South West NRM

Case Study

The potential for soil carbon to offset farm emissions

In 2021, eight livestock producers from south-west WA had their greenhouse gas emissions analysed by Integrity Ag and Environment under Landcare Farming's Carbon Footprint Project.

The analysis, which used the SB-GAFv1.3 tool, estimated that the farms emitted between 392 and 3,196 tonnes of carbon dioxide equivalent (CO2-e) over 12 months in 2021. The most dominant emission was enteric methane, which accounted for an average of 74% of emissions (Figure 1), with total methane accounting for 79% (Figure 2). As expected, emissions increased with herd size, which ranged from 162 head of cattle to 1,032 head.

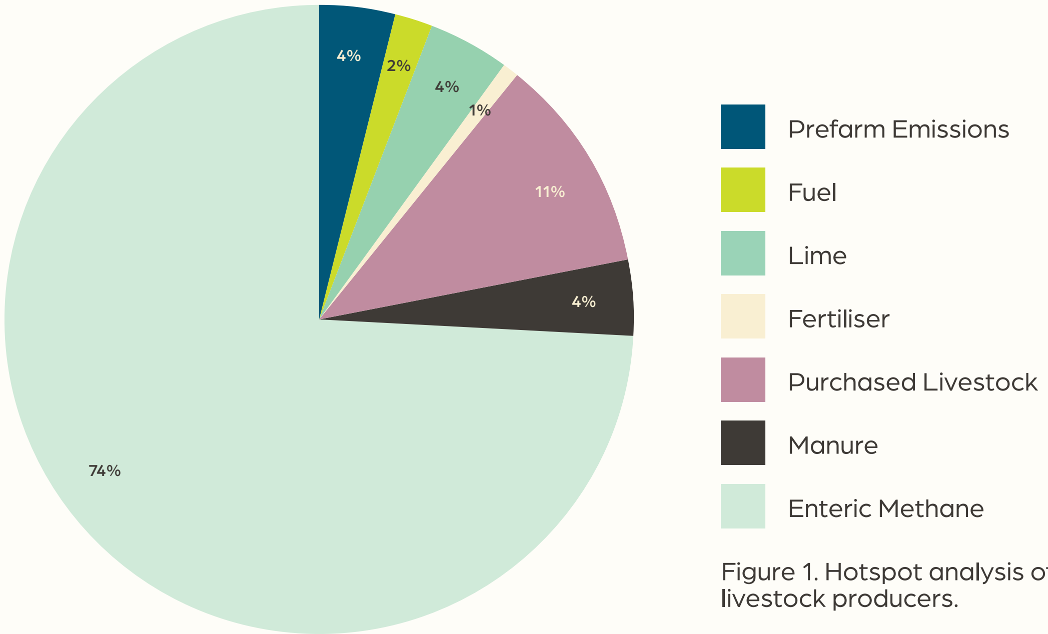

Figure 1. Hotspot analysis of average emissions for livestock producers.

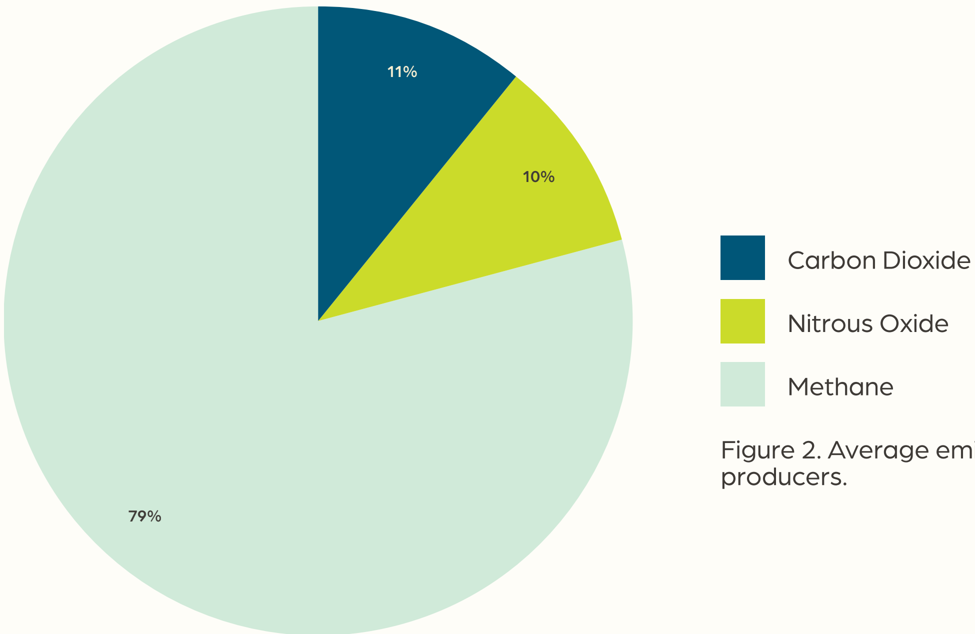

Figure 2. Average emission sources for livestock producers.

Soil carbon

To reduce their carbon footprint, most producers wanted to better understand the potential for increasing soil carbon to offset (or inset) emissions. Sequestering carbon in soil, rather than in trees, is a more attractive alternative for these producers because they have relatively small holdings (200 ha – 1100 ha, with larger holdings having up to 40% remnant vegetation), so consider themselves to have minimal room to revegetate and remain commercially viable. This is especially the case in the South West where the cost of land is high and requires a financial return.

Soil carbon is also attractive because some producers are trialling perennial pastures or diverse, legume-based pasture mixes that could increase soil carbon. Also, most have recently improved grazing management to improve pasture root growth and biomass production.

To help growers understand their capacity to offset emissions with soil carbon, South West NRM, through funding from Landcare Farming, developed **local soil carbon benchmarks** to enable comparisons between farms and across soil types, and to investigate whether any practices were associated with higher levels of soil carbon. Funding also aimed to establish a **practical protocol** for soil sampling to a depth of 30 cm so producers can confidently record change over time and assess the effect of management on soil carbon.

In addition to these aims, South West NRM also used the footprints developed by Integrity Ag and Environment to conduct an "emissions analysis" that estimates the proportion of emissions that could be offset by gains in soil carbon.

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Emissions analysis

For each farm, emissions for 2021 were analysed by:

1. Identifying the number of hectares grazed on each farm that are available to sequester soil carbon;
2. Calculating the level of emissions per grazed hectare (dividing total emissions by grazable hectares);
3. Converting emissions per hectare into tonnes of soil carbon per hectare required to offset emissions by dividing the above result by 3.67; and
4. Applying a potential sequestration rate to calculate the percentage of emissions that could be offset.

The potential sequestration rate applied was 0.15 tonnes of carbon per hectare per year. This is an assumption based on scientific evidence that suggests sequestration rates of between 0 – 0.3 tonnes of carbon per hectare per year could be achieved in the top 30 cm of soil. The mid-range figure of 0.15 was taken.

It could be argued that more carbon can be captured below 30 cm. While this is possible, the soil carbon pool decreases with depth so contributions may not be significant. Alternatively, it could be argued that with decreasing rainfall forecast into the future, biomass production and therefore carbon stocks may decline over time. So, this assumption could be an under-estimate or over-estimate. Either way, it provides some indication for the rest of the analysis.

Results of the analysis show that, with the assumed sequestration rate of 0.15 tonnes of soil carbon per hectare per year, these farms would offset 9–28% of their annual emissions. Most results fell between 9% and 16% with a median of 14.5% (see Table 1).

The 'break-even' scenario for producers, where they could offset all their emissions, including any produced by running the project, and pay for the administrative and monitoring costs associated with a soil carbon project, appears unlikely in this scenario. Sequestration rates would need to be 5 to 12 times higher than assumed here. Research suggests that larger gains are more likely where existing levels are well below local benchmarks.

Farm	Beef average head	Sheep average head	Total emissions 2021 (tCO@–e)	Grazed hectares	Emissions per grazed hectare	Soil carbon sequestration required (tonnes/ha/yr)	Emissions offset at 0.15t C/ha/yr
1	1010	0	2666	475	5.61	1.53	10%
2	1032	0	3196	509	6.28	1.71	9%
3	192	1654	1004	250	4.02	1.09	14%
4	450	435	1154	320	3.61	0.98	15%
5	285	0	814	215	3.79	1.03	15%
6	1	1970	838	184	4.55	1.24	12%
7	162	0	392	200	1.96	0.53	28%
8	760	0	1706	500	3.41	0.93	16%

Table 1. Emissions and soil sequestration analysis.

Soil carbon benchmarks

Soil carbon was sampled at four sites on ten farms (including the eight described above) in 20 x 20 m plots to a depth of 30 cm following the method outlined in the Soil Carbon Research Program (SCarP).

Results from surveys suggest that:

- The levels of soil carbon of the 40 plots sampled were generally at the upper end of values expected for the south-west region of Western Australia.
- However, there was variability between paddock sites across the same farm and between the farms. This suggests that there could be potential for some, likely small, accumulation of soil carbon, particularly in the subsoil.
- There were no clear relationships between soil carbon and other measured variables, which makes it impossible to make any specific recommendations from these data.

Soil organic carbon is driven by higher net primary production and lower biomass decomposition. Plant production can be increased by addressing soil constraints. Previous work shows that sandy coastal soils have significant subsoil constraints that could be addressed, such as nutrition, compaction, soil acidity and poor nitrogen fixation in legumes. However, increasing plant production typically requires an increase in herd size to remain viable, and a bigger herd results in more methane emissions and a bigger carbon footprint to offset.

Depth (cm)	Sand		Loamy sand		Sandy loam		Loam	
	%TOC	C t/ha	%TOC	C t/ha	%TOC	C t/ha	%TOC	C t/ha
0 – 10	4.1	46	6.4	62.4	6.4	71.9	5.3	63.8
10 – 20	1	17.7	4	43	2.5	34.4	2.6	38.5
20 – 30	0.4	8.2	2.4	31	1.4	23.1	1.7	25.1

Table 2. Median Total Organic Carbon (%) and calculated carbon content (t/ha) for common soil textures at each depth. The number of samples per texture/depth ranged from 7 to 14. The two measures are closely correlated. Anomalies (e.g. loamy sand and sandy loam at 0–10 cm) can be attributed to differences in bulk density (higher bulk density increases tonnes per hectare) and gravel content (higher % gravel reduces tonnes per hectare).

A protocol was developed for sampling soil and monitoring change in soil carbon. It is largely based on the CSIRO's SCaRP (Soil Carbon Research Project) method but includes more detail in step-by-step procedures. Key points were highlighted in developing this procedure.

- Limit sampling to 20 x 20 m plots to minimise soil types sampled.
- Monitor 3–5 replicate plots within each soil type. Where soil is variable, more plots will increase confidence in results and detect smaller changes.
- Monitor plots every five or more years.
- Collect soil samples at the same time of year and use the same equipment for subsequent sampling events.
- Use the same laboratory for each sampling event to minimise the risk of variation due to any differences in lab protocols.
- To properly benchmark soil carbon, you need to convert percent carbon into tonnes of carbon per hectare, requiring measurement of bulk density, gravel and moisture content of soil samples (request these from lab).
- Make sure you ask the laboratory to test for Total Organic Carbon (Leco). Standard Walkley & Black soil organic carbon tests are not used in sequestration projects, and experience suggests that producers should be wary about comparing results for this test from different labs for high carbon soils, e.g. >5%.
- Get samples to the laboratory promptly. Avoid having samples caught in the postal system over the weekend. Keep samples cool until dispatched, or dry samples in an oven at 40 oC before posting (even in summer). These measures are to avoid microbial breakdown of soil organic matter and loss of carbon between being sampled and arriving at the lab where they will be dried.
- Collect samples without disturbing the topsoil but take care to avoid collecting excessive plant material from the soil surface.

Group meetings

Farmers involved in the project met three times to discuss how they can move towards carbon neutrality and how they can build soil carbon. These events featured guest presenters, including SW WA's Regional Soils Coordinator Jen Clausen, and carbon service providers and consultants. Some key points recorded from these events include:

- Baseline your farm emissions each year for five years to remove variability in emissions.
- From baselines, identify opportunities and strategies to reduce emissions.
- Look for opportunities to increase productivity.
- Farms will need "insets ". This is a term for carbon offsets that are not sold but are instead retired to offset farm emissions. If farms sell carbon credits earnt from a soil carbon project, they cannot use those credits to offset their emissions and move towards carbon neutrality.
- Buy agricultural inputs that are carbon neutral.
- Control the message. Speak to stakeholders such as buyers about your emissions and your strategy to reduce them.

The second meeting included a presentation from a carbon service provider, who discussed the practicalities of sampling for a soil carbon project under the Emissions Reduction Fund. Key points included:

- Variation in soil carbon is a critical issue when designing a project. If fewer samples are taken, there is less confidence that the average result is actually the average carbon level. Taking more samples increases our confidence in the result, and a credible change is more likely to be detected and credited.
- In a carbon project, one-to-two soil samples are typically taken and tested for every ten hectares. A project needs a minimum of nine samples but more samples can better detect change.
- There is not much difference in cost between collecting a 30-centimetre-deep sample and a one-metre-deep sample, so consider sampling to one metre.
- However, sampling to one metre can be problematic in our rocky soils.

Final event

The final event featured presentations on the project and more broadly on farm sustainability and carbon accounting. A total of 38 people attended, including 21 farmers.

Feedback suggests that the key practice change likely to occur as a result of the event is to baseline greenhouse gas emissions, and improve management to increase efficiency and productivity, thereby achieving a reduction in emissions per kilogram of liveweight produced.

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