REGENERATIVE FARMING AND SOIL HEALTH AT SCALE WITH O'NEILL VINTNERS

A CASE STUDY

QUANTIFYING THE JOURNEY FROM CONVENTIONAL TO REGENERATIVE FARMING

The future of regenerative agriculture must prioritize outcomes: resulting in improved crop quality, enhanced profit margins and environmental benefits. Achieving this requires understanding soil health through measurement. Improving the health and activity of the soil microbiome improves the carbon cycle and provides opportunities to sequester carbon across the entire agriculture sector. In the wine industry, regenerating soil health enables growers to cultivate a new expression of terroir and to achieve a lower cost of production for a higher quality product. Wine businesses powered by quantifiable soil health and carbon sequestration data can differentiate themselves in their growing practices and wine quality.

O'Neill Vintners is a leader in this practice. As a Certified California Sustainable Vineyard & Winery, O'Neill tackles everything from clean energy solutions, to sustainable water treatment, and regenerating soil health. Their work significantly reduced O'Neill's environmental impact and laid the foundation for the winery's B-Corp Certification and True Zero Gold Certifications.

THE CHALLENGES

- Assessing the impact of regenerative practices through a side-by-side trial at Robert Hall vineyard in Paso Robles, CA. The goal was to quantifiably demonstrate the impact of regenerative practices on vineyard soil health, carbon accrual, microbial activity, as well as other operational factors such as water use optimization and, most importantly, grape and wine quality.
- Converting and certifying 40 vineyard acres to regenerative, then expanding that regenerative trial to 130 acres.
- Quantifying impact and showing clear ROI before scaling regenerative practices to 200+ growers.

QUANTIFYING

Gathering accurate data to clearly demonstrate and quantify the results of regenerative practices was a major roadblock for O'Neill. Caine Thompson, managing director at Robert Hall Winery and head of sustainability at O'Neill, began searching for a solution. At the time, they were using annual soil samples and other methods including USDA models to understand their carbon sequestration. Caine wanted higher accuracy than what the models could provide and more frequent and reliable data on soil carbon stocks than what annual soil samples afforded him. He remembers thinking that there was "a missing link in how to quantify and understand what was happening in the soil with regenerative versus traditional farming."

MAIN BUSINESS OBJECTIVE

O'Neill aimed to offset carbon emissions from production and the supply chain through a shift to regenerative practices in the vineyard. They also wanted to achieve carbon neutrality within their own agricultural supply chain without relying on carbon offset programs, which have come under scrutiny. However, they needed an accurate and reliable way to measure the changes in soil carbon stocks caused by the changes in their farming practices.

ADDITIONAL BENEFITS

- Building soil structure, improving water holding capacity and infiltration
- Improving the vitality and activity of the soil microbial communities
- Creating cooler in canopy temperatures in the regenerative block, mitigating the risk of fruit quality loss during heat waves and reducing heat-stress in those blocks

CAINE THOMPSON

Managing director at Robert Hall Winery and head of sustainability at O'Neill Wines

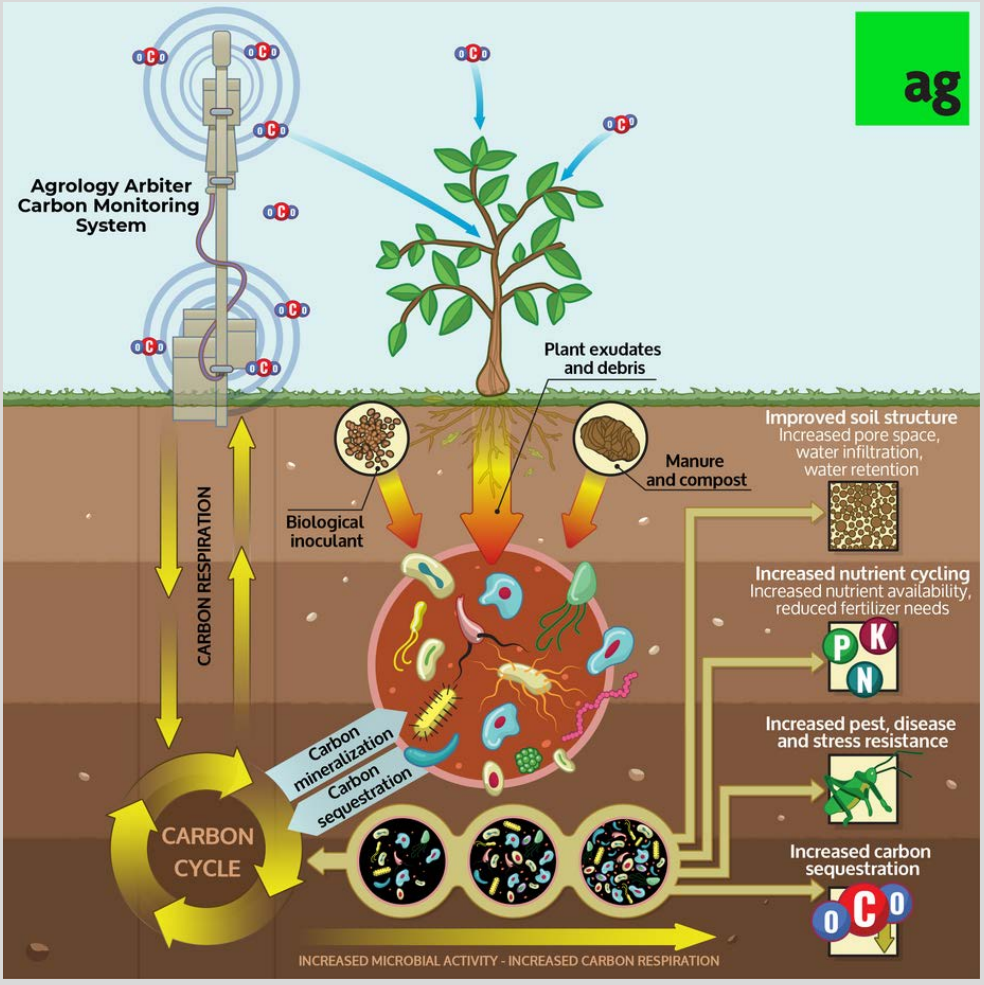
APPROACH

Caine found Agrology and realized that it solved these problems. The Agrology Arbiter System could clearly quantify the impact that regenerative practices had on soil microbial activity, soil carbon stocks, and could monitor and correlate secondary factors such as soil moisture, water retention, and in-canopy temperature differences.

Caine and his team initially started with a small Agrology deployment, but upon seeing the impressive results and clear differences in carbon flux between the conventional and regenerative farmed vines, they decided to expand the use of Agrology across more of their acreage.

> **"We now have real-time feedback and data to demonstrate the positive impact regenerative farming is having on our soil carbon stocks. Agrology empowers us to compare practices and see in real-time the differences in the soil microbiome and carbon respiration."**

HOW IT WAS DONE



1. Installed the Agrology Arbiter Carbon Monitoring System in side-by-side regenerative and conventionally farmed vines.

2. Ran trial within a single block, with the same varietal - the only difference being a change in cultural practices. Regenerative practices included reducing tillage, year-round cover cropping, and incorporating sheep instead of mowing.

3. Continuously monitored and quantified the changes in soil carbon flux between the regenerative and conventional rows, using the Agrology mobile app and the desktop Agrology Grower Portal.

As seen in the above graphic, the Arbiter System continuously monitors the carbon cycle via soil carbon respiration. Increasing the health of the microbiome had numerous ecological and production benefits including improved water infiltration and retention (drought resistance), more active nutrient cycling and improved nutrient availability (decreased need for fertilizers and inputs), and increased pest, disease and stress resistance of crops (healthier, higher quality crop). In addition to this, Caine was able to have a clear understanding of the increased carbon sequestration that was occurring thanks to this transition to regenerative agriculture - not with models, practice-based estimates, or remote sensing, but with ground-truth data directly pulled from in the vineyard.

CREATING TERROIR

O'Neill investigated how the soil microbiome actually creates a richer terroir and a higher quality product, keeping the grapes from the regenerative and control blocks separate all the way through the winemaking. Anecdotally, they found the wines from the regenerative block to have a clearer expression of terroir, which is backed by numerous studies that show the soil microbiome's effect on crops' secondary metabolite production. These secondary metabolites are organic compounds that are often associated with higher wine quality such as sugars, phenolics, anthocyanin, tannins, and other bioflavonoids. Some of the changes between the regenerative and conventional rows were apparent to the naked eye. Caine and his team could visually see that the regenerative rows clearly had increased vegetative growth, greener and healthier leaves, increased pest resistance, and overall a more robust canopy (as seen below).

"Although specific functions can be attributed to specific microorganisms, it is the total microbiome and its interactions that affect plant health and terroir."
-Berendsen et al., 2012,"

Regenerative

Conventional/Control

THE RESULTS

REGENERATIVE	VS	CONTROL

- In 2021, yield for the regenerative vines was 14% higher than the control vines and in 2022 the yield was 3% higher.
- In 2022, YAN levels were 13% higher than the control.
- Increased metabolic activity of the soil microbiome, indicated by substantial soil respiration levels 100% of the time.
- Soil respiration spikes in the regenerative block peaked at over 10,000PPM.
- Average volumetric water content was 17% higher than the control with the same applied irrigation.
- Daily peaks of canopy temperature were on average 7°F lower, with a larger spread in hotter weather.

- Very low-level metabolic activity of the soil microbiome.
- More than 95% of the time there was little to no soil carbon respiration.
- Soil respiration spikes in the control block peaked at just 1,900PPM (8,100 below the regenerative block), during the 5% of the days that soil respiration occurred.
- Lower volumetric water content indicated a deceased water holding capacity of the soil.
- Higher canopy temperatures contributed to increased stress on the grapes, as well as a decline in grape quality.

COST ANALYSIS	CONTROL '21	REGENERATIVE '21	CONTROL '22	REGENERATIVE '22
Tons per acre	4.83 tons	5.52 tons	2.16 tons	2.23 tons
Cost per acre	$6,204	$6,833	$6,938	$7,583
% difference in cost per acre		10% increase/acre		9% increase/acre
Cost per ton	$1,284/ton	$1,237/ton	$3,200/ton	$3,402/ton
% difference cost per ton		3% cheaper per ton		6% more expensive per ton

**2022 was one of the driest years on record in San Luis Obispo, resulting in the incredibly low yields. This likely skewed the results as well, inflating the cost/ton of the regenerative rows above what they would be in a normal year.

> **"I never thought in my wildest dreams this type of difference could exist in the microclimate of one block of a vineyard with two different approaches."**
> **- Caine Thompson**

SOIL CO2 RESPIRATION

CANOPY CO2 CONCENTRATION

HIGHLIGHTS

INCREASED METABOLIC ACTIVITY

Agrology data quickly demonstrates increased metabolic activity of the soil microbiome on the regenerative rows (a sign of healthy soil) vs low-level metabolic activity in the conventional rows.

O'Neill's data showcases signature CO2 concentrations and CO2 spikes indicating a healthy soil respiration curve. The green line indicates CO2 respiration in conventional blocks, whereas the yellow line represents the carbon respiration in the regenerative blocks.

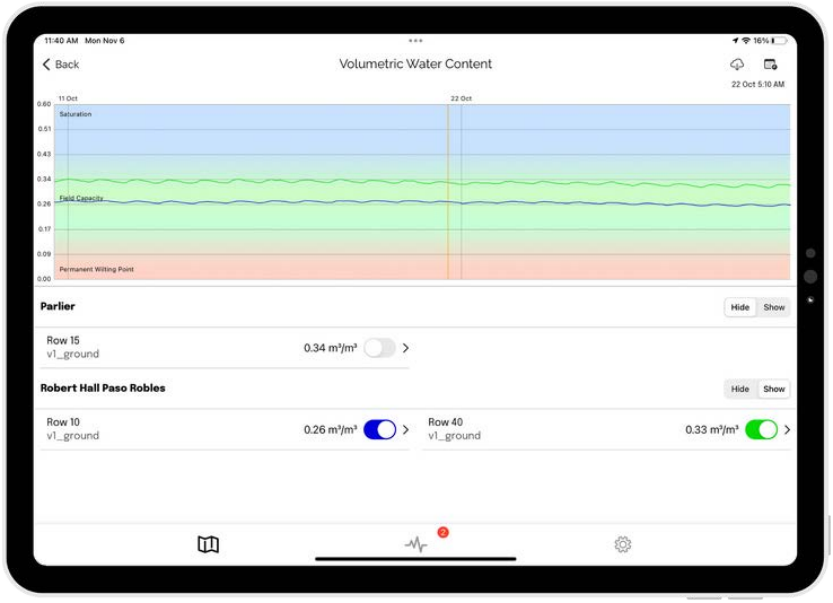
CLIMATE POSITIVE RESULTS

The soil carbon respiration curves indicate that the soil is alive and respiring (higher levels) vs flat-lining (lowest levels). Although a bit counter-intuitive, soils with higher levels of carbon respiration are more climate positive. This due to the fact that increased carbon respiration is indicative of increased carbon cycling, meaning more carbon is sequestered in the thriving microbial community.
Agrology also quantified the increased carbon sequestration of the regenerative blocks by monitoring the in-canopy concentrations of CO2. The graph on the right reveals how the regenerative blocks (the green line) had consistently lower CO2 concentrations in the canopy compared with the conventional blocks (the blue line). The regenerative block consistently had concentrations below the background atmospheric concentration of approx. 420 ppm, revealing how the regenerative block is pulling CO2 out of the atmosphere and bringing it into the canopy, the roots, and the soil in the form of exudates.

ECOLOGICAL BENEFITS

Caine was able to see other ecological co-benefits from his switch to regenerative agriculture practices as well. He said these were captured by the Arbiter System and were apparent to the naked eye. Caine and his team clearly saw that the regenerative rows had increased vigor, a greener and healthier looking canopy, increased water holding capacity, and increased pest and disease resistance.

SOIL MOISTURE MONITORING/VOLUMETRIC WATER CONTENT



HIGHLIGHTS

The data revealed a clear improvement in water holding capacity in the regenerative rows (green line) vs. the conventional rows (blue lines), which helped save water through a reduction of irrigation events.

This improvement was likely caused by the improved soil structure and pore space, which improved water infiltration (reducing runoff) and water retention (reducing drought stress), while also allowing deeper root penetration.

One of the benefits of regenerative farming practices is better water retention of the soil, which makes crops more resilient to drought and allows growers to irrigate less often.

“Agrology has been amazing. It’s super easy to use, it’s intuitive, and pulls in more data than we even thought was possible. From soil moisture to temperature, to carbon flux and everything in between, all of the data is all right there and Agrology is quantifying everything that’s happening with our soil over time. And their support is second to none. It has been a great partnership so far.”

THE IMPORTANCE OF CONTINUOUS GROUND-TRUTH MEASUREMENT

Caine and his colleagues at O'Neill quickly understood the importance of the continuous ground-truth measurement Agrology provides. He said, “There is so much variation with land, soils, topography, and practices that we knew we needed real soil data to quantify the impact of our specific practices. By gathering more data and more information we have site-level details and we can truly put our hand on heart and say yes, we are able to sequester carbon through our practices.”

Agrology’s ground-truth data around carbon flux allowed Caine and his team to quickly see (and quantify) the impact of their transition to regenerative agriculture. With this knowledge and data in hand, Caine is confident that expanding their acreage in regenerative production is the right business move.