

Global Research Alliance

Capacity Building Workshop

Measuring Carbon Stocks in Soil

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Australian Government

Department of Agriculture, Fisheries and Forestry

Outline

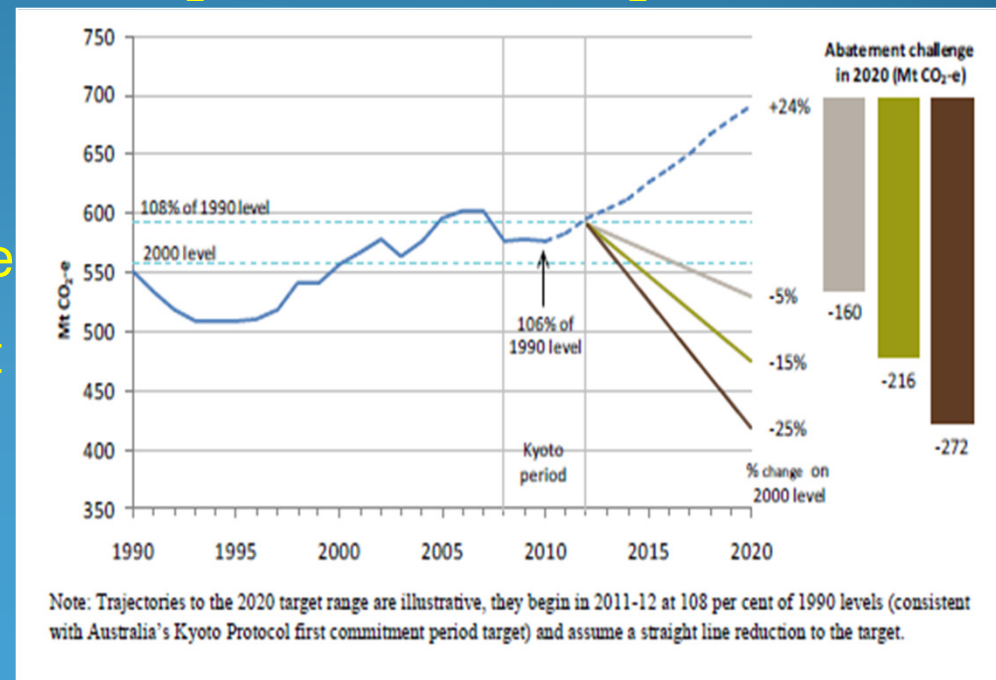
- **Background**
- **Methodologies – protocols and technical considerations**
- **Sources of Variation/uncertainty**
 - **Sampling**
 - **Spatial**
 - **Temporal**

Background

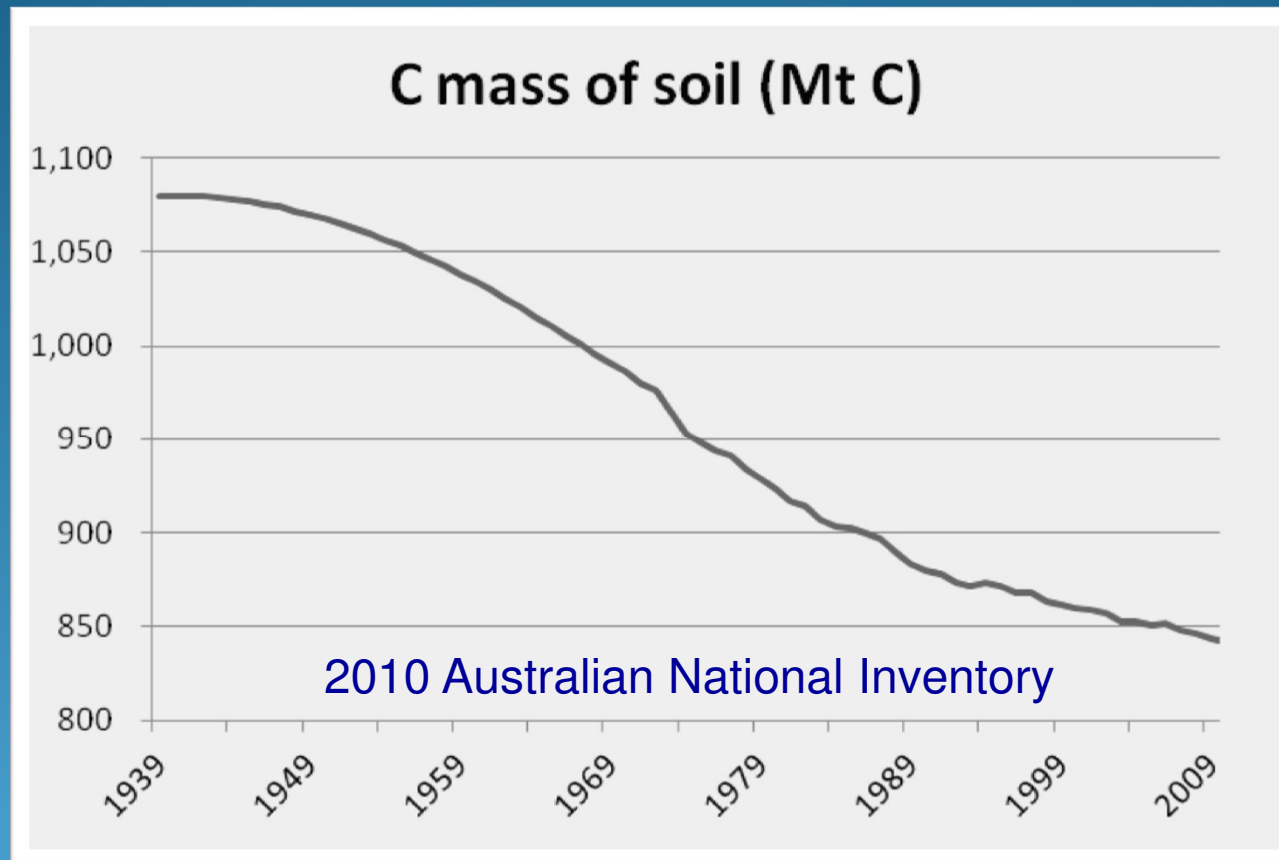
GHG Emissions Projections

- Australia - average 582 Mt CO₂-e per year Kyoto period (2008–12)
- Projected to be +24% by 2020 (without mitigation)
- Require abatement of between 160 Mt CO₂-e and 272 Mt CO₂-e in 2020


- Soil is the largest terrestrial C store
- SOC key component of abatement
- Carbon Farming Initiative (CFI)



National change in soil C in cropped soils



Require measured data to estimate, predict
and model these changes



Measurement Methodology: Protocols and Technical Considerations

Methodology

How do we measure soil C ?

Require reliable, robust, consistent measures of soil carbon to identify auditable change over time.

Factors that need consideration :

- Sampling protocol
- Spatial variability
- Temporal variability
- Laboratory/measurement error



Sampling Protocols (measured data)

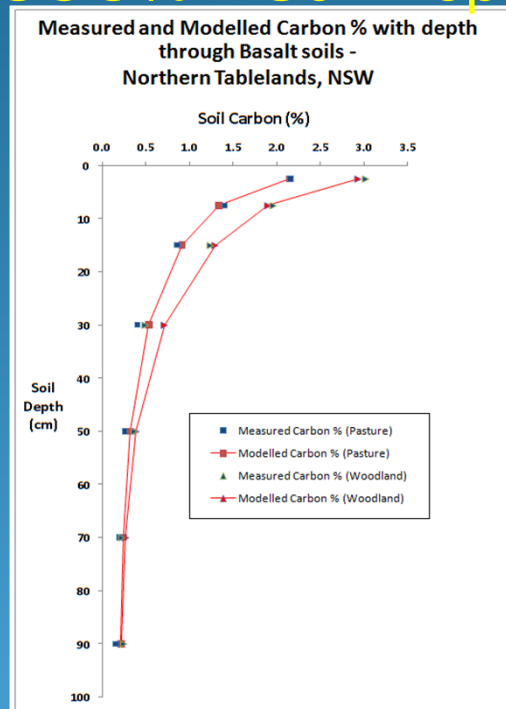
$$\text{SOC tC ha}^{-1} = \text{SOC\%} \times \text{Soil Depth} \times \text{Bulk Density} \times \text{Area}$$

Sample depths

- 0-5cm/0-10cm ?
- 10-20cm
- 20-30cm

Sample preparation

- Generally sieved to <2mm
- Gravel Content Correction
- Bulk Density Calculation



Inclusion of plant matter will alter result by factor of 2

Calculating Soil Carbon (tC ha^{-1})

Equivalent Mass

Equivalent Mass

Mass of soil to 30cm @ BD 1.2 t/m^3

$$0.3 \times 10,000 \times 1.2 = 3,600 \text{ tonnes}$$

30cm



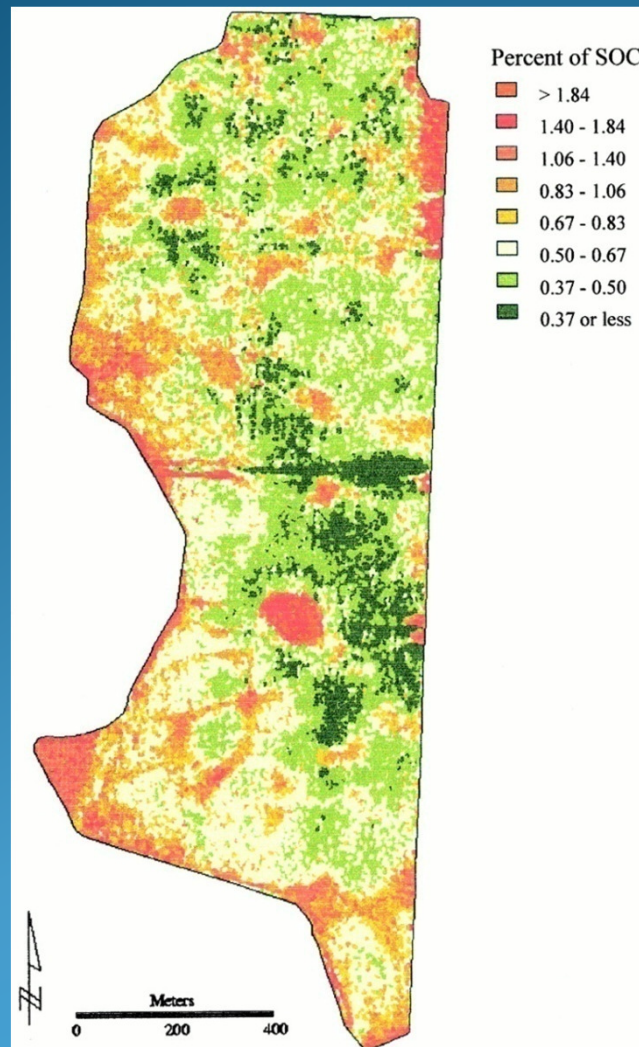
36cm



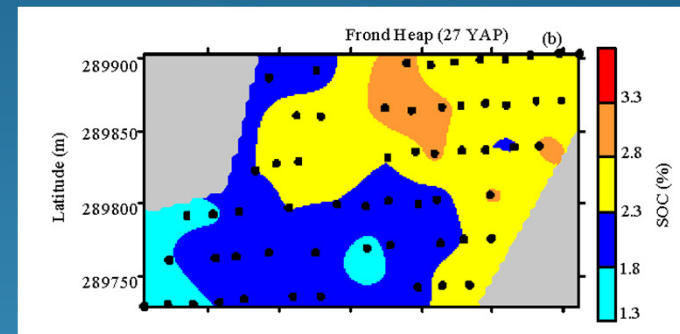
Sources of Variability/Uncertainty in soil carbon estimation

- **Spatial**
- **Temporal**
- **Laboratory**

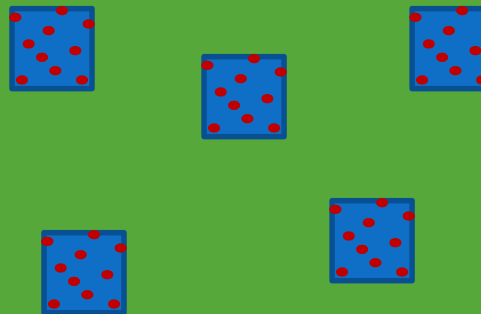
Spatial Variability: sampling design



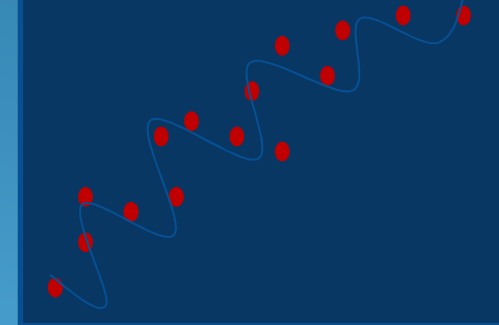
DPI Victoria



Australian Sampling strategy



Transect sampling



Spatial Variability: sample numbers

How many samples are required ?

Is our sample representative of the site / landscape ?

Minimum detectable difference between samplings

Don et al. (2007)

100 samples	>0.4 tC/ha (Arenosol) OR	> 0.8tC/ha (Vertisol)
20 samples	>1.2	> 2.8

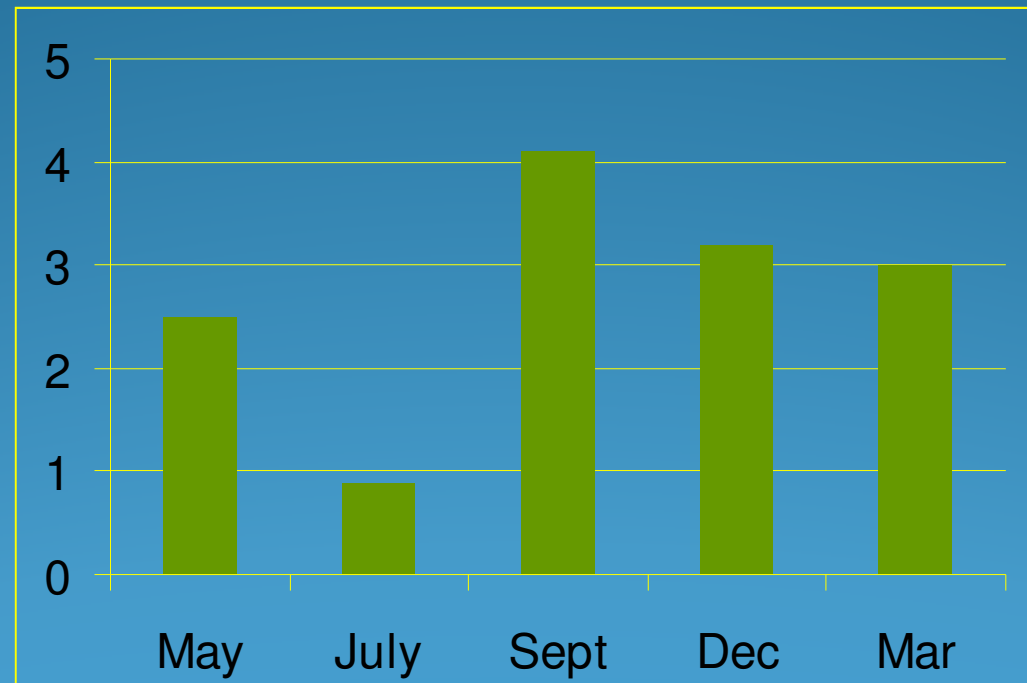
As sample number increases so does precision and confidence – inherent variability = diminishing returns

Sampling strategies designed around cost and practicality !
Standard number – defined precision/confidence ?

Temporal Variability

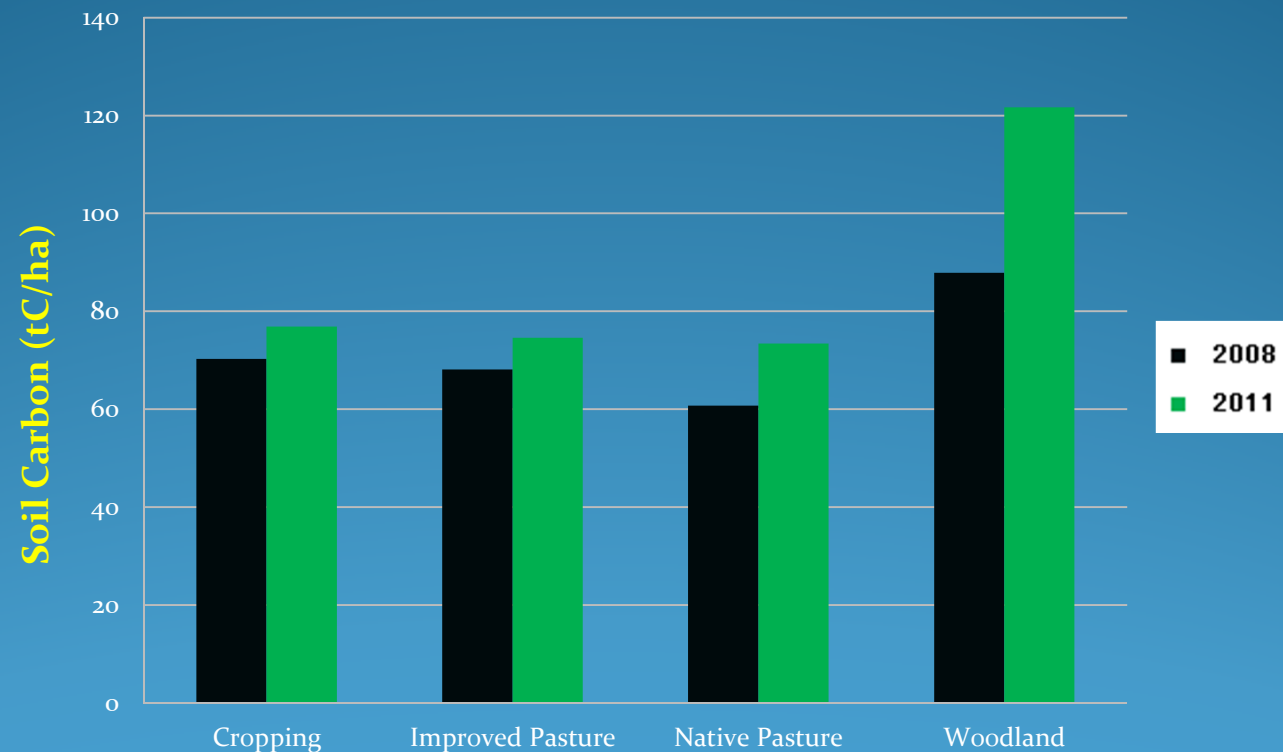
40% variation between winter and spring
(*Kikuyu grass* - Skjemstad unpublished)

C Sequestration
tC/ha/yr



Temporal Variability: repeat sampling

Temporal Variability in SOC 2008-2011



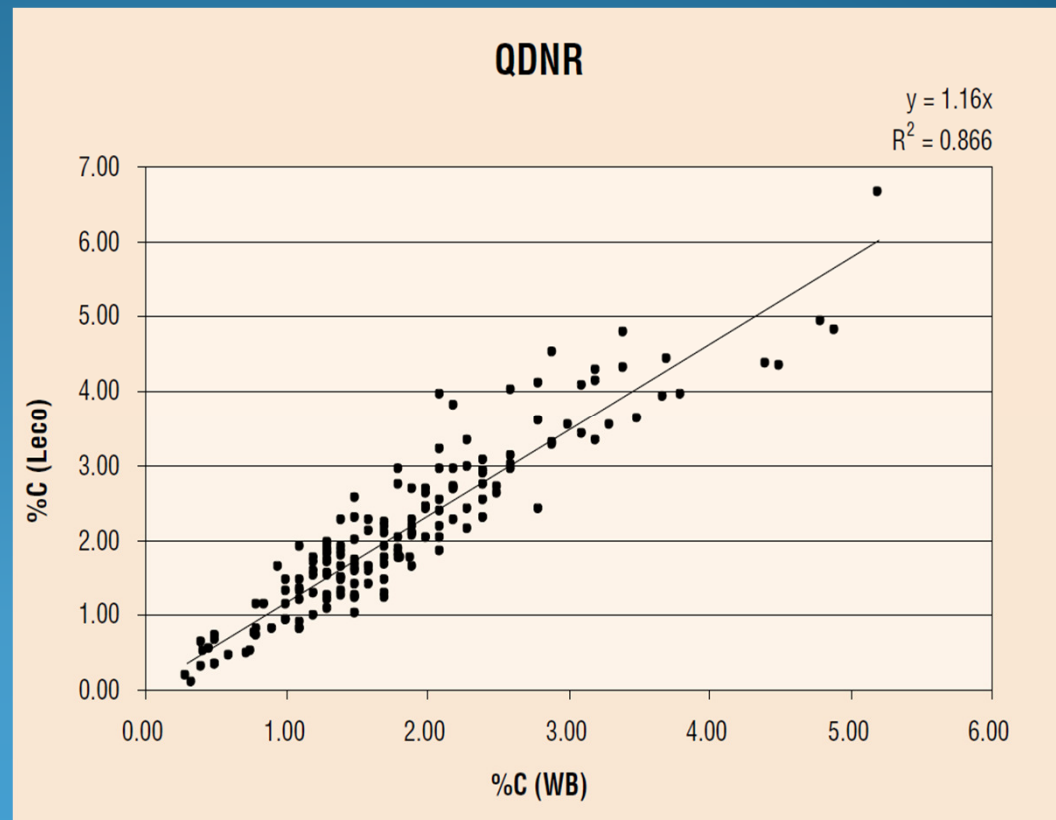
Wilson et al. Unpublished Data

Laboratory measurements

What laboratory test is used to analyse for soil carbon ?

Methods of analysis

- Walkley and Black
- Heanes wet oxidation
- Leco furnace
- NIR & MIR



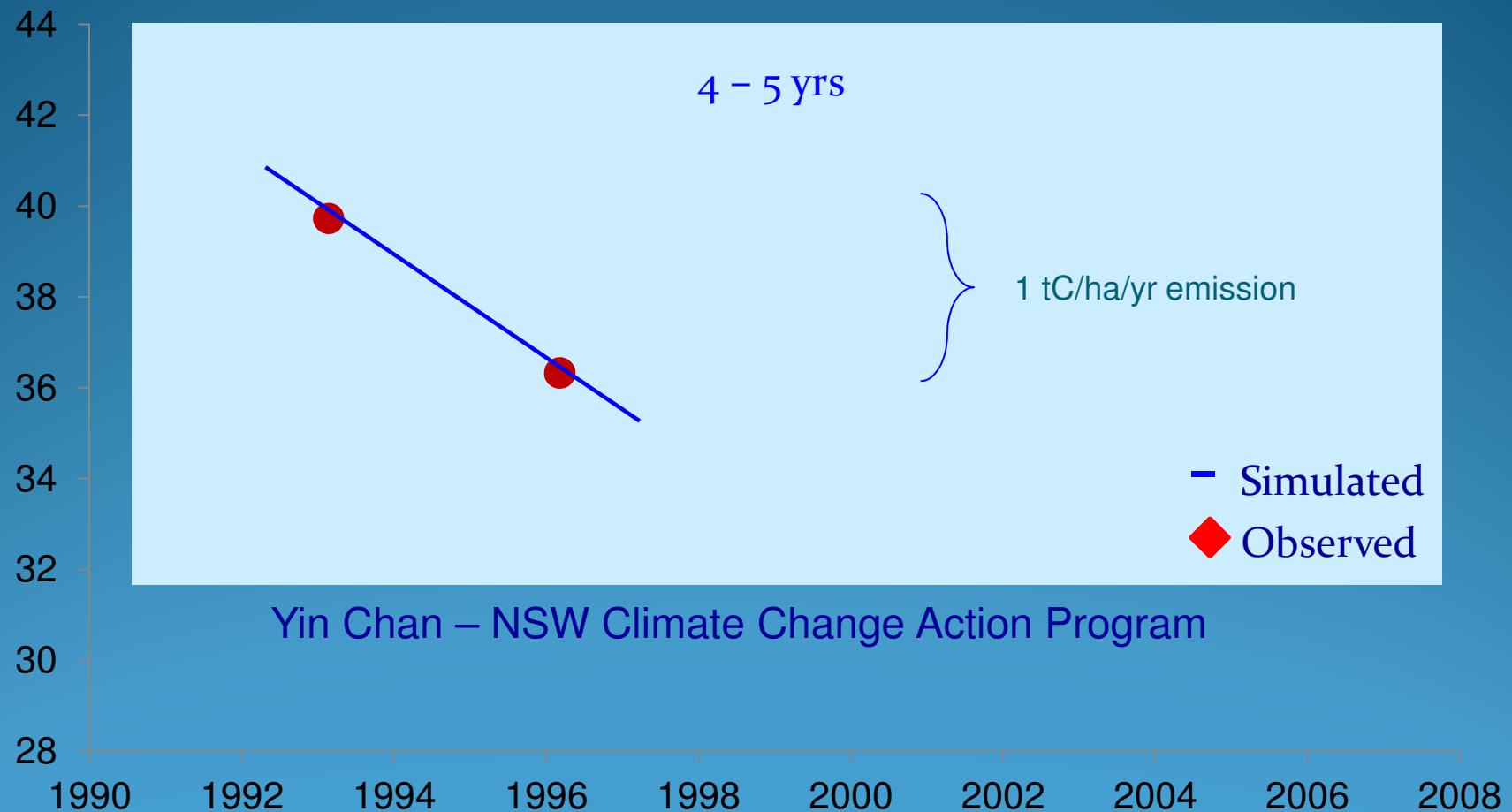
Other Considerations

- Should we measure at all ??

(requirements for C trading)

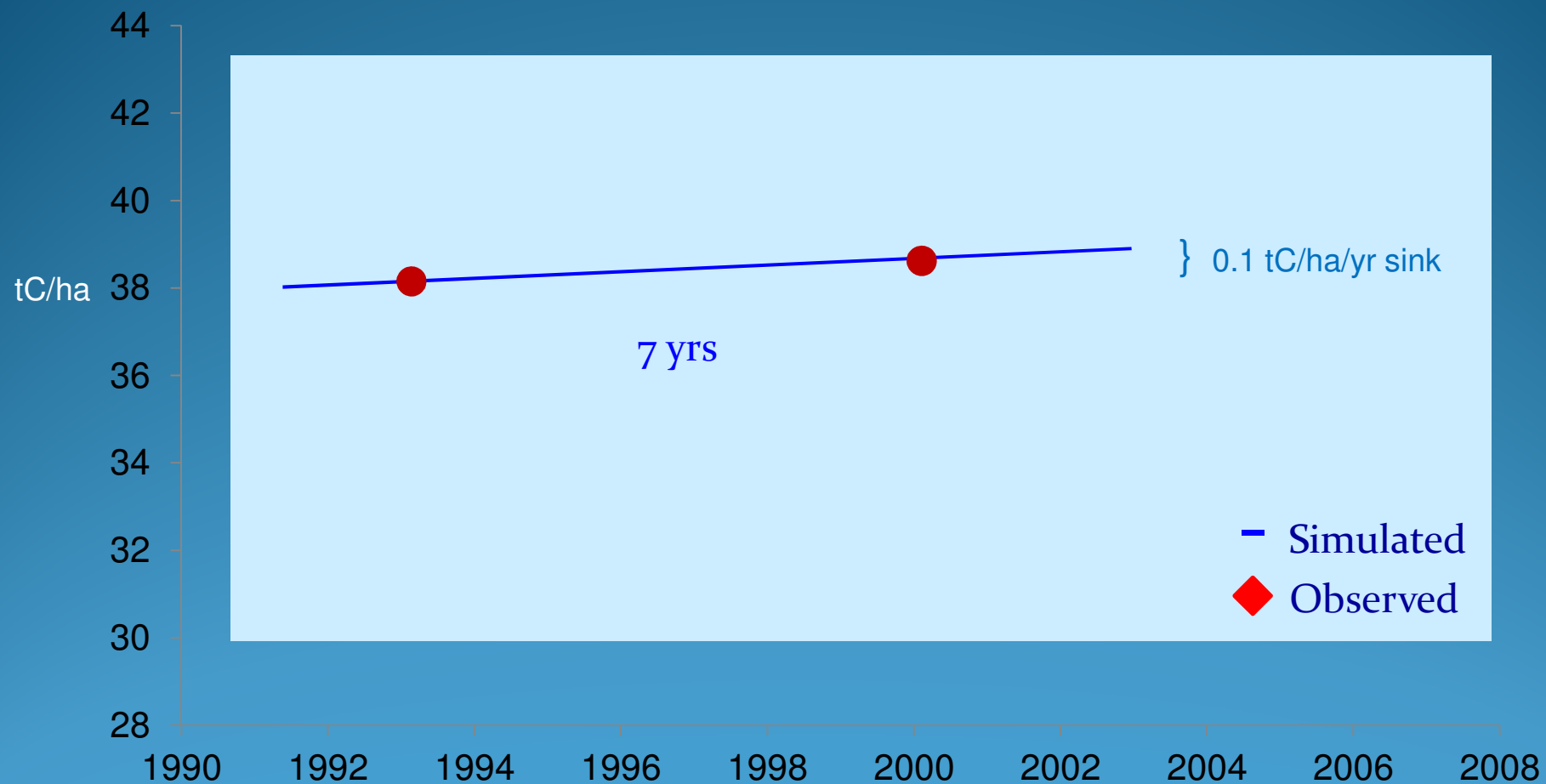
Over what time frame should we monitor for soil carbon ?

Example: NSW pastures (TOC)

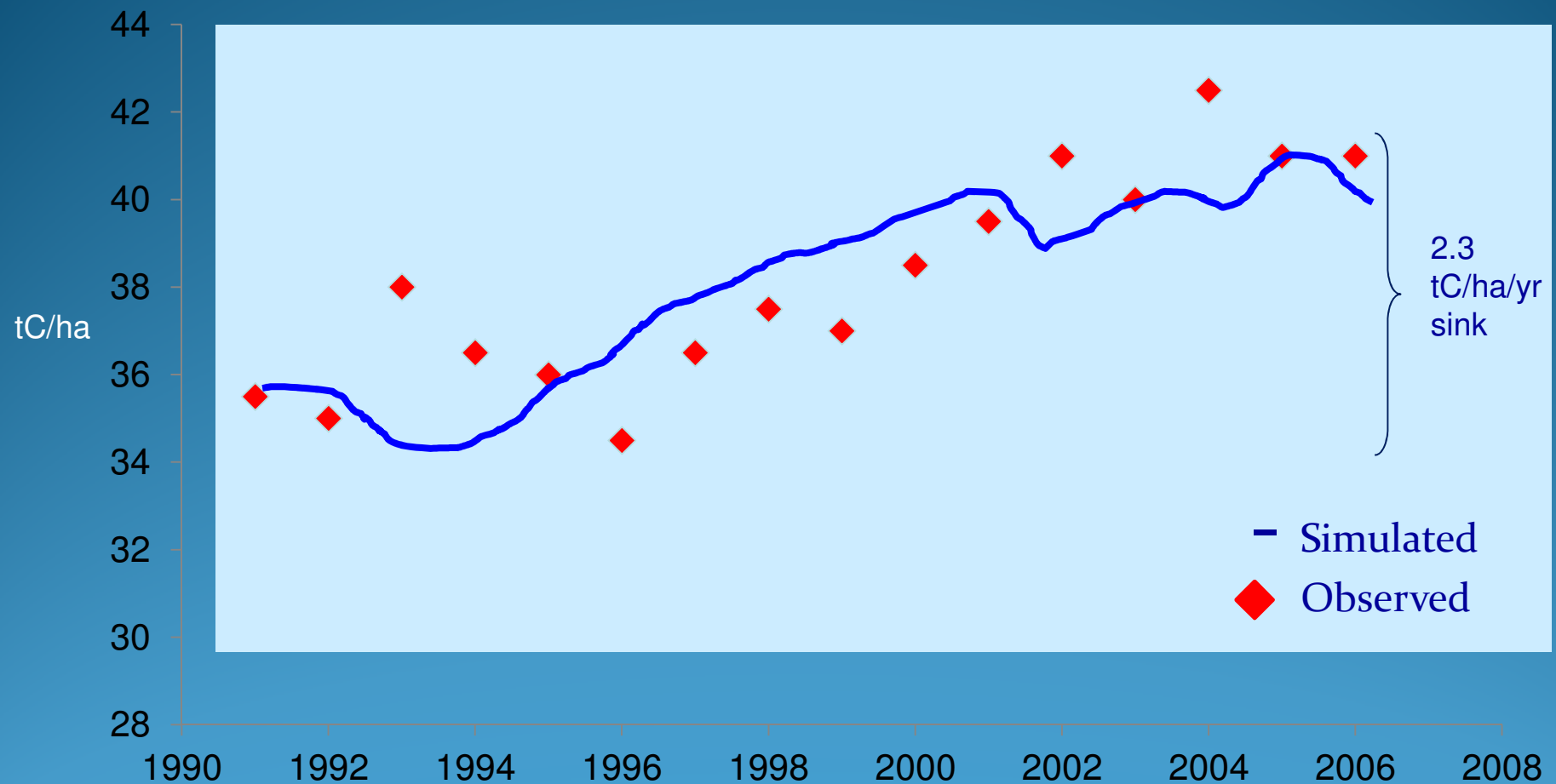


Simulations based on FullCam (incorporating RothC)

Example: NSW pastures (TOC)



Example: NSW pastures (TOC)



The background of the slide is a solid blue color. At the top, there are several wavy, horizontal lines in shades of blue and teal, creating a layered, landscape-like effect. The lines are smooth and flow across the width of the slide.

Soil Carbon in GHG Accounts

Measurement programs

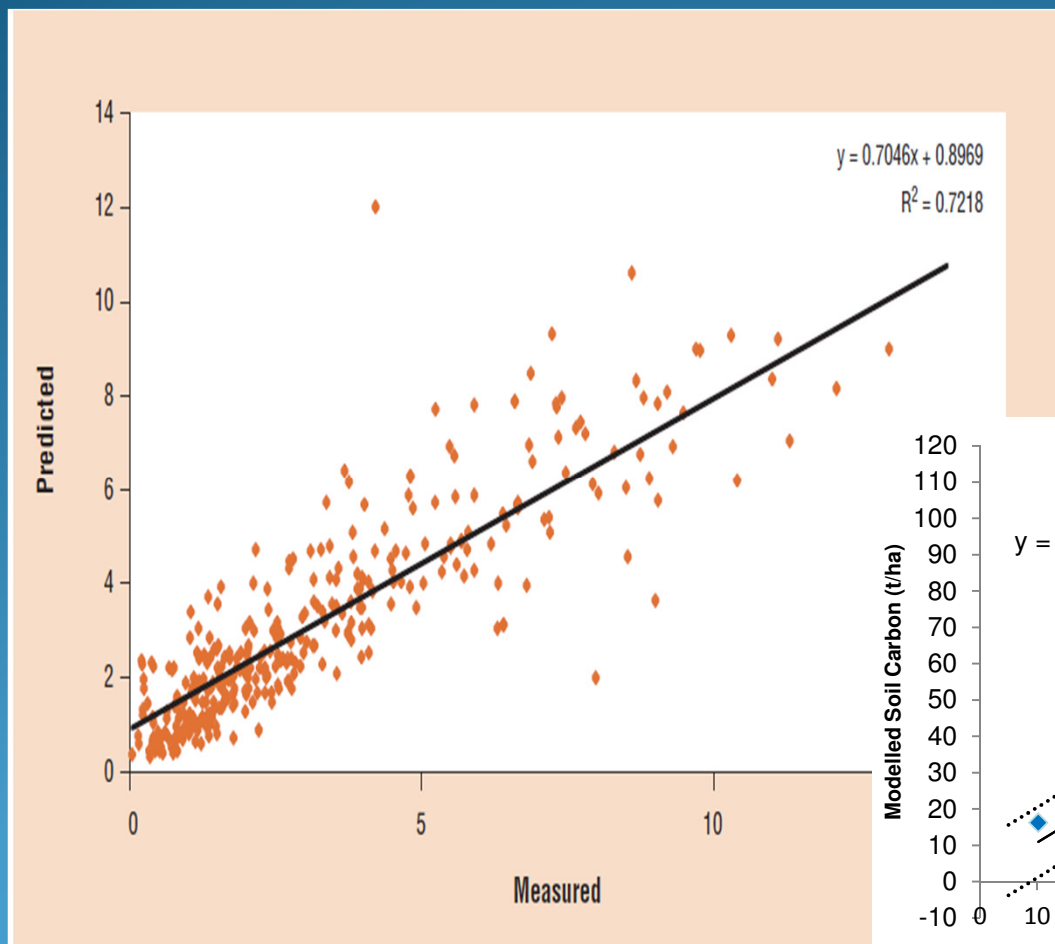
Combined sources of variability:

Field sampling (15 - 40%CV) 7.5 – 20 tC/ha
[includes spatial & analytical] (McKenzie et al. 2002, Brown 1999, Janik et al. 2002)

Bulk density (Timm et al. 2004, Sanderman et al. In press)
(10-20% CV) 5 - 10 tC/ha

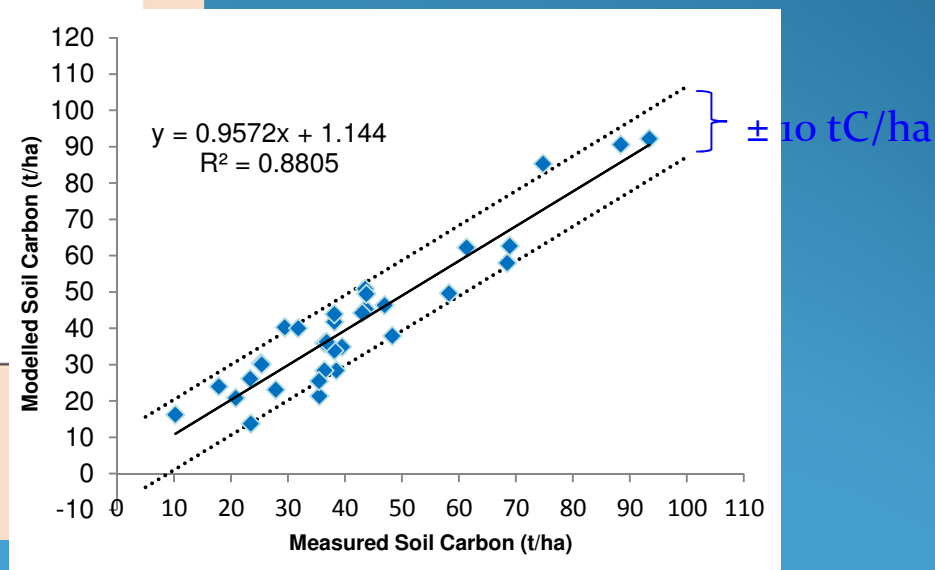
Combined variability = $\sqrt{7.5^2 + 5^2}$ = 9 - 22 tC/ha

Comparison between FullCAM and measured soil data



- Roth C
- DNDC
- DayCent/Century

Similar results



Conclusions

- All countries need to report on GHG emissions
- Soil Carbon a potentially significant store
- Require reliable, robust and repeatable measures of soil carbon
- Measurement associated with a range of sources of variability
 - *Spatial*
 - *Temporal*
 - *Laboratory*
- Measurement programs need to account for this variability
- Modeling has promise for SOC estimation with defined confidence
- BUT Data hungry, propagation of errors ?
- Need to define precision and confidence.



Thank You

Questions ?

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