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Carbon Sequestration in Agricultural Soils: Separating the muck from the magic

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Outline

- Introduction
- Selected soil management systems
  - Potential global carbon sequestration
  - Problems
    - Lack of good data – measurement uncertainties
    - Ancillary GHG impacts
- Role for isotope studies

Opportunity knocks

- Selman Waksman classic 1937 book
- Soil Association
- Nutrient mining→ SOM decline →

55-90 Pg CO_2 + CH_4 → Atmosphere

- Now - Soil Organic *Matters*

Areal extent/potential

Management system	Current area 10^6 ha (% ∑ Ag area)	Pot' l area increase 10^6 ha	Issues
Agroforestry	1023 (21%)	630	Above ground C↑
Conservation tillage	100 (2%)	1252	N_20↑
Holistic rangeland management	?	?	CH_4↑
Permanent pasture	3356 (69%)	From crop land?	CH_4↑
Organic farming	30 (0.6%)	0?	N_20↓
Biochar	???		Economics ?
System rice intensification	2? (0.02%)	4?	N_20↑? CH_4↑?

Literature C sequestration rates

- Organic farming

  -0.5 to 1.2 t C ha^{-1} $year^{-1}$ cf. conventional

- System for rice intensification

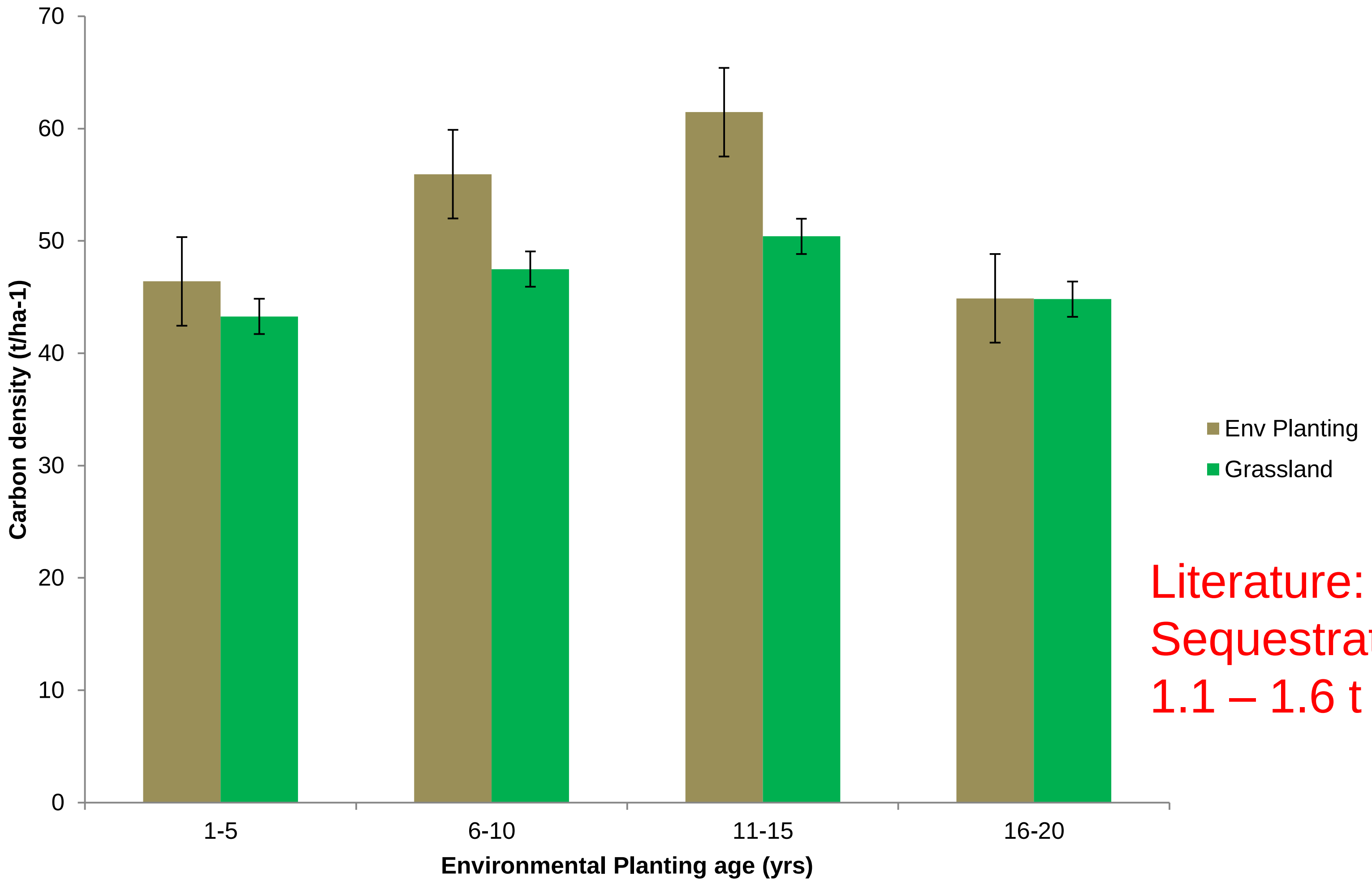
  116 kg C ha^{-1} $year^{-1}$

- Biochar

  Depends on feedstock availability/cost

Agroforestry

Soil carbon density to 30cm (t/ha^{-1})



Literature:
Sequestration
1.1 – 1.6 t C ha^{-1}

Conservation tillage

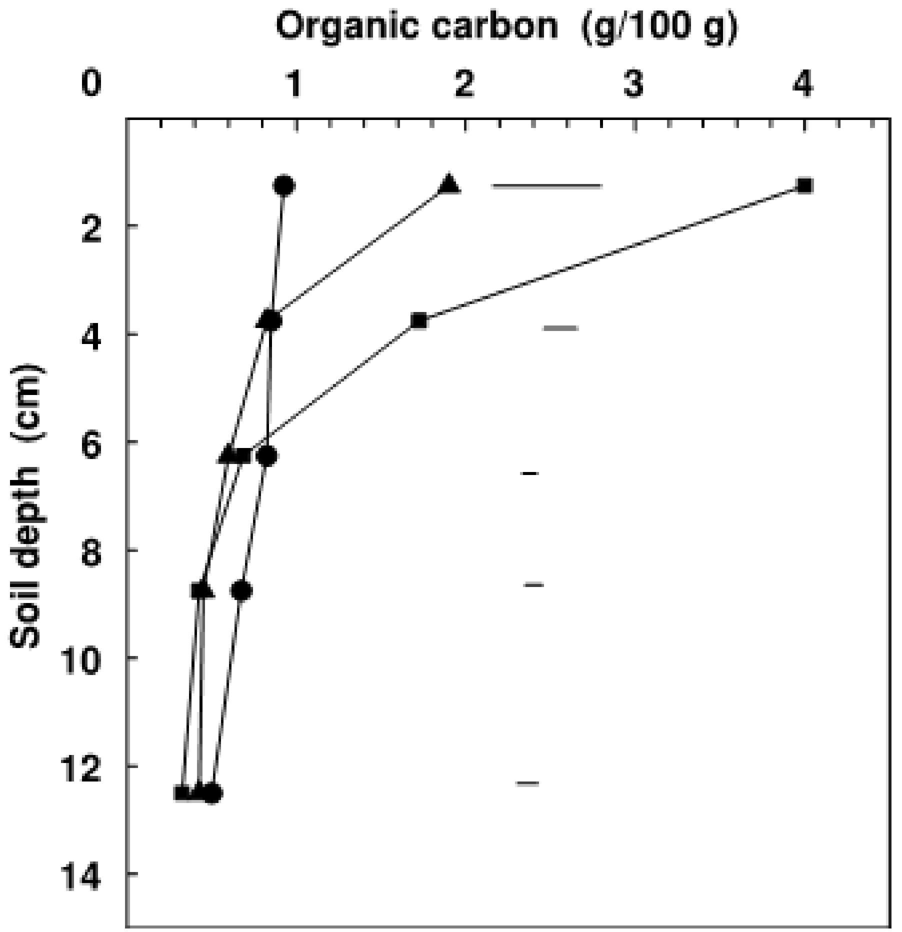


Figure 2. Soil organic carbon profiles under different tillage and stubble management and pasture after 3 years, Cowra, New South Wales (Chan and Mead 1988). ●, conventional-tilled–stubble-retained; ▲, direct-drilled–stubble-retained; ■, permanent pasture. Horizontal bars indicate l.s.d. (*P* = 0.05).

Literature:
Sequestration
0.1 – 1.3 t C ha^{-1}

Source: Chan *et al* ., 2003

Regenerative grazing – anecdotal evidence

Kachana Station, Kimberley region of WA

November 1992

End of dry season

November 1997

End of dry season
1 mth after 3rd graze

November 1998

End of dry season
3 mths after 3rd graze

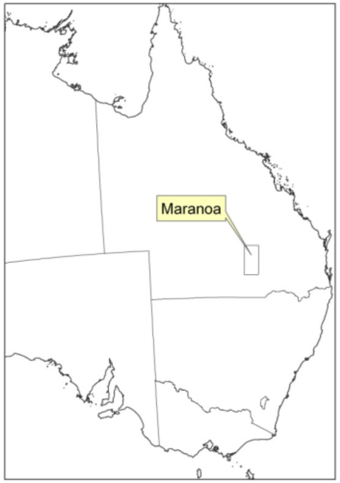
July 1999

Mid dry season
2nd graze

1992: <1 stock day/ha/yr ⟹ 1999: 800-1100 stock day/ha/yr

Methane reduction

Kangaroos vs ruminants



First pass estimates of carbon sequestration potential for the Maranoa district (1.9 million ha)

	tonnes CO_2e savings
Enteric methane savings (25% livestock reduction)	54,347t/yr
Soil sequestration and rangeland rehabilitation (10% of potential) CSIRO	133,992/yr
Total average/yr	**188,139/yr**
Total 30 yrs	**5,650,170/30yrs**

Source: Wilson unpublished data

Pasture improvement

Grazing and soil carbon is complex – often conflicting results

On average, management changes increased soil carbon (Conant *et al* 2001)

- Grazing management, cessation of overgrazing
- Conversion to pasture (from native veg* or agriculture)
- Fertilisation
- Improved grass species
- Irrigation

* Only for well managed pastures and may be net loss from above ground biomass

Soil C pasture improvement

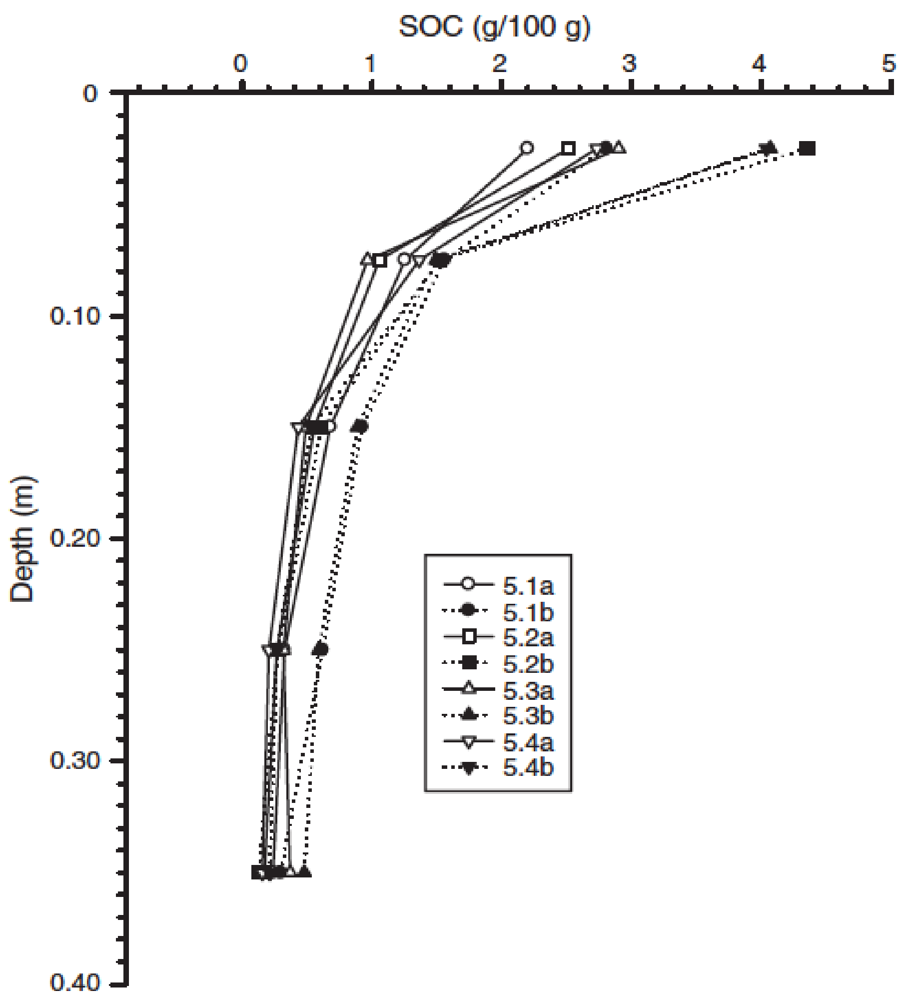
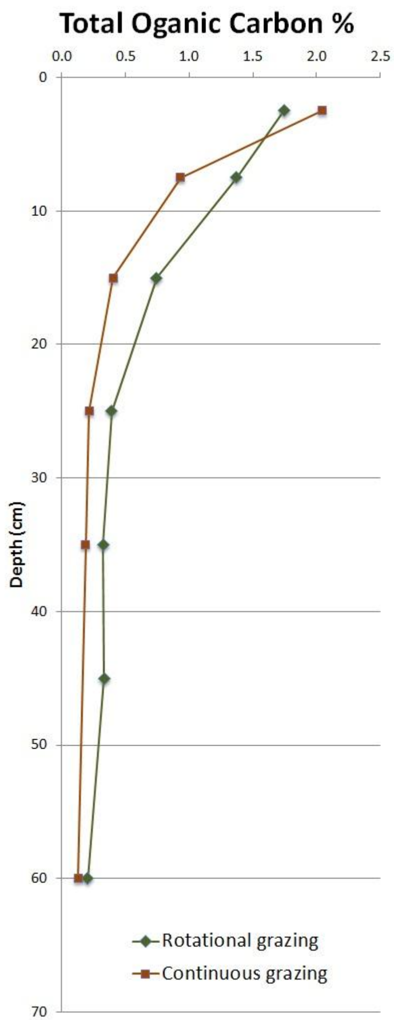


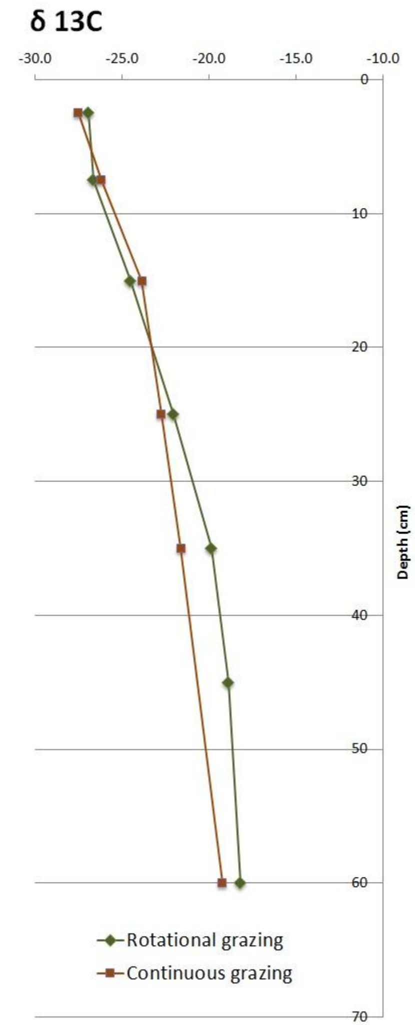
Fig. 3. Soil carbon concentration with depth under unimproved pastures (keys followed by 'a') and improved pasture (keys followed by 'b') treatments at 4 locations in central NSW.

Source: Chan *et al* ., 2010

Rotational grazing effects C

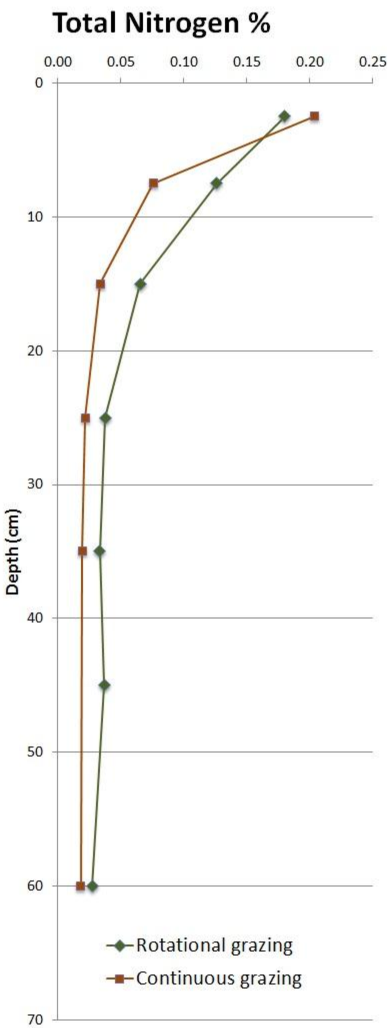
Carbon % and δ13C

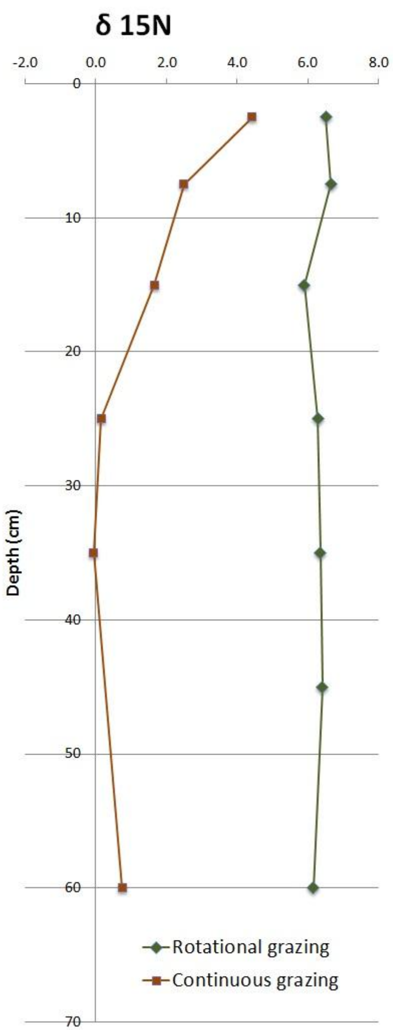




Rotational grazing effects N

Nitrogen and δ15N





Measurement problems

Conventional soil carbon studies:

- High variability so longer time frame needed
- Dearth of long term studies
- Bulk density a key parameter
- Landscape dimension not considered

+ lack of awareness and rigour

↓

Unreliable published data

Role for isotope studies

- Fluxes of C inputs in soil pools
  - NAM C3 vs C4 plant residues
  - ^{14}C pulse and continuous labelling
  - Real-time ^{13}C transformations
- Residence time of C pools
  - Labile fraction – ‘Holy grail’
- C interactions with N
  - Role of BNF – ^{15}N abundance
  - Tracing organic and inorganic N inputs
  - Profile studies of ^{13}C and ^{15}N

Conclusions

- Opportunity knocks
  - – Driven by need for more reliable data
  - – Define questions
    - *Rate of soil C change*
    - *Residence time of added C in soil*
  - – Focus on important land management systems

    Rangelands, pastures, agroforestry & conservation tillage
  - – Utilise latest advances in isotope methodology
- Coordinated international efforts needed