Matthew Warnken:

Well, hello, everyone. Welcome to Grow Top Soils, the webinar series that AgriProve is running. This is the third webinar in the seven-part series. And I'd first like to begin by acknowledging the traditional custodians of the land where they're meeting from wherever around Australia, and pay our respects to elders past, present and emerging. My name is Matthew Warnken, I'm the managing director of AgriProve. AgriProve is a soil carbon project developer with the prime focus of enabling landowners to participate in carbon markets and emerging environmental markets. And help the farmers to access additional revenue.

Matthew Warnken:

We're really pleased to be hosting this seven-part webinar series with Declan McDonald, who's the principal soil scientist with Regen Soils, to really look at how we unpack that journey on how to improve soil health and how to grow soil carbon. Declan is a professional soil scientist, more than 30 years' experience in soil and agriculture. We've had the good fortune of tuning into the past two webinars, the first one being on how soil works and how plants grow. And the second one on organic matter, the cornerstone of soil health and sustainable production.

Matthew Warnken:

Just how fortunate we are to have Declan unlock a lot of those concepts and put it in really relatable terms. And certainly for me, the last webinar session, just in terms of conceptualizing soil as that three legged stool, the physical, the biological components, the chemical components, but front and center, soil organic matter has been critical to nutrient holding capacity of the soil. And then the key takeaways that stood in my mind from last webinar was related to the nutrient holding potential soil. And the cationic-exchange capacity of sand being around nine, clay being around 25, but soil organic matter being 300 to 400, as just so essential to that nutrient transferability to plants.

Matthew Warnken:

And then another key takeaway for me, was that nearly two thirds of the soil organic carbon is made up of soil microbial detritus, so the dead bodies of microbes and the other fun word I learned during the week was Necromass as another way of talking about that. So, really just highlighting just the fundamental importance of that microbial activity to building soil organic carbon. And as always not having these discussions in that abstract concept, but really try to bring it fundamentally back down to those land production systems. So, how do we build soil organic carbon with a commercial focus on reducing costs, increasing profits, and ultimately reducing overall risks.

Matthew Warnken:

This third webinar is on soil biology, millions of years in the making. Before I throw to Declan, as always, just some housekeeping for this webinar, we are recording the webinars they will be available on our website if for whatever reason you drop out and can't access it. So, if you miss a session, that will be available. We're going to run this session for around about 40 minutes. Declan's presentation leaves time for questions at the end. And the session is also being streamed on YouTube Live. There is a chat pane on YouTube Live for questions or comments. If you're on through Zoom, please use the Q&A button for questions. And also, you're free to make the user comment function throughout the webinar, you can send a message to everyone or just the host and panelists.

Matthew Warnken:

So, Declan, we're up to three, webinar three of seven. So without any further ado, we'll get you to come off mute and start your video and then start that presentation. Really looking forward to this week's installment on how to Grow Top Soils. Thanks, Declan.

Declan McDonald:

Thanks, Matthew. Just to reiterate what Matthew was saying, this series is trying to build a picture, starting from a point of no assumed prior knowledge about how soil works and how plants grow. And we're stepping through the story of organic matter which we did last week. We're going to talk about soil biology this week. And as I said, it's difficult to talk about these things in isolation, because there's such overlap, we're talking about systems here. So there is a necessary overlap between these different subject areas. But the focus today certainly is on soil biology.

Declan McDonald:

Next week, we're going to talk about minerals. And that's principally about the role of macro and micro nutrients. The following week, we'll talk about managing that fertility to build soil carbon. So this is where we were beginning to link these concepts together. The following week, we'll talk about management practices that complement that. And then finally, we'll talk about bringing it all together, which is around monitoring and evaluation, and figuring out how to know that we're making progress.

Declan McDonald:

Okay, so the core principle, I think that we really need to take on board. And to me, this stating the bleeding obvious, but I think we still haven't gotten it. And that is that all life depends on the soil and there can be no life without soil and no soil without life, they have to evolve together. And this is a quote from a famous naturalist from back in 1938.

Declan McDonald:

So, the United Nations has taken a really strong interest in soil biodiversity in recent years, and they're trying to really raise awareness of the critical importance of soil biodiversity, not only from the point of view of general biodiversity and ecosystem function, but really as an underpinning element in sustainable landscapes. And I'll leave you to read those quotes.

Declan McDonald:

So, in 2001, there was a Convention on Biological Diversity and so biodiversity came out of that. A Global Soil Biodiversity Atlas was published in 2016 and focused very strongly on the roles of soil organisms, which we will talk about further going through this presentation. A few of the slides that I'm using today, come from my time with the Victorian Government and there was a large program that I was part of, which was a soil health initiative and at the time, we produced some really great resources around soil health and around soil biology as well and some of the slides are from there.

Declan McDonald:

And what this is showing is that in very simple terms, we can break up the components of the soil biological population into microflora and microfauna and this is a division by size, principally. And over on the right you can see 10 times magnification right down to more than 100 times magnification to see things like bacteria, archaea, funguses and the like, slightly larger and this represents levels of the food

chain as well where we've a lot of progress over and nematodes feeding on the bacteria and fungal, the microflora there.

Declan McDonald:

Collembola and mites their principal functions as you can see here are as shredders and driving nutrient cycles. And then we have what we refer to as soil engineers up the top end, the earthworms, beetles, ants and termites that are physically moving soil around and substantially re-engineering the macro environment. What's really important as well, and what we tend not to pay so much attention to are the invertebrates, which kind of occupy the space between the micro organisms and the macro organisms. And this relates to the mites in particular, which make up a really huge proportion of the invertebrate population and assorted life stages of other insects and arthropods. Again, these all have a really significant role in nutrient cycling because of their, if you like, pre-processing of materials before fungi and bacteria get stuck into them.

Declan McDonald:

Now, we've talked about why soil biology is important. So, the first and foremost thing is, it decomposes plant residues. And this is a bit like, I don't know if you'll remember the stories of, I think, it was Naples in Italy when the mafia who control the rubbish collection decided they weren't going to pick up any refuse anymore. And suddenly, the city was just buried in its own garbage. And, of course, it was a disaster zone. Well, so what would be for the planet, if we didn't have all these workers busily breaking down our organic matter and keeping it cycling. And you'll recall last week when we talked about organic matter, almost the most important thing that has to happen with organic matter is it's got to move, it's got to cycle and it's got to keep moving. And it's that cycling that releases nutrients, makes nutrients available and sustains life by keeping energy systems flowing through the soil and above the soil.

Declan McDonald:

Soil biology is critically associated with soil structure. And we talked a bit about that last week. And we'll talk about that in future weeks too, in terms of really what these guys are doing is they're trying to rearrange their home and oftentimes, we're working against that with our management practices. Soil biology is regulating plant nutrient supply. And that's very much through that organic matter cycling that I talked about. Soil biology strongly influences the manifestation of pest and disease pressure, and we'll talk about that a little bit more as we go through, as well.

Declan McDonald:

Major role in degrading pesticides and herbicides and other toxic compounds in the soil, I always think it's amazing that we have this appreciation of clear running mountain streams and without fully realizing that it's the soil and everything that's living in the soil, really that is doing the cleaning for us and keeping a little bit the decomposing function. It's keeping our environment clean, and providing ecosystem services to us for that very reason, regulating water quality, as I've just mentioned. And mediating greenhouse gas capture and release carbon dioxide, methane, nitrous oxide, and we could say a lot more about that.

Declan McDonald:

So what regulates soil biology, and these are some of the resources out of the Victorian soil health initiative. There's primary regulators and secondary regulators, and the primary regulators, primarily

relate to climate and geochemistry. Soil water, temperature, soil type, and that's soil texture that we talked a bit about last week, and soil pH. And the secondary regulators relate to organic matter quality and quantity, management practices, principally things like disturbance and inputs, what we're putting into the soil.

Declan McDonald:

So we'll step through some of these regulators. So, we have an understanding of what impacts soil biology and by understanding what impacts soil biology that is going to provide us with information about the management practices that we employ, and whether they're supportive of increased soil biological population and improved soil function, or whether it's going to have a negative impact on soil function. So, as an example, earthworm abundance and this is some work that, I think, Pauline Meili did, who was the possibly still is the principal microbiologist with the Victorian Government looking at worm populations. And so a really strong correlation between rainfall and worm populations.

Declan McDonald:

Traditionally, we use 600 millimeters as is the kind of threshold below which worm populations really drop. But I've seen well managed farms in lower rainfall areas that still have reasonably healthy worm populations. But certainly as we move into the drier landscapes, termites and ants take over the role of earthworms in terms of that soil engineering function.

Declan McDonald:

What's really important to understand is that when we talk about soil biology millions of years in the making, and I made this point in the first presentation, that everything that lives in the soil has got really sophisticated adaptive strategies to changing climatic conditions. And certainly amongst the bacteria and the fungi, they're very responsive to changes in conditions. So, they produce resting bodies in the form of spores which are which tend to have a high levels of protection against environmental pressures, which make them very effective resting bodies, which can survive really long times of adverse conditions in the soil and maintain the DNA, so that when conditions change, the organism is triggered to grow again and can flourish when conditions are suited.

Declan McDonald:

We talked about land use, and I think I shared this graph before and the land uses in question here, are listed on the right hand side because it's difficult to read along the x axis. But what this is showing is land use and tillage in particular here we're seeing as a key regulator, so where we have perennial grassland systems on the left, we have high arthropod populations in this particular study. And where we have high levels of disturbance, particularly around potatoes. Pyrethrum was a little bit of an outlier here, but that's got more to do with the fact that the understory of pyrethrum cultivation is kept bare with herbicide use, and also the exudates from pyrethrum may not be so conducive to high soil biological populations in monocultures.

Declan McDonald:

And we talked last week, a bit about the importance of soil organic matter as the primary energy source in soil. So, where we have high organic matter, it doesn't necessarily mean that we're going to have high microbial populations, but it is a precursor to high microbial populations. And we certainly saw that in the Tasmanian study, where we had particularly high levels of soil organic matter, we had high proportions of soil arthropods.

Declan McDonald:

There's always a lot of interest in the impact of chemicals on soil microbiological populations. And there's no definitive answer really on this because we have so many different types of chemicals. Some papers report increases in soil microbial biomass in response to a particular chemical being applied, and others show a deleterious effect. I think where we see a positive response from the soil microbiological community, it's where they're able to access the particular chemicals, as a food resource, and so that the population expands as a result.

Declan McDonald:

But this work by Gupta from South Australia, I think, is probably more representative if we are to generalise about chemical impacts on soil microbiological populations, to show that the soil generally has a strong capacity to recover. And this relates back to when I was talking about the resting spores of soil microbiology, when there's a toxic event and organisms start getting killed off, many will be triggered into the formation of resting spores to survive the event. And then as conditions improve, or the toxic compounds get decomposed by more tolerant organisms of the microbial community, they're able to access these compounds as a food resource and conditions improve. We see populations rebounding.

Declan McDonald:

And depending on the chemical used, we have degrees of reversibility. Some chemicals, and you can put the organophosphates, for example, or PFAS, not that PFAS are a herbicide into this category, but we have compounds that are so toxic that the effect is irreversible. I think the really important point that Gupta was showing in this work is what happens when there's repeat applications. We impact on the system's capacity to rebound and it is slower to recover. And although it's not shown here, we can clearly see that if there's another application here, the capacity of the system to rebound is going to be further impacted.

Declan McDonald:

And the example that I always use is when you go into your local park, and there's a routine application of random or some of the herbicide on the edge of the path to stop the grass growing onto the path, we end up with a dead zone there. And there's usually one or two species that are able to survive there and they proliferate as weeds and of course, then the council has to come along and spray them again. But we end up with a semi dead zone as the capacity of the system to recover as in to degrade the toxic chemical becomes overwhelmed by the volume of chemical that remains as residue in the soil.

Declan McDonald:

So, when we talk about herbicides of necessity I've been very generic here, because there's lots of different kinds of herbicides and with varying effects. But what this study looked at was the impact of herbicide use on nitrogen fixing bacteria and on the impact of herbicides on nodulation of legumes. And where we have no herbicide, we've got effective nodulation on this root here. And with herbicide, we have that impact where nodules don't form and nitrogen fixation does not occur.

Declan McDonald:

This work was also done by Pauline Meili, and she looked at the impact of lime application and the influence of lime on soil biology. And lime is a really widely used impact to alleviate soil acidity and

specifically the pressure from Aluminum and soils at very low pH. But this study showed that there was an increase in the activity of ammonium oxidizers in soil. And what this infers is an improvement in the function of the nitrogen cycle, where we have an increase in ammonium oxidizers, which are a critical element in the nitrogen cycle.

Declan McDonald:

And of course, most importantly, biology regulates biology. And we have this principle called the Elton Principle, which holds that the greater the complexity of a microbiological community in terms of number and diversity of organisms, the greater the stability. Now, this is a general principle of biodiversity. And we understand that the more biodiverse communities are, whether they're in the soil or above ground, the more stable and functioning that they're going to be. We know that diverse swards support diverse biological communities. And that diversity supports increased resistance to pest and disease pressure. And this in turn, provides increased resilience to agricultural soils. And I've got a few more examples of that as we go through.

Declan McDonald:

Now, I'm going to talk a little bit more now about soil biodiversity and focusing on the importance of promoting biodiversity as in multiples of species in the soil and multiples of species in the sward and what we're growing and what we're putting into the soil to try and promote that diversity below ground. So, when we talk about soil health, we're talking about the ecological attributes of the soil. And this is part of what I've described as our new learning about soil is that soil biodiversity may not be a soil property that's critical for the production of a given crop. And this is where, I guess conventional agriculture has been able to ignore soil biodiversity to a degree because by putting on lots of really powerful and effective fertilizers, we've been able to grow the crop, but this is beginning to explain why we're seeing soil quality deterioration or failing responses to the same level of fertilizer, because soil biodiversity is a property that may be vital for the continued capacity of the soil to support that crop because of all the work that soil biodiversity does in maintaining soil function in using that fertilizer that's applied and working with plants to support plant health and root function.

Declan McDonald:

There was a very large review done across a number of continents that compared organic and conventional agriculture and found that organic farming increases biodiversity at every level of the food chain. And the majority of those studies found that organic farming benefited wildlife, a few showed that there was some detrimental effect. And there was 25 that produced mixed results or suggested no difference.

Declan McDonald:

When we're looking at managing biodiversity for carbon and for nitrogen, this Dutch study studied eight plants, four grasses and four forbs. I'll just bring up these small graphs here, which essentially are showing the top line here are soil carbon stocks, soil nitrogen stocks and root biomass. And we can see that there's an increase here with plant species richness across all of these measures here above ground biomass, organic carbon decomposition, and potential net nitrogen mineralization.

Declan McDonald:

So, the same study showed that diversity had a positive impact on microbial biomass and activity. And that increases in carbon came from 'new' carbon, carbon inputs from root exudates. And I think we

touched briefly on that last week, talking about this liquid carbon pathway as some people refer to it as, which is the amount of carbohydrate coming into the system from root exudates.

Declan McDonald:

These effects were highest under high plant diversity. And as we talked about last week, microbial Necromass, that microbial detritus ends up in the humus pool. And this particular study showed that soil organic matter with markers of microbe-derived products constituted 34% of soil organic matter, whereas the study that I cited last week was close to double that contribution.

Declan McDonald:

Just a brief word about soil exudates and soil organic carbon sequestration, what this study showed, or what this study contrasted, rather, was the difference between living roots and plant tops going into the soil. Living roots only where the plant tops were removed. And the third treatment where liter only both root and shoot was applied. And what the study showed was that there was a significantly greater quantity, and we're talking about between two and 13 times greater efficiency of carbon sequestration, where we have living roots around rather than where the organic matter was applied to the soil directly.

Declan McDonald:

And this has got a lot to do with the, if you like this liquid carbon pathway that I mentioned, whereby these labile carbon and dissolved organic carbon compounds are efficiently microbially, complexed, turned over and deposited into the mineral associated soil organic carbon pools.

Declan McDonald:

An example of the influence of living roots year round comes from Col Seis, who's up in New South Wales, and I'm sure many of you have heard of Col or heard him speak. And he's the joint developer of pasture cropping. And one of the great things, I think, that Col was able to demonstrate was substantial changes in his soil quality to depth from having living roots year round, and because he's employing pasture cropping, he's got a summer dominant pasture species and he's growing annual cereals in that system. So he's maintaining living roots 12 months of the year, and the differences that have accrued to his soil compared to his brother who's farm is immediately over the fence and who hasn't employed these innovative practices is really a sharp contrast. And quite a bit of work has been done investigating this on Col's property and has demonstrated a range of improvements in soil properties, not the least of which is increase in soil organic matter over time.

Declan McDonald:

This piece of work also interestingly shows the importance of a diversity of plants and soil microbes to unlock… You'll recall last week, we talked about humus as a really important pool as a bank of nutrients that drives production in ecological systems and also that can be captured to drive production and agricultural systems as well. And it essentially shows two pathways. One is the release of organic acids by the plant and these directly destabilize the bonds that complex organic matter to the mineral fraction of the soil and release that organic matter for microbial degradation and release of nutrients. And then we have the release of soluble carbohydrates by the plant that are stimulating so microbiological activity so that they can access and break some of those bonds so they can drive that carbon cycle from the humus pool also.

Declan McDonald:

So, these are the kinds of benefits that we get where we have higher levels of diversity in our soil, higher diversity of root architecture, and as a consequence, higher diversity in our microbial populations. Many of you might remember the kind of manufacturing craze from the, I guess it was the 80s the Japanese just in time concept where you didn't stockpile large banks of inventory, because that was a cost to the system, rather you accessed your required inputs in a just in time basis. So they would arrive when you need them rather than before. And nature has always operated in a just in time system, where through communication between plant roots and the microbial mutualisms in the soil, nutrients and water etc, are made available as the plant needs it not in advance.

Declan McDonald:

Now, this graph here, and I think I mentioned this before, but just as a reminder, tells us still how little we know about these microbial populations in the soil and how I think as a result we need to treat them with a lot more respect to knowing that these organisms have evolved over millions of years and perform really important functions in the soil and yet our knowledge of them remains very low, developing but low.

Declan McDonald:

So this summarizes what I've been talking about here, this is, in essence, the cycling of nutrients, where, recall in week one, we talked about the capture of energy from the sun, the manufacturer of the original primary producer of food sources that being fed into the soil to feed the mutualism that exists in the soil, the functioning of the soil, and the benefits then that of course, accrue to us as growers.

Declan McDonald:

Now, when we're talking about managing soil biodiversity, why restoration takes time, this was an interesting study on grasslands, formerly used as agricultural fields. And the study reported that all the known groups soil organisms were present from the start in this system, but something was missing. And what appeared to be missing and what was found to be missing was links between them, the communication between them was missing. And so the author's talked about the group's not socializing. And because they weren't socializing, the community wasn't ready to support a diverse plant community. And this is further evidence for people that say, "I'm going to go organic," and drop everything and the system crashes. If we're going to transition through to a regenerative model, we need to take a considered approach and a strategic approach and step through this and know kind of too sudden movements, but following the principles that we're covering in this series of webinars, we're going to step through a process in a considered way, it doesn't have to be too slow, but in a considered way that's going to allow the system to move with us.

Declan McDonald:

And what this study showed is when nature restoration progresses, and these links are made, function is restored. And one of the things that came out of this study was, again, that the central role of soil fungi, as drivers of this interconnectedness in the system, and how and the role that fungi play in the development of new networks in the soil.

Declan McDonald:

And so as I said before, our understanding of soil biodiversity principally came from the very limited information we got from petri dishes, and now we're inundated with information. And our key

researchers are working now to unlock all of this information to try and lift the lid on our understanding of what is in the soil and how it's working.

Declan McDonald:

Now, briefly, I'll just mention that the ubiquity of microorganisms that we need to be aware of in agriculture is more than just in the soil. There's biology in the seed, there's organisms that live on the leaf, there's organisms that live on and in the roots inside plant parts, as well as in the soil. When we talk about managing these, the biology of the seed can be, although we might not fully understand how all of that works, we can enhance that. And certainly a lot of grower experiences showing that pretreatment of seed can enhance the germination and the early vigor in those seeds. And there's trials with various inputs underway, currently in Bengworden doing some work looking at the use of Nutrisoil and Digestate on germination and early emergence.

Declan McDonald:

I've mentioned this guy Johnson Su, this is a method to enhance fungal populations on seedlings and the role that that has on early emergence and vigor as well. I'm involved in similar trials up in Lake Boga looking at Nutrisoil, compost extracts, and blends of the same. And then things like trace elements and other microbial treatments which we need to evaluate on a case by case basis.

Declan McDonald:

So, when we're talking about managing soil biodiversity, we talked about soil organic matter as a primary energy source, we talked about the importance of diversity, the uniqueness of each crop in terms of its root architecture and the residues that it contributes to the soil. So practices that are going to encourage that are increasing diversity, some multi species, intercropping if we can, in our otherwise monocrops. Can we say, non competing legumes sitting underneath a cereal crop that's going to benefit soil and cash crop alike? Can we look at tillage practices, improving living conditions means enhancing soil structure, and we'll talked about that going forward. Covering the soil is such a critical principle in all of this work. And we'll talk about that going forward in the next coming weeks as well. And as well as looking at the impacts of compaction and drainage.

Declan McDonald:

So if we are going to try and enhance early seedling emergence and vigor, how we treat seed is with generally fairly low application rates per tonne of seed. And we can do that using auger systems, or we can do it a little bit more primitively using something like a cement mixer.

Declan McDonald:

This is David Johnson, and he's from Texas, one of the Southern American universities. And he's essentially got this static compost pile which is made up, normally, when we make compost, we look for a starting carbon to nitrogen ratio on the order of about 30 to one, he's probably starting off with here with more than 100 to one, it's essentially a highly carbon based mix. And because it's a highly carbon based mix, it really requires fungi to break it down. And this is a very slow, long term process, but his product at the end is a highly fungal dominated compost. And he's been doing some really fascinating work, which has shown amazing responses to, not only early seedling emergence and vigor, but to overall crop productivity from enhancing fungal populations in the soil.

Declan McDonald:

Again, work that we can do about enhancing foliar or soil biodiversity, we can look at foliar sprays and other treatments. And as I said, we need to treat these things with caution. With compost teas and the like, I've seen quite impressive results and I've seen nothing happen at all. So, what we're trying to do is, see if there's an available ecological niche that requires filling in a soil. And if we're filling that with a compost tea we'll see a really good response. If there's no available niche or the organisms that are already there in the soil are already doing an excellent job, they'll consume what we apply for dinner, and we'll see no result. But these are just some examples of application rates of some of these commonly used inputs that you can try out on your own land.

Declan McDonald:

And very quickly, this is an example of a couple of innovative growers from Canada growing and really kind of brutal, inhospitable conditions, short growing season. And they're paying particular attention to their trace elements, as well as some stimulants that are going to help promote biological activity at sowing. So, there's lots of different ways that we can cut this and we're limited only by our willingness to try new things. There's lots of good information coming out now, not only in the scientific literature, but in the popular literature as well. But I caution you a bit with what's coming out in the popular literature, a lot of that is just pop.

Declan McDonald:

So, in summary, this is where we're up to, week three here. And hopefully, we're slowly building this picture on how you can apply some of these practices on your own land. Okay, Matthew, back to you. And time for some questions.

Matthew Warnken:

Great, thank you so much, Declan. As usual, just a great range of material covered just capturing that complexity of soil biology in this webinar. I particularly liked the linkages you've got in there, especially those of the Italian Mafia, the 80s production system of just in time, obviously not to be confused with the song from us the same era of right on time, that could be top of your playlist and no doubt. Also, shout out to Col Seis who is also in Damon Gameau's film 2040, it has a great section on soil carbon. I'd encourage anyone if you haven't seen that film 2040, as well worth watching. A lot of material, obviously to unpack the slides will be made available as well as this recording of the webinar.

Matthew Warnken:

But then just looking at that discussion on soil biology. And the importance of the classes of biology, microflora, microfauna, mesofauna, macro fauna, and the functions that in terms of their cycling of organic matter, Declan, did strike me, especially what you were talking about the fundamental aspect of soils and we do often gloss over that, but is fundamental to pretty much everything, soil structure, nutrient supply, pest and disease pressure. The one that stood out to me was water quality. And when we're talking about this sort of clear pristine streams, it's actually the soil and the microbial activity in the soil biology, that's actually delivering those crystal clear streams.

Matthew Warnken:

Then again, the great concept of biology, regulating biology, importance of year round living roots and going on and on again, maybe just to kick off, we talked a lot about this week, the need for diversity, obviously, multi species has been a key part in that. I think one of your slides, Declan, was a point about

that there was a beneficial results in nitrogen, basically from the biological diversity even though there's no legumes planting, or did I miss read that slide?

Declan McDonald:

No, what that relates to is nitrogen mineralization in the soil and what we're talking about with plant diversity. And so microbiological diversity is having enough specialists in the soil that are able to unlock the nitrogen that exists in the bank of soil organic matter, which we talked a lot about last week. Organic matter is the central bank of the soils economy, and it's where the reserves of gold are held. And that needs to trickle out at the same time as trickle in to feed the system. So it's what's maintaining stability in the system, it's what's maintaining essential flow of nutrients, and nitrogen is one of those.

Matthew Warnken:

Flowing on from that you are aware of any studies, Declan, that pick up a greater level of nutrient density or nutrient quality in food that's coming from systems with high biological activity, high soil microbial populations?

Declan McDonald:

Look, I'm aware of a number of studies that have looked at this, and I'm not sure that I've seen any that are kind of completely definitive about this. There's a lot of controversy about this kind of current common phrase of nutrient density. And I'm not entirely sure what that means. But I certainly would expect that the availability of all essential macro and micro elements is going to be enhanced in a system where all of the working parts are there and functioning. So when soil function is high, when nutrient cycling is high, and when all the inputs to the system are feeding that machinery, are feeding that function. And I think where we have really strong associations, then between plants and the soil microbiological community, that is built up around ensuring the supply of those essential elements.

Declan McDonald:

I'm not sure if I talked last week, but there's a remarkable intelligence in the soil where plants are able to signal to the soil microbiological community exactly what their needs are. And when plants are able to signal into a soil that's highly functioning, then there's going to be workers there to deliver that to the soil. But in a soil that's a monoculture where there's limited root exploration because of the mono dimensionality of roots in that system. All of those functions may not be working, as well as in a more diverse system.

Matthew Warnken:

Declan, the other issue you brought up in today's session, in terms of impacts on soil biology, with the use of herbicides, and how that can affect biological communities. From practical perspective, how would you go about, how would a farmer go about telling what herbicides are reversible versus what herbicides would fit in that irreversible category?

Declan McDonald:

I really don't know that I can answer that question, Matthew. I don't know if you saw the kerfuffle during the week about herbicide residues here in Victoria, that I found myself in the center of. But in that particular case, we were looking just at one family of herbicides, which are the phenoxy acid herbicides, and there's probably 30 different active ingredients, different compounds in that one family

alone. And the research that I did showed that the half life of those compounds varies quite a bit. So that means even in that one family of herbicides that are some that are much more degradable than others and others that will have a more toxic and longer term effect on soil biology. So I don't know if anybody has teased that one apart. It's such a big question.

Matthew Warnken:

Maybe looking at it from another way, do you have any thoughts in terms of the quickest way to restart populations that might have been declining from herbicide use, like probiotics or biological stimulants or anything like that. Do you have any thoughts as to how you could restart or improve biological counts?

Declan McDonald:

Yeah, I think that's a much better way to look at it, Matthew, because, the reality is in modern farming, in so many situations, we have to use herbicides. So if we have to use herbicides, how can we use them most strategically and in a way that really minimizes the impact on soil biology. And there's a few things that growers can do. Many herbicides have higher efficacy and lower pHs, so there's a common trend now to lower the pH of tank mixes to about four and a half and by increasing the efficacy in that way, we can use 50% less of the active ingredient. So we're putting less into the soil.

Declan McDonald:

The other thing, and I haven't seen much research on this, but this is actively promoted by regenerative growers is to combine a carbon source with the tank mix, and the carbon source most popularly recommended is fulvic acid. Because it's function's not only as a carbon source to provide, essentially organic matter to help the affected soil microbial community to bounce back from the toxic shock if you like of the herbicide being applied, but it also acts as a key later, which helps to increase the efficiency of plant uptake. So, if we're using less active ingredient, we're getting it into the plant quicker, we're increasing the effectiveness of it in the plant. There's less collateral damage, if you like of, spray missing its target and ending up in the soil.

Matthew Warnken:

And maybe just following on that, I think what you're referring to are some of the issues around the compost and compost quality that was in the press. But as a general rule in terms of compost, there's a question in terms of the heavy thoughts on the regulation of the compost industry, how do farmers go about ensuring there are good quality compost, in terms of confidence in that product that they can apply to land?

Declan McDonald:

Look, one of the one of, probably the supreme irony that came out of this issue of the herbicide residues in compost is that, people are saying to me, "Well, what can I do? I've got it in my soil now, how can I fix it?" Well, unfortunately, there's nothing we can do to fix it, there's not some magic spray that we can put on to make the residue go away. The half-life of these compounds is a measure of the capacity of soil microbial communities to degrade the active ingredient. So, the irony is that the best possible place for these residues to be is in a healthy biodiverse compost, because that is the environment that is best able to break these down if the compound is not so toxic that it will overcome the capacity of the of the organisms to degrade it.

Declan McDonald:

So, fungi, as we said, seem to have a key role in a lot of these functions. So having a mature compost and the longer we let a compost mature, generally the higher the fungal population in the compost is going to be and it also provides enough time to break down any of those residues. So when it comes to getting that mature compost out on farm, hopefully, we've done as much as we can to manage any nasties that might be in there.

Matthew Warnken:

Speaking of breaking down residues, Declan, would you recommend application of liquids or granulars to further boost microbial activity to say breakdown mulches that are being applied or break down compost that are being surface applied?

Declan McDonald:

Look, there is scope to do that. And in fact, only yesterday I was recommending, as a treatment for people say who have applied this compost into their own gardens is to apply some dynamic lifter, some form of nitrogen and to keep the soil or the compost moist. So what we're doing here is we're tipping the carbon to nitrogen ratio in favor of decomposition. So by providing more nitrogen, we're going to hasten the breakdown of the carbon that's in there. And in so doing, we're going to temporarily boost soil microbiological or the microbiological populations in that compost. And where we have high microbiological populations, we're maximizing the likelihood of breakdown of some of these residues. So yes, adding some nitrogen into the systems as a temporary measure to hasten the decomposition is likely to be helpful.

Matthew Warnken:

Sticking with the applying organic matter to land, do you have any observations on incorporating compost into the to the soil level as opposed to just surface spreading?

Declan McDonald:

Yeah. I'm not sure if we touched on this last week or not, Matthew, but incorporation of compost is always a preferable strategy but not at the cost of tillage. So if you've got a pasture, that's been down for 30 years, cultivating that just to get Compost in is going to do far more harm than good. So in a situation like that my recommendation is that the pasture is grazed and quite hard, quite short. So that when we apply the compost, we're maximizing compost soil, surface soil contact, and then we want to allow a long rest period to allow that pasture to grow up through the compost. And in so doing create that humid microenvironment at the surface of the soil, that's going to promote a colonization of that compost by surface growing, fungi and bacteria and hasten its incorporation into the soil.

Matthew Warnken:

Great, we're coming up to the top of the hour, Declan. So we'll just round out this webinar with a couple more questions. And this comes back to another aspect you raised in today's session, seed treatments. I'm so interested in your thoughts in terms of seed treatments, and maybe other biological stimulants to build microbial populations in low rainfall zones, say under 300 millimeters and whether or not they there's any prospects in this being a pathway to building soil carbon?

Declan McDonald:

Well, firstly, seed treatments are not new. And the obvious example there is the treatment of legume seeds with rhizobium bacteria. So that when we plant those legumes in the soil, that the correct rhizobia are going to the soil with the seed so that those plants then form nodules and sequester potentially considerable quantities of nitrogen from the atmosphere. What we're talking about now with seed treatments to enhance not only germination and early seedling vigor, and ultimately crop yield is a progression of thinking around harnessing beneficial microbial influences on plant development and on plant roots and on early colonization of plant roots and an early establishment of those networks that we talked about in the soil to promote early soil function.

Declan McDonald:

Now, what has surprised everybody is some work by cropping family called the Haggerty's over in Western Australia, and they're in the northern cropping district on very low rainfall, I think about 400 millimeters and pretty poor soil, the kind of super marginal land that many farmers have walked away from, and they have embarked on a kind of, "Well, we've got not a lot to lose." And they have pioneered a lot of seed treatment, and the use of things like Nutrisoil, on their seed, with very low to no input. And again, growing on sandy soils and they're getting remarkable results. Results that are really drawing the attention of a lot of people because, the kind of results that, I think, traditionally would have said that "No, that's just not going to work. There's too many things against you, rainfall is too low, soil quality is so poor, it's not going to work." But it's further lifting the lid on the potential of harnessing soil biology, in our cropping systems. And they're helping to rewrite the rule books.

Matthew Warnken:

Right. And then just closing out then in a related thing, just how much diversity do we need to access biological benefit? And what kind of plant groups are we looking for in plants diverse species?

Declan McDonald:

Look, it's a really good question, how much diversity is enough? And I don't know that I can answer that question. If we were to go into a hectare of natural, healthy bushland in Australia, we'll probably find that there's hundreds of different species all growing in that area of land and all contributing different things to that bushland ecosystem, both above and below ground. So, I don't know that there is a number that I can say, "You have to have this number of species", but when you consider that most of our agricultural systems, for years, we've been focusing really on cash crops on mono crops on fairly narrow pasture species of two to three primary species, we don't have to do very much to increase diversity by 100% in those systems.

Declan McDonald:

And you part of that increased diversity is an increase in root architecture and any grower will know that there's substantial difference between the root system in a clover compared to a ryegrass compared to a fodder rape. And all of these plants are exuding different chemicals with different properties into the soil and which are different food systems which are feeding different elements of the soil. So, if you think about our Amazon jungle, and if there's no food for the monkeys, if there's no food for the sloths and whatever else, they're not going to be there. But if we can reintroduce the food source for those organisms their populations can be sustained.

Matthew Warnken:

Great. Thanks, Declan. Apologies, we didn't get to everyone's questions, we'll try and pick them up next webinar session. You've been watching how to grow top soils, the science of soil carbon. This was the webinar on soil biology, millions of years in the making. Thanks to our team. Shout out to Mel for putting the webinar together. Thank you very much, Declan, once again, from Regen Soils for guiding us through this week's webinar. Really looking forward also to next week, Mineral management - the role of macro and micro elements. That will be webinar series number four. If you have any follow up questions or queries or comments, feel free to reach out to us at team@agriprove.io. Otherwise, thank you very much for your attention. And we looking forward to meeting back at the fourth webinar as we continue this series on how to grow top soils. Thank you and bye for now.

Declan McDonald:

Thank you all