A snapshot of current soil C and N research

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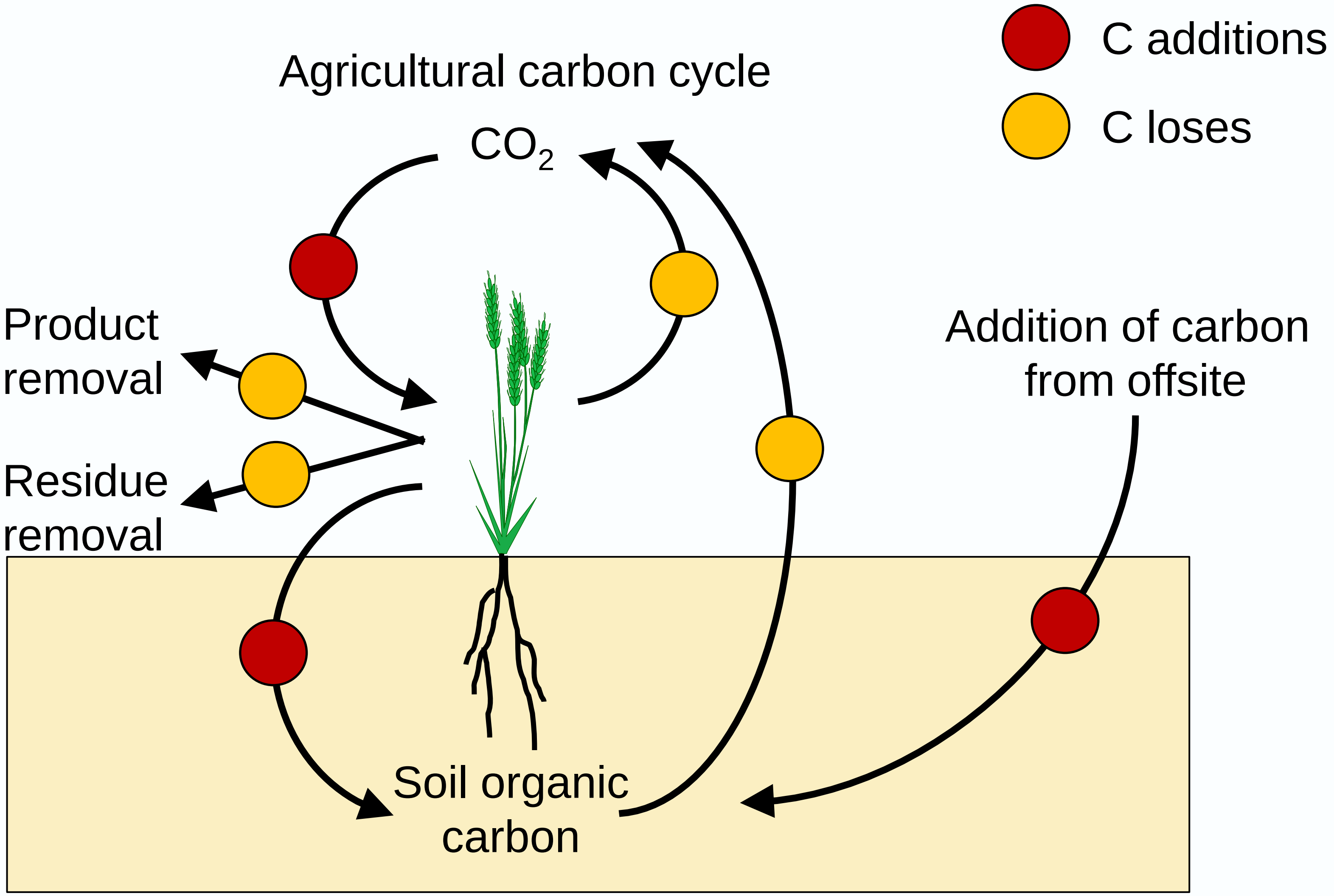
Australian Government
Department of Agriculture

Carbon cycle in agricultural systems



What determines soil organic carbon content?

$$\text{Soil organic carbon content} = f\left(\text{Inputs of organic carbon}, \text{Losses of organic carbon}\right)$$

Inputs

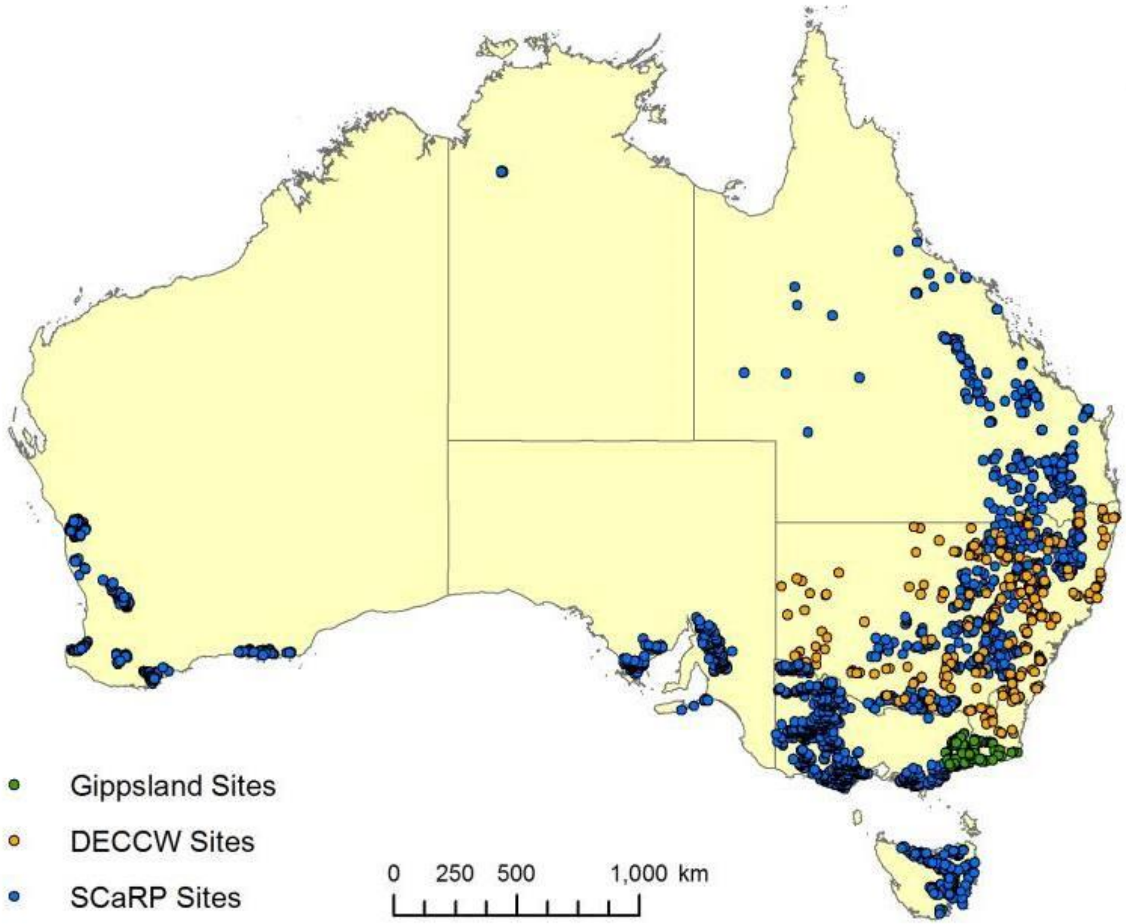
- Net primary productivity (capture by plants and added to soil)
- Addition of organic materials from offsite

Losses

- Conversion of organic C to CO_2
- Protection offered by soil minerals
- Extent of cultivation

National soil carbon programme

Sampling locations and soil samples collected and analysed



Samples collected and analysed by SCaRP

- 17,721 samples
- 3,836 sites

Additional samples analysed

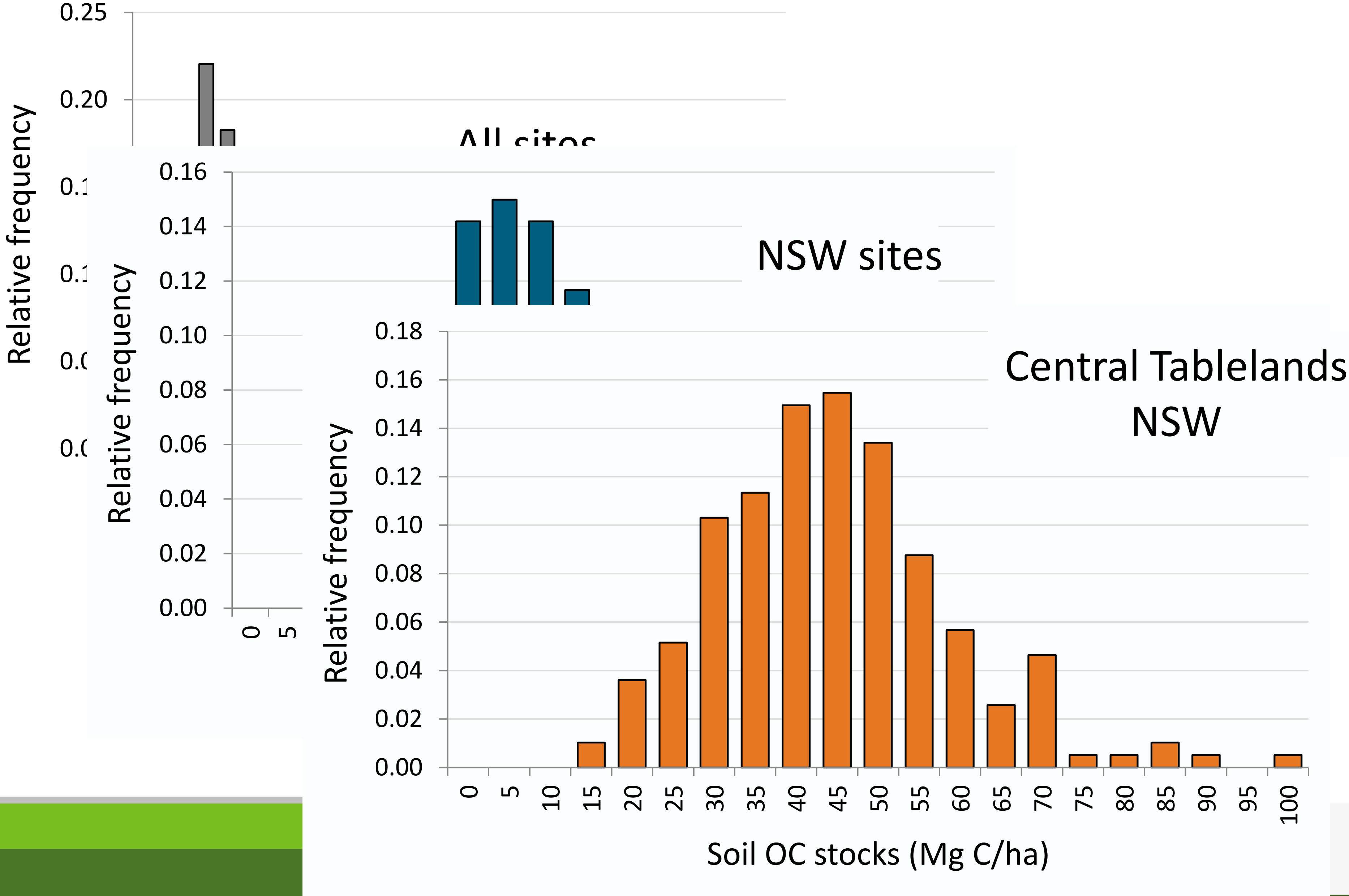
- 2774 samples
- 690 sites

Total

- 20,495 samples
- 4,526 sites

>92% from farmer paddocks

Variations in 0-30 cm soil carbon stocks



An assessment of the carbon sequestration potential of organic soil amendments

Why amend soils with organic wastes and their products?

- Alternative destination rather than disposal
- Results in recovery and recycling of nutrients, reducing cost of fertilisers to farmers and horticulturalists
- Potential benefits to 'soil health'
- Sequestration of C in the soil to offset anthropogenic CO_2 emissions
  - Requires 'permanence' of 100 years
  - Clearly this can't be measured – it must be modelled
  - It is therefore important to have the best information to build predictive modelling capacity

An assessment of the carbon sequestration potential of organic soil amendments

- This project will quantify the relationship between the chemical composition of organic carbon and how it decomposes in a variety of potential soil organic amendments.
- Spectroscopic techniques will be used to measure carbon chemistry and long-term incubation experiments will quantify degradation dynamics.
- The data generated will be used to define the relationship between chemical composition and potential longevity and/or stability of different types of organic amendments in soil.

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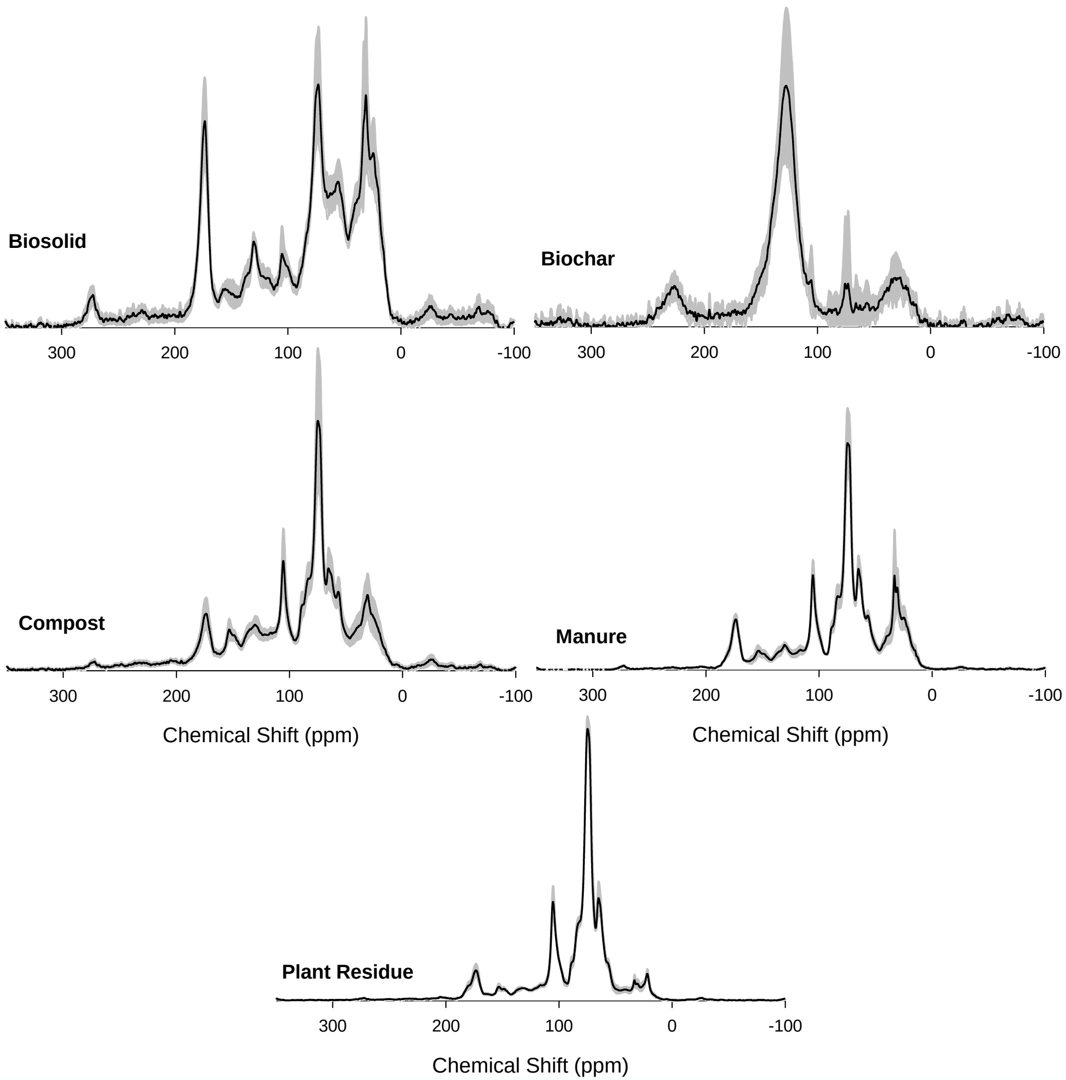
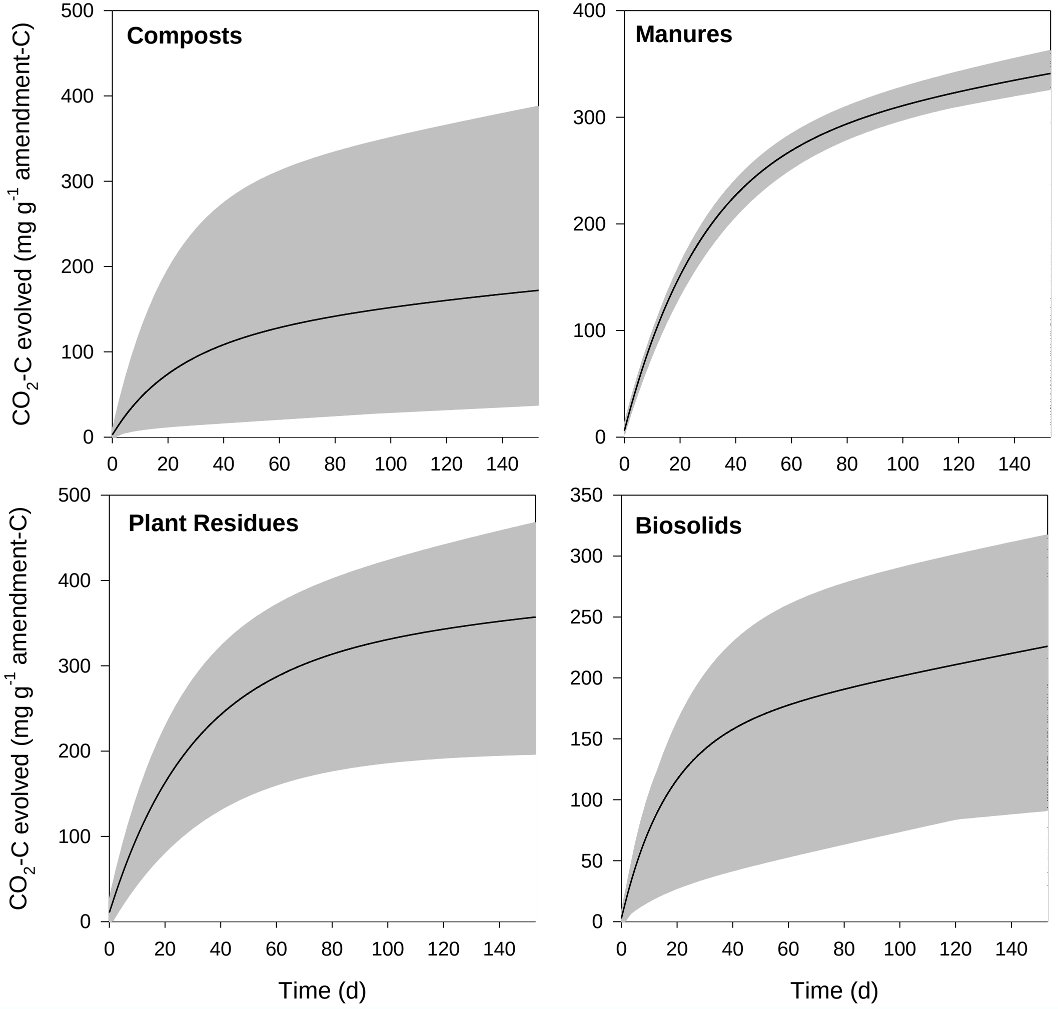
NMR



- ^{13}C-CP/MAS NMR spectra of the five different OA groups
- Black line is the average spectrum, grey areas are +/- STDEV

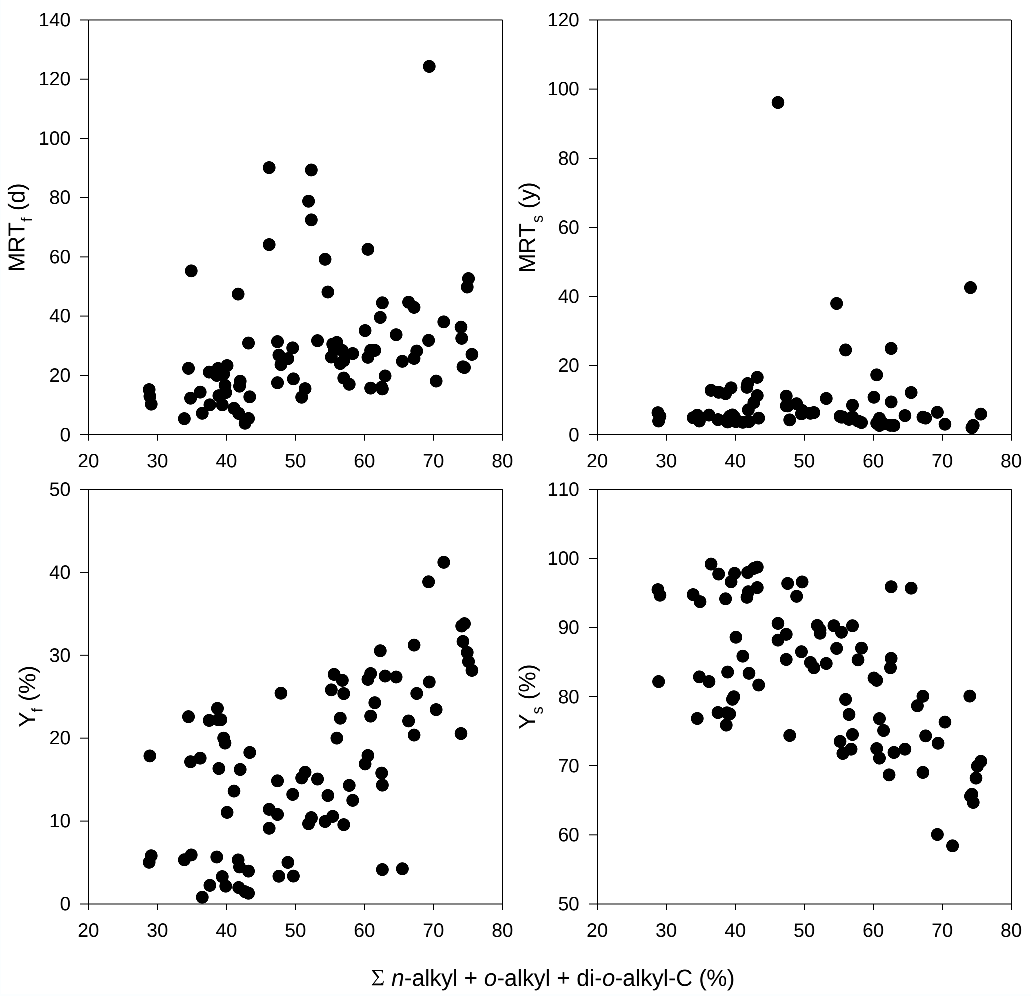
- Most variation in biosolids and composts
- Most of signal from biochars in the aryl-C region
- Both the manures and plant residues gave similar spectra

Respiration of OA-C



- Black lines are the mean value
- Grey areas are the min / max
- Biochars not pictured as very low mineralisation rates in the sand-soil mixture
- Manures behave very similarly – average loss after 140 d is 32%
- Large variation within plant residues, composts, and biosolids – range between 5-45% of added C lost over 140 d

Relationship between OA-C mineralisation and NMR



Relationship between key mineralisation characteristics and labile C as measured by NMR

- Top two panels
  - Little relationship so far between rate of turnover of fast (L) and slow (R) pool
- Bottom two panels
  - Some relationship between partitioning of OA-C to fast (L) and slow (R) pools

Conclusions – organic amendments

- If you add an OA to your soil, a proportion of that C will be lost through mineralisation
- There appears to be a strong link between the organic chemistry (relatively easy to measure) and the stability (time consuming to assess) of the OAs used in this project
- It should be noted that the addition of OAs may have many other effects including altering soil structure, water availability, nutrient cycling, microbial communities and their functions, etc…

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How does soil C content and chemistry affect N cycling and N_2O fluxes?

nature geoscience
PUBLISHED ONLINE: 31 JULY 2011 | DOI: 10.1038/NGEO1207
LETTERS

Carbon benefits of anthropogenic reactive nitrogen offset by nitrous oxide emissions

Sönke Zaehle[1]*, Philippe Ciais[2], Andrew D. Friend[3] and Vincent Prieur[2]

Additions of reactive nitrogen to terrestrial ecosystems—primarily through fertilizer application and atmospheric deposition—have more than doubled since 1860 owing to human activities[1]. Nitrogen additions tend to increase the net

We perform a set of model simulations aimed at isolating global and regional effects of anthropogenic Nr addition due to fertilizer applications and atmospheric deposition from those due to changes in land-cover, atmospheric $[CO_2]$, and climatic changes

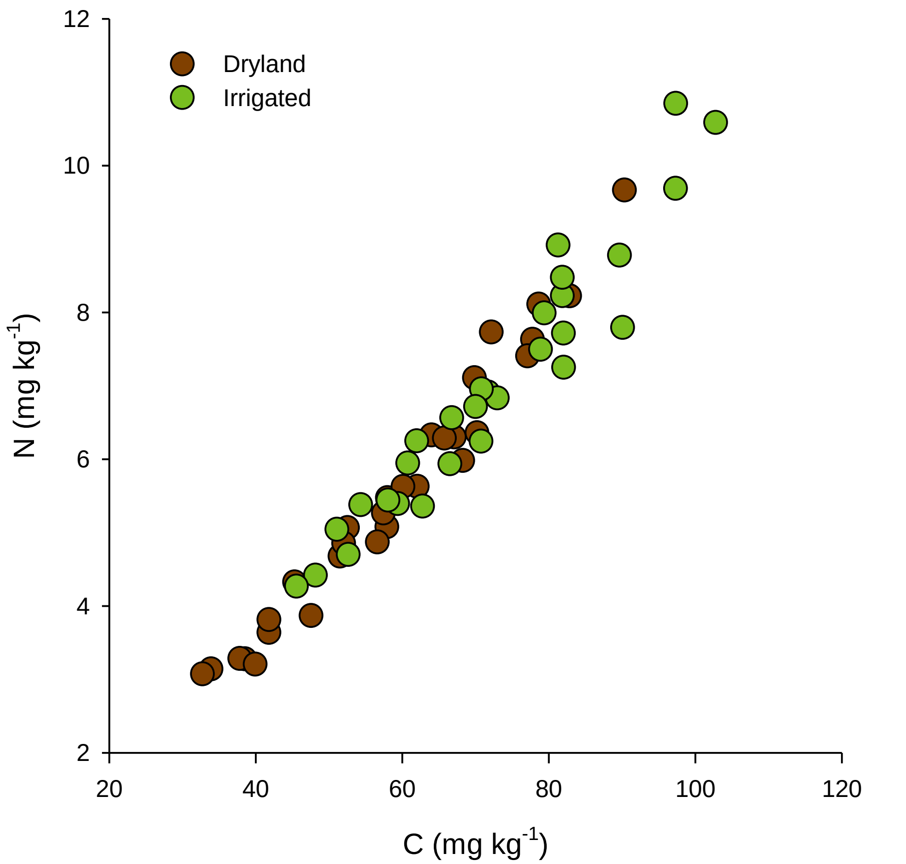
Experimental design

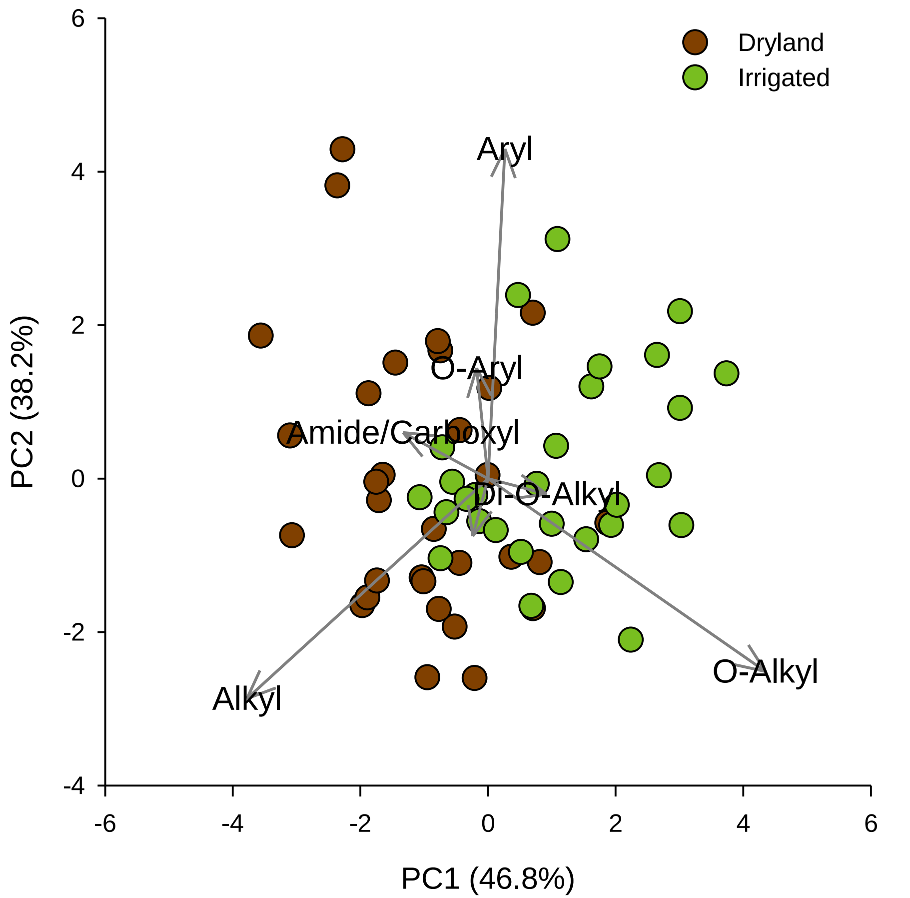
We know that increases in SOM improve soil "health" and can increase nutrient cycling

The question is whether or not this increase in nutrient cycling might also result in a potential increase in N_2O emissions, to an extent that might offset C sequestration from increased inputs?

- We selected eight paddocks with centre-pivot irrigation to provide a gradient of C content and chemistry, by sampling outside and inside the irrigated area
  - Reduces the chance of underlying fence-line variation beyond differences manifested from increased plant inputs due to irrigation
- Samples were taken from top 5 cm, including intact cores
- N_2O and CO_2 flux was measured on the intact cores
- A range of N-cycling assays were carried out
- C chemistry was assessed by NMR and MIR

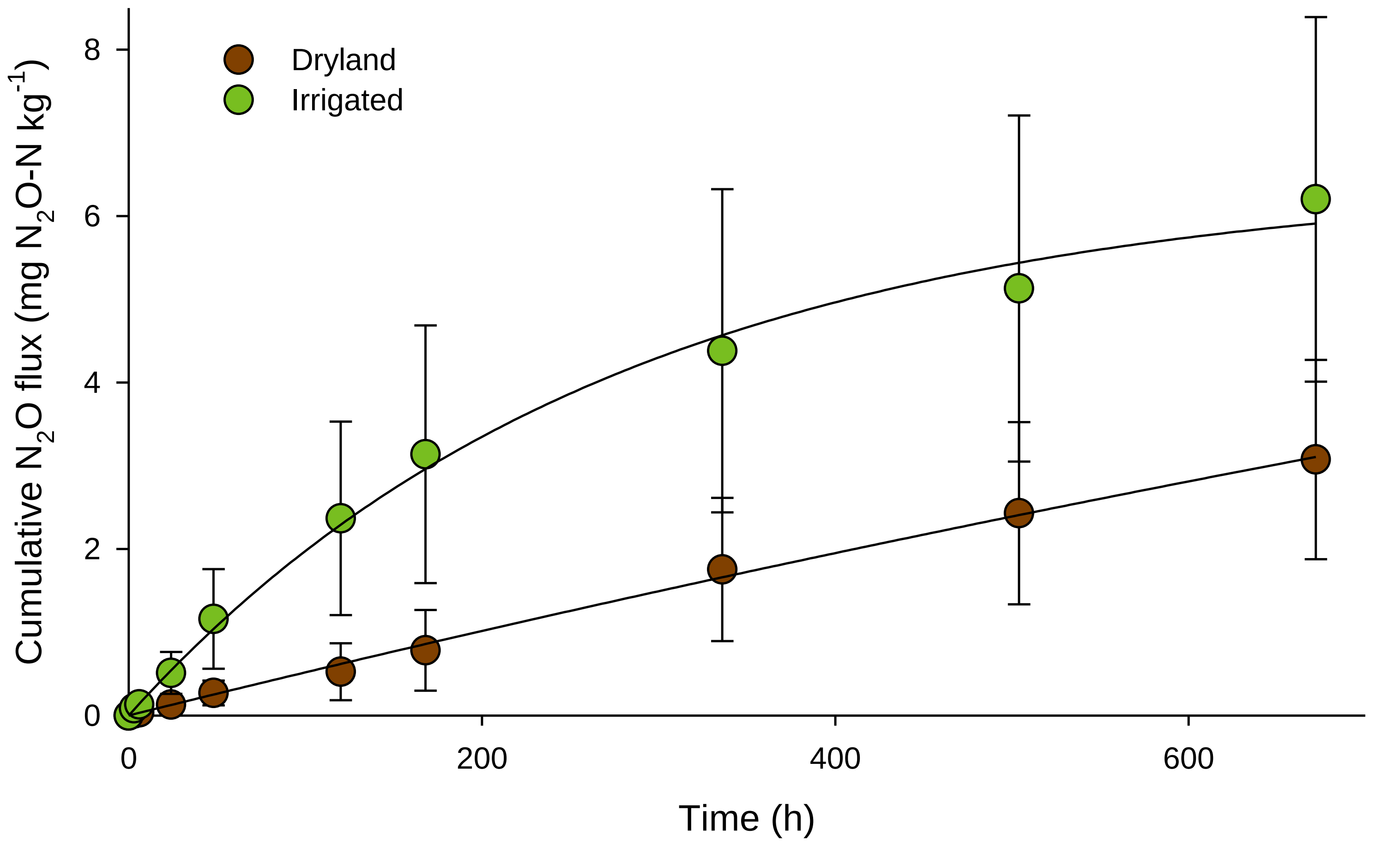
Soil organic matter



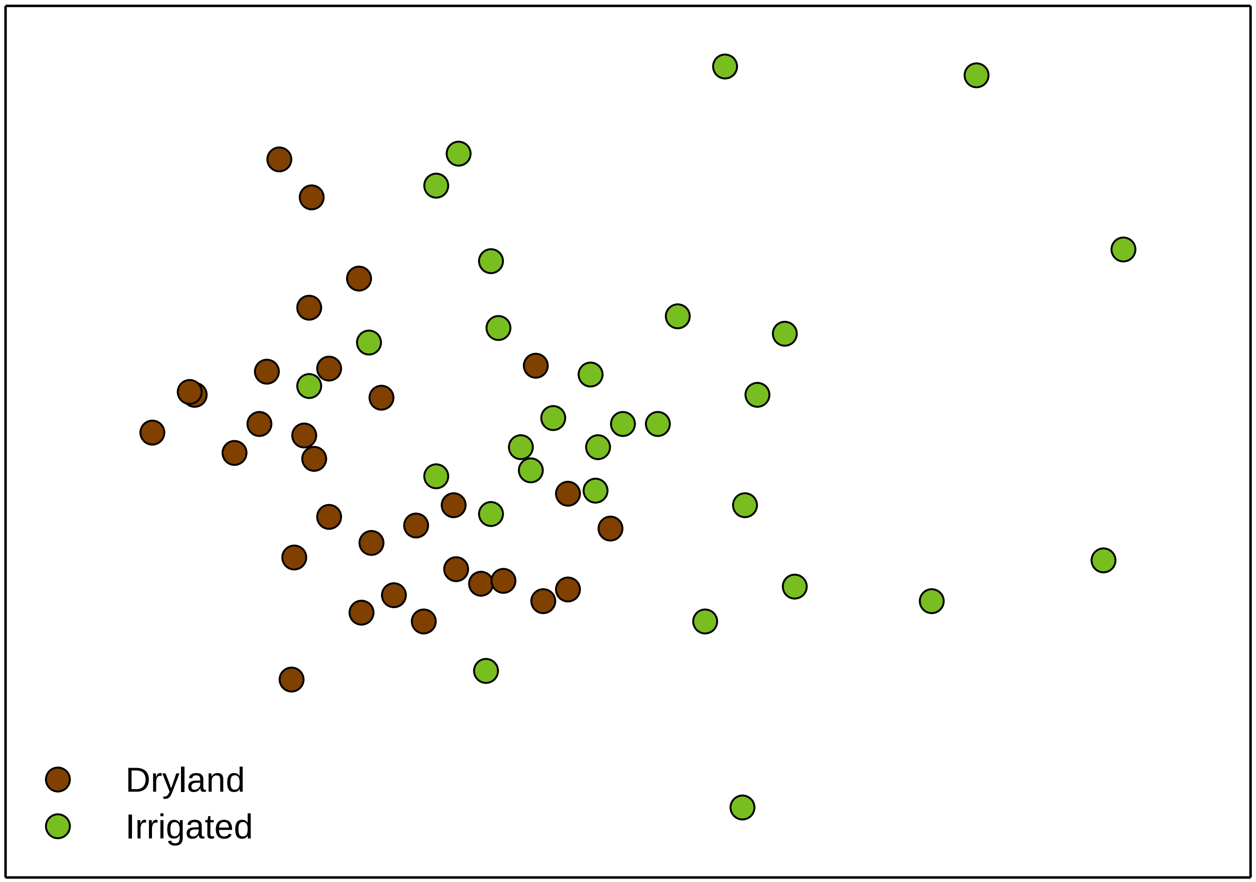


Soil N_2O flux

Both initial 24 h rate and total flux are significantly different



N cycling rates



Preliminary conclusions

- N_2O emissions greater in the irrigated pastures
- Significant C/N gradient across the 64 sites
- OM chemistry also differs significantly, as does overall N cycling

Where to next?

- It's clear that N_2O implications need to be considered where soil C stocks may be being increased
  - There are two angles here:
    1. How do the in-lab incubations relate to field measurements?

       Plant-soil feedbacks – Do in the field or find ways to accurately represent this in the lab
    2. Establishing the mechanisms so the process can be modelled:

Biological:	Different microbial communities?
	Plant N / C pool regulation?
Chemical:	Role of fast-cycling DON?
	What constitutes 'available' N?
Physical:	Water / Oxygen?

Thank you

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