Matthew Warnken:

Well, good afternoon or good morning, everyone and welcome. I'd like to very much welcome everyone today to our second episode in our webinar series on how to grow Top Soils. I'd like to begin by acknowledging the traditional custodians on the land on which we're gathered today and pay their respects to their elders, past and present and emerging. My name is Matthew Warnken, I'm the managing director of AgriProve. AgriProve's a soil carbon product developer that basically enables landholder participation in carbon and other environmental markets, enabling farmers to access additional revenues. We're hosting a seven-part webinar series, and are very fortunate to have Declan McDonald who is the principal soil scientist of Regen Ag, also here as the presenter to help unpack that journey on how to actually improve soil health and how to grow soil carbon.

Matthew Warnken:

Declan's a certified professional scientist, has a wealth of experience in soil, in Agriculture and a variety of roles from both the public and private sector and so is very well placed to provide you those unique insights into growing soil carbon, and the science behind how to grow soil carbon. The first webinar was on how soil works and how plants grow, and my key takeaway from that episode was the shift that occurred in agricultural practices post Second World War. As part of that Green Revolution was a shift towards feeding the plant and not necessarily feeding the soil. And the results of losing phosphorus solubilizers, nitrogen fixes, the removal of deep roots, due to the tillage and soil disturbance. And a key one for me was that loss in biodiversity, I think a Declan quoted this a figure of 80,000 arthropods down to 6,000 arthropods per square meter. To end up in this situation where we've got agriculture systems that are dependent on external inputs and landscapes that have lost literally millions of tons of soil carbon.

Matthew Warnken:

So our challenge, which is also our opportunity is to reverse this trend with a focus on agriculture practices that grows soil carbon, that do so with the real commercial focus on reducing costs, increasing profits, and essentially deploying a risk management strategy, and an adaptation strategy to a changing climate. Today's webinar is on organic matter - the cornerstone of soil health and sustainable production. Before we get started, just some quick housekeeping points, we are recording the webinar so each module will be available on our website, so you can catch up if you do miss a session of the seven-part series. We'll be running for about an hour, Declan will be speaking for roundabout 45 minutes and we will have question time at the end.

Matthew Warnken:

Today's session is also being streamed on YouTube Live. And there is a chat pane on YouTube Live for questions and comments. If you're attending via the Zoom webinar, we do have that Q&A for questions, and you're very much welcome to ask those questions throughout the webinar, and to use the chat function if you've got any other comments. And just on the Zoom part, you can send a message to everyone or just the host and the panelists. So once again, we're very fortunate, very happy to have Declan here as our presenter, and I’d like to welcome Declan onto the webinar series and episode number two. Over to you, Declan.

Declan McDonald:

Okay. Thanks very much, Matthew. Thanks for that introduction. Now, I'm just going to start sharing my screen and hopefully you can all see my opening slide. Organic matter - the cornerstone of soil health. Can you see that? I trust you can.

Declan McDonald:

Okay. So this is the second in the series of seven webinars. What I wanted to do was start off simply last week talking about how soil works, and Matthew paraphrased that really well. Today we need to get stuck into organic matter, because it really is the cornerstone of soil health. So we need to understand organic matter and its role in agroecology, in systems management, because it really does underpin the resilience and strength and productivity of our soils. Next week we're going to be talking about soil biology in some detail, the week after mineral management, the week after managing fertility to build soil organic matter and soil organic carbon, then we'll talk about management practices to grow carbon and we're going to wrap it up on week seven to talk about monitoring and evaluation, so how do you know that you're making progress.

Declan McDonald:

So let me get on with it. We've got a bit to cover today, so I'm going to go through some of these things, hopefully not too quickly, but quickly enough. So I'm going to start off, What is soil organic carbon? Well, it is a fixed component of soil organic matter and I certainly use the terms interchangeably, although strictly speaking I shouldn't. Soil organic carbon is pretty much a consistent 58% of soil organic matter. Total soil carbon, I should just make the point, includes inorganic carbon, so inorganic carbon is carbonates. Some soils have high levels of carbonates other soils have got almost none, but just to understand that there's a difference between total organic carbon and total soil carbon. Soil organic matter is made up of anything that is living or was once living.

Declan McDonald:

In addition to organic carbon, soil organic matter contains a range of essential macro and micro elements and because of that soil organic matter is the primary energy source in the soil. And just to illustrate that point, you can see here this is some basic analysis of humans, bacteria, fungi, crop stubble, humus, and what's called light fraction, I'll talk about that form of organic matter as we go through, and you'll see that the carbon nitrogen phosphorus sulfur proportions are fixed in all of these different organisms. But the real point I want to make here, is to show that there are substantial components of macro elements and micro elements not shown in organic matter, and that is what drives production, that's where so much energy is coming from.

Matthew Warnken:

Excuse me, Declan, just with the presentation, you're actually in presenter view. I wonder if you might be able to just toggle that onto just seeing the main slide.

Declan McDonald:

I know what you mean. Yes, I can do that. I'm going to stop sharing and then I'm going to share again. Yes, okay. I think that will sort us out.

Matthew Warnken:

Yes, that's great. Sorry to interrupt your flow.

Declan McDonald:

No, that's fine. So that looks better. Thank you for that.

Declan McDonald:

Okay. Soil carbon is so important as a component of soil organic matter, because it really controls these three key functions in soils; soil physics, chemistry and biology. We often talk about this being the stool with three legs, and the organic matter is the seat and it's connected by each of these three legs, and these three legs have to be functioning optimally for that stool to be robust, resilient, and to bear the weight of production demands that we put on it. Now, since the Green Revolution we've had an overly strong emphasis on the chemical side of production, followed by the physical, then by biological. So we're beginning to bring the biological function back into the frame, because we have really suffered the loss of it. Okay. So important for profitability and important for long-term viability. I've covered off on those points.

Declan McDonald:

Okay. So I shared this slide I think last week, and really this is just reminding us again that we have lost so much carbon with clearing the land and with cultivating the land and the kind of farming that we have used, whether it's been tillage or whether it's been grazing. And so many of our landscapes have been grazed in a way that worked in cool west northern climates, but absolutely do not work in warm dry Australian climate, and we really need a completely different model of grazing, in my opinion, to sustain grazing landscapes and to return much of this lost soil carbon to the system. So we want soil carbon and we want a lot of it. As I said, it's the primary energy source in soil, so it's food for soil microbes, it holds water, it's a really significant element in the soil, and as I'm showing there, relatively small increases in soil organic carbon and organic matter massively increases the amount of water that's held in a hectare of fertile soil. Organic matter has a huge role to play in nutrient holding capacity.

Declan McDonald:

So we'll talk later about cation exchange capacity which is a measure of the soils' ability to hold nutrients. So for example, a sandy soil might have a cation exchange capacity of five, a clay soil might have a cation exchange capacity of 25, but organic matter might have a cation exchange capacity of 300, 400. So you can see in this way, it punctures enormously above its weight in terms of its nutrient holding capacity. It has a huge role to play in soil structure in the way that the soil is organized and in the way that the soil organisms organize the soil for their benefit. So this big relationships between structure and yield, which I'll talk about, soils are softer when they're well-structured. Compaction and structure work, they're opposite ends of the scale, compaction is major damage to soil structure, and of course we need soil structure for rapid infiltration of water and exchange of gases between the soil and the atmosphere. And we'll talk about organic amendments as we go through too, because they're not all created equal.

Declan McDonald:

How do we get it? Well, we can grow it, crop roots and stubble's, intercropping, ground cover. The most important thing really, is keeping the soil covered at all times. And zero till is a mechanism that recognizes that in a cropping situation where it is harder to maintain ground cover year round. We can buy it in, in the form of animal manures and composts. And the obstacles to sequester in higher levels of soil carbon, it is really about imbalances in the soils demand for organic matter, so we have to look after the critical balance of soil carbon in, soil carbon out, and things like overgrazing and burning are ways that we lose large volumes of soil organic matter really very quickly. There's issues about cost, handling, and transport to bring in carbon if we're going to import animal manures and compost, and then there's issues about the quality of the material that we're bringing in. Is all organic matter equal and how do we figure that out? So we'll cover some of these points as we're going through.

Declan McDonald:

So our traditional understanding of sequestering soil organic matter has always been just grow bigger crops, and as you can see, big roots means a lot of organic matter going into the soil. Now, the conventional wisdom has always been we grow bulk organic matter for the soil by growing big crops, so we put lots of fertilizer on to grow big crops, but we're learning now that that is not working. And we know it's not working because we've gone out on to landscapes where there's been high levels of fertility where high levels of fertilizer have been applied over years, and that is not always returning high levels of soil organic matter. What we're understanding more and more, is the role of soil microbial biomass and their contribution to the soil carbon pool and this relatively new research is showing we're able to discriminate now, thanks to some sophisticated tools, the origins of soil carbon and we're learning that microbial detritus is contributing really significant quantities to the total soil organic carbon pool, far more than was ever previously appreciated.

Declan McDonald:

Now this has got really critical consequences for the way that we farm because we have ignored the biological dimension so much over the last 60 plus years. If that's where most of our sequestered organic carbon is coming from, well it's no surprise that we have depleted organic matter and that we're having difficulty reinstating some of those previous levels of organic matter. So we have a huge dependency on microbes to sequester that organic matter, and there's more and more evidence coming through of the effectiveness of high biological populations and soil carbon sequestration, and in fact a very good example, is one of Matthew's clients Niels Olson in South Gippsland who received the first carbon credits for carbon sequestration, and I suspect that a significant contribution that elevated carbon came from microbes on Niels' farm.

Declan McDonald:

Now before we go too much further, I just want a cover off on some terminology. I have talked about soil carbon being a component of soil organic matter, when we talk about carbon sequestration, I'm sure most of you understand this, but I'm just covering off that it implies a measure of permanence. So we're taking carbon from the atmosphere and we're putting it in the soil and we want it to stay in the soil, because we want to increase soil organic matter, we want to restore those lost quantities of soil organic matter. The carbon farming initiative is the mechanism through which farmers get paid for carbon, I'm not going to talk about, Matthew is the expert on that, but I will talk about carbon pools. And what we talk about here with carbon pools, is the fact that carbon exists in different forms in the soil. So the three principal pools that we talk about are labile, humus and recalcitrant, and as you can see, there's a few other names just to add to the confusion, where sometimes labile carbon is referred to as particulate carbon or the light fraction of carbon. Humus is often referred to as the slow pool of carbon and recalcitrant carbon has been referred to as inert carbon or resistant carbon. We know now that it's anything but inert, but these names will still pop up from time to time.

Declan McDonald:

Now, to highlight the main differences between these three pools, I'm going to show you a slide that looks a little bit complex but I'll step you through it so that it's relatively easy to understand. On the left hand side here, the graph represents changes in clay content, so down the bottom here where we've got zero clay, we've really just got sands or silts. Up the top here, we've got a hundred percent clay. Most of our soils are similar in this region here, sandy loams will be somewhere around here, maybe 10, 15, 20% clay, clay loans will be 25 going up to 40% clay, and above 40% we're into light clays and heavier clay. So most of our soils are going to be in this area here. On the bottom axis here, we're showing some of the different soil properties that soil organic matter influences, cation exchange capacity which is the nutrient holding potential of a soil structure, energy for biological processes, provision of nutrients and soil thermal properties.

Declan McDonald:

So the different pools of soil organic matter, so the recalcitrant, the old slowly turning over carbon, and the less slow turning over carbon, humus. These forms of organic matter contribute enormously to the nutrient holding potential of the soil and also the water holding potential of the soil. When we look at soil structure, we see that particulate, the younger, the faster turning over carbon is contributing really significantly to soil structure as is humus. When we look at energy for biological processes, we see that the particular carbon has got a big role to play here and that's because it's less protected in soils, its more valuable for microbial consumption, and a small proportion of the humus is constantly turning over as well. In terms of provision of nutrients for plants, we have a small amount coming from the particulate matter, but the humus is the real reserve of nutrients for plants in soil.

Declan McDonald:

And thermal properties, it's really around humus and the recalcitrant carbon, because these are the very dark colored carbons that influenced soluble color, and soil color is directly influencing soil thermal properties. I'll kind of touch back on these points as we go through and talk about other properties. I really just want to make a point here, that these pools are not fixed, they're constantly moving. And they need to constantly move, so as one pool is depleted it gets topped up by fresh organic matter coming in, so this is the fresh stuff, that very labile material coming in, that gets used up very quickly. A proportion of that material is going to go through the microbial biomass, so the bugs will eat this stuff and then as the bugs die, and remember I was saying that microbial biomass is contributing hugely to soil organic matter, this is going down into the slow-moving pool, the humus pool. And as this material gradually gives up its nutrient load through microbial degradation, it again enters this part of the cycle where it becomes available for plant uptake.

Declan McDonald:

Some of the carbon from all of these pools, as it's consumed by soil microbes it's released as CO_2 to the atmosphere, and when we burn with either burning stubble or grass fires or forest fires, that's when the recalcitrant carbon component it's a form of charcoal, and that's when it gets laid down. So the really important point here is, this is moving all the time and it must move and if it doesn't move, we have serious problems, we have a constipated system that is really where the soil is going to be hard, nutrients aren't fighting, plant growth is going to struggle. So when we have high microbiological and macro biological populations, they're the things that are driving the cycle, and that's when nutrients are being released for plants to grow, more material has been coming in and being processed. So think of this as a factory with goods in, goods out, cycling through, the busier it is, the faster it is, the more efficient it is, the better that factory is going to work.

Declan McDonald:

And I often use the analogy of the old analog watch where we have wheels spinning at different speeds and we need them all to move at the same time, at their own speed for the watch to work as a whole, and so it is with the carbon cycle. If all of these wheels spin at the speed that they're supposed to spin at, we have a perfectly functioning system. Now, let me talk for a minute about what influences carbon capture, because there's a lot going on here. Firstly climate is probably the biggest influence, and we've got this fancy word called humification, and really all that means is the process of humus development in soils, and it works best in cool dump locations and it works least well in warm dry locations, which is why in Australia, the highest organic carbon soils in the country, are pretty much found in the off ways and in the Tasmanian Highlands. And the lowest levels of organic matter will be found in the dry interior. So where we have moisture, where we have cool conditions we have retention and building up of soil organic matter in the humus pool and we have the opposite happening in warm and dry locations.

Declan McDonald:

And the second biggest influence on carbon capture is management practices, and soil disturbance whether we're tilling or trying to reduce that tilling, its soil disturbance really accelerates carbon loss. And one of the main reasons for that of course, is it influence on the carbon cycle, it basically brings organic matter into more intimate contact with soil microbes and temporary promotes soil microbial populations, but they quickly exhaust the available carbon. And the third point of course is the quantity of carbon going into the system. So once upon a time, the sustainability and the fragility of our systems was driven by green manure and the return of other forms of organic matter brand manures, et cetera, going back into the system. With the advent of the Green Revolution and the development of powerful fertilizers we said, "Well, these grow, crops, fast and well, we don't need to worry about putting manures, et cetera back into the system." And that of course has created a considerable draw down in soil organic matter.

Declan McDonald:

And the third thing that strongly influences soil organic matter levels in soil, is the soil texture, the proportion of sand versus clay in the soil, and as you saw in that slightly complicated diagram that I showed you previously, the cation exchange capacity is largely made up of the humus and recalcitrant carbon components, and basically the more clay there is in a system to a point, the more organic matter it's capable of holding. And finally, time. Time is everything here because organic matter builds up slowly, usually more slowly than we're able to deplete it, so it requires real commitment and resolute effort to make sure that there is enough organic matter going in every year to continue the build-up, the sequestration of carbon in our soils. So other influences on carbon capture are soil pH, so the chemical environment, drainage has a big influence on carbon capture which refers to the chemical and physical environment, soil structure has a big role in the capture of carbon also, and things like salinity and overgrazing, and again the volume of organic inputs.

Declan McDonald:

I'm just going to touch briefly now on each of these points and just mention why they influence carbon capture. You will be familiar with the diagram, the graphic on the left, which shows as we move away from a neutral or slightly acid pH where we have optimum availability of all macro and micro elements, the availability of different elements becomes constrained in strongly acid or strongly alkaline soils. But interestingly, the cation exchange capacity as is shown here, and I mentioned before how significant the cation exchange capacity of organic matter is, and this is just looking at cation exchange capacity of the different types of organic matter, so green is the recalcitrant, the very, very slowly turning over material, the humus is also the slow pool, and the particulate organic matter is the labile carbon, the faster turning over pool. The soil pH is a significant influence on the cation exchange capacity, on how much nutrients these different forms of organic matter can hold.

Declan McDonald:

So yes, we can grow crops quite well down at 5.5, but as you can see we're definitely not optimizing our system for production if we're trying to work at a pH of 5.5. If we were up here at the pH of high sixes or seven, you can see that we're doubling the cation exchange capacity of the benefit of the cation exchange capacity from the different components of organic matter. Waterlogging, it's a bit of a no-brainer when we look at this slide here, but if all this soil here is waterlogged, it's going to be biologically drowned. So we're not going to be getting carbon sequestration because we're not getting roots or anything growing in here, and we're not getting microbes living in here. So we want our soils to be well drained so that these roots can grow to depth, we can have microbiological activity to depth and we have soil carbon sequestration to depth.

Declan McDonald:

And when we're talking about optimizing physical condition for soil carbon sequestration, we're talking about the impact of tillage on structure waterlogging and compaction, and I have to use these analogies of the flooding or catastrophes such as earthquakes, and you see what it does to human habitation, so if you imagine this is a poor network in the soil and this is where soil organisms used to live, well the tractor has just gone through this part of the paddock, they're all crushed, that soil is not going to be functioning particularly well at all. Now why this is so important for yield is, a well-structured soil high in organic matter has got more air, has got better drainage, has got better opportunities for root expansion, has got better opportunities for microbial population enhancement.

Declan McDonald:

It was done by colleagues in Tasmania a number of years ago, that looked at the percentage of a crop yield and that was aligned with the structure score of the soil. So this was a visual assessment that said, "Okay, this soil here is compacted and cloddy with a score of four or five, this soil over here is beautiful friable, it's been well looked after, there's been lots of fresh inputs of organic matter at 10, and with the same level of inputs, look at what the yields are." So over here where somebody is achieving 50% of the potential yield from that soil and from those inputs, and the final over here is achieving 90 plus percent of potential yield. So this is what's on offer here, substantial increases in yield for the same level of input and obviously, these farmers over here are profitable and forward-looking, whereas these farmers here are pretty stuck. Part of the reason why, if our soils are in poor condition, the efficiency of our nutrient use is significantly constrained.

Declan McDonald:

And this is some work that I did on a project when I was with the Victorian government with Monash University, looking at compost use on dairy farms in South Western Victoria, and this component of the work looked at nutrient use efficiency between a group of farms. These are all conventional farms, but a group of them were using composts and a group were just using no compost, both were using fertilizer. This group was using less chemical fertilizer because they were allowing for the nutrients that were coming through in compost, and as you can see there was considerable variation between the two groups, but if we just look at nitrogen for times sake, we'll see that this compost using farmer, really did not have very good nutrient use efficiency. Even though he was using compost, there was obviously stuff that he wasn't doing right, with 20% nitrogen use efficiency that's pretty poor, 80% of is nitrogen was not contributing to production.

Declan McDonald:

Whereas on this farm here, 44.5% of the nitrogen was contributing to production. Now, nitrogen is a hugely volatile element, so it's trying to escape the system all the time, so a value like this relatively is really quite good, but this also explains why nitrogen is quite a polluting element. What this table shows, is that looking at just nitrogen use efficiency, three of the best were compost users. One of the conventionals had very good nitrogen use efficiency, and this one here was equal best as well. So there was overall, when we looked at the scores across the four essential elements here, we had overall improved nutrient use efficiency when compost was used in conjunction with conventional fertilizers. And this is to do with the contribution that composts were making to the structure of the soil. And when we're talking about soil structure, we're talking about the friability of soil. Now this is a clay soil under an orchard near Drouin, and you can see my spade has smeared the side of the hole a bit, but you can see the soil is generally friable, high surface area, with good moisture and penetration.

Declan McDonald:

These photographs were taken from the row directly opposite of which were the control rows showing business as usual under orchards, a sprayed out undervine and with the same irrigation practice, the same everything else, look at the cracking in the soil, and this is where the irrigation was dropping from the elevated irrigation line here. You can just see the small area in which water was penetrating into this profile, the soil here was dry and here it was dry and it was miserable by comparison. This was a little serendipitous discovery, I was running a trial up near Stanhope on a cropping farm, and I was looking at the crop and then I realized, just outside of the crop in the area, there was some stubble from last year. Now these are difficult soils, they're like clays, they're sodic, they dispersive, and as you can see what happens with these soils is just under the influence of rainfall, the surfaces seal up.

Declan McDonald:

Well, I noticed here was where the line of stubble was from the previous year, we had this fine aggregation happening at the surface, and this is as this stubble is breaking down and releasing its carbon into the microbial pool, they are working the soil surface and we can see when we look just a little bit more closely, we have sealed surface here, where this organic matter, we have this lumpy porous surface where we're going to get infiltration, here we're going to get runoff. Okay, really we need to move on, I've already got a little over five minutes left, and haven't covered everything I want to say, so I'm going to have to skip over some of the things, but it'll give you the idea of some of what we want to cover.

Declan McDonald:

So we can optimize biological condition for soil carbon sequestration through our management practices, and none of this is rocket science, this is what we've talked about for years, avoiding compaction, avoiding waterlogging, trying to minimize the use of deleterious sprays, et cetera. I won't talk too much about the use of compost today, but suffice to say that there's a lot of confusion about, is compost a fertilizer or a soil conditioner? And I can't tell you how many farmers I've spoken to that said, "Well, I tried compost, it didn't do anything so I've stopped using it." Compost is primarily a soil conditioner, like with the example of nutrient use efficiency that I showed you on the dairy farms, the contribution from compost is really about increasing soil organic matter and all the benefits to the soil structure and the soil environment that that brings about. Yes, there's nutrient availability from compost, but that comes later. The first thing that we want to see from compost is a gradual improvement in nutrient use efficiency.

Declan McDonald:

I developed a calculator a few years ago to look at how much we can reduce fertilizers by, when we're using a plant compost at a particular level, but I won't dwell on that now. It's important to show that, and this is a graph taken from a Rothamsted experiment that's been going since 1852, and what it's really showing is that soil carbon changes take place over long periods of time. Soil carbon storage capacity is finite for a particular soil, and the largest changes happen early on in the piece. But when we stop putting organic matter into that soil, we see levels starting to drop again and they drop quite quickly as we have talked about. Similarly, if we want to crop a pasture system, we'll see a sudden drop in soil carbon and that decline continues over a number of years as is shown here, and then when we convert that cropping land back to permanent pasture, we'll get a bounce back, as the soil carbon begins to increase, but you can see that most of the bounce back in the early years comes in the labile carbon pool and it takes longer for the humus to recover.

Declan McDonald:

But what it's showing, is that once we're on this trajectory, we've just got to keep going and we've got to add year on year, because it takes time. The real benefit, and this is a bit of a psychedelic graph, but what this is showing is that if we apply composts or manures, the nitrogen for example, gets released out of these. Because nitrogen is a highly desirable element in nature, lots of organisms have evolved mechanisms to compete, and compete very strongly and quickly for it, so what that means is when some nitrogen becomes available to the system, the soil microbes grab it first and immobilize it in their bodies and so plants only get maybe 10% of it in year one. But if we're applying organic matter compost year on year on year, that 10% that's available in year one, is 4% in year two, and it's maybe 2% of that every subsequent year, but you can see it gradually builds up to a point where the nitrogen availability is sufficient to meet the systems needs.

Declan McDonald:

And this is why conversion to a regenerative agriculture system is a gradual process and the benefits take time to accrue, but when they accrue they deliver a system that has such deep resilience that it's going to cope with the preparations that we experience by way of flood, and drought, and heat, and cold so much better than a soil with depleted organic matter. These are a whole bunch of examples of work that I've done where we've increased organic matter under horticulture in agriculture. This is a trial that I did here up in the irrigation district in Northern Victoria. This is a yield map, green is good, red is bad, we applied compost subsurface to this part of the paddock here and this was the yield change in the following season, and out of that we have proceeded and we're extending this practice across the whole farm.

Declan McDonald:

I recently completed a large project on compost undervines to show huge savings in water in particular and vine quality when the surface of the soil is covered. This is some work from New South Wales that showed the role of composts on controlling a disease-causing nematodes, did a similar trial up in the Goulburn Broken region under apples, lots of examples under dairy, and lots of examples coming through now with their cover cropping and this is from a farmer at Drouin, and he's a dairy farmer growing these big cover crops, introducing diverse with architecture, its working down deep into the soil, so bringing the soil to life to depth. And this is an example of how his grazing it, taking most of that top cover off and then allowing a proportional die back in plant roots to feed the soil.

Declan McDonald:

So to quickly summarize, managing soil carbon is critical to adaptation, resilience and sustainability, you can grow it or buy it, massive benefits to water and nutrient holding, massive benefits to soil structure and deep rooting, huge improvement in plant resilience and reliability of yields. It controls disease outbreaks in soils either completely, or greatly reduces the severity of them, and most critically it feeds the soil. So I'll pull up here, and see if we've got any questions.

Matthew Warnken:

Thank you very much, Declan, for that. As always such a wide variety of material that's been covered. All of the people on the webinar, just to highlight, that the slides are available, so they'll be sent out or so not contact us at team@agriprove.io, because there are some great materials there. Declan, intended some of those case studies on the projects that you're working on and I think would be of interest. So yeah, again some key things that stood out there, was again, some great conceptualizations, soil was the three-legged stool, it's the physical, the biological and the chemical, and organic matter is central, that nutrient holding potential soil, so what was it, sand with the cation exchange capacity of nine, was the cation about 25, is that right? And organic matter at 400.

Matthew Warnken:

So just showing that potential again, great matters, food for biology, it's a story for beyond. Can that water and nutrient availability. Probably the thing that really stuck out to me, Declan, was that figure on the contribution of soil microbial detritus. Or was that, nearly two thirds contribution?

Declan McDonald:

Yeah. Absolutely, and I think that is such a stunning wake up call, and that paper that I cited there is from 2020. So a lot of this research is really comparatively recent, because now we have the tools to be able to tease open that soil organic matter and see where did it actually come from and we're discovering compounds like ketone in there. Well, plants don't make ketone, where did that come from? Well, that's coming from soil fungi and again, we keep coming... Soil fungi is constantly keeps creeping back into the frame whether we like it or not, it's a really important component of the soil ecosystem.

Matthew Warnken:

Yeah. So again, just seeing that's a wealth of opportunity in terms of understanding that biology so I'm really looking forward to next week's webinar. I hope no one phones for biology. And also, Declan, just one of those conceptualizations in terms of you and make that link to modern infrastructure about the impact of waterlogging and flooding, and impact of compaction on human infrastructure in terms of earthquakes in this sort of like bring that down to the soil story and what a great graph too in terms of nitrogen. Nitrogen is a rainbow tied charting the pathway on the regenerative journey. We do have some questions, I'm just going to run them, but maybe just a quick one, just a terminology question on mineralization of carbon. Could you just say what mineralization is?

Declan McDonald:

So, mineralization of organic matter, I probably should have said it, but I said mineralization carbon, but there I go interchanging those two trials, which I shouldn't do. Basically it's the release of the mineral component of the organic matter. In my work I test a lot of compost in the land and the Australian standard that requires compost to have a minimum of 20% soil carbon, so that means a minimum of 35% organic matter, and so often people say, "25% of organic matter, isn't compost all organic matter?" Well, the example I give, is if you take a log which you think is all organic matter, you burn it on the fire, there's a whole lot of ash left. That ash is made up of calcium, magnesium, potassium, what I call the ash elements. They're the mineral elements, the nitrogen goes off in the flame and sulfate is lost that way as well, but when that's in the soil those mineral elements get released out of the organic matter and become available for soil microbes and plants to use.

Matthew Warnken:

Declan, you talked a lot in this webinar about the importance of structure and then I guess the question is, in increasing soil organic matter, does that actually improve soil structure and nutrient deficiency? And then maybe this as a follow-up to that comment on compost, is the use of compost in soil structure, so is the gains from compost, is it improved nutrient efficiency or is it the actual nutrients in the compost?

Declan McDonald:

It's all of those things, Matthew. The first thing that we look for from compost really is a change in the environment of the soil, and we get the change in the environment of the soil because basically we're bringing in food for the population that's working the soil to try and sustain their environment. So remember, this is a huge underground system. So imagine the biggest underground mine in the world that you can imagine, so if we were to discover lots more gold there, we would bring in all these extra resources to make the mine bigger so we could get at the gold. So when we introduce compost, we're feeding the soil organisms, those populations breed up and they start fixing up the mess that we created with our compact of practices, and they start rebuilding soil structure.

Declan McDonald:

When we have rebuilt soil structure and we have a soil that's breathing and draining, that's where the nutrients going into there, are captured quickly by the clay or by the soil organic matter and held in a form that's available to plants, so our nutrient use efficiency has greatly improved. If we apply nitrogen to a soil that's waterlogged, most of that nitrogen is going to convert to a gas and will be lost either as very damaging nitrous oxide or as plain old N2.

Declan McDonald:

I've lost you. You're muted.

Matthew Warnken:

Declan, does the same logic apply to nutrients that are already locked up in the soil profile, improving health, improving structure, improving cation exchange capacity, does that actually unlock nutrients that are bound up in the existing profile for that nutrient store?

Declan McDonald:

What we're doing when we're increasing soil organic matter, we're increasing the efficiency of the entire factory. So what that means is, we've got more workers. More workers down in the mine, they're clearing out a collapsed part of the mine, they're putting the shutters back up, and they're able to get back into that part of the mine that had previously collapsed. And that's where some of the gold, the gold in the form of phosphorus, the gold in the form of nitrogen and the form of whatever else, and so they're now able to access it where previously they weren't and because the populations are bigger, there's more specialist phosphorous solubilizers in that workforce as well. So it's about improving the entire efficiency. And when we're talking about soil improvement in a regenerative agriculture system, we're talking about optimizing soil function. And the soil function is all of the things that I'm talking about, getting high populations of workers in there, getting the soil to breathe, getting the soil to drain, improving access to some of these locked up and hidden elements.

Matthew Warnken:

Great. A few more questions on related to compost. So compost does created an equal, so do you have any views on how to assess what kind of compost is right for what kind of particular soil or management system?

Declan McDonald:

Look, I do. There's a lot to be said on that, and probably much more than I'm able to say now.

Matthew Warnken:

An eight part of the webinar series.

Declan McDonald:

Really, yes that's appendix A. Yeah. But suffice to say that what goes into the compost obviously influences strongly compost quality, the way the compost is managed while its composting, so we need to have optimal air and water in that compost and we usually achieve that by turning the compost, and then the amount of time that's left. So all that composting is, it's like a time-lapse photography of what happens to organic matter in the soil, so in the soil it might take five years example for x amount of humus to form, but the same amount of humus might form in a well-managed compost pile over a 16 week period. So the quality of material that goes in, the way it's managed, the amount of time that it's allowed, influences the quality of compost and the stability of that compost. And that influences really what the purpose of the compost is and for as well.

Matthew Warnken:

And to follow on, again with the compost, just if we had any comments in terms of the incorporation of compost into similar impermanent plantings under natural rainfall, this is under trees, sprinklers, or under drip irrigation?

Declan McDonald:

Yeah, look, I've been to many investigations in orchards for example, where the drip line is placed on the surface of the soil and there's compost and whatever is placed above that, if there's very little rainfall and that compost and moss remains dry most of the time, great from a weed control point of view, because it’s just not going to break down. So it’s not going to get into the soil, it needs moisture to fall on it to make it wet, to stimulate biological activity, to make it break down, to make it go into the soil. Now, ideally with compost you want to turn it into the soil if you can, which is fine in an annual system, but in a perennial system you don't want to be disturbing the soil.

Declan McDonald:

So in a grazing system for example or under perennial horticulture, I would generally recommend grazing the grass down or cutting it down in the pasture or under the trees, pretty low, applying your compost and then letting the pasture grow up through the compost thereby providing a microclimate at the surface of the soil to assist that compost to break down. The microclimate will be elevated humidity and increased biological activity at the soil surface.

Matthew Warnken:

Just a quick book end on the compost, that happened back at the last webinar, just on the practicalities, how is compost actually spread onto farms and incorporated particularly into grazing systems?

Declan McDonald:

That was seen as a major impediment for a long time, which is why most larger farmers in particular, just didn't even consider it. But I'm working with large corporates in the north of the state and what we're doing, we're taking compost from Melbourne, we're using backloading, so the transport is very cheap, the loads are large and we're using appropriate equipment to spread it, so big belt spreaders. So this can be handled like any other large bulk product, yet you absolutely have to be set up for it, but we've done the maths on it and it is entirely affordable on broad acre. And we're seeing more and more of it happening on broad acre now, so it does require a bit of investigation, it does require a bit of shopping around to get those lower backloading rates, but it's entirely feasible.

Matthew Warnken:

Great. We're approaching the top of the hour, just a couple questions to round out this webinar, Declan. You talked about management as having an impact on levels of soil organic carbon and the risk, so what do you think the biggest risk of management activities are and the biggest risks to increasing soil organic carbon?

Declan McDonald:

Well, probably the biggest risks are, and I'm going to talk I think next week, about...

Matthew Warnken:

The biology...?

Declan McDonald:

Yes, but I'm going to introduce some of the concepts of regenerative agriculture, and some of the key principles of regenerative agriculture starts with keeping soil covered, minimizing disturbance, maximizing diversity in the system, trying to have living roots year round, and introducing livestock. So that's not exactly in order, but certainly keeping the land covered at all times is critically important, because usually we're going to keep covered with organic matter and we keep it covered with organic matter there year round, and particularly if we've got something growing year round, we've got organic matter going into the system all the time. When we avoid disturbance, as we talked about last week, the huge difference in soil invertebrate populations between perennial undisturbed system, the pastures, compared to the conventional potato population. It was less than a tenth of the population in the disturbed soil, so if we want to sequester carbon, we've got to work with the creatures that will sequester it for us which is the living component of the soil which we'll talk about next week.

Matthew Warnken:

Right. And then, one that was again today, we're talking about the importance of soil structure, so can you look at some physical mechanisms in terms of improving soil structure such as the deep ripping, what are your thoughts there?

Declan McDonald:

Look, deep ripping has its place, but I've seen an awful lot of deep ripping done because it makes us feel good when we do it, we feel like we're really doing something opening up the soil only to have to realize that within 12 to 24 months we're back at square one again. And we've probably done more damage, so actually we're not back at square one, we're back at square one minus one, in a couple years' time, but if there is a need to deep rip and I always say, "Well, okay. You want a deep rip, what are you going to do next?" And what that means is…

Declan McDonald:

What are you going to do differently to ensure that the disturbance that you've created with that deep ripping is going to be preserved, and usually what that will mean is, you're going to have to grow bigger roots than you were growing before, you're going to have to put more organic matter into that system than you had previously put, to sustain the benefit of the ripping, lest it fall back into a same minus one in two years' time.

Matthew Warnken:

So the importance of integration with all these things, you can't just look at it in isolation?

Declan McDonald:

Exactly.

Matthew Warnken:

That's great, Declan. We're at the end of this webinar, and there were a few questions which we will try and pick up next week, that we didn't have time to get to today. This has been the webinar on organic matter - the cornerstone of soil health and sustainable production, and thanks to the AgriProve team in particular Mel Addinsall for putting all the technical details of the webinar together. Thanks to our presenter Declan McDonald, from Regen Soils. The next webinar, soil biology, millions of years in the making, so I'm really looking forward to that. And as always, if you do have any questions or comments on the webinar, things you'd like us to pick up on, feel free to email the team at AgriProve on team@agriprove.io. Thanks again.