FAQ Soil Organic Carbon

Measurement of soil organic carbon

Comment: Lisa Warn, Facilitator Mid Goulburn branch GSSA Healthy soils group: *(Soil Webinar 27/7/2021)*

My concern is that some people are getting C credits for changes in soil C measured only after a few years? Which I think is way too short a period because of the variation and error around measuring carbon. And they don't have control paddocks to compare with, so in research we would have a control paddock to be able to say yep that's definitely our management input that has changed the carbon and not a random thing like seasons or sampling. If they go back in a couple of years' time, C could have gone down because of seasonal variation and nothing to do with what they did. C is very variable between years even without changing anything.

A: Dr Susan Orgill, NSW DPI

Yeah, I hear you for sure and that's where I think you need to weigh up the risks. Because when you enter a carbon trading agreement, you first have to say what your practice change is going to be. Then you estimate what that increase is going to be and then you have a crediting period and then you get your credits. You need to keep C increasing and there's that risk if you are not seeing a solid practice change benefit and if there is bounce around, then there's the risk you have to hand back.

The way you get around that is to do background research. Minimise risk by starting from the lower base line level. Demonstrating that you are getting an increase and being real. You might be issued with credits in the first five years but you don't need to onsell. So after 10 or 15 years and find you are not increasing SOC, you still have those credits sitting with you and you can hand them back or they might be worth a higher value.

Most definitely you can be risk adverse and still participate in emerging C markets but all the practices on the positive list are all the things we want to be doing anyway. Then you have to demonstrate that it is not business as usual for you. That's where the better farm managers are saying I'm already fertilising, managing soil acidity and have good grazing management already. They are getting carbon benefits already, just not the trading part.

Comment: From Felicity Turner, Facilitator Meningie Field Livestock & Pasture Healthy Soils group *(Soil Webinar 27/7/2021)*

And that is the challenge... the carbon market is potentially rewarding the laggards and not the innovators/early adopters.

Q: Some farmers have reported changes like 1% or even higher in soil organic carbon in just two years. Could this be true? *(31/8/2021)*

A: Lisa Miller, SFS No, this is not feasible.

Here is why.

Firstly, are we talking about a 1% change in 0-10cm of soil or 0-30cm of soil, the depth carbon stocks are measured in? And how compacted or squashed is the soil because a squashed soil will contain more soil and therefore more carbon. This is measured by bulk density. For example, a clay loam in south-west Victoria has a typical BD of 1.3g/cm^3 in the topsoil.

If we are talking about a 1% change in 10cm with BD of 1.3 g/cm^3, then the type of organic carbon change required is 13 tonnes C per hectare. Calculated by the following:

10,000m^2 in one hectare x 0.1m soil depth x 1.3g/cm^3 bulk density x 1% C= 13 tonnes C per hectare. This is because 1% soil organic carbon = 1 g carbon per 100g of soil = 10g carbon per kg of soil.

But organic matter (OM) contains 58% organic carbon.

So 13t C/ha is equivalent to growing 22.4 t/ha of OM (13 x OC to OM conversion 1.72). But bugs eat 90% of it and return the carbon back into the atmosphere as carbon dioxide gas, so only 10% remains to contribute to the C pool. Therefore, to get 22.4 t/ha of OM (& 13t C/ha), we actually need to grow a total of 224 t OM/ha of both roots and shoots. 22.4 ÷ 10% = 224 t OM/ha.

A rough rule of thumb used by Cam Nicholson, Nicon Consulting to work out how much is above ground biomass to grow is a ratio of 1:1.5 for a perennial pasture. So, for phalaris
1.5 is below ground (roots, AM fungi, glomalin etc) to 1 above ground (shoots, stems, leaves). In other words of the total OM grown, 40% above ground, 60% below ground. 1÷ (1+1.5) = 0.4 and 1.5 ÷ (1+1.5) = 0.6

So, using this ratio to calculate above ground material you need to grow 90 t OM/ha and 134 t OM/ha below. 224 x 0.4 = 90 t/ha and 224 x 0.6 = 134 t/ha.

You can see that to grow an extra 90 t DM/ha over a couple of years, would be near impossible. We normally grow about 10 DM/ha. Even if we increased our pasture growth by 4 t DM/ha this would mean it would take us 22.5 years to change organic C by 1% (90 ÷ 4).

13t ha = 22.4 t /ha = 224 t/ha => Ratio 1:1.5
C OM after bugs eat 90%

90 t/ha

134 t/ha

(some product loss in grazing)

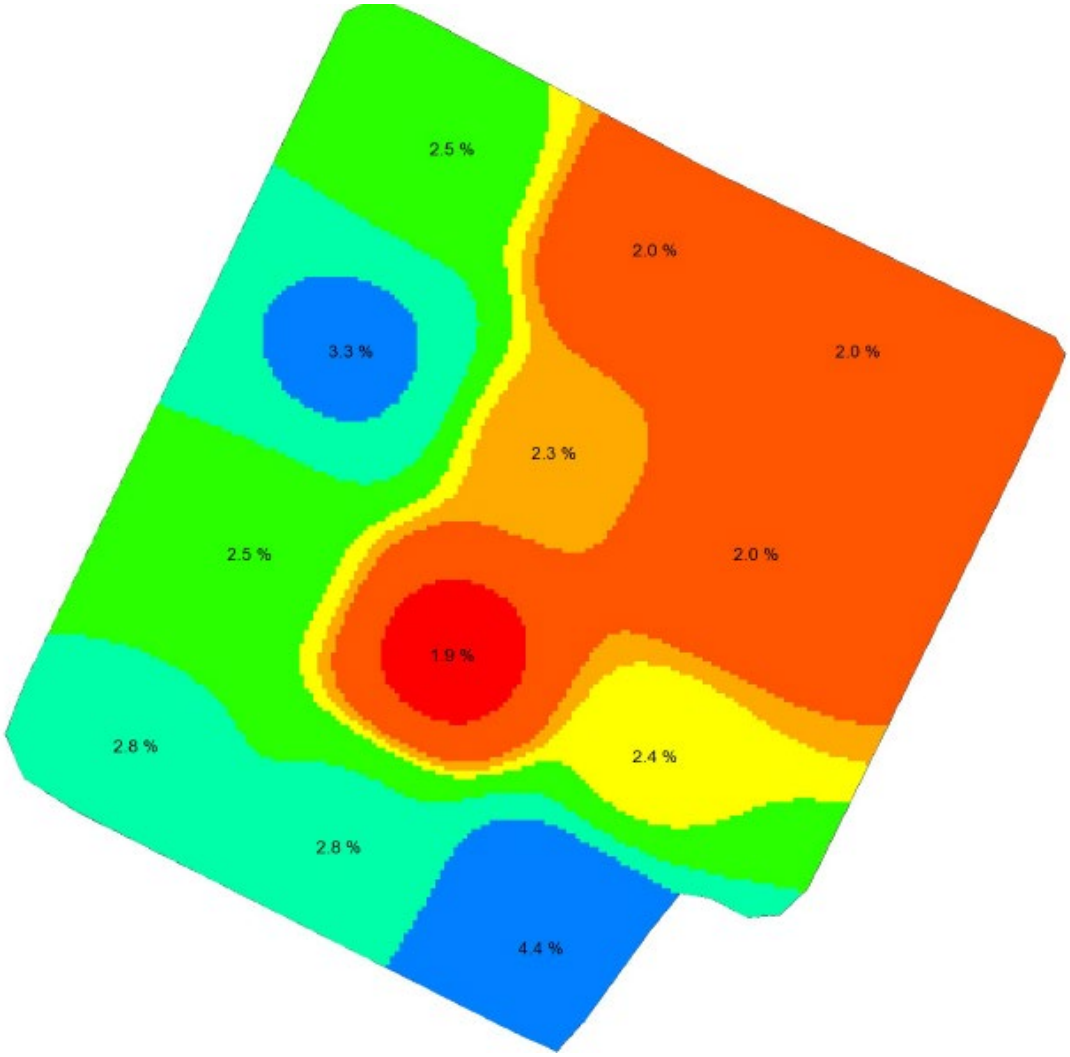
The other factor to consider is nutrients needed to build organic carbon. Humus is the type of soil organic carbon we strive for (more stable and resistant to microbial breakdown) and 1 t/ha contains 60 kg/N/ha, 12 kg P/ha and 9 kg S/ha. So, if we need to grow an extra 90 t DM/ha to achieve a 1% organic carbon, then the nutrients have to be present or added, or simply put you don't build organic carbon (humus).

Q: Lisa: What soil sampling regime would be typical for C trading in terms of cores/hectare & costs/hectare to pick up the relatively small expected changes of 0.3 to 0.8 tonnes of carbon/ha/year down to 30cm that one might expect over 5 years?

A: Robert White, Retired Professor at the University of Melbourne *(GSSA conference 4/8/2021)*
The protocols for soil sampling are set down in the CER (Clean Energy Regulator) regulations. Number of samples will depend on the size of the Carbon Estimation Area (CEA), with a lower

density per ha the larger the CEA. Costs of sampling and analysis can range from $30 to $100 per ha, depending on the precision aimed for and the natural variability of the system.

Comment: Lisa Miller, SFS. Carbon trading price is $16/t/ha, so no wonder people are saying that the costs involved of trying to show change under variable makes carbon trading unattractive and why the Clean Energy Regulator is trying to develop testing methods to bring back paddock costs to $3/ha. Checkout the carbon mapping of our Rokewood Pasture Trial site: Wingeel paddocks. The paddock is only 3 hectares in size but organic carbon varies from 1.9% to 4.4%. SOC can vary substantially across space and time in a paddock, as such, a well-planned sampling strategy is needed.



Grazing management carbon benefits
Comment Jim: Not all that convinced that grazing management plays much of a role in soil C stocks - grazing management being restricted to temporal and spatial management of stock over the landscape excluding "ungrazed" situations. *(Soil Webinar 27/7/2021)*

A: Dr Susan Orgill, NSW DPI
Jim raises a good point and I hope he noticed that I didn't actually refer to set stocking, as I agree it is not reality in most cases.

What I wanted to highlight was that planned grazing is key – have goals around opening up for legumes, allowing seed set of key species, and importantly don't overgraze or else you run the risk of losing SOC via erosion. These are all consistent with increasing OM supply and reducing loss. With regards to set stocking, in one of the studies I was involved with (replicated grazing trial around Berridale – paper available) we decided to remove the set stock treatment in our analysis as it was an open cell (replicated across paddocks) that of course stock rarely went and grazed near plus we decided it wasn't all that relatable. The point of that paper is grazing livestock (not locking up paddocks) is key.

I have also published data showing no difference in SOC stocks between rotational grazing and 'continuously grazed' (acknowledging the point from earlier) – but key to this is that the results were found to be confounded by the rotationally grazed sites being no-input fertiliser sites – and this, like Yin's work, was a field survey point in time, not replicated grazing trial. There's plenty of data out of the USA on the impact of grazing intensity and duration, and some of our DPI work has also related this to increases in biomass production, similar to the Vic work.

I do think we can be clever in the way we use grazing animals to influence pasture composition, quality and quantity – but this is only one component and there are other things happening to influence SOC.

Question Lisa: Who was the author of the Victorian work you alluded to on soil carbon benefits in grazing systems? *(Post Soil Webinar 27/7/2021)*

A: Dr Susan Orgill, NSW DPI. Paper I referred to with $ value of benefits is; Meyer RS, Eckard RJ Cullen BR, Johnson IM (2015). "Process modelling to assess the sequestration and productivity benefits of soil carbon for pasture." Agriculture, Ecosystems & Environment 213: 272-280. DOI: 10.1016/j.agee.2015.07.024.

Comment: Lisa Miller, SFS More information on this work mentioned below is at:
http://piccc.org.au/research/wfsam/subproject/soil-carbon

Soil carbon benefits in grazing systems

Whole farm systems analysis from the WFSAM project

Researchers investigated the on-farm benefits of soil carbon accumulation following a transition in land use from cereal cropping to grazed pasture. The impact of increased soil carbon on pasture production (due to changes in

soil nitrogen mineralisation and plant available water holding capacity (PAWHC)) was measured at two different soil carbon starting points (high and low), on two soil types in two climatic zones.

Over the 20-year simulation:

- Soil organic carbon accumulation was faster in low carbon soils (0.3-0.48 t C / ha / yr) compared to their high carbon counterparts (0.02-0.23 t C / ha / yr)
- The increased pasture production associated with higher soil carbon was valued at $42.51-$157.19 / ha
- The entire value on low rainfall sites ($42.51-$133.54 / ha) was attributable to increased PAWHC.
- On high rainfall sites, increased nitrogen mineralisation increased pasture production on high carbon soils. The increase in N mineralisation on high rainfall sites was valued at $85.03-$95.61 / ha.

The comparisons between high and low carbon soils suggest that the direct farm benefits of high soil carbon on nitrogen mineralisation and associated pasture production alone are substantial. These on-farm benefits are far more compelling motivation for increased soil carbon than the trading of this additional carbon in national or international carbon markets, given likely prices, risks associated with permanence rules, and in particular the monitoring, reporting and verification overheads.

Nitrogen

Question Lisa: Mark and even Jason prior to you mentioned the importance of N to build soil carbon, and you mentioned the importance of legumes so perhaps in the grazing systems, keeping and promoting clover growth in the rotational grazing management space with perennial grasses is going to be important. Is this right? *(Post Soil Webinar 27/7/2021)*

A: Dr Susan Orgill, NSW DPI

Nitrogen is essential for building SOM; so grazing practices that open the pasture sward up and allow for legume regeneration (assuming they also are nodulated with effective and functioning rhizobia) is key. But on grazing management, keeping plants actively growing for longer also assists with building SOC. So, in the same sense that overgrazing can reduce actively growing plants, so can under grazing. Grazing management terms seem to be tied to strong emotions… wars have started over less… but strategic or planned grazing (for lack of a better term) that supports legume regeneration (and function), maximises ground cover and optimises the amount of time plants are actively growing is linked with increasing SOC. Some parts of the landscape are more responsive to this than others.

Species Diversity

Q Lisa: Can you please comment on the species diversity area in assisting with building soil carbon? You opened my eyes up to the idea that probably they are putting out different root exudates and so attracting microbes, which helps to build better soil health, but I'm not entirely sure it helps them increase C more so than single species? You had written species diversity in green, so perhaps not entirely proven yet? *(Post Soil Webinar 27/7/2021)*

A: Dr Susan Orgill, NSW DPI

There is some published data (including a Nature paper) coming out of the USA on mixed species plantings. I'm yet to find anything on the 8 species 'rule' of some camps but I'm keeping a (realistic) open mind. Benefits are around diversity of complex carbon molecules, deposition of carbon in different parts of the soil matrix, supporting different microbes, different growth patterns (therefore carbon inputs – type, depth, exudates and root morphology included). There is ad hoc data on this in Australia, but to the best of my knowledge little published data in Australia (more lack of focus than

it doesn't work though – some trials coming online). Question then becomes does the benefit of this outweigh the benefit of a big healthy perennial pasture with annual legume – not sure this has been tested – but in the scheme of things maybe not. Certainly – multi-species seem to support a greater diversity of microbes – data seems to support that.

Comment: Lisa Miller, SFS
There was some research being undertaken in the UK presented at the GSSA 2021 conference by Anna Thomson, Agriculture Victoria which was a comprehensive trial looking at multispecies in dairy pastures versus just perennial ryegrass with urea. It seemed in some years, multispecies had better biomass production than just the nitrogen fertilised perennial ryegrass.

Soil carbon stubble benefits
From Craig: This question follows the comment regarding carbon credits, and the ability to sell something that is retained and offers further benefits. There is news of a bioenergy plant at Ararat, producing gas and biochar from cereal straw. Today we've heard about the importance of: increasing SOC and managing pH, growing more DM, protecting structure, retaining soil cover. What should farmers consider long term, vs short term gains of financial returns and residue management for immediate crops? And, the implications of those points have in correctly valuing the straw? *(Soil Webinar 27/7/2021)*

A: Dr Susan Orgill, NSW DPI
That's a situation specific example. So, if its opportunistic this year to sell the straw, that you couldn't sow through anyway and still retaining some, then that's the decision you could make. I remember going to a site in WA and they were harvesting stubble for biochar. Their row lines were 80cm apart and there was not much happening in that paddock. So, the value was in the standing stubble and organic matter retention for protecting the soil surface. I'm bias anyway it's all about the soil. But if you had to burn anyway then that seems like a sensible option.

Comment: Michelle McClure Facilitator of Hamilton Healthy soils group.
That's the good thing about the high rainfall zone, we do create lots of biomass but there is a tradeoff with going into a cropping system and how you sow into it and we are still working out how to deal with it.

Dr Susan Orgill, NSW DPI
Treat it a bit like a recipe. Stubble going in, add a whole lot of nutrients to break it down quickly to get humus formation but there's a very real cost to that.

Lisa Miller, SFS: 1 t/ha of humus contains 60 kg/N/ha, 12 kg P/ha and 9 kg S/ha.

For more FAQ go to:
https://www.agric.wa.gov.au/soil-carbon/soil-organic-matter-frequently-asked-questions-faqs