HOW DO YOU MEASURE SOIL HEALTH AT SCALE?

Featuring Dr. Cristine Morgan

Chief Scientific Officer, 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. Today we're asking, how can we measure soil health at scale? Here to answer that question is our expert, Dr. Cristine Morgan, the Chief Scientific Officer at the Soil Health Institute.

At the Soil Health Institute, Cristine develops the scientific direction, strategy and implementation for soil health research programs. She's also developed methods for easily measuring soil carbon that were adopted by the U.S. Department of Agriculture. Cristine focuses on applying her knowledge to address the real-world problems that farmers and ranchers are experiencing. Her depth of knowledge about soil health and measurement makes her the perfect person to answer today's question. So Cristine, welcome. It's great to have you here.

Cristine Morgan:

Thanks, DJ. It's nice to see you again.

DJ May:

It's good to see you, too. So we'll jump right in. Why should we measure soil health and what does it mean to measure it at scale?

Cristine Morgan:

Okay. Well, I think the first thing to recognize is that any time we care about something, we want to measure it, right? So I always say, if you treasure it, measure it. That's what we do with our own health. Hopefully every year we go in and check our cholesterol and our blood pressure, right? So that's why we want to measure soil health. We're at a point, especially in agriculture, where we know that we rely very heavily on our soils to produce food, feed and fiber.

We also know that a lot of the practices that we've been using have degenerated our soils and we want to regenerate them. So if we're changing our practices and wanting to improve soils, then we need to measure those soils to know that what we're doing is changing how the soil is functioning, its soil health.

DJ May:

Great. Yeah. So then when you look at that, I mean, that's one thing on one farm in one field, but what does it mean to do it at scale?

Cristine Morgan:

Yes. Measuring soil health at scale is a very different concept than even what I'm used to having come from academia. What we mean by at scale is the measurements that we make have to be relevant, they have to tell us something useful, right? They need to be actionable, but they also need to be relevant wherever we are in the United States, or the continent or the globe, wherever we're measuring it.

So the first thing that we have to be able to do at scale is we have to afford it. If we're talking of tens of thousands, hundreds of thousands of measurements, it can't be that expensive. So we really have to think, take off the academic soul scientist hat and think, how can we minimize this set of measurements so that anyone can do them? There are laboratories around that can do them reliably and repeatedly, and interoperably, which means if I have some measurements at one lab and measurements at another lab, can I think about how those two measurements can represent the same numbers if they actually should represent the same numbers?

So that's what we mean about at scale. It has to be affordable, has to be practical, and there has to be access to be able to make that measurement. In the United States, we're very blessed with good labs, high quality labs, and even then, sometimes we stumble with the interoperable question like are the labs using the same methods, are the methods so different that we're getting different numbers. But then when you think about moving outside of the United States and some other countries, there isn't the access that we are very spoiled with. So we need to think about measurements that could be... So access, access is an important part.

DJ May:

Okay. Okay. No, that's really helpful. So you want to compare apples to apples, essentially.

Cristine Morgan:

Yes.

DJ May:

But it seems like that's a lot of different constraints. Which measurements work at scale?

Cristine Morgan:

Well, we had this North American project to evaluate soil health that we have just finished. We partnered with over 100 scientists, looked at 124 long-term agricultural research sites in the U.S., Canada and Mexico. We evaluated over 30 soil health measurements with the purpose of identifying this minimum suite that's practical and affordable, AKA scalable.

From that, we considered how each soil health indicator responded to management, whether, and how it was influenced by local factors like soil type. Then also, we looked at that cost and practicality, availability and redundancy of all these measurements because once again, it has to be accessible. It has to be affordable, which means we can't measure everything. We fell on three measurements that we find are very important.

One is soil organic carbon. I know that's a shocker, but what is the concentration of carbon in the soil? We're talking about soil health, we're just measuring the top 15 centimeters as a representation of the direction the soil is moving. So soil organic carbon concentration, wet aggregate stability, and I want to get this right, potential mineralization of carbon, which some people call that burst of CO2 or that soil respiration in the laboratory. So carbon, carbon mineralization and wet aggregate stability.

DJ May:

Okay. So taken together, what do those three measurements mean? What do they tell you about your soil?

Cristine Morgan:

Yeah. So we're looking at redundancy. Though it sounds like they might be redundant, we're really trying to parse out what can these individually tell us about soil health. Well, carbon, the amount of carbon in the soil tells us what the microbes have to eat, and everything going on in the soil, all this process, the soil is living, which means you have to feed your living things. So that carbon is just telling us what is the food source in the soil. That carbon primarily is like the broken down plant materials, some microbial, dead microbial bits and some live microbial. But primarily, it's the broken down soil organic matter in the soil. So that's just telling us what there is to eat. Carbon's also the building block of so many things.

Secondly, potential mineralization of carbon. That measures the soil microbial community response to being rewet after the soil's been dried. So this burst of CO2, essentially, you wet up the soil in a controlled lab condition, and the microbes that are alive come to life. They eat up some of the carbon and they have this burst of CO2. This measurement represents the activity of the microbial community, and it's linked to the soil's ability to cycle carbon and nutrients.

Then lastly, aggregate stability. That's soil structure. I'm a soil physicist. This is my favorite measurement. Soil structure is really the backbone of vitality in soil. It decides how the pores are distributed. Soil structure allows the water to get into the soil, redistribute in the soil, and provide a stable way for water to be exchanged between the soil, the storage place, and the living component, the plant roots and the microbes, and the fauna and the soil. So that's what aggregate stability is getting us. We take a little aggregate, we wet it up, and we see how stable it is once it's been wet. We can take that measurement with a smartphone, with just a photograph. So that also makes it very accessible.

DJ May:

Excellent. Yeah. So you can take that one with a smartphone. The other two are lab tests, right? You'd have to take a sample and send it off.

Cristine Morgan:

Yeah. The CO2 burst, I call them kitchen measurements. You can buy a little detector that will change color in different CO2 concentrations. So you could do the CO2 burst outside of a fancy wet lab. But carbon concentration, you really do need to send that one to a lab to get a good

measurement today, but we're working on... There is new technology where you can just scan it visible near infrared reflectance and get carbon. It just depends on how accurate you want the measurement. So there are ways to get all three of these without going to a wet lab. So once again, we're really looking forward and thinking about access and opportunity to do this at scale.

DJ May:

Okay. Now, earlier you mentioned your yearly checkup like you would go and get your cholesterol taken. How often should you take these measurements out in the field?

Cristine Morgan:

About once a year you should take them, and also about the same time every year. Soils wet and dry seasonally. There's different microbial activity going on with whether or not you have an active crop growing, or if the plants are growing actively. So if you take it in the spring, take them in the spring every year. If you take it in the fall, take it in the fall every year. That will just help reduce a lot of the noise in your data if you're looking at it from year to year.

We also recommend that you compare it to a soil, a similar soil that perhaps is under ideal soil health management practices, so that it's under perennial roots, like a grassland or an orchard or the side of your field or something like that, so that you can see how good your soil can be. At the institute, we're working again on a scalable concept we call soil health targets, where we're baselining soil health for our most actively used agricultural soils in the U.S.

DJ May:

Okay. Now, I know this is probably really regional. You should stick pretty close to your own field. I mean, how far can you go with that soil sample to get your own target?

Cristine Morgan:

Yeah, we're learning. I think if you stay within county roughly, and you're in the same soil texture. So we talked about these three measurements, but another measurement that we take at least once is the texture, the percent sand, silt and clay, so that we know as we compare soil health under different management, that we're comparing apples to apples, we're comparing similar soils. Because a really healthy sandy soil could have the same soil health metrics as a degraded clay soil, right?

So you can't compare sandy soils to clay soils. You can't compare wet soils to dry soils on the landscape. So we have to be thoughtful about that. But I think that most farmers and practitioners have a good feeling for where their soils are on the landscape and how they vary and can make a pretty smart job of it.

DJ May:

Great. Great. Now, you kind of touched on this before, but I'm curious, as you move forward with these protocols, what are the challenges to getting this to everyone or getting everyone on the same page to measure their soil health?

Cristine Morgan:

Communication. I mean, oh my gosh, all the challenges with scale. Getting the labs interoperable, creating this database of baselines and targets so that I as a single person, maybe I have a 1,000 acres that I'm managing, well, I just want to go collect the soil health of my 1,000 acres and then I'd like to take my measurements just like we do today with NRCS soil mapping, right? I'd like to just put my measurements into a program on the computer and it gives me the scale of like this is how healthy your soil is today and this is how healthy it could be.

That's our goal at the Soil Health Institute, is to work with partners and get that kind of information to people, and again, affordable. We want access because I'm a soil scientist, at the end of the day, I'm passionate about soils. When I retire, I just want more people to have access to soil information and understand how their management practices affect their soil functioning.

DJ May:

Yeah. Great.

Cristine Morgan:

So that's the goal.

DJ May:

No, that is--I think that's a very admirable goal and I'm excited to see where everything goes. I think there have been a lot of changes even in the last few years, so.

Cristine Morgan:

It's so exciting to be a soil scientist right now. People know the word soil even, right? There's a little bit of reverence when they say the word because as a society, we're really understanding soil's role and these existential challenges that we have today. How cool is that? I love it.

DJ May:

Right. Yeah. Yeah, it is. It's super exciting. Cristine, I have one bonus question for you.

Cristine Morgan:

Uh-oh.

DJ May:

It's kind of big picture. I know, I know. How do you see what the Soil Health Institute is doing with scale and these measurements--how does it relate to carbon markets or programs?

Cristine Morgan:

Oh, trick question. First, I have to say that increased carbon in the soil is a co-benefit to improving your soil health. We have shown in our economics that in some economic partial budgets of farmers that have adopted soil health management practices, they're making more per acre on average than any carbon market's paying right now for carbon. So it pays to practice soil health as a farmer.

However, I think carbon markets, they're the icing on top where you can get more recognition for adopting soil health management practices. A lot of the things that we're doing with soil health targets can give farmers an idea. When I say we want to be able to say, "How healthy is your soil? How healthy can it be? How much carbon's in your soil and how much carbon can your soil store?" is another question we're asking. I just don't talk about it much because I want people to keep their eye on the ball.

But I love the fact that carbon markets are investing in many of the technologies that we need to be better soil health practitioners as well. So I say go carbon markets and let's get it done and let's get our soil functioning, take care of this natural resource, and as a co-benefit, stuff some carbon from the atmosphere into it and move on.

DJ May:

Great. Great. Well, thank you so much, Cristine. I'm really glad I had you here.

Cristine Morgan:

All right. Thanks, DJ.

DJ May:

If you want to read some of the research that Cristine mentioned in today's episode, check out the show notes. If you're curious about carbon sequestration or practices that can improve your soil health, or if you have other questions about carbon and ecosystem services that you want us to answer, come visit us at decode6.org.