soilquality.org.au

Biology

ORGANIC CARBON STORAGE IN WESTERN AUSTRALIAN SOILS

Key points

- Maximum storage of soil organic carbon in Western Australian soils is rarely achieved, as sub-optimal climatic conditions (rainfall; summer fallow) and soil management issues (biological, chemical and physical constraints) often restrict plant growth and returns of plant residues.
- To increase organic carbon storage in soil, it is important that management practices remove any constraints to plant growth, where it is cost effective to do so.
- Strategies that deliver organic matter below the surface 10 cm soil layer are more likely to build soil organic carbon.

Soil Carbon Research Program—Australia's Farming Future

Sustainable management of soil, in particular organic carbon, is essential for the continued viability of Australian agriculture. Increasing the organic carbon retained in soil (also known as sequestration) improves soil quality and can also help to reduce atmospheric carbon dioxide. The Soil Carbon Research Program (2009–2012) identified land uses and management practices that growers can use to increase soil organic carbon storage and improve production in a changing climate.

Sampling sites

The program measured soil organic carbon at more than 1000 sites within the Western Australian agricultural region, covering a range of agricultural practices, land use history and soil types (figures 1 & 2). The sampling sites were dominated by deep sands (50% of all sites) or shallow duplex soils (21% of all sites). These soil types have low surface clay content making it difficult to store water and physically protect organic matter from microbial breakdown. As a consequence soil organic carbon stocks were low.

Further samples were collected from (a) established field trials to assess the rate of change in soil organic carbon and (b) representative soil type sites to assess methods of determining bulk density (required to calculate organic carbon stock, t C/ha) (figure 2).

Figure 1: *David Hall (DAFWA) and Andrew Wherrett (UWA) checking land use histories prior to soil collection.*

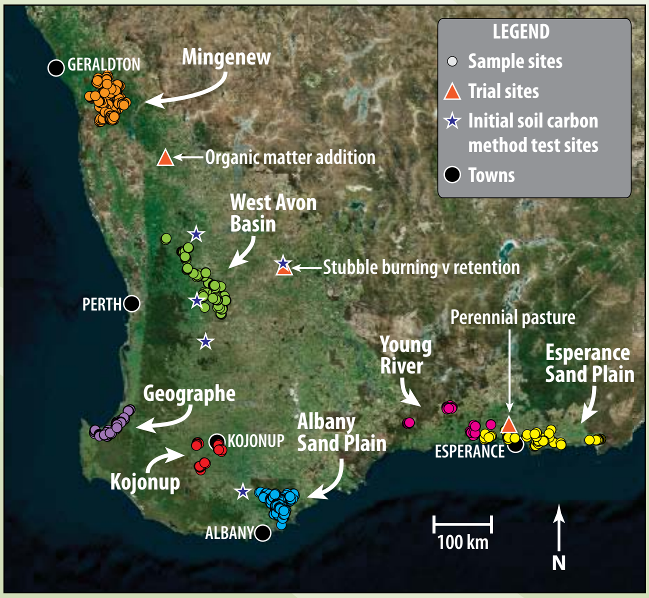

Figure 2: *Satellite image of the Western Australian agricultural area showing the location of sampling sites, trial sites and initial soil carbon methodology test sites.*

Soil organic carbon values

Soil organic carbon stocks (***actual*** carbon storage) ranged from 3.4 t C/ha in a Tenosol (deep sand) under mixed farming to 231.3 t C/ha in a Tenosol (deep sand) under perennial pasture. Best separation in average ***actual*** carbon stocks occurred when grouped by land use (table 1). Modelling indicated that there was further capacity for carbon sequestration in WA soils (***attainable*** carbon storage, figures 3 & 4).

The 0–10 cm soil layer contained more than 50% of the measured organic carbon within the top 30 cm of the soil (table 2). Modelling suggests the 0–10 cm layer is largely saturated (full) in terms of organic carbon storage. There was greater capacity for these soils to store more soil organic carbon below 10 cm; findings suggested these layers are currently at less than half their storage capacity. Strategies that input organic matter to depth are required to realise this additional capacity.

***Table 1:** Average **actual** soil organic carbon (0–30 cm) measured for a range of farming practices in the WA agricultural region indicates the importance of land use in management strategies for increasing soil organic carbon storage. Note: these land uses span a wide range of rainfall gradients.*

LAND USE	SOIL ORGANIC CARBON (t/ha)
Continuous crop	25
Mixed farming	36
Beef production—annual pasture	70
Beef production—perennial pasture	61
Dairy (fodder removal)—annual pasture	93
Dairy (irrigated)—annual pasture	92
Dairy (grazed feed out)—annual pasture	101

***Table 2:** Average **actual** soil organic carbon measured for the Albany sand plain. Soil organic carbon storage changed with soil depth and land use.*

LAND USE	SOIL ORGANIC CARBON (t/ha)		
	0–10 cm	10–20 cm	20–30 cm
Perennial pasture	70	24	14
Annual pasture	56	19	11
Continuous cropping	25	11	7
Mixed cropping	29	12	8

Rates of change

Based on paddock history and measured data, annual rates of change in soil organic carbon were:

- 0.1 t/C ha for stubble retention compared to burning in a low rainfall environment
- 0.2 t C/ha for clay addition to sandy soil
- 0.4 t C/ha under perennial pasture (> 500 mm rainfall).

Modelling suggested annual increases in the range 0–0.7 t/C ha were possible over the next 50 years in the higher rainfall areas.

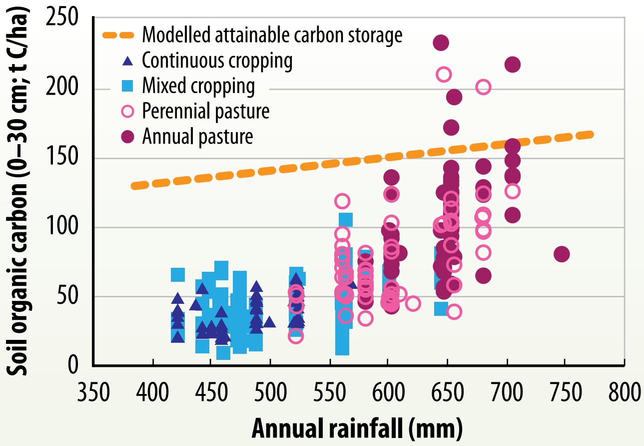

***Figure 3:** **Actual** soil organic carbon stocks for Albany sand plain region. Data are the average of soil groups. The line represents the **attainable** soil organic carbon stock values as predicted by carbon modelling.*

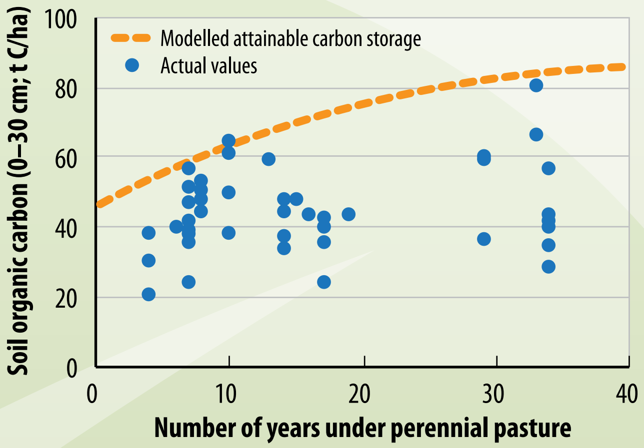

***Figure 4:** **Actual** soil organic carbon at sites on the Esperance sand plain (blue dots) was usually lower than the amount the model predicted. The line represents the **attainable** soil organic carbon stock values as predicted by carbon modelling.*

This means that rapid and large increases in soil organic carbon stocks are not likely in these soils; although land areas are large providing small gains over millions of hectares. Based on annual rates of soil organic carbon change, and the associated spatial variability in soil organic carbon stocks, changes should be monitored on a ten-year time scale.

Authors: **Daniel Murphy**[1], **Tim Overheu**[2], **Andrew Wherrett**[1], **Karen Holmes**[2], **David Hall**[2] and **Frances Hoyle**[2]

[1]The University of Western Australia [2]The Department of Agriculture and Food, Western Australia

Australian Government
Department of Agriculture, Fisheries and Forestry

GRDC
Grains Research & Development Corporation
Your GRDC working with you

This project was supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry under its Climate Change Research Program and the Grains Research and Development Corporation (GRDC).

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

GROWER GROUP ALLIANCE
Working in partnership with researchers and industry

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieving International Excellence