American Farmland Trust
SAVING THE LAND THAT SUSTAINS US

New York Forage Crop Soil Health

THE RESILIENCE REPORT

THE FUTURE, TODAY

American Farmland Trust (AFT) partnered with Regrow and the USDA Agricultural Research Service to model 50 years (2022-2072) of western New York dairy forage cropping systems under likely future climate conditions. We wondered **which management decisions today could help western New York farmers 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 rye cover crops) to understand how these practices impact crop yields, nitrogen (N) use efficiency, soil carbon sequestration potential, and water quality. We also used satellite imagery to assess soil health practice implementation across New York. Explore the next few pages of our results and see “How we did this” on page 6.

**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.*

PHOTOS THIS PAGE BY KEVIN KEENAN FOR AFT

IN A NUTSHELL, WE FOUND:

YIELD RESILIENCE

For years 2022-2072, an 80-ac New York corn grain field combining rye cover and no-till was predicted to **protect 25% more N from leaching and to have a 14% greater crop yield per year** compared to the same field with conventional till and no cover crop.

SOIL CARBON GAINS

Corn (grain and silage) and soybean systems with a rye cover crop were predicted to **gain 67-71% more soil organic carbon (SOC) per year** than systems without a cover crop.

SLOW IMPLEMENTATION

Satellite imagery analysis revealed that cover crops on New York corn-soybean acres are increasing by about 0.5% per year. At this rate, it will take 80 years for New York corn and soybean acres to reach 50% implementation of cover crops. No-till acreage is declining by about 0.8% per year.

GOOD TO KNOW

In the model, we compared four soil health practice combinations:

- **conventional till and no cover crop**
- **conventional till with a rye cover crop**
- **no-till and no cover crop**
- **no-till with a rye cover crop**

...in three cropping systems (table at right). We used soil information from 16 field crop sites across western New York. The systems were modeled for years 2022-2072 accounting for likely future changes in temperature and precipitation, we refer to this as "future conditions." (More info on page 6.)

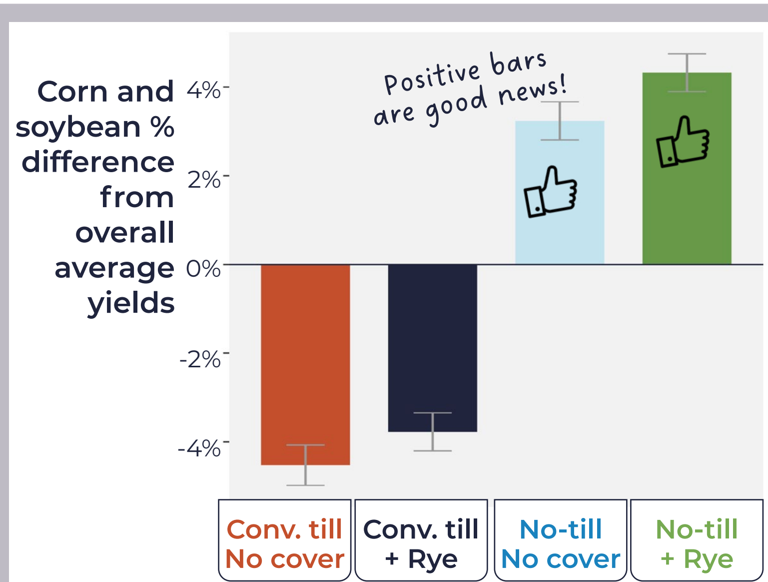
Crop systems	N rates per acre
Corn on corn (grain)	Split applied UAN totaling 187 lb N
Corn on corn (silage)	140 lb N as manure + 47 lb N as UAN
Corn - soybean	Split applied UAN totaling 151 lb N in corn

YIELD GAINS WITH SOIL HEALTH

We can't talk about resilience without talking about how soil health practices affect yields. The **chart to the right** shows the average (2022-2072) annual yields for **corn grain, corn silage, and soybean** from the model as % difference from the overall average (0% line). We're showing the data in relative terms rather than absolute yields because we're interested in how yields compare among the different practices, while recognizing that exact future crop yields are hard to predict.

Yields were below the overall average with conventional till (2 left-most bars) and above average with no-till (2 right-most bars). The no-till yields were 7.5% greater on average. Adding a rye cover crop to no-till increased crop yields a small but significant amount (green bar).

For corn and soybean systems using strip till or zone till, the predicted yield % difference from the overall average was -1.6% without a cover crop (not shown in chart) and 0% with a cover crop on average from 2022-2072.



Error bars indicate standard error among modeled sites and systems.

Key findings

Corn and soybean crop yields with no-till tended to be more resilient under future climate conditions compared to crop yields with conventional till.

Adding a rye cover crop to no till further improved crop yield resilience.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NITROGEN SAVINGS FOR WATER & WALLET

A resilient, healthy soil uses nutrients efficiently and keeps nitrogen (N) out of waterways. The **chart below** shows the average annual nitrate leaching (nitrate lost below the rooting zone) in lb N per ac for the three different cropping systems (three panels below).

Across the board, the rye cover crop reduced nitrate leaching (dark blue and green bars). Except in corn grain monoculture, no-till also reduced nitrate leaching (light blue bars).

Except in the case of corn grain monoculture, **no-till with a rye cover crop (green bars) reduced nitrate leaching more than either practice alone.**

Comparing the cropping systems, the corn-soy rotation has lower nitrate leaching than the corn grain monoculture in all but the conventional till without a cover crop (red bars). The lower nitrate is in part because the corn-soy system received no N fertilizer input in soybean years in the simulations.

Except for the system with conventional till without a cover crop (red bars), the corn silage monoculture had less nitrate leaching than the other two systems. This could be in part because 75% of the corn silage annual N inputs were manure in the simulation. Organic N tends to remain in the soil longer than synthetic N, which tends to easily leach from the soil. Remaining in the soil longer means cover crops have a greater chance to reduce annual nitrate leaching.

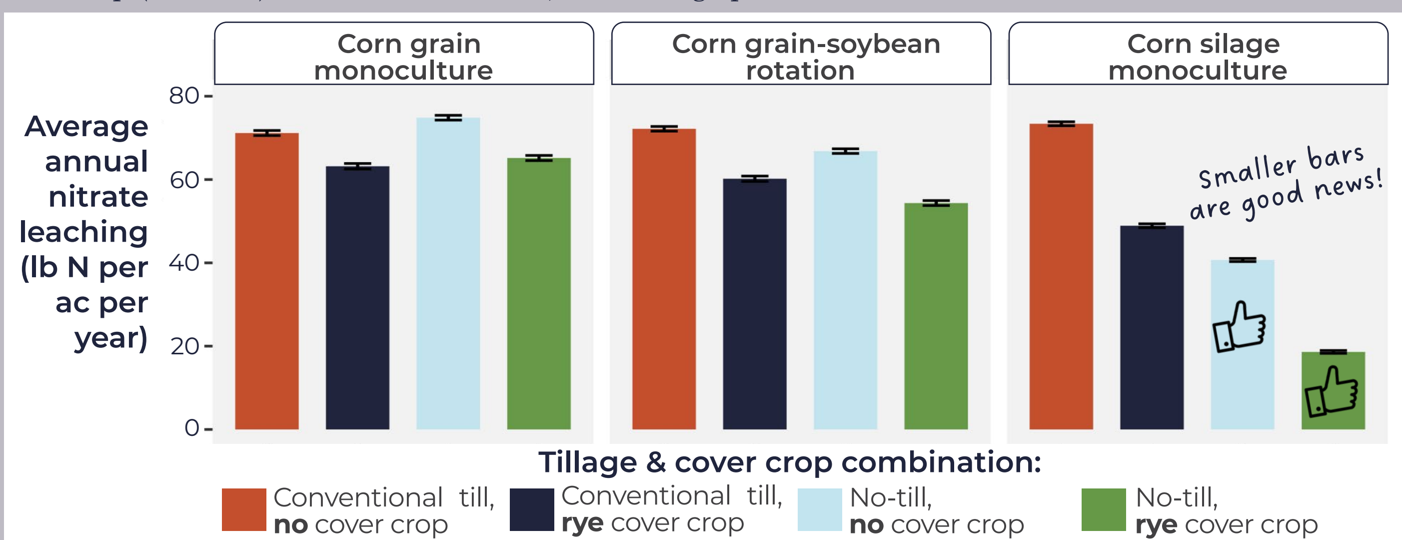
No-till seemed to reduce nitrate leaching in corn silage by its effect on improving soil organic matter (data not shown).

What do these findings mean for a farmer's pocketbook? In 2023, the average price of N fertilizer was $0.60 per lb N[1]. According to the model an 80-ac field of corn grain in a corn-soybean system with conventional till and no cover crop will leach about 5,800 lb N—**that's about $3,500 per year in fertilizer costs down the drain.** Whereas the same field with no-till and a rye cover retained 25% more N and had a **14% greater crop yield** (data averaged into chart on previous page).

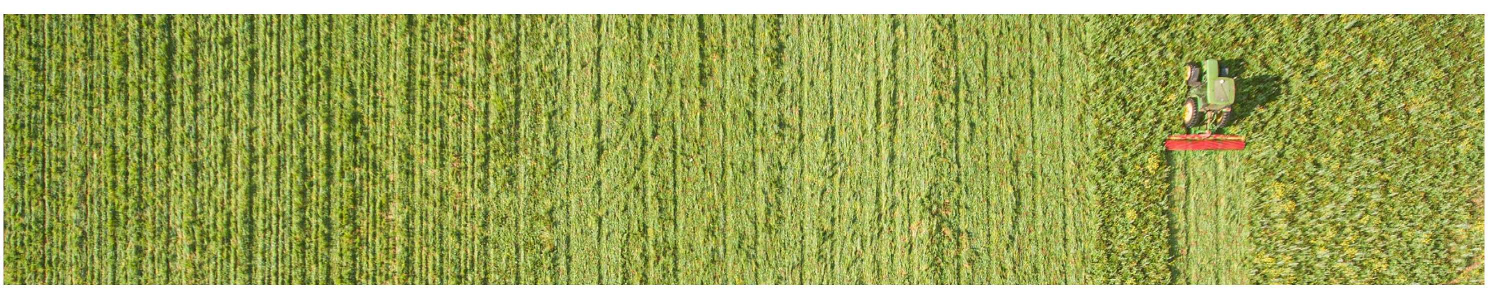
Key findings

Adding the rye cover crop to conventional till reduced nitrate loss by 20% on average.

Combining rye cover with no-till reduced nitrate loss by another 23% (36% total reduction) on average.



Error bars indicate standard error among modeled sites.



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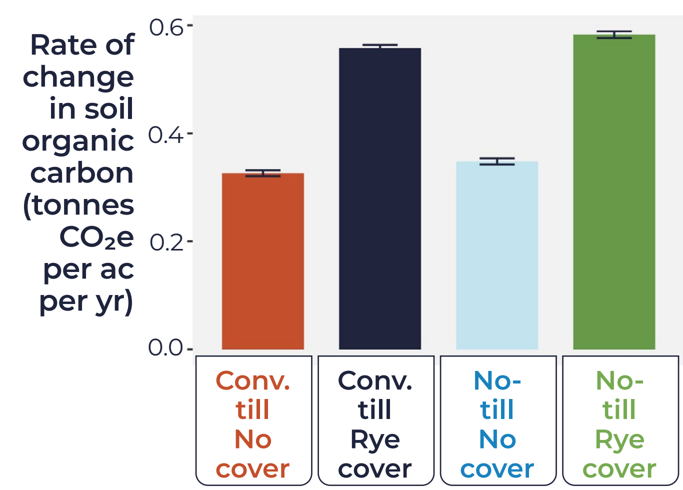
BUILDING SOIL CARBON

A soil's organic matter can be an indicator of its resilience to weather extremes. More soil organic matter means greater water holding capacity to protect crops during a drought. Higher soil organic matter percentage can mean greater aggregate stability and water infiltration allowing the soil to drain more rapidly. Soil organic carbon (SOC) can be an indicator of soil organic matter (and can be estimated in the model). The **bars below** depict the modeled annual rate of change in SOC averaged across the three cropping systems for years 2022-2072.

According to the model, all systems gained some SOC in an average year (all bars are positive). The presence of a cover crop improved SOC gains: Compared to conventional till without a cover crop (red bar), the systems with conventional till and a rye cover crop (navy blue bar) gained 71% more SOC per year. Compared to no-till without a cover crop (light blue bar), the systems with no-till and a rye cover crop (green bar) gained 67% more SOC per year.

No-till had a smaller effect than cover crops. Without cover crops, no-till systems (light blue bar) had 7% greater rates of SOC gain than conventional tillage systems (red bar). With cover crops, no-till systems (green bar) had 4% greater rates of SOC gain than conventional tillage systems (navy blue bar).



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.

Key findings

Adding the rye cover crop increased SOC sequestration rate by about 70%.

No-till had a much smaller, but still significant, positive effect on SOC gains as well.

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COVER CROP & NO-TILL IMPLEMENTATION IN NEW YORK

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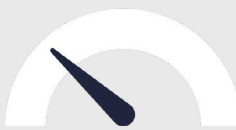
This report highlights how a particular soil health management system can build resilient soils. So, how much progress have we made in terms of acres implementing soil health practices?

We used satellite imagery to detect cover crops and tillage intensity (more info on next page). We found that in 2018-2021, on average:

8.6%

(±0.6%)

of New York corn and soybean acres had a **cover crop.**



25.8%

(±1.0%)

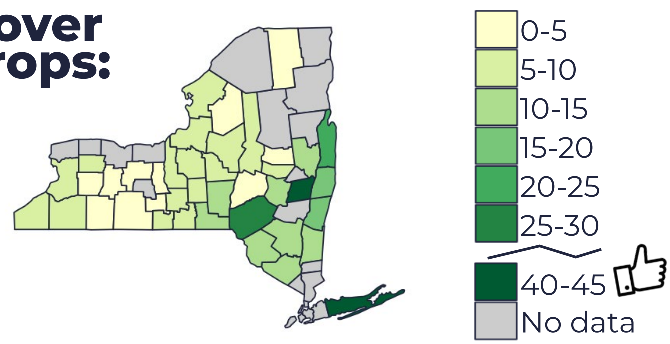
of New York corn and soybean acres used **no-till.**

We found the following trends **for the years 2015 to 2021:**

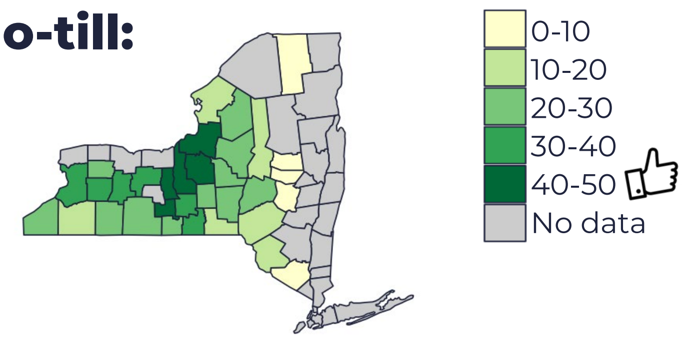
- **Cover crop** acreage is increasing by about 0.5% (±0.1%) per year. *Meaning out of 100 acres without cover crops the previous year, one new half-acre will have cover crops the next year. If we assume a constant 0.5% rate of change into the future, it will take **83 years** to reach 50% implementation of cover crops in New York.*
- **No-till** acreage is declining by about 0.8% (±0.3%) per year.
- **Reduced tillage** acreage is increasing by about 1.7% (±0.4%) per year.
- **Conventional tillage** acreage is increasing by about 0.8% (±0.1%) per year.

The maps below show satellite-derived (methods info on next page) county averages for 2018 to 2021 in **% of corn (grain and silage) and soybean acres implementing...**

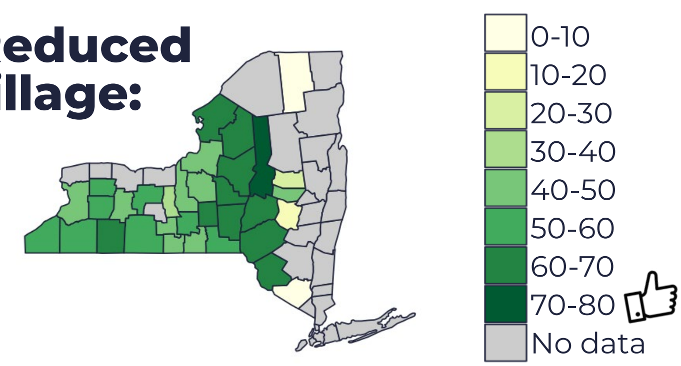
Cover crops:



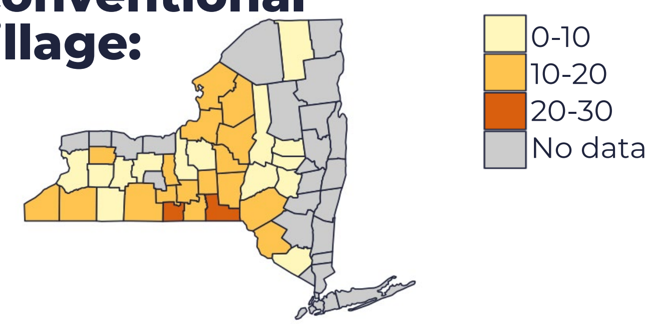
No-till:



Reduced tillage:



Conventional tillage:



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

The previous pages show how cover crops and no-till can build healthy soils and make New York forage cropping systems more resilient to future climate conditions. Here are some potential **next steps** for implementing or improving your cover cropping and tillage practices:

- AFT's **New York-based Demonstration Farm Network** farmland.org/project/genesee-river-demonstration-farms-network/
- AFT's **Soil Health Economics Case Studies** feature 5 New York farms https://farmlandinfo.org/publications/soil-health-case-studies/
- **New York Soil Health** www.newyorksoilhealth.org/
- Women farmers can join AFT's **New York Women for the Land** program farmland.salsalabs.org/newyorkwomenfortheland
- **Talk to someone who can help** by reaching out to AFT's Senior Agricultural Specialist for New York, Aaron Ristow: aristow@farmland.org.

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. The model has been extensively validated[2,3]. The results here summarize model output from model predictions for how 16 soil sample sites across western New York dairy forage cropping systems respond to one climate scenario, called RCP 6.0, using one coupled climate model called IPSL-CM5-LR. There are many scenarios and models with different predictions.

Practice adoption

To estimate acres implementing soil health practices in New York we used the Operational Tillage Information System (OpTIS). OpTIS uses earth-observing satellite data to document tillage intensity (by looking at residue cover) and cover crop adoption (by looking at green plant growth in the winter). OpTIS removes winter cash crops using the USDA Cropland Data Layer.

Technical note

In this report, we only touch on the highlights of our analysis. We also created a technical note with more details about DNDC and OpTIS methods. It is available at farmland-info.org/publications/resilience-reports/, **which is where you can also download this report.**

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

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ENDNOTES

1 Iowa State University Extension and Outreach. (January 2024). Ag Decision Maker: Estimated Costs of Crop Production in Iowa (File A1-20). Retrieved on February 6, 2024 from https://www.extension.iastate.edu/agdm/crops/html/a1-20.html

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

3 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

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