Can new technology incentivize farmers to capture carbon in their soil?

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Regenerative agriculture practices — such as no-till farming, composting, and cover cropping — can help to store carbon in the ground. They also provide benefits to farmers, including healthier soil and increased water retention. Credit: NRCS Oregon

The Scenic Hudson Soil Lab is a rather unassuming structure. Sitting atop a hemp farm within New York's Hudson River Valley, the lab is unadorned, and no bigger than a roadside diner. The inconspicuousness of the site, however, belies the importance of the research going on inside.

In the past few years, the lab has become the regional hub for a burgeoning group of scientists, farmers and entrepreneurs who gather here to analyze soil core samples taken from local plots of land, measuring these samples for their organic carbon content. As more landowners look into the possibility of generating and selling carbon offsets—the legal deeds verifying that one ton of carbon dioxide has either been captured from the atmosphere, or not emitted in the first place—the research going on inside the lab is crucial.

Farmers have, for years, known about their theoretical ability to offset carbon emissions by managing their land in a way that captures carbon dioxide from the atmosphere and stores it in the soil—a set of practices sometimes referred to as regenerative agriculture. But measuring the carbon drawdown within the soil as a result of such practices has proven difficult and nuanced over time, and farmers have generally eschewed these practices, which require more labor than conventional agriculture.

But thanks to a wave of new technological developments, there is hope that the incentive structure might change for farmers, who collectively can make a significant dent in reducing carbon emissions. By some estimates, if the 1.2 billion acres of American agricultural land (more than half of the U.S. land base) transitioned towards regenerative farming practices, it could sequester up to 20 percent of the carbon required to reach the Biden administration's goal of fully offsetting America's carbon emissions by 2050.

Specifically, a number of companies are piloting novel remote imaging technologies that could help to streamline how farmers measure the amount carbon in their soils. Until now, the expense and time associated with measuring soil carbon content has been a major hurdle for farmers hoping to generate carbon offsets on their land. If these new technologies prove effective, they could greatly accelerate the ongoing effort to make the agricultural industry carbon negative.

Measuring soil carbon from the sky

The emergence of these technologies comes at an opportune time for farmers, who, theoretically, are well positioned to capitalize on a growing demand for carbon offsets. As the public has become more aware of the risks associated with a warming climate, it has increasingly applied pressure to polluters to do more to mitigate their emissions. In fact, throughout the COVID-19 pandemic, the number of corporations pledging to become carbon neutral has doubled. But currently, less than 2% of transactions in voluntary carbon markets—platforms through which verified carbon offsets are traded—are derived from agriculture.

"Offsets traditionally come from either renewable energy installations that replace hydrocarbon generation, industrial process changes that reduce or eliminate emissions relative to a baseline, or reforestation projects," says Satyajit Bose, a professor at Columbia University who lectures on the intersection between sustainability and finance.

"If new technologies can reduce the (financial) verification burden on farmers by introducing economies of scale… it could be much a more efficient process," continues Bose.

Firms developing these technologies are deploying fleets of drones, planes, and satellites equipped with precision imaging cameras. These images, when cross-referenced with soil-core samples like the ones being analyzed at Scenic Hudson Soil Lab, are producing some of the most accurate models of soil carbon ever recorded. The models, which rely on advanced machine learning and artificial intelligence algorithms, are helping researchers remotely track and predict soil carbon levels.

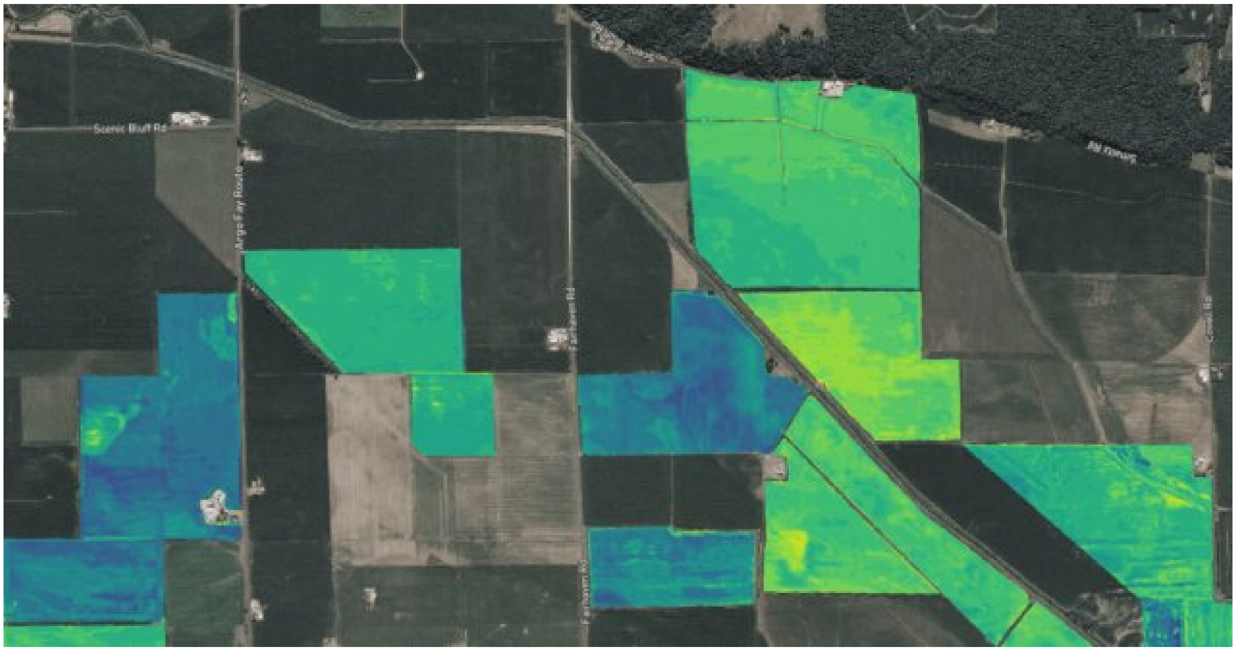
"It is called hyperspectral imaging," explains Petra Sikorski, referring to the underlying imaging technology that is, in part, fueling the rise of the "geospatial analytics" industry. Sikorski is the director of business development for Cloud Agronomics, a Boulder-based firm that is one of a few ag-tech startups helping to pioneer this nascent sector.

Crucially, this technology requires that farmers only produce a single round of upfront soil-core samples—what Sikorski calls "ground-truth data"—in order to build models to track carbon remotely. This shift represents a major improvement from the status quo, where landowners traditionally have needed to present an ongoing series of soil samples to measure and verify carbon drawdown.

On a granular level, Cloud Agronomics' imaging technology enables its researchers to view significantly more bands across the spectrum of light. Given that carbon in the soil has unique chemical properties which reflect certain wavelengths of light, Cloud Agronomics will have the ability to fly a plane with a hyperspectral camera over a plot of soil and predict how much carbon is in that soil.

Though this technology is imperfect in that there is still a substantial margin of error in its soil-carbon readings, it is, according to Sikorski, a major improvement over the existing geochemical models produced from aerial images.

The ability of hyperspectral cameras to provide such detailed insight has been known for years, Sikorski continues. "But (until this point) it has not been successfully commercialized for agriculture, and specifically not for soil carbon."



Cloud Agronomics carbon sequestration imaging overlaid onto a public map.

Benefits for farmers

For farmers whose work is notoriously risky, the potential stream of income generated from producing carbon offsets could be both a hedge in a world where a changing climate is disrupting traditional agricultural patterns, and a needed complementary source of income.

"It could really represent a license to print money," says Ann Marie Gardner, an advisor to the landowners that are sponsoring the research being done at Scenic Hudson Soil Lab. Gardner is especially bullish on the prospects for farmers if they are able to more efficiently access carbon markets.

"We are getting to a place technologically in which we will be able to track carbon data from farms in a way that hasn't really been possible before," continues Gardner. "If we can demonstrate that we have the potential to sequester carbon at scale in soil, it will hopefully be an incentive for the public to invest in the farming practices that produce these results."

Cloud Agronomics' product is already attracting farmers, who are, in increasing numbers, requesting to be included in pilot programs testing the imaging technology.

"Right now, customer demand exceeds our sales capacity," says Sikorski. "We are simultaneously in the process of commercializing and piloting this technology with some of the largest companies in agriculture."

The need for a higher price on carbon

Despite the growing interest, there still are major obstacles preventing platforms like Cloud Agronomics from scaling up. Many experts are not convinced that investing in generating carbon offsets is worth the trouble for farmers, even after taking into account a reduced price to verify them.

"It can cost a farmer between $250 and $400 an acre to transition a farm to become regenerative, and profitability and yield can suffer for three years," states Sam Schiller, the founder of Carbon Yield, a firm that councils farmers on whether and how to transition their land management practices so that they can enroll in carbon markets.

"After the transition, operating profits can be enticing, but most farms don't have enough cash on hand to cover that challenging transition, and there are few economic and agronomic supports that are tailored to meet that acute need," adds Schiller.

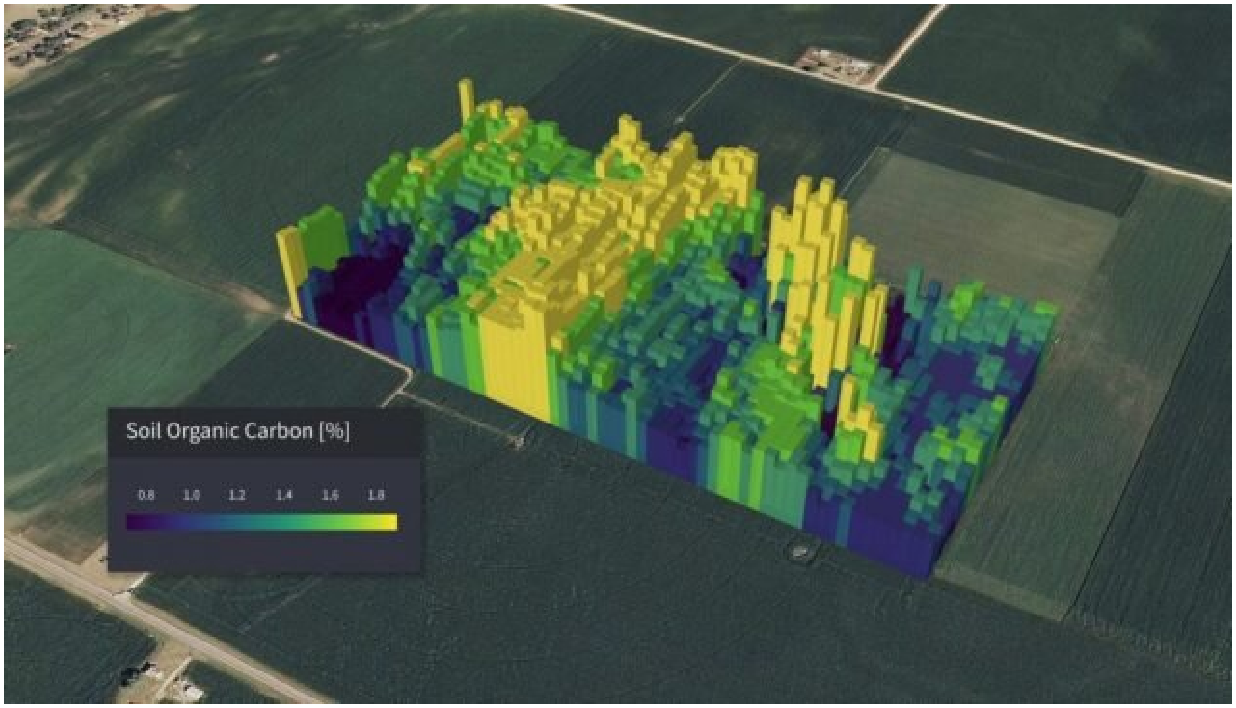
Echoing this sentiment, Secretary of Agriculture Thomas Vilsack recently admitted that "the actual payments (that farmers receive for carbon credits) are not necessarily significant—not enough anyways to compensate for the hassle that's connected with the carbon market."

With most carbon credits being sold in the range of $15 to $20 per ton of carbon, the math for farmers is murky. Most experts agree that to entice more farmers to enroll their land in carbon sequestration programs, there will need to be higher prices for offsets in the marketplace.

"For the price that carbon is going for right now, it's not a sound investment to be taking soil samples," says Sally Flis, who has a doctorate in soil science and advises farmers on sustainability strategies on behalf of Nutrien Ag Solutions, one of the country's largest agricultural supply companies. "In the $15-20-dollar range (for carbon offsets), it's at best a breakeven proposition for most farmers."

Aligning the price of a carbon offset to reflect the financial reality on the ground for farmers is one of the main initiatives that Gardner and her partners at the Scenic Hudson Soil lab are working on. "When you look at the literature about how carbon is priced in the market, credits should be going for closer to $100," Gardner explains.

The World Bank agrees. In its most recent report assessing economic incentives and carbon prices, it concluded that a price between $50 and $100 per ton of carbon will be needed to effectively reduce carbon to be in line with the goals set forth by the Paris agreement.



A depiction of a field's varying carbon levels, stemming from data gathered by a hyperspectral image. Credit: State of the Planet

Fortunately, the same imaging technologies that are helping farmers to track carbon levels in their soil are also being leveraged to make carbon emissions more traceable and transparent for the general public to see. In the next few months, a team coordinated by Al Gore is hoping to launch the "Climate Trace Coalition," which will provide freely accessible data across an array of polluting industries, from agriculture to shipping to ground transportation.

"It is going to really begin to put pressure on polluters to clean up their act, and maybe turn to carbon markets," adds Gardner, who is representing the agricultural sector as a special advisor on the Climate Trace Coalition.

When prodded on whether people will be willing to pay a higher price for carbon offsets, Gardner maintains that it is possible.

"Looking at the younger generation, a more climate conscious generation, we think they will be willing to pay more for carbon offsets. And when you keep the price as low as it is now, people will just keep polluting, so how is that an effective solution if we are trying to actually decarbonize?"

But even if younger, more climate-conscious firms are willing to pay a higher price, getting larger corporations to do so will be tricky. Larger companies looking to offset their carbon emissions are understandably sensitive to the price of carbon offsets considering that they might be buying thousands of them each year to balance out their emissions.

The "missing link" according to Flis, is that there is a "lack of confidence at the moment from larger buyer side companies in what we are doing around agriculture-generated carbon credits."

Gardner thinks that building such confidence on the buyer side will require more data that definitively demonstrate the co-benefits of carbon sequestration. These benefits include: healthier and more productive soils, increased biodiversity, cleaner water, and less vulnerability to natural disasters.

"You have to tell a story when you are selling a carbon offset," explains Gardner. "When you make the co-benefits more vivid, and you are no longer paying for just carbon emission reductions, that's when you can start to charge that higher price."

A growing number of firms are devoting time to statistically analyzing these co-benefits. A recent study by the Soil Health Institute, a non-profit based out of North Carolina, found that out of 100 farms spanning

10 states that had recently adopted regenerative soil health practices, 85% earned higher revenues, 67% had increased yields, and 97% reported increased resilience to extreme weather conditions.

"There is a stack of benefits associated with adding carbon to the soil, especially relative to other forms of carbon offsets," echoes Nick Reinke, the senior manager of strategy and market development at Truterra, a farmer owned co-op devoted to promoting agricultural sustainability. "But there isn't a straightforward way to account for those various benefits within a carbon credit."

"We have incredible publicly available data from the USDA," continues Reinke. "We are doing our best to combine these datasets with field-specific management data in novel ways to deliver insights that are actionable on the farm."

Ideally, the new data streams stemming from companies like Climate Trace and Cloud Agronomics can further demonstrate these "stacked benefits" by providing ongoing data points that can be used to build more robust models tracking how carbon sequestration affects both micro-trends within a plot of land, and macro-trends in larger ecosystems.

Even if this information takes a few years to be reflected by price signals in carbon markets, public discourse around the nuances of carbon pricing is gaining traction as more people buy into the notion that there is real value in sequestering carbon in the soil beyond the fact that it is no longer in the atmosphere.

For example, Light Phone, a cellular technology company founded in 2015, recently committed to paying $100 per ton for its carbon offsets. On its website, a blurb justifying the company's decision to buy the higher priced carbon offsets states:

"When offsets are too cheap it incentivizes 'pollute-and-forget' behavior…to actually adjust the psychology of consumption to account for externalities, we need to be able to feel the burden of these externalities. At $100 a ton, offsetting the Light Phone isn't prohibitively expensive, but expensive enough to make you think about what you are purchasing."

Now, the task is persuading more companies, through both science and economics, to think like this.

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