Australian soil carbon stocks: a summary of the Australian Soil Carbon Research Program

LAND AND WATER/SUSTAINABLE AGRICULTURE FLAGSHIP

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Soil Carbon Research Program (SCaRP)

Objectives

- Apply consistent methodology to quantify soil carbon stocks
- Assess MIR as a rapid and cost-effective means for quantifying soil carbon stocks and composition
- Test automated devises for measuring soil bulk density
- Quantify soil carbon stocks under different land management strategies at regional levels
- Provide temporal soil carbon stock data for FullCAM/NGGI development
- Quantify the inputs of carbon to soils under perennial pasture systems

Issues beyond the scope of SCaRP

- The sampling methodology used in SCaRP was not appropriate to:
  - quantify soil carbon stocks in a paddock
  - quantify rates or amounts of carbon sequestration in Australian soils

Background - Composition of soil carbon and definitions

Soil carbon ≤2 mm

OC = organic carbon

IC = inorganic carbon

TC = Total carbon = (**OC** + **IC**)

Carbon accounting is focused on **OC**, may Australian soils contain **IC**

Soil organic carbon ≤2 mm – complex mixture of many materials

POC = particulate organic carbon (2000–50 µm excluding charcoal)

HOC = humus organic carbon (≤50 µm excluding charcoal)

ROC = resistant organic carbon (≤2000 µm charcoal)

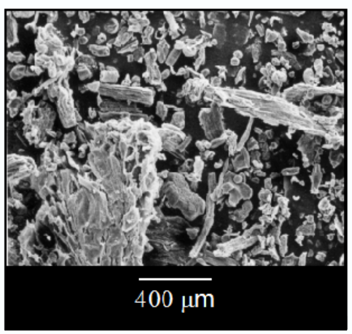
Why are we interested in fractions of soil carbon?

- Quantifying fractions is not a requirement for soil carbon accounting

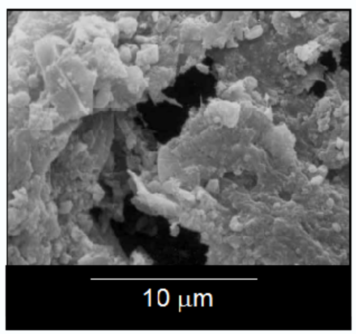
- Provides data for initialising and calibrating FullCAM - used in the NGGI

- Provides an indication of the vulnerability of soil carbon to subsequent change

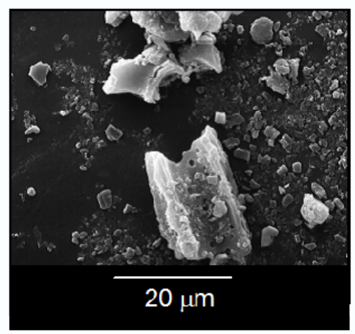
POC



HOC



ROC

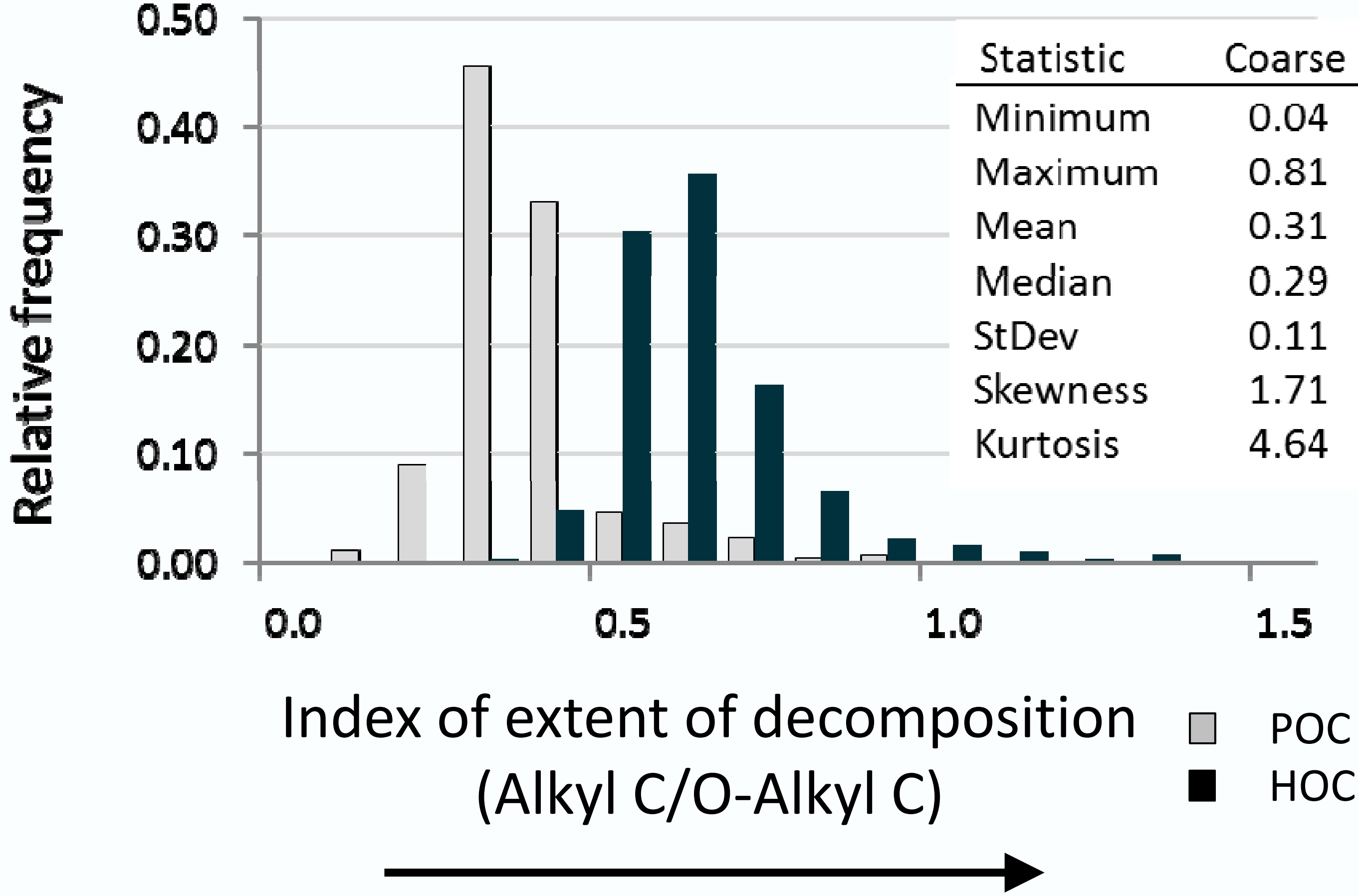


Vulnerability (V)

$$V = \frac{POC}{HOC + ROC}$$

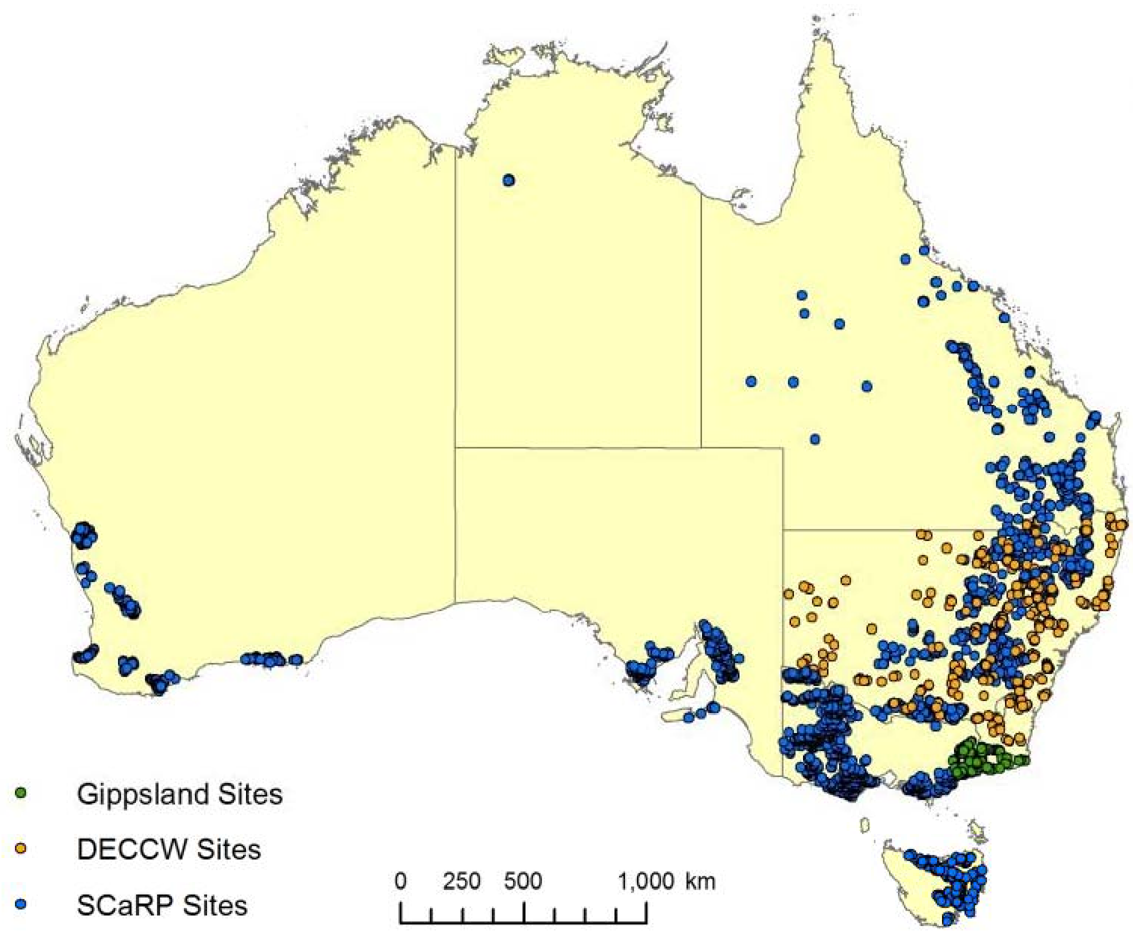
$$V = \frac{POC}{HOC}$$

Composition of POC and HOC



Statistic	Coarse	Fine
Minimum	0.04	0.30
Maximum	0.81	1.62
Mean	0.31	0.57
Median	0.29	0.55
StDev	0.11	0.15
Skewness	1.71	2.35
Kurtosis	4.64	9.98

Sampling locations and soil samples collected



Samples collected and analysed by SCaRP
- 17,721 samples
- 3,836 sites

Additional samples
- 2774 samples
- 690 sites

Totals
- 20,495 samples
- 4,526 sites

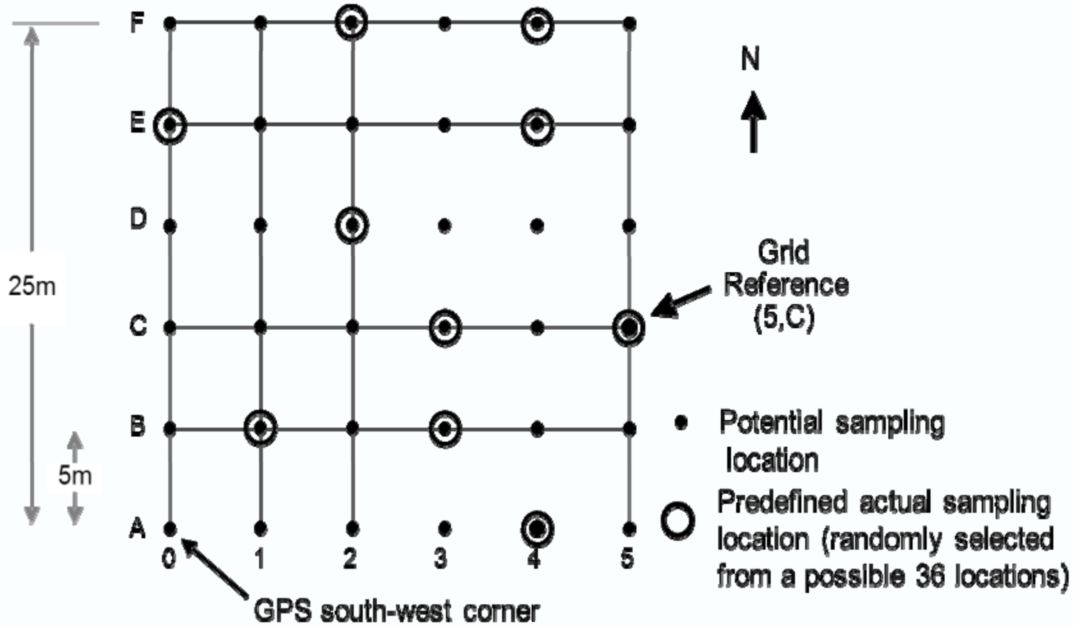
>92% from farmer paddocks

Soil sampling methodology

Some variance in the process used to select sampling locations

Once the locations of sampling sites were defined – everything was consistent from that point

Sampling site

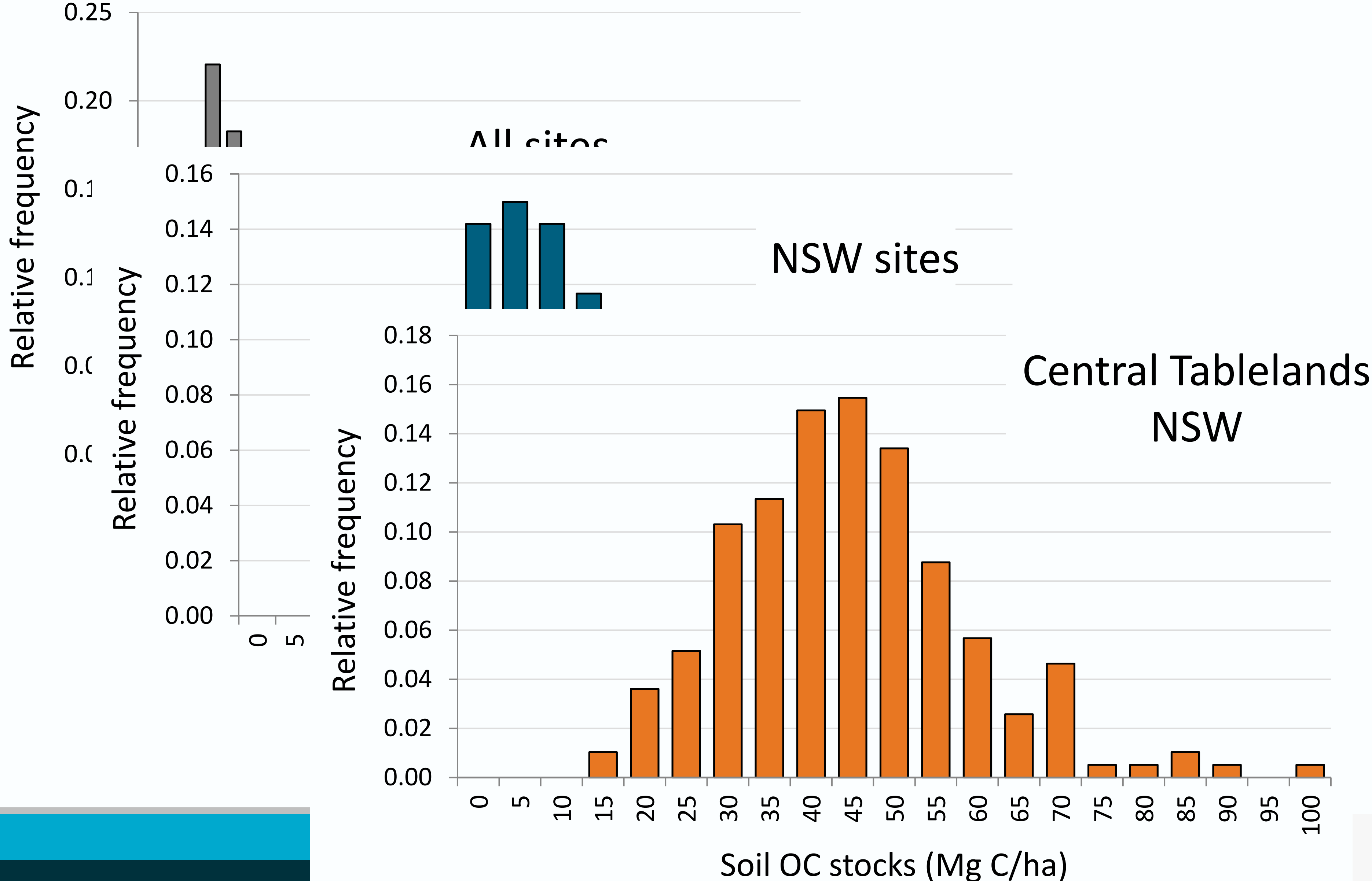


Processing and Analyses

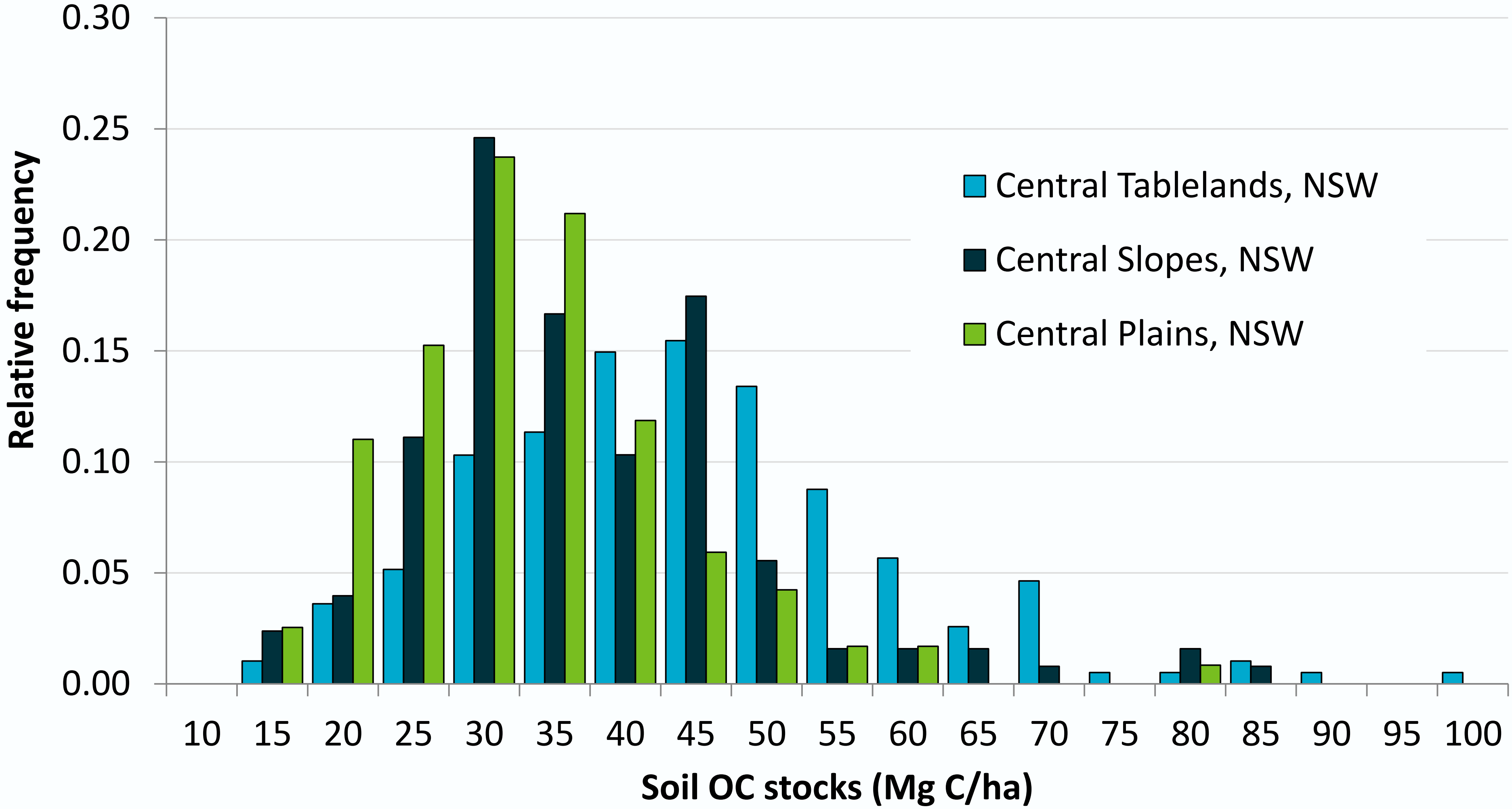
Air dry
Crush
Sieve ≤2 mm
Split ≤2 mm subsamples using riffle boxes

- Fine grind
  - TC, OC, IC, TN and MIR
  - Fractions
    - POC (2000-50µm)
    - HOC (<50µm)
    - ROC (<2000µm)

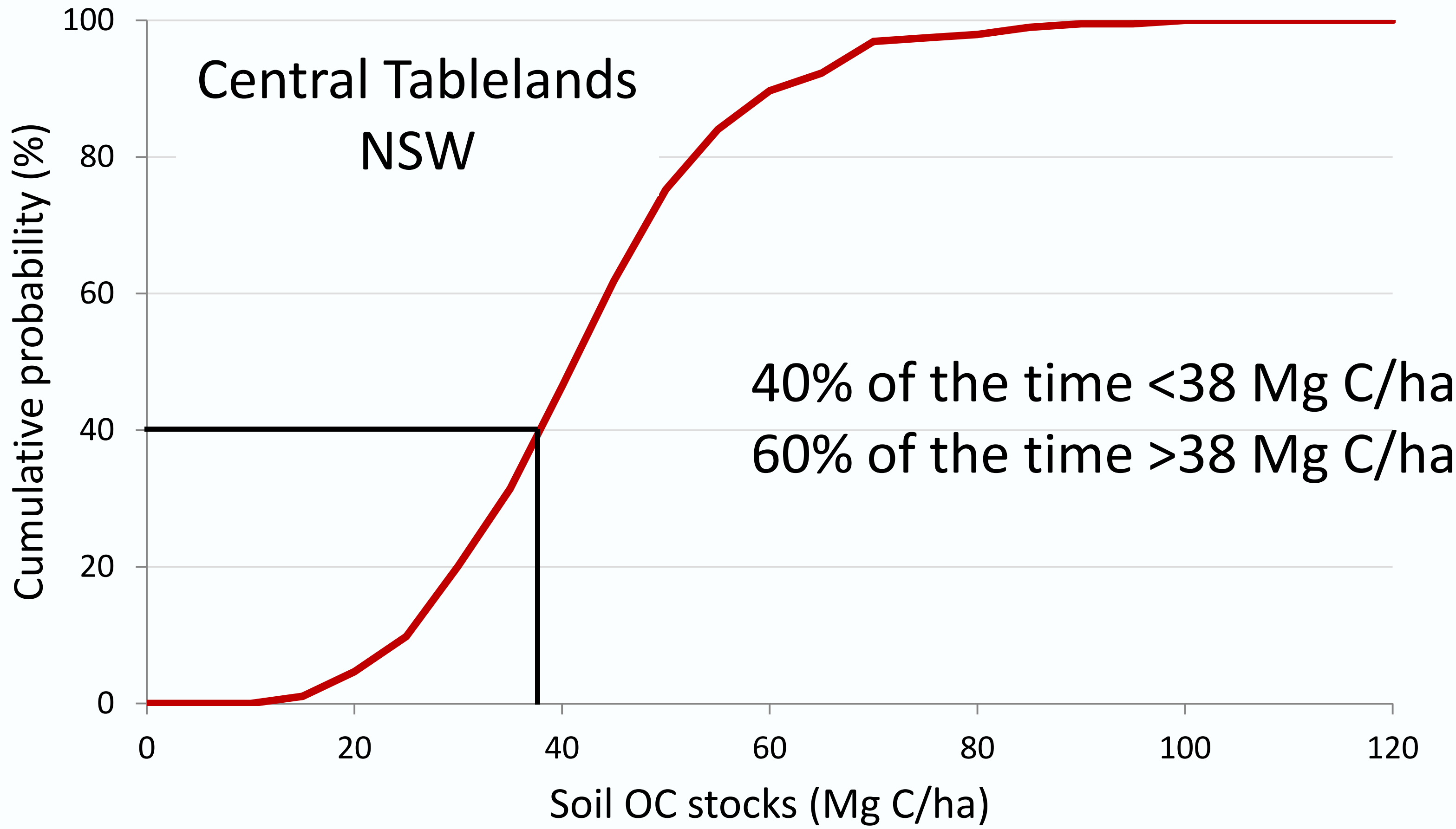
Variations in 0-30 cm soil carbon stocks



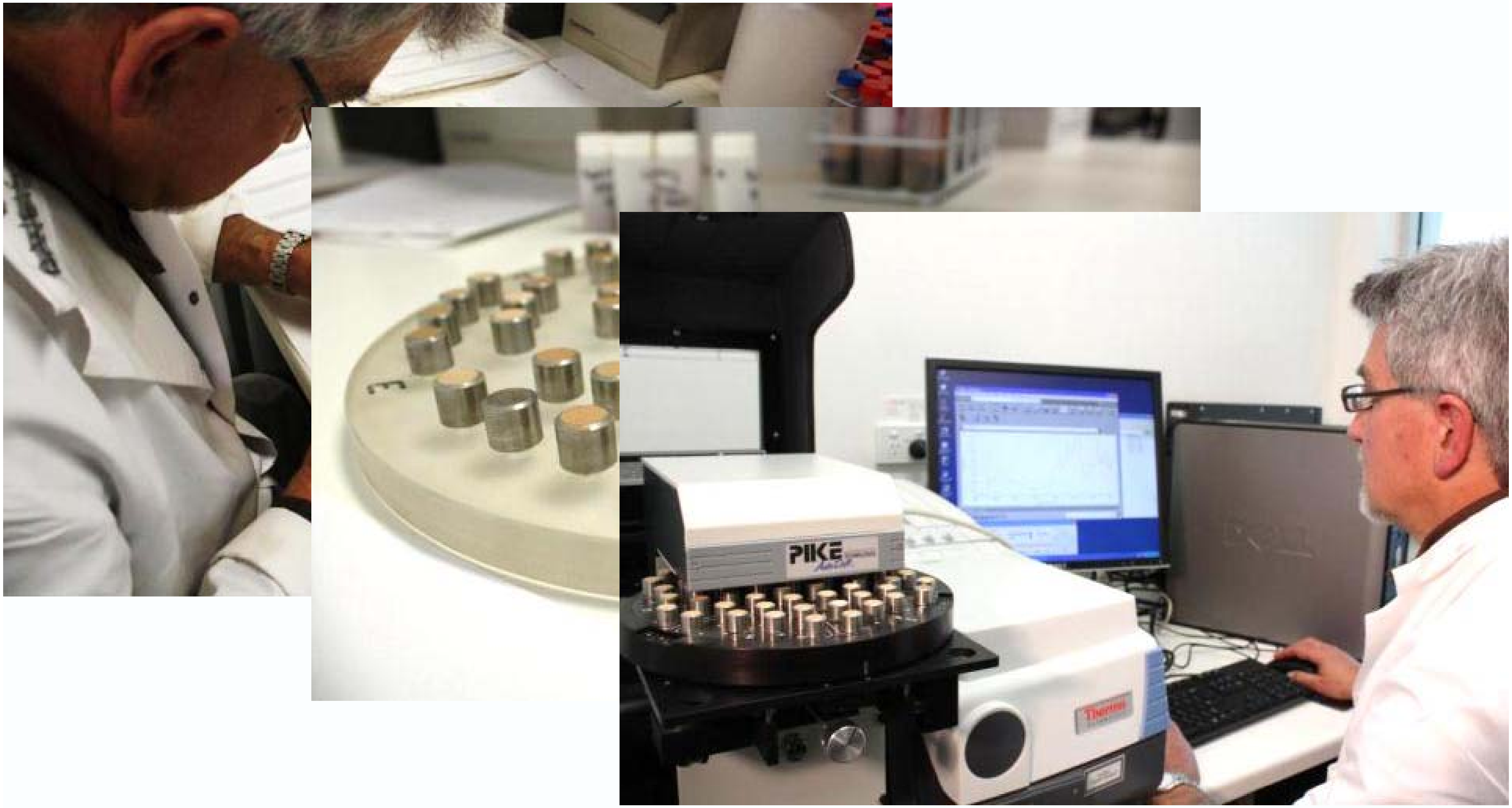
Variations in 0-30 cm soil carbon stocks



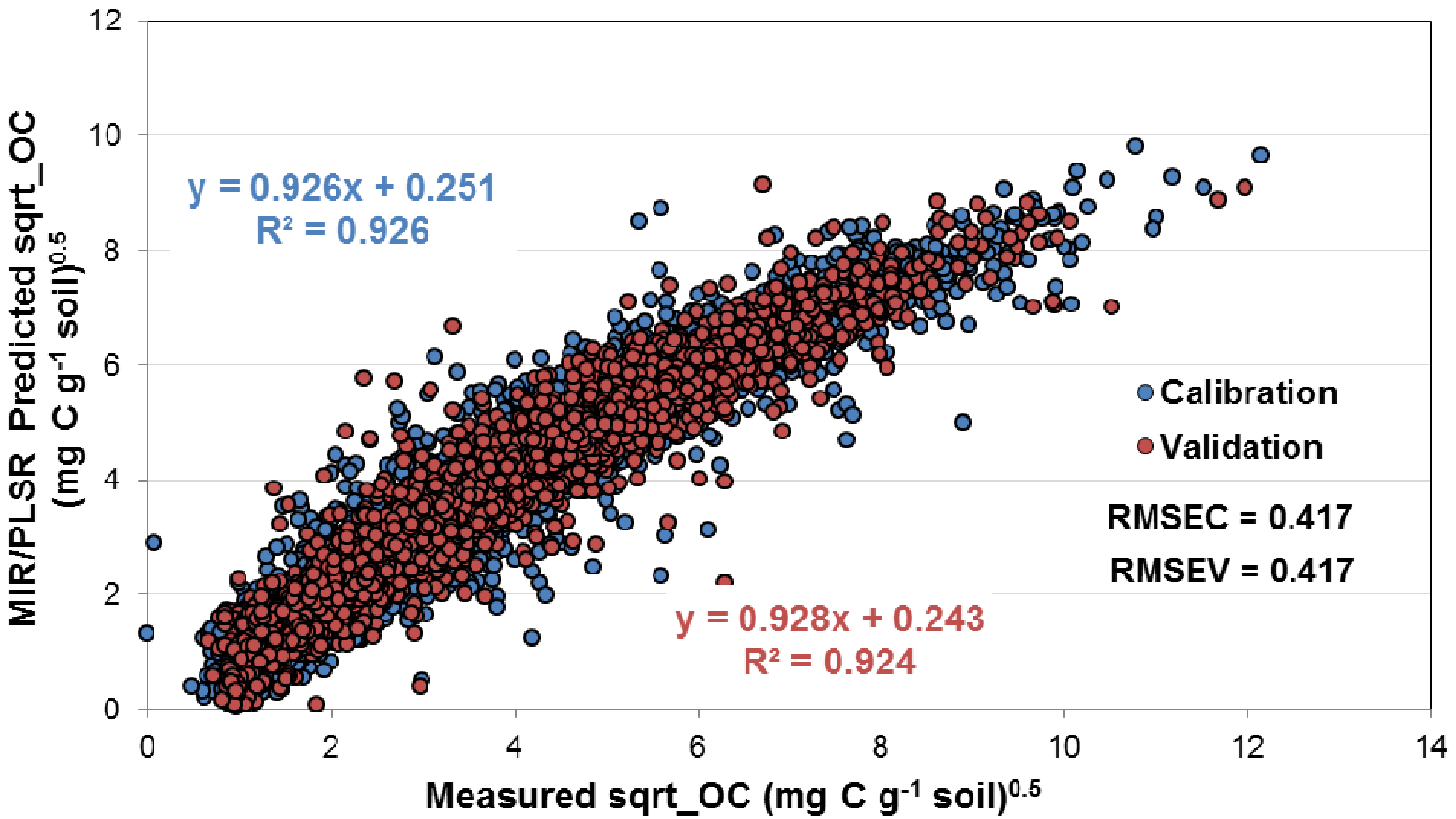
Creation of cumulative probability distributions



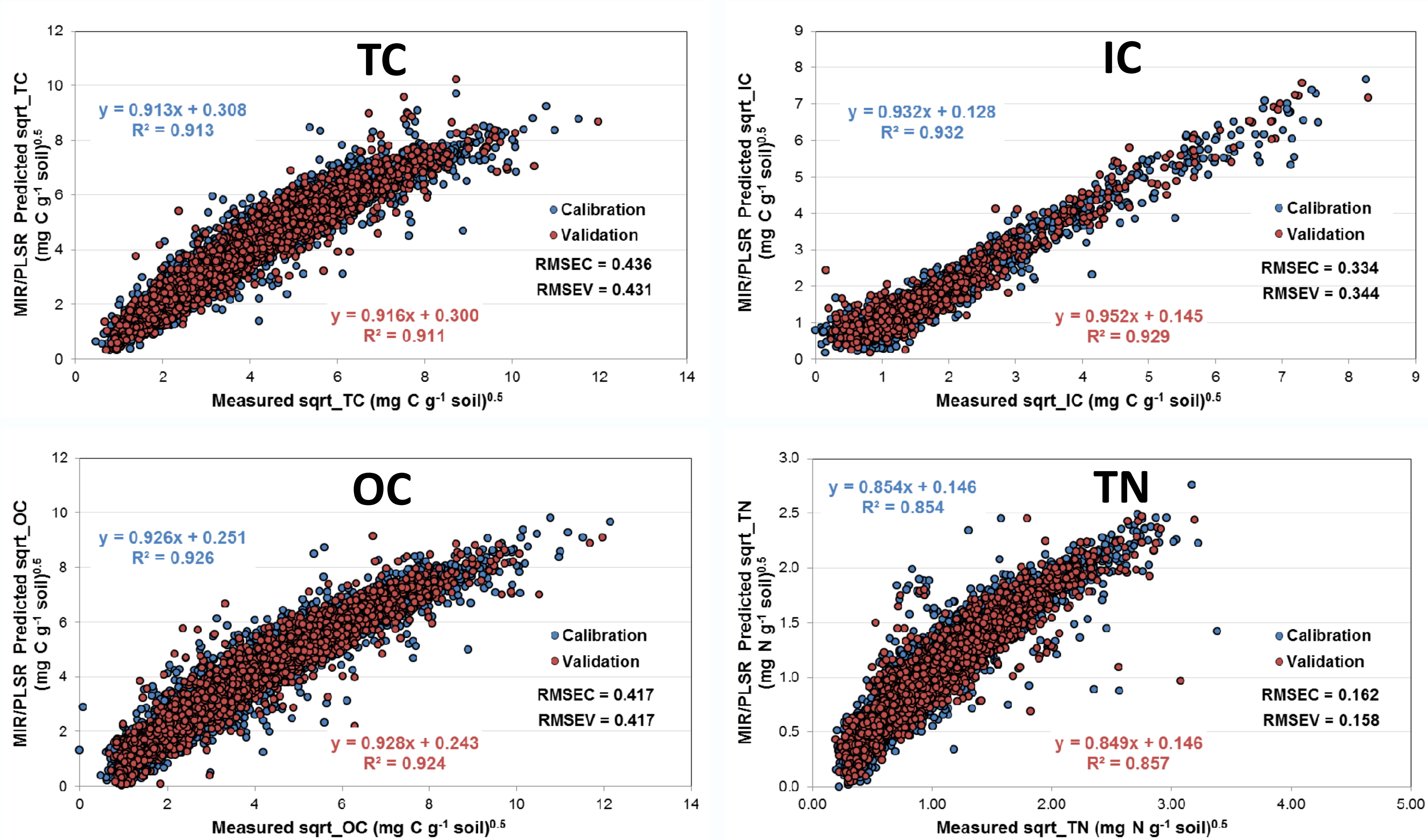
Assessing the ability of MIR/PLSR to predict soil C and its allocation to different forms



MIR as rapid method of analysis for soil organic carbon

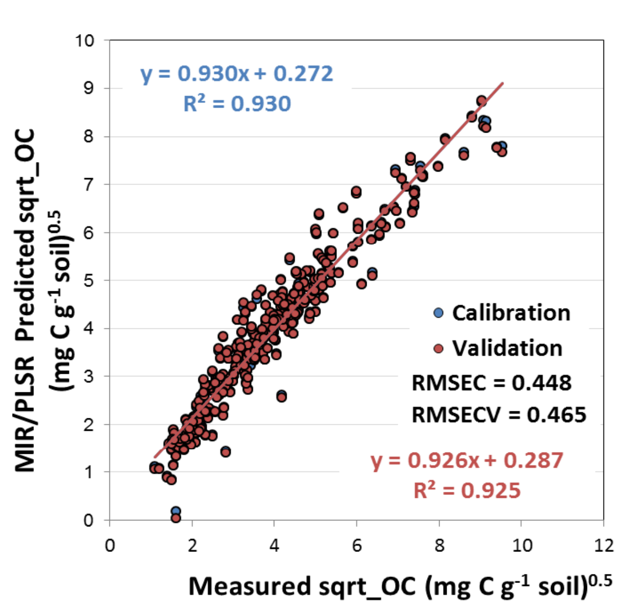


MIR as rapid method of analysis for TC, OC, IC and TN

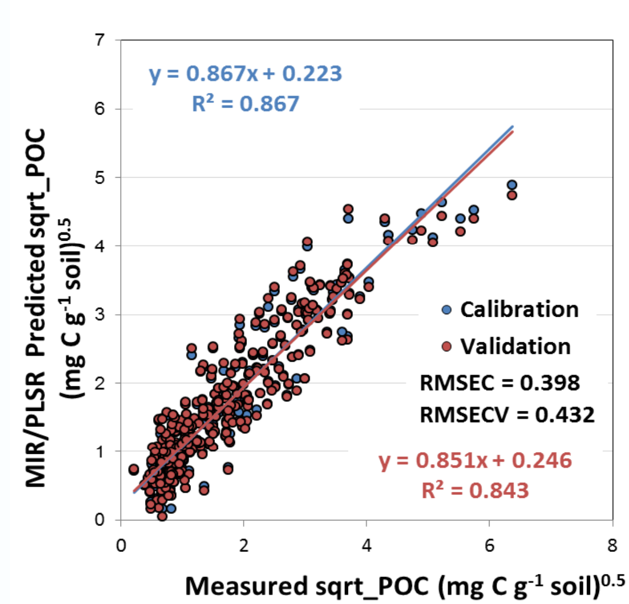


MIR as rapid method of analysis for soil OC fractions

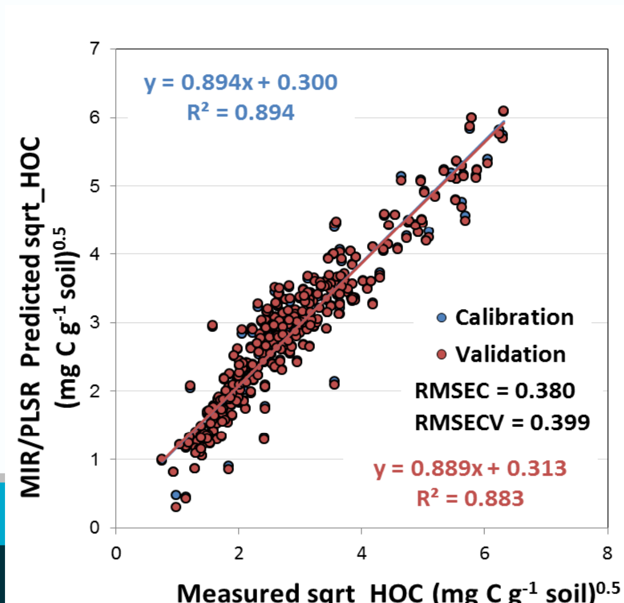
OC



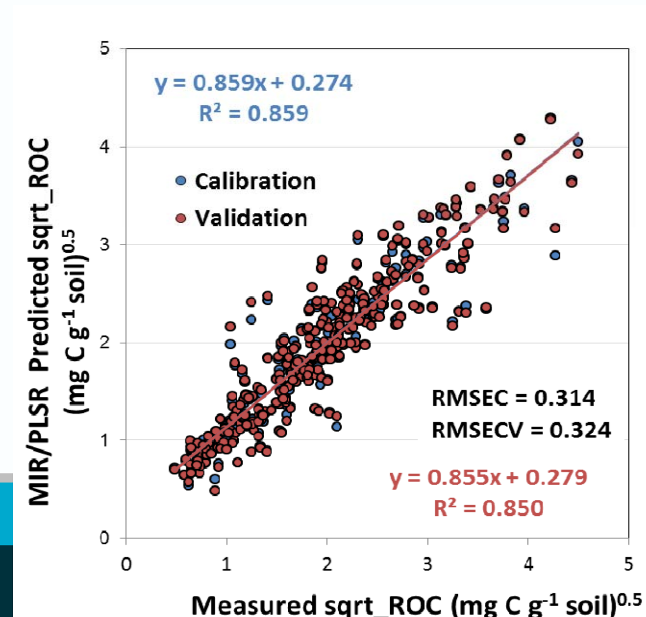
POC



HOC

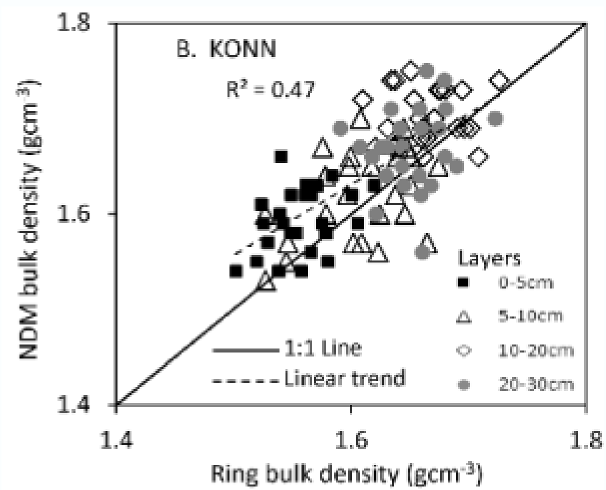


ROC



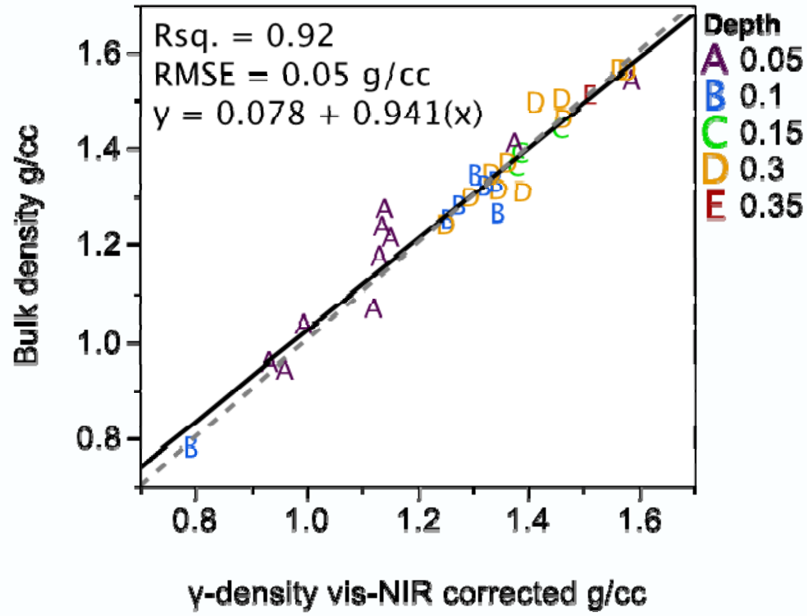
Rapid assessment of bulk density – gamma radiometrics

WA Project – soil surface



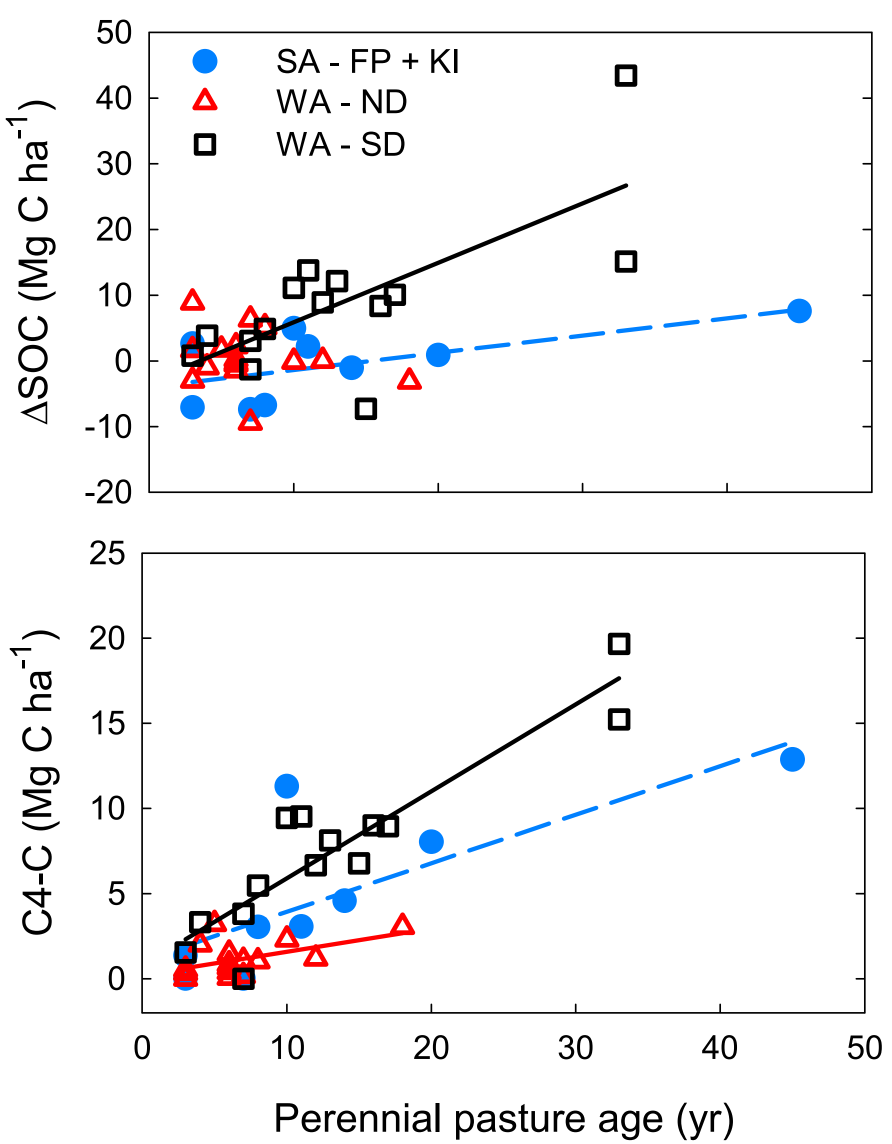
- Impact of NDM vs cores on soil C stocks small
- Bulk density accounted for <4% of variation in C stock

CSIRO – core scanner



- Required correction for water content
- NIR predicted water contents sufficed
- Potential to take this technology to the field

Soil carbon under perennial pasture : C3/C4 transition

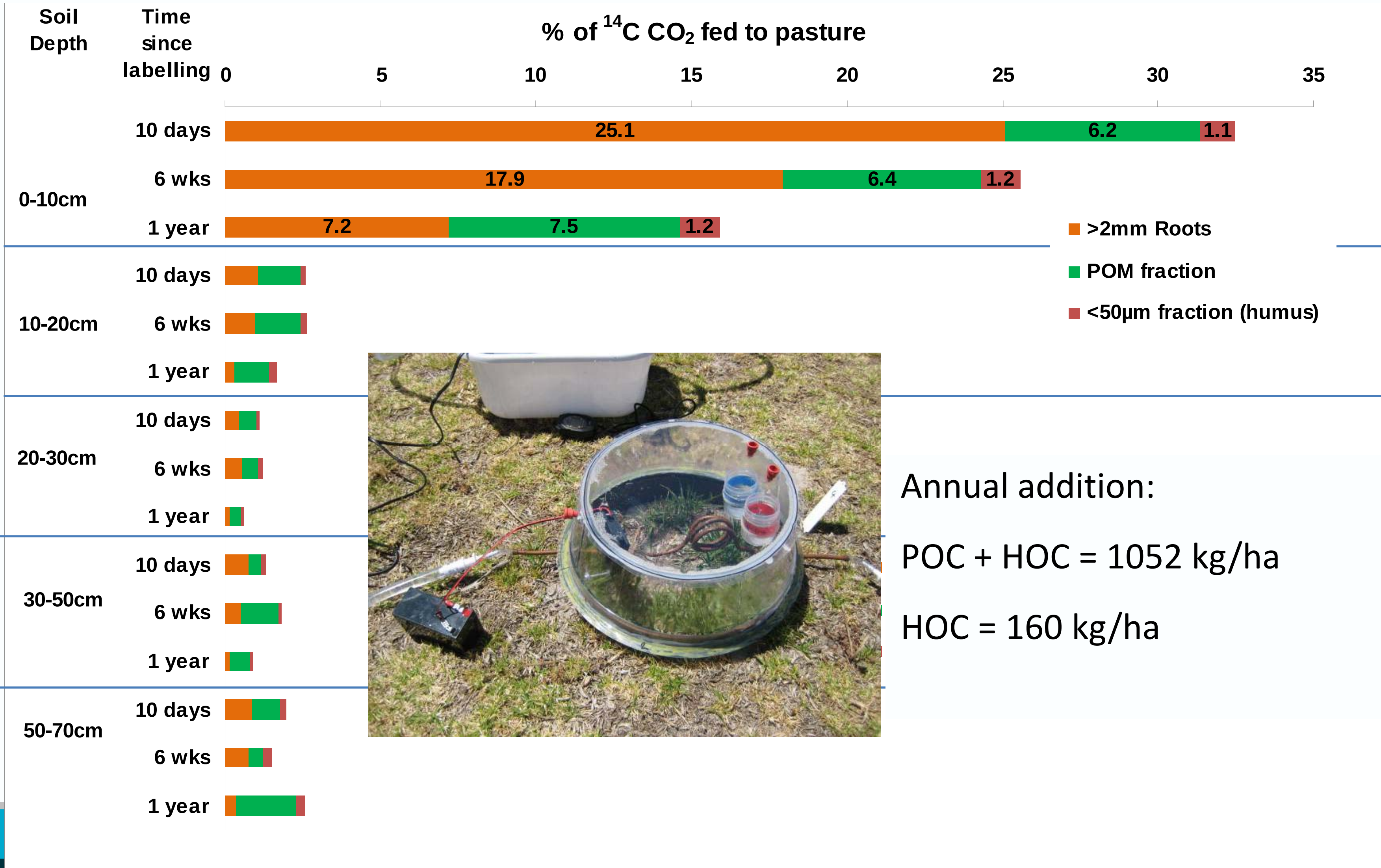


Regional SOC sequestration rates:

- 0.9 ± 0.3 Mg C/ha/y for kikuyu in WA
- No trend for panic/Rhodes in WA
- 0.3 ± 0.1 Mg C/ha/y for kikuyu in SA

- Kikuyu more responsive than pastures with a mix of panic/Rhodes grasses
- Approximately 80% of change due to C4-SOC

Input of carbon to soil under kikuyu perennial pasture: fate of ^{14}C CO_2-C

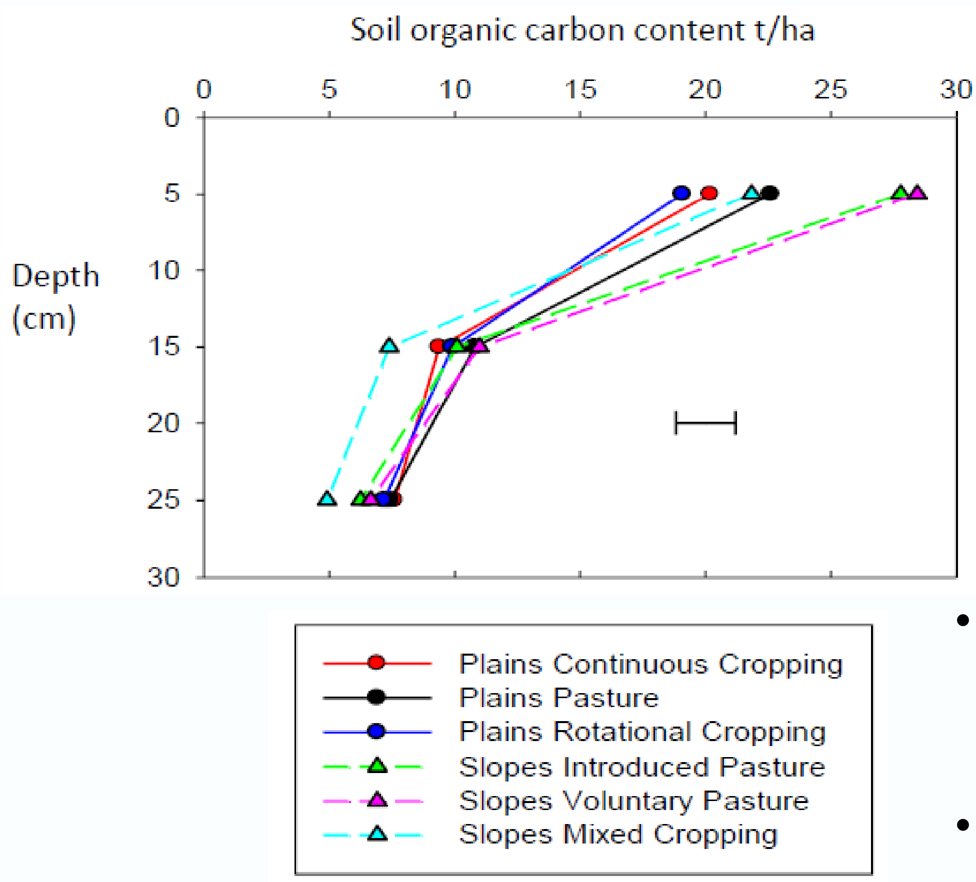


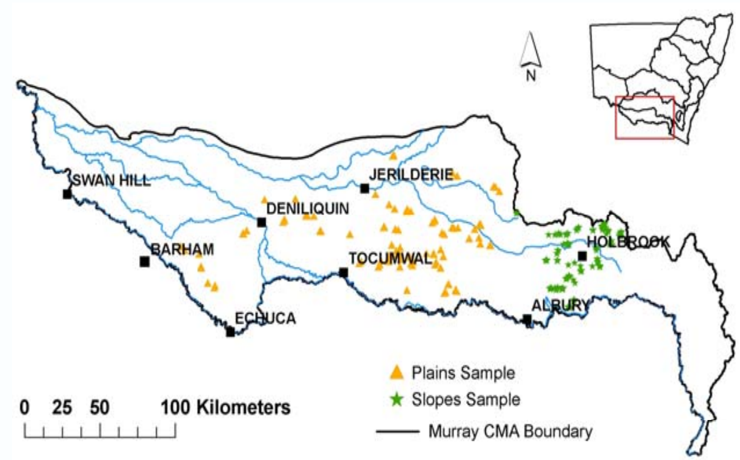
Annual addition:

POC + HOC = 1052 kg/ha

HOC = 160 kg/ha

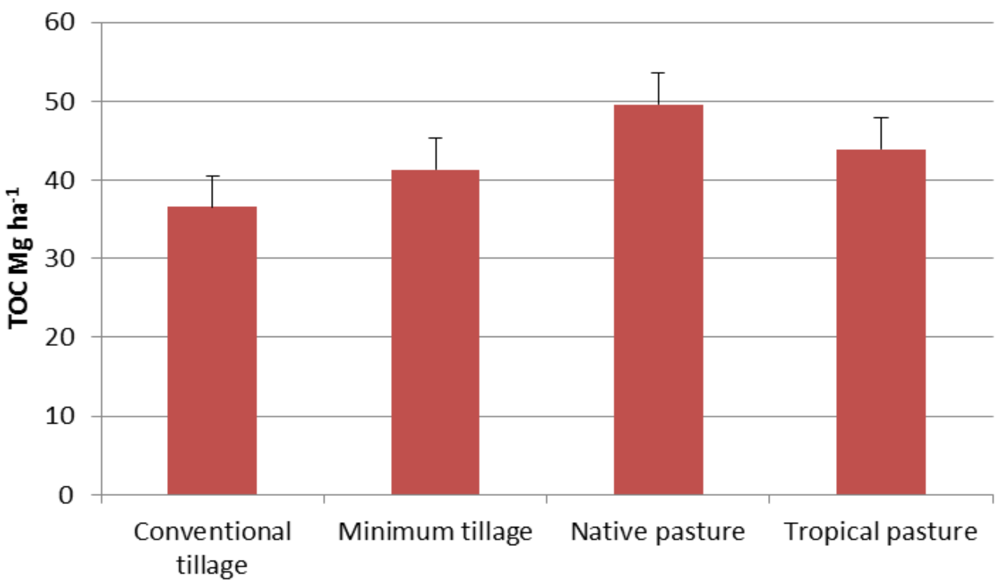
Murray CMA – soils of the slopes and plains



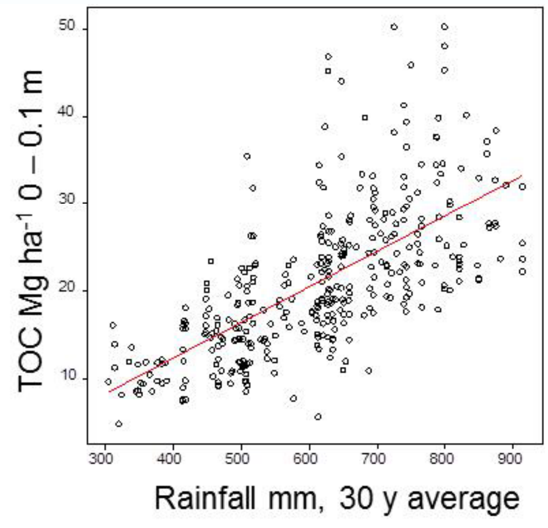


- Slopes: introduced and voluntary pastures contained more carbon than cropping
- Significant variations were confined to 0-10cm
- Increasing trend with rainfall, decreasing trend with Apr-Oct temperature

NSW – Northwest slopes and plains



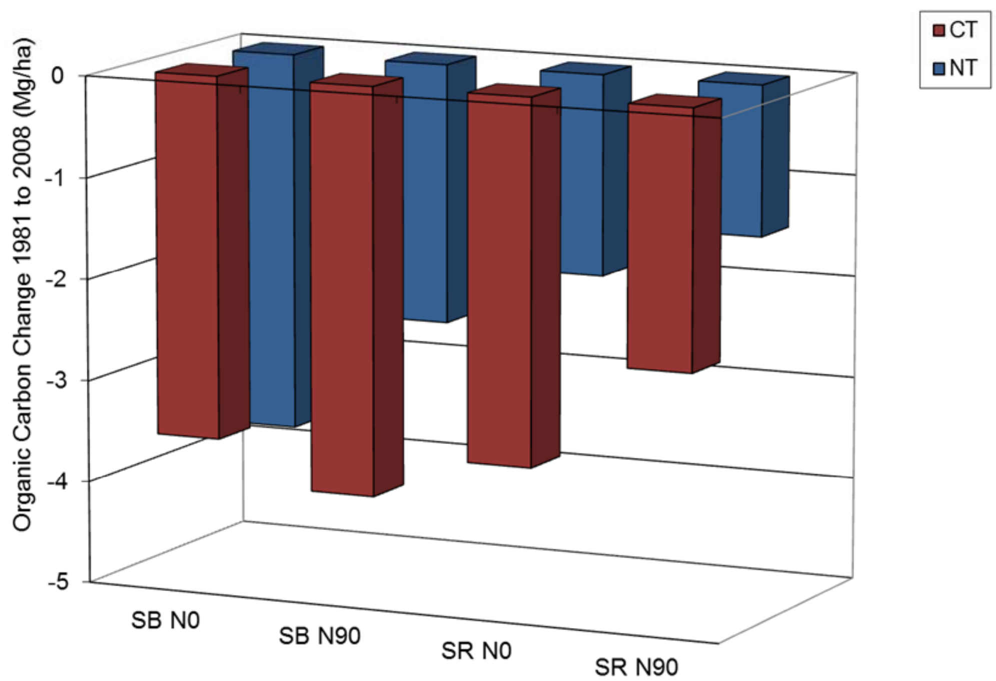
- SOC stocks higher in pastures than cropping
- Tillage differences were not significant
- Pasture type – may be an impact of land use history



- Natural gradients are important
- Correlations were found with soil type, clay content, rainfall, temperature and elevation

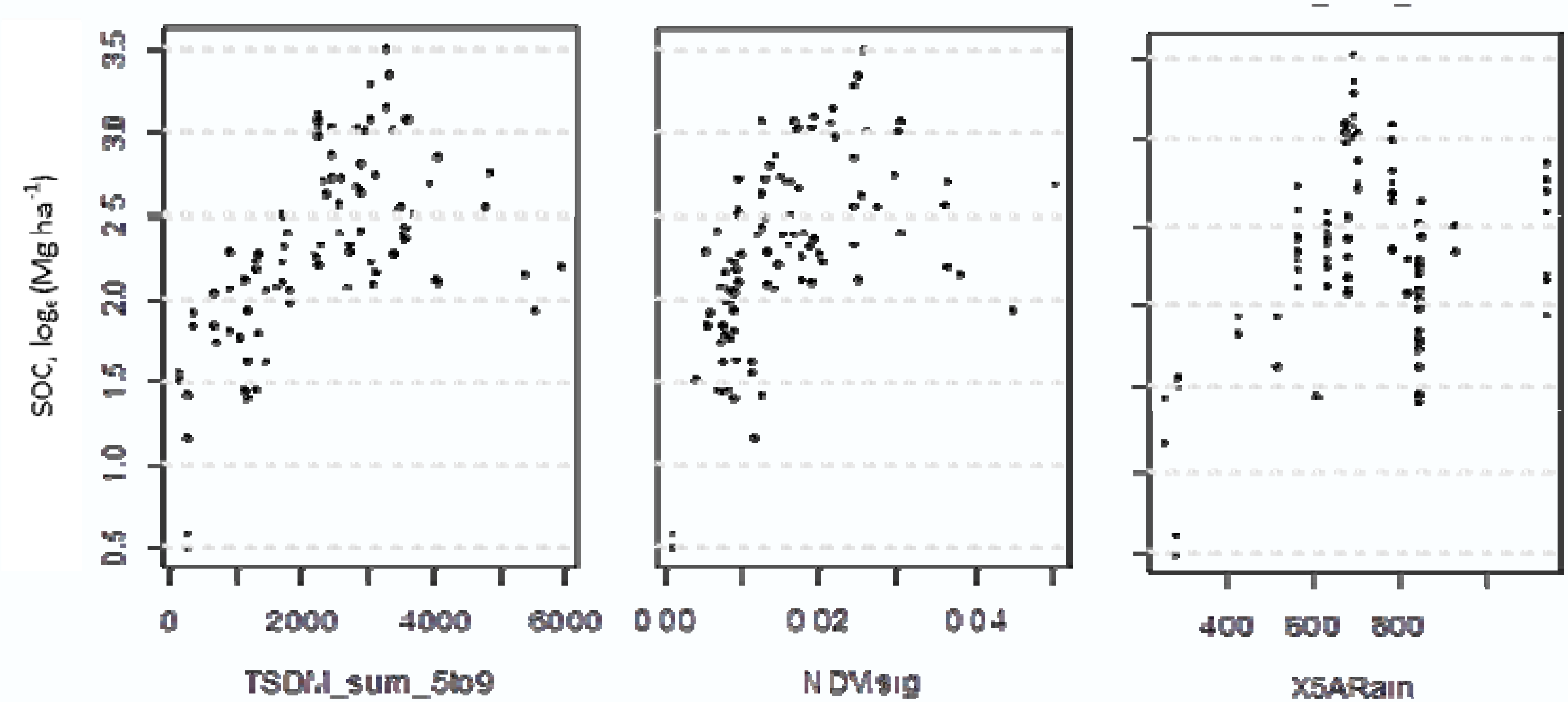
Queensland cropping lands

Hermitage long-term trial (1981-2008)



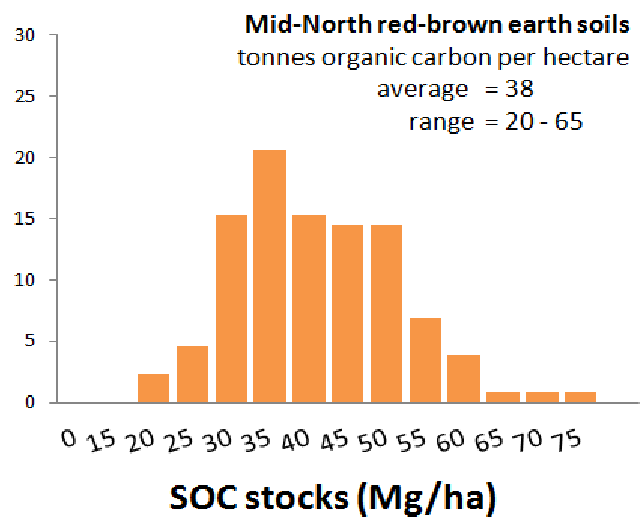
- No evidence that no-till or stubble retention can increase soil carbon stocks
- NT and stubble retention decreased extent of loss for 0-10 cm layer but not 0-30 cm layer

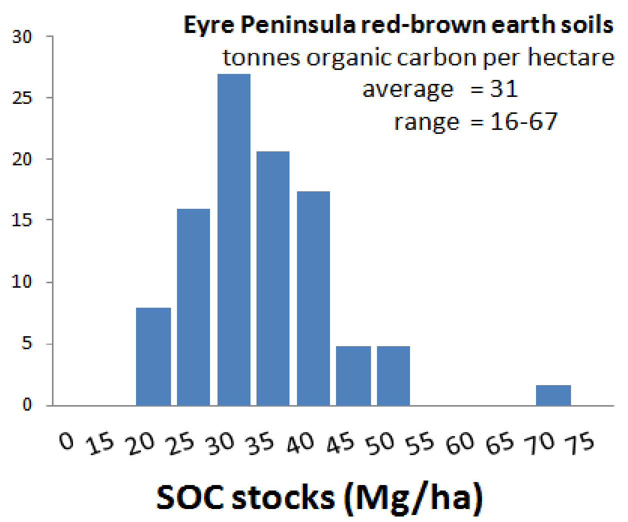
Queensland rangeland systems

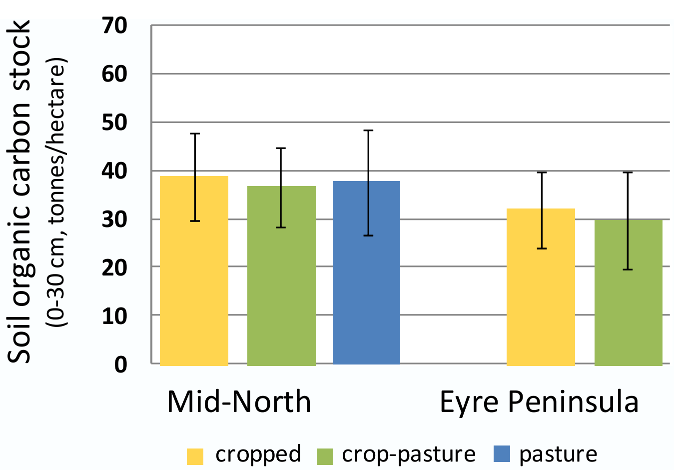


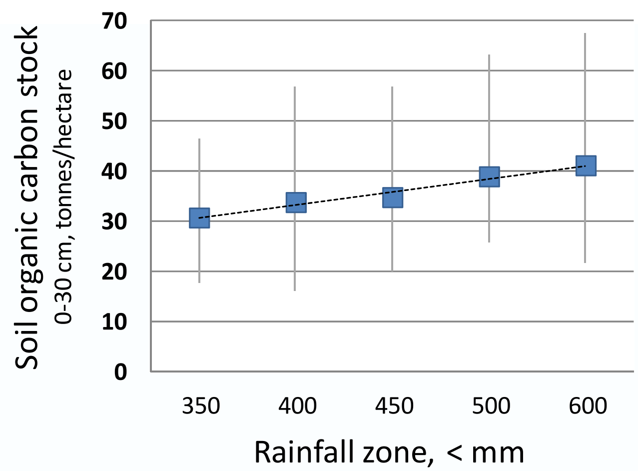
- Non linear trends with increasing shoot dry matter production, NDVI, and annual rain for 0-10 cm SOC stocks
- Soil type was also important
- Potential for remote sensing to provide key information

South Australia – dry land cropping soils









Victoria – soil carbon in cropping and pasture systems

Location	Management practices	Duration (y)	SOC difference (Mg OC/ha)
Hamilton	P rate and grazing intensity	27	nsd
Ararat	Grazing management	5	nsd
Horsham, LR1	Cropping systems	94	≤5
Horsham, SCRIME	Cropping systems	13	≤3
Walpeup	Cropping systems Cultivation	27 27	≤2 nsd

nsd= no statistical difference

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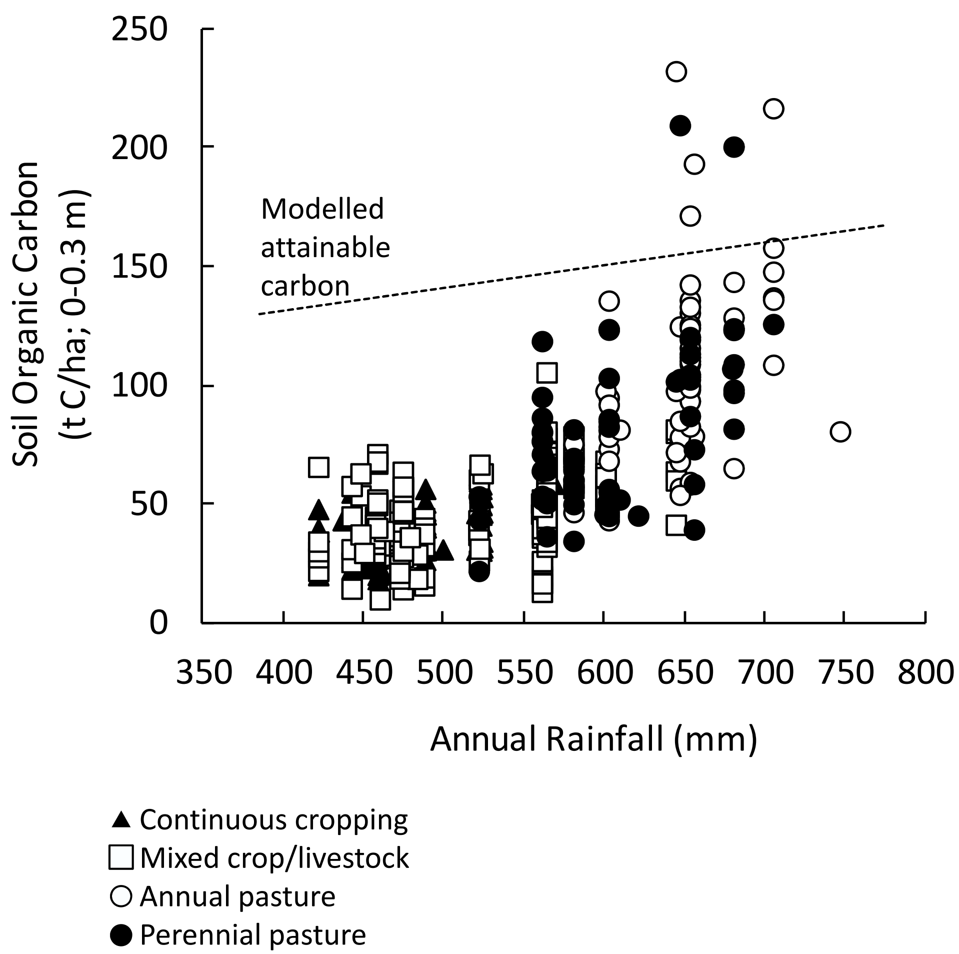
Western Australia



Albany Sand Plain

- Some pasture systems are at or above modelled attainable soil carbon stocks
- Cropping and mixed crop/livestock were lower than pasture systems and generally 50% of modelled attainable values

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Summary and future directions

- Significant progress in measurement technologies
  - Ability to generate a suite of soil carbon data with one analysis (assess vulnerability of soil carbon change, provide input to models)
  - How to extend the capability developed?
  - Need to develop a coordinated nationally consistent approach – central MIR spectral library accessible to regional labs
  - We need to catch and analyse samples that do not fit current calibrations – build the prediction system through time
  - How do we optimise predictions and enhance certainty?

- Sampling was not comprehensive
  - Some important regions, managements, soil types were not included
  - New management strategies have not been assessed

Summary and future directions

- Temporal measurements are required to quantify sequestration
  - Establishment of monitoring system
  - Verification requirements – expensive ongoing requirement (are there alternatives)
- More to be extracted from the data collected and collation with other datasets
  - Creation of a national repository for data and new data
  - Further examination of covariates and ability to predict spatial distributions of soil organic carbon stocks and composition.
- Many regions did not show a statistically significant effect of defined management practices on soil carbon stocks
  - At least partially due to variability that existed within management classes
  - Are we doing the right thing by binning up on broad management classes – should we be considering alternative metrics?

Thank you

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