Transcript of Episode 019 of the Plants Dig Soil podcast – "Carbon in its Proper Place."

Hello! This is Scott Gillespie and welcome to the third season of Plants Dig Soil. In this podcast, you will learn how to think critically about regenerative practices as you work to incorporate them into your agricultural, horticultural, and home gardening systems.

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Last season's episode called "013 Caution on Carbon Payments"[1] ended up generating a lot of discussion on the topic of carbon buildup, soil organic matter, and how it is sequestered (or not) in the soil. Much of what I brought up in that episode was not new but was just pulling together many articles and following sources cited within those articles.

My original thought for the episode was to try to get a clear framework for how I could approach carbon payment plans for my clients. I would not be providing them or working with any companies that do provide them. I simply wanted a way to evaluate the options and help them choose who they should work with.

I went in thinking that since we are doing regenerative practices it means that carbon is building up. When there are industries and even individual consumers wanting to purchase offsets for their unavoidable carbon releases it makes sense to try to monetize them. When starting down the regenerative path there can be higher costs initially as the system adjusts, so having another revenue stream is a nice addition to the farm.

You probably have guessed it – it was not as simple as I first thought. What really changed my thinking was a study, that I put into the end of the episode, that showed long-term cover crops were actually mining the soil of carbon. It made no sense to me at the time but the sites were randomized and replicated, and had been running for 19 years.

The difference in this study from all the others that I had come across was the depth of sampling. The studies ranged in depth from as little as 5 cm to as much as 30 cm deep. Most were around the 15 cm mark. By going 200 cm deep they found that although the top depths did show more carbon buildup, the bottom depths showed less carbon buildup. When the conventional plots were compared to the cover crop plots totaling up the carbon across the entire 200 cm there was *less* overall carbon.

While this is one study in one environment, it should not be discounted. Deep sampling is extremely hard to do and increases the cost of analysis by 5-10x the amount that would be needed with just shallow sampling. Before getting too far into this, I want to back up and look at what soil organic matter is to help work through what I think is going on here.

The way that we think about organic matter has taken a major shift in the past 20 years. When I was studying in school for my agricultural degree, it was perceived as simply bits of leftover living material that could not be broken down any further. This is where the idea was derived that we can decrease carbon dioxide levels in the air by putting it into the soil has come from. The new paradigm of soil organic matter is that there is always a microbe that can break it down.[2] It is just a matter of finding that one microbe and getting it into the same space as the organic matter to break it down. In this way of thinking, organic matter is thought to be in a state of constant flow.

The most rapidly cycling organic matter is the living and recently living material. Energy is harnessed from the sun by taking carbon dioxide and creating a high energy molecule called glucose, commonly just referred to as plant sugar. It may be used right away for energy in the plant or exuded into the soil for microbes to use. Of course, the plants do not give for free – they expect something back from the microbe – be it a nutrient, a molecule, or protection from other microbes. If it is used for energy, it may go right back into the atmosphere as carbon dioxide within minutes of its synthesis.

If it is not used for energy, it may get integrated into the structure of a plant or a microbe. It may last for days or years in this bound up state. However, at some point something will break it down. The carbon will be used for energy and then released back to the atmosphere as carbon dioxide again.

When we talk of "getting the biology working for us" this is what we are talking about. A more fully functioning biology in the soil will help to hold nutrients in place and release them when needed for the plants. Having some plants growing in the off season – after harvest and possibly before seeding – keeps these communities active by sending more carbon exudates down into the soil while the plants are alive and providing materials for them to work on when the plants have died.

When we measure the organic matter in a soil test this portion is not included because it cycles so rapidly. We measure the material that sticks around, and the best measurement comes when we take it from cool soils in the fall or spring when most biological activity has shut down for the year. What we measure is what is referred to as particulate and mineral associated organic matter.

Particulate organic matter is simply the non-living bits that will fit through a certain size of sieve in a lab. It is more of a human convention than anything biological, as the scale based entirely on our frame of reference. When looking at it under a microscope you would still be able to see what it originally was. You might see spores, pollen grains, fungal hyphae, or bits of a leaf[3]. The typical cycling of this material is 1-50 years.

Mineral associated organic matter is the next stage in degradation, but this organic matter will not bear a resemblance to its original form. You would not be able to see them on standard microscope as they are complex and very stable molecules that are resistant to further breakdown. These molecules are what contribute to your cation-exchange capacity – that is, the ability to hold and release nutrients – and the water holding capacity of the soil. Typically, these molecules last for decades or centuries. They are not easily broken down in tillage events as they are adsorbed to the mineral components of the soil.

[Transition Music]

If you really want to dive deep into what soil organic matter is I suggest you check out episode 8 of the People Nature Food Podcast where Tom Franklin talks to Dr. Jocelyn Lavallee about this in much more detail than I am going into. She also drops a big bomb on the biological stimulants sector: humic acid does not exist in nature! It is an artifact of our measurement of soil organic matter.

So why am I inserting this into this episode? Well, I only found this podcast after I had written the entire episode and was about to hit "record". Tom found me and we have talked for an episode (or two, depending on how he edits it) as he launches his new season of his podcast. I do not have a link for the episode I am in, but it should be posted not long after this one so be sure to check out the main page of the People Nature Food Podcast[4] and look for the one with me. And if you do not see it, be sure to ask Tom when it is coming. Okay – back to the episode.

[Transition Music]

In considering how organic matter is formed, let us think through how it could be that cover crops do not increase soil organic matter. My line of thought had been that the more types of plants growing in the soil and the longer they stay in the soil should mean more organic matter deposition. However, if we think about the soil and all the microbes that live in it, we can see that their goal is not to hoard it or store it. Their goal is to use it.

There is a certain amount of organic matter that is needed for the soil to hold together, and to buffer nutrient cycles. A certain amount is need to buffer energy supplies. Plants provide the energy source to the system – the sugars – but there are times when they can not be providing this energy. It may be too cold to grow, or there may not be enough water. Disease, insects, animals or even hail may have killed them. They also may have completed their lifecycle and have now died with no new plants on the way yet. It is at these times that the carbon and nutrient supplies are used underground.

Think of money as analogous to carbon. It is used a lot in stories that try to explain the carbon flow. It is good to have a buffer of money built up so you can pay for things that come up that you were not expecting. If you keep a good buffer – perhaps six months to a year – then you can ride out the tough times and then work to build that buffer up in the future. But there comes a time when you need to stop saving and start spending. You could live a frugal life building up a nest egg but if you died with a million dollars in the bank, who benefits? Perhaps your children, maybe your relatives, most definitely the government will.

So this is what I think is going on with cover crops: They are putting carbon in its proper place. The most beneficial place for it is near the surface. This is the place where the majority of the roots are. More root exudates end up here. More microbial life grows here. More nutrients end up here. The depths of the soil are for water storage. They are not the best reserves of carbon and nutrients if for most of the time they are dry and cool.

Sequestering carbon is not natural. We look at it from a human perspective and see it as a solution to rising CO_2 emissions. When carbon is sequestered it is not just carbon we are locking away. Consider that when we talk about 1% of organic matter in a soil just over half of that is carbon. The rest is made up of the leftover life forms and complex molecules that were formed when they were living.

In an acre of soil we approximate a 6” depth to have 2 million lbs. of soil. Every 1% of organic matter represents 20,000 lbs. and of this 12,000 lbs. is carbon, 1,000 lbs. is nitrogen and 100 lbs. each of phosphorus, potassium, and sulphur.[5] If you think in hectares you can adjust the depth to 13.5 cm and then the numbers still work just with kilograms instead of pounds.

With so much energy and nutrients locked up in organic matter, this is why I think we are seeing the system use it and not hoard it. If this is the true nature of the soils, then carbon payment programs for sequestering carbon may be built on a false foundation.

The lead author to the study I have been referencing states it best: “If we only measured soil C [carbon] in the top 30 cm, we would have assumed an increase in total soil C increased with WCC [winter cover crop] alone, whereas in reality significant losses in SOC [soil organic carbon] occurred when considering the 2 m soil profile. Ignoring the subsoil carbon dynamics in deeper layers of soil fails to recognize potential opportunities for soil C sequestration, and may lead to false conclusions about the impact of management practices on C sequestration."[6]

[Transition Music]

Like in the last episode, I hope I have not deflated your expectation for regenerative agriculture too much. Taking the long view and digging deeper shows that things may not be happening as fast as we would like. They may not even be working the way we expected. However, this does not mean we give up on things. The benefits to holding the land in place, unlocking legacy nutrients, scavenging deeper nutrients, fixing some nitrogen from the air, and mining soil particles for some phosphorus are still beneficial.

The initial cost to this is going to be time, money, and water. Time being in your time planting crops and managing the system. Money, in buying seed, running machinery, and perhaps in paying employees to do this work. Water, in that the more plants that are growing the more water will be used. In my area, water is usually limiting cash crop growth so this is a real expense.

However, in the years and decades to come you will start to get the payback in more stable nutrient cycles and a soil that can hold onto more water and is better able to infiltrate intensive rain events. The most robust study[7] I have found on paybacks shows that it takes about three years to break even from the transition to cover crops. After those three years you see net gains to your bottom line year over year.

So where should you be putting your efforts?

To review, there is the active portion. This is the part that is made of living and recently living plants, microbes, and soil organisms. It may only last minutes if the sugars are used for energy and may last up to a few years if it sits on top of the soil as residue.

The next pool is the particulate level. It is made up of the fine pieces of the active portion that we can not see with the naked eye. Under a microscope you would still be able to recognize its original form in the shape of pollen grains, fungal hyphae, or cells from a leaf. This pool will either be broken down for energy and released as carbon dioxide, or it will move on to the next pool. The time it sticks around in the soil is typically 1-50 years.

The final pool is the mineral associated pool and is made up of complex molecules leftover from decomposition of the particulate organic matter pool. Eventually these molecules are broken down for energy, but they may stick around for decades or centuries. In the time that they do stick around they are valuable sites for nutrient and water storage.

What you target is based on your time scale. Right now, you can realistically only target the active pool. The immediate payback in this pool is holding your soil in place from wind and water erosion.

Over the course of the next 5-10 years, you will see an increase the particulate organic matter pool as this active pool contributes more to it. As you pass the farm onto the next generation, your work building the particulate organic matter pool will give them a larger pool of mineral associated organic matter to work with. Fundamentally the only way you can build up carbon is to have living plants on your soil as much as possible.

When you have plants making sugars, they are making the carbon that will feed the pools below ground. When there are no living plants there is no new energy being added to the system. The soil microbes and larger organisms still need energy and so carbon within the organic matter is their prime target. This principle is what inspired the name of my consulting company and the name of my podcast – Plants Dig Soil.

[Transition Music]

Remember to get local advice before acting upon this information. If you do not know who to talk to, get a hold of me and I will help you find someone. If you are in my local area and need help, contact me. It is always free to chat. If we get to the point that the scope broadens to consulting work, we can work out a plan that fits your budget.

Would you like to keep up with me through a free monthly newsletter? Go to www.plantsdigsoil.com/contact and select the newsletter option. If you have not subscribed to the podcast yet please make sure you do that in your favourite app. If you are a long-time listener – will you consider leaving me a review? This helps others discover the podcast. If you know of someone that would enjoy this, please be sure to share it with them directly or through your social networks.

If you are still listening, you are probably like me and like to know what the catch is. Why am I putting out this information for free? The reason is that I love to learn, and I love to share the information. My knowledge has been built up from experiences in my own garden, advising clients in my consulting business, and from reading the latest books and articles on agronomy and regenerative agriculture.

I have a B.Sc. (Agr.) with an agronomy focus and a M.Sc. with a focus on Plant Science. Beyond my formal education, I have attained, and maintained, my Certified Crop Advisor designation and am a member in good standing with the Alberta Institute of Agrologists.

Nearly everything I talk about is from free resources posted to university and research organization websites. Books that used to be hard to track down are available to buy or borrow for nearly anyone with an e-reader. The information is out there – sifting through it all is what takes the time.

I make my living entirely from consulting. I do not sell any products, software, or systems. I strive to be as independent and as unbiased as possible so I can provide the best advice to my clients and help as many people as possible move from conventional to regenerative agriculture.

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[1] Scott Gillespie. 2020. 013 Caution on Carbon Payments. https://www.plantsdigsoil.com/podcast/013-caution-on-carbon-payments
[2] Bobbi Helgason. 2020. How Soil Microbes Transform Plant Residues into Soil Organic Matter to Maintain Healthy Soils. https://aia.in1touch.org/document/5697/Helgason%20AIA%20webinar.pdf
[3] Bobbi Helgason. 2020. How Soil Microbes Transform Plant Residues into Soil Organic Matter to Maintain Healthy Soils. https://aia.in1touch.org/document/5697/Helgason%20AIA%20webinar.pdf
[4] The People Nature Food Podcast. 2019. Episode 8: Predicting Soil Organic Matter Dynamics-The Best Way Forward Is With POM and MAOM. https://www.spreaker.com/user/peoplenaturefood/som-pom-maom-final
[5] RealAgriculture. 2021. Soil School: Does organic matter really matter? https://www.realagriculture.com/2021/01/soil-school-does-organic-matter-really-matter/
[6] Nicole Tautges et al. 2019. Deep soil inventories reveal that impacts of cover crops and compost on soil carbon sequestration differ in surface and subsurface soils. https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.14762
[7] SARE Outreach. 2019. Cover Crop Economics. https://www.sare.org/resources/cover-crop-economics/