


NSW GOVERNMENT | Murray CMA CATCHMENT MANAGEMENT AUTHORITY

The sequestration of carbon in soils

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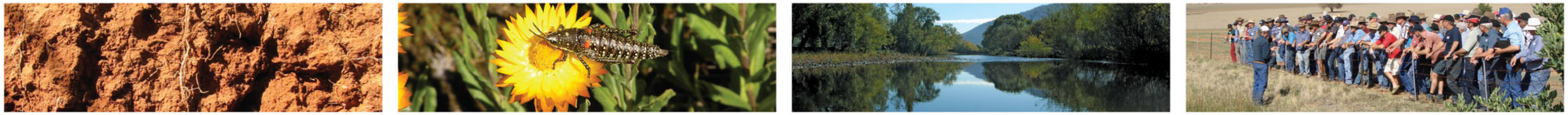
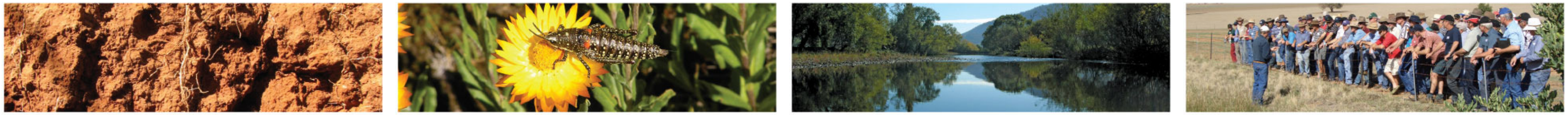
Introduction

- Another soil carbon presentation!
- A win:win – Opportunities for financial support to sequester carbon & SOM critical for soil resilience
- Potential storage of C in soil is important for GHG abatement – soil management to play a key role
- 3000 Soil C research papers 2000-2010
- Overview
  - **How is carbon sequestered**
  - **How much can be sequestered**
  - **The importance of soil organic matter**
  - **Some of the realities of soil carbon sequestration for trading**
  - **What to do about it?**



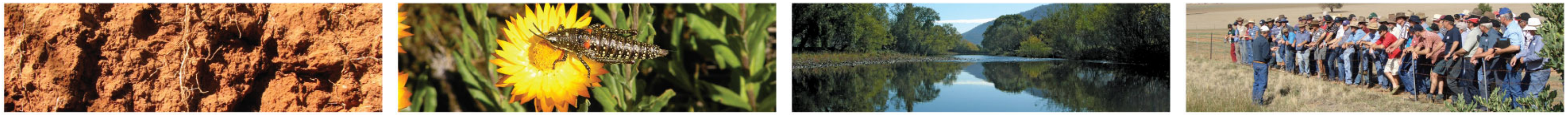
What is soil carbon sequestration?

- The transfer of CO_2 from the atmosphere to the soil through photosynthesis and its storage where it cannot be readily lost through microbial respiration, erosion or leaching.
- Soil Carbon = Mineral forms of carbon exist in the soil primarily as carbonates of calcium or magnesium
- Soil Organic Carbon (SOC) a component of soil organic matter (SOM), which also includes a variety of living and non-living materials in various states of decay
- Carbon - relatively consistent quantities in SOM organic matter allowing it to be readily measured – SOC x 1.72 = SOM
- Essential building block of living organisms (50% of cells = C), used in cell structure, biochemistry and nutrition



Soil Organic Carbon forms

- Leaf to humus
- Each source of OM = a unique combination of components (sugars, starches, lignin, C:N ratio etc) influencing its rate and pathway in C cycle
- Interaction with complex soil biota – bacteria v fungi
- As material ages = more biologically resistant = longer residence time
- Its influence over soil function changes
- Carbon pools (<2mm)
  - **Labile v light fraction v coarse (> 53µm fragments)**
  - **Humus**
  - **Charcoal**

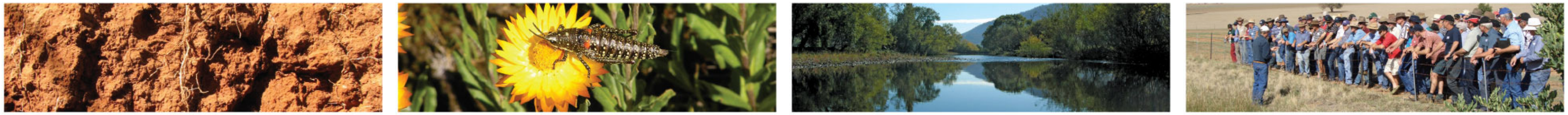


How is carbon sequestered in soil

- Key point – the mechanisms involved in the storage of carbon in soils are still only poorly understood

- Soil carbon levels are the result of – climate, vegetation & organisms, topography, parent material and management

- Rates of sequestration & storage are highly variable in space & time.



How is carbon sequestered in soil

- By adding more carbon to the soil than is lost during the year ➔ Tally up your balance sheet

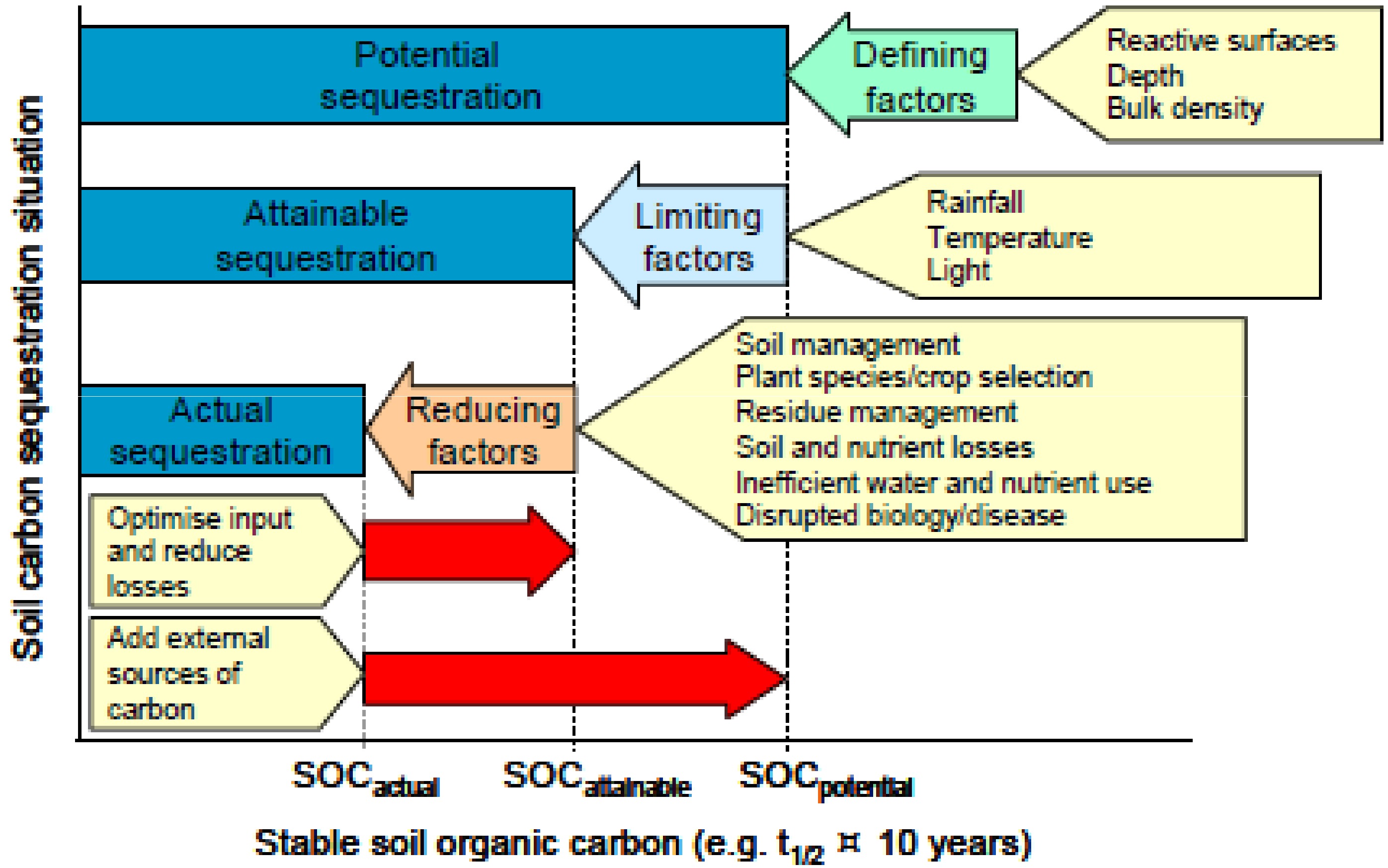
- Primarily by slowing down the rate of soil biota respiration or access to carbon forms in the soil
  - Placing it at depth within the soil
  - Incorporating within soil aggregates
  - Converting it into other forms that are more slowly broken down
  - Complexing it with other elements and compounds (Fe/Al etc)
  - Preventing the loss of carbon through erosion (maintaining groundcover, preventing overgrazing etc)




How much carbon can be stored?

- Potential storage - Fixed limit to C Sequestration potential
  - **Soil texture (surface area)**
  - **Soil depth**
  - **Bulk density**
- Attainable Storage (variable - environmental)
  - **Solar radiation, Climate (particularly rainfall & temperature)**
  - **Soil condition – limitations on growth (salinity, acidity, physical)**
  - **Existing soil carbon content**
  - **Soil biota – species, population, activity, diversity etc (controls on activity)**
- Actual storage (management – seasonally influenced)
  - **Plant species type, diversity, composition, population dynamic**
  - **Grazing frequency, duration, intensity**
  - **cultivation practices (Residue management, Crop rotations etc)**



Leslie, Baldock, Schmidt & McDonald (2009)




How much SOC can be stored

- If your sole aim is to store carbon in the soil – you can store significant quantities – if however your primary aim is farming than you need to temper expectations.
- NB: What is the net impact on GHG balance for your property
- Systems improvement – large increases are possible
  - Native forest → Crop = -42%
  - Pasture → Crop = - 59%
  - Crop → Pasture = +19%
  - Crop → Plantation = +18%
  - Crop → Secondary forest = +53%

How much SOC can be stored

- Management practice balance sheet – CSIRO Review
- Shifts within existing cropping/mixed system

	SOC Benefit	Conf
– **Input efficiencies**	**0/+**	**L**
– **Stubble management**	**+**	**M**
– **Reducing tillage**	**0/+**	**M**
– **Pasture leys and crop rotation improvements**	**+/++**	**M/H**
– **Organic matter additions**	**++/+++**	**H**

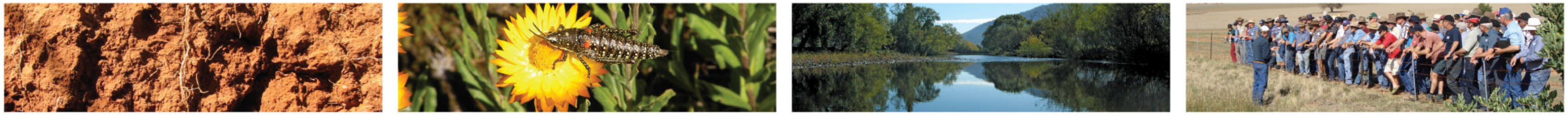
- Shifts within existing pastoral system

– **Increased productivity**	**0/+**	**L**
– **Rotational grazing**	**+**	**L**
– **Shift to perennials**	**++**	**M**

- Shifts to different system

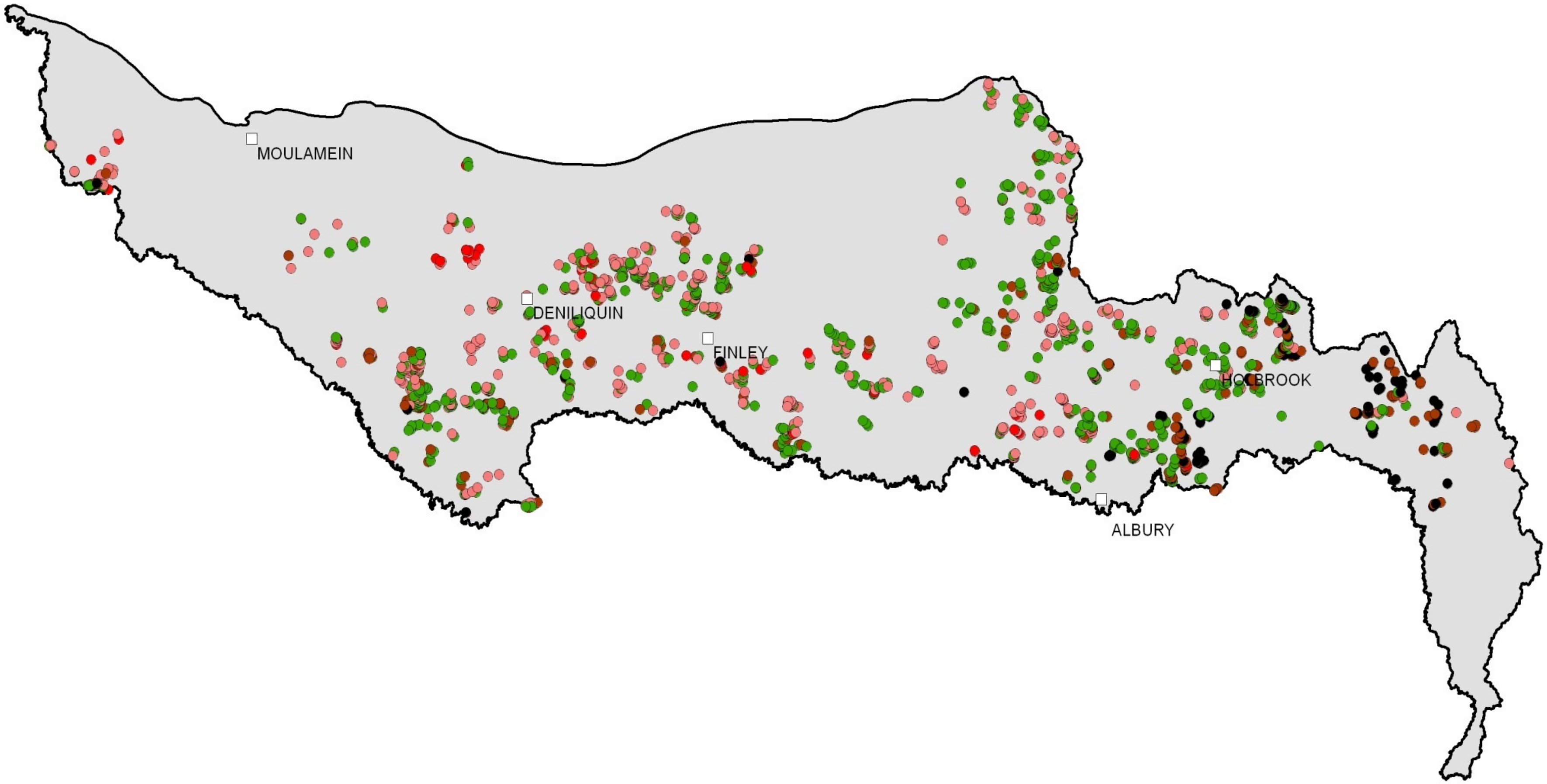
– **Conventional to organic**	**0/+/++**	**L**
– **Cropping to pasture**	**+/++**	**M**
– **Retirement of land & restoration of degraded land**	**++/+++**	**H**

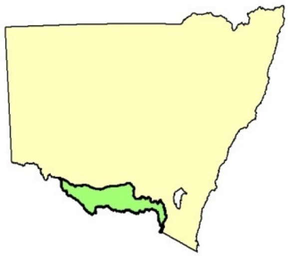
(Sanderman, Farquharson, Baldock (2009)



How much SOC can be stored

- Conant et al (2001) – C seq rates on 115 pastoral sites worldwide
  - **Fertilisation / grazing (Mg C / ha / yr) 0.3-0.35 (42)**
  - **Cultivation to pasture 1.01 (23)**
  - **Earthworm introduction 2.35 (2)**
  - **Improved grass species 3.04 (5)**
- Chan et al (2010) - 5 management comparisons on 23 farms (local)
  - **Significant differences found only on pasture improvement using P fertilisers**
  - **Substantial proportion sequestered as humified C**
- Young et al (2005) – comparisons of 7 different land uses Nthn NSW
  - **Soil carbon - Grassy Woodlands = pasture > cropping (0.2-0.6m considered)**
  - **> 0.8m no significant difference**
- Soil Carbon Research Project – Murray CMA
  - **200 sites throughout the Murray Catchment comparing 3 land uses on 1 soil type x 2 zones**
  - **10 years of consistent land use**





THE MURRAY CATCHMENT
Organic Carbon (%) 0-10cm

N

Mapper name: Marissa Ellis
Date prepared: 11th June 2009

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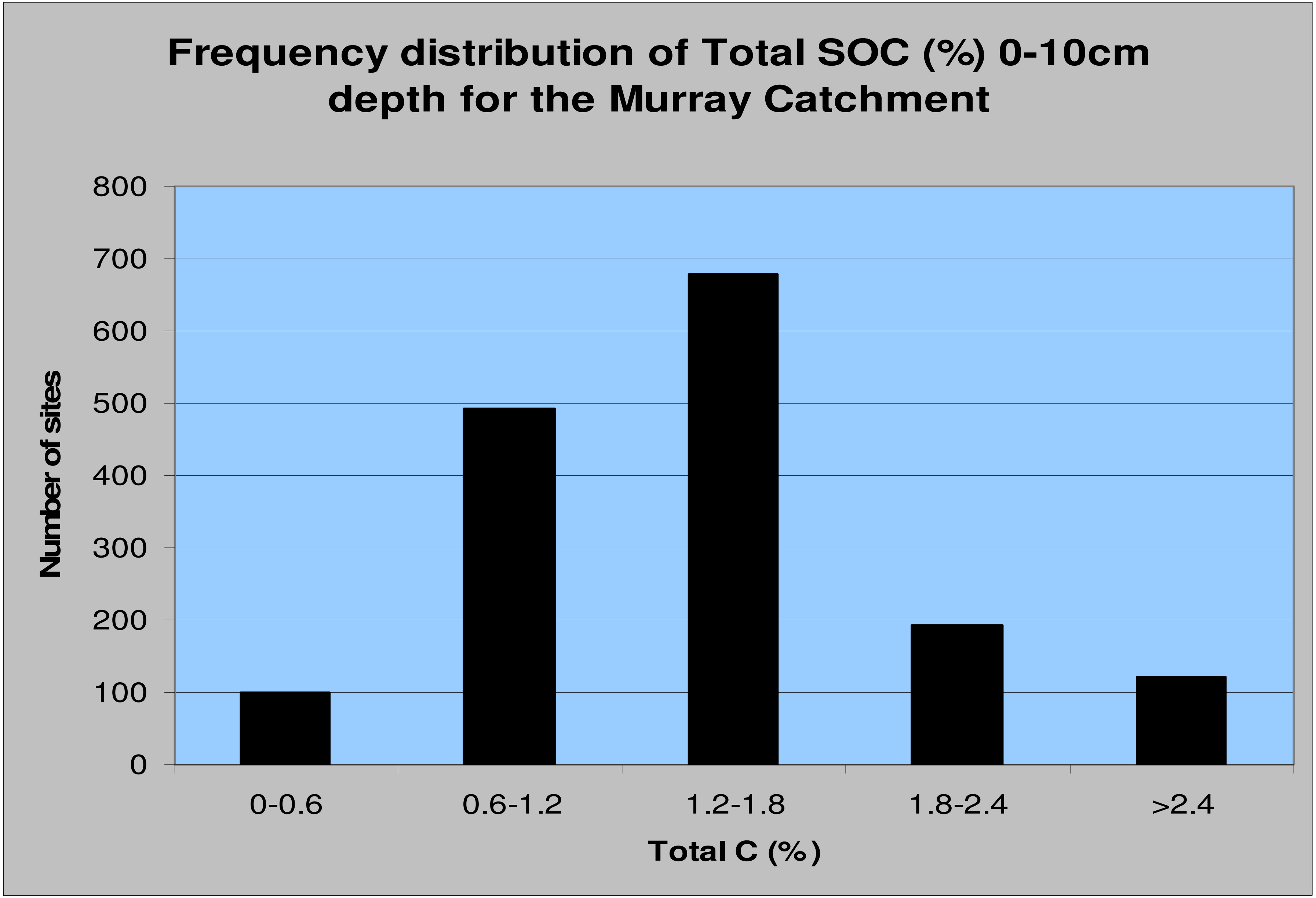
50 25 0 50 100 Km

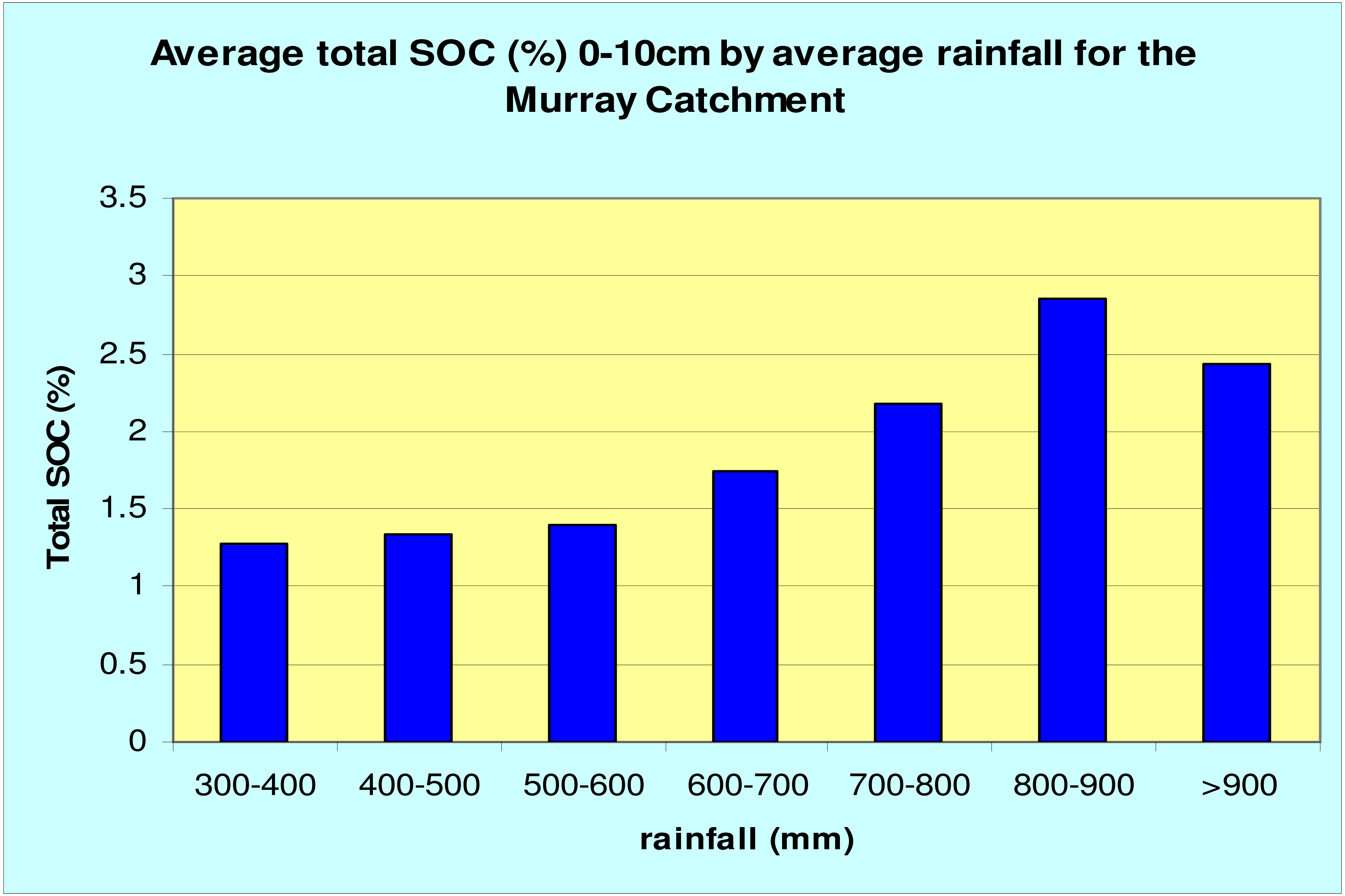
Legend

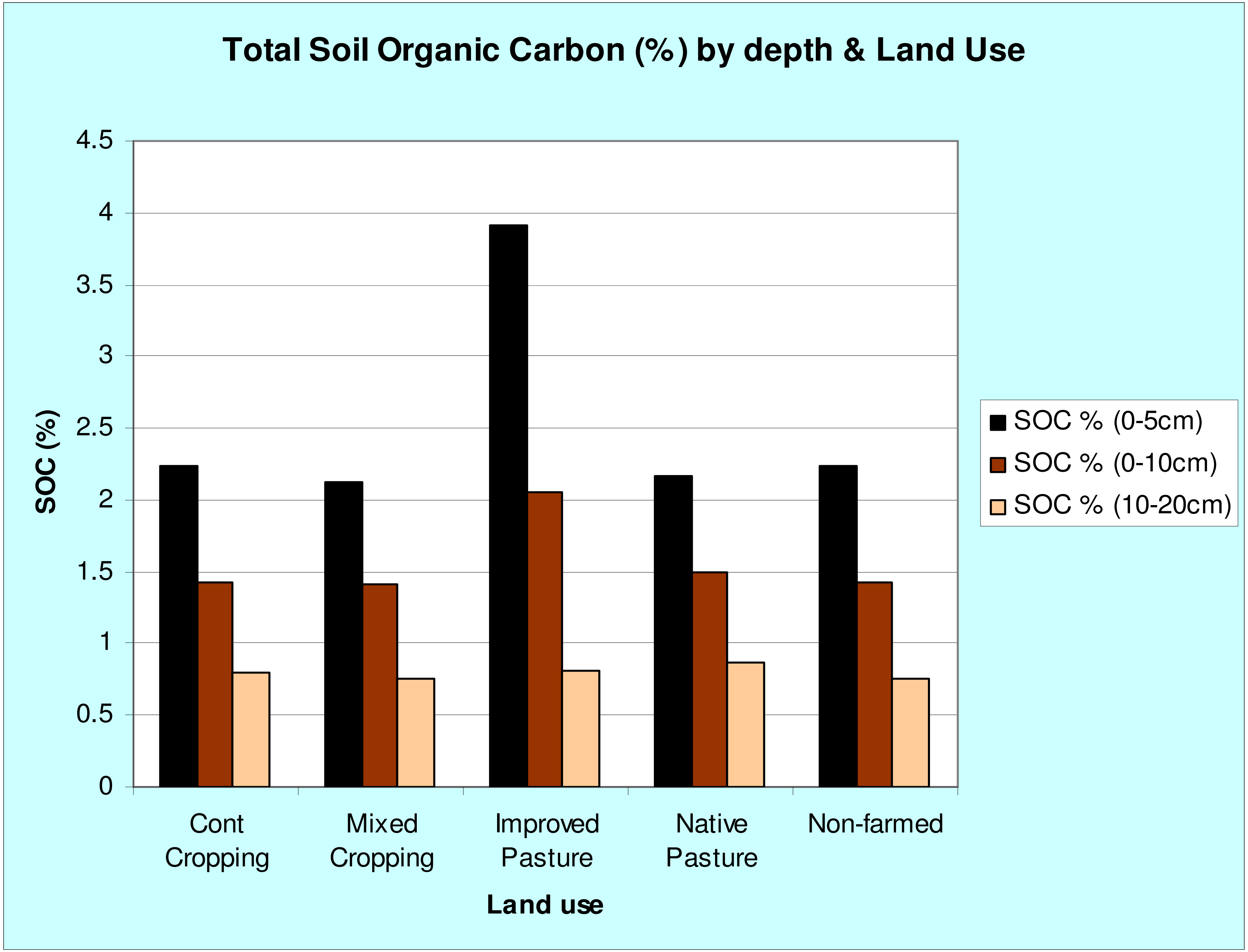
Organic Carbon (%) 0-10cm

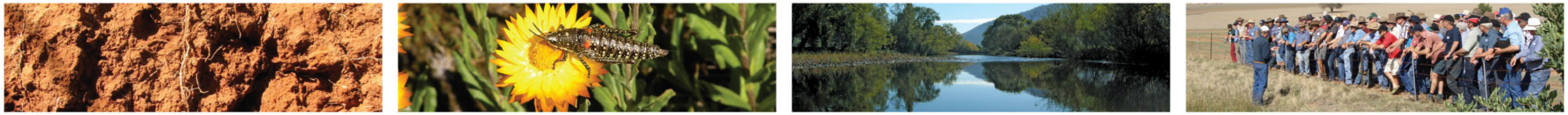
- <0.6
- 0.6 - 1.2
- 1.2 - 1.8
- 1.8 - 2.4
- >2.4



Frequency distribution of Total SOC (%) 0-10cm depth for the Murray Catchment
Number of sites
800
700
600
500
400
300
200
100
0
0-0.6
0.6-1.2
1.2-1.8
1.8-2.4
>2.4
Total C (%)


Average total SOC (%) 0-10cm by average rainfall for the Murray Catchment
Total SOC (%)
3.5
3
2.5
2
1.5
1
0.5
0
300-400
400-500
500-600
600-700
700-800
800-900
>900
rainfall (mm)


Total Soil Organic Carbon (%) by depth & Land Use
SOC (%)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Cont Cropping
Mixed Cropping
Improved Pasture
Native Pasture
Non-farmed
Land use
SOC % (0-5cm)
SOC % (0-10cm)
SOC % (10-20cm)



How much SOC can be stored

- Native Grasses – A new system (poorly researched)
  - Holistic/cell grazing, pasture cropping, low input etc
  - Socio-economic system – profit & genuine stewardship
  - Managed native species – little is known about their influence on soil C
    - **Root growth & rhizosphere interactions – stored deeper & in less labile forms?**
    - **Seasonal growth (year round groundcover) – C3 & C4 species**
    - **Tolerances (resilience & resistance) to climatic & soil constraints**
    - **Starting point – degraded or failed conventional systems**
  - Long interval grazing – root deposition & growth
  - Large diversity → what is that impact on soil biota (efficiencies?)
  - The mycorrhiza influence?



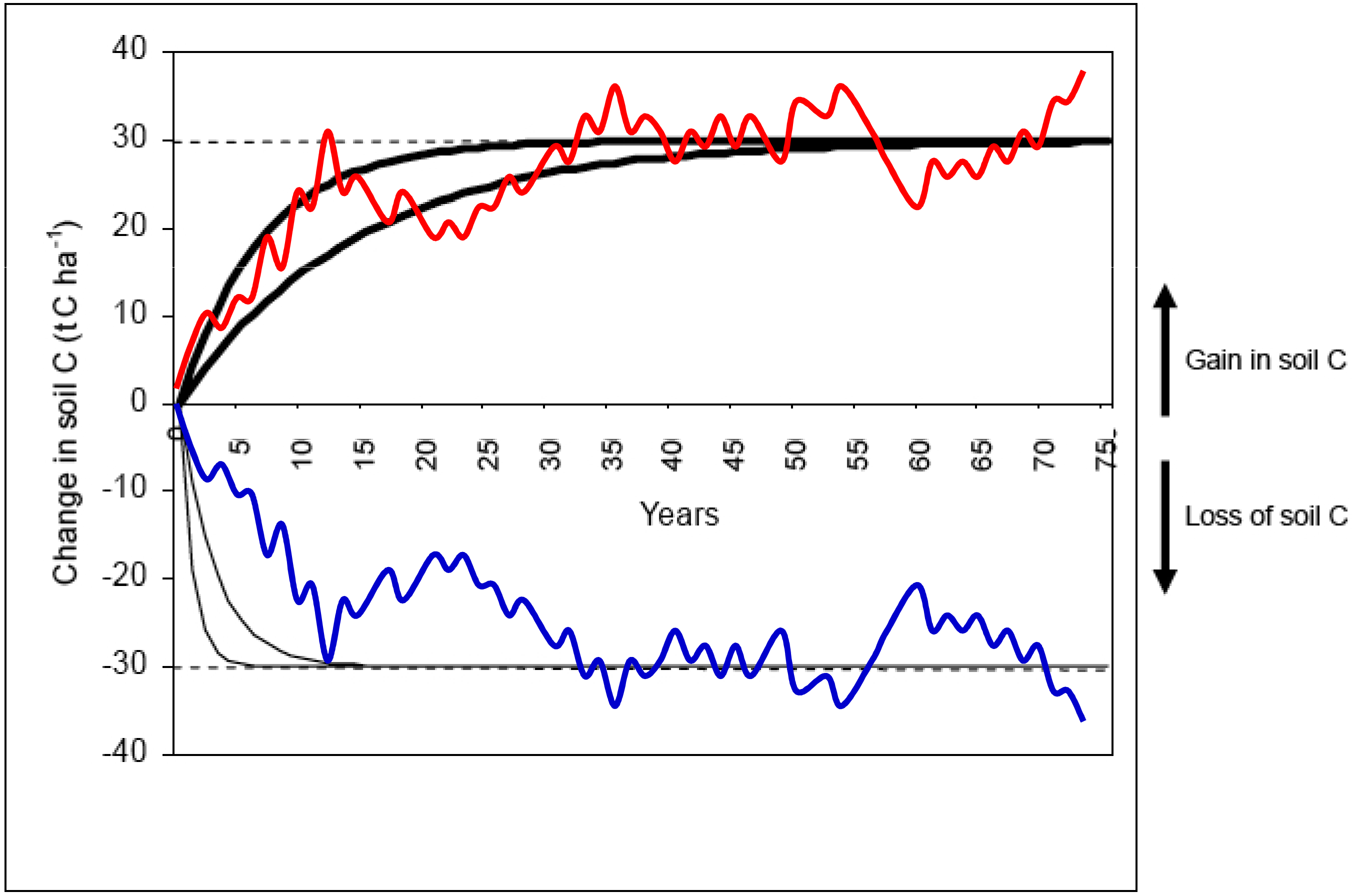

Soil Carbon Variability

- Soil carbon equilibrium – levelling off of the amount sequestered → Losses = Gains
  - Most occurs initially
  - Differs for crops v pastures - 10-15 years v 50-60 years
  - Differs in different environments & for different systems
- The carbon pulse through the soil
  - Australian environment & carbon dynamics
  - Last decade → significant C loss (erosion) depending on management – If you can minimise those losses
  - Last 2 years – very large biomass pulse (low stock numbers)
  - Unique Australian biological systems evolved to cope with that – hibernation etc – Free living N fixing, AMF etc

Soil Carbon Variability

- Soil carbon variability – over time and space





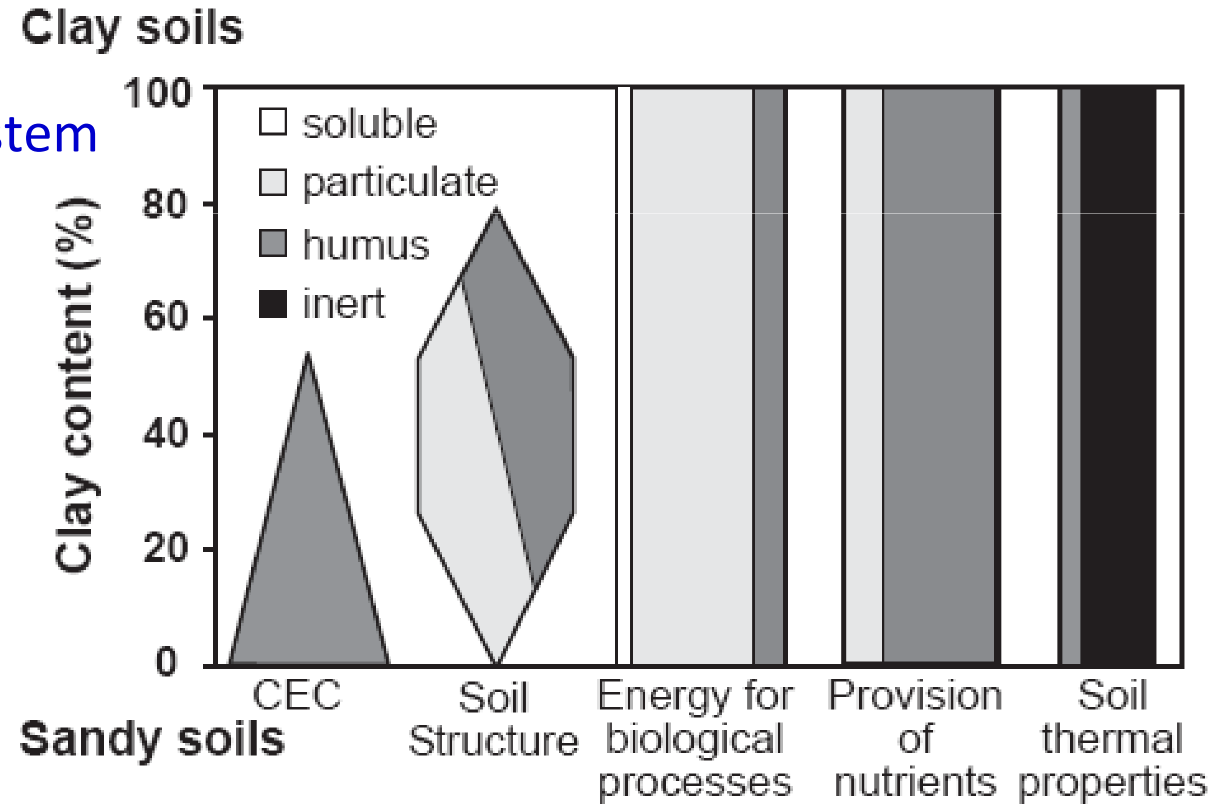

Soil Carbon Variability

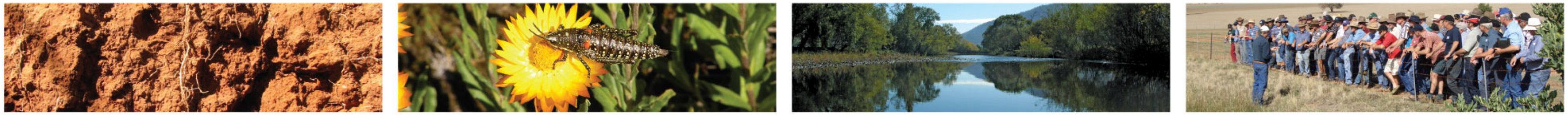
- Soil carbon variability
  - 12 month period near Gerogery & Binalong
  - 24-76% variability over time & 28-30% variation within 10m^2 grids
- Variability in carbon pools – background losses
  - Some suggestion humus & more recalcitrant C is still being lost following on from conversion to agriculture
  - Are you actually measuring sequestered C
  - NZ scenario
- Implications for measurement
  - As a snapshot on its own
  - Compounded with bulk density




Organic matter

- What is an optimum SOC ➔ 2%?
  - Soil texture
  - Soil function
  - Management system



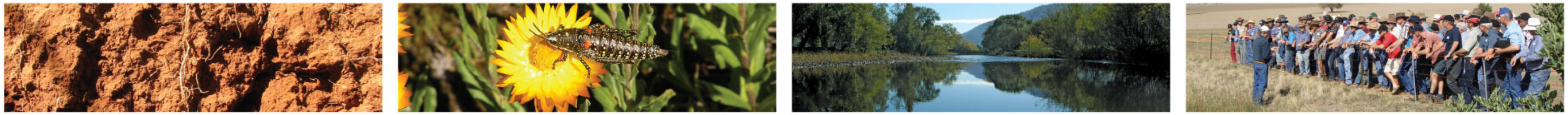


Organic matter

- Balance, above these theoretical optimums - SOC stored is nutrient / energy not utilised
- The importance of labile – as an indicator of soil health & particular as an indicator of soil resilience
  - Biological processes
  - Nutrient source
  - Aggregation
- In cropping systems most of the initial production gains come from the labile component

The Carbon Farming Initiative

- Why is there reluctance to fully embrace soil carbon sequestration as a financially viable carbon sequestration mechanism.
- Integrity standards
  - Additional
  - Permanent
  - Avoidance of leakage
  - Measurable and verifiable
  - Conservative
  - Internationally consistent
  - Supported by peer review science



Additionality

- Many of the agricultural practices recommended for increasing Soil C sequestration are best practice recommendations for increasing farm productivity and sustainability in general
- How do you separate what would have happened anyway to genuine C sequestration
  - would you pay for what would have happened anyway
  - Is it a genuine abatement - the point is to reduce atmospheric green house gases
  - Time & cost taken to individually assess on a case by case basis
  - Practices may become best practice in the future




Permanence

- 100 years

- The process is reversible – C stock must be maintained

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