Vineyard Soil Health

THE RESILIENCE REPORT

American Farmland Trust

THE FUTURE, TODAY

American Farmland Trust (AFT) partnered with Regrow and USDA Agricultural Research Service to model 50 years (2022-2072) of California vineyard systems under likely future climate conditions. We wondered which management decisions today could help California wine grape growers achieve the best financial and environmental resilience outcomes under future climate conditions. We ran the model* with and without soil health practices (no-till and barley or fava bean cover crop) to understand how these practices impact soil carbon sequestration potential and erosion control. Explore the next few pages of our results and see "How we did this" on page 4.

**The model is built on data from field studies, and we acknowledge the inherent uncertainties from modeling. Modeling is a valuable tool for understanding potential future outcomes.*

IN A NUTSHELL, WE FOUND:

COVER CROPS BUILD SOIL ORGANIC CARBON

According to the model, soils in vineyard systems without cover crops tended to lose soil organic carbon (SOC), while vineyards with a cover *gained* SOC. The fava bean cover gained more than twice as much SOC as the barley cover crop.

LESS EROSION WITH COVERS

Compared to vineyards with bare alleys, the barley or fava bean cover crop cut sediment loss by 70% across all future climate conditions.

GOOD TO KNOW

We simulated wine grape systems with drip auto-irrigation from April through September. The modeled systems had different cover crop and tillage practices: no cover crop, a barley cover crop, or a fava bean cover crop (photo below); and conventional tillage (4 inch deep discing every July) or no-till. Cover crops were planted 2 weeks after grape harvest and terminated 2 weeks prior to bud break. The grapes received UAN fertilizer totaling 45 lb nitrogen (N) per acre per year. We ran the model for years 2022-2072 accounting for likely future changes in temperature and precipitation.

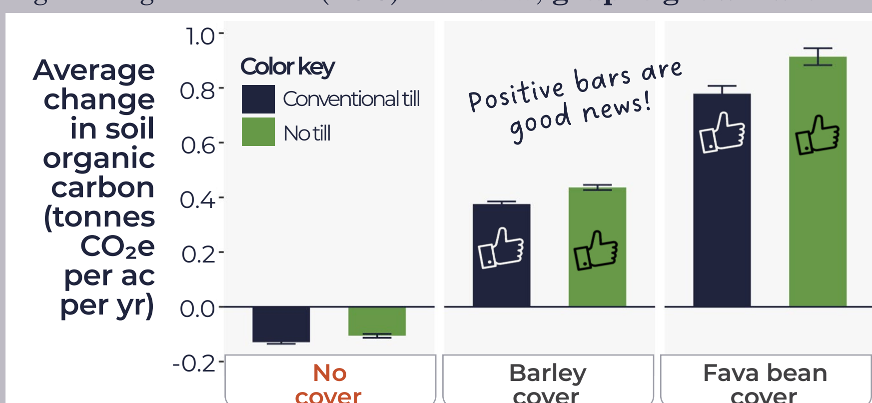
STORE MORE SOIL CARBON

A soil's organic matter content can be an indicator of its resilience to weather extremes. More soil organic matter means greater water holding capacity to protect vineyards during a drought. Higher soil organic matter percentage can mean greater aggregate* stability and infiltration of water to allow the soil to capture more rainfall and drain more rapidly during extremely wet periods.

One way to measure soil organic matter is by measuring soil organic carbon (SOC). We used the model to estimate changes in SOC in California wine grape systems.

In the **chart below**, the bars represent the average annual change in SOC for 2022 to 2072. The system without a cover crop lost some SOC on average every year. **Grapes grown with barley cover** sequestered more than 4x as much SOC as was lost by the grapes with no cover. Fava beans produced more biomass than barley, so as shown in the right-most panel below, **grapes grown with fava bean cover** sequestered over 8x as much SOC as was lost by the grapes with no cover.

The fava bean cover with no-till (fava bean green bar) **sequestered 18% more SOC than fava beans with conventional till** (fava bean blue bar). Wine grape systems using a mix of barley and fava beans are likely sequestering SOC somewhere in between the barley and fava bean systems shown here. *Please note that our no-cover system simulated alleys with bare ground, so a vineyard with no cover crop but maintaining resident vegetation could have results closer to the cover crop systems.*



Notes: It is reasonable to expect these rates for 10-20 years but not for 50 years. Error bars indicate standard error among modeled sites.

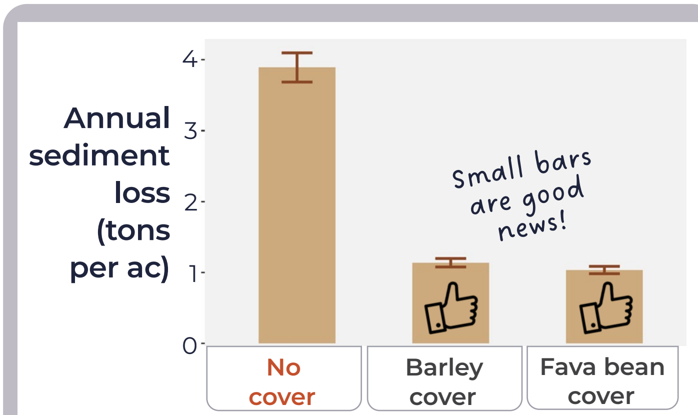
*A soil aggregate is soil organic and mineral particles joined together, the basic unit of soil structure, and the foundation upon which many soil functions depend.

KEY FINDING

According to the model, adding a cover crop is key for sequestering soil organic carbon and building more soil organic matter (and resilience!) in grape systems in a likely future climate.

Vineyard with fava bean cover crop. STEFANO LUBIANA 2012 CC BY 2.0 DEED

PROTECT THE SOIL



Error bars indicate standard error among modeled sites.

Cover crops build soil health and help keep the soil in place. So, let's look at how cover crops may protect soil from erosion in the future. The **chart above** shows how the modeled **California wine grape systems without a cover crop lost more than 3x the sediments lost by a system with a barley or fava bean cover crop.** Tillage did not have a strong effect on sediment loss, according to the model.

The chart above shows sediment loss averaged across all years and weather types. We can also compare sediment loss by type of spring weather (normal, abnormally dry, moderately wet, etc.) (data not shown). In a moderately wet spring (precipitation in the 80-90 percentile range), the soil protection benefit shown above increases such that wine grape systems grown with barley or fava bean cover, compared to no cover, reduced sediment loss by 60%. **This suggests that when future weather conditions get more challenging (especially wet) cover crops will help build soil function and, therefore, soil resilience.**

KEY FINDINGS

Compared to no cover crop, barley and fava bean cover crops cut sediment loss by 70% across all future climate conditions.

Barley and fava bean cover crops build soil resilience to extremely wet weather.

So, what do YOU want to do for the future of your vineyard?

The previous pages show how a cover crop and no-till can build healthy soils and make California vineyards more resilient to future climate conditions. Here are some potential **next steps** for implementing or improving your soil health:

- Wondering how the economics work out for grape growers using cover crops and reducing tillage? Check out AFT's **Soil Health Farmer Profiles**, featuring four California wine grape growers: https://farmlandinfo.org/publications/soil-health-farmer-profiles/
- A helpful resource is "**Soils for Farmers**" ucanr.edu/sites/soils/Soils_for_Farmers/, a web-based guide from the University of California Agriculture and Natural Resources. It includes information specifically for grape growers.
- **Talk to someone who can help** by reaching out to AFT's Senior Agricultural Specialist for California, Paul Lum: plum@farmland.org.

YOU MIGHT BE WONDERING...

...why this report does not include how future climate change, cover crops, and no-till affect **grape yields, water use, and nitrate leaching**. The model we used (see below) has been developed and calibrated to estimate soil carbon change across a wide range of conditions but has not been similarly adapted for simulating crop yield, water use, or nitrate leaching in vineyard systems under non-stationary future climate conditions. AFT's partner, [Regrow](), is working to improve the modeling framework to expand the scope of rigorously addressable outcomes in these systems.

Wine grapes move along a conveyor belt. NIALL KENNEDY 2010 CC BY-NC 2.0 DEED

HOW WE DID THIS

The model

DeNitrification-DeComposition (DNDC) is a computer simulation model of carbon and nitrogen cycling in agricultural ecosystems. DNDC has been peer-reviewed, and applied across a wide range of agricultural ecosystems globally[1,2]. The results here summarize model output from 16 soil sample sites across California wine grape production areas without extensive model validation. The results here show how the model predicts California grape agroecosystems will respond to one climate scenario, called RCP 6.0, using one coupled climate model, called IPSL-CM5-LR. There are many scenarios and many climate models that produce different climate predictions.

Technical note

In this report, we only touch on the highlights of our analysis. We also created a technical note with specifics for how the model simulations were set up in DNDC. It is available at **farmlandinfo.org/publications/resilience-reports/, which is where you can also download this report.**

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[1] Gilhespy, S. L., Anthony, S., Cardenas, L., Chadwick, D., del Prado, A., Li, C., Misselbrook, T., Rees, R. M., Salas, W., Sanz-Cobena, A., Smith, P., Tilston, E. L., Topp, C. F. ., Vetter, S., & Yeluripati, J. B. (2014). First 20 years of DNDC (DeNitrification DeComposition): Model evolution. Ecological Modelling, 292, 51–62. https://doi.org/10.1016/j.ecolmodel.2014.09.004

[2] Giltrap, D. L., Li, C., & Saggar, S. (2010). DNDC: A process-based model of greenhouse gas fluxes from agricultural soils. Agriculture, Ecosystems & Environment, 136(3), 292–300. https://doi.org/10.1016/j.agee.2009.06.014

If you have questions about this report or suggestions for improving it, please email **Dr. Bonnie McGill**, AFT Senior Climate and Soil Health Scientist bmcgill@farmland.org. For more information, visit www.farmland.org/climate.

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