HOW DO YOU MEASURE SOIL CARBON?

Featuring Dr. Jason Ackerson

Research Soil Scientist, Soil Health Institute

DJ May:

Welcome to the Decode 6 Podcast, where we take your questions about carbon and ecosystem services and match them to the experts with the answers. I'm your host DJ May. And today's question is, how do you measure soil carbon? Joining me to answer that is our expert, Dr. Jason Ackerson, a research soil scientist at the Soil Health Institute. At the Soil Health Institute, Jason works on soil carbon measurement and discovery projects. His past research from his time at Purdue University focused on developing proximal sensors to measure soil properties and develop digital soil maps. He's a fantastic person to give us an overview about measuring soil carbon and what you need to do in the field. So Jason, thank you so much for being here today.

Jason Ackerson:

Yeah, thanks. Thanks for having me.

DJ May:

Well, we'll jump right in. So first of all, give us the background. Why is there a need for accurate soil carbon measurement?

Jason Ackerson:

Yeah, great question. So soil carbon is really important for a lot of reasons. The first one is, it's one of the primary indicators of soil health. So higher soil carbon concentrations and stocks are associated with improved soil health or good indicator of soil health. And a lot of the work that Soil Health Institute has done through our North American project to evaluate soil health measures has really indicated that it's one of the best indicators of improved soil health.

And so along with that come a host of ecosystem service benefits, like improved water retention, improved nutrient cycling, that are all associated with those increased carbon concentration. So it's a really good indicator of soil health. The other reason folks might be interested in measuring soil carbon stocks specifically, is they're a really important aspect of enrollment in any ecosystem service marketplace or soil carbon crediting program. So if a farmer or producer is interested in joining up with a program that's selling carbon credits, they need accurate measurements of their carbon stocks.

DJ May:

Excellent. Yeah, we'll get into that in a little bit more detail. But first of all, if you're interested in measuring your soil carbon stocks, how do you go about setting this up in the field? How are you going to measure it?

Jason Ackerson:

Yeah, so the nice thing about soil carbon stocks is that a lot of the measurements and sampling protocols are really similar to what we see for routine fertility sampling. So carbon sample starts

with developing a sampling plan and having an idea of where you're going to sample. But mechanically, in the field, the first aspect is a composite sample. So we typically recommend somewhere between 10 to 15 sub cores that get mixed up into a single composite.

So anyone who's familiar with fertility sampling has probably done some level of composite sampling. And for carbon, it looks really similar. Where carbon differs from routine fertility sampling is that we also need a volumetric sample. So we need to collect a bulk density sample to then convert those concentrations to a stock measurement. So that requires selecting a known volume of soil, usually one large soil sample collected with a bulk density core.

So to summarize, in general, sampling for soil carbon stocks, you need a composite sample that will be used to measure soil carbon concentration. But in addition to that, you'll need some sort of bulk density sample. So for SHI, the Soil Health Institute, we recommend a single composite sample, and that might be a composite of somewhere between 10 to 15 cores and a single bulk density sample for each sampling location.

The other nuance to carbon sampling, and this applies really only to enrollment in soil carbon crediting programs, is that the typical sampling depth for most carbon registries is zero to 30 centimeters. So if you're used to or accustomed to fertility sampling to six inches depths, you really need to increase that to 12 inches or 30 centimeters depths for eligibility for soil carbon crediting.

DJ May:

And is that for both the composite sampling and the bulk density?

Jason Ackerson:

Yeah. Yep. And we have either some evidence that shows that to get the most accurate stock measurements, you really do need to be splitting up sampling depths. So the gold standard, I would say, for sampling for soil carbon stocks would be a zero to 15 centimeter composite and a zero to 15 centimeter bulk density paired with a 15 to 30 centimeter composite and a 15 to 30 centimeter bulk density. So for any sampling location, we're really looking at four individual samples to represent that zero to 30 centimeter stock.

DJ May:

Excellent. So break it down just a little bit more for me. When you're looking at the analysis of the composite sample and the bulk density sample, what are you learning from those measures?

Jason Ackerson:

Yeah, so we break those samples up into two different sampling or laboratory analysis paths. So the first one, the composite sample, we're looking at measuring the carbon concentration of the soil. So this is the mass of organic carbon per mass of soil solids.

So the way we typically analyze this is with a dry combustion analyzer, soil's ground and processed similarly to fertility samples. But instead of, you might be familiar with, a loss on

ignition method where the soil is burned in a low temperature furnace and we measure the organic matter concentration, we're using a much higher combustion rate and specifically measuring the amount of carbon that comes off of that soil as it's combusted. So it's a really accurate measure of just how much carbon is in the soil. So that's a really important distinction between carbon and organic matter.

Organic matter tests the legacy data on loss on ignition really focus on the complete organic matter concentration. So that includes nitrogen compounds and hydrogen compounds, all the other bits that make up organic matter. With the dry combustion test or so a carbon concentration measurement, we're looking at just the amount of carbon that's in the ground. So that's a really critical distinction. So that's what we do with the composite samples. On the bulk density side, we're really just looking to get the mass of dry soil in a known volume of samples.

So the field sampler will have collected a known volume and the laboratory end, they really just need to weigh that sample, dry it out so they remove all the water, and then get a water free mass basis of that soil volume. So we can then calculate a density for that sample.

DJ May:

Great. Okay. So I'm just curious if I were out in the field setting up the sampling, what are some challenges that you run into? What makes this kind of setup difficult? And how can you anticipate those challenges to do a better job?

Jason Ackerson:

Yeah, that's a really great question. And this is one of the things that makes sampling for soil carbon stocks really tricky, and one of the reasons it ends up being more expensive than typical fertility sampling. The main aspect of that, the challenge is the bulk density sample we need to take a sample of... It's a larger sample volume, so we're collecting much more soil than people would be accustomed to with the standard push probe.

The other thing we really need to be careful of is avoiding any compaction of that soil. So we don't want to smash any extra soil into that volume that will artificially increase the bulk density and give you some bias in your results. But the other key consideration there is there's a big trade off between labor accuracy and time in the field. To collect a composite bulk density sample, if you were to collect multiple samples, would require hours of field labor, which is just unfeasible for most commercial operations.

So one of the reasons we recommend a single bulk density sample is really just to streamline that field operation. The downside to that, it saves you some time, but the real downside is you're really relying on only one measurement. So if that measurement is collected in a location in the field that is somehow been compacted or has altered through the sampling process, you get a really bad result. So relying on only one sample puts you in a kind of vulnerable position. So field techs need to be really cognizant and take their time in collecting consistent bulk density samples. It's as much as we'd like to say that soil science is all science, sometimes there's an art to it. And certainly field experience and expertise collecting bulk density samples pays off in quality data.

DJ May:

Excellent. So if I were out in the field and I accidentally compacted my bulk density sample and I sent it off to the lab, how would that change the data? What would it look like when I got it back compared to what it should be?

Jason Ackerson:

Yeah, so just a couple quick things that are good practice if you're dealing with this data, always look at your bulk density concentrations or bulk densities and make sure they're within a reasonable range. So we typically don't expect to see them in excess of 1.7 for zero to 30 centimeter section.

Those values are possible, but they're relatively rare. So we're talking those are 95% outliers. So that's the first step is to check to make sure your data fall within a reasonable range. And there's some good literature out there to show what those ranges should be. So anything between 1.1 and 1.7, I wouldn't worry too much about. In those tails below 1.1 and above, 1.7, I would be worried about it. So that's the first check I would always do with data. But the consequence of compacted soils is that when you go to calculate your stocks, that will be artificially high.

So to measure or to predict the soil carbon stock, we take the concentration measured from our composite sample and multiply it by the bulk density and the sampling depth. And that gets you the massive carbon per unit area in the field. And if you have a higher density, that will increase your stocks artificially, which can give you sort of a false positive. If you're doing the soil health test, you might think your soil is actually healthier than it would be. And for carbon auditing, it can have real severe consequences if you go back to remeasure.

So if you say, come back to the soil, come back and measure it in five years, your stock might be actually higher in year one versus year five only because of the compaction. So we need to be really careful in monitoring cases, where we're planning on measuring, and then remeasuring at some later day that those data are really of high quality.

DJ May:

Yeah. Well, that's a perfect segue because I was going to ask you, what advice would you give a CCA, a farmer or a soil scientist who's trying to set that baseline maybe for the first time, maybe they've never measured their field soil carbon before?

Jason Ackerson:

Yeah, that's a great question. So the first thing I would do, and this is not a science thing, this is a technique thing, is I would go out and practice collecting bulk density samples. I would go in and take my field team or whoever's going out and doing the sampling with me and going out and making sure that we're following a consistent protocol, consistent methodology, and that the field staff is very aware of the importance of quality bulk density data.

So that would be the very first thing I would do is if I'm setting up this program for myself, I would set up a training day, have all of my field technicians out, and we'd go and we'd collect a bunch of

data and just set everyone's expectations about the work required and the sort of field practice. So that would be the very first thing as a training piece.

The other thing I would focus on is really having a well-defined and structured sampling plan before your field operations. So knowing where you're going to go and collect samples in a field, and that those locations are at least to your best of your knowledge representative of the field. And there's lots of work in precision agriculture and in soil sampling around the best way to design those sampling schemes. But really having a plan from the start so that you know you're going to have a representative sample. And that those sampling plan is repeatable for multiple sites and for multiple years.

DJ May:

Excellent. Okay. So keep track of what you're doing is basically what I'm hearing.

Jason Ackerson:

Yeah. I mean, ultimately we see most errors in field in data come from the field side of things. Laboratories are pretty consistent, and when we see errors, they're cropping up in the field, either through user error from sampling or through mislabeling a bag or having the sample location tracked in the wrong part of the field. Those are where you're most likely to see errors. And that's the same for any soil sampling approach. But when you're dealing with carbon stocks that are going to be measured or remeasured, it's really important to make sure that all of those pieces are correct throughout the whole chain of the sampling event.

DJ May:

Excellent. Well, is there anything that I didn't ask you that you want to mention, Jason?

Jason Ackerson:

I don't think so. That pretty much sums it up.

DJ May:

Awesome. Well, thank you so much for your time today. I'm glad we had you here.

Jason Ackerson:

Yeah, thanks DJ. This was fun.

DJ May:

If you're curious about measuring soil carbon and you want to read some related research, check out the show notes. And if you've got questions about sequestering carbon improving ecosystem services or how to put all of this into practice, come visit us at Decode6.org. You can send us your questions and there are lots of resources for you to learn more. We'll see you there.