Almond**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 almond systems under likely future climate conditions. We wondered which management decisions today could help California almond 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 triticale or fava bean cover crop) to understand how these practices impact soil carbon sequestration potential and water quality. 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

Soils in almond systems grown without cover crops tended to lose soil organic carbon (SOC), while almonds grown with a cover *gained* SOC. Combining the fava bean cover crop with no-till further increased SOC.

LESS EROSION WITH COVERS

Compared to almond systems with bare alleys, almond systems with a triticale cover crop lost 17% less sediments, and almond systems with a fava bean cover lost 61% less sediments.

A cover crop growing in a California almond orchard. PHOTOS THIS PAGE BY SHAWN LINEHAN FOR AFT.

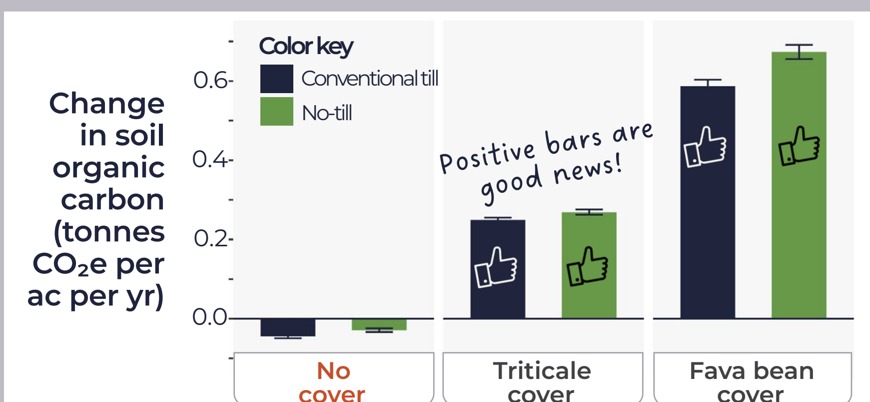
GOOD TO KNOW

We simulated almond systems with drip auto-irrigation from April through Sept. We modeled almond systems with: no cover crop, triticale cover crop, or fava bean cover crop; UAN fertilizer totaling either 220 lb nitrogen (N) per acre per year; and conventional tillage (6 inch deep disc pass every April, no inversion) or no-till. Cover crops were planted 2 weeks after almond harvest and terminated 2 weeks prior to bud break. We ran the model for years 2022-2072 accounting for likely future changes in temperature and precipitation. We refer to this as "future conditions."

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 orchards during a drought. Higher soil organic matter percentage can mean greater soil 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 our model to estimate changes in SOC in California almond 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. Almonds grown with triticale cover sequestered SOC, and the amount did not differ between tillage types. Fava beans produced more biomass than triticale, so the fava bean system sequestered over twice as much SOC as the triticale system. The fava bean system with no-till (green bar) sequestered 14% more SOC than fava beans with conventional till (blue bar). Almond systems using a mix of triticale and fava beans are likely somewhere in between. *Please note that our no-cover system simulated alleys with bare ground, so a system with no cover crop but maintaining resident vegetation could have results closer to the cover crop systems shown here.*



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.

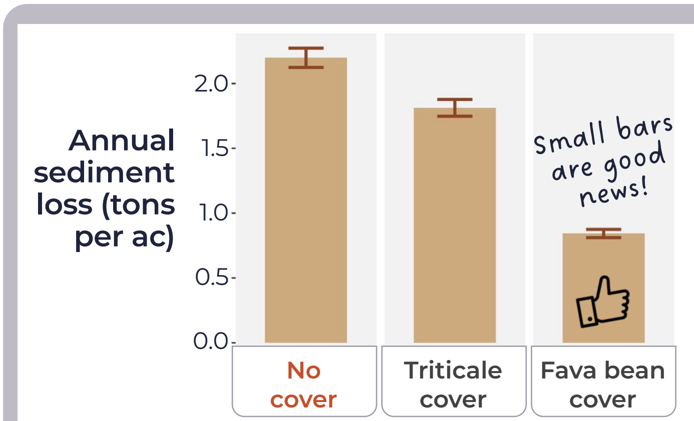
*A soil aggregate is soil organic and mineral particles joined together, the basic unit of soil structure and the foundation upon which many soil functions depend.

KEY FINDING

According to the model, adding a cover crop was key for sequestering more soil organic carbon in almond systems on average in a likely future climate.

Children playing in a triticale cover crop in a California almond orchard. SHAWN LINEHAN FOR AFT.

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 future erosion. The **chart above** shows how, compared to almond systems without a cover crop, the model estimated that systems with a triticale cover crop lost 17% less sediments (soils lost to waterways). Almonds grown with a fava bean cover crop lost 61% less sediments on average. In this modeled system, tillage did not have a strong effect on sediment loss.

We can also compare cover crop performance by type of spring weather (normal, abnormally dry, moderately wet, etc.) (data not shown). Even in a moderately wet spring (a March-May period totaling 2-7 inches of precipitation), the soil protection benefit shown above for fava bean cover, compared to no cover, still reduced sediment loss by 53% on average. Triticale had a minor, but statistically insignificant, effect on sediment loss in moderately wet springs. This suggests that when future weather conditions get more challenging (especially more wet) fava bean cover crops will help build soil function and, therefore, soil resilience.

KEY FINDINGS

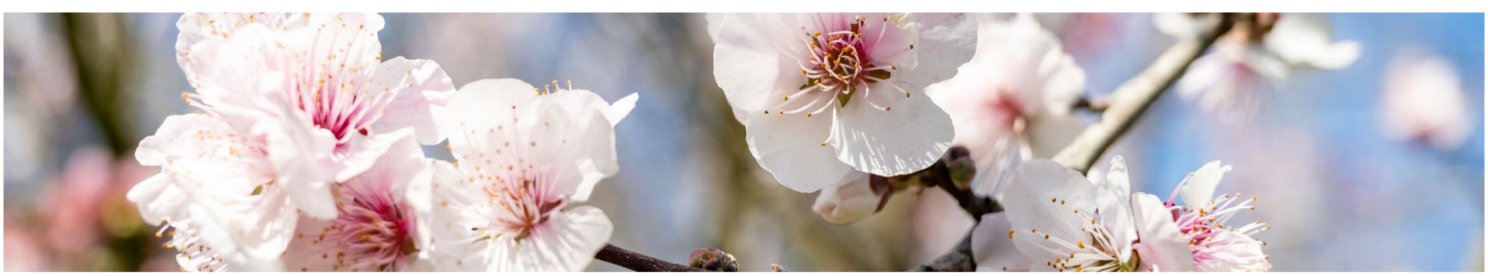
Compared to no cover crop, on average triticale reduced sediment loss by 17%, and fava bean cover reduced sediment loss by 61%.

Fava bean cover crop builds soil resilience to extremely wet weather.

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

The previous pages show how a cover crop and no-till can build healthy soils and make California almond systems 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 almond growers using cover crops? Check out AFT's soil health economic case studies, three of which are on California almond growers: farmlandinfo.org/publications/soil-health-case-studies/
- 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 almond growers.
- **Talk to someone who can help** by reaching out to AFT's Senior Agricultural Specialist for California, Paul Lum: plum@farmland.org.



Almond blossoms. SHAWN LINEHAN FOR AFT.

YOU MIGHT BE WONDERING...

...why this report does not include how future climate change, cover crops and no-till affect **almond 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 orchard 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.

A Great Blue Heron in a California almond orchard.

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 almond production areas, without extensive model validation. The results here show how the model predicts California almond 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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