USDA

United States Department of Agriculture

Natural Resources Conservation Service of South Dakota

FOCUS ON SOIL HEALTH

How Extreme Weather, Economics, and Building Resilience Are Leading to More Use of Soil Health Practices in South Dakota

SOIL HEALTH DATA IS ACCUMULATING

Some South Dakota producers have been using practices like no-till farming, cover crops, and sound grazing practices for years. They've discovered these practices significantly change their soils for the better, and that healthy soils are the key to a much more resilient operation, whether on cropland or grazing land.

Many have been willing to share their evolutionary, pioneering pathways to a new, regenerative approach to farming and ranching. We continue to appreciate their willingness to serve as mentors and to show and tell their success stories to anyone wanting to listen and learn.

As more and more producers use these practices, progress is being monitored in a number of ways. In the pages that follow, we bring together recent extreme weather data from the National Weather Service, trends to less tillage and no tillage from our USDA Natural Resources Conservation Service (NRCS) Cropping Systems Inventory (CSI), increasing use of cover crops from the USDA Farm Service Agency data and NRCS program reports, and economic information on soil health systems from 10 South Dakota producers.

Our intent is to focus on soil health, reporting on the most recent status of these soil building practices, in perspective with trends over time. Included are comments from producers who tell why they keep their soil covered as much as possible, use no-till instead of disturbing their soil, use crop rotations and grazing practices that promote plant diversity, keep live roots growing in the soil as much as possible, and integrate livestock in their operation where possible.

That focus on soil health has significant potential to bring not only resilience to farming and ranching operations, but also to be the basis for healthier, longer lasting land and water resources across this great state.

Robert Lawson
Acting State Conservationist

A series of Drought Monitor Maps from the National Drought Mitigation Center shows the extent of drought across South Dakota in 2021.

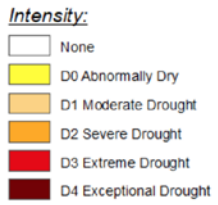
2021 Weather: **Drought All Over, All Year**

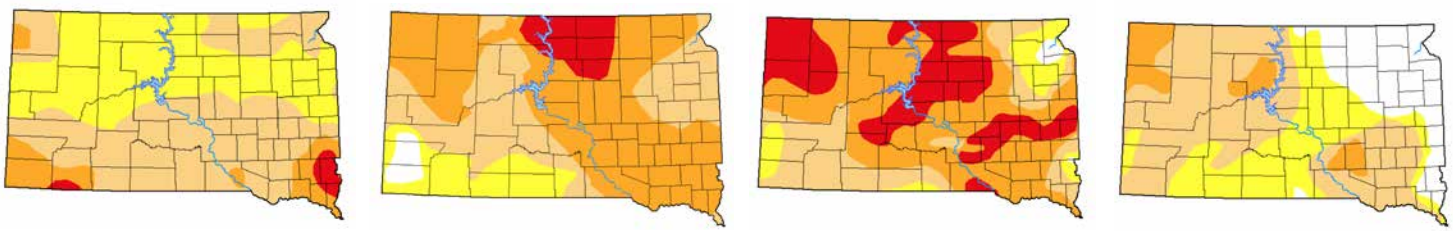
The 2021 year began with the entire state either abnormally dry or in a moderate drought, with severe drought in three of the state's four corners.

By mid-April, most of northwestern and north-central South Dakota had advanced to severe or extreme drought.

By mid-June, nearly all the state was enveloped in moderate, severe, or extreme drought. Conditions worsened through August.

Drought eased in northeastern South Dakota in late October and November, but the western two-thirds of the state continued to be abnormally dry or in a moderate drought, with pockets of severe drought, at the end of November.



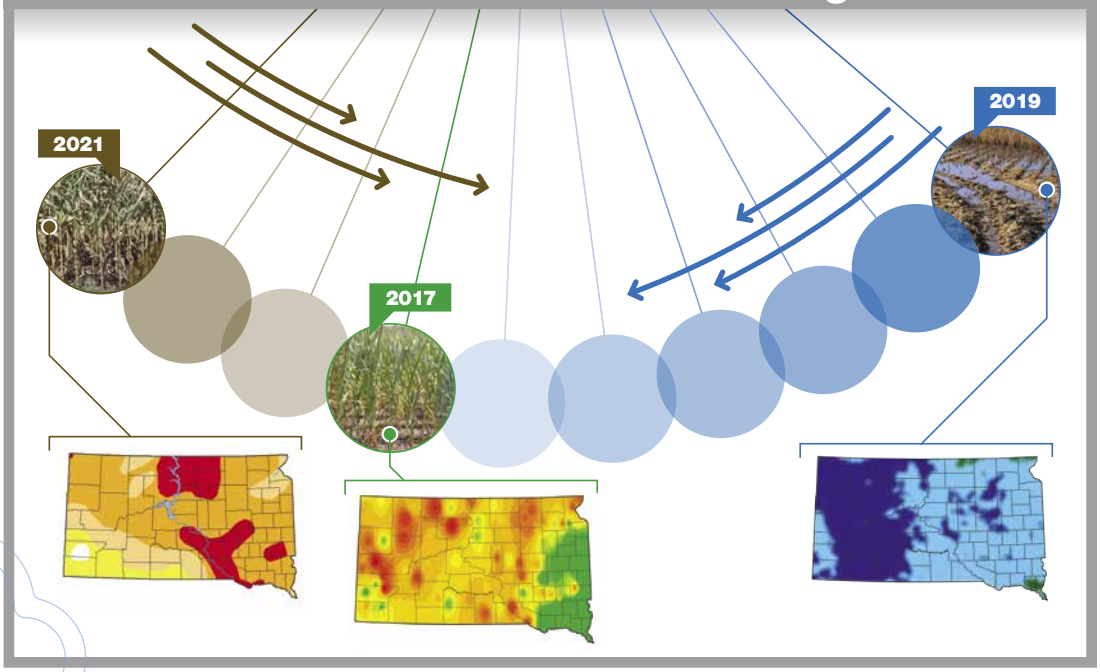


January June August November

Expect more wild weather

In the last 30 years, South Dakota has averaged 14% more 1-inch or greater rainfall events than historical averages. The National Oceanic and Atmospheric Administration (NOAA) projects these heavy precipitation events will increase, and annual rainfall will increase, at the same time the intensity of droughts will increase.

South Dakota's **Severe Weather Swings**



The Weather Service Drought Monitor Map on August 1, 2017, showed all but far eastern South Dakota in drought. Two years later, record rainfall waterlogged the state—followed by a statewide drought in 2021 as shown in a July 6, 2021, Drought Monitor Map.

TRACKING TILLAGE OVER TIME

The NRCS first started to help track tillage across the nation in 1982. National tillage tracking was discontinued in 2004; after nine years, NRCS in South Dakota resumed tracking tillage methods in 2013, with biennial "snapshots in time" observing conditions at more than 25,000 field locations across the state.

Initially, tillage methods were monitored because of the value of crop residues in slowing soil erosion. Mulch tillage, for instance, which leaves at least 30% crop residues on the soil surface after planting, curbs soil erosion more than reduced tillage or conventional tillage, systems that leave less protective residues.

In South Dakota, NRCS resumed the tracking of tillage methods in large part because of the value of no-till systems in building healthy cropland soils. No-till disturbs very little soil at planting—minimal soil disturbance is one of the five principles of healthy soils. Now the dominant system for planting crops in South Dakota, no-till is the choice for farmers who want to build healthy soils because it promotes microbial action in the soil that leads to healthier soils. The practice also saves time, fuel, and equipment costs.

2021 Cropping Systems Inventory: **No-Till Steady, Stable Anchor for Soil Health Systems**

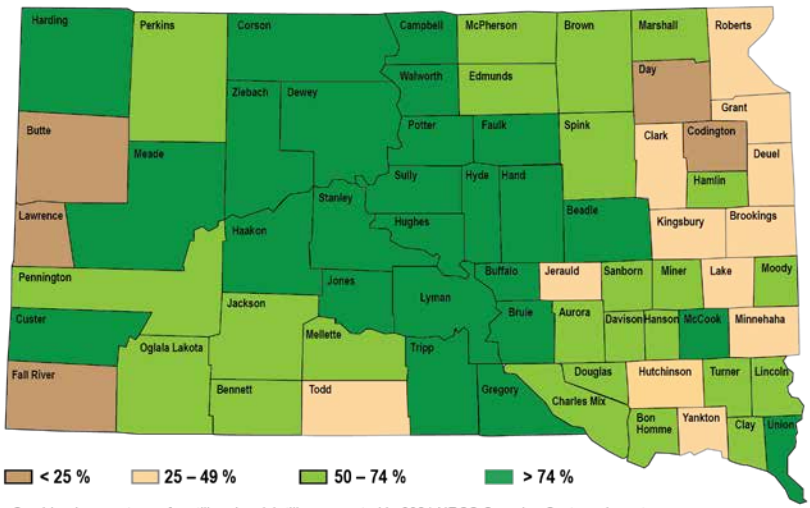
No-till farming systems help achieve two of the five principles of building healthy soils—armoring the soil and growing crops with minimal soil disturbance. The CSI conducted by the USDA Natural Resources Conservation Service shows South Dakota farmers used no-till on 37% of cropland in the state in 2004; no-till use grew to 46% of cropland in 2015, and 50% in 2019.

In 2021, use of no-till continued to be strong, with 48% of the cropland being planted with no-till systems. Couples with the use of mulch tillage on about one-fifth of the cropland in the state, two out of every three acres in the state is protected with high residue cropping systems.

No-till is now the dominant choice of cropping systems by South Dakota producers. It's an all-important anchor practice for building healthy soils because it prevents soil erosion and encourages microbial action in the soil that builds soil structure and increases organic matter.

> This place was leased to some other folks before I got involved. The weeds had pretty much taken it over. You get a lot of wind here and there was a lot of soil moving, too. Instead of going in there and tilling the ground and getting rid of the residue the worms need, we've gone to strictly no-till and cover crops.
>
> **Chris Grubl,** *Meade County*

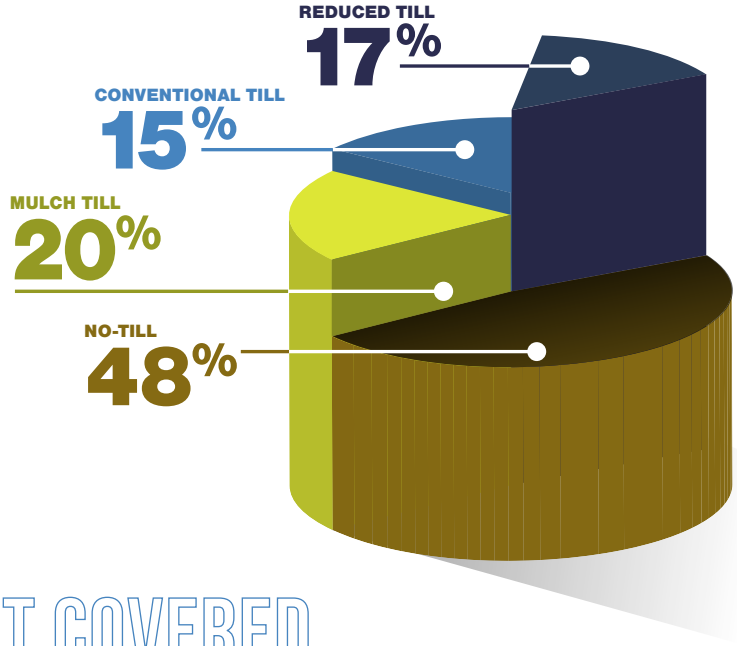
NO-TILL AND MULCH TILLAGE PERCENTAGE OF TOTAL CROP ACRES
South Dakota 2021 CSI



Combined percentage of no-till and mulch tillage reported in 2021 NRCS Cropping Systems Inventory

CROPPING SYSTEM ACRES	2004	2013	2015	2017	2019	2021
No-Till	4,873,352	6,229,856	6,475,903	6,190,063	4,943,535*	6,496,260
Mulch Tillage	2,851,399	2,603,467	3,097,171	3,006,885	1,826,469*	2,745,302
Reduced Tillage	3,165,728	2,665,327	2,393,269	2,408,289	1,482,247*	2,317,668
Conventional Tillage	2,178,121	2,357,387	2,111,708	2,254,002	1,642,050*	2,077,726

** Waterlogged fields in 2019 prevented several million acres from being planted.*



GOT IT COVERED

TWO OF EVERY THREE CROP ACRES IN HIGH RESIDUE SYSTEMS

Since 2015, South Dakota farmers have consistently protected more than two-thirds of the cropland soils in the state with high residue no-till or mulch tillage systems. The NRCS CSI shows the dominant cropping system is no-till, with half or nearly half the cropland in no-till in both 2019 and 2021.

Drying soybean leaves show effects of drought in 2021. Soybean yields were highly variable with localized rainfall, but once again, as in 2017, no-till and cover crop fields saved moisture in a year that every drop of water saved was important.

COVER CROPS:
Key to Building Healthy Cropland Soils

The USDA Farm Service Agency reported cover crops use on 403,720 acres across South Dakota in August of 2021.

The reason so many people are excited about the potential for cover crops is that they are a significant component in four of the five principles involved in building healthy soils on cropland.

MORE FARMERS TAKE ADVANTAGE OF GOVERNMENT INCENTIVES

While the acres of cover crops established with monetary incentives from the NRCS Environmental Quality incentives Program (EQIP) and Conservation Stewardship Program (CSP) represent only a small part of all the acres of cover crops used in South Dakota, the acres of cover crops established through those programs has grown steadily. In 2017, about 58,000 acres of cover crops were seeded with assistance from EQIP and CSP. That acreage grew to 138,960 acres in 2019, and significantly higher again in 2021, to 150,458 acres.

COVER CROPS

1. Armor the soil, protecting against harsh wind and rain. They also help reduce evaporation rates, moderate soil temperatures, and reduce soil compaction.
2. Increase the diversity of plants in a cropping system, particularly when a diverse cover crop mix is used. Diverse plants result in diverse roots, which diversifies the microbial life in the soil—a key to faster regeneration of topsoil.
3. Extend the length of time growing roots can feed soil microbes. In particular, when cover crops are interseeded into growing rowcrops, or allowed to grow longer in the spring as farmers "plant green," microbial action continues strong.
4. Are a way to integrate livestock into the natural soil-building process. Nature's way of building resilient prairies included grazing by millions of bison and other wild animals—cover crops not only extend a grazing season for livestock producers, they offer the opportunity to apply urine and manure to soils in a natural way.

Cover crops integrate livestock into rowcrop operations, offering economic advantages and soil improvement.

Cover crops interseeded into growing row crops extend the time living roots are growing throughout the soil and feeding microbes; they can be grazed to further benefit the soil and add economic benefits.

Corn crop residue and a rye cover crop in a no-till system combined to protect and improve the soil in this soybean field in 2021.

> Cover crops allowed us to graze cattle more months of the year. Our decisions were initially driven by economics, but it just so happens season long cover crops for forage means diminished feed needs, less work, and better quality of life for our family as well as life in the soil.

Trevor and Kristy Zantow, *Leola, SD*

Apply sound grazing practices to build healthy grassland soils

More than half the ranchers in South Dakota—some 50 to 60 percent—practice at least a simple rotational grazing system, according to a 2018 rancher survey by South Dakota State University (SDSU). Their reasons may be for more forage production or similar reasons other than building healthier soils.

But those who have been using sound grazing practices for years have discovered that using sound grazing practices does, in fact, result in healthier grassland soils. In turn, applying basic soil health principles used on croplands to grasslands builds resilient, productive grasslands, as well as healthy soils.

Rotational grazing, for instance, keeps pastures from being overgrazed, leaving enough grass cover to keep the soil armored. Just as importantly, live roots keep growing in the soil to feed microbes as pastures are rested and allowed to recover after grazing. The shorter term grazing encourages more even use of forages, resulting in more diversity of plant species—another important principle to follow in building healthy soils.

The bottom line: you can't build healthy grassland soils without applying sound grazing practices, nor can you get the most production from your grasses without applying the principles of soil health.

A key to rotational grazing is leaving a healthy amount of grass after grazing to allow plants and roots to rest and recover, and feed microbes.

> I grew up rotating pastures and learning to read the grass, with a take half, leave half mentality. We've learned how to deal with drought. We've kept up with our rotating, keep moving cows through pastures even in a drought, and it's helped our range condition.
>
> **Britton Blair,** *Sturgis, SD*

EASY TO REMEMBER GRAZING PRINCIPLES: Remember the R's!

One simple way to keep the best of the grazing principles in mind is to remember the R's. That's rotate, rest, and recover, along with proper stocking rates and maintaining healthy root systems.

Rotating pastures is the grazing management technique that enables pastures to be rested. This period of **Rest** after grazing, in turn, allows time for both plants and their roots to **Recover**. This recovery time promotes regrowth and natural diversity in grasslands. Optimum stocking **Rate** matches the amount of expected forage to numbers of livestock, helping ensure grasses will not be overgrazed. Giving plant **Roots** time to recover after grazing is critical to long-term plant health, as well as to feeding soil microbes that build healthy soils able to infiltrate and hold rainfall. Keep the R's in mind to set the framework for resilient soils, grasslands, and ranches!

Enthusiasm for Soil Health

SURVEYS SHOW INTEREST, USE OF SOIL HEALTH PRACTICES

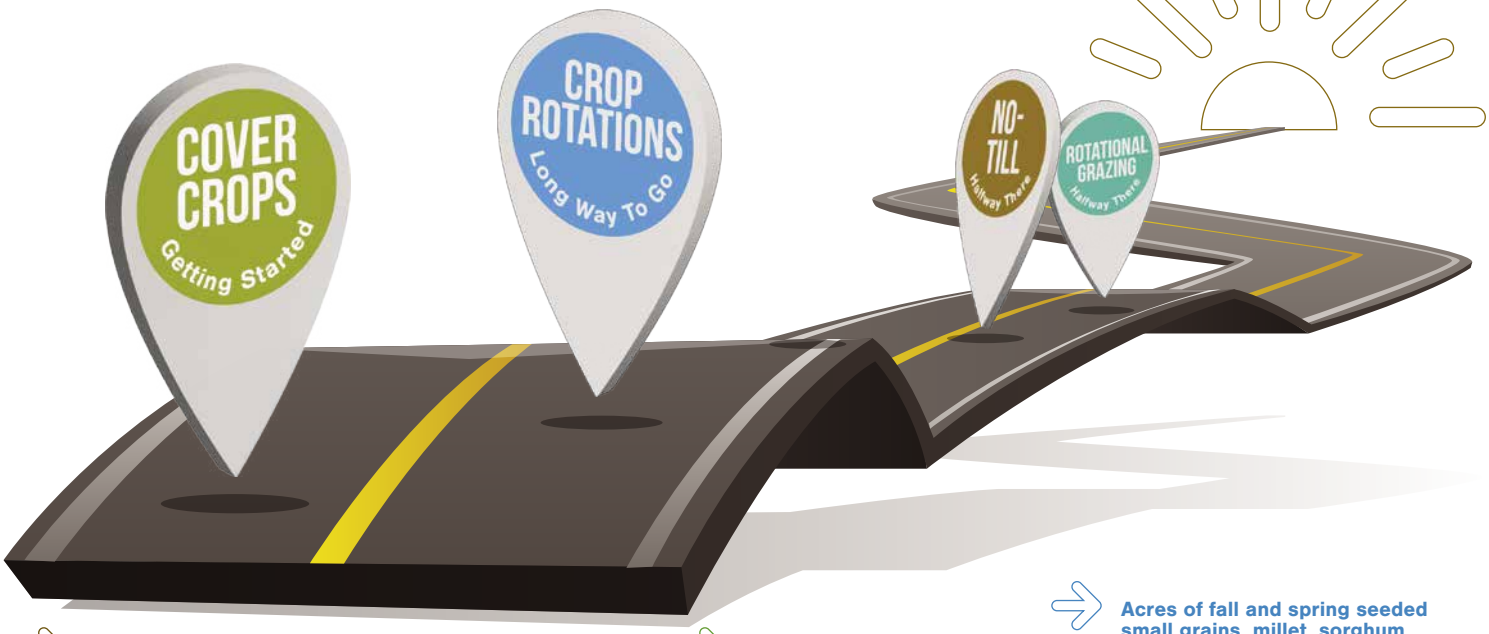
Both landowners and tenants continue to indicate an interest in using soil health practices such as cover crops and no-till planting systems on the land they own or operate, according to surveys by SDSU. Among the findings:

- Three-fourths of the 3,713 landowners who responded to a 2018 SDSU survey said they are either very interested in or already working with their tenants to conserve and build healthy soils on land that they own but do not operate.
- An SDSU survey of South Dakota producers conducted for the South Dakota Soil Health Coalition in late 2019 suggests a significantly higher percentage of producers who are using soil health practices experienced less stress, are more satisfied with farming/ranching, and are more enthusiastic about their futures than their peers who farm with conventional methods. Specifically, 31% of soil health farmers/ranchers reported increased profitability in 2019, compared to 12 percent of conventional producers. When asked to look ahead for 3 to 5 years, 69% of soil health producers predicted farm profitability would increase, compared to 36% of conventional farmers.
- Replies from a 2021 SDSU survey of 350 producers in eastern South Dakota showed more than half of them were using some combination of conservation tillage, cover crops, more than three crops in a diversified crop rotation, and integrated crop and livestock management practices. While the majority of the 350 producers perceived very little change in profits from using the practices, in each case a significant percentage of farmers perceived a profit increase of at least 5%—conservation tillage 44%; cover crops 24%; diversified crop rotation 37%; and integrated crop and livestock management 32%.

FORMULA FOR HEALTHIER SOILS:

ROADS TO RESILIENCE

Farmer/Rancher Use Of Key Soil Health Practices



No-till was used on 48% of South Dakota cropland in 2021
– USDA/NRCS Cropping Systems Inventory

Cover crops were used on 3% of South Dakota cropland in 2021
– USDA/NRCS Farm Service Agency

Rotational grazing systems are being used by 50% – 60% of South Dakota ranchers
– 2018 South Dakota State University rancher survey

Acres of fall and spring seeded small grains, millet, sorghum, sunflowers, and other crops used in diversified crop rotations totaled less than 3 million acres in 2021
– USDA/NRCS Cropping Systems Inventory

An economic analysis of soil health systems on 10 South Dakota farms

The Soil Health Institute (SHI) and Cargill interviewed 100 farmers in 2019 in nine Midwest states who have adopted soil health systems, including 10 farmers from eastern South Dakota.

Their goal in talking to farmers who have adopted soil health systems was to acquire production information for evaluating their economics, based on partial budget analysis. Using this approach, the Institute was able to compare costs and benefits of a soil health system before and after adoption of that system.

The information on these next three pages comes directly from the SHI Cargill report from those interviews with South Dakota producers. The complete report, including information from all 100 farmers, is called “Economics of Soil Health Systems on 100 Farms” and can be found online at the Institute’s Web site at *https://soilhealthinstitute.org/economics/*

The intent of conducting the project and sharing results is to provide farmers with the economics information they need when deciding whether to adopt soil health practices and systems.

Soil Health Producer Economics

HIGHLIGHTS BY THE NUMBERS FROM 10 SOUTH DAKOTA PRODUCERS WHO HAVE ADOPTED SOIL HEALTH SYSTEMS

1690
Average number of crop acres

95
Percentage of crop acres using no-till

22
Percentage of crop acres using cover crops

70
Percentage of the farmers reporting increased yield using a soil health management system

0
Farmers reporting a yield decline using a soil health management system

$30.03
Average cost reduction per acre to grow corn with a soil health system

$14.84
Average cost reduction per acre to grow soybeans with a soil health system

$54.03
Average increased net income per acre for corn, based on standardized prices

$50.66
Average increased net income per acre for soybeans, based on standardized prices

Source: Soil Health Institute/Cargill interviews with 10 South Dakota producers

Geographic distribution of the 10 farms in South Dakota used for economic analysis of soil health management systems.

10 OPERATIONS STRONG ON NO-TILL, COVER CROPS USE

The 10 South Dakota farms assessed in the project raised crops on an average of 1,690 acres, with 776 acres of corn, 746 acres of soybeans, and 100 acres of wheat.

The 10 farmers interviewed reported that they have adopted no-till on an average of 95% of their planted land. This is nearly double the adoption of no-till in South Dakota overall, and well more than double the 37% cropland adoption of no-till for the U.S. The 10 farmers interviewed also reported using cover crops on 22% of their cropland, compared to 2% for the state and 5% for the nation.

FERTILIZER EXPENSES REDUCED, YIELDS INCREASED

Fertilizer and amendment expenses were reduced by an average of $21.59/acre for corn and $7.30/acre for soybeans, with a majority of farmers implementing nutrient management practices such as grid soil sampling (70%), variable rate fertilizer application (60%), and split application of nitrogen (90%) as part of their overall soil health management systems.

None of the 10 South Dakota farms reported a yield decline from adopting a soil health management system. In fact, 70% reported increased yield, averaging 6.40 bu./acre for corn and 3.70 bu./acre for soybean (Table 2).

> I've seen moisture savings, increased water holding capacity, and higher water infiltration rates and organic matter along with lower fertilizer rates and machinery costs. We have the ability to plant and harvest in more adverse conditions while maintaining yields. Overall, it means more stable crop yields in all conditions with a lower cost of production and higher profitability.
>
> **David Kruger,** *Milbank, SD*

Additional Benefits

In addition to such benefits that directly impact profitability, these farmers also reported several other benefits from adopting a soil health system, such as increased access to their fields. All farmers also reported less water runoff, indicating improved water quality and a protected license to operate.

Interestingly, these farmers were monitoring changes in their soil organic matter levels, and 80% reported that those levels increased by an average of 1.8% due to the soil health management system. Research has shown that higher soil organic matter increases a soil's available nutrients and available water-holding capacity, which is consistent with reduced fertilizer application, increased crop resilience, and improved field access observed by these South Dakota farmers.

Partial Budget Analysis

Partial Budget Analysis was taken from the SHI report. More detailed information is available online at *https://soilhealthinstitute.org/economics/*

Partial budgets were calculated to assess changes in expenses and revenue associated with adopting a soil health management system. The results were averaged across the 10 South Dakota farms, as presented in Table 2.

Table 2. ***Partial budget analysis[1] of adopting a soil health management system for 10 South Dakota farms. Unless shown otherwise, the units are $/acre (2019 dollars).***

	CORN		SOYBEAN	
	Benefits	**Costs**	**Benefits**	**Costs**
Expense Category	**Reduced Expense**	**Additional Expense**	**Reduced Expense**	**Additional Expense**
Seed	0.00	4.70	2.00	4.70
Fertilizer & Amendments	21.59	0.00	7.30	0.00
Pesticides	10.79	12.85	9.10	13.59
Fuel & Electricity	3.45	1.52	3.87	1.24
Labor & Services	12.15	5.40	9.77	6.88
Post-harvest Expenses	0.00	2.88	0.00	1.18
Equipment Ownership	15.58	9.06	16.56	7.35
Total Expense Change	**63.56**	**36.41**	**48.60**	**34.94**
	Additional Revenue	**Reduced Revenue**	**Additional Revenue**	**Reduced Revenue**
Yield, bu.	6.40	0.00	3.70	0.00
Price Received[2], $/bu.	4.20	4.20	10.00	10.00
Revenue Change	**26.88**	**0.00**	**37.00**	**0.00**
	Total Benefits	**Total Costs**	**Total Benefits**	**Total Costs**
Total Change	90.44	36.41	85.60	34.94
Change in Net Farm Income	**54.03**		**50.66**	

[1]*Expenses and expected yields based on farmer reported production practices. (https://soilhealthinstitute.org/economics/)*
[2]*Commodity prices applied to yields based on long-term average prices. S. Irwin, "IFES 2018: The New, New Era of Grain Prices?" Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, January 11, 2019.*

> We've had some land in no-till for 39 years, and are having good luck with what we're doing. My biggest pieces of equipment are the planter, a sprayer, a combine, and a tractor to pull the planter. I don't have those extra costs for a big disc, big ripper, big field cultivator, or big 4-wheel drive tractor.
>
> **Ross Hanson,** *Garretson, SD*

SOIL HEALTH INSTITUTE

CONCLUSION

The farmers interviewed who have been practicing no-till have been doing so for about 23 years, and those growing cover crops have been doing so for approximately seven years. Such levels of experience, along with the above comparisons with state and national adoption levels, show that the farmers interviewed for this project are clearly leading the way and therefore offer substantial opportunity for others to learn from their experiences in adopting soil health systems. It is also clear that these farmers have been successful at implementing soil health systems across a range of climates in South Dakota.

New Technology Continues to Confirm Benefits of Soil Health Practices

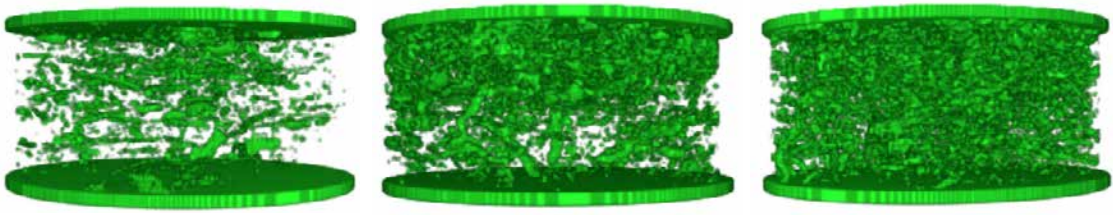
Now that extracted soil samples can be scanned with x-rays and computerized tomography (CT), researchers from SDSU used that technology in 2021 to compare porosity, water retention, and internal water movement from 3 management systems from producer fields in McCook County, South Dakota. Scanned soil core samples compared conventionally tilled soils, soils farmed with soil health practices, and native grass prairie soils, which have been shown to have superior soil health characteristics.

TABLE 1. Soil parameters under different farming practices evaluated for soil health conditions.

Practice	Porosity	Bulk Density	Internal water movement	Soil Organic Carbon
	%	lbs./ft3	inches/hr	%
SH - No-till, diversified crop rotation with cover crops, livestock integration	57	73.7	4.7	3.34
CS - Conventional tillage, corn/soybean, no cover crops, no grazing	49	94.3	0.8	2.94
NG - Native Grass (well managed pasture)	67	61.8	8.2	4.18

The analysis showed dramatically higher internal water movement and soil organic carbon and increased porosity in soil health systems and native grasses, along with lower bulk density, than with conventional tillage.

"The stunning CT images are easy to understand, and show in three dimensions what was confirmed with traditional measurements," says Anthony Bly, SDSU Extension Soils Field Specialist. "It is very clear that soil health farming systems that use no-till, diverse crop rotations, and livestock integration can attain soil porosity and internal water movement similar to the native grass levels. This work strongly confirms the importance for adopting soil health practices in South Dakota. More water stored in the soil will greatly mitigate dry periods, improve water quality, and reduce soil losses from erosion."



Conventional | Soil Health | Native Grass

The CT scan pore spaces are shown in green. The fewest pore spaces, with less connectivity, are found in a conventionally tilled corn and soybean field that had no cover crop or grazing. Pore space in the soil health system with no-till, diverse rotation, cover crops, and livestock grazing looks much more like that in well-managed native grass pasture.