Illinois 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 Illinois corn and soybean cropping systems under likely future climate conditions. We wondered which management decisions today could help Illinois 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 Illinois. 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 PIERO TAICO FOR AFT

IN A NUTSHELL, WE FOUND:

YIELD RESILIENCE WITH COVER CROPS & NO-TILL

For years 2022-2072, an 80-acre Illinois corn-soybean field implementing soil health practices (rye cover, no-till, 170 lb N per acre) had 12% greater corn yields and 75% fewer lb N lost to leaching compared to the same field implementing conventional practices (no cover, conventional till, and 220 lb N per acre).

SOIL CARBON GAINS

Rye cover crop increased soil organic carbon 2.5x faster than the system with conventional till and no cover crop. Cover crops plus no-till reduced annual sediment loss by 70%.

SLOW IMPLEMENTATION RATES

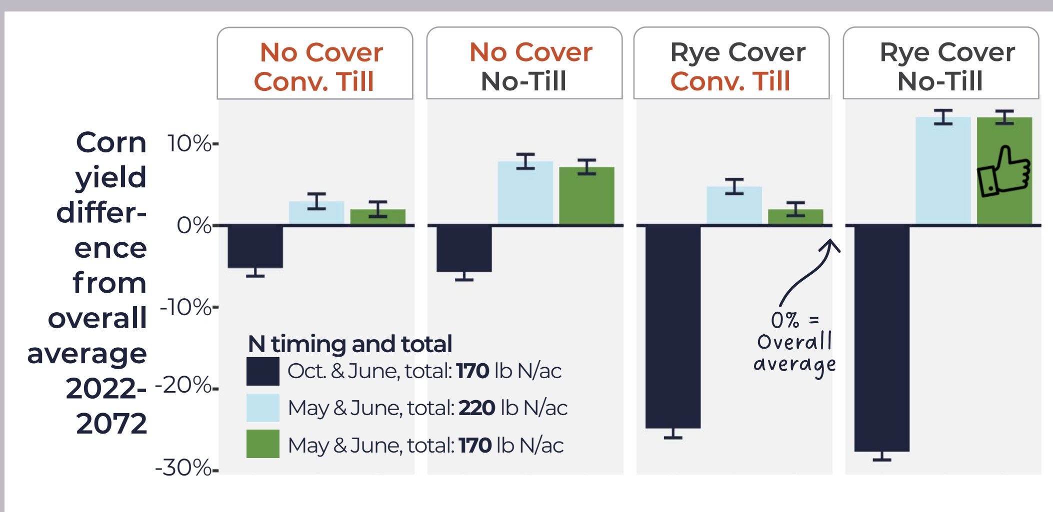
Satellite imagery analysis revealed that cover crops on Illinois corn-soybean acres are increasing by about 1% per year. At this rate, it will take until 2066 for Illinois to reach 50% implementation of cover crops. No-till acreage is declining by about 1.4% per year.

GOOD TO KNOW

In the model, we compared four corn-soybean systems with and without no-till and a cereal rye cover crop before both corn and soybeans. Rye was terminated two weeks prior to planting. Each system was modeled with three nitrogen (N) programs: Applications in Oct. and June totaling 170 lb N/ac, applications in May and June—one totaling 170 lb N/ac and one at 220 lb N/ac. All N fertilizer was urea, except the Oct. application was anhydrous ammonia. USDA grower surveys report the Illinois average N rate is 170 lb/ac per year[1], and U. of Illinois reports conservation-minded farmers using 220 lb/ac per year[2]. The corn-soybean systems were modeled for years 2022-2072 accounting for likely future changes in temperature and precipitation; we refer to this as "future conditions."

YIELD GAINS WITH SOIL HEALTH

We can't talk about resilience without talking about yields and financial implications of management decisions. In the **chart below** we show the average annual corn yield from the model averaged across years as % difference from the overall average (0% line). We're showing the data in relative terms rather than absolute yield amounts because we're interested in how yields compare among the different practices, while recognizing that future crop yields are hard to predict.



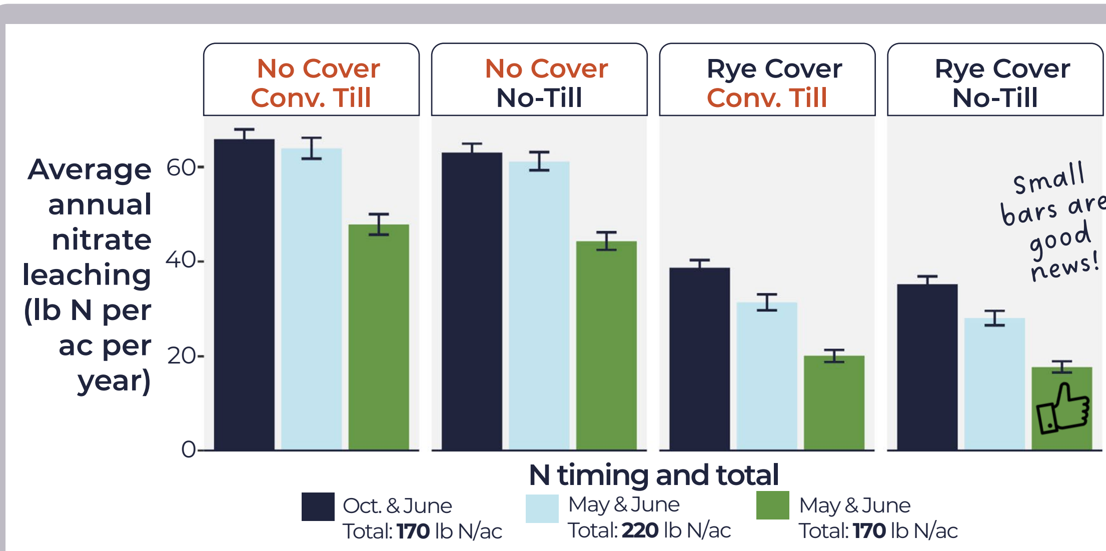
Key findings

Corn grown with rye cover, no-till, and May & June applied N had much greater yields in the future climate than corn grown without those practices.

Across the board, corn yields for May & June applied N at 170 lb N/ac performed just as well (not statistically different) as 220 lb N/ac.

KEVIN KEENAN FOR AFT

NITROGEN SAVINGS FOR WATER & WALLET



Note: Error bars indicate standard error among modeled sites.

Key findings

Adding the rye cover crop to conventional till reduced nitrate loss by about 50%.

Combining rye cover with no-till reduced nitrate loss by another 10%.

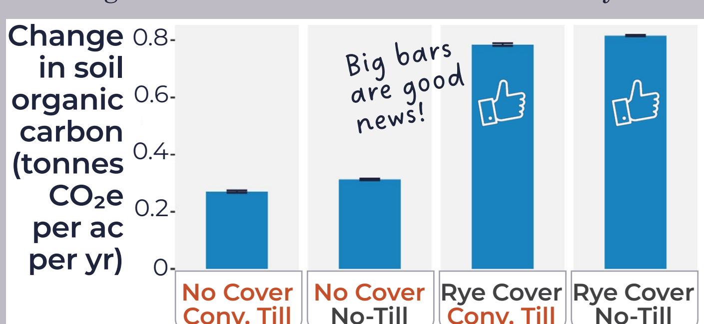
A resilient, healthy soil uses nutrients efficiently and keeps N out of lakes and streams. The **chart above** shows the 2022 to 2072 average annual nitrate leaching (nitrate lost below the rooting zone) in lb N/ac for the corn-soybean rotation. Cover crops and no-till individually reduced N leaching. Adding them together had an even greater reduction in N leaching (right-most panel). The model results suggest N tends to cycle most efficiently in the May & June applied N at 170 lb N per ac (green bars).

In 2023, the average price of N fertilizer was $0.60 per lb N[3]. According to the model, an 80-ac field with no cover crop, conventional till, and May & June applied N totaling 220 lb N/ac will leach about 5,700 lb N—**about $3,400 per year down the drain**. But an 80-ac field with a rye cover, no-till, and May & June applied N totaling 170 lb N/ac would leach only about 1/4 as much N (only about $950) **and had a 12% greater crop yield** (previous page).

STORE MORE 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. One way to measure soil organic matter is by measuring the soil organic carbon (SOC). We modeled changes in SOC in the same Illinois cropping systems from previous pages. The **bars below** depict the average change in SOC for years 2022-2072. In some years soils *gained* SOC and in some years soils *lost* SOC.

The results did not differ much between the N management programs, so each bar below is the average of the three N programs. According to the model, the systems with **a rye cover crop are gaining over twice as much SOC per year as the systems without a rye cover crop.**



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 the soil organic carbon sequestration rate *more than 2.5x*.

Cover crops had the greatest effect on SOC, according tot he model. No-till increased SOC slightly compared to conventional till.

PROTECT THE SOIL

Note: Error bars indicate standard error among modeled sites.

Reducing disturbance and protecting the soil with cover crops build soil health and help keep the soil in place. The **chart above** shows how sediment loss (soil lost to lakes and streams, in other words, erosion) under future climate conditions in Illinois corn-soybean systems with no-till lose the least sediments, especially when combined with a cover crop. **In other words, pairing no-till with cover crops can have a greater benefit than either practice alone.** The results did not differ much between the N management programs, so each bar above is the average of the three N programs.

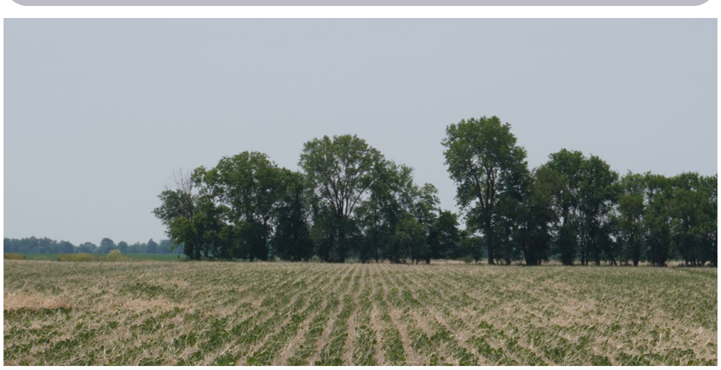
When we looked at the model results by type of summer weather (drought, normal, wet, etc.) we found that **no-till with cover crops dramatically reduced soil erosion even in abnormally wet and moderately wet years** (results not shown).

Key findings

Compared to conventional till without a cover crop, no-till reduced erosion by 40%.

Adding the cover crop to no-till reduced sediment loss by another 30%.

No-till and cover crops increase soil resilience to extremely wet weather.



PIERO TAICO FOR AFT

REAL ILLINOIS FARMERS SEEING SAVINGS FROM **SOIL HEALTH**

The **Thorndyke family** of Ford County (photo above) uses a cereal rye cover after both corn and soybeans, apply all their N in the spring with a split application, and use strip and no-till. They have seen a **$34 per acre net income increase** due to yield benefit and decreased input costs. (Photo courtesy the Thorndykes)

The **Ifft family** of Livingston County (photo above) has achieved an **additional $22 per acre net income** using cover crops and split application of N in the spring and summer. (Photo courtesy the Iffts)

Read more about these family farms and their soil health economics at farmlandinfo.org/publications/soil-health-case-studies/.

COVER CROP & NO-TILL IMPLEMENTATION IN ILLINOIS


KEVIN KEENAN FOR AFT

This report highlights how soil health management systems can build resilient soils and farms. 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 details next page). We found that in 2018-2021, on average:

7.9%

(±0.3%)

of Illinois corn and soybean acres had a **cover crop.**

41.3%

(±0.7%)

of Illinois corn and soybean acres used **no-till.**

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

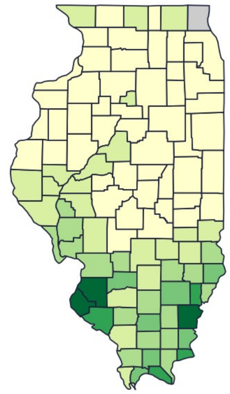
Cover crop acreage is increasing by about 1% (±0.1%) per year.
Meaning, out of 100 acres without cover crops the previous year, one new acre will have cover crops the next year. If we assume a constant 1% rate of change into the future, it will take 43 years for Illinois to reach 50% implementation of cover crops.

No-till acreage is declining by about 1.4% (±0.2%) per year.

Reduced tillage acreage is increasing by about 1.1% (±0.2%) per year.

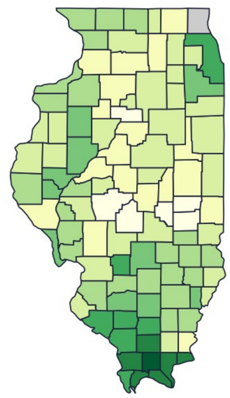
Conventional tillage acreage is increasing by about 0.8% (±0.1%) per year.

The maps below show satellite-derived (see page 5) county averages for 2018 to 2021 in **% of corn and soybean acres implementing:**



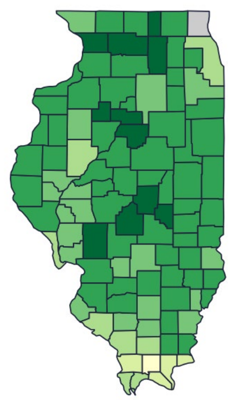
...cover crops

0-5
5-10
10-15
15-20
20-25
25-30
No data



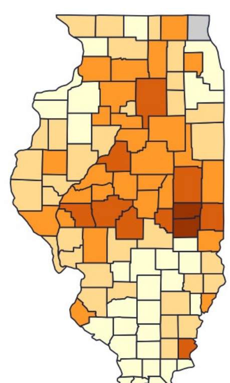
...no-till

10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
No data



...reduced tillage

0-10
10-20
20-30
30-40
40-50
50-60
No data



...conventional tillage

0-10
10-20
20-30
30-40
40-50
No data

REBECCA DROBIS FOR AFT

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

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

- A helpful resource to get started is **"An Introduction to Soil Health Practices"** from the Illinois Sustainable Ag Partnership and co-authored with AFT staff.
- **Get recognized** for the soil health practices you're already implementing and track your improvements by enrolling in Illinois STAR (Saving Tomorrow's Agriculture Resources) for free.
- **Talk to someone who can help** by reaching out to AFT's Midwest Conservation Agronomist, Torey Colburn: tcolburn@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[4,5]. The results here summarize model predictions for how 32 soil sample sites across Illinois corn-soybean croplands 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 Illinois, we used the Operational Tillage Information System (OpTIS). OpTIS uses earth-observing satellite data to document tillage intensity (by looking at the 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 specifics for how the model simulations were set up in DNDC and more about how OpTIS works. It is available at **farmlandinfo.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**, AFT Senior Climate and Soil Health Scientist bmcgill@farmland.org. For more information, visit www.farmland.org/climate.

This project was supported by a grant from the Foundation for Food & Agriculture Research (# CA19-SS-0000000002).

ENDNOTES

1 https://quickstats.nass.usda.gov/
2 https://farmdocdaily.illinois.edu/2022/10/fall-anhydrous-ammonia-application-practices-and-profitability-on-fields-enrolled-in-precision-conservation-management.html
3 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
4 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
5 Gilhespy, S. L., et al. (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