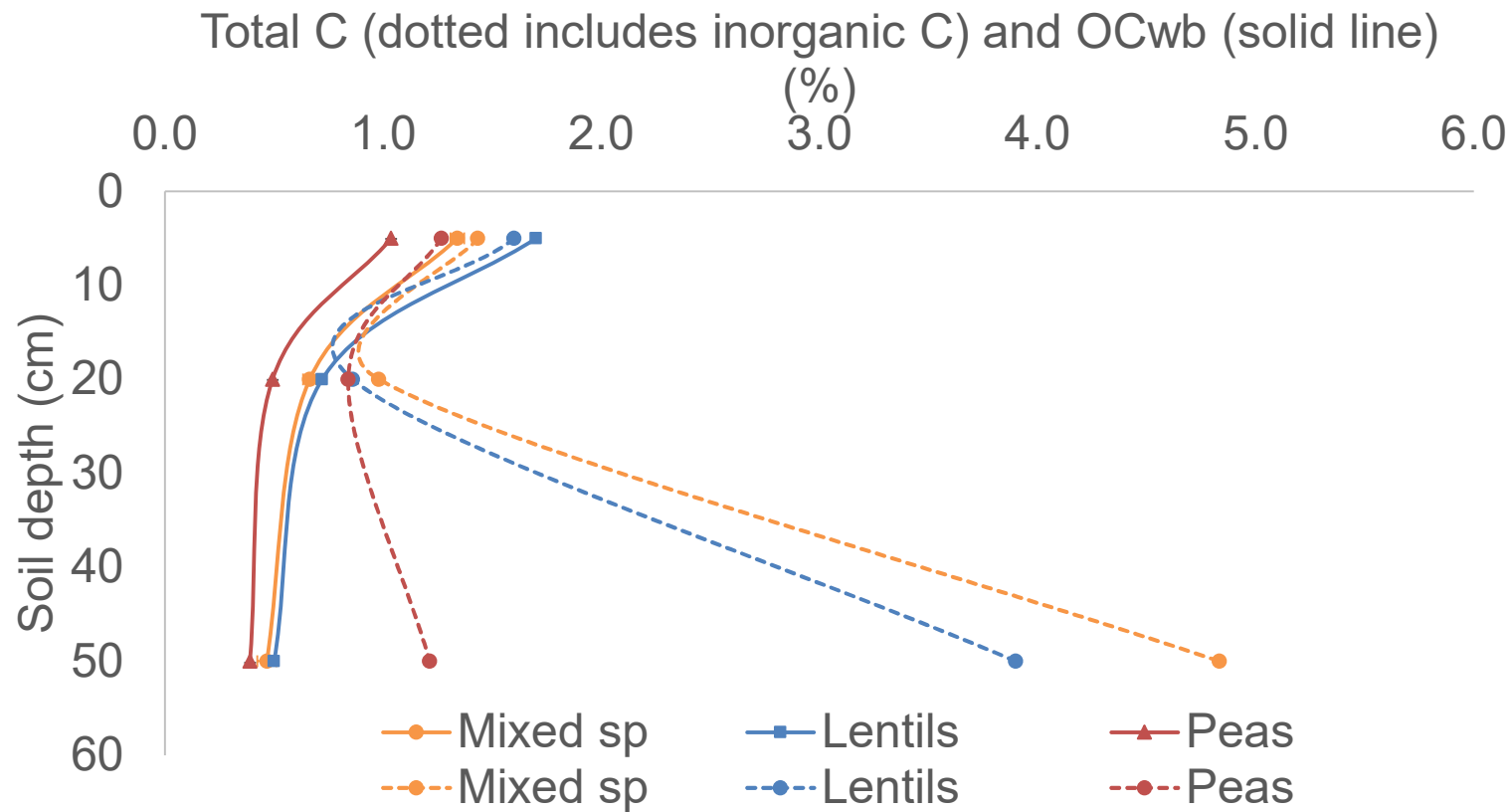


Equilibrium will rule



Be aware of rates of OC change and what will affect it

# The test you do is important



# Lag time before change OC measured?

Best bets based on what we have seen

After a change in practice

- 3-5 years, up to 10 years in lower rainfall sandy soils???

After fire event

- can be an immediate loss, highest seen is 30% in severe hot burn areas, often minimal loss if soil is still covered

After drought

- may not see an immediate decline unless soil is disturbed and uncovered
- OC may remain stable then a decline in 1-3 yrs that could take a few years to increase following return of production

Expect a lag time in OC concentration after a change has occurred



# OC is variable

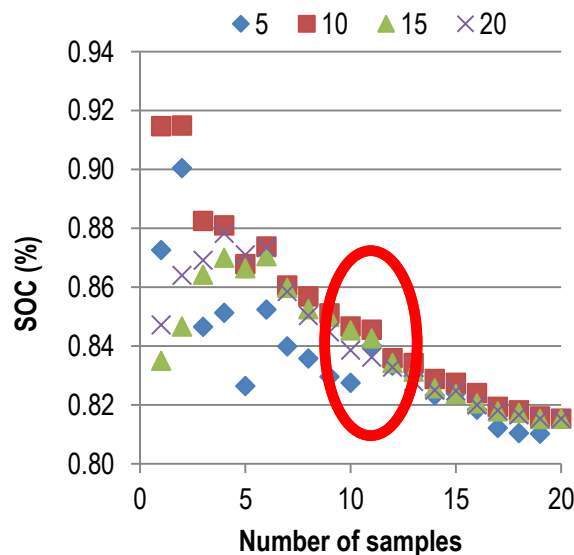
Collect samples carefully

Paddock

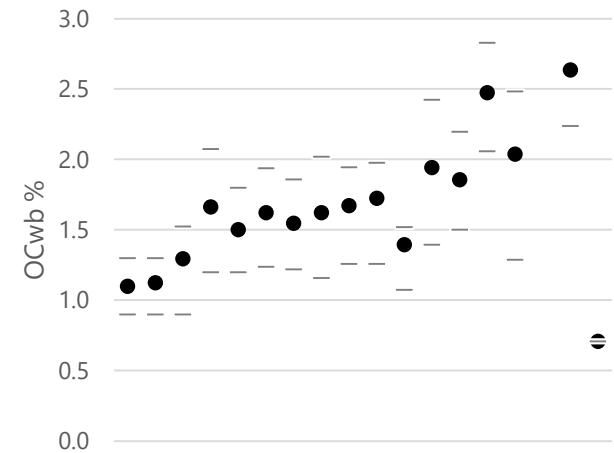
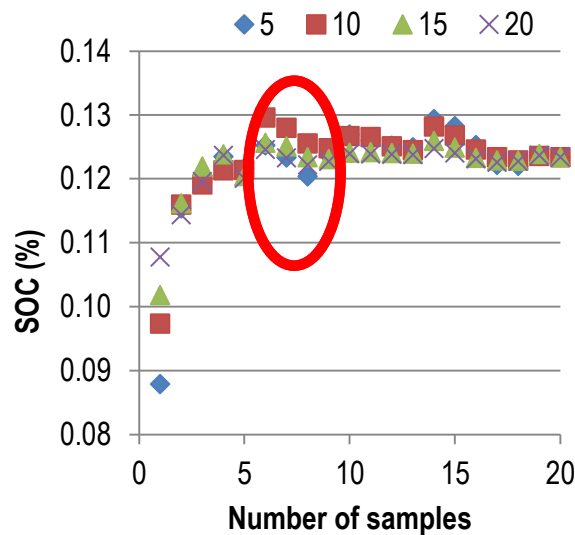
Down profile

Over time

0-10cm



20-30cm



Minimum samples  
10 in 25 m x 25m  
20 in a paddock same texture

Can collect ~1/2  
number in clay subsoil

Collect at the same  
time each year  
Often summer

# OC Stock is influenced by

OC Concentration

From Clay  
Modification project

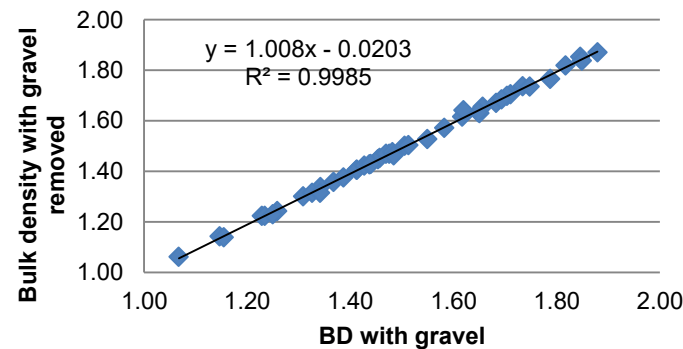
OC explains ~ 75%  
of OC stock

*Rainfall ~ 23%*  
*Clay conc 17%*

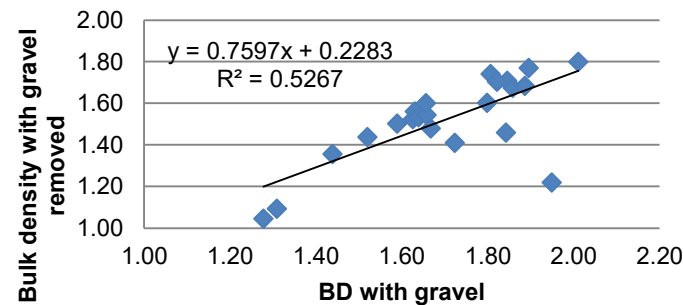
Pick a method and  
stick to it

Gravel

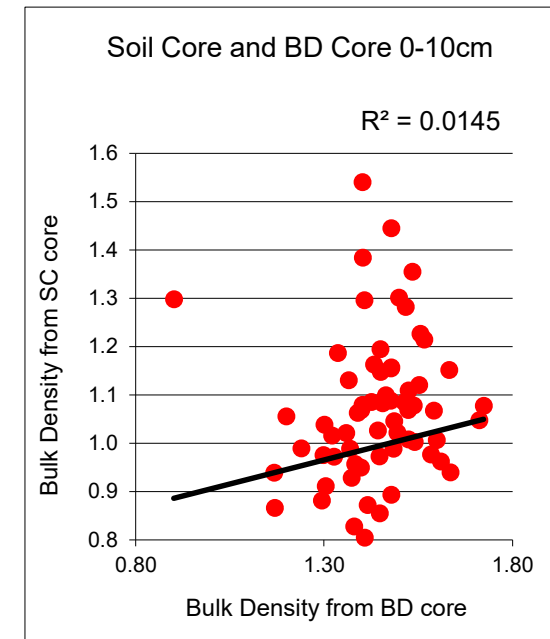
Gravel 1-5%



Gravel >15%



Way bulk density collected

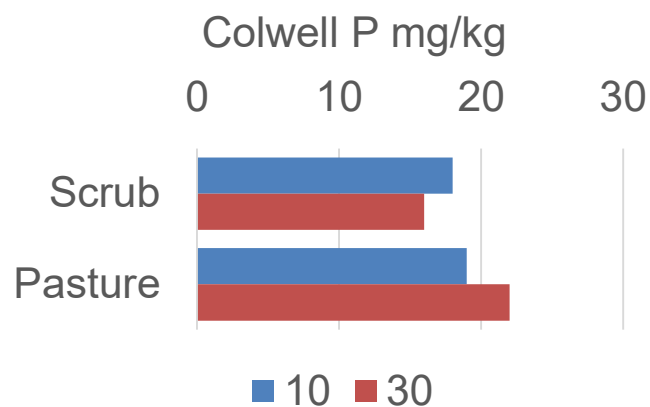
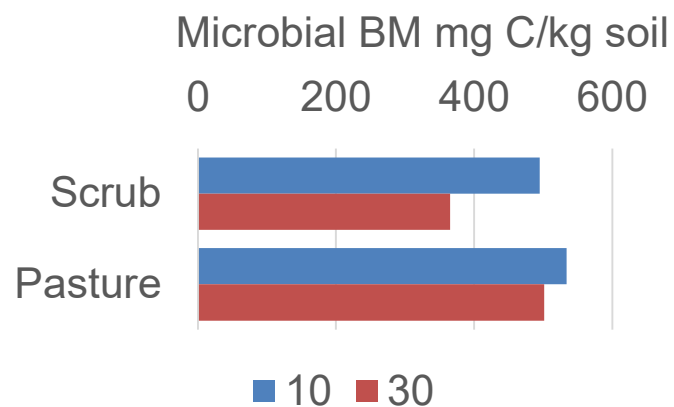
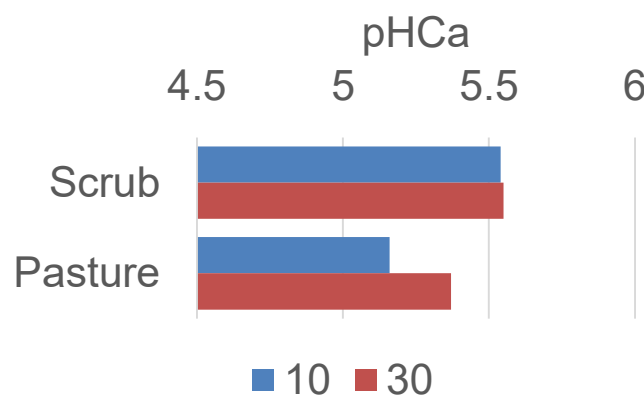
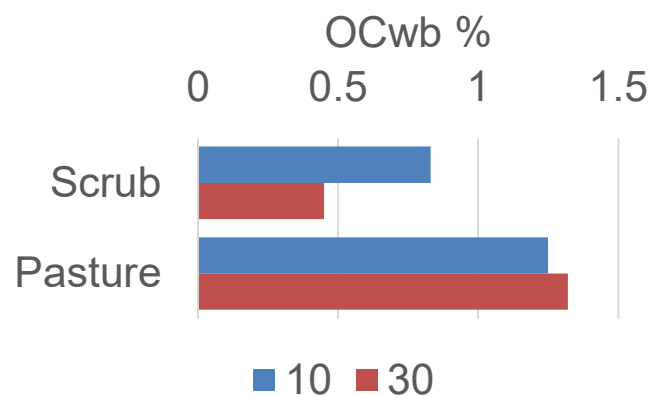


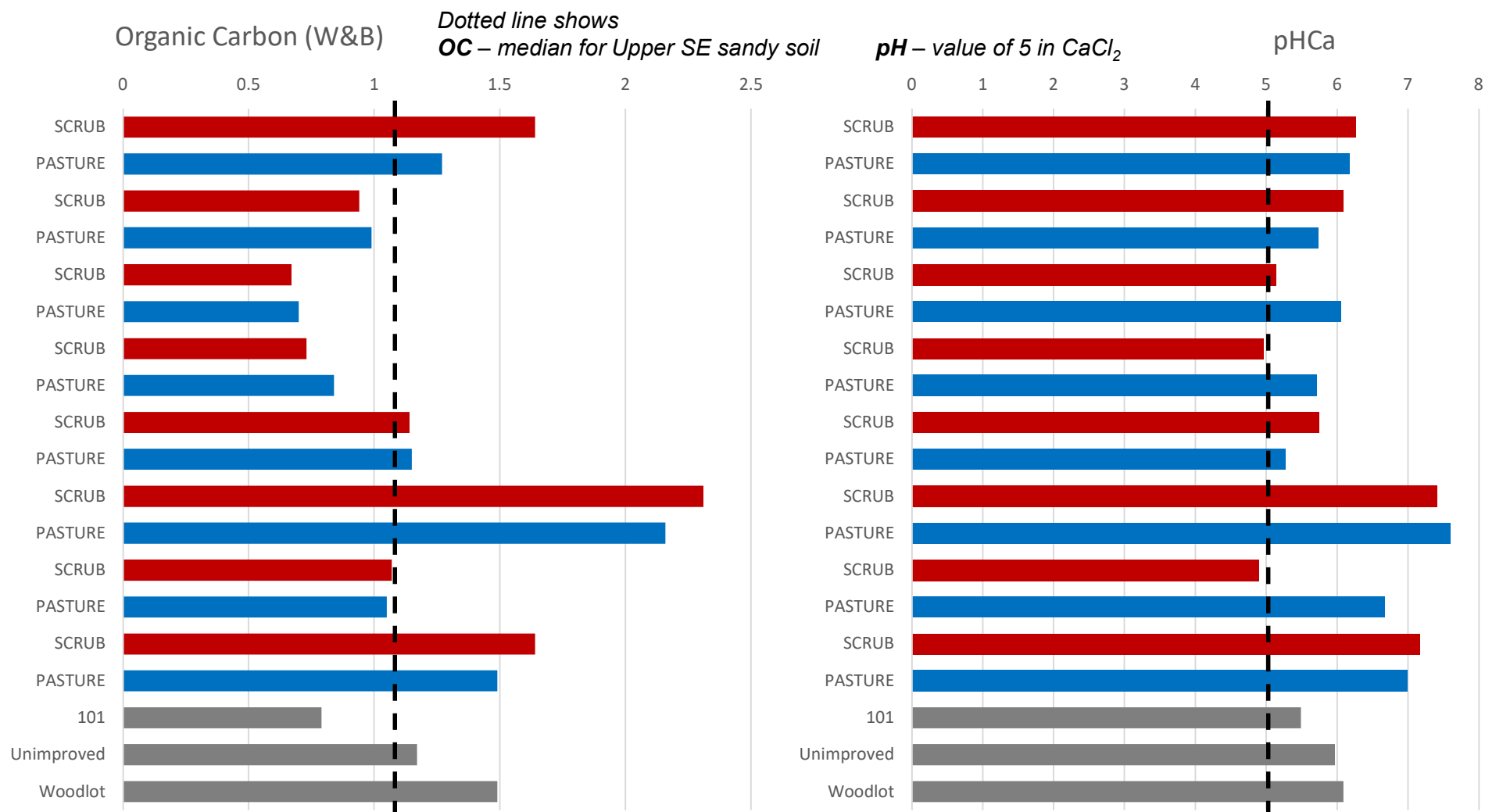
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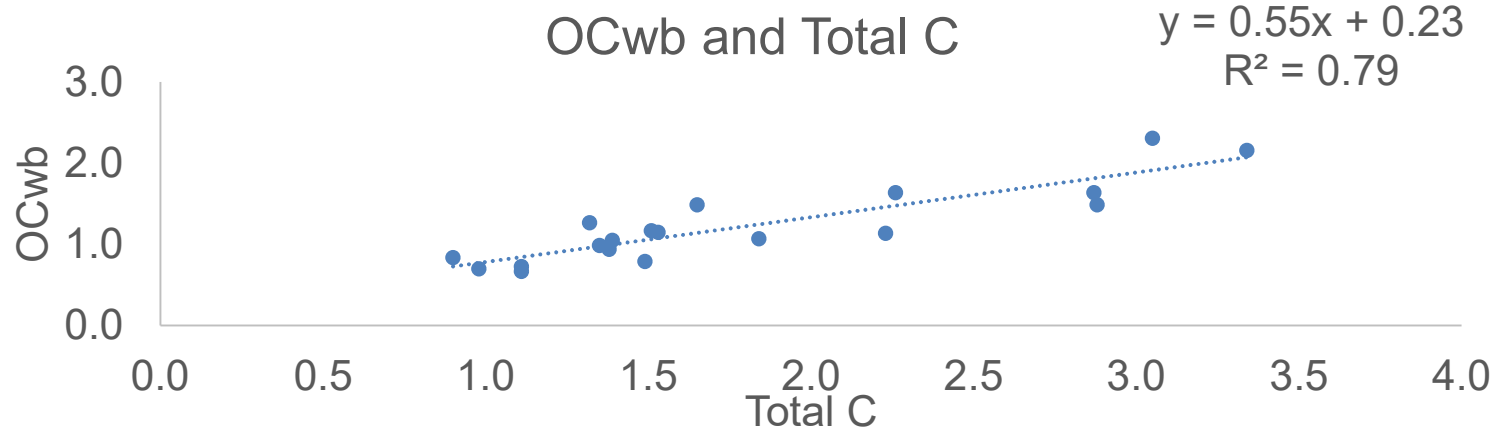
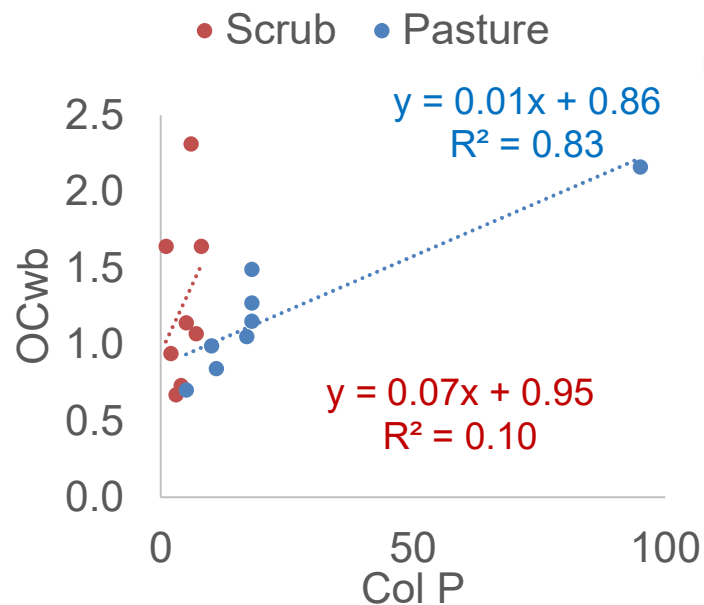
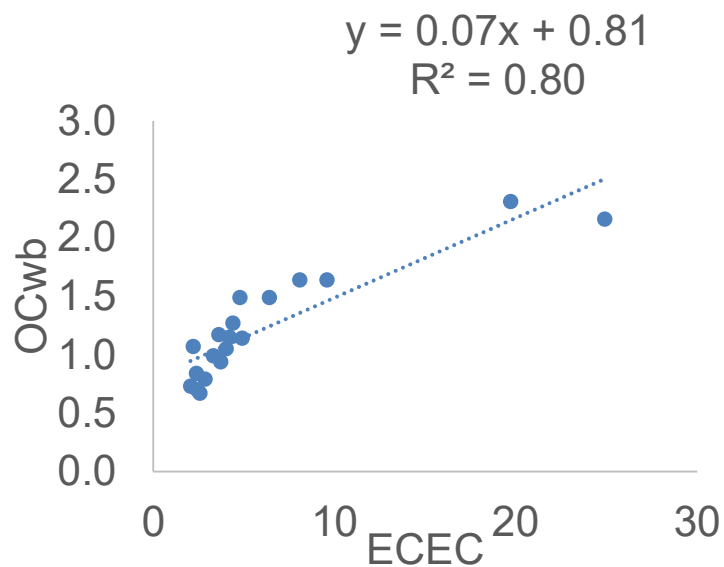
# Your soil test results

## What do they mean?

# First sampling







Recovery rate  
WB to TC

Scrub 64%  
Pasture 80%