

Using Aerial Imagery to Determine Cover Crop Impacts on Cash Crop Growth and Development



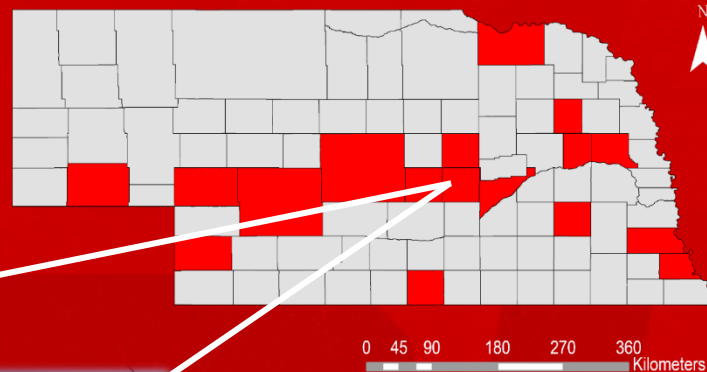
Andrea Basche and Fernanda Krupek
Department of Agronomy and Horticulture
University of Nebraska-Lincoln

Ames, IA
April 2013



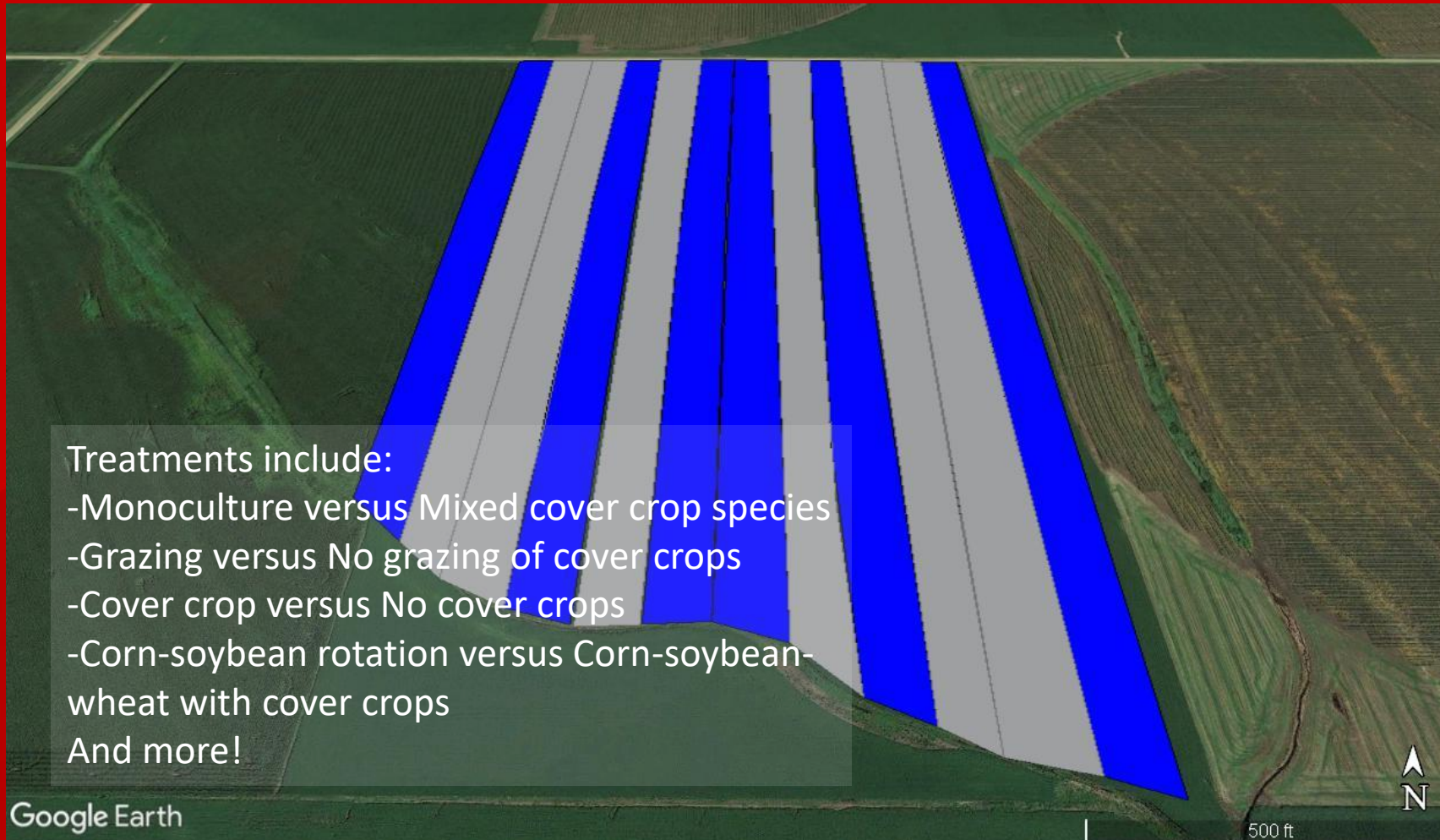
UNL-NRCS Nebraska Soil Health Initiative

- A total of 17 studies were assigned with cooperating growers in 2016 or 2017
- Five year commitment to on farm-research with soil health management systems



Plot layout

- On-farm research using a farmer-initiated approach: research questions on agricultural conservation practices were generated by the farmer based on their resource (e.g. soil) concern
- Randomized, replicated field length strips placed across fields to match grower equipment widths



Treatments include:

- Monoculture versus Mixed cover crop species
 - Grazing versus No grazing of cover crops
 - Cover crop versus No cover crops
 - Corn-soybean rotation versus Corn-soybean-wheat with cover crops
- And more!

- Standard/required data collection (for UNL On-Farm research reports)
- ✓ Cash crop yield monitor data
 - ✓ Soil health assessments: NRCS protocol and Haney test (commercially available test)
 - ✓ Agronomic management form

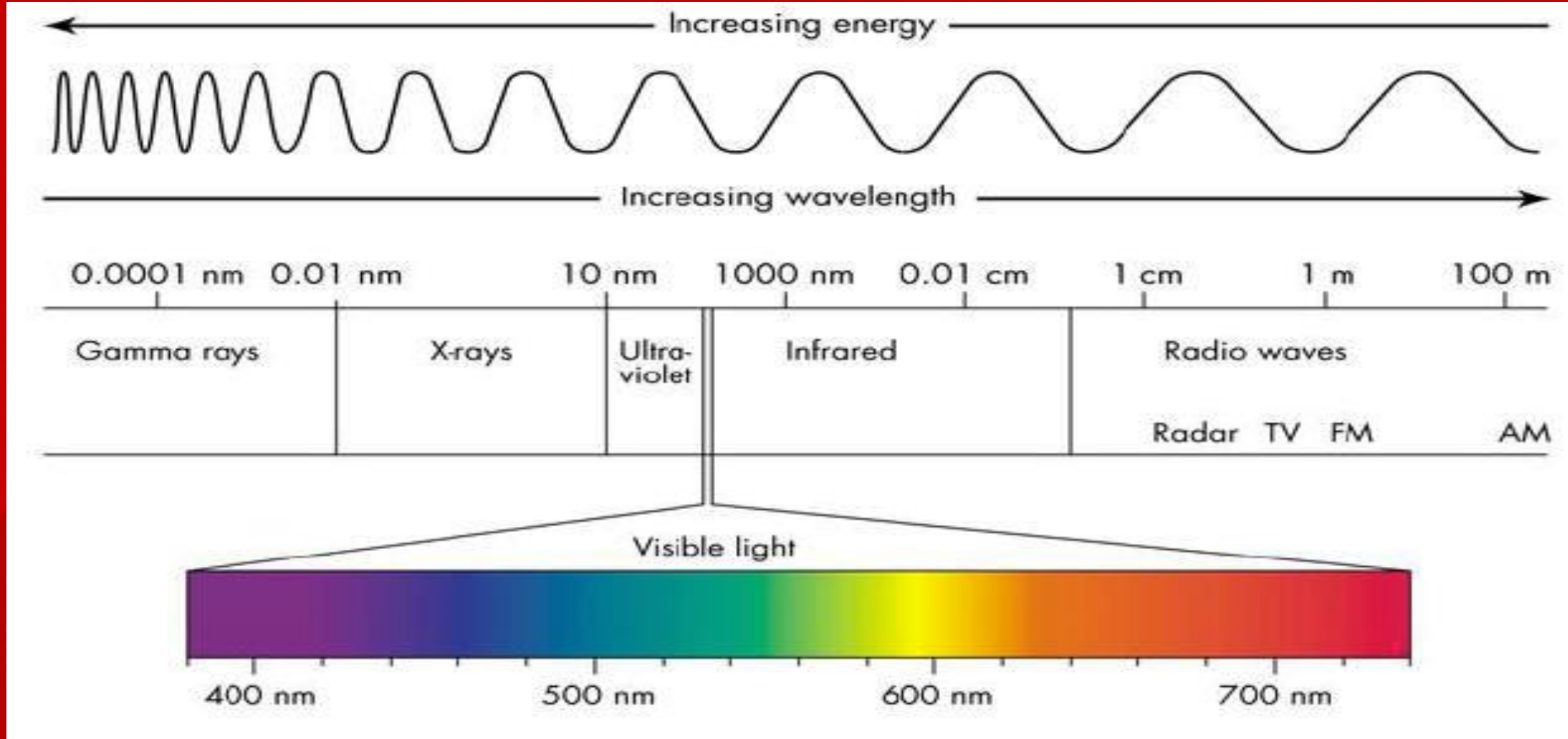
Imagery collection

- Selected farmer's fields were signed to receive weekly aerial imageries throughout their cash crop growing season
- Multispectral airplane imagery acquired from TerrAvion

		wavelength*
channel 1	BLUE	430-500 nm
channel 2	GREEN	490-580 nm
channel 3	RED	575-700 nm
channel 4	NIR	830-880 nm
channel 5	GREEN2	545-590 nm
channel 6	RED2	576-652 nm
channel 7	Thermal	7500-13000 nm
channel 8	Alpha	-



Science behind the imagery
Starting with solar radiation



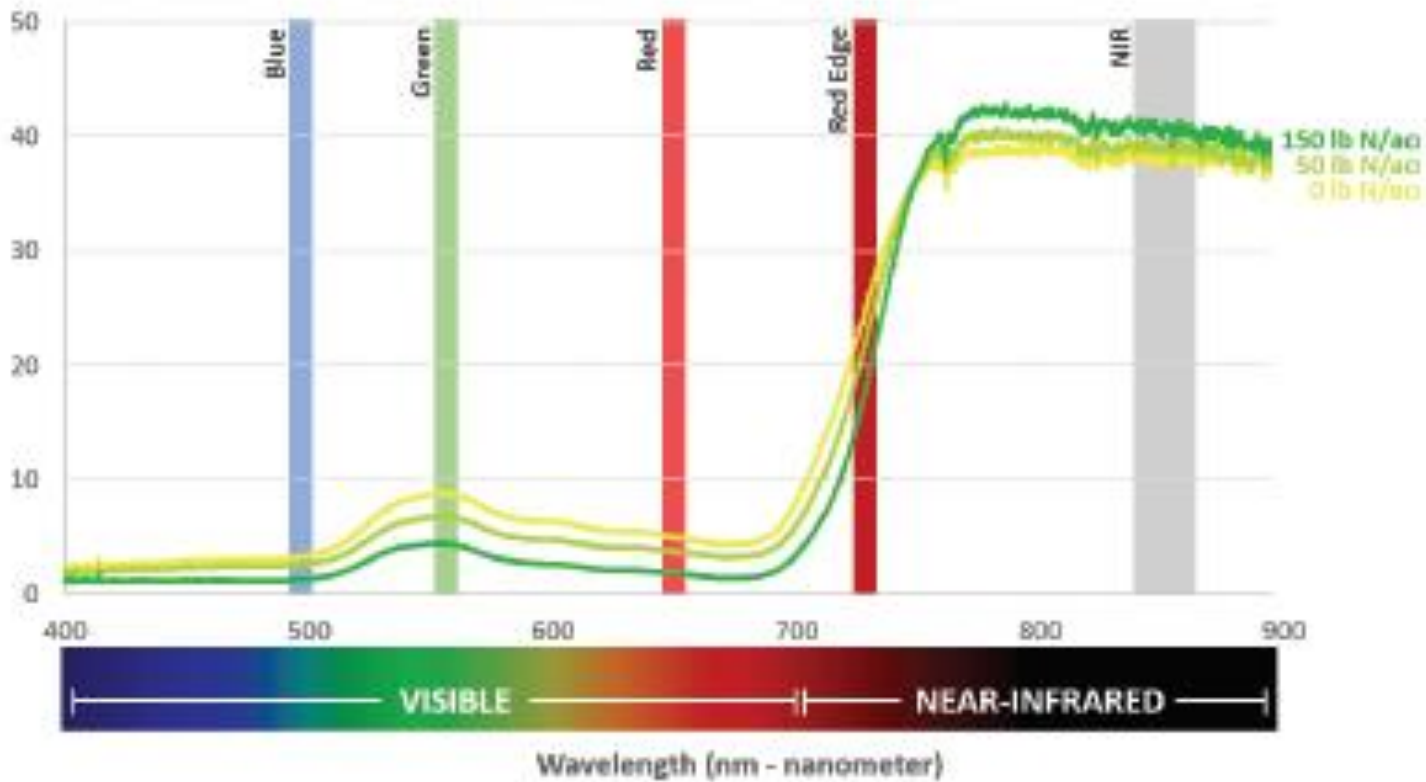


Figure 2. Spectral reflectance of healthy and stressed plants in visible and near-infrared regions.

NDVI =
Normalized
Difference
Vegetation
Index

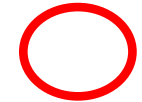
NDVI =
NIR – Red /
NIR + Red

Indicator of
chlorophyll
content and
canopy density

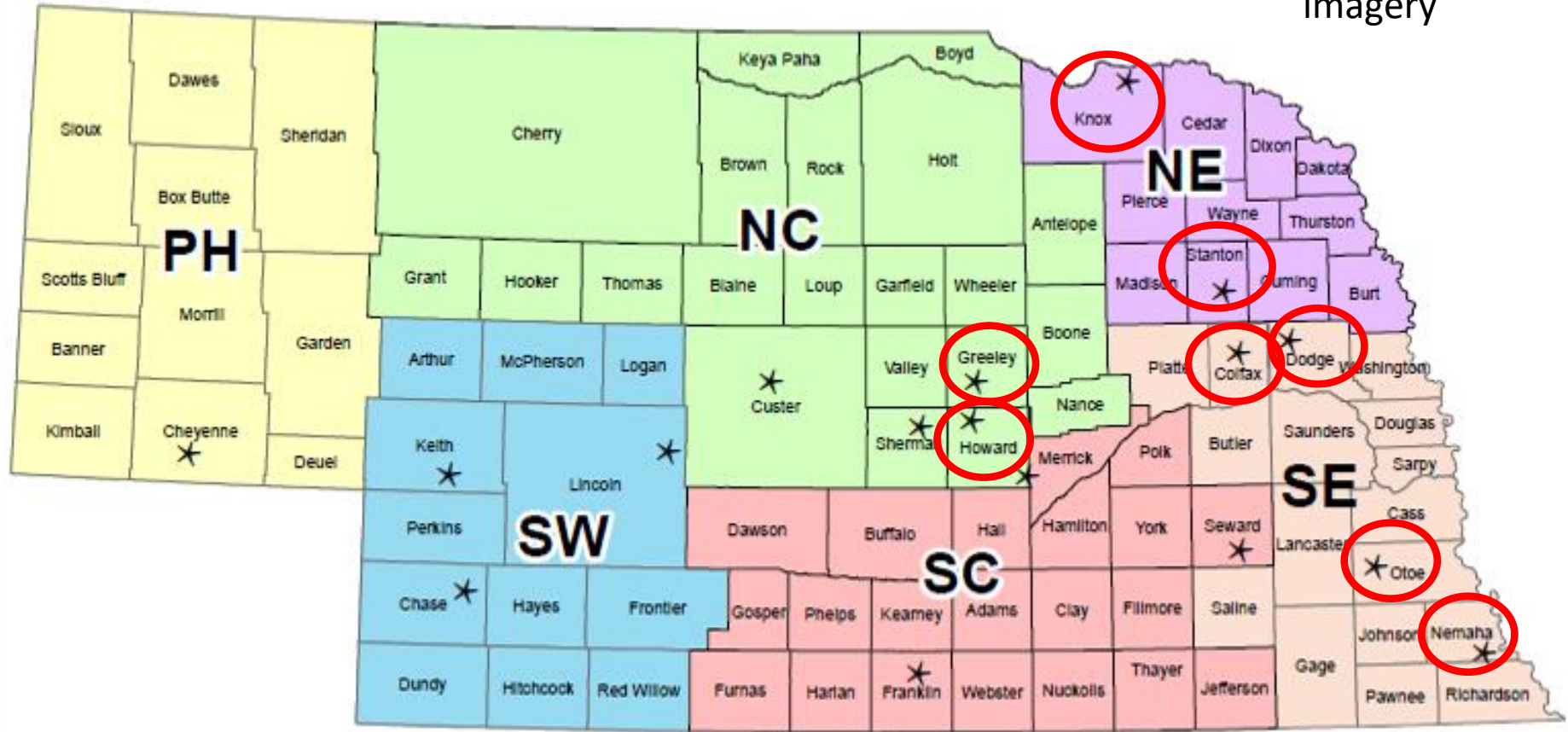
Source: UNL Extension
Publication, Getting
Started with Drones in
Agriculture



Soil Health Demonstration Fields



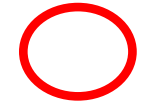
2020 in-season imagery



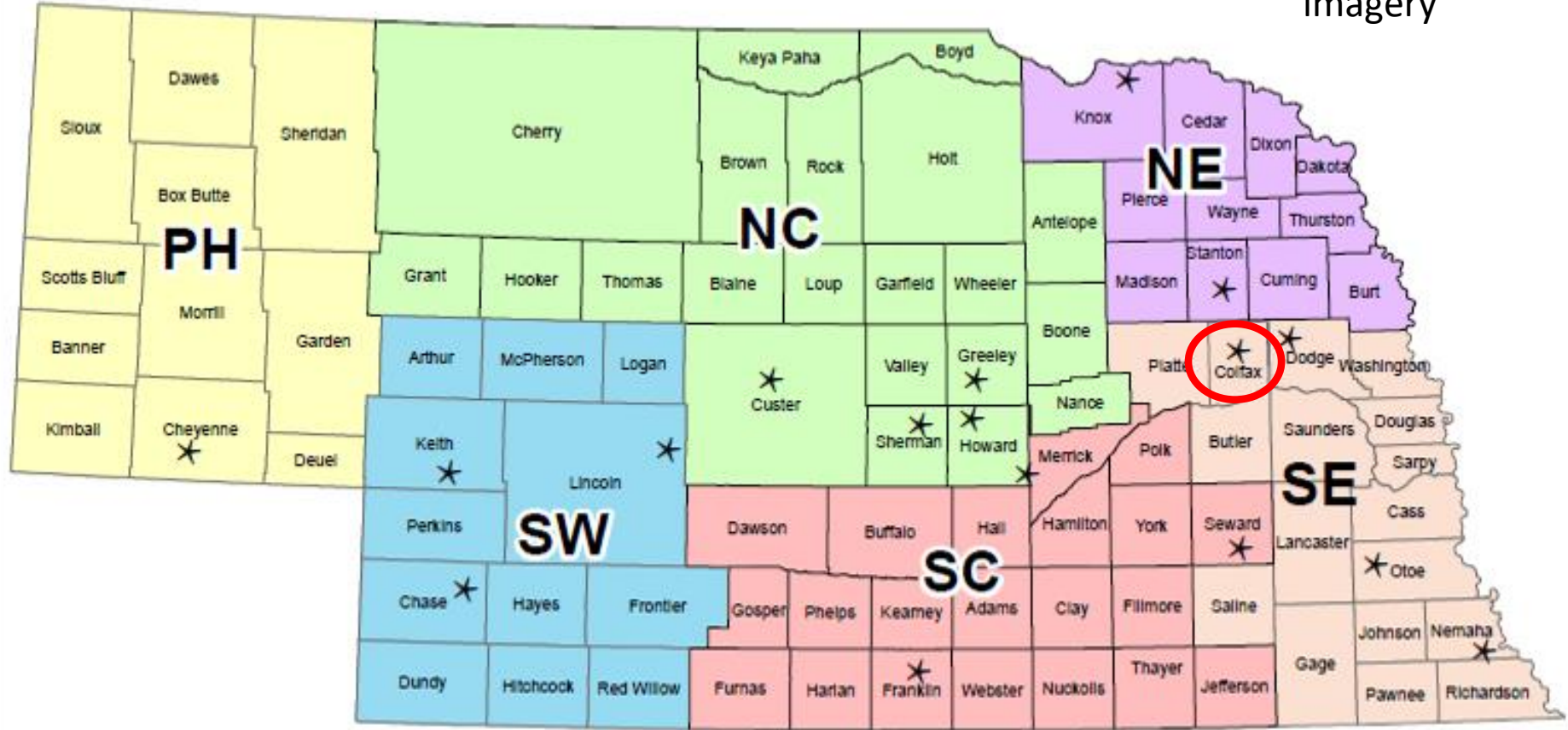
* 17 - Demonstration Fields



Soil Health Demonstration Fields



2020 in-season
imagery

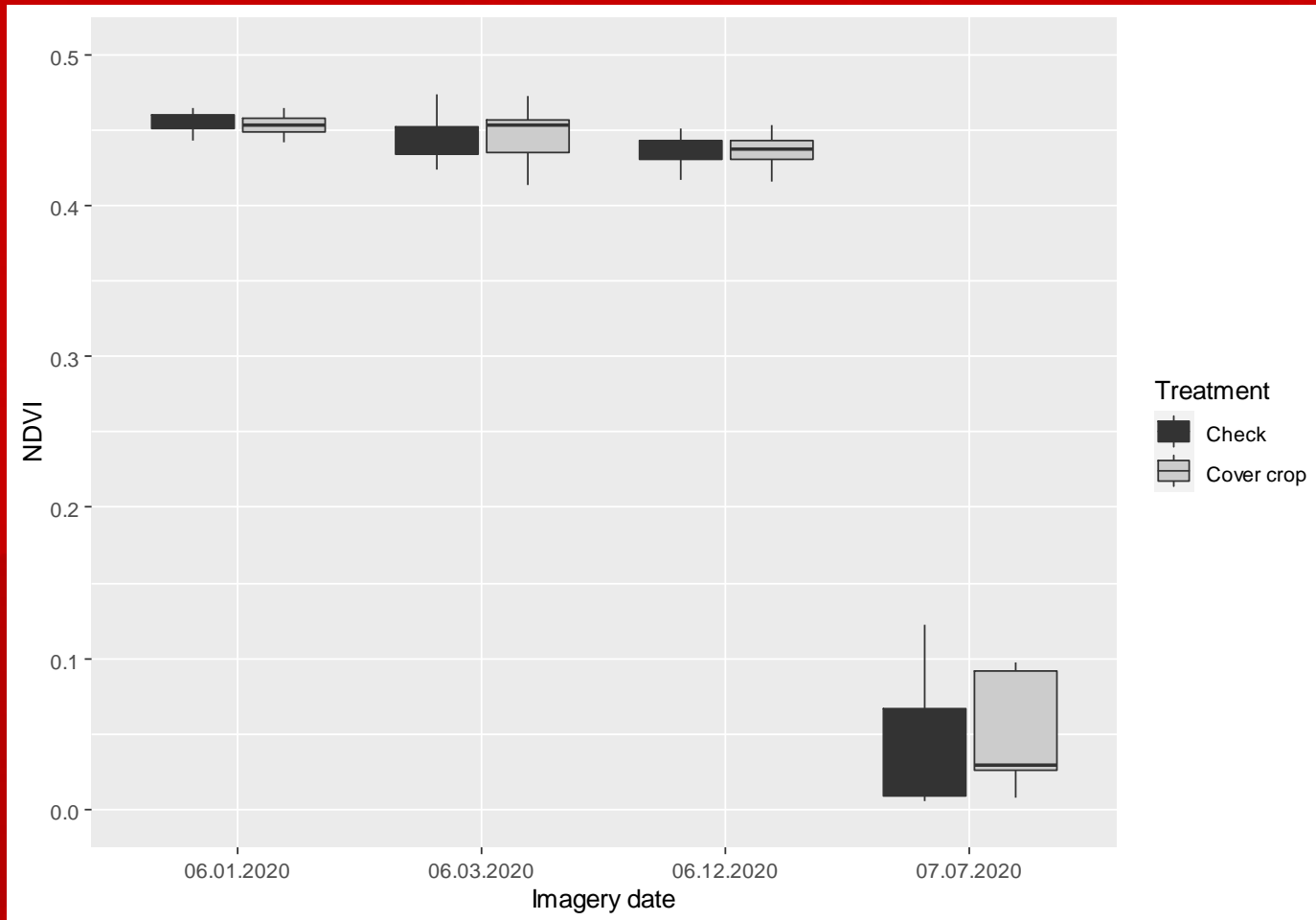


* 17 - Demonstration Fields



- 2020 Cash Crop: Wheat
- 2019-2020 Cover Crop: Multi-species mix
- Soil health system evaluated: Cover versus No crop (no-till, non-irrigated)

Colfax County



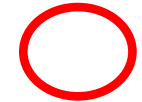
No difference
in NDVI

No difference
in wheat yield

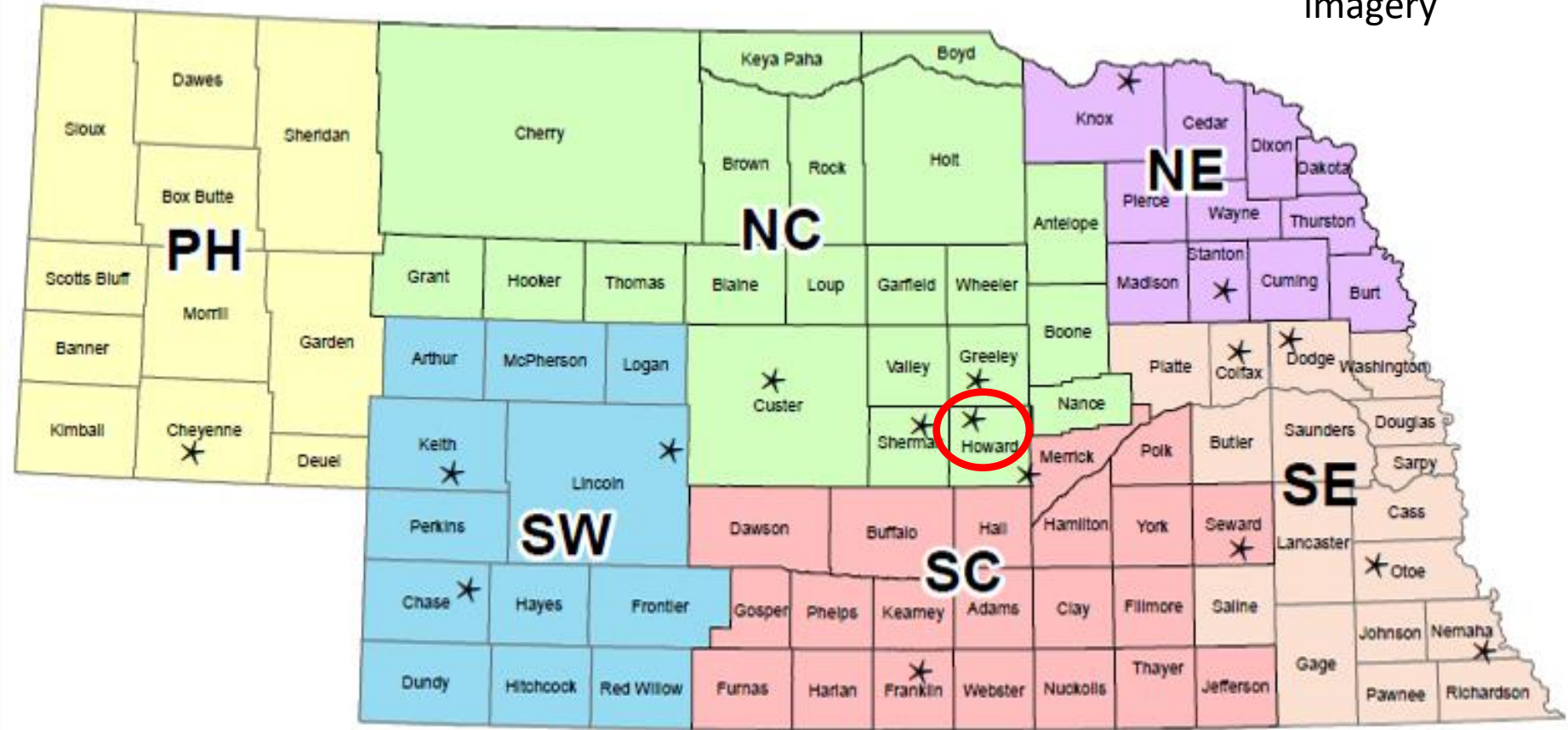
No cover crop
biomass
estimate in
2019



Soil Health Demonstration Fields



2020 in-season
imagery

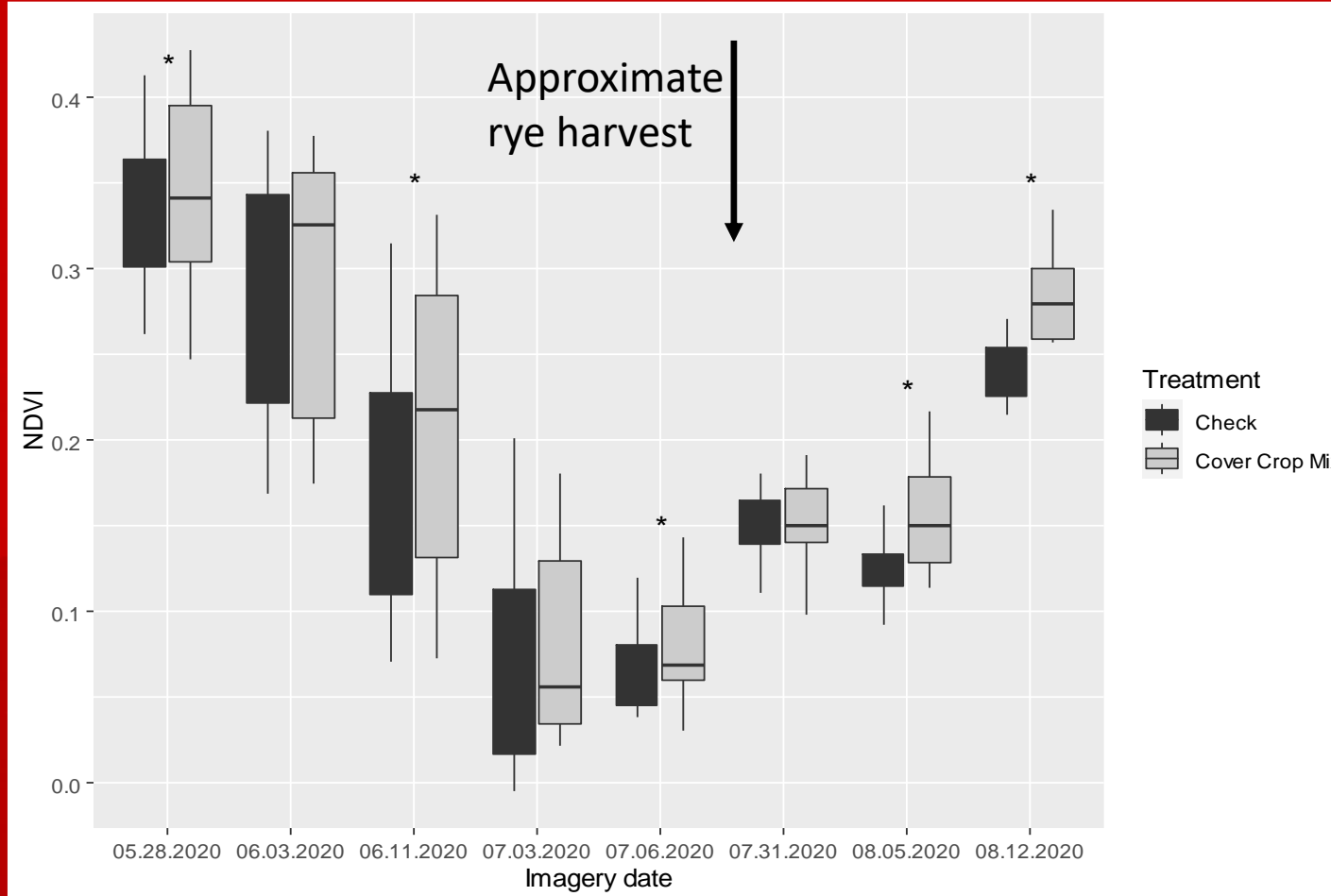


* 17 - Demonstration Fields



- 2020 Cash Crop: Rye
- 2019-2020 Cover Crop: Multi-species mix
- Soil health system evaluated: Cover versus No crop (no-till, irrigated)

Howard County



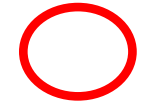
Higher NDVI in rye following cover crops

No difference in rye yield

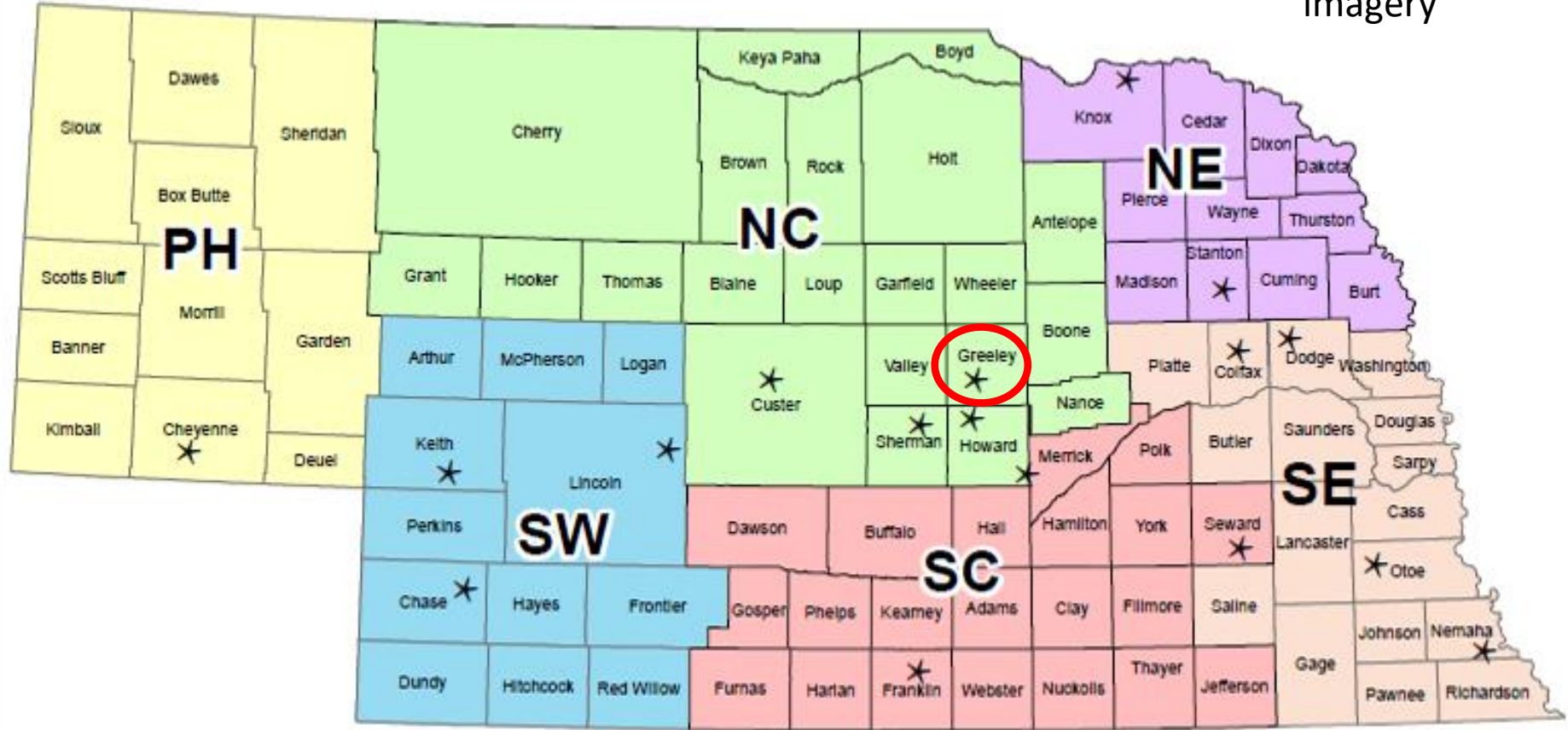
2019 cover crop biomass 2740 lbs/ac



Soil Health Demonstration Fields



2020 in-season
imagery

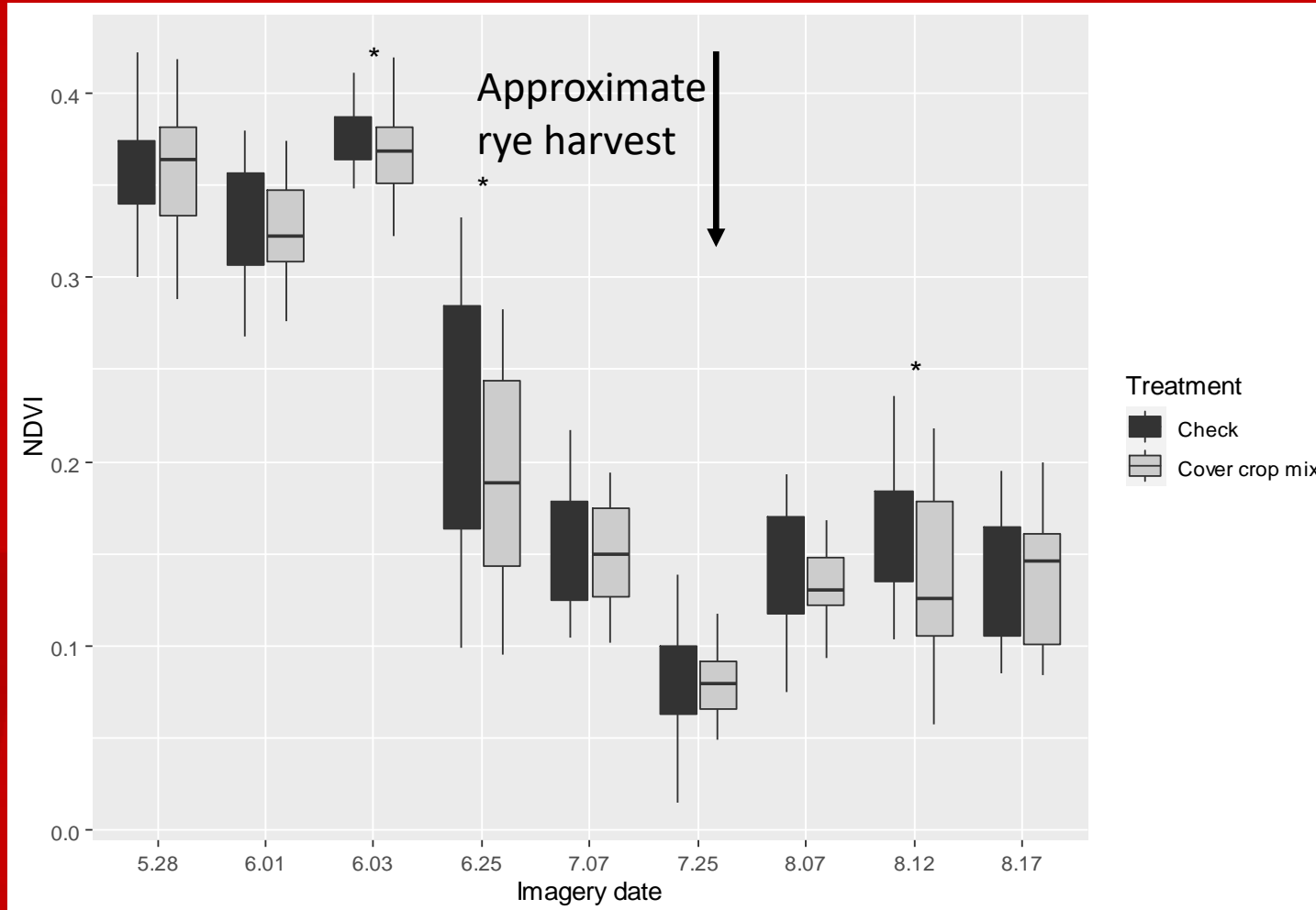


* 17 - Demonstration Fields



- 2020 Cash Crop: Rye
- 2019-2020 Cover crop: Multi-species mix
- Soil health system evaluated: Cover versus No crop (no-till, irrigated)

Greeley County



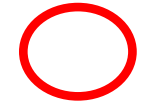
Higher NDVI in rye following no cover crop

No difference in rye yield

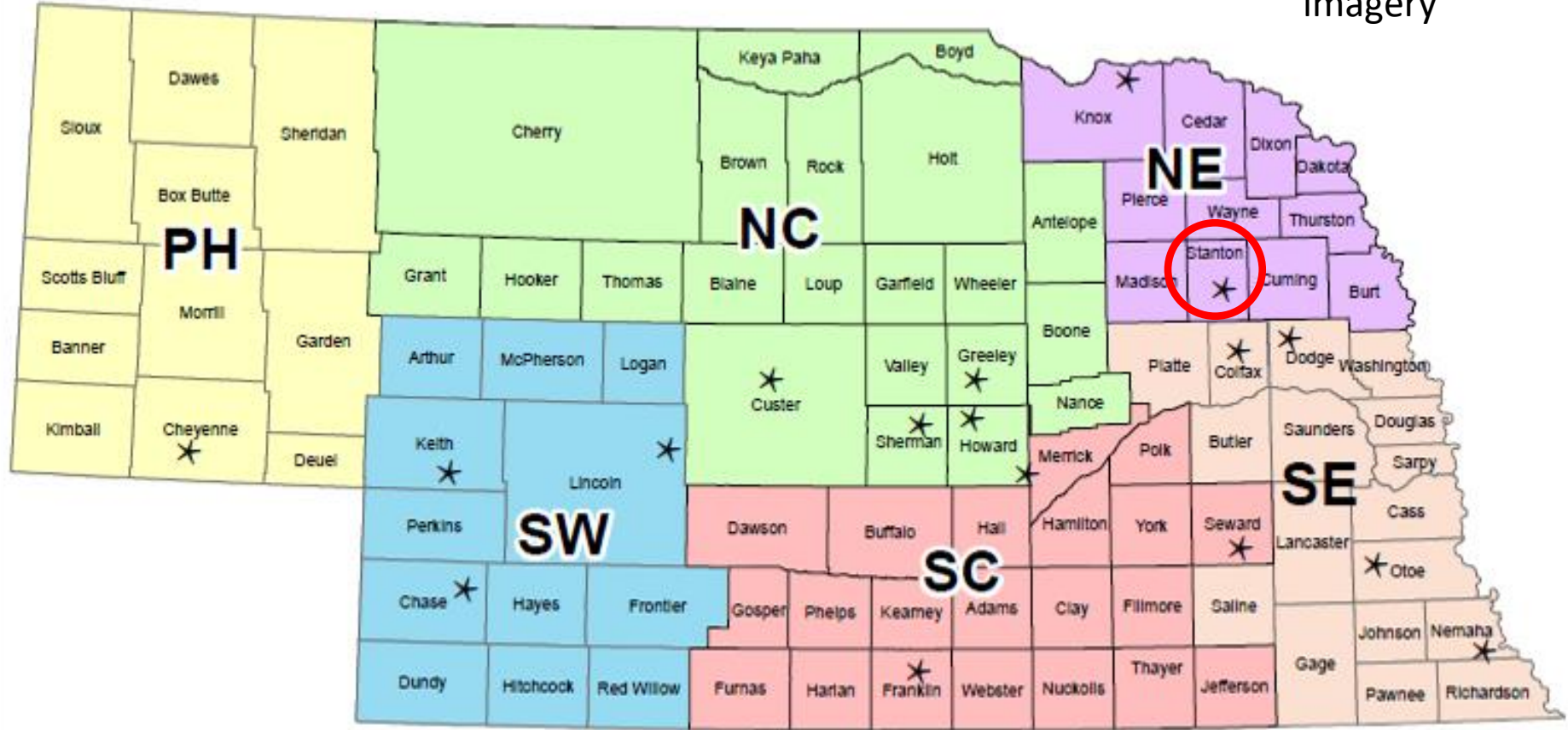
2019 cover crop biomass 141 lbs/ac



Soil Health Demonstration Fields



2020 in-season
imagery

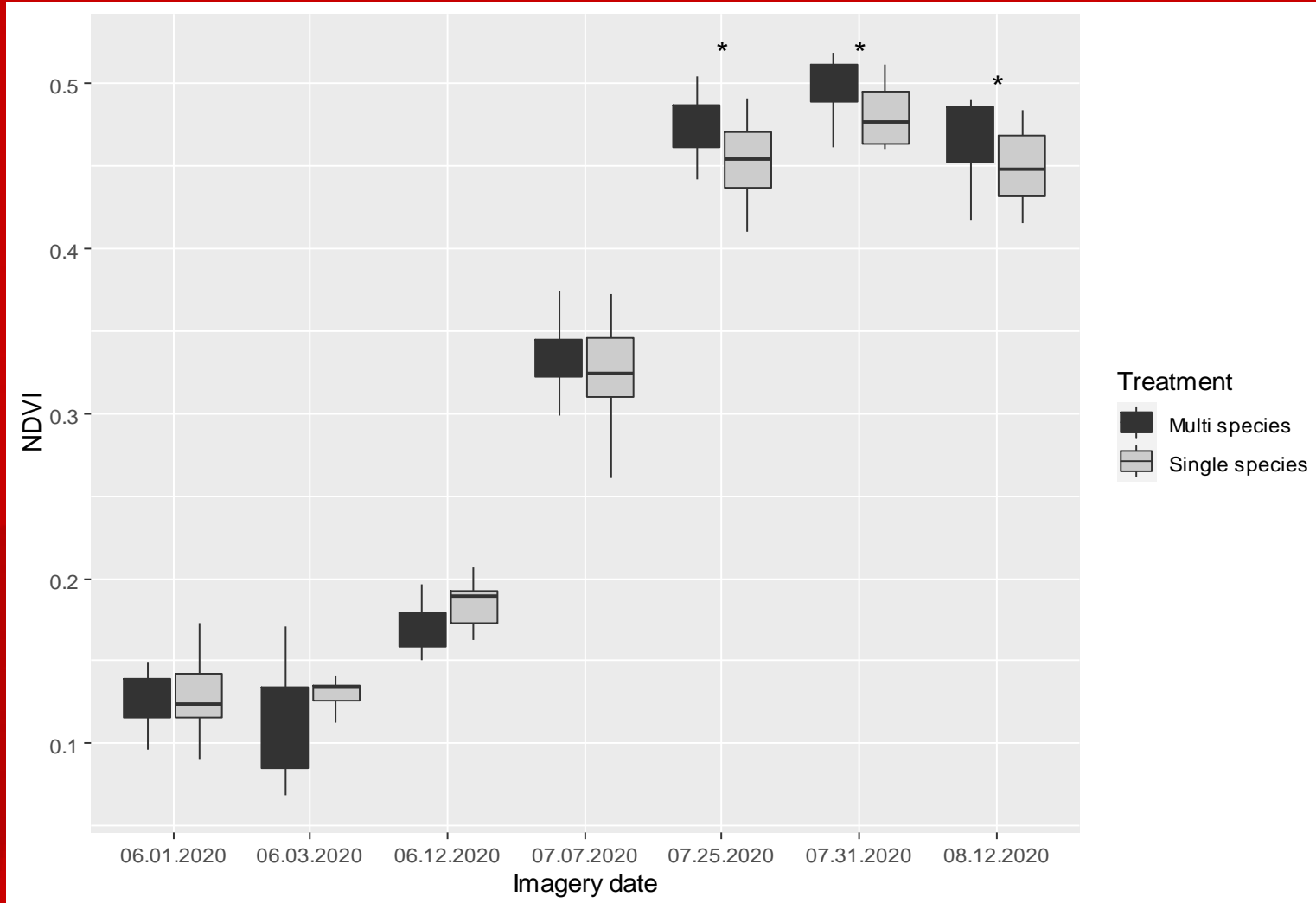


* 17 - Demonstration Fields



- 2020 Cash Crop: Soybean
- Soil health system evaluated: Monoculture (cereal rye) cover crop versus Cover crop mix (no-till, non-irrigated)

Stanton County

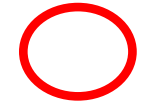


Higher NDVI in soy following cover crop mix (very low biomass)

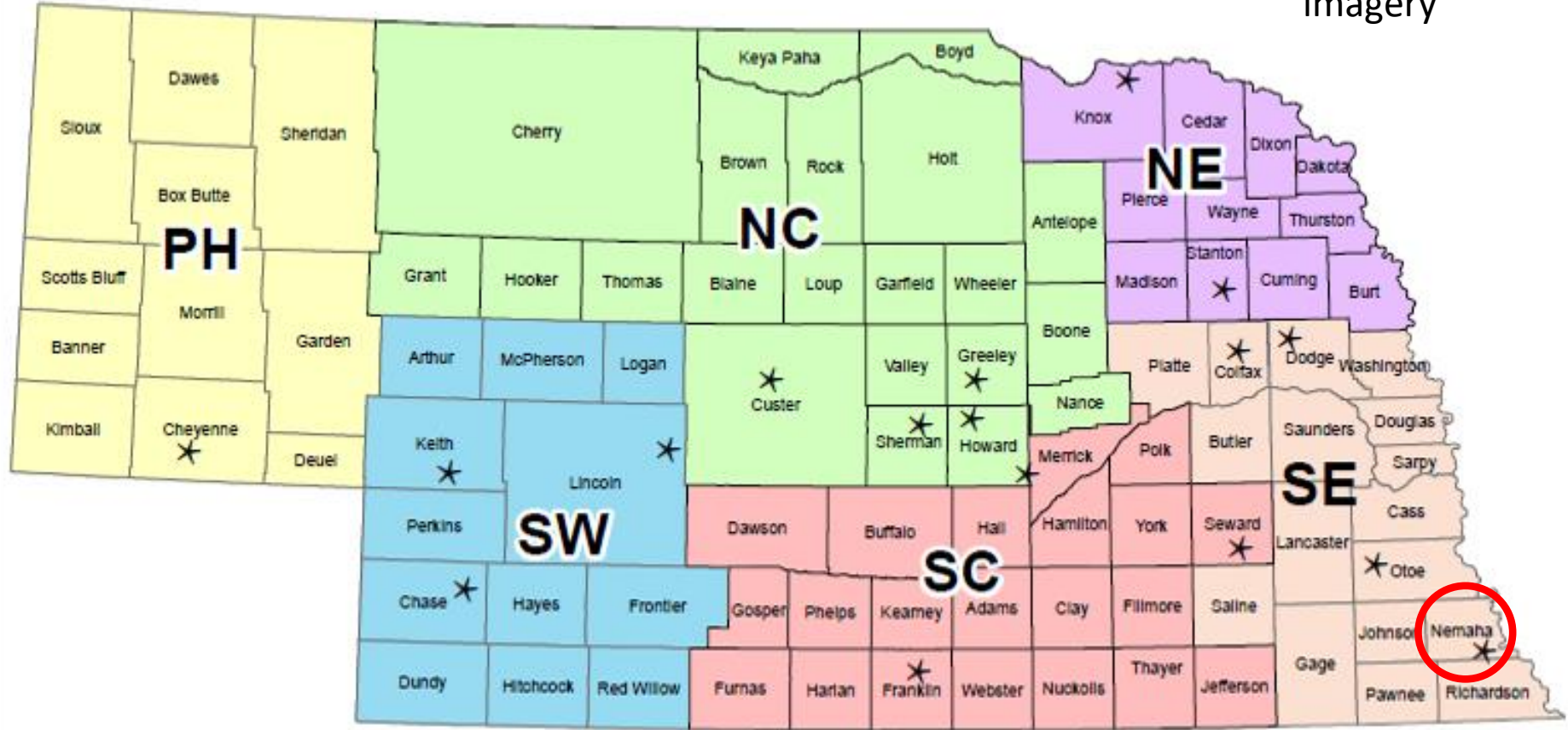
Higher yield (+7 bushel) in cover crop mix



Soil Health Demonstration Fields



2020 in-season
imagery

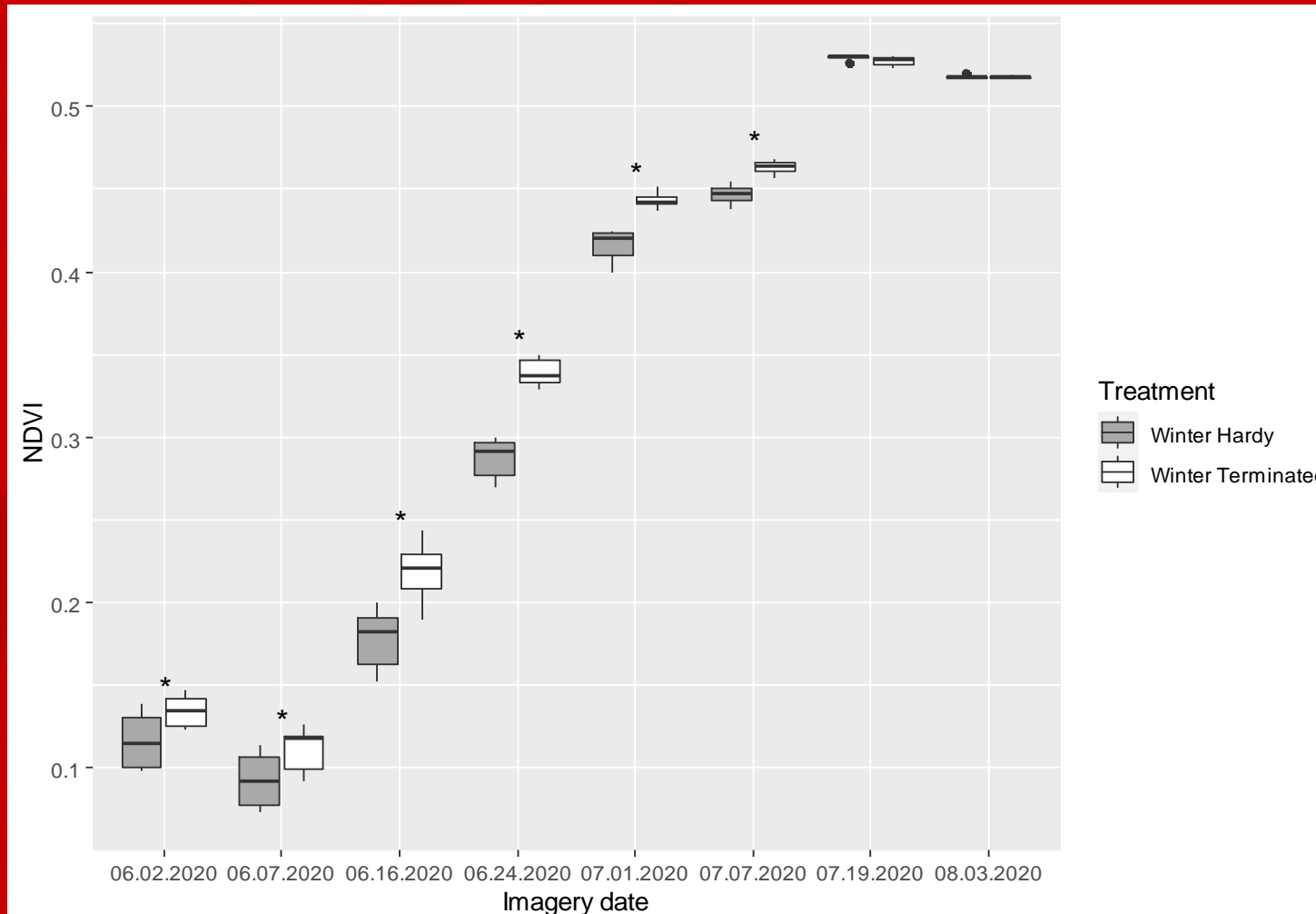


* 17 - Demonstration Fields



- 2020 Cash Crop: Soybean
- Soil health system evaluated: Winter terminated (oats + brassicas) versus Winter hardy cover crop (cereal rye + brassicas) (no-till, non-irrigated)

Nemaha County

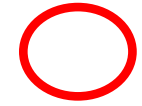


Higher NDVI
in soy
following
winter
terminated
cover crop
(low biomass)

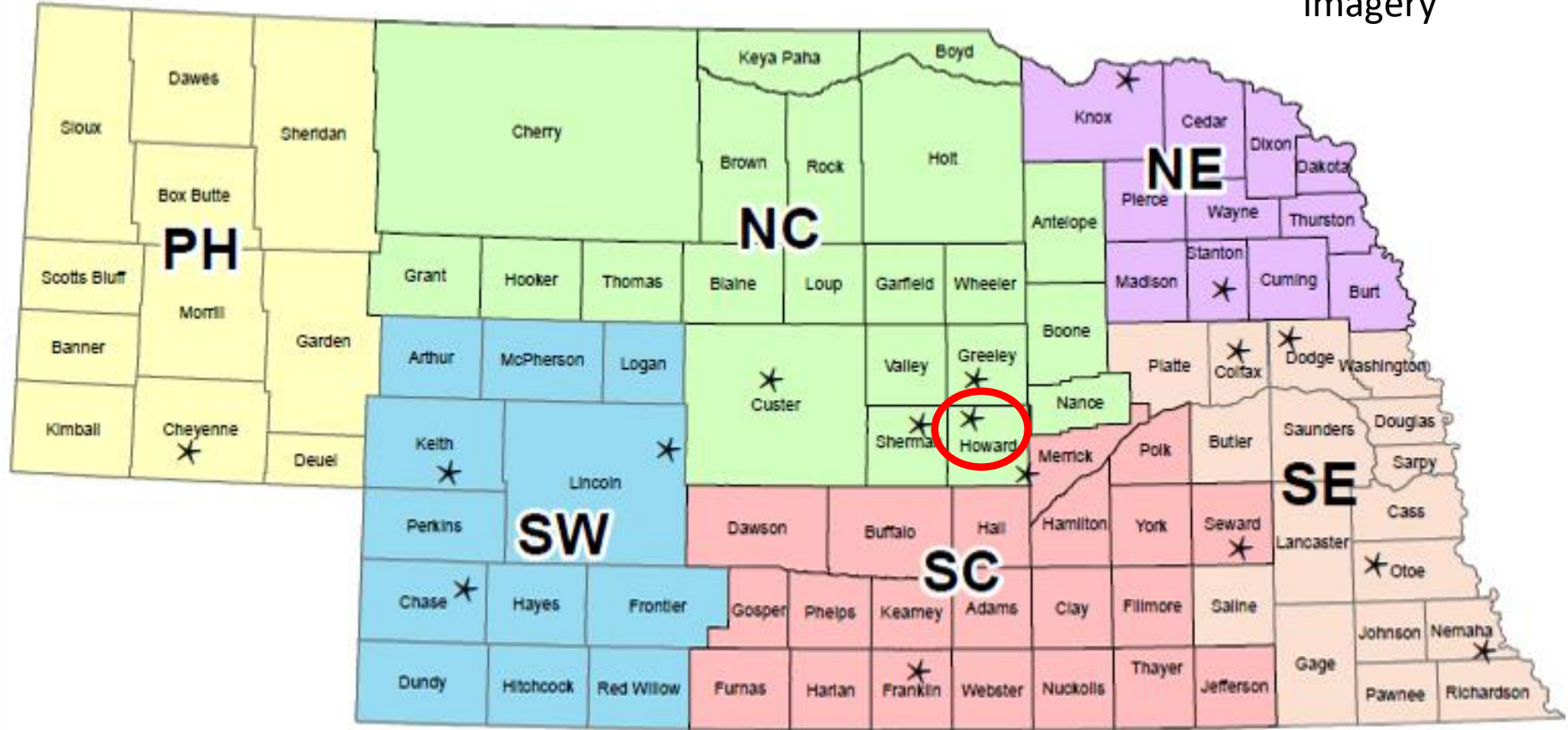
No yield
differences



Soil Health Demonstration Fields



2020 in-season
imagery

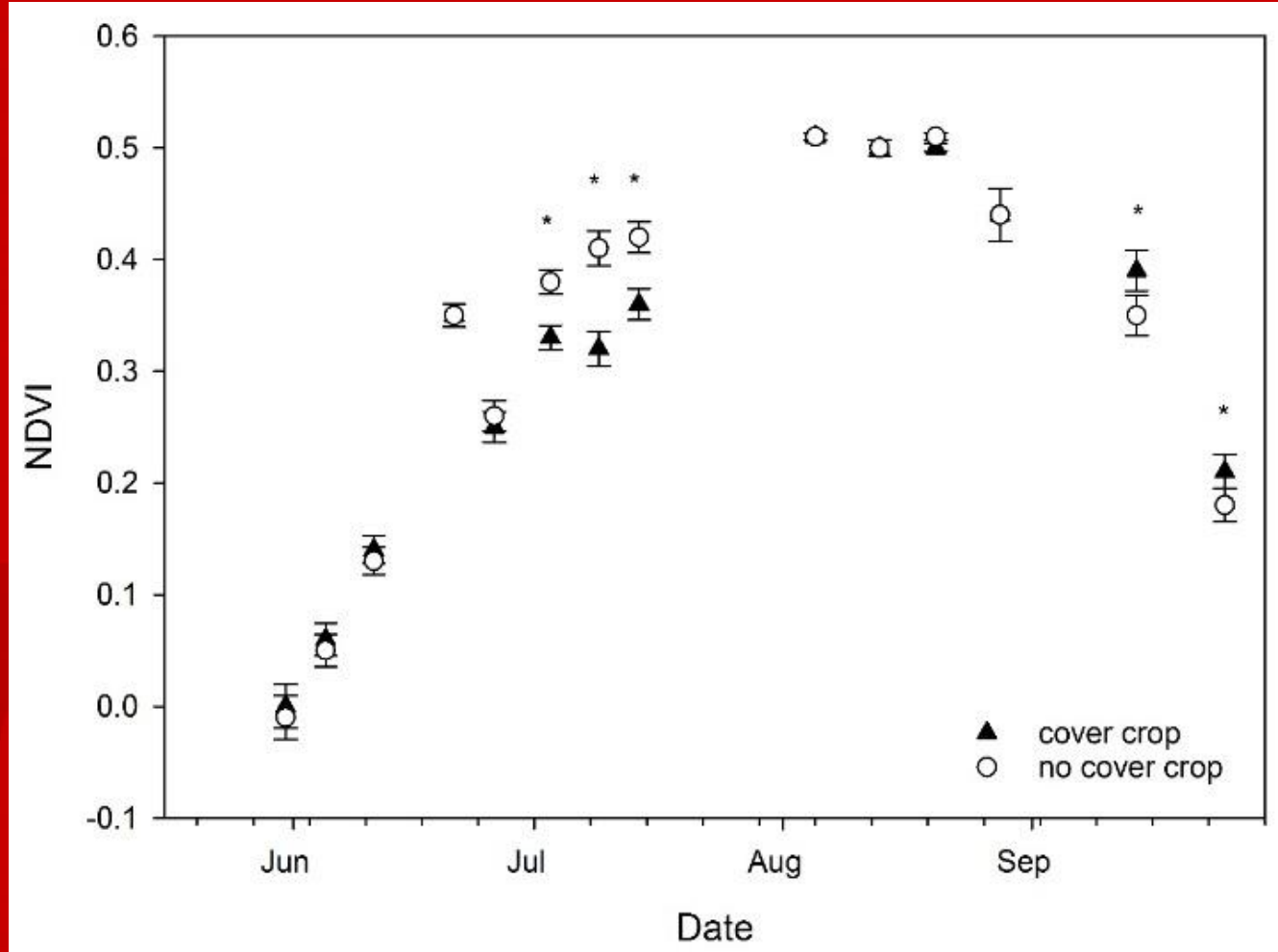


* 17 - Demonstration Fields



- 2019 Cash Crop: Soybean
- 2018-2019 Cover crop: Multi-species mix
- Soil health system evaluated: Cover versus No crop (no-till, irrigated)

Howard County



Higher NDVI in soy following no cover crops

Cover crop biomass was 2740 lbs/ac

No difference in soybean yield

Summary of Results

County	2020 Cash Crop	Cover crop treatment comparison & biomass	NDVI differences	Yield impact	Soil trends
Colfax	Wheat	No cover versus cover crop (no cover crop estimate in 2019)	None	None	None
Greeley	Rye	No cover versus cover crop (141 lbs/ac in 2019)	Higher in rye following no cover (2x in June)	None	Higher soil health score with cover crop
Howard	Rye	No cover versus cover crop (2740 lbs/ac in 2019)	Higher in rye following cover crop (3 dates)	None	Increasing soil health score trend with time, higher score with cover crop
Howard	(2019) Soybean		Higher in soybean following no cover crop (3x in July)	None	
Stanton	Soybean	Cover crop monoculture (85 lbs/acre) versus mixture (14 lbs/ac)	Higher in cover crop mix (3x in July-August)	Higher in mix	Increasing infiltration rate with time
Nemaha	Soybean	Winter terminated (no estimate) versus winter hardy cover crop (796 lbs/ac)	Higher in winter terminated (6x in June-July)	None	Increasing infiltration rate with time

Imagery Summary



- **We are using imagery as a diagnostic tool to better understand how cover crops impact cash crops during the growing season**
 - Yield represents one time point that does tell us about in-season impacts
- **In some crops/fields, we have seen no in-season differences or inconclusive trends**
- **It does appear that greater cover crop biomass could suppress soybean growth/development but generally do not see yield impacts**
 - We are not 100% sure why this might be occurring
- **Even with differences in treatments on these farms, we can see trends of some soil properties and soil health scores increasing**

Imagery Summary



- **Help us think through this! What might be occurring? What have you found with in-season cover crop impacts?**
- **Some of our ideas include:**
 - Cover crop biomass impact on moisture and/or temperature
 - Stand count differences (possibly result of pests)
 - Delayed or accelerated germination/development of the cash crop
 - Weed suppression



Second annual
collaborator meeting,
February 2020

On-Farm Research Network
Laura Thompson, Nathan Mueller and
extension educators across the state

USDA-NRCS
Aaron Hird, State Soil Health Specialist,
and NRCS staff across the state



Department of Agronomy and Horticulture
Andrea Basche, Daren Redfearn, Fernanda Krupek (PhD
student), Elizabeth Oys (MS student), Nilovna Chatterjee
(former postdoc), Dania Ozorio (former visiting scholar)

Using Aerial Imagery to Help Determine the Impact of Cover Crops on Cash Crop Growth and Development

OCTOBER 15, 2020

Fernanda Souza Krupek - Agronomy Graduate Research Assistant | Dania Vieira Branco Ozorio | Andrea Basche - Assistant Professor in Cropping Systems | Daren Redfeam - Extension Forage Crop Residue Specialist | Laura Thompson - Extension Educator

The Nebraska On-Farm Research Network does not endorse the use of the products tested in on-farm research trials. While treatments are replicated within trials and may be repeated across multiple sites under various conditions, your individual results may vary.

Is There an Effect of Cover Crop Mixtures on Subsequent Cash Crop Yield?

The benefits of planting cover crop mixtures include the potential for additional nutrients to the subsequent cash crop, improved livestock feed and improved soil health, among other benefits. Farmers adopting multispecies cover crops are also interested in learning about the yield response of the crop planted following a cover crop. An experiment in Tennessee found that after 3 years using a multispecies cover crop mixture, soybean yield increased by 13% (68 bu/ac) in comparison with low-diverse cover crops and a no-cover treatment (Chu et al., 2017). Other analyses of research from the United States and Canada have found that cover crop mixtures can increase corn yield by 30% more than grass cover crop species alone (Marcello and Miguez 2017). Studies have also found that cover crops can adversely affect crop yields, but the mechanics explaining yield penalties are often uncertain or inconsistent (Eckert, 2013; Kasper et al., 2015). Thus, appropriately constructed mixtures may increase opportunities to gain the soil health benefits and result in positive, neutral, or negative effects on yield. As a result, there is growing interest in using cover crop mixtures and understand their overall contribution to the cropping system. Through education and on-farm assessment, Nebraska landowners part of the [Soil Health Initiative \(SHI\) \(soilhealth.org\)](#) are evaluating the effects of diverse cover crop mixtures on both soil properties and agronomic indicators of soil health.

Remote Sensing as a "Visual Diary" of the Growing Season

Farmers in the Nebraska SHI are exploring tools and features to evaluate crop performance and crop health insights. End-of-season yield, the ultimate metric to evaluate crop performance, does not tell farmers the full story of how the cash crop performed throughout the growing season. Remote sensing techniques can be used to provide farmers a "visual diary" of their season and document how crop and soil responded to weather, pests, or diseases during the growing season as a result of management decisions such as cover crops. Such information can be used as a tool for in-season decisions (for example, water and nutrient application), as well as management plans for the following year.

This report focuses on lessons learned from one of the on-farm demonstration fields established as part of the Nebraska SHI located in Howard County. The 96-acre field is in a corn-soybean-small grain rotation and became part of the initiative in 2017. The study compared the use of a cover crop mixture versus no-cover crop in randomized and replicated field-length strips. The cover crop mixture drilled in September 2018 (the second year of continuous cover crop use) comprised of a 9-species mixture recommendation based on NRCS cover crop guide. On May 10th, 2019 cover crop aboveground biomass was collected before chemical termination on May 14th, 2019. Total biomass for cover crop was 123 ton/ac or 2500 lb/ac. After cover crop termination, soybean was planted on May 16th, 2019 at a 30-inch row spacing. Additional information about the site management can be found in the [2019 SHI on-farm research report \(soilhealth.org\)](#). High-resolution imagery (including natural color, infrared, and thermal) were acquired on a weekly basis during the soybean growing season from "Ter Avior" (<https://www.terradion.com/home/usa/nebraska.com/>; San Leandro, CA).

Deciphering Yield Results Through NDVI and Thermal Imagery

The soybean grain moisture, yield, quality, and net return were not different following the cover crop versus no cover crop (Table 1). To determine how the cover crop mixture impacted soybean crop growth, we analyzed the normalized difference vegetation index (NDVI) from the growing season imagery. The NDVI, a ratio of red to near-infrared light, is a metric derived from plant canopy spectral reflectance that gives a quantitative estimation of vegetation growth and biomass. The index varies between 0 and 1 with very low NDVI values representing areas of bare soil and high NDVI values corresponding to dense vegetation. Thus, NDVI data correlates to plant vigor, and differences in vigor on a field can show the effect of varying management, such as cover crops. For this field, the NDVI data showed lower values for soybean in strips that followed cover crops in July, and higher NDVI values in September (Figure 1).

Table 1. Soybean yield, yield components, oil, moisture, and marginal net return for cover crop mix and no cover crop treatments.

	Pods/plant	Grain/plant	Lipolic (%)	Saturated fat (%)	Protein (%)	Oil (%)	Fiber (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ (\$/ac)
Check	48.5 A	103 A	6.7 A	10.6 A	34.0 A	19.6 A	4.9 A	15.0 A	67.9 A	\$46.67 A
Cover Crop Mix	49.9 A	107 A	6.6 A	11.1 A	35.1 A	19.3 A	4.8 A	16.8 A	69.5 A	\$24.69 A
P-Value	0.897	0.771	0.88	0.397	0.365	0.175	0.178	0.21	0.779	0.605

†Values with the same letter are not significantly different at a 90% confidence level.
 ‡Yield values are from cleaned yield monitor data. Bushels per acre adjusted to 13% moisture.
 †Marginal net return based on \$8.00/bu soybean, \$24/ac cover crop seed, and \$16.40 drilling.

Despite the lack of soybean yield and grain quality differences, how do we explain the vigor differences as shown by NDVI developed throughout the season? By looking at NDVI and other indices patterns developed in the soybean crop development cycle, we can make inferences about crop health and some attributes such as photosynthetic capabilities and canopy nitrogen and water status (Brega et al., 2020; Guo et al., 2017; Mercante et al., 2011). Here, we found that NDVI values were higher in the no cover crop treatment soybean during July, but by the end of the growing season the NDVI values were higher in the soybean following the cover crop treatment.

Our next step was to look at the thermal imagery to try to better understand the potential impact of the cover crop during the soybean growing season. Thermal patterns may develop in a field during the early and middle parts of the season, particularly around the time of heavy precipitations or drought conditions in rainfed systems. Plant vigor may be correlated with thermal patterns. In general, low vigor that corresponds to warmer thermal patterns can mean water stress due to varied reasons such as poor soil quality, drought, inadequate irrigation, to name a few. Thermal imagery can show plant water stress, through the canopy temperature measurements. Water stress induces stomatal closure in plants to prevent transpiration and the loss of water. As a result, drought soil conditions lead to higher canopy temperatures. Also, plants with higher canopy temperatures have more visible wilting symptoms that indicate high correlations between wilting scores and NDVI.



Figure 1. Aerial imagery from July 9 (left) and September 25 (right) displayed as true color (top) and normalized difference vegetation index (NDVI) (bottom). Strips with cover crop and no cover crop are indicated. Far-right inset images are pictures taken on September 26 in cover crop and no cover crop treatments.

Continued Effort to Detect Cover Cropping Effects on Cash Crop Growth and Development

In order to better understand the differences observed in the 2019 aerial imagery and how cover crop management impacts water availability and cash crop yield and quality, ground-based measurements will be obtained for the remainder of the project. The goal is to better understand the spatial-temporal variability of soil and crop performance as affected by cover crop use. Combining aerial imagery with ground-based measurements may provide opportunities to better manage cover crops to maximize soil health benefits while protecting cash crop yields.

Acknowledgment

Authors would like to thank the Natural Resources Conservation Service (USDA-NRCS) and Robert B. Daugherty Water for Food Global Institute (DWFI) for funding support.

References

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Tags: Soil Health Initiative | Soil Health | Cover Crops | On-Farm Research | Nebraska On-Farm Research Network



<https://cropwatch.unl.edu/2020/using-aerial-imagery-help-determine-impact-cover-crops-cash-crop-growth-and-development>



SOIL HEALTH INITIATIVE

DEMONSTRATING SOIL HEALTH MANAGEMENT ACROSS NEBRASKA

The University of Nebraska, the Natural Resources Conservation Service, and Nebraska farmers and ranchers are participating in a state-wide effort to enhance the adoption of soil health and rangeland health management systems through the Soil Health Demonstration Farms and Ranch Initiatives. These initiatives will establish in-field management comparisons across the state to showcase grazing management and cropping system comparisons.

[READ MORE \(SOILHEALTH/ABOUT\)](#)

[Explore videos from the annual on-farm research results meeting, February 2020 \(cover-crop-seminars\)](#)

Related Articles





Fall Cover Crops

Aaron Hird, NRCS State Soil Health Specialist, provides information on planting winter hardy cover crops this fall and the types you might want to consider.

EMAIL US



<https://marketjournal.unl.edu/september272019>



Soil Health and Management

UNL Assistant Professor Dr. Andrea Basche walks us through some of the different soil management practices used during a recent Extension event. See how these different practices could help you achieve your soil health goals.

<https://marketjournal.unl.edu/january102020>



Aerial Imagery

Andrea Basche, UNL Assistant Professor, and Fernanda Souza Krupek, Agronomy Graduate Research Assistant, talk about a soil health study that uses aerial imagery to measure crop yields.



<https://marketjournal.unl.edu/december042020>

Soil Health Initiative On-Farm Research Reports

2019 Reports

- [Colfax \(Soil-Health/Colfax-2019.pdf\)](#)
- [Franklin \(Soil-Health/Franklin-2019.pdf\)](#)
- [Greeley \(Soil-Health/Greeley-2019.pdf\)](#)
- [Hall \(Soil-Health/Hall-2019.pdf\)](#)
- [Howard \(Soil-Health/Howard-2019.pdf\)](#)
- [Nemaha - Corn \(Soil-Health/Nemaha-Corn-2019.pdf\)](#)
- [Nemaha - Soybean \(Soil-Health/Nemaha-Soybean-2019.pdf\)](#)
- [Stanton \(Soil-Health/Stanton-2019.pdf\)](#)

2018 Reports

- [Franklin \(Soil-Health/Franklin_2018.pdf\)](#)
- [Knox \(Soil-Health/Knox_2018.pdf\)](#)
- [Merrick \(Soil-Health/Merrick_2018.pdf\)](#)
- [Nemaha - Corn \(Soil-Health/Nemaha_Corn_2018.pdf\)](#)
- [Nemaha - Soybean \(Soil-Health/Nemaha_Soybean_2018.pdf\)](#)
- [Otoe \(Soil-Health/Otoe_2018.pdf\)](#)
- [Stanton \(Soil-Health/Stanton_2018.pdf\)](#)

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[On Farm Research Background Form \(/soilhealth/backgroundform\)](#)

[Project Guidelines \(/soilhealth/projectguidelines\)](#)



Thank you!
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“The nation that destroys its soil, destroys itself.” – Franklin Delano Roosevelt



Photo: Dorothea Lange; The Library of Congress, Prints & Photographs Division