Regenerative Agriculture: Working Alongside Farmers to Manage for Soil Health

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Regenerative agriculture: working alongside farmers to manage for soil health

1. Soil health initiative: project description and main goals

2. EXPERIENTIAL: learning from practice

3. TECHNICAL: learning from science-oriented research exploring the management effects on soil, crop, and environmental outcomes

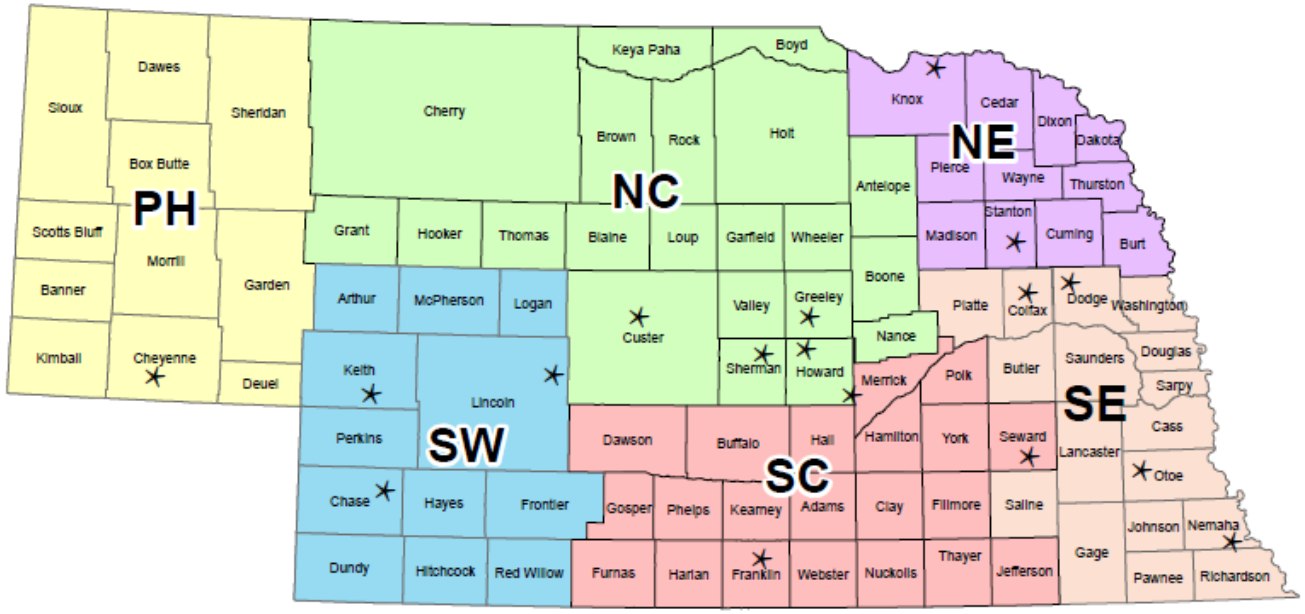
- "Understanding water dynamic under changes in land use and soil type"
- "Comparisons of soil health assessments between different transitions to soil health management systems in Nebraska"
- "Using remote sensing as a tool for evaluating the effectiveness of soil health building practices under extreme weather conditions"

4. SOCIAL: learning from other farmers experience

Regenerative agriculture: working alongside farmers to manage for soil health

UNL - NRCS Soil Health Initiative:

- A total of 17 studies were assigned with cooperating growers in 2016/2017
- A 5 years on farm-research and demonstration on soil health management systems
- Provides voluntary, incentive-based technical and financial assistance for soil conservation practices (e.g. cover cropping, no or reduced tillage, conservation crop rotation, prescribed grazing).



https://cropwatch.unl.edu/soilhealth

★ 17 - Demonstration Fields

Regenerative agriculture: working alongside farmers to manage for soil health

Project objectives:

- Maintain or enhance soil health by addressing the four soil health management principles
- Collect necessary data to validate the use of soil health management systems
- Provide farmers the opportunity to research conservation practices in the environment where they possibly would be implemented.

Cover crop prevents field damage after “Bomb Cyclone” flooding

*“The creek came out of its banks and out of 75 farmable acres, 70 of them were underwater. It probably took about **five days** before the **water was off** the bottom end of the field. The rye survived, and the field came out of it. I cannot imagine what that **field would have looked like** if the **rye had not been there**,”* Seim said.

Source: High Plains Journal, by Joanna Pope, NRCS. Sept. 2019

I like numbers and I like to farm

Obermeyer is enjoying being part of the Nebraska NRCS Soil Health Initiative, "The testing includes winter kill and spring burn down of cover crops. I like the winter kill idea because it is letting Mother Nature kill the cover crop, rather than having to apply another herbicide. ***Farmers*** *who have not pursued* ***cover crops and other types of conservation practices*** *should really* ***consider the savings on fertilizer, capturing water runoff, and providing feed for livestock****. It takes management to do this, but it's* ***worth*** *it."*

Source: Midwest Messenger, by Kerry Hoffschneider. Sept. 2019

Leading the pack in soil health practices

*"I want to break up the hard pan with a **cover crop** and its **root system**," he said of his objectives. "The other **main goal** is **water infiltration**, holding water so it is available for the crop to use when Mother Nature does not give us the moisture we need. We are very fortunate to have a good irrigation supply in Central Nebraska, but I think we need to learn how to be **more efficient with our water** because we are not going to gain more. In fact, we are going to have less in the future.", Sack said.*

Source: Midwest Messenger, by Kerry Hoffschneider. Jan. 2020

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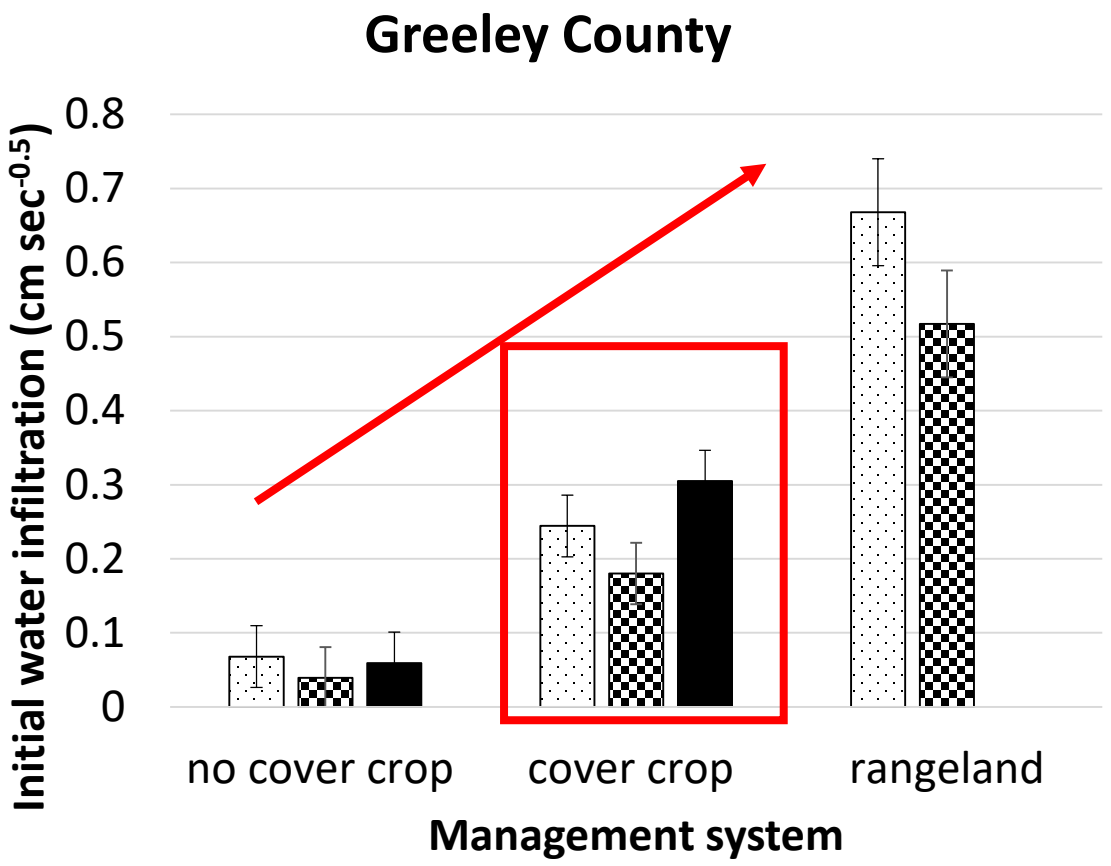
"Understanding water dynamic under changes in land use and soil type"

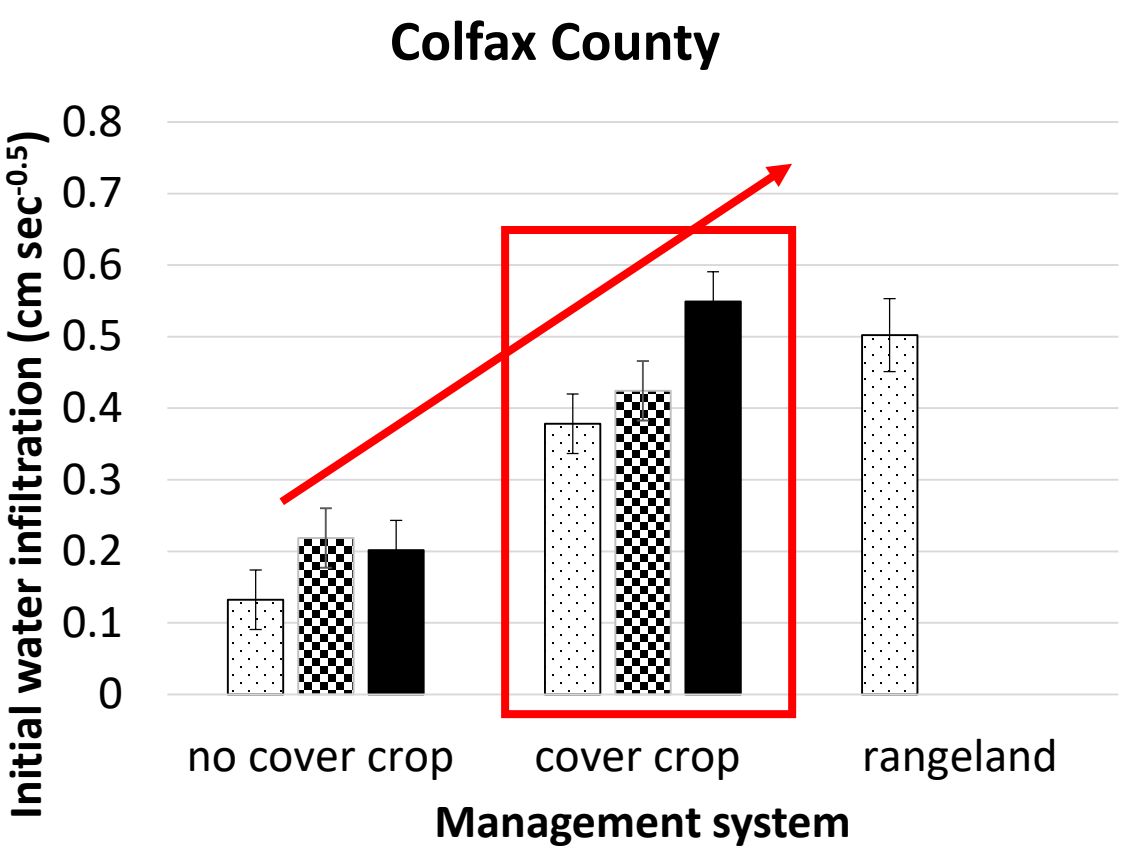
- Sorptivity measurements (initial water infiltration) were conducted in Summer 2019 at 4 on-farm fields testing cover crop and no cover crop (third consecutive year of cover crop use)
- Fields with varying histories of tillage practices
- Reference condition of native or naturalized vegetation - frame soil health metrics in terms of condition relative to soil capacity or capability
- Objective: compare crop management systems to a reference state.

Understanding water dynamics under changes in land use and soil type



- Hersh-Gates complex, 17-30% slopes
- Valentine loamy fine sand, 3-9% slopes
- Gates silt loam, 3-6% slopes, eroded

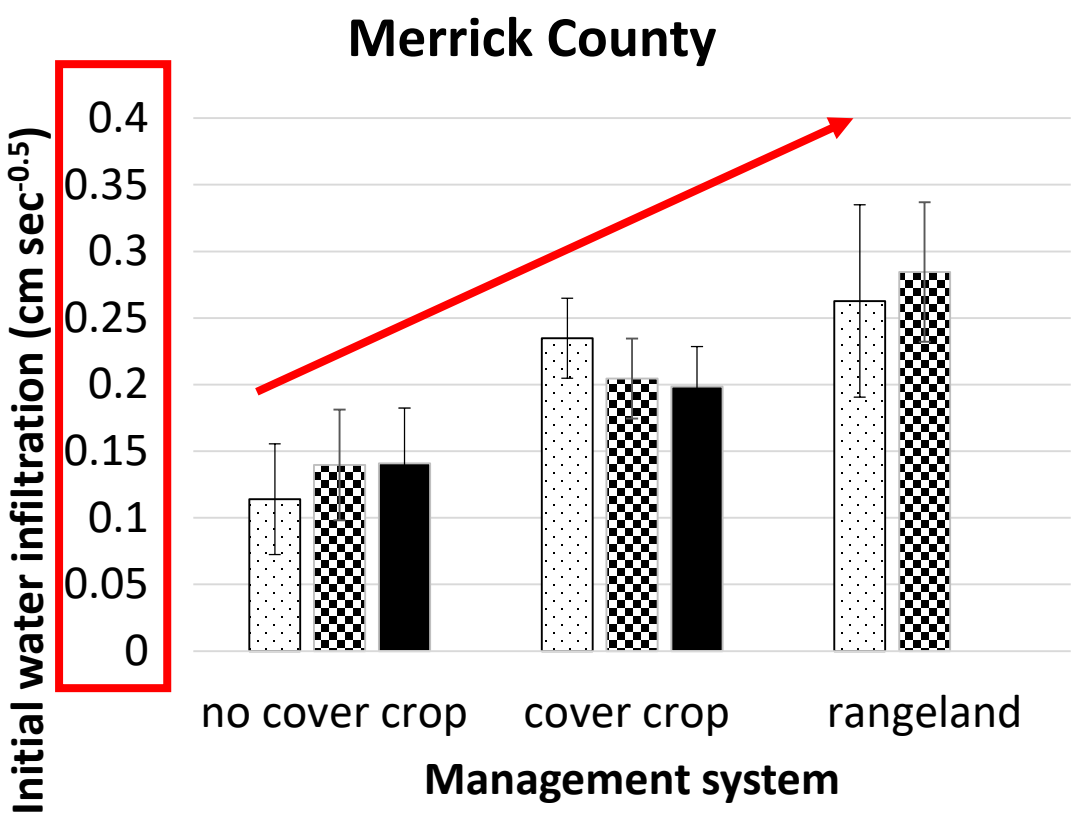
10 years of no-till



- Moody silty clay loam, terrace, 0-2% slopes
- Moody silty clay loam, 2-6% slopes
- Moody silty clay loam, 6-11% slopes

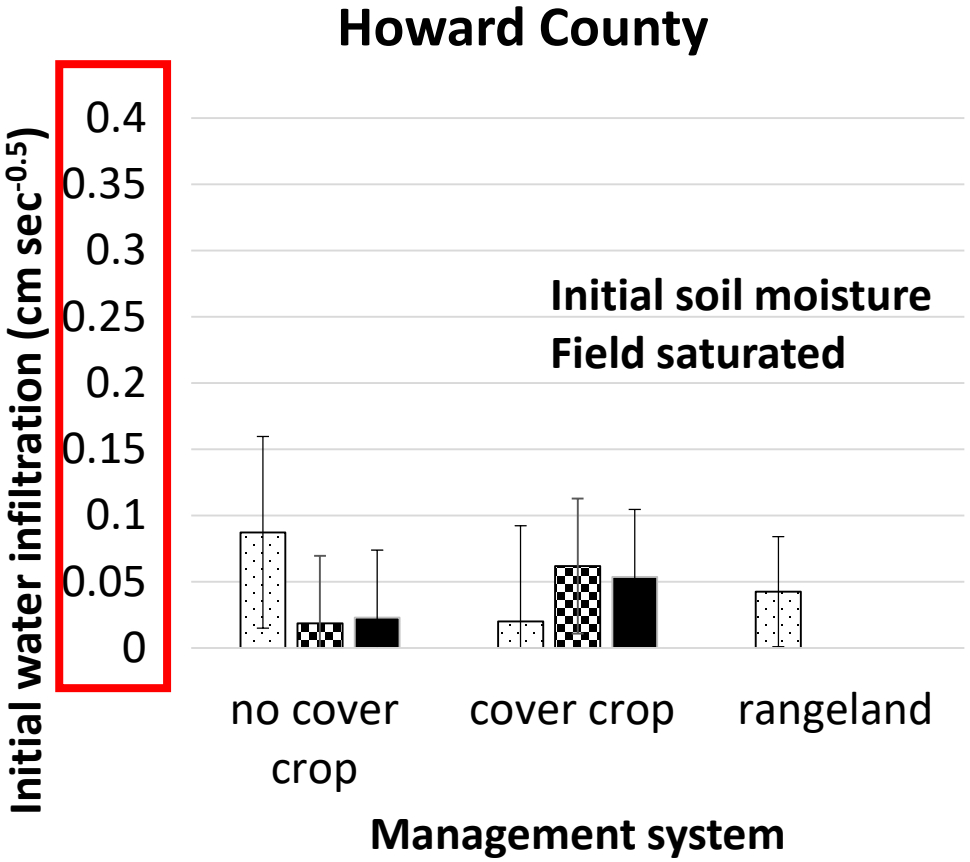
20 years of no-till

Understanding water dynamics under changes in land use and soil type



- Kenesaw silt loam, 1-6% slopes
- Valentine and Thurman soils, 0-17% slopes
- Thurman loamy fine sand, 0-2% slopes

Strip-till



- Harney silt loam, 0-1% slopes
- Holdrege silt loam, 0-1% slopes
- Hord silt loam, rarely flooded

2 years of no-till

Understanding water dynamics under changes in land use and soil type

- Initial soil moisture affected the initial water infiltration rate and should be taken into consideration when comparing different sites.
- Averaged across different soil type and sites, cover cropping increased initial soil water infiltration by 59% compared to conventional farming systems (no cover cropping).
- Long term benefits of cover cropping and soil health management systems are more evident under reduced soil disturbance (soil that has not been tilled for many years).

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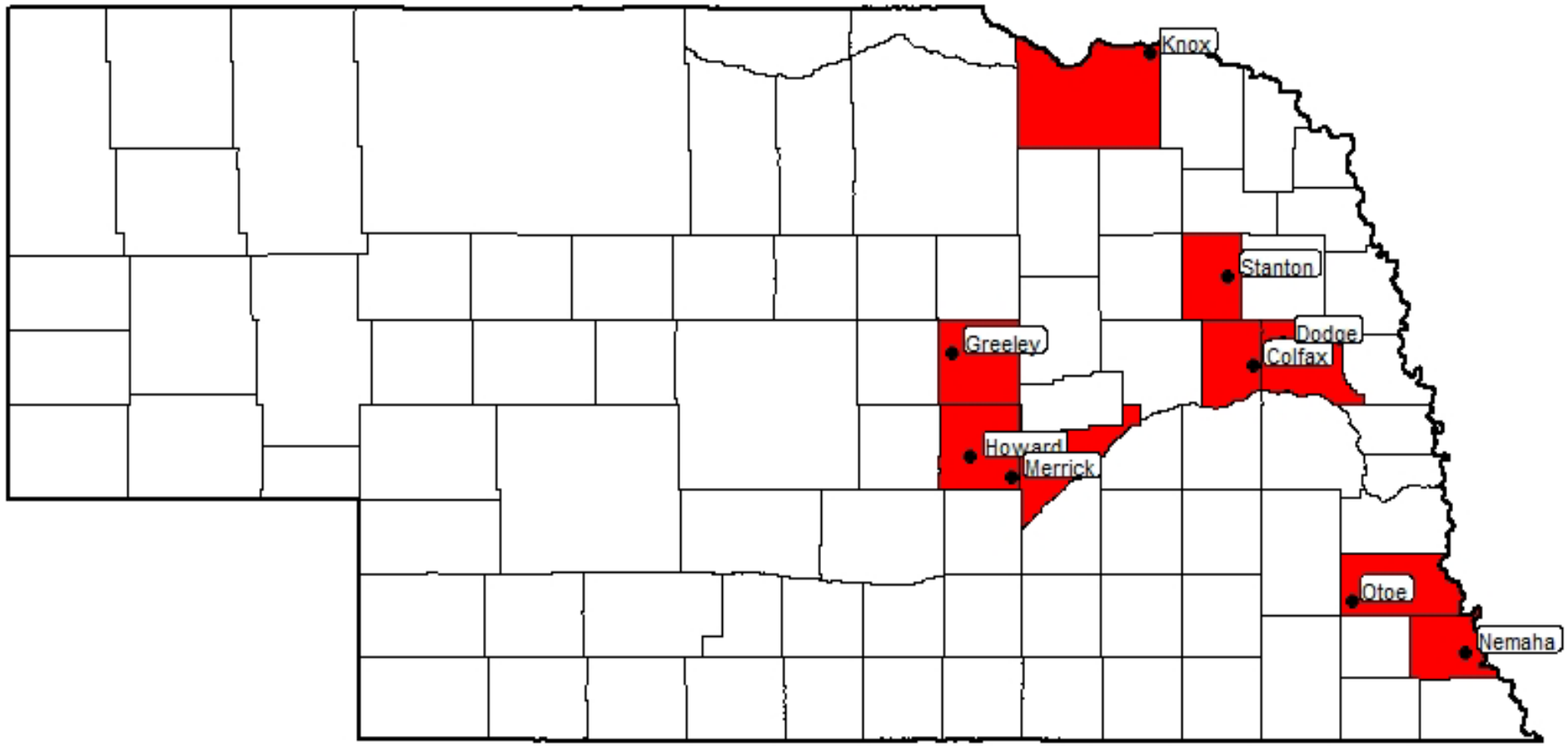
"Understanding water dynamic under changes in land use andsoil type"

"Comparisons of soil health assessments between different transitions to soil health management systems in Nebraska"

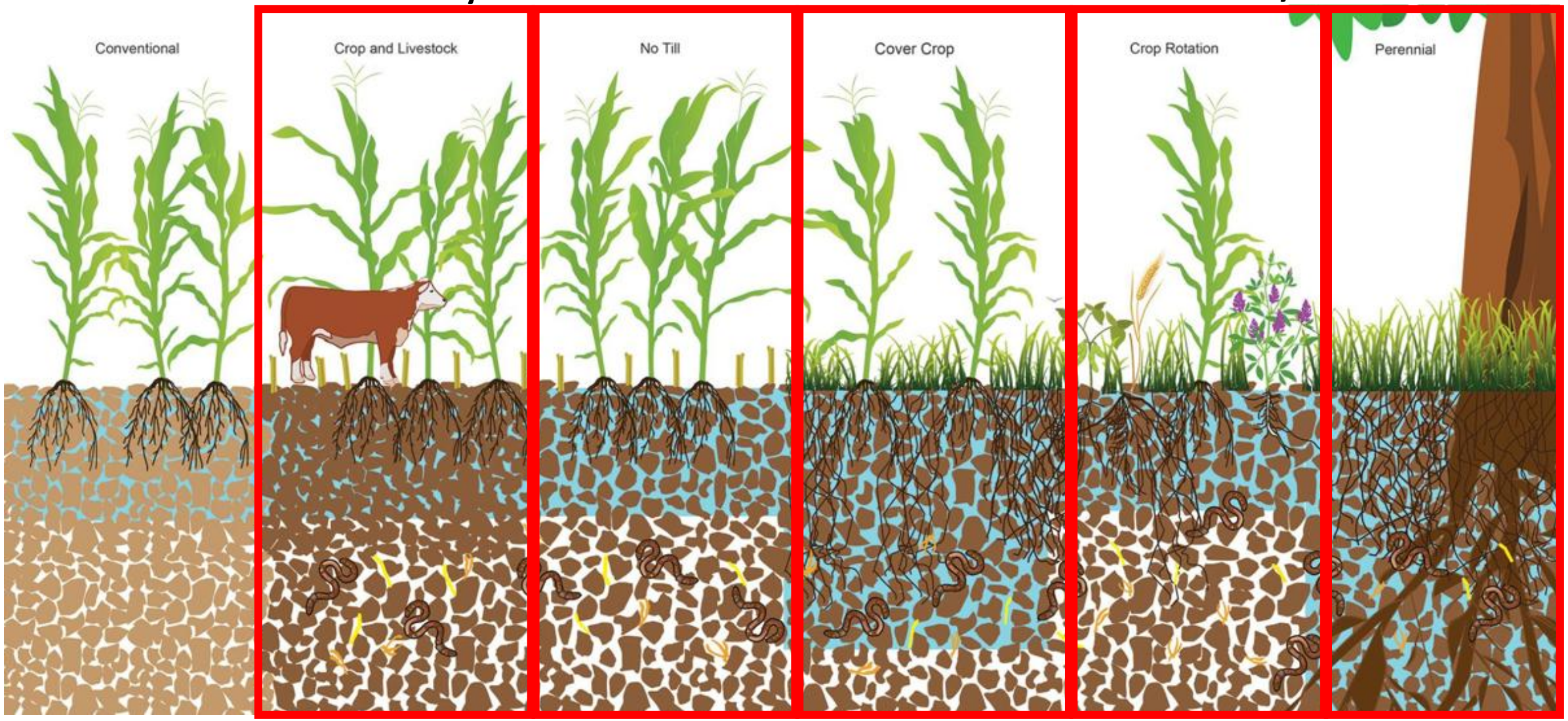
- Soil health assessments including Haney test (HSHT) and NRCS Soil Health Assessment Protocol (NRCS-SHA) were conducted in 2017, the first year of the five-year experiment established at 8 on-farm fields as part of the Soil Health Initiative.
- Relative effects of a continuum of practices on a transition to soil health cropping systems.
- Matrix score used to classify soil undergoing slow shifts in soil health over time.

Regenerative agriculture: working alongside farmers to manage for soil health



Regenerative agriculture: working alongside farmers to manage for soil health

Maximize biodiversity | **Minimize disturbance** | **Maximize soil cover** | **Maximize biodiversity**



Source: Basche and DeLonge, 2019

Maximize continuous living roots

Comparisons of soil health assessments between different transitions to soil Health management systems in Nebraska

County	Fallow no:1, yes:0	Cover crop yes:1, no:0	Cover crop multispecies yes:1, no:0	3+ cash crop rotation yes:1, no:0	Grazing yes:1, no:0	Manure yes:1, no:0	Tillage no:1, yes:0	Composite rank
Greeley	0	0	0	0	0	0	1	1
Greeley	1	1	1	0	0	0	1	4
Howard	0	0	0	0	0	0	0	0
Howard	1	1	1	0	0	0	1	4
Howard	0	0	0	0	0	0	1	1
Merrick	0	0	0	0	0	0	0	0
Merrick	1	1	0	0	0	0	0	2
Colfax	0	0	0	1	1	1	1	4
Colfax	1	1	1	1	1	1	1	7
Otoe	1	1	0	1	0	1	1	5
Otoe	1	1	1	1	0	1	1	6
Nemaha	1	1	1	1	1	1	1	7
Nemaha	1	1	1	1	1	1	1	7
Knox	1	1	1	1	1	0	1	6
Knox	1	1	1	1	0	0	1	5
Stanton	1	1	0	1	0	0	1	4
Stanton	1	1	1	1	0	0	1	5

Farmers whose composite scores **were higher or equal to 4** were considered practicing **soil health management systems (SHMS)**, whereas those with rank scores **lower than 4** were considered in the **conventional practice** category.

Comparisons of soil health assessments between different transitions to soil Health management systems in Nebraska

Soil properties	Conventional	SHMS	F value; p-value	Difference (%)[1]
NRCS soil health assessment				
Bulk density (g cm^{-3})	1.26	1.17	$F_{(1,94)}$=10.54; 0.002	-7.1
Infiltration (inch/$hour^{-1}$)	3.13	8.49	$F_{(1,71)}$=3.57; 0.063	171.2
Water holding capacity	6.27	6.78	$F_{(1,86)}$=12.53; 0.0006	8.1
Water filled pore (%)	34.44	47.70	$F_{(1,86)}$=32.24; <0.0001	38.5
Soil porosity (%)	52.28	56.53	$F_{(1,86)}$=12.53; 0.0006	8.1
Soil temperature (°F)	45.15	49.43	$F_{(1,82)}$=28.62; <0.0001	9.5
Volumetric water content (%)	18.06	26.92	$F_{(1,94)}$=54.53; <0.0001	49.1
NRCS Soil Health score[2]	14.17	16.44	$F_{(1,77)}$=16.27; 0.001	16.0

[1]Difference = [(SHMS – Conv)/Conv]*100. SHMS outperformed conventional soil management = green; conventional outperformed SHMS = red;

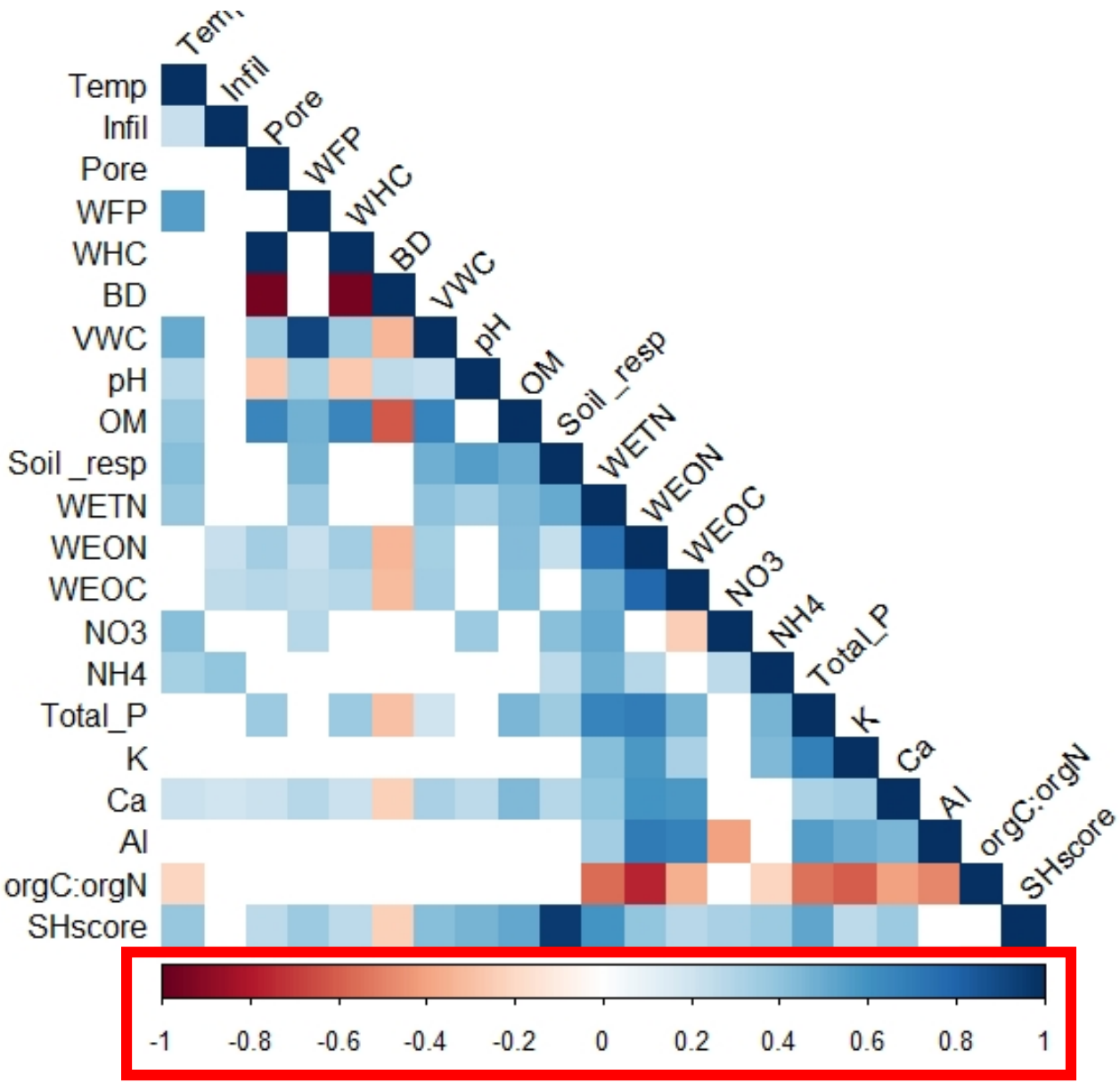
[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (averaged from 1-3): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.

Comparisons of soil health assessments between different transitions to soil Health management systems in Nebraska

Soil properties	Conventional	SHMS	F value; p-value	Difference (%)
Haney soil health assessment				
Organic matter (% LOI)	1.72	2.83	$F_{(1,72)}$=30.53; <0.0001	64.5
Soil respiration CO_2-C (ppm)	56.84	86.88	$F_{(1,72)}$=9.69;0.003	52.9
Sodium (ppm Na)	19.25	10.84	$F_{(1,66)}$=17.68; <0.0001	-43.7
Cupper (ppm Cu)	0.37	0.86	$F_{(1,45)}$=17.69; 0.0001	129.7
Iron (ppm Fe)	122.52	87.15	$F_{(1,63)}$=3.53; 0.073	-28.9
Aluminum (ppm Al)	221.0	163.3	$F_{(1,72)}$=3.17; 0.079	-26.1
Inorganic N (ppm)	3.57	5.64	$F_{(1,48)}$=12.26; 0.001	58.0
Inorganic P (ppm)	14.28	21.92	$F_{(1,48)}$=2.82; 0.0997	53.5
Organic P (ppm)	4.60	6.37	$F_{(1,48)}$=5.29; 0.0258	38.5
Total P (ppm)	22.00	37.64	$F_{(1,48)}$=3.30; 0.0757	71.1
Soluble salts (mmho/cm)	0.13	0.16	$F_{(1,51)}$=4.36; 0.0418	23.1
Organic N release (ppm N)	7.66	14.24	$F_{(1,36)}$=18.95; 0.0001	85.9
Haney test Soil Health score[3]	8.63	10.98	$F_{(1,74)}$=7.08; 0.0096	27.2

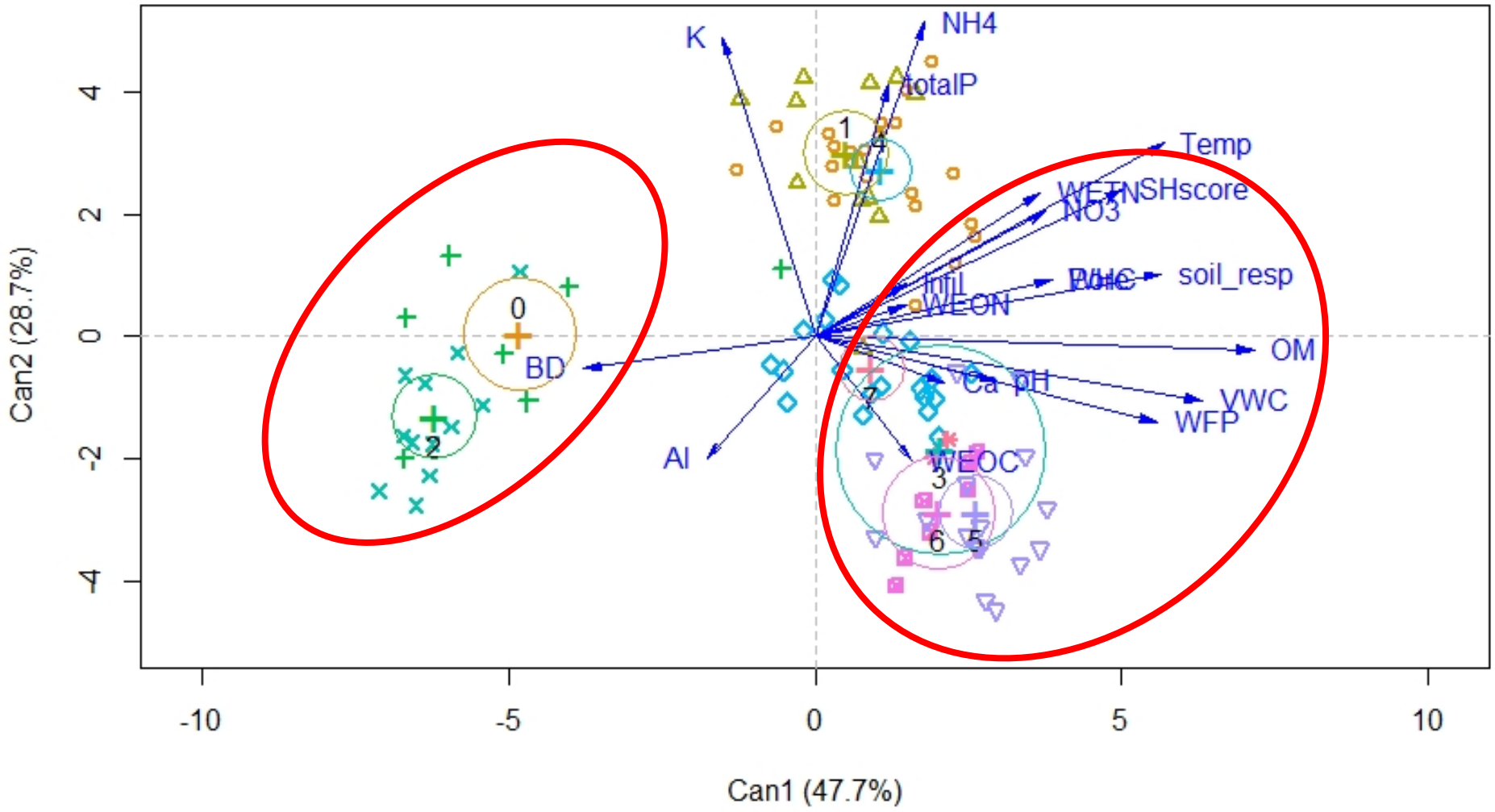
[3]Calculated using the amount of CO_2–C release in 24 h along with a separate procedure from the H3A extract to measure soil concentrations of water-extractable organic C (WEOC) and water-extractable organic N (WEON). SH score = CO_2/10 + WEOC/100 + WEON/10 (Roper et al. 2017).

Comparisons of soil health assessments between different transitions to soil Health management systems in Nebraska



Soil health management systems on-farms support improvements in indicators of soil properties in Nebraska

"How does the field composite ranks cluster into groups and what is the relationship of soil properties with these groups?"



Soil health management systems on-farms support improvements in indicators of soil properties in Nebraska

- Most of the chemical and biological soil indicators integrated into the HSHT were statistically different between conventional and soil health management systems.
- The HSHT results and the NRCS Soil Health Assessment found higher scores or values in the soil health management systems compared to the conventional system.
- Results demonstrated the effects of the legacy and history of the management.
- The use of CDA added on visualization and interpretation of the main soil properties driving the gradual adoption of conservation farming practices.
- These results provide a basis for a common framework for soil health assessment in systems-level shifts to more regenerative farm systems.

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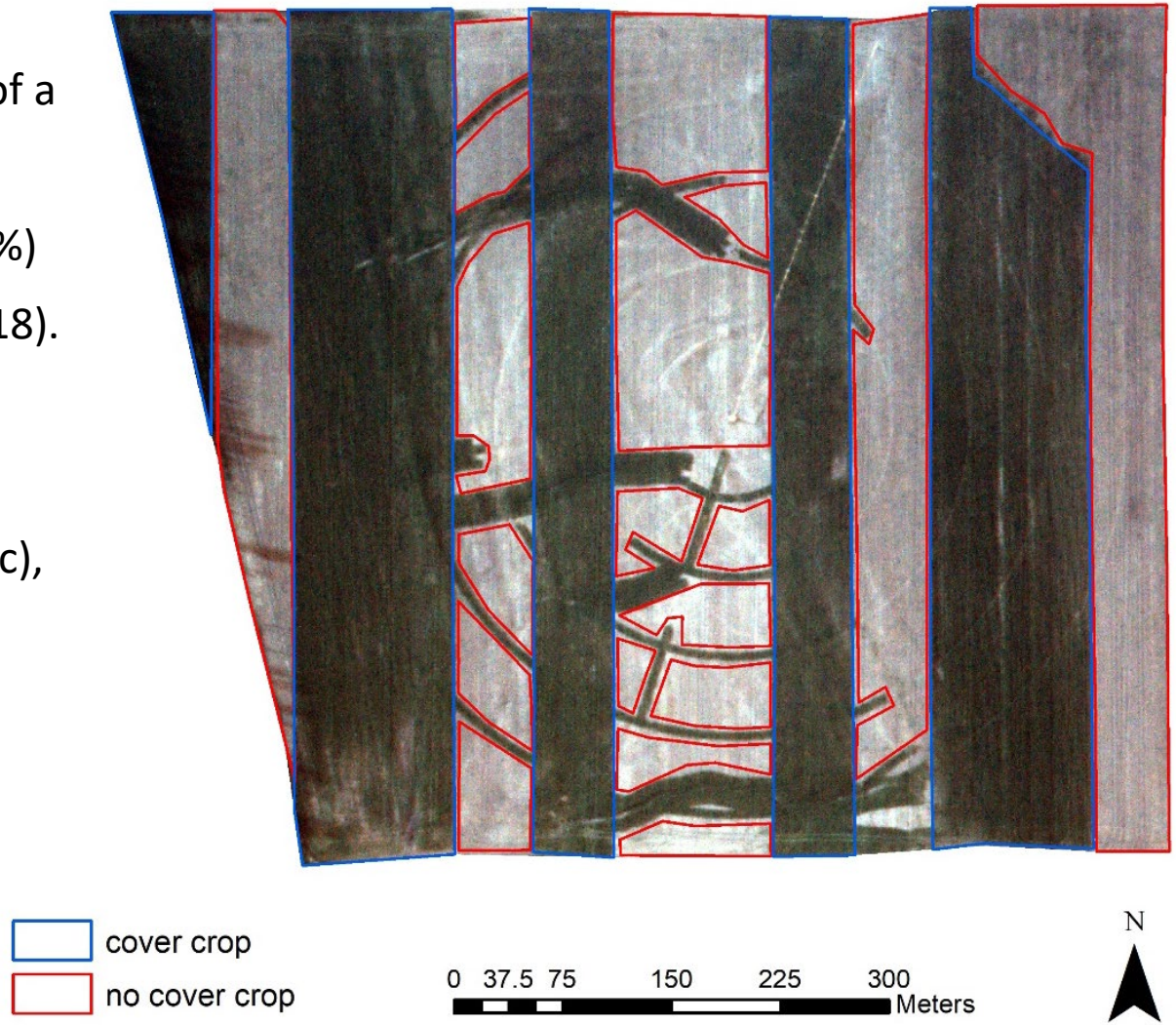
"Using remote sensing as a tool for evaluating the effectiveness of soil health building practices under extreme weather conditions"

Using remote sensing as a tool for evaluating the effectiveness of soil health building practices under extreme weather conditions

- Cover crop versus no-cover cropping strips designed in spatially balanced blocks (n=5) during the fallow period of a corn-soybean rotation
- Silty clay loam soil (sand: 30.5%, silt: 39.04%, clay: 30.39%) that belongs to the Holdrege series (Soil Survey Staff, 2018).
- Cover crop mixture was drilled in September 2018 (the second year of continuous cover crop use).
- CC mixture (NRCS cover crop guide) - cereal rye (33 lbs/ac), turnip (0.8 lbs/ac) rapeseed (1.6 lbs/ac), African cabbage (0.6 lbs/ac), forage collards (0.5 lbs/ac), sunflower (1.1 lbs/ac), hairy tech (1.6 lbs/ac), radish (1.1 lbs/ac), and winter lentil (1.0 lbs/ac).
- CC biomass (n=5, mean ± std = 3.08 ± 0.82 Mg ha^{-1})



Using remote sensing as a tool for evaluating the effectiveness of soil health building practices under extreme weather conditions

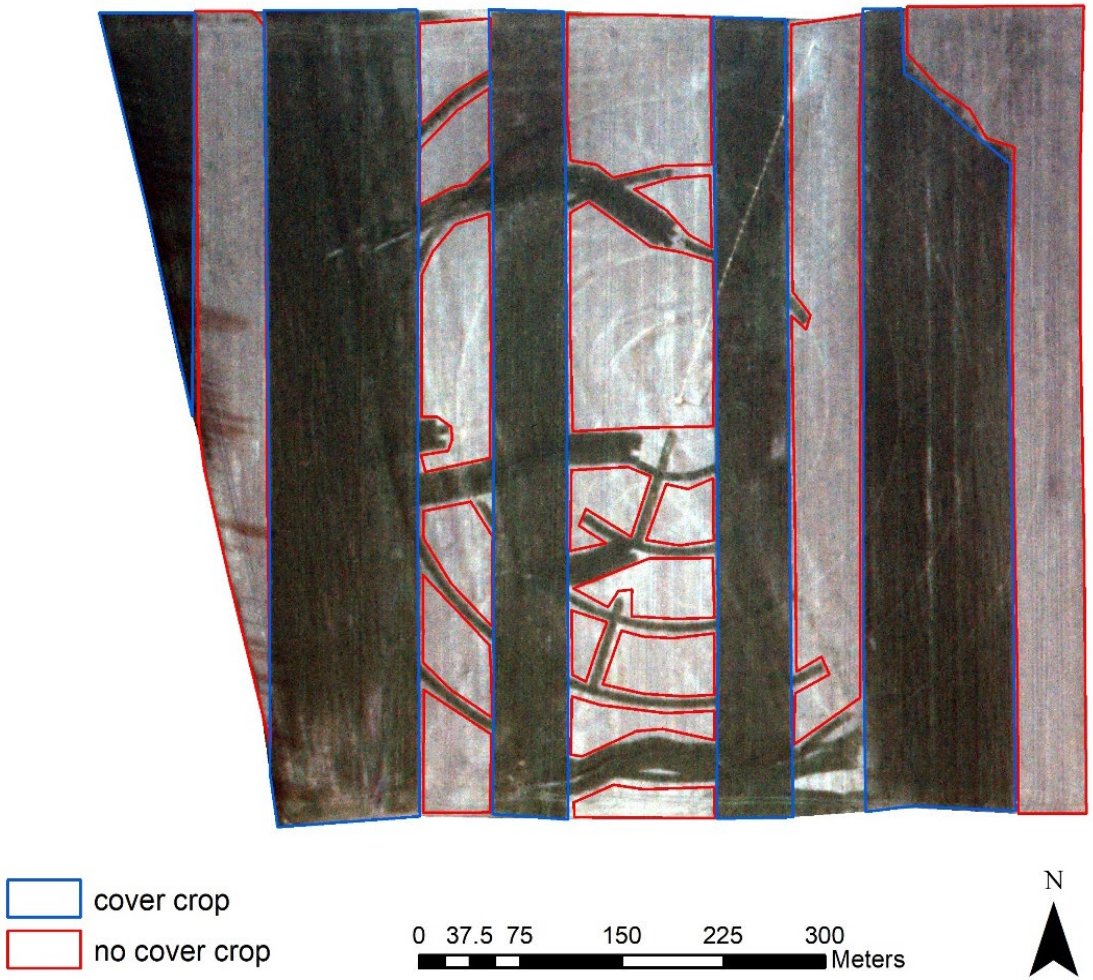
- CC termination: May 14th, 2019
- Soybean (variety A2405RX) sowing: May 16th, 2019
- Soybean harvest: September 30th, 2019

Data collection

- Soil sample (0-5 cm depth): August 16th, 2019
- Soybean yield components and grain quality: September 26th, 2019
- Multispectral remote sensing data: weekly to biweekly deliveries of high-resolution crop health, thermal, and infrared imageries.

TerrAvion (https://www.terravion.com; San Leandro, CA), a commercial aerial imagery data provider.

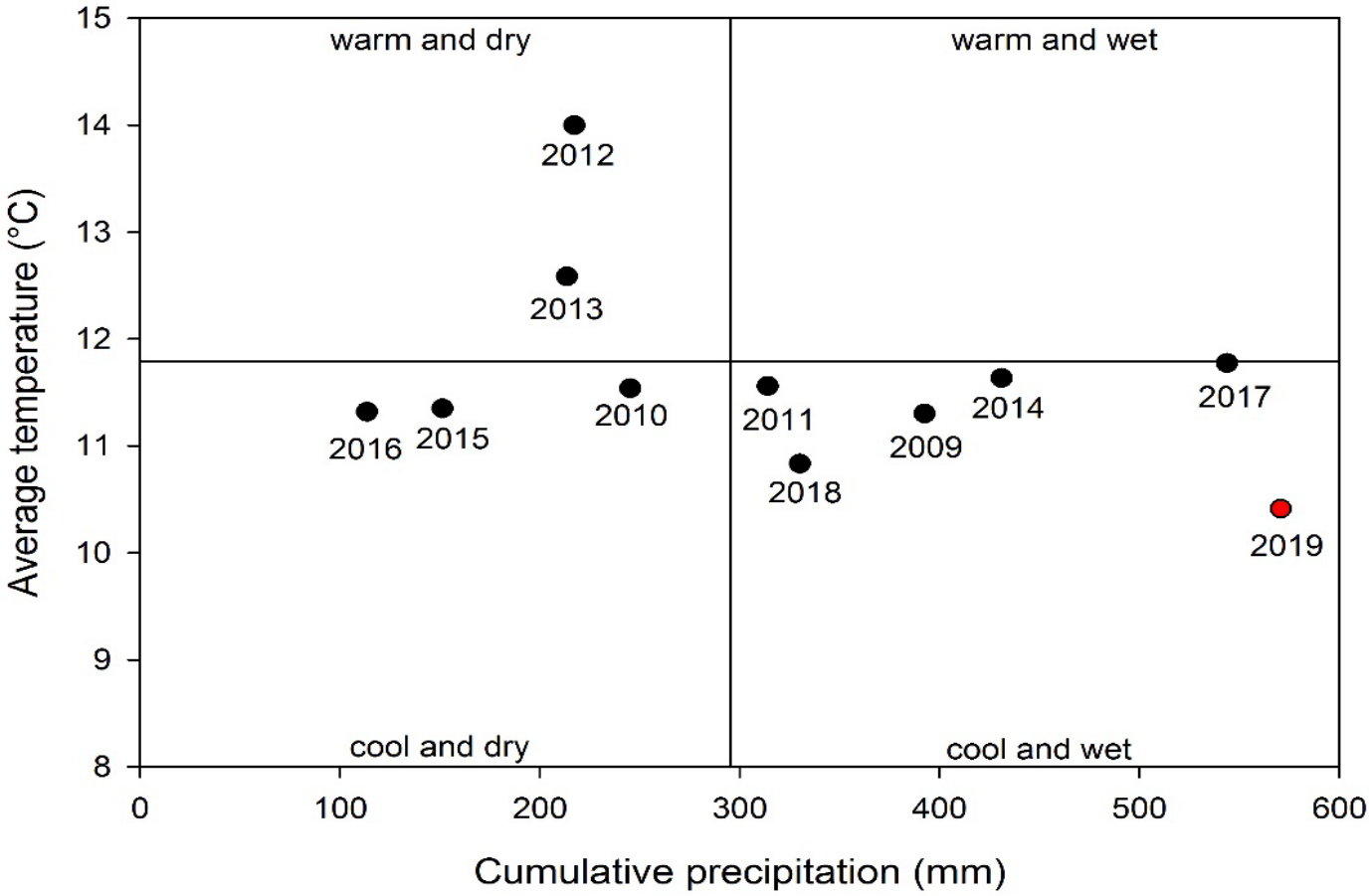
17 - 20 cm spatial resolution on 8 bands in visible, NIR, and thermal regions



Using remote sensing as a tool for evaluating the effectiveness of soil health building practices under extreme weather conditions

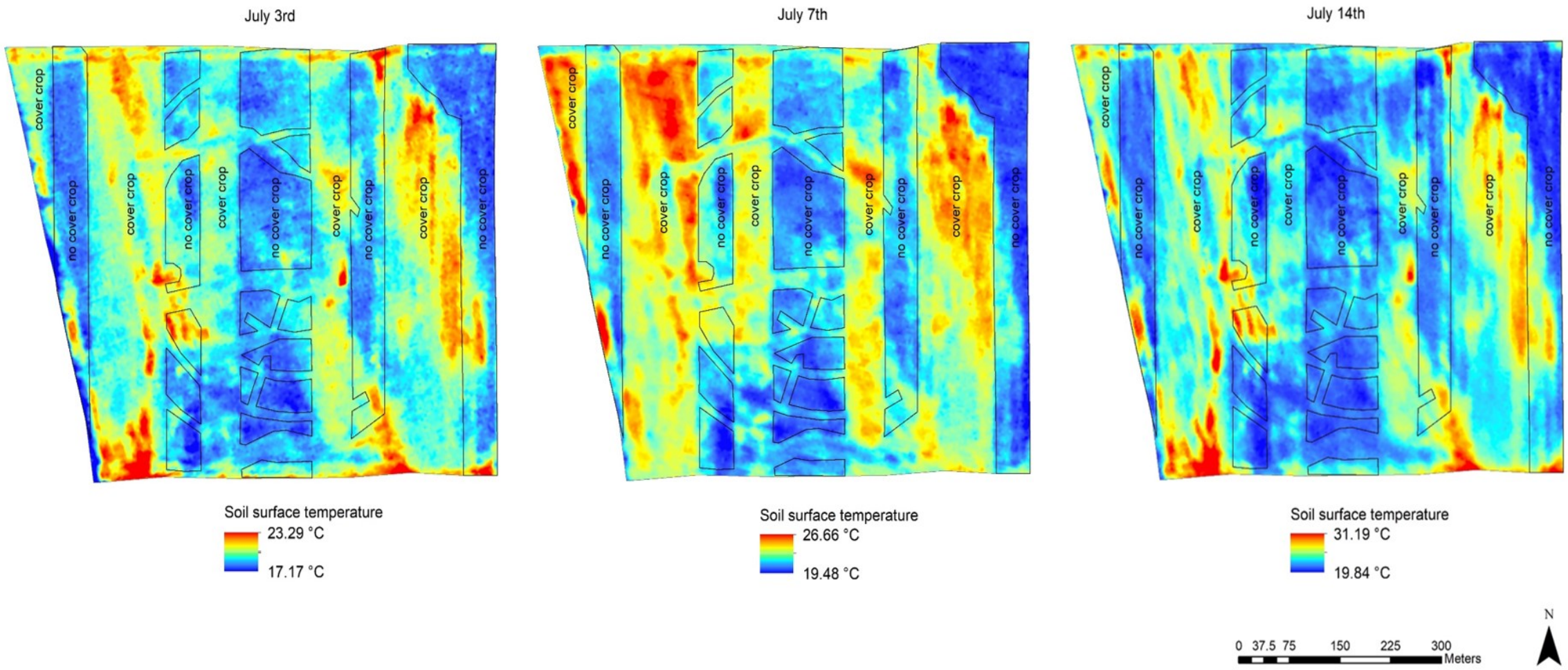
- Weather station (Alda 3W) from the Automated Weather Network of the High Plains Regional Climate Center (https://hprcc.unl.edu/awdn.php).

How does field with cover crop experiments in place for 2 years respond to these atypical torrential rains during the cash crop growing season compared to soils that were left bare?



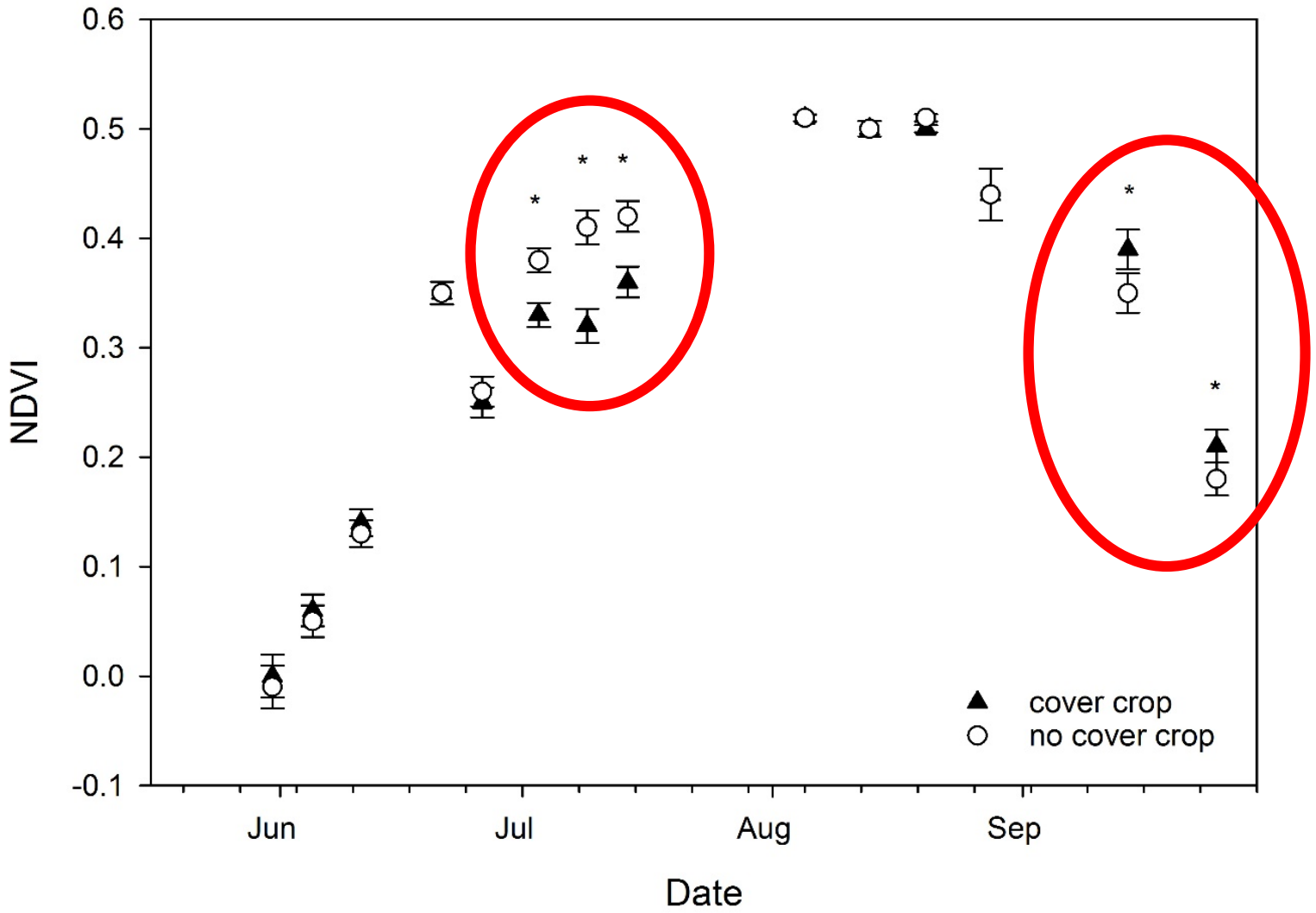
Year classification based on cumulative precipitation and average temperature during the growing season (05/16 - 09/30). Reference lines correspond with the 10-year average of cumulative precipitation (295.13 mm) and temperature (11.78 °C).

Using remote sensing as a tool for evaluating the effectiveness of soil health building practices under extreme weather conditions



Spatial and temporal distribution of soil surface temperature across cover crop and no cover crop strips after 49.76 mm of rainfall events distributed from June 27th to July 14th. The temperature differences could be a result of canopy difference or water that has not infiltrated in the no cover crop strips.

Soil health management systems on-farms support improvements in indicators of soil properties in Nebraska



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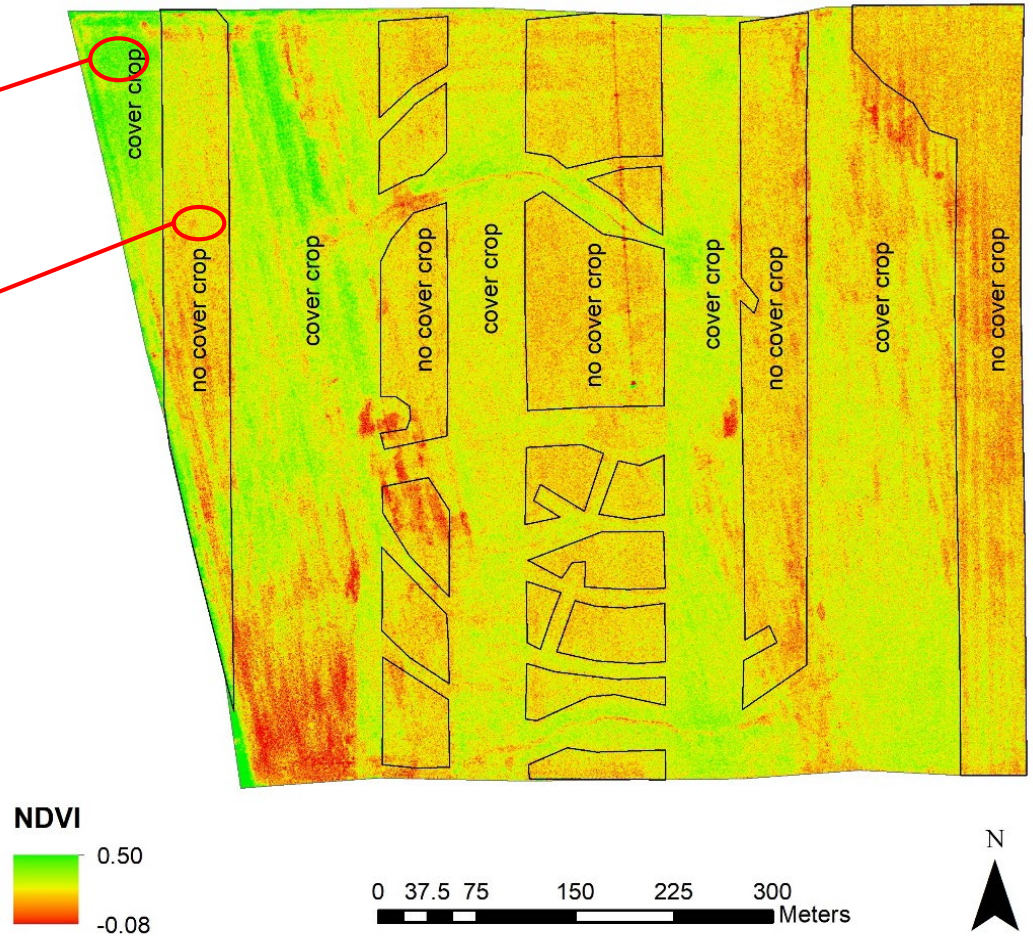

Picture of soybean planted on the cover crop (left) and no cover crop strips (right). Pictures were taken on September 26th, 133 days after soybean sowing.

Soil health management systems on-farms support improvements in indicators of soil properties in Nebraska

Soybean yield component and quality averaged across cover crop and no cover crop strips (sampled on September 26th).

Yield components	Treatment		*p-value*
	cover crop	no cover crop	
Pods per plant	49.5 ± 10.3	48.5 ± 10.3	0.897
Grain per plant	106.8 ± 18.4	1030 ± 18.4	0.771
Yield (bu/ac)	69.5 ± 7.3	67.9 ± 7.3	0.779
Moisture (%)	16.8 ± 1.8	15.0 ± 1.8	0.210
Linoleic (%)	6.6 ± 0.2	6.7 ± 0.2	0.880
Saturated fat (%)*	11.1 ± 0.6	10.6 ± 0.6	0.397
Protein (%)*	35.1 ± 0.9	34.0 ± 0.9	0.385
Oil (%)*	19.2 ± 0.3	19.6 ± 0.3	0.175
Fiber (%)*	4.8 ± 0.1	4.9 ± 0.1	0.178

*calculated at 13% grain moisture

Soil health management systems on-farms support improvements in indicators of soil properties in Nebraska

- High-resolution multispectral imagery collected at multiple points throughout the growing season can provide details on how management decisions and weather conditions and events affected the cash crop.
- The thermal and vigor patterns developed in this field during the season helped us to identify CC effects on subsequent cash crop following seasons with above-average water inputs.
- Aerial imagery NDVI analysis showed lower values for soybeans following cover crops in July. Soybeans following cover crops were not as large or canopied as soybeans following no cover crop. In September, the soybeans following cover crops had higher NDVI representing soybeans which were not as mature. Soybeans following the no cover crop treatments had greater leaf senescence and were more mature.
- The treatments did not result in differences in soybean moisture, yield, or quality.

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SOCIAL: learning from other farmers experience – field days and annual meetings

Regenerative agriculture: working alongside farmers to improve soil health

Social setting where we are sharing ideas – Field days and annual meetings

- Boundary organization
- Knowledge network manager
- Social capital

Farmers, Nebraska Extension educators, and NRCS employees at the NRCS-Nebraska Extension Soil Health Initiative Meeting held in York in March 2019.

Regenerative agriculture: working alongside farmers to improve soil health

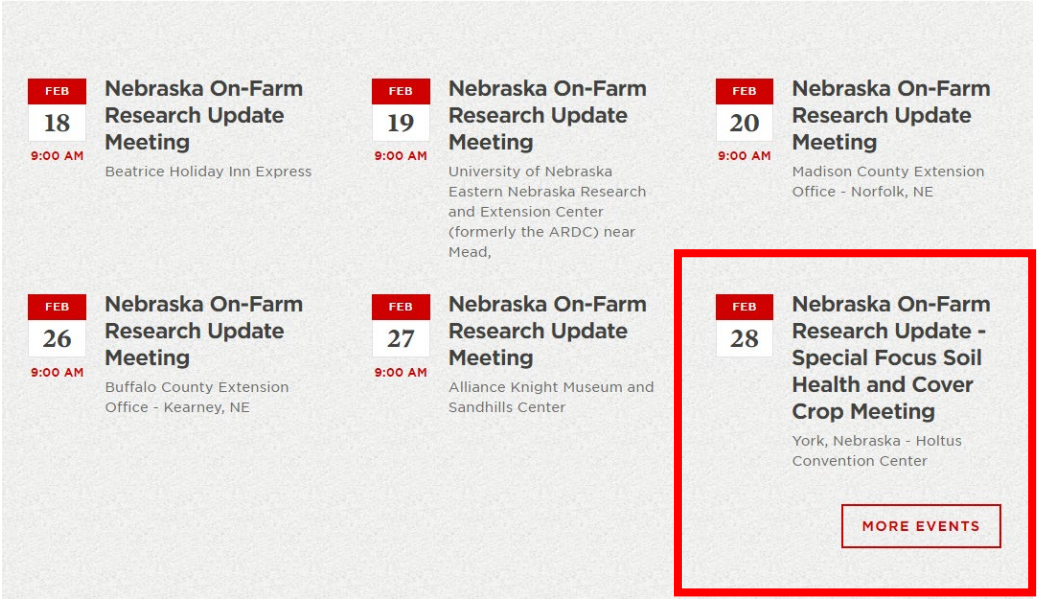
2019 Annual meeting highlights

- Attendees ≈ 30 (producers, extension educators, UNL faculty and NRCS personnel)

Value-added of the project to collaborator's operation, service area or region

- "Hope to see improvement in soil health, reduced erosion and better **water infiltration**".
- "Improve soil health is an **investment in the future**".
- "It demonstrated a **successful diversified rotation** where the producer has proved that markets are available for these lesser known cash crop."
- "It is also **a great demo for multispecies cover crop** and the potential it provides."
- "It gives us **real information** and observation opportunities on my farm with **less financial risk**."
- "Field days to share what we have learned."

Regenerative agriculture: working alongside farmers to improve soil health



Time	Topic	Speaker(s)
9:00-9:15am	Introductions	Andrea Basche and Daren Redfearn, UNL Agronomy and Horticulture Aaron Hird, NRCS
9:15-9:30am	What Small-Business Owners Need to Know About On-Farm Research	Nathan Mueller, UNL Extension
9:30-11:00am	Presentation of on-farm research reports	Aaron Hird, NRCS Laura Thompson, UNL Extension Farmer collaborators in attendance
11:00-11:30am	Keynote presentation Soil Health: A Microbial Perspective	Rhae Drijber, UNL Agronomy and Horticulture
11:30am-12:00pm	Discussion and participant survey	Andrea Basche
12:00pm-12:45pm	Lunch	
12:45-1:00pm	Announcements	Andrea Basche Laura Thompson
1:00-1:30pm	Research update from UNL Agronomy and Horticulture from Soil Health Initiative farms	Fernanda Krupek, UNL Agronomy and Horticulture
1:30-2:00pm	Soybean cultivar selection to increase cover crop productivity	Chris Proctor and Jenny Rees, UNL Extension
2:00pm	Continue on farm research reports and adjourn	Aaron Hird, NRCS Laura Thompson, UNL Extension Farmer collaborators in attendance

Thanks!

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EXTENSION USDA NRCS