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Biology

CARBON STORAGE ON THE ESPERANCE SAND PLAIN, WESTERN AUSTRALIA

Key points

- Most sites on the Esperance sand plain had lower carbon storage in soil than the "attainable" carbon storage *(or upper limit)* predicted by computer modelling.
- Changing management to overcome soil constraints to production can increase carbon storage in soil.
- The average soil carbon storage under perennial pasture (kikuyu) was not different from annual pasture.
- This is due to (1) the coarse textured sands providing little physical protection to organic matter from microbial breakdown and (2) inherently low levels of nitrogen and other nutrients required to form organic matter.

Soil Carbon Research Program—Australia's farming future

Sustainable management of soil, in particular soil carbon, is essential for the continued viability of Australian agriculture. Increasing the 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 is working to identify land uses and management practices that growers can use to increase soil carbon storage and improve production in a changing climate.

Carbon storage in soil

The amount of carbon that soil can store varies. This is due to:

- Clay—As the clay content of soil increases, it increases the ***potential* carbon storage** of the soil.
- Climate—When the climate allows greater plant productivity, it increases the ***attainable* carbon storage** of the soil towards the ***potential*** carbon storage.
- Management—Growers can influence whether or not their ***actual* carbon storage** is as high as the ***attainable*** carbon storage.

For more information, see the fact sheet "How much carbon can soil store?"

Esperance sand plain

Soils on the Esperance sand plain in Western Australia range from deep sands to shallow duplexes. Close to the coast, beef production dominates and some producers use perennial pasture (often kikuyu) to combat the 'autumn feed gap'. Perennial pastures have longer survival, deeper rooting and greater plant biomass during summer months. As a result, it has been proposed that they may store more soil carbon than annual pastures.

Soil samples were collected at over 100 sites on the Esperance sand plain (figure 1 and 2). ***Actual*** carbon storage was measured to a depth of 30 cm. Findings from perennial pasture and annual pasture were compared. The ***attainable*** carbon storage for the soil types and climate on the Esperance sand plain was estimated using computer modelling. This was compared to the ***actual*** carbon storage from the reference sites.

Figure 1: *Satellite image of the Esperance sand plain showing the soil carbon sample sites. The sample area was 170 km from east to west and 30 km from north to south. Rainfall in the sampling area was greater than 500 mm.*

Figure 2: *Sampling soil from under annual pasture on the Esperance sand plain (image T. Daniels).*

Did perennial pasture have greater carbon storage than annual pasture?

Soils under both annual and perennial pasture on the Esperance sand plain contained on average 45 t C/ha to a depth of 30 cm. Soil carbon storage under perennial pastures was not greater than under annual pastures (table 1). Changing from annual pasture to perennial pasture has not increased soil carbon storage on these soils, and is likely due to the sandy nature of the soils. Soils with coarse texture have lower ***potential*** to store carbon than soils with more clay.

Table 1: *Carbon storage (tonnes per hectare) in the 0–30 cm layer of deep sand or shallow duplex soils under either perennial kikuyu pasture or annual pasture.*

Soil type	Carbon storage (t/ha)	
	Perennial pasture (kikuyu)	Annual pasture
Deep sand	45.5	40.3
Shallow duplex	42.9	48.4

Carbon is stored in soils as soil organic matter. This means that when carbon is stored, other nutrients (such as N, S, P) are also stored with carbon in the organic matter. For example when you sequester 10 t/ha of carbon this ties up 1 t/ha of nitrogen. Therefore poor nutrient retention may limit ***attainable*** carbon storage in coarse textured soils.

Was the attainable carbon storage achieved?

At most sites on the Esperance sand plain, ***actual*** carbon storage was less than ***attainable*** carbon storage predicted by modelling (figure 3). Modelling using realistic management scenarios suggest no further increase under annual pasture, while perennial pastures could reach on average 60 t C/ha over 40 years. This means that at these sites, a theoretical increase in ***attainable*** carbon storage under perennial pastures of on average 15 t C/ha is possible over 40 years. This represents a small annual increase in soil carbon storage (0.4 t C/ha). The project confirmed that perennial paddocks that had been established for about 30 years had measured soil carbon stocks in the range 30 to 80 t C/ha (average 49 t C/ha) highlighting the large variation between individual paddocks.

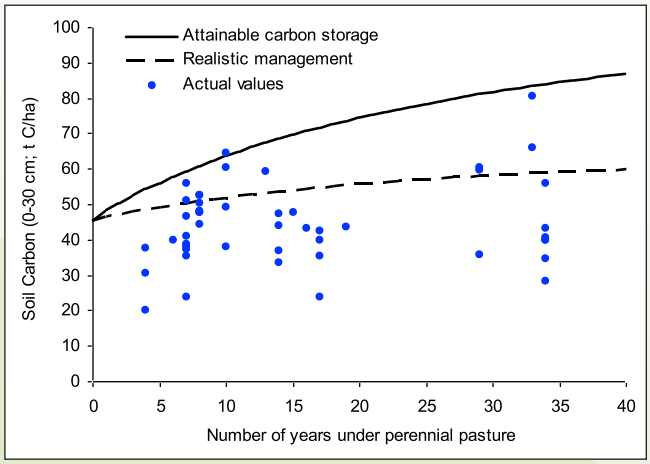

Figure 3: *The **actual** carbon storage at sites on the Esperance sand plain (blue dots) increased the longer kikuyu was grown but was usually lower than the amount the model predicted under realistic management scenario. The **attainable** carbon storage limit was modelled assuming 100% water use efficiency, 12 month growing period and 100% residue return.*

Achieving the ***attainable*** carbon storage requires maximum plant growth and maximum returns (plant residues and manures) in any farming system. Therefore, to increase carbon storage in soil, it is important that management practices remove any constraints to plant growth, where it is cost effective to do so.

Can clay amendments increase carbon storage?

Claying, which is commonly practiced on the Esperance sand plain, is used to overcome water repellency. The aim is to increase the clay content in the surface of the soil to at least 5%—applications of 100–300 t/ha clay will be needed. Because clay physically protects organic material from microbial breakdown, claying water repellent sands has been shown to increase carbon storage. Clay amendment, has been shown to increase carbon storage by 2 t C/ha over 10 years when the clay content of the topsoil was increased from 1 to 6 % clay. For more information, see the fact sheet "Water repellency"

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