Satellite Data and Agronomic Decisions

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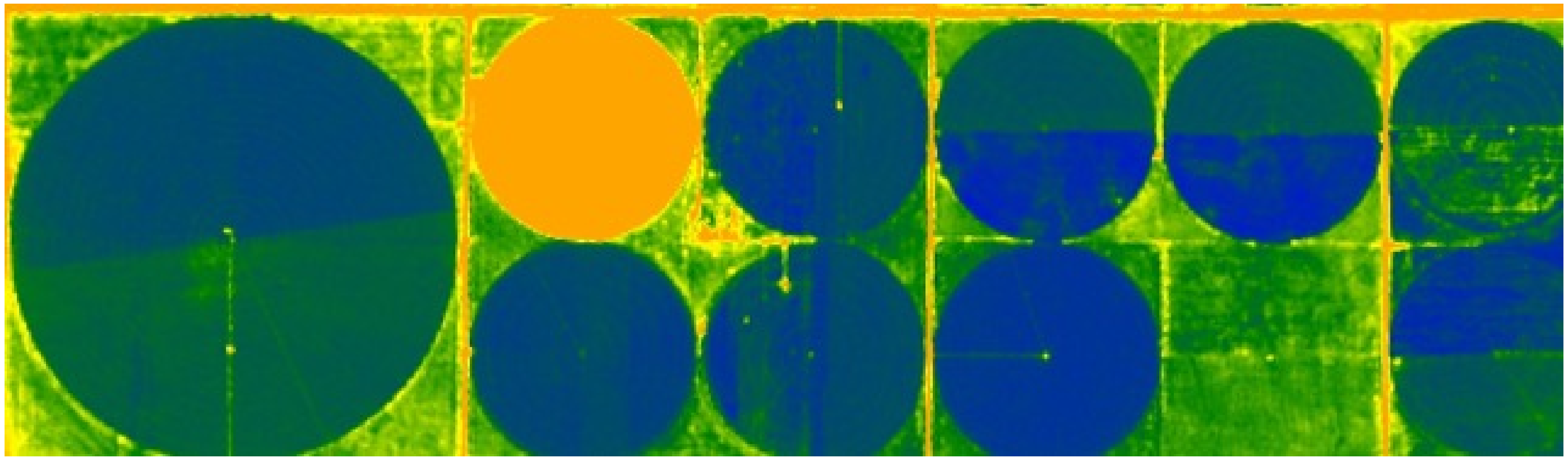
Sebastian Varela, University of Illinois (former Kansas State University)



KSU CROPS
Crop Production Team

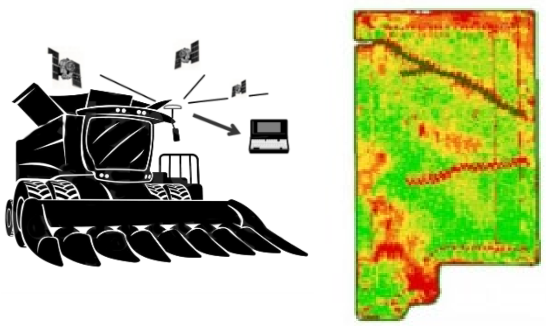
KANSAS STATE UNIVERSITY

Outline

1. Value of Satellite Imagery
2. Satellite Imagery
3. Applications In Agriculture (In-Season Management)
4. Case Study, example
5. Summary

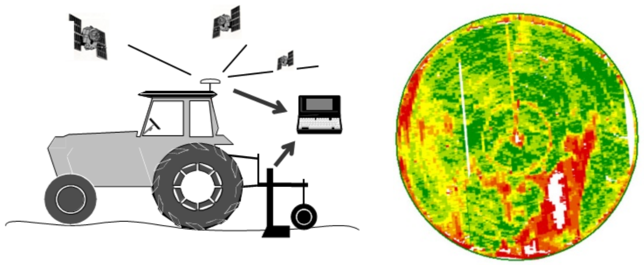
How much information can I collect on my farm?

Yield maps



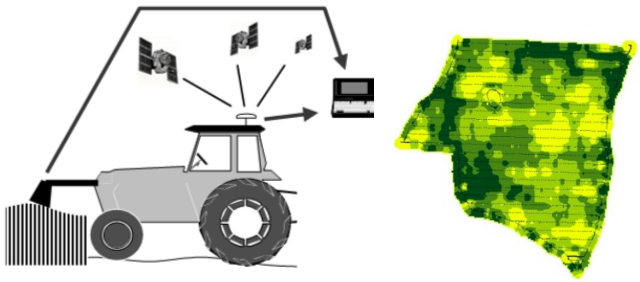
~ 650 Kb

Soil sensors (e.g Veris)



~ 600 Kb

Proximal sensors (e.g N-sensor)

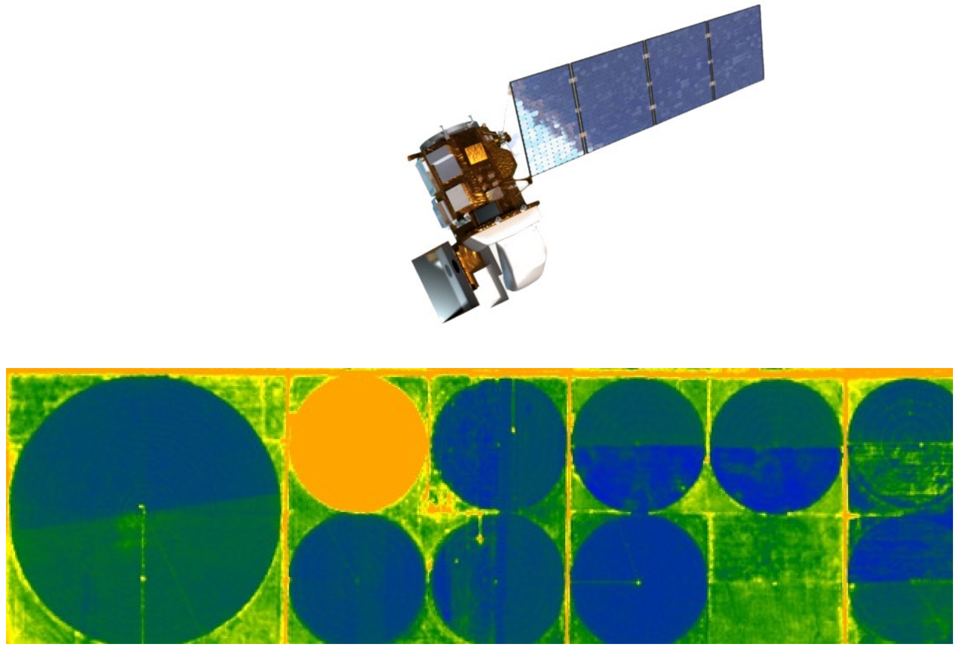


~ 600 Kb

Drones with multispec. cameras

~ some Mb to Gb

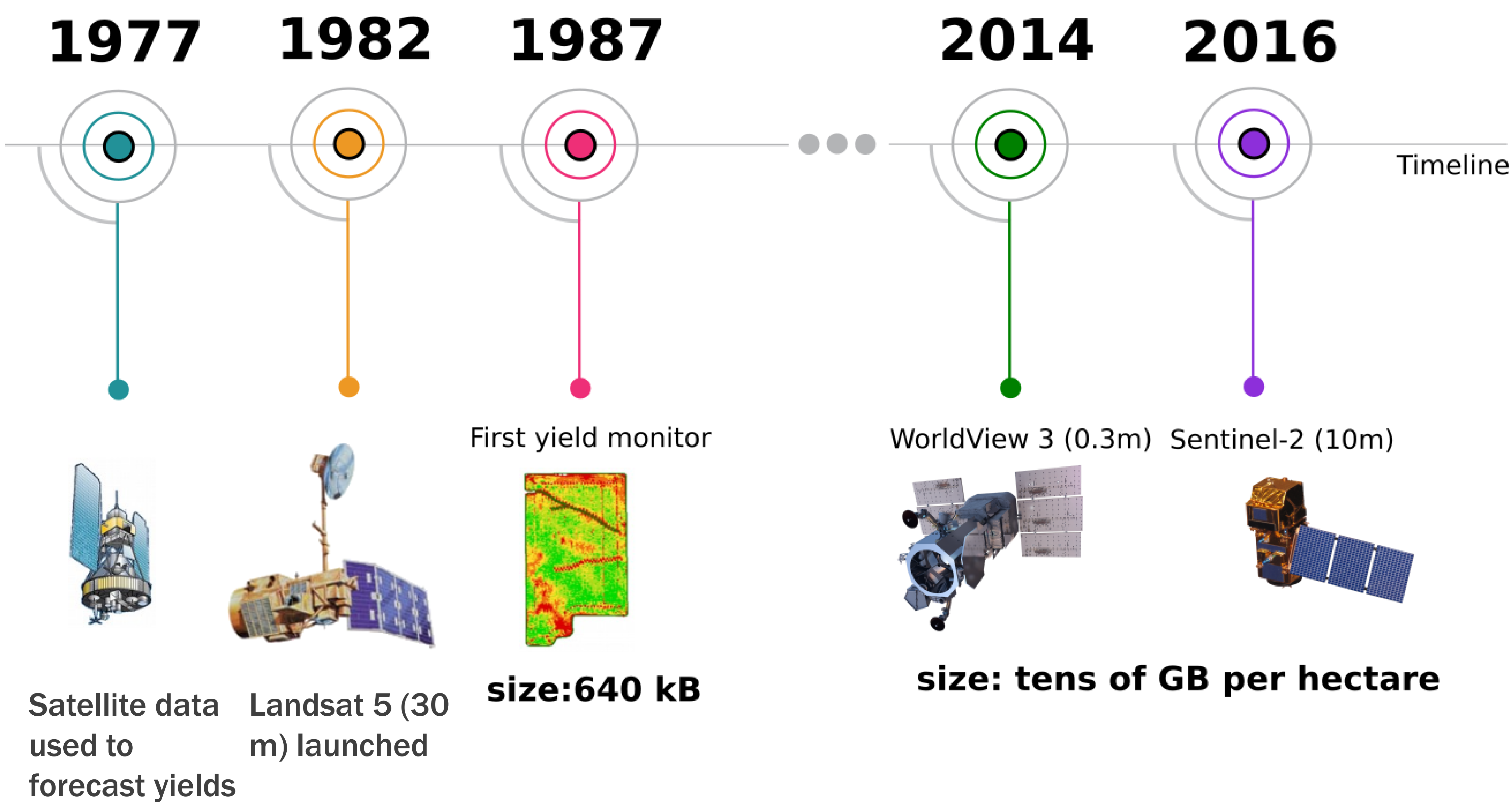
Satellites



~ some Mb

Remote Sensing (e.g. satellite)

- Integration of digital Ag layers and development of tools.



Value of Satellite Imagery

InnovationSeries VISIONConference Learning Center

PRECISIONAg® GLOBAL HUB FOR AG TECH INNOVATION

Professionals Systems Management Hort Tech Ag Tech Global Learning Ev

Field Monitoring & Sensors: Download The Special Report

Back On The Map: Satellite Imagery Emerges As A Valuable Tool

"Remote sensing utilizing drones is very labor intensive at the moment, and that's not likely to change in the near future"

For many years satellite imagery was a solution in search of a viable precision agriculture system in which it could deliver value. In-season, on-demand imagery was often hampered by cloud cover and a dearth of available satellites for taking images. Until recently, as a stand-alone tool it hadn't carved itself a stable and consistent place in the crop production regimen.

Over the past decade, the number of satellites has increased significantly, improving the quality and frequency of the images available to agriculture. Planet Labs, which purchased BlackBridge and its RapidEye satellite constellation, is supplying Wilbur-Ellis and Crop Production Services with imagery to support their precision programs.

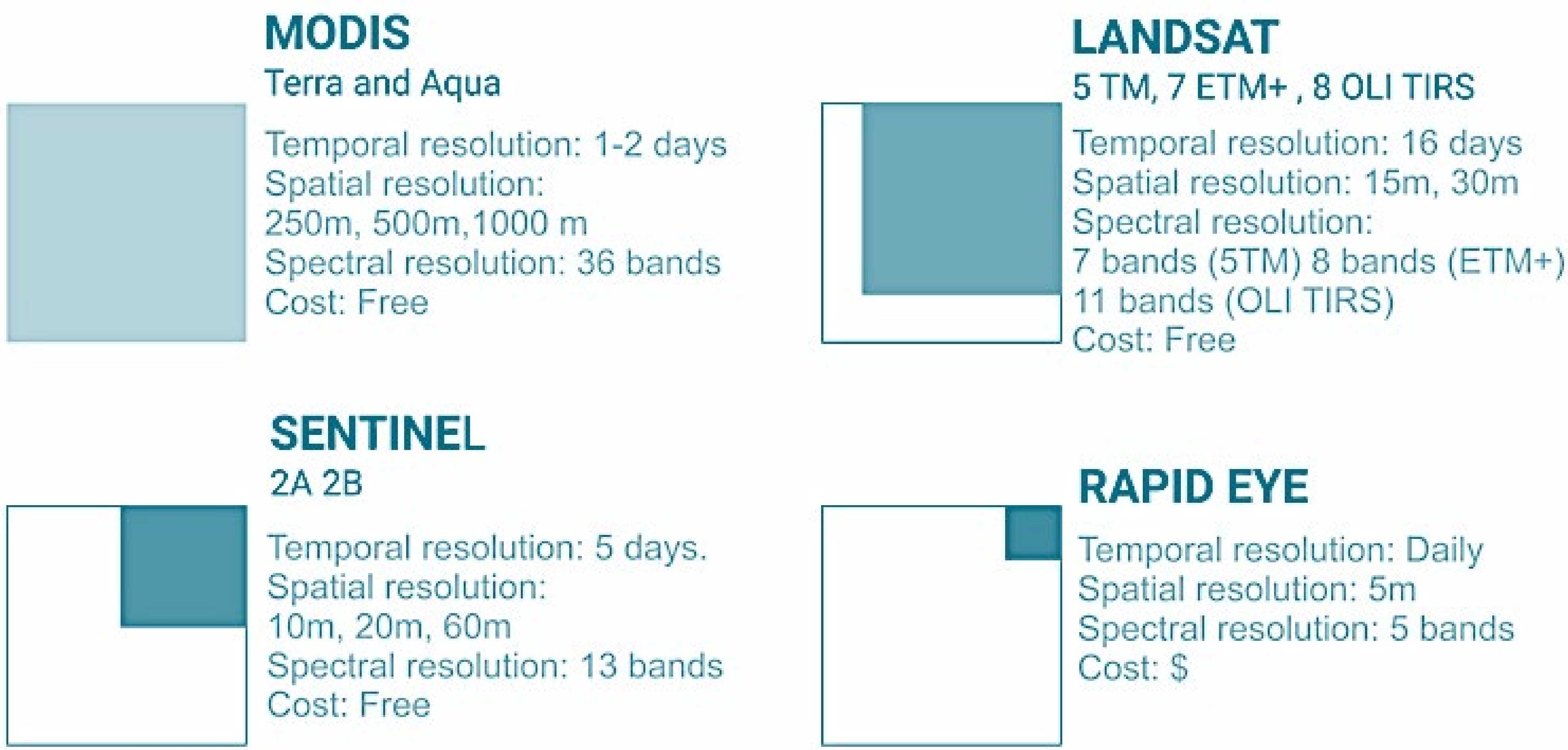
Planet also delivers satellite imagery to agronomy/technology consulting firm Farmers Edge. Ron Osborne, Vice President of Innovation, says that while they're doing some work with UAV imagery — specifically with Canadian drones-as-a-service

Satellite Imagery "101"

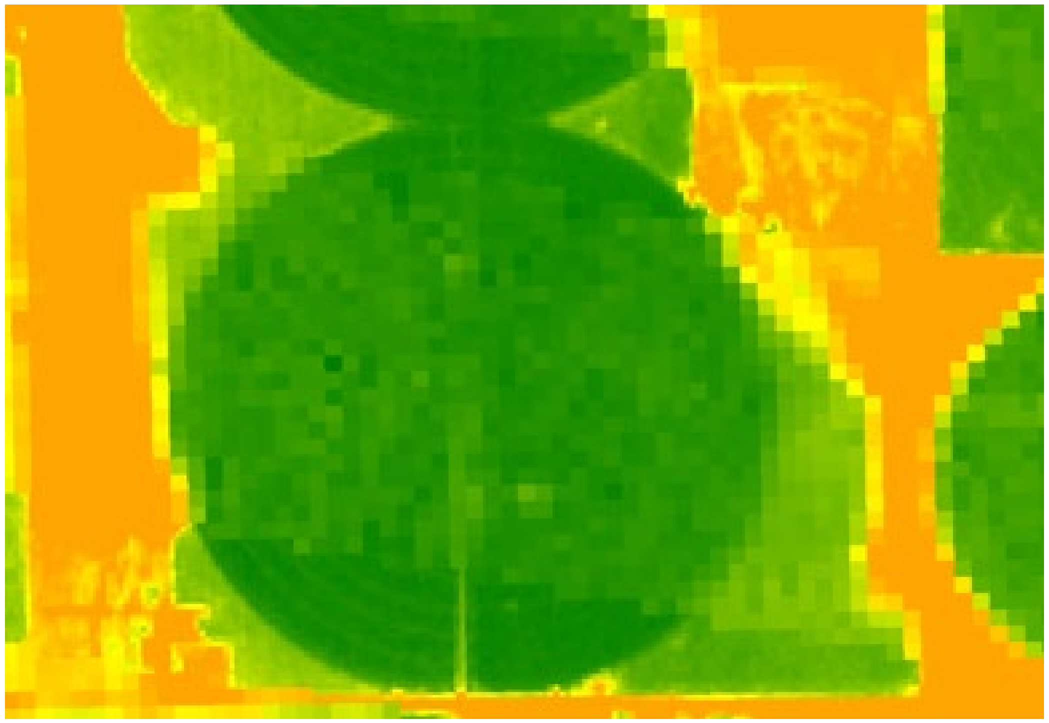
Temporal Resolution indicates the frequency (time interval) for obtaining imagery from the same point.

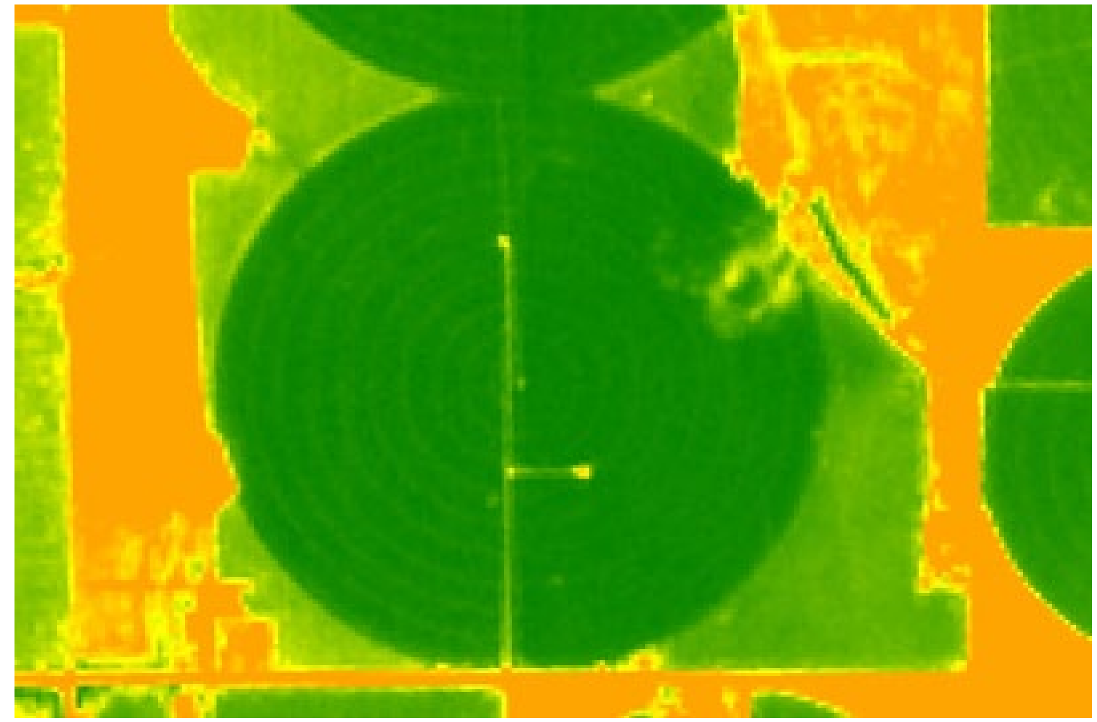
Spatial Resolution refers to the level of detail visible in an image: the smaller the area by each pixel, the greater the details that can be captured.

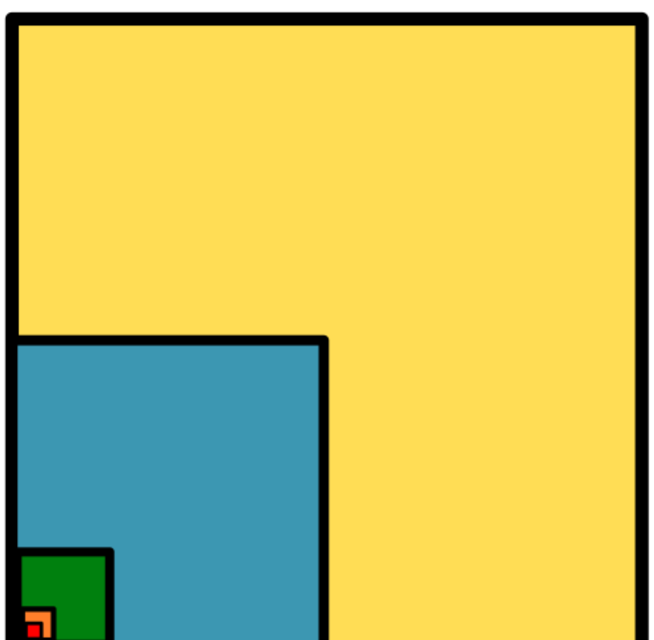
Spectral Resolution denotes to the number and width of the spectral bands in a sensor. The narrower these bands, the higher the spectral resolution.



Satellite Imagery “101”

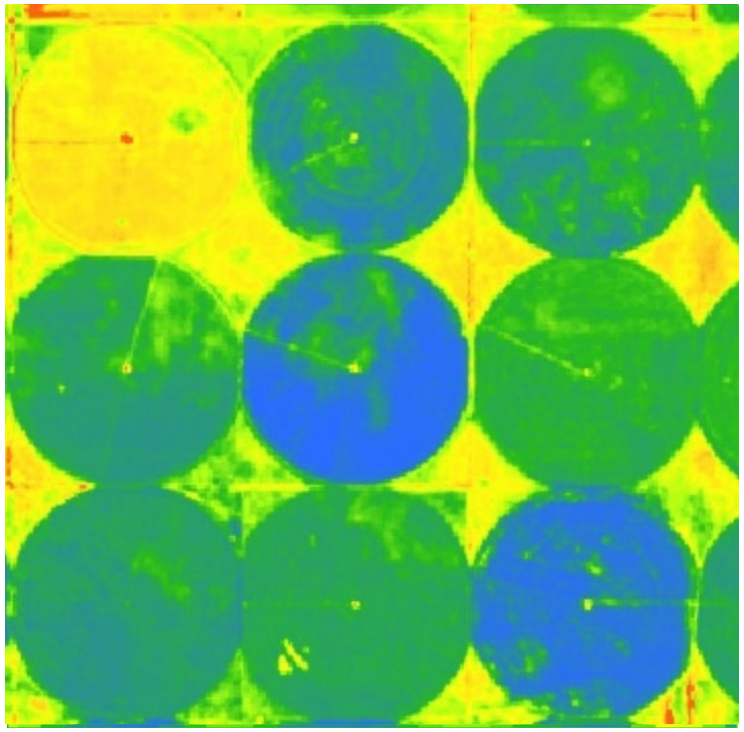






Satellite	pixel size (m)	area (acre)	revisit time
MODIS	250	15.4	daily
Proba-V	100	2.4	daily
Landasat	30	0.22	16-days
Sentinel	10	0.03	5 to 10-days
RapidEye	5	0.001	5.5 days

Different options for different scales



MODIS – 250m - 1 day

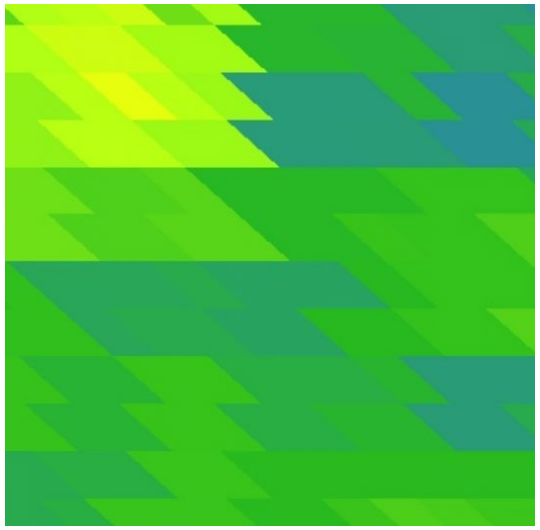
Proba-V – 100m - 1 day

Landsat 8 – 30m 16 day

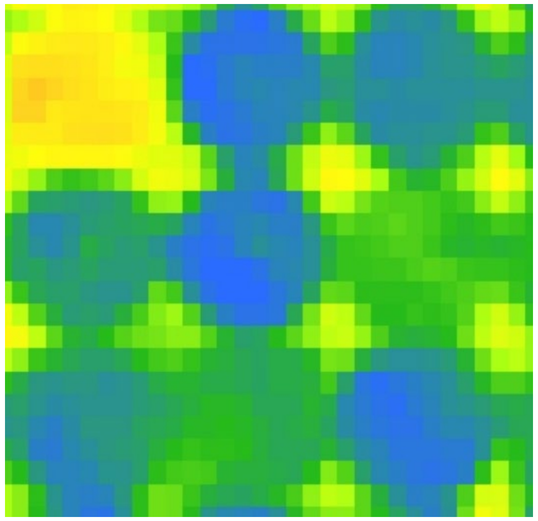
Sentinel 2 – 10m - 5 day

FREE OPTIONS

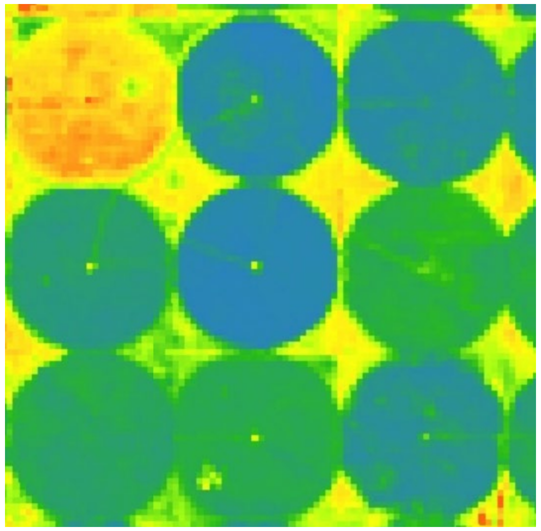
MODIS – 250m



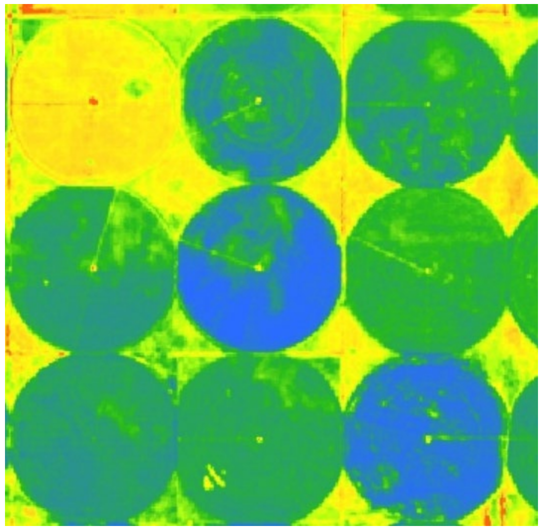
Proba-V – 100m



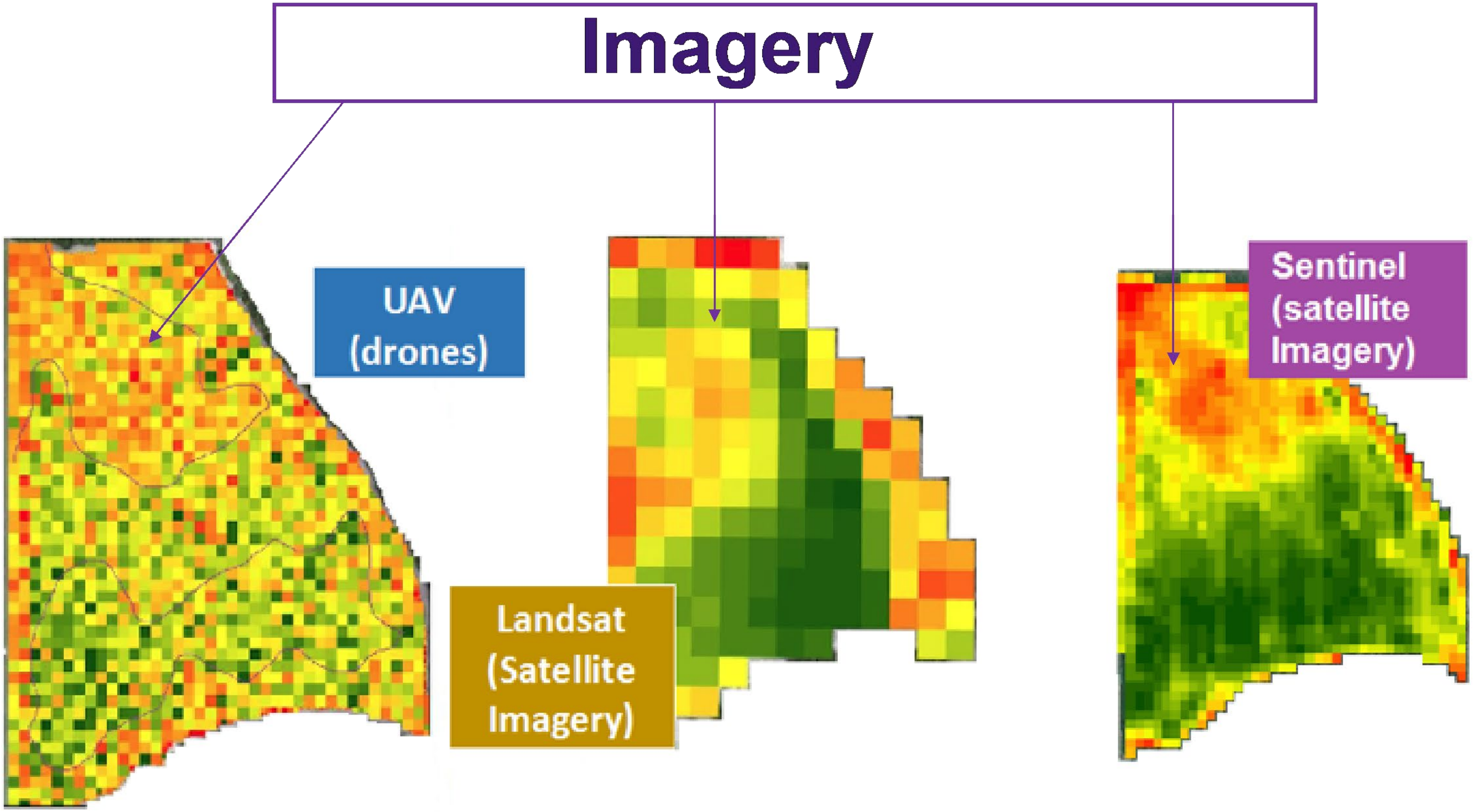
Landsat 8 – 30m



Sentinel 2 – 10m



Satellite Imagery “101”



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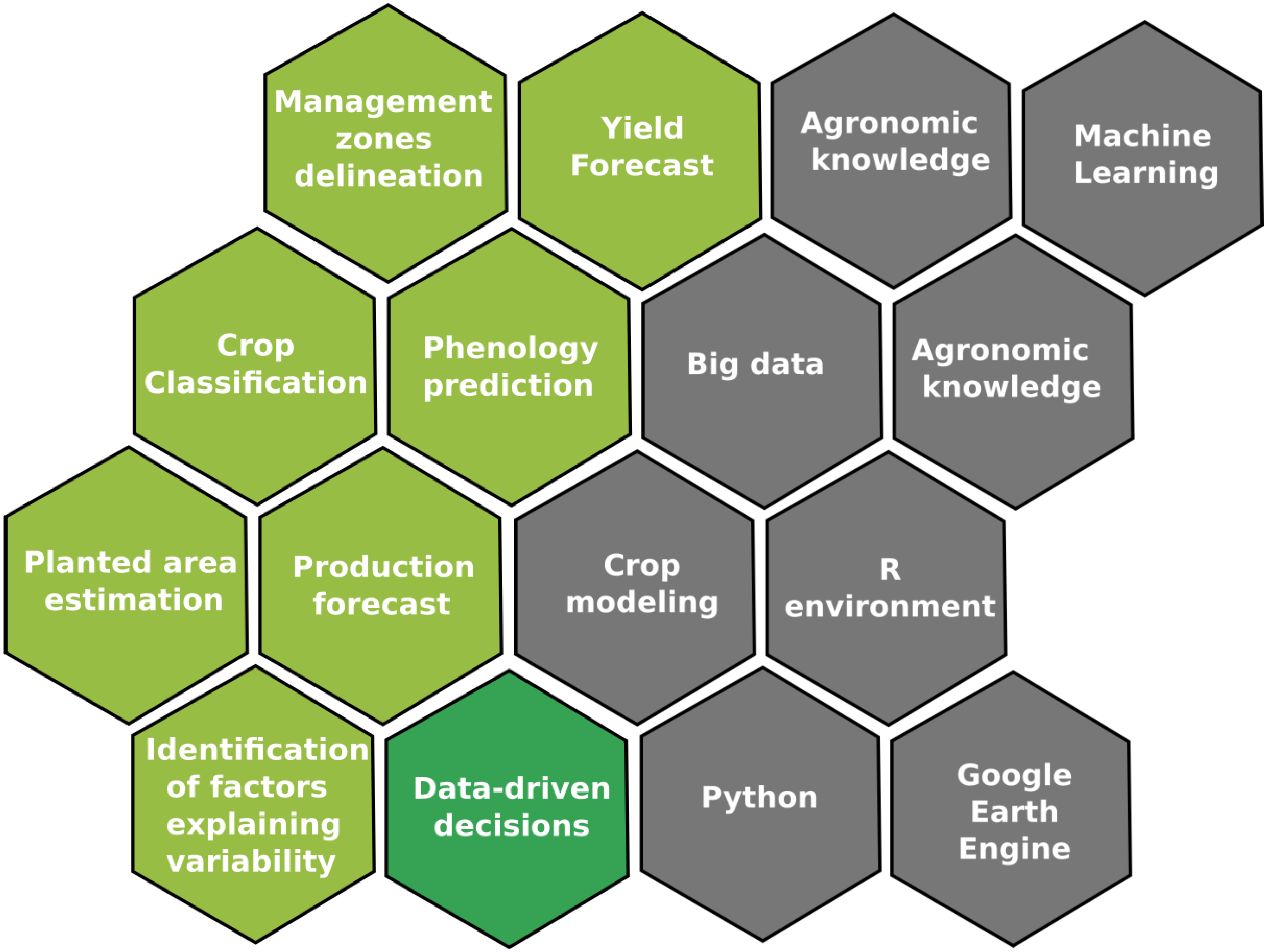
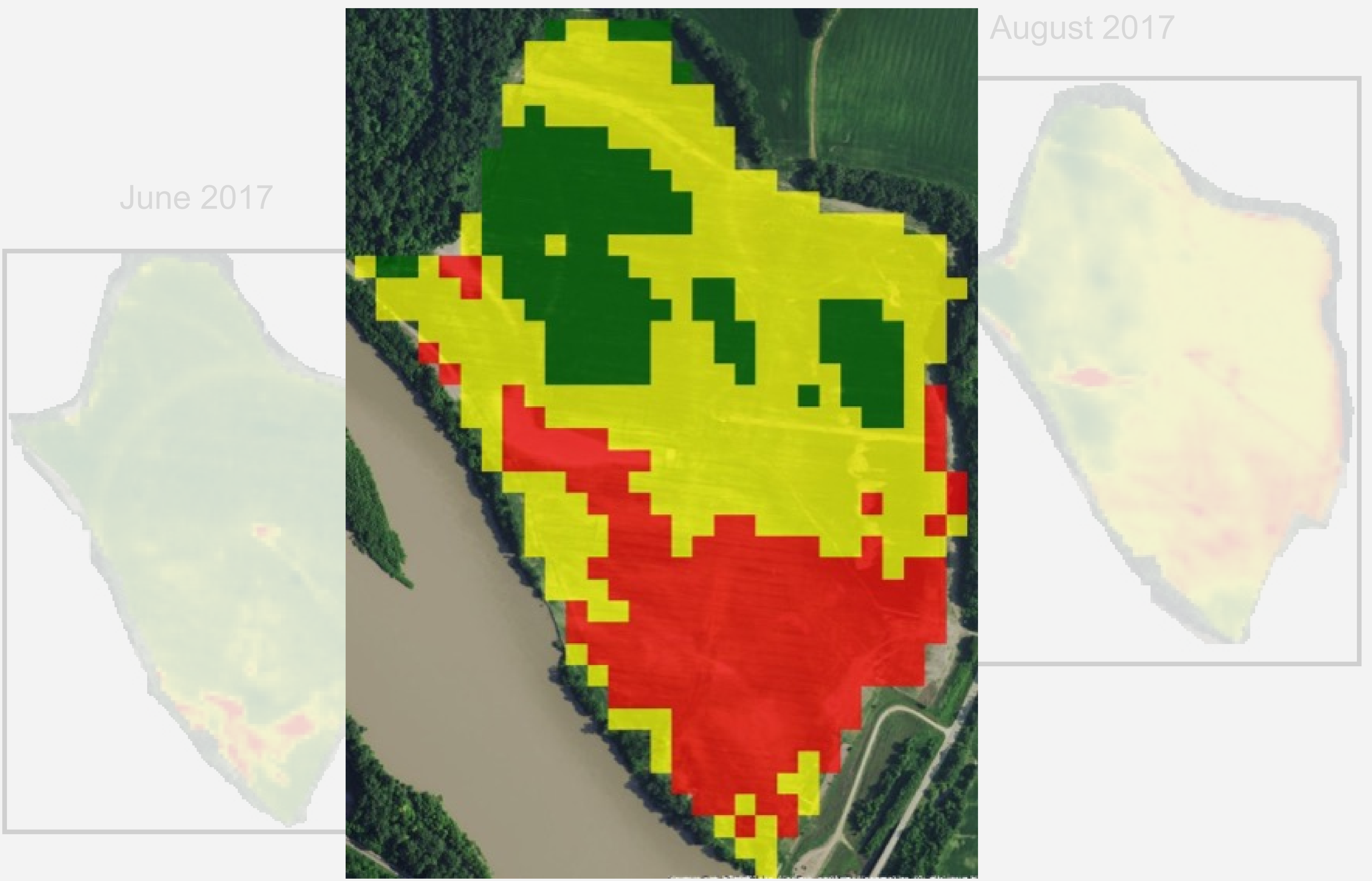
Applications for satellite imagery



Applications of Satellite Imagery

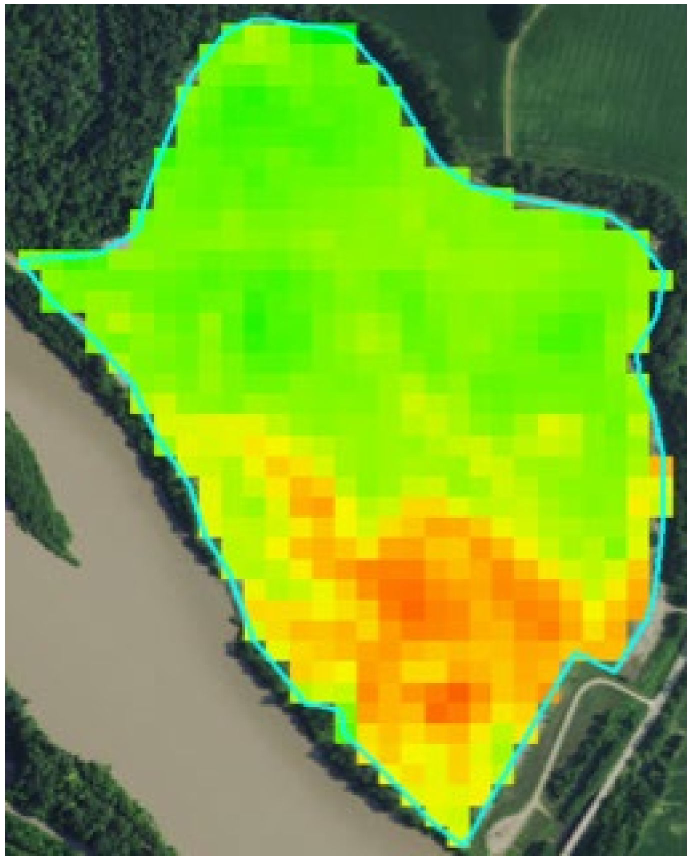
- Seasonal (within a season) and temporal (across seasons) monitoring of crop vegetation (evaluating stress factors such as drought, heat, nutrient deficiency, etc.).
- Crop scouting, sampling and field trips according to the field dimensions and the potential targets.
- Forecasting yields at varying scales: county, regional, & state.
- Site-Specific Management (SSM) using prescription maps to variable seeding rate/fertilization, depending on differences in environments.
- Environmental impact assessment, fires, floods, to tracking potential changes in land use, and the status of the fields.

Seasonal crop vegetation status, same crop same year

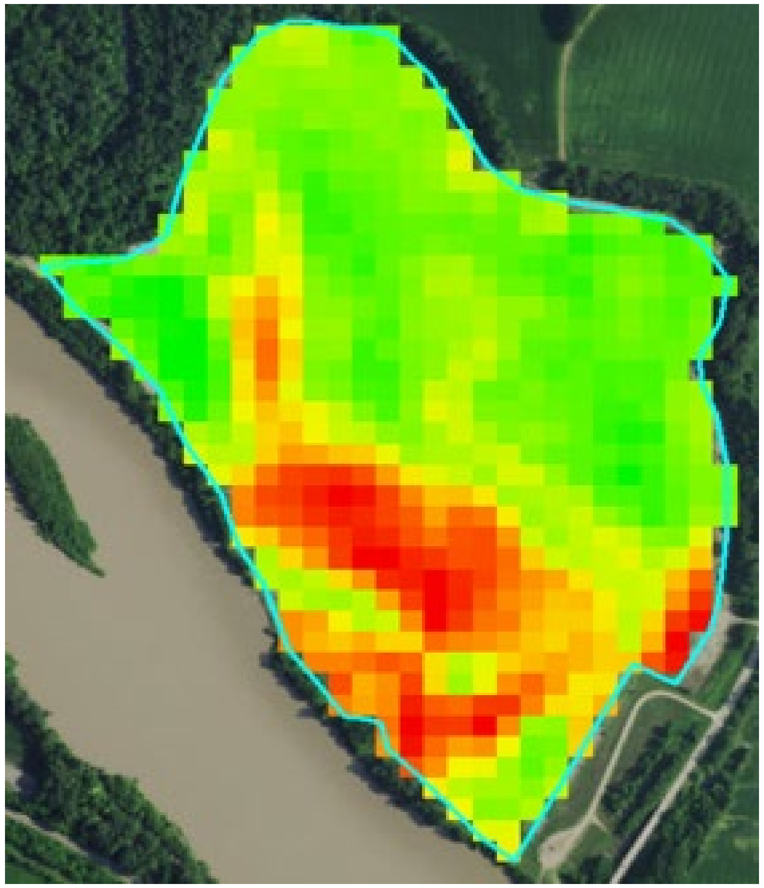


Same field, different years

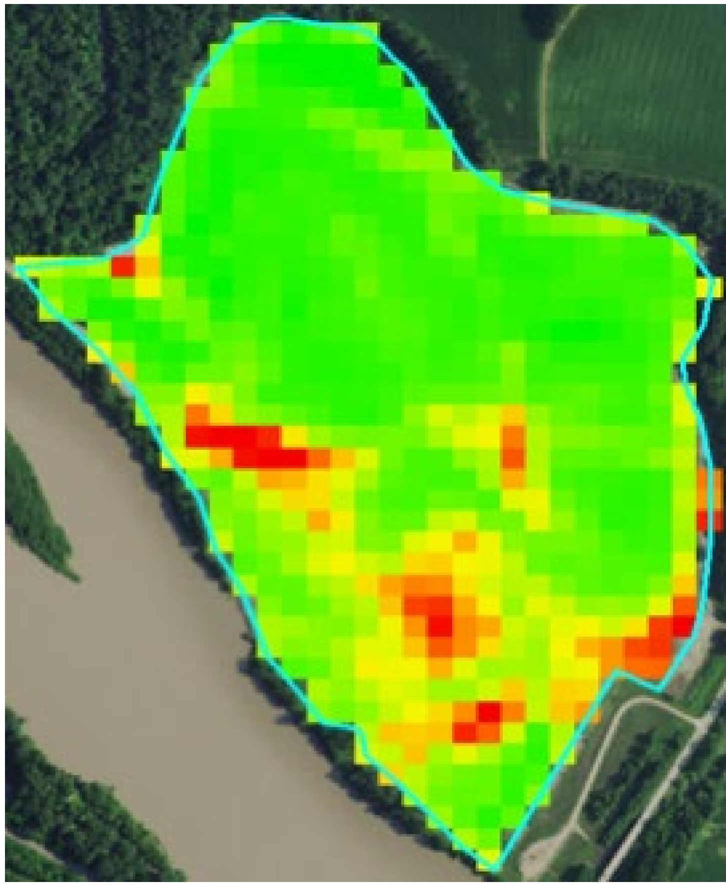
Summer 2013



Summer 2014



Summer 2016



Landsat 8

Temporal changes, Looking into NEW LAND (example CRP land)

SATELLITE DATA ANALYSIS:

Summer crops 2012-2013-2014-2015-2016-2017

NDVI July

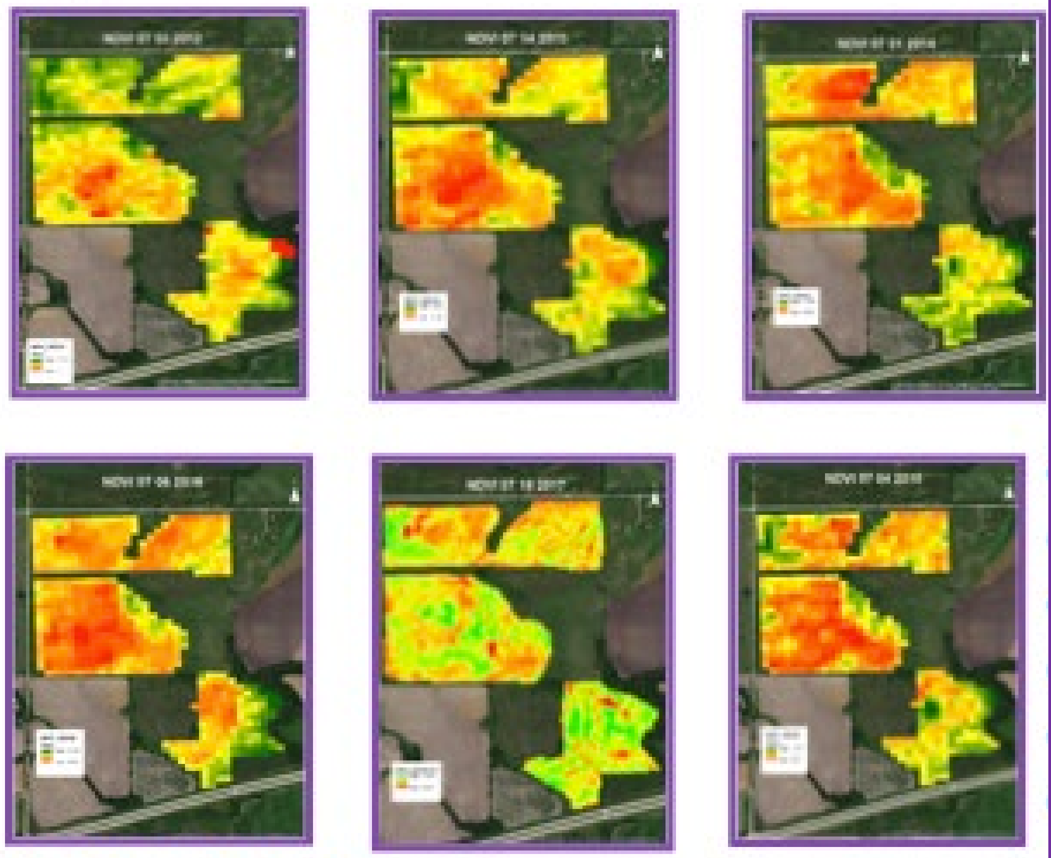
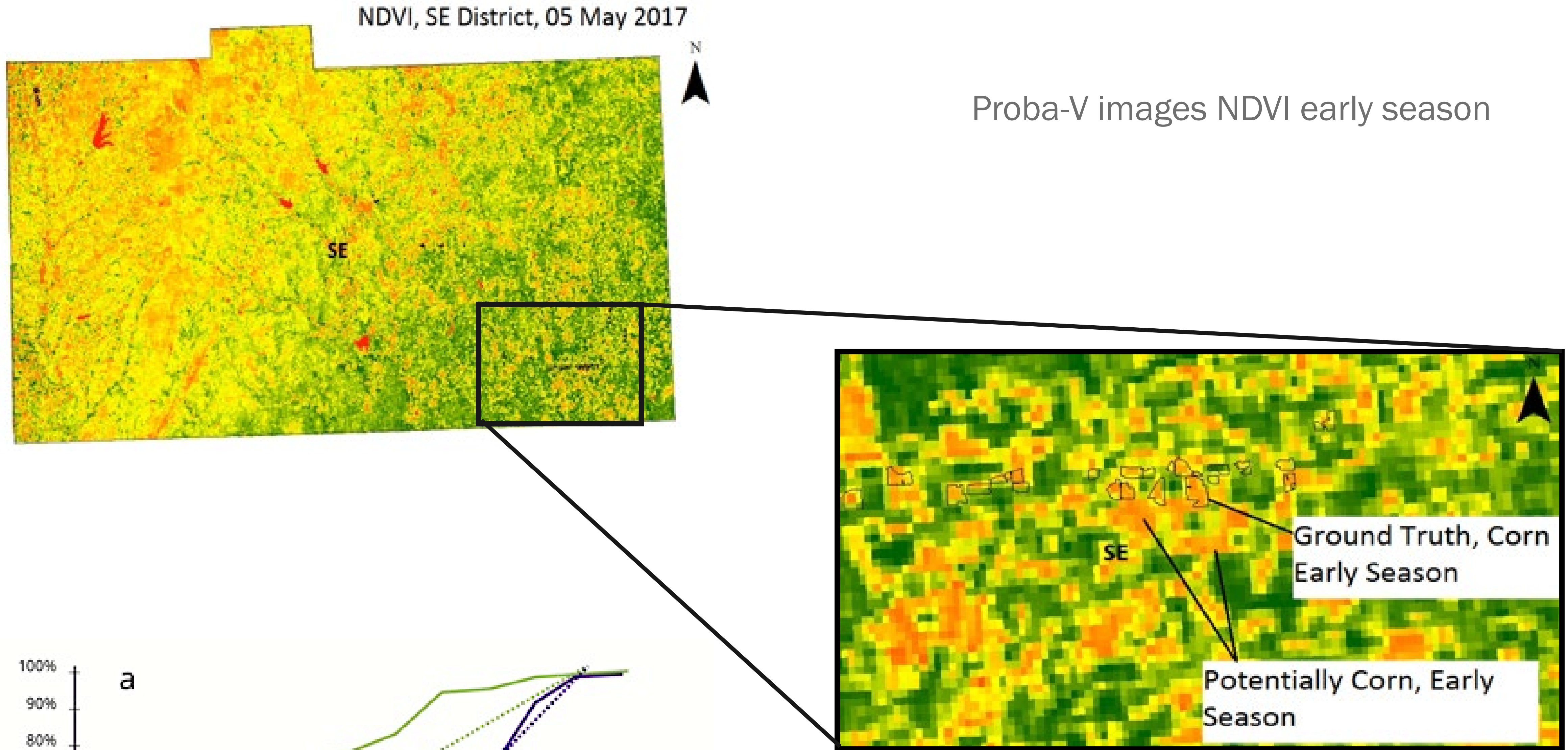
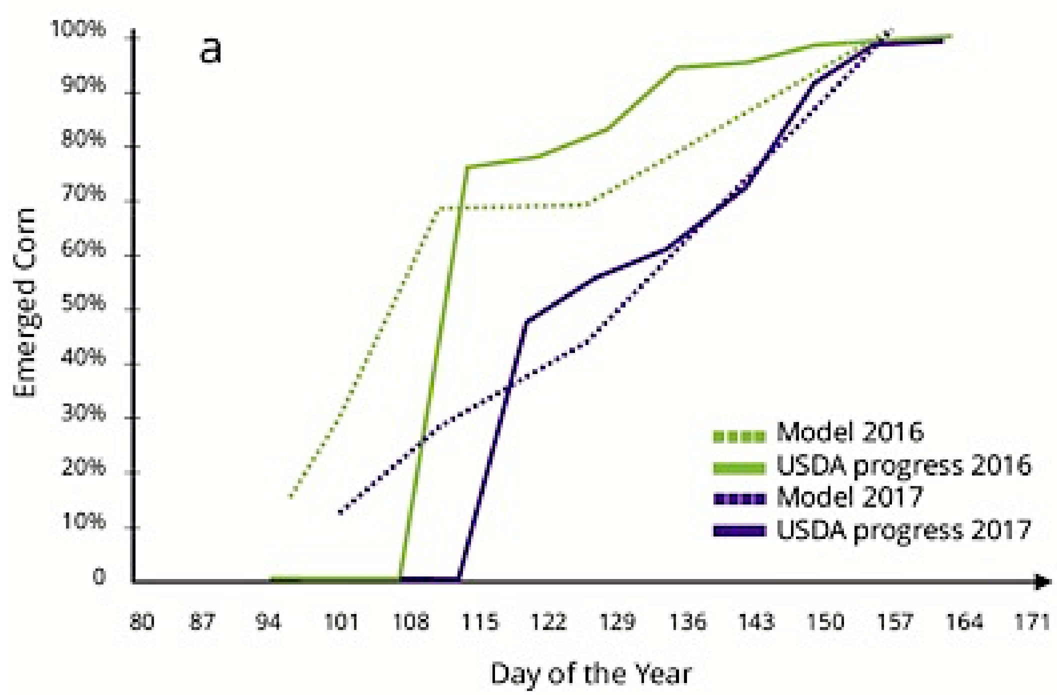


Figure 3: NDVI L7 July 2012
Figure 4: NDVI L8 July 2013
Figure 5: NDVI L8 July 2014
Figure 6: NDVI L8 July 2015
Figure 7: NDVI L8 July 2016
Figure 8: NDVI S2A July 2017

”Real-time” Crop Progress Reports

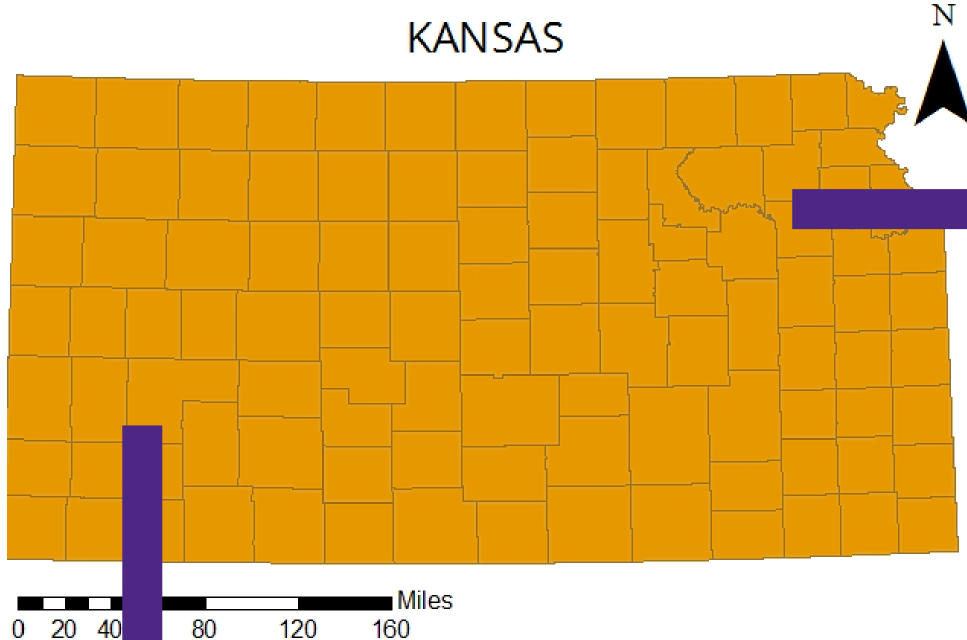


Proba-V images NDVI early season

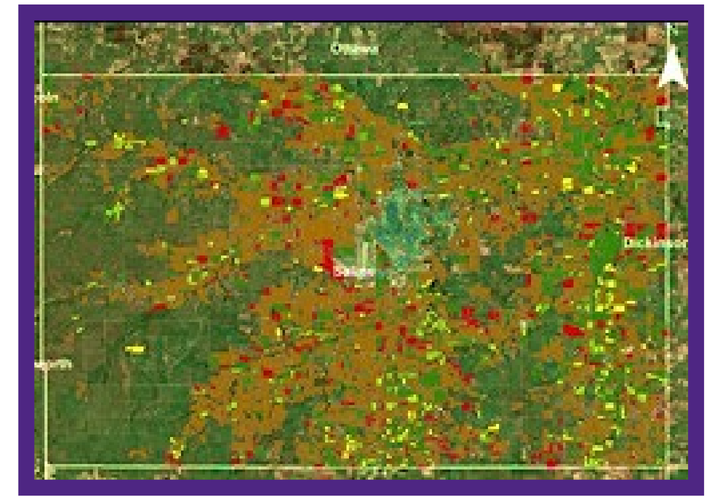


STATE AND COUNTY LEVEL

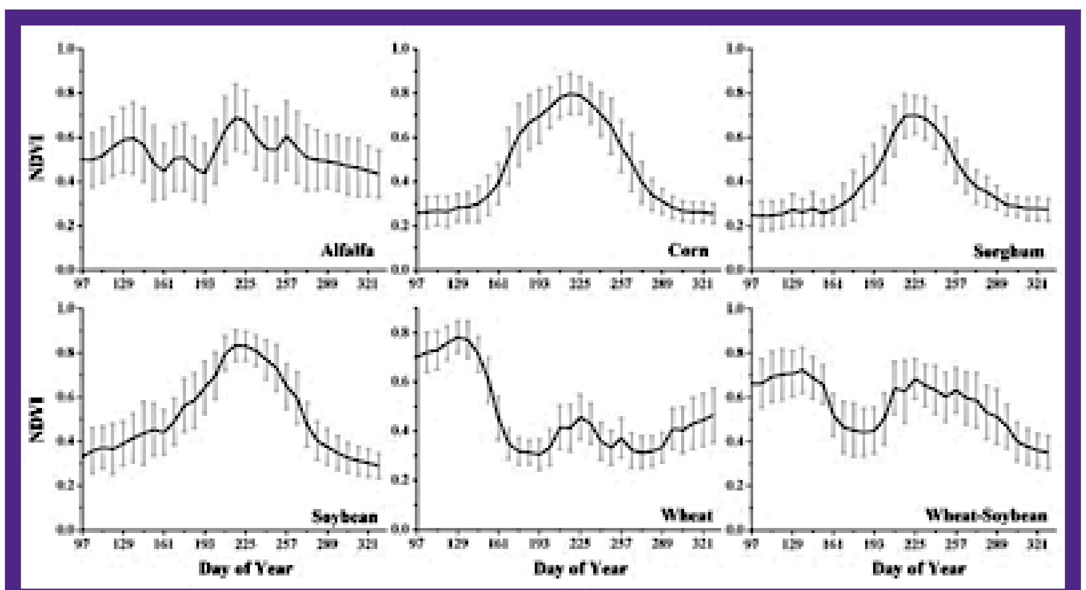
Crop identification



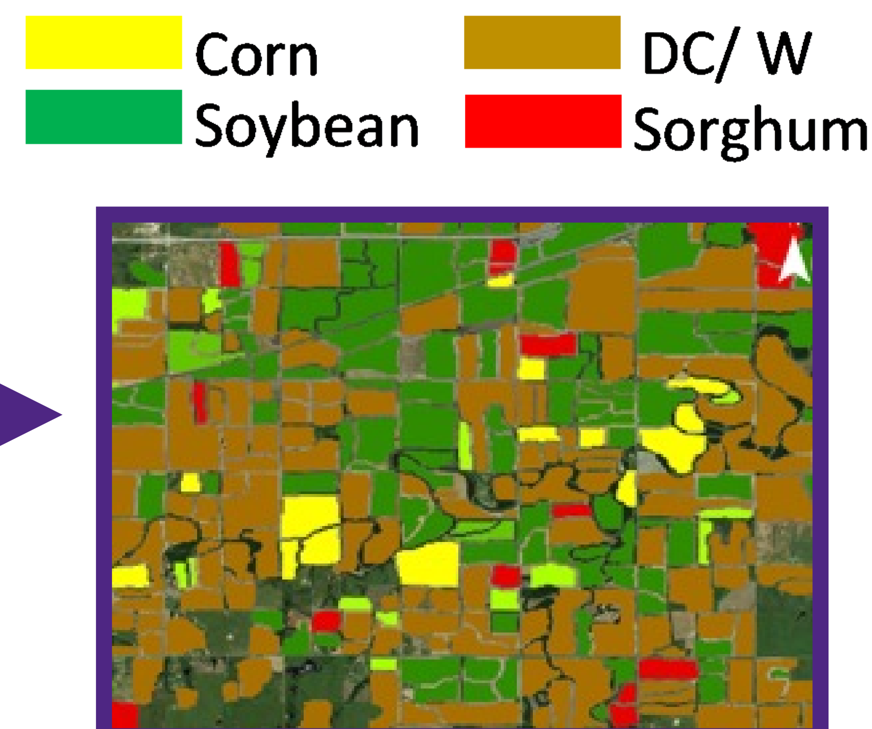
SALINE COUNTY



Soybean and corn area quantification via satellite imagery

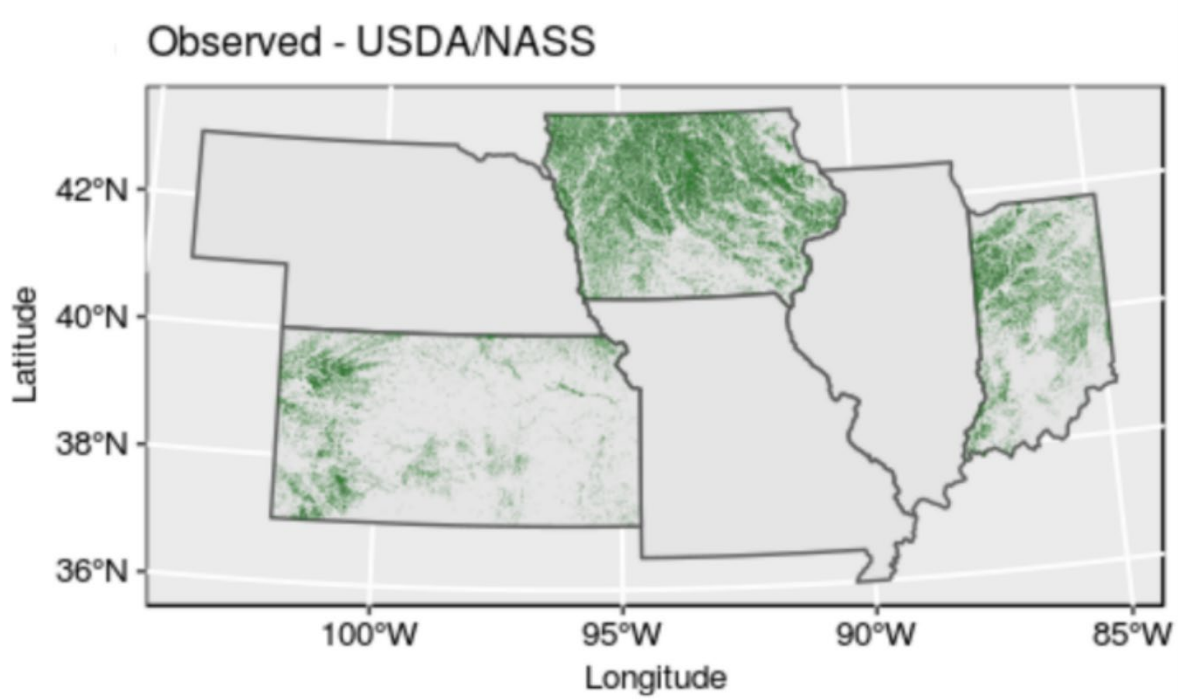


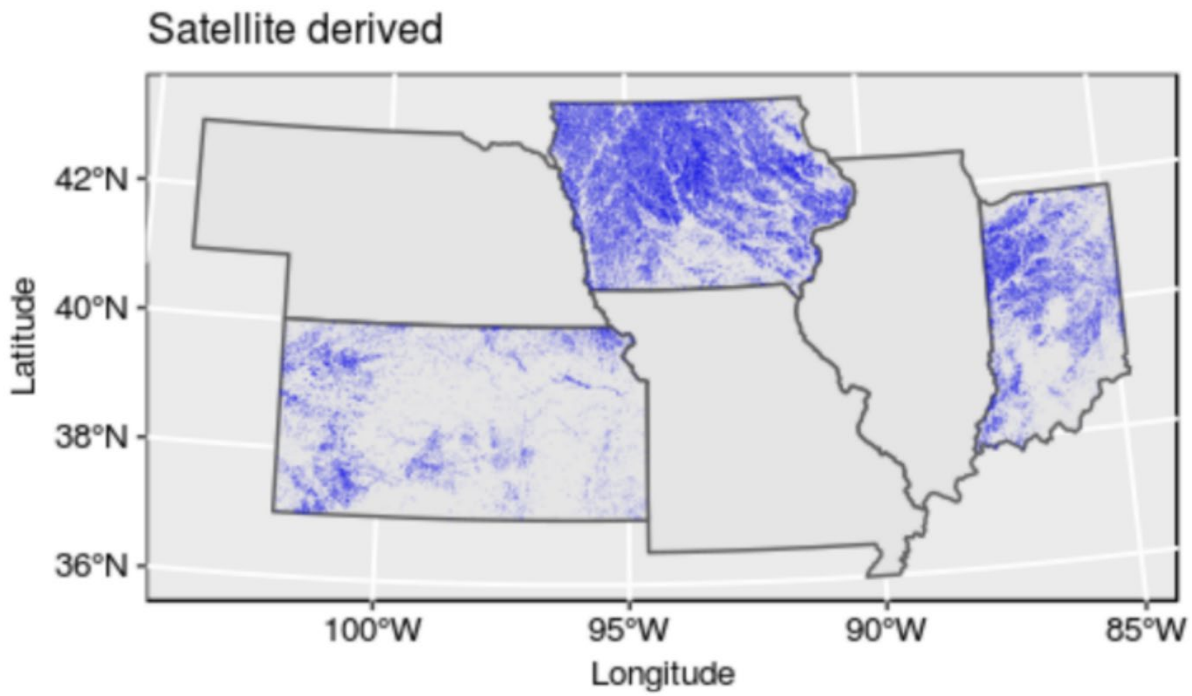
Year-based phenology and spectral response by crop type



Crop classification

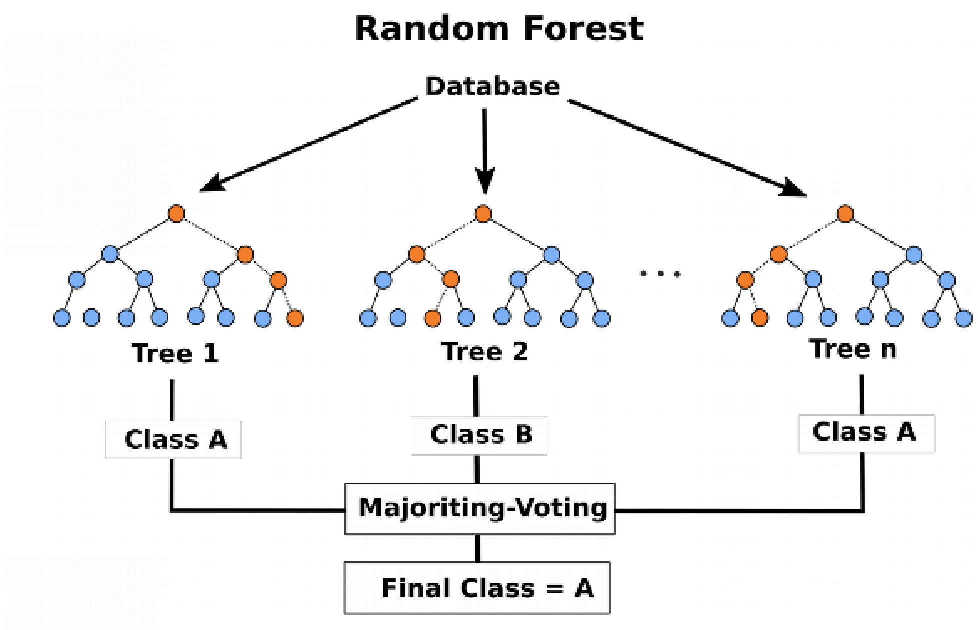
250 m RESOLUTION





MODIS – NDVI and EVI

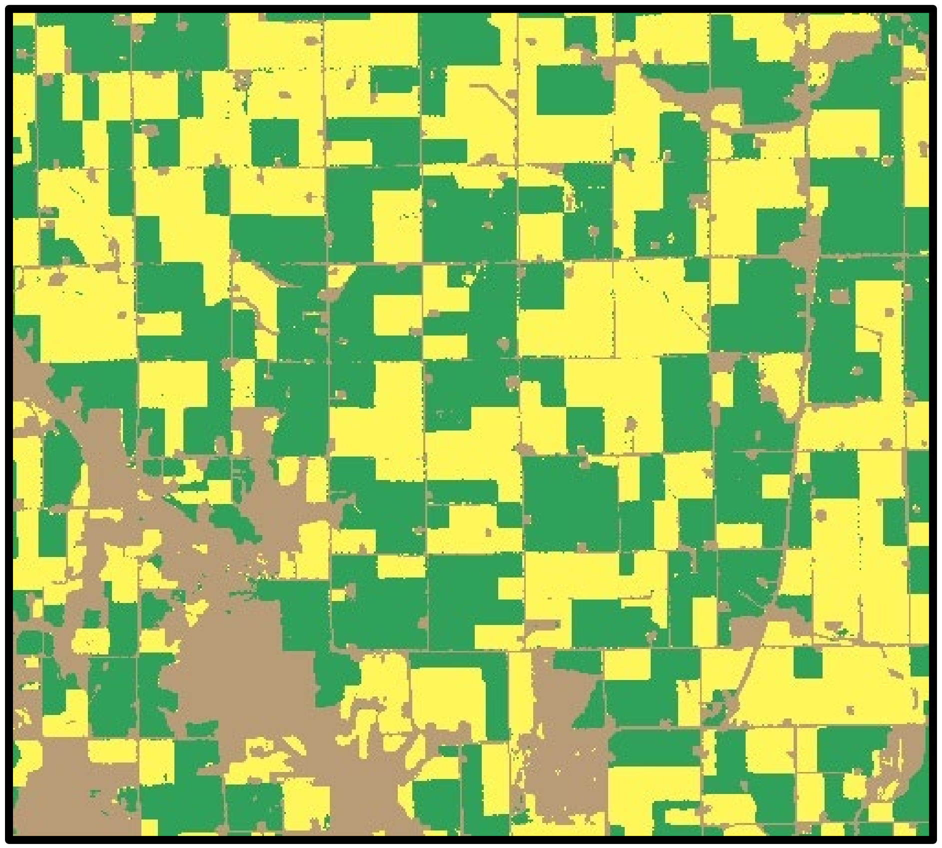
Machine Learning



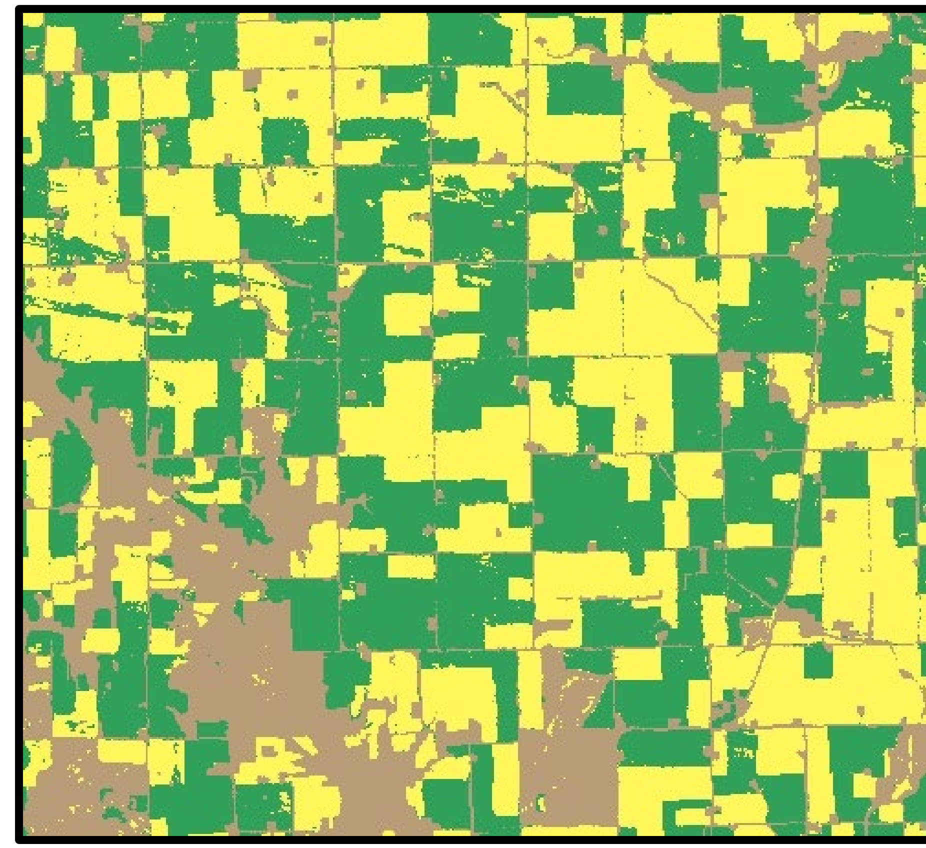
30 m RESOLUTION

Crop classification

Observed - CDL



Satellite classification



Overall accuracy : 89%

- Landsat 5
- Landsat 7
- Landsat 8
- Elevation
- Slope
- SAR

Other

Corn

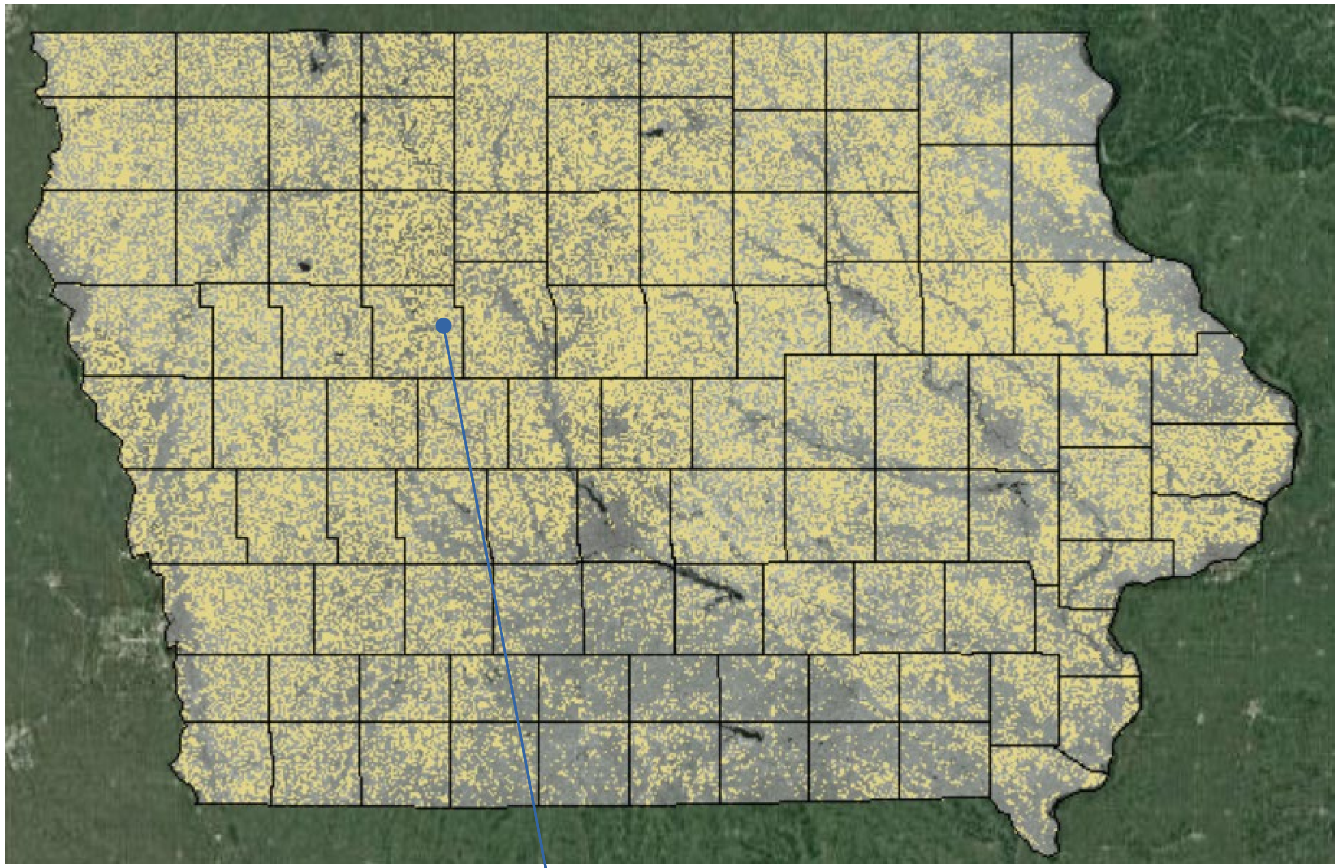
Soybean

Users accuracy

Corn: 92%

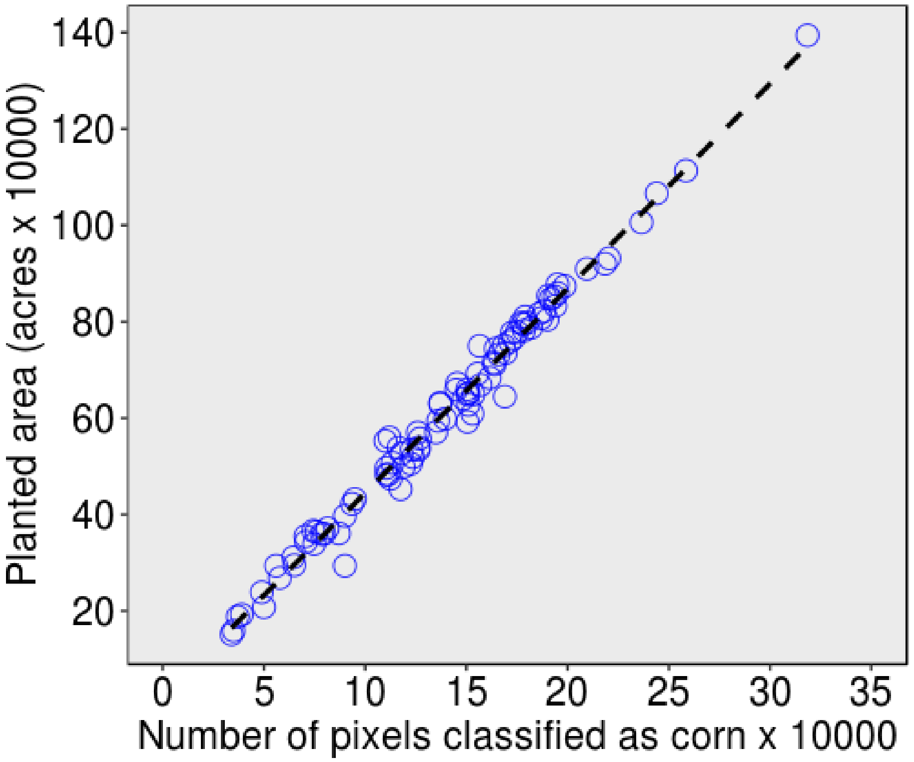
Soybean:95%

Area estimation



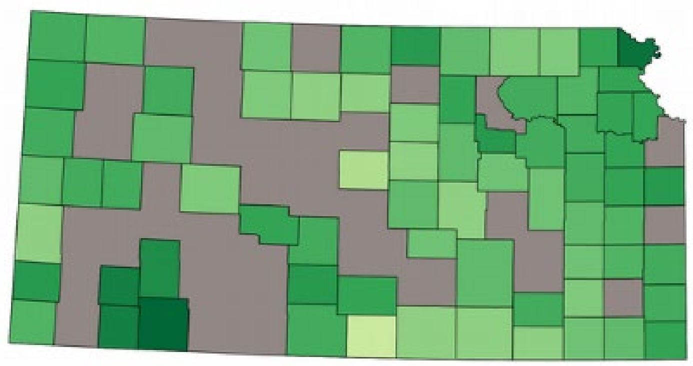
Corn field location in Iowa 2017

Number of pixel classified as corn positively correlated with planted area

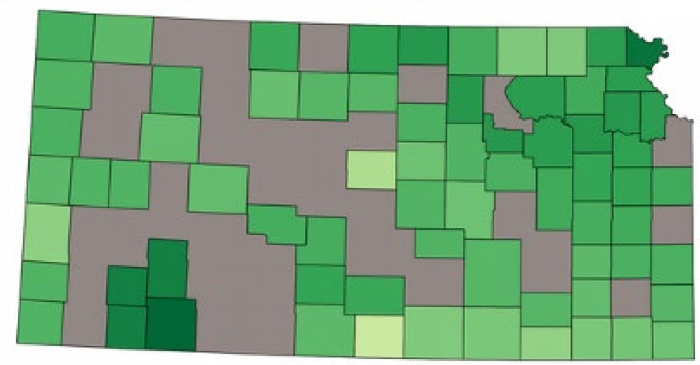


Yield forecast at regional level

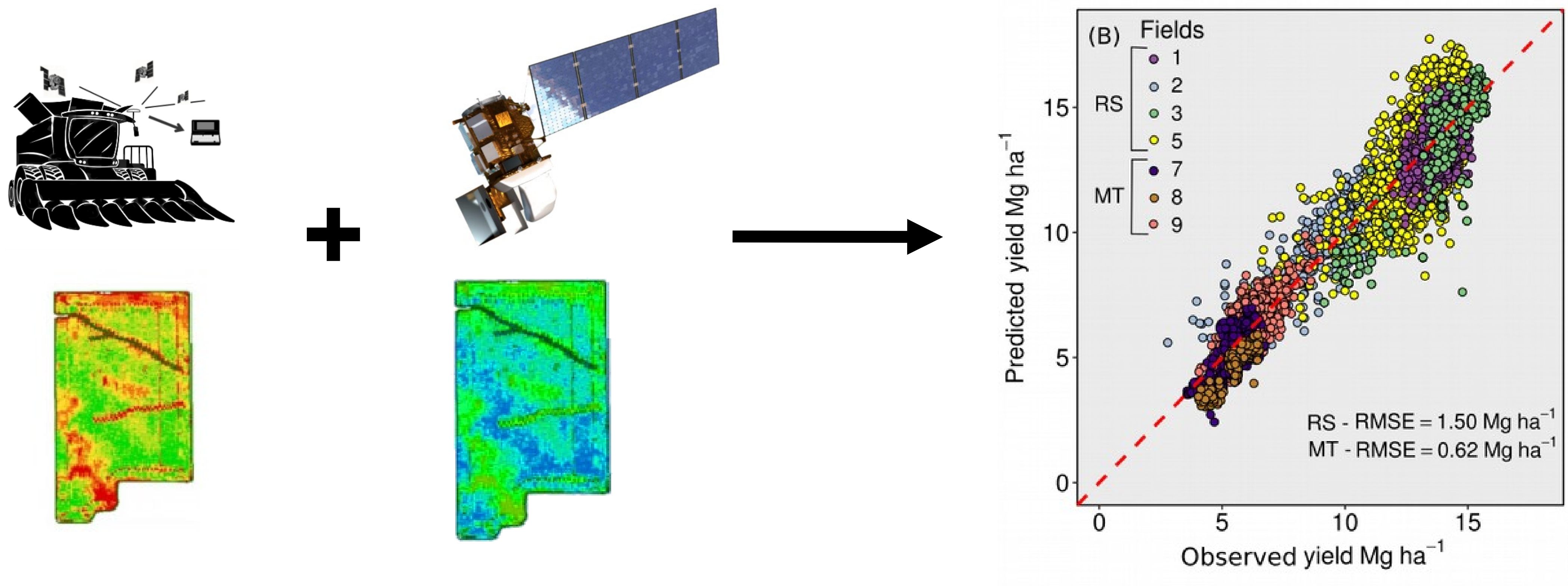
USDA corn yield

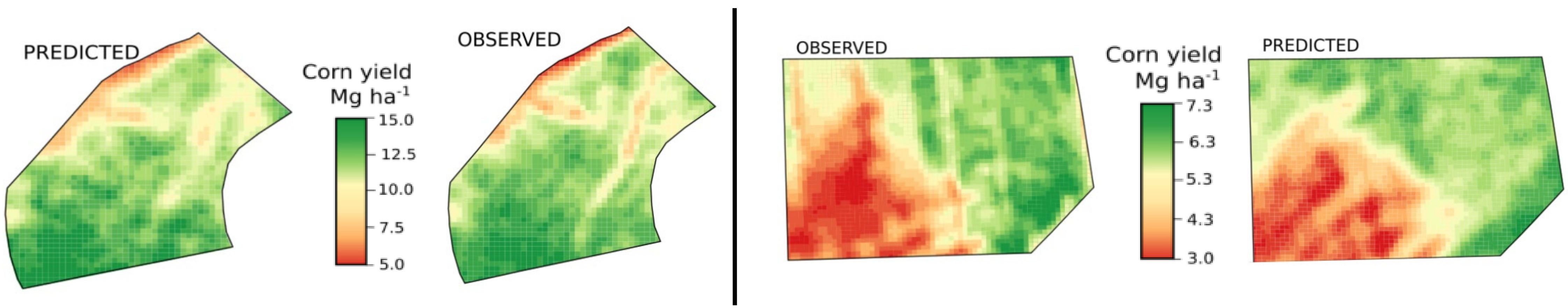


Satellite derived yield

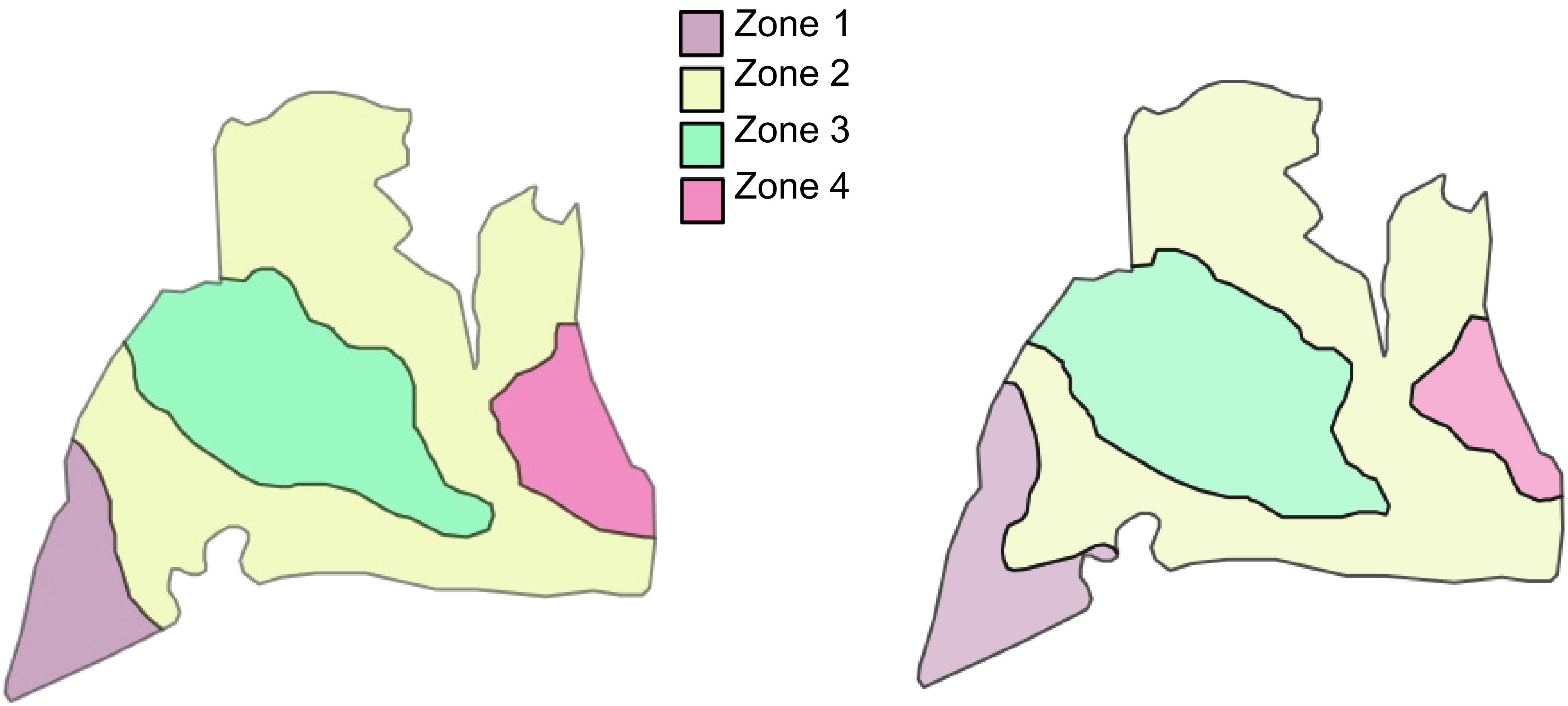


Yield forecast at field level





Management zones delineation



Management zones based on 8 years of **yield map**

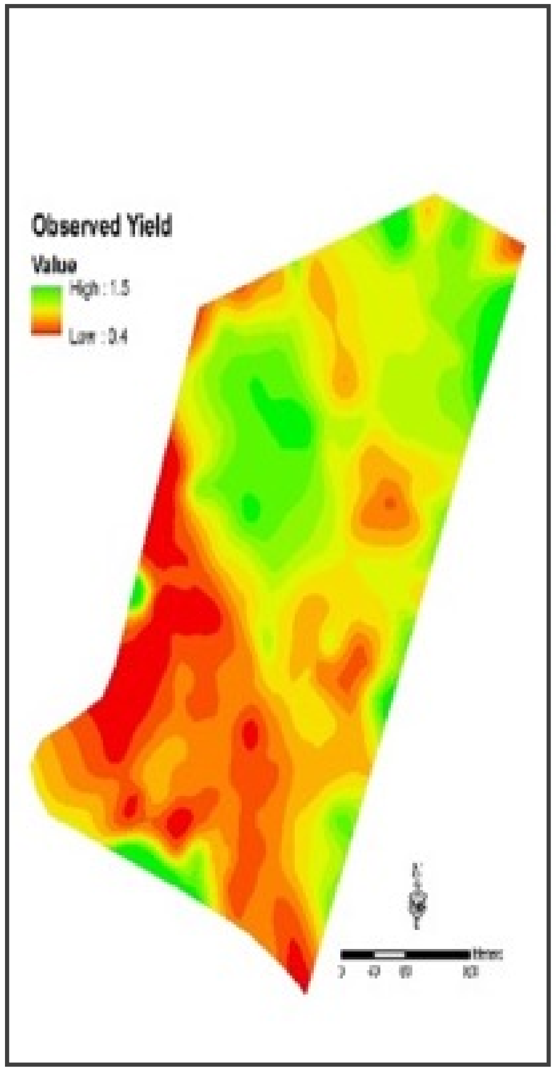
Management zones based on 8 years **satellite data**

r = 0.72
P < 0.01

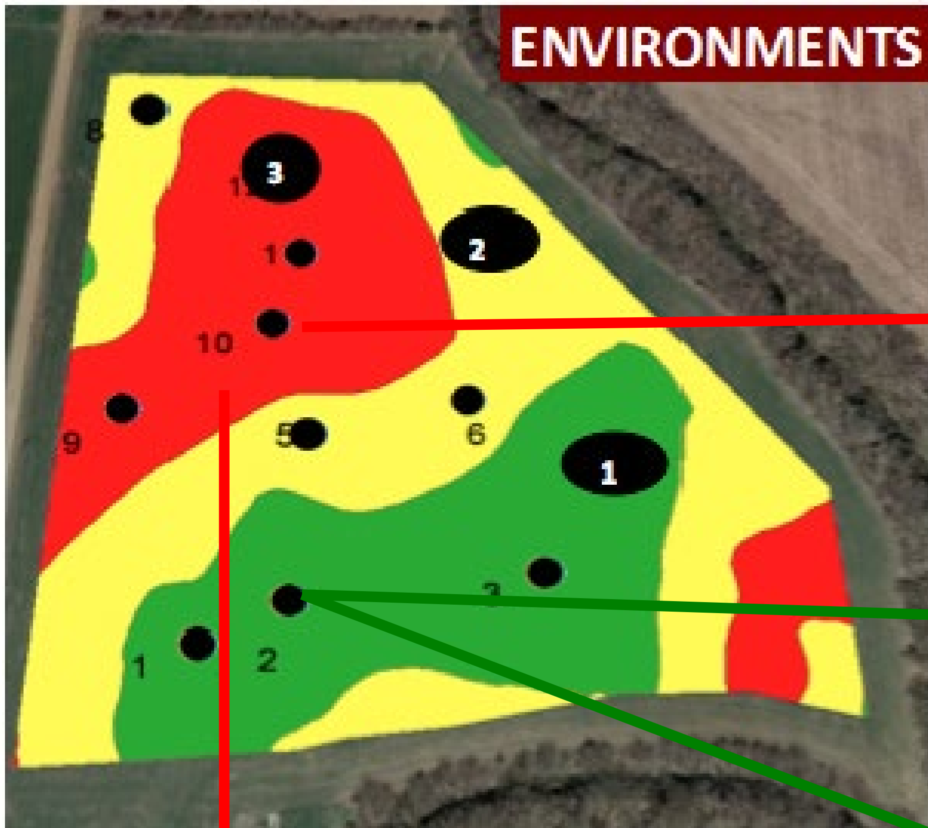
***Landsat* 5, 7 and 8 using Green Chlorophyll index - GCVI**

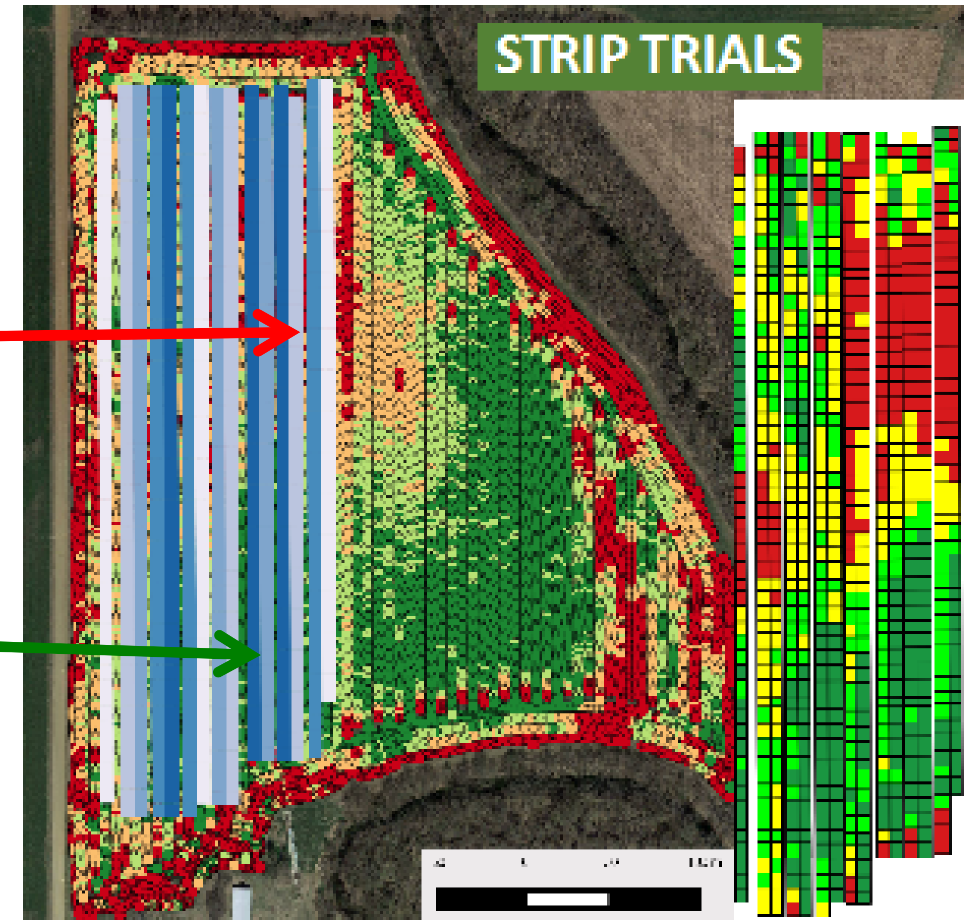
Yield forecast, mid-season satellite imagery in corn and harvest yield monitor information

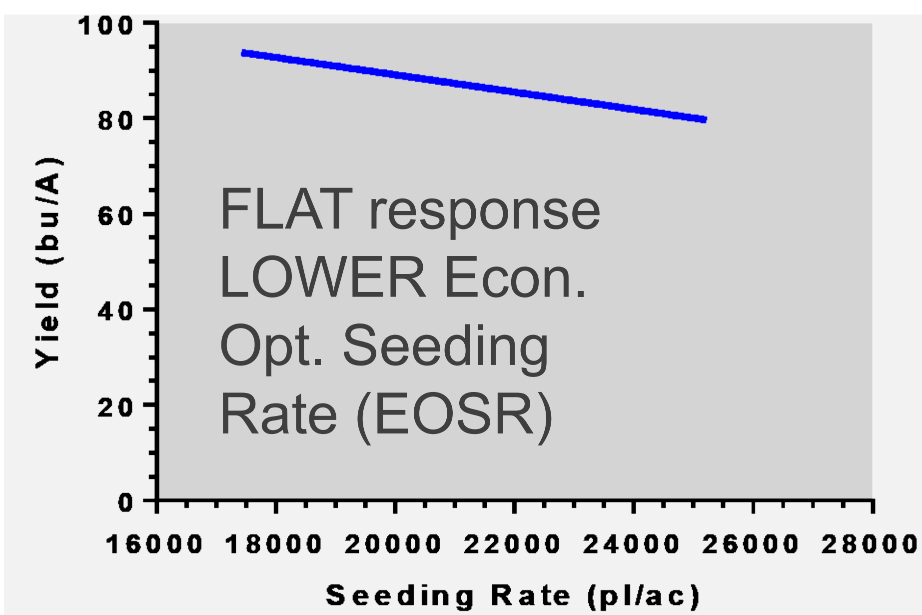
Observed Yield

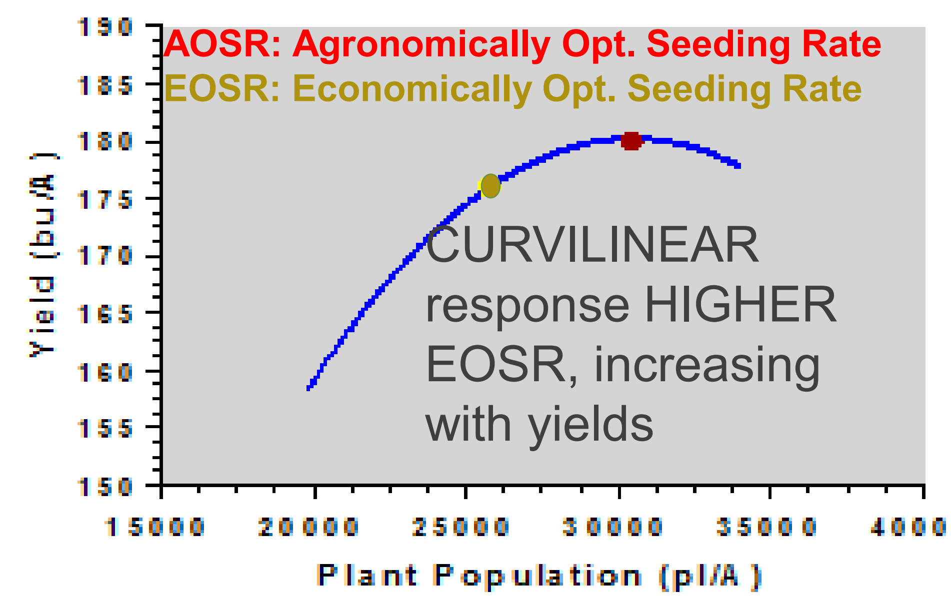


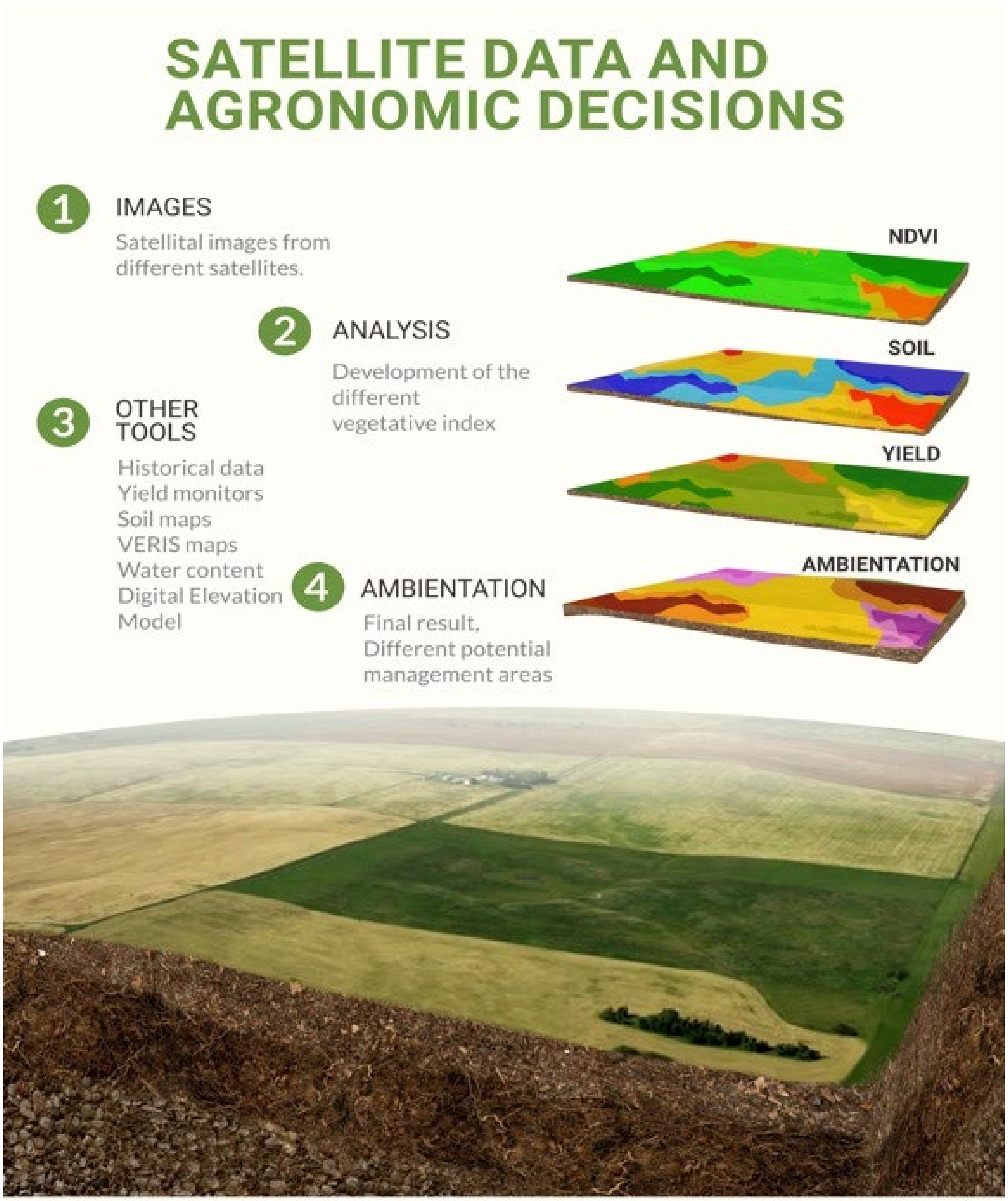
Use of Satellite Imagery for On-Farm Research: Interpretation











On-Farm Research

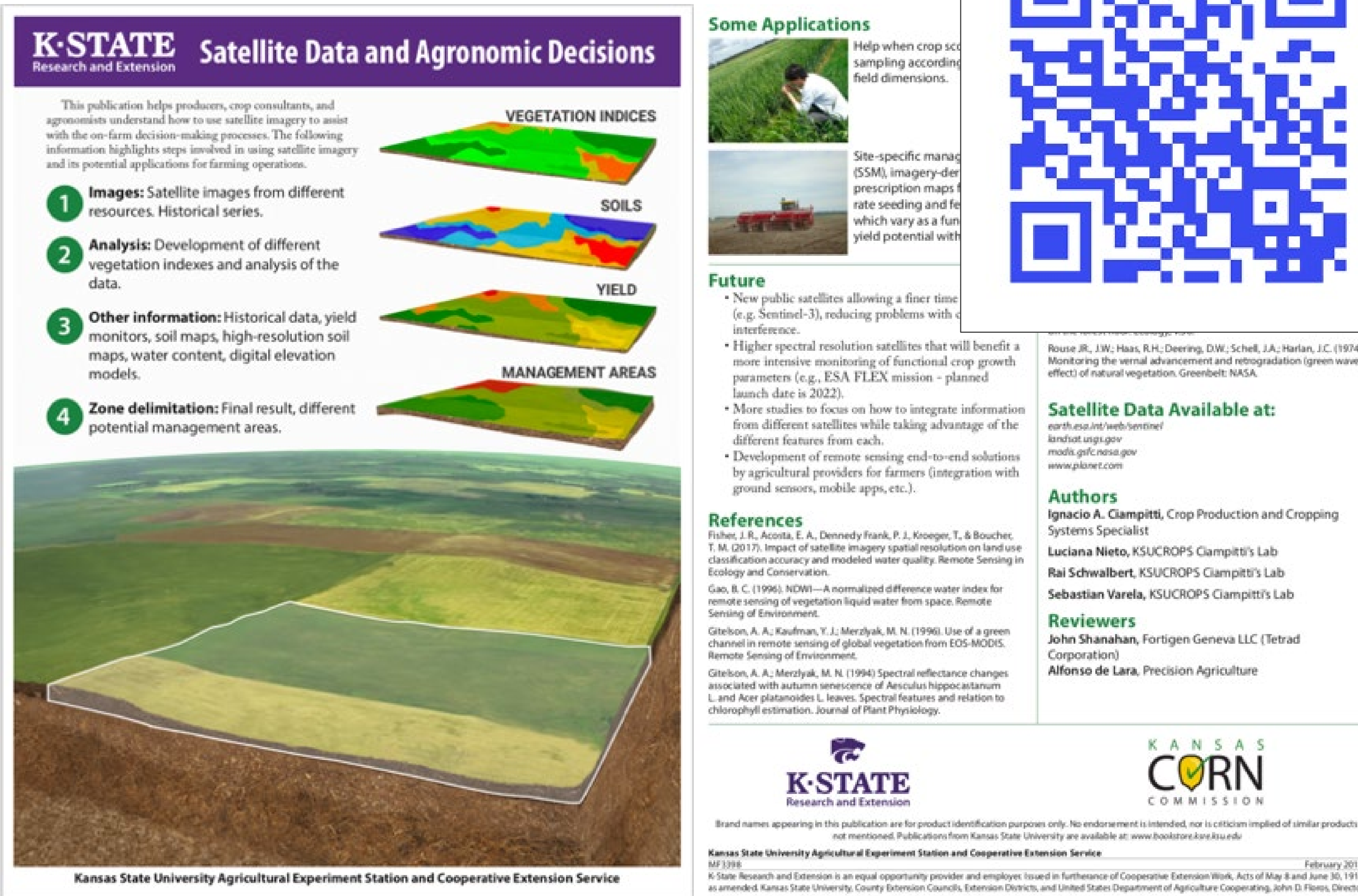
+

Precision Ag Tools

+

Site-specific management = more $$$

NEW PUBLICATION



K·STATE Research and Extension

Satellite Data and Agronomic Decisions

This publication helps producers, crop consultants, and agronomists understand how to use satellite imagery to assist with the on-farm decision-making processes. The following information highlights steps involved in using satellite imagery and its potential applications for farming operations.

1. **Images:** Satellite images from different resources. Historical series.
2. **Analysis:** Development of different vegetation indexes and analysis of the data.
3. **Other information:** Historical data, yield monitors, soil maps, high-resolution soil maps, water content, digital elevation models.
4. **Zone delimitation:** Final result, different potential management areas.

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

Some Applications

Help when crop sc
sampling accordin
field dimensions.

Site-specific manag
(SSM), imagery-der
prescription maps f
rate seeding and fe
which vary as a fun
yield potential with

Future

- New public satellites allowing a finer time (e.g. Sentinel-3), reducing problems with interference.
- Higher spectral resolution satellites that will benefit a more intensive monitoring of functional crop growth parameters (e.g., ESA FLEX mission - planned launch date is 2022).
- More studies to focus on how to integrate information from different satellites while taking advantage of the different features from each.
- Development of remote sensing end-to-end solutions by agricultural providers for farmers (integration with ground sensors, mobile apps, etc.).

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Gao, B. C. (1996). NDWI—A normalized difference water index for remote sensing of vegetation liquid water from space. Remote Sensing of Environment.

Gitelson, A. A.; Kaufman, Y. J.; Merzlyak, M. N. (1996). Use of a green channel in remote sensing of global vegetation from EOS-MODIS. Remote Sensing of Environment.

Gitelson, A. A.; Merzlyak, M. N. (1994) Spectral reflectance changes associated with autumn senescence of Aesculus hippocastanum L. and Acer platanoides L. leaves. Spectral features and relation to chlorophyll estimation. Journal of Plant Physiology.

Rouse JR., J.W.; Haas, R.H.; Deering, D.W.; Schell, J.A.; Harlan, J.C. (1974) Monitoring the vernal advancement and retrogradation (green wave effect) of natural vegetation. Greenbelt: NASA.

Satellite Data Available at:

earth.esa.int/web/sentinel
landsat.usgs.gov
modis.gsfc.nasa.gov
www.planet.com

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Thank you!

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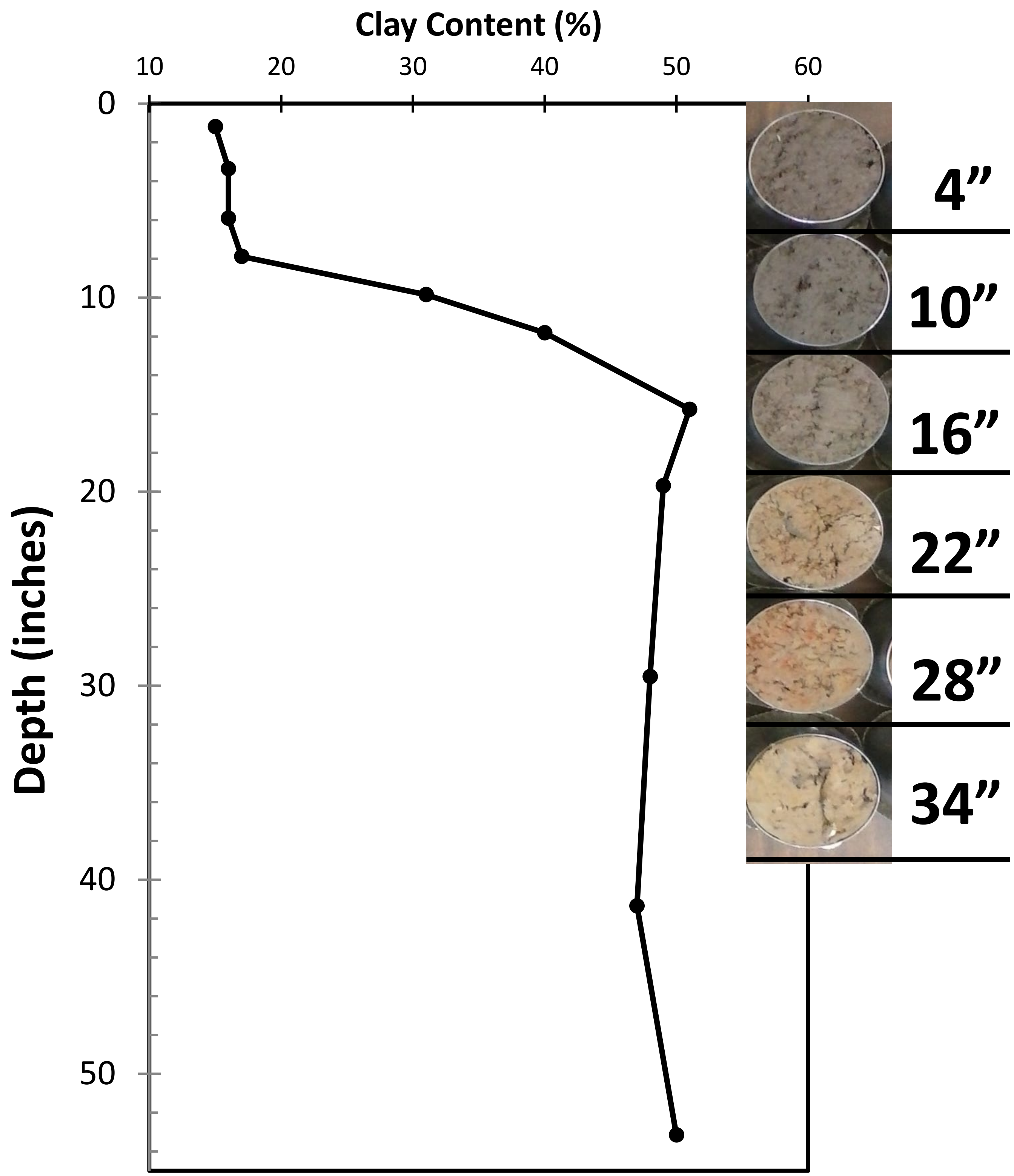
KANSAS STATE UNIVERSITY


Cover
Crop
Investment
Gretchen Sassenrath
Lonnie Mengarelli

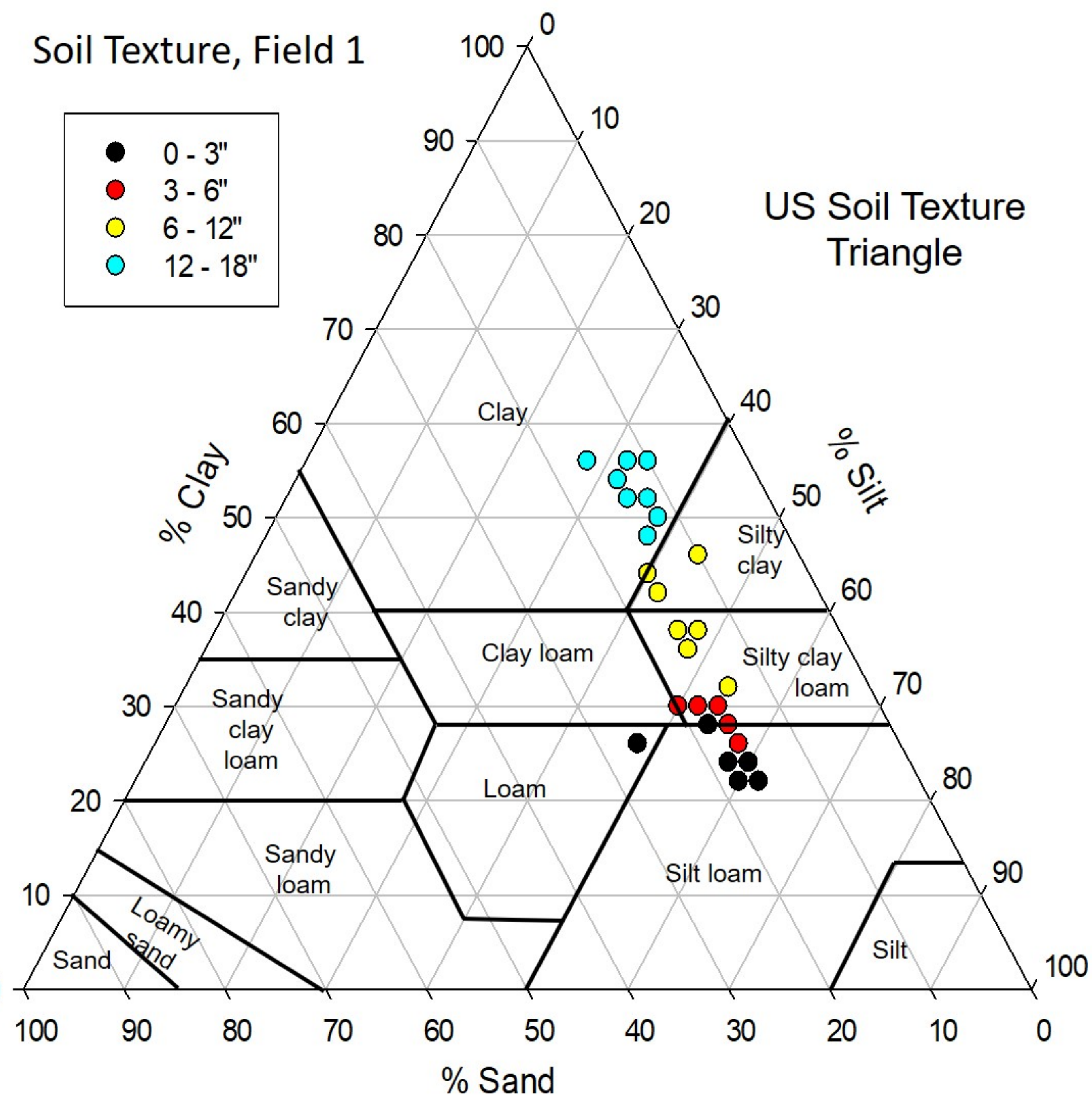
Crop production: rotation of corn/winter wheat/soybeans

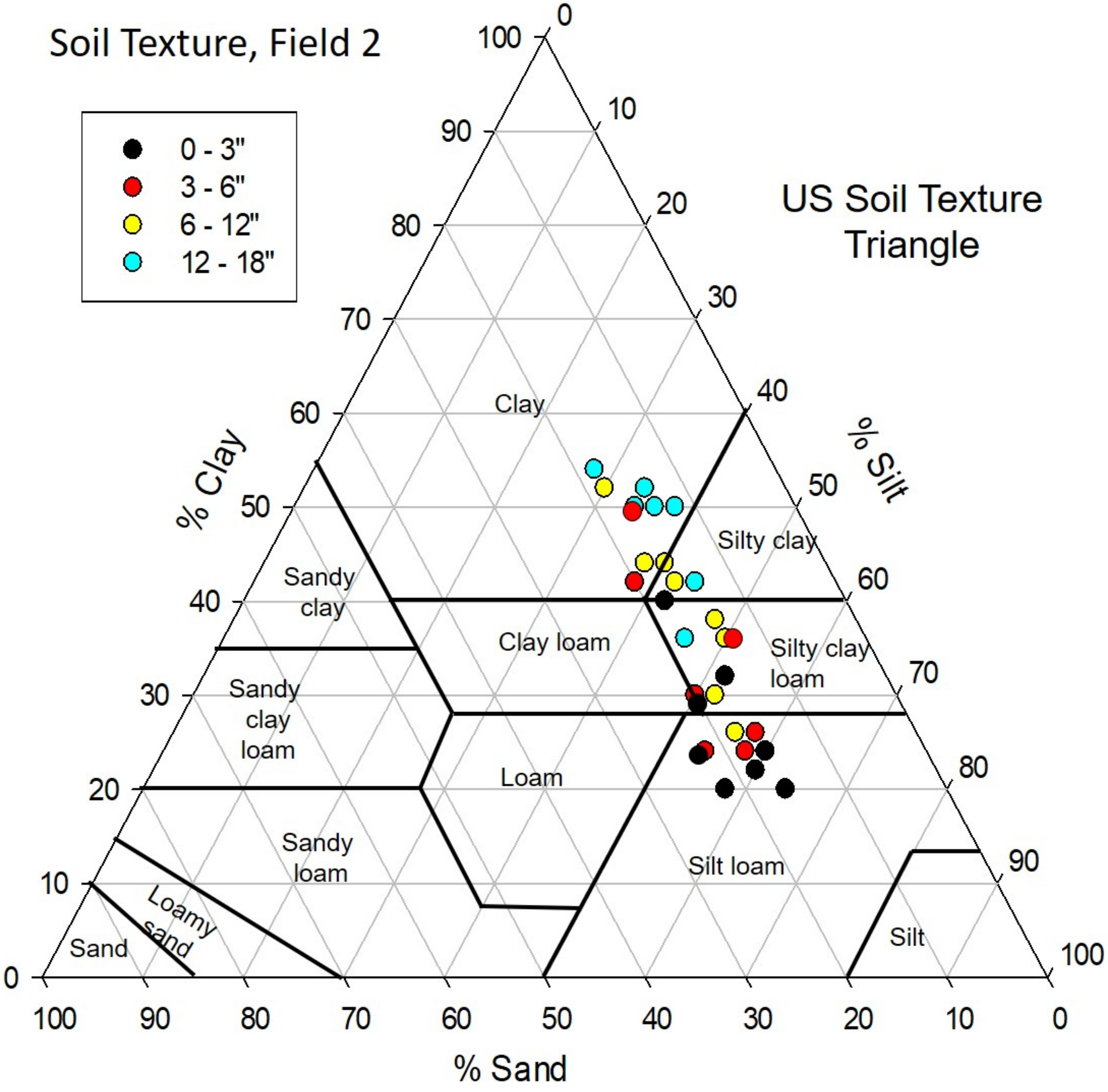
Animal production: cow/calf on pasture



Buckley et al., 2010, Effect of tillage on the hydrology of a claypan soil in Kansas. SSSAJ, 74:2109-2119


0.6% slope
> 35 inches rain/year


Soil Texture, Field 1
0 - 3"
3 - 6"
6 - 12"
12 - 18"
US Soil Texture Triangle
% Clay
% Silt
% Sand
Clay
Silty clay
Sandy clay
Clay loam
Silty clay loam
Sandy clay loam
Loam
Silt loam
Sandy loam
Loamy sand
Sand
Silt



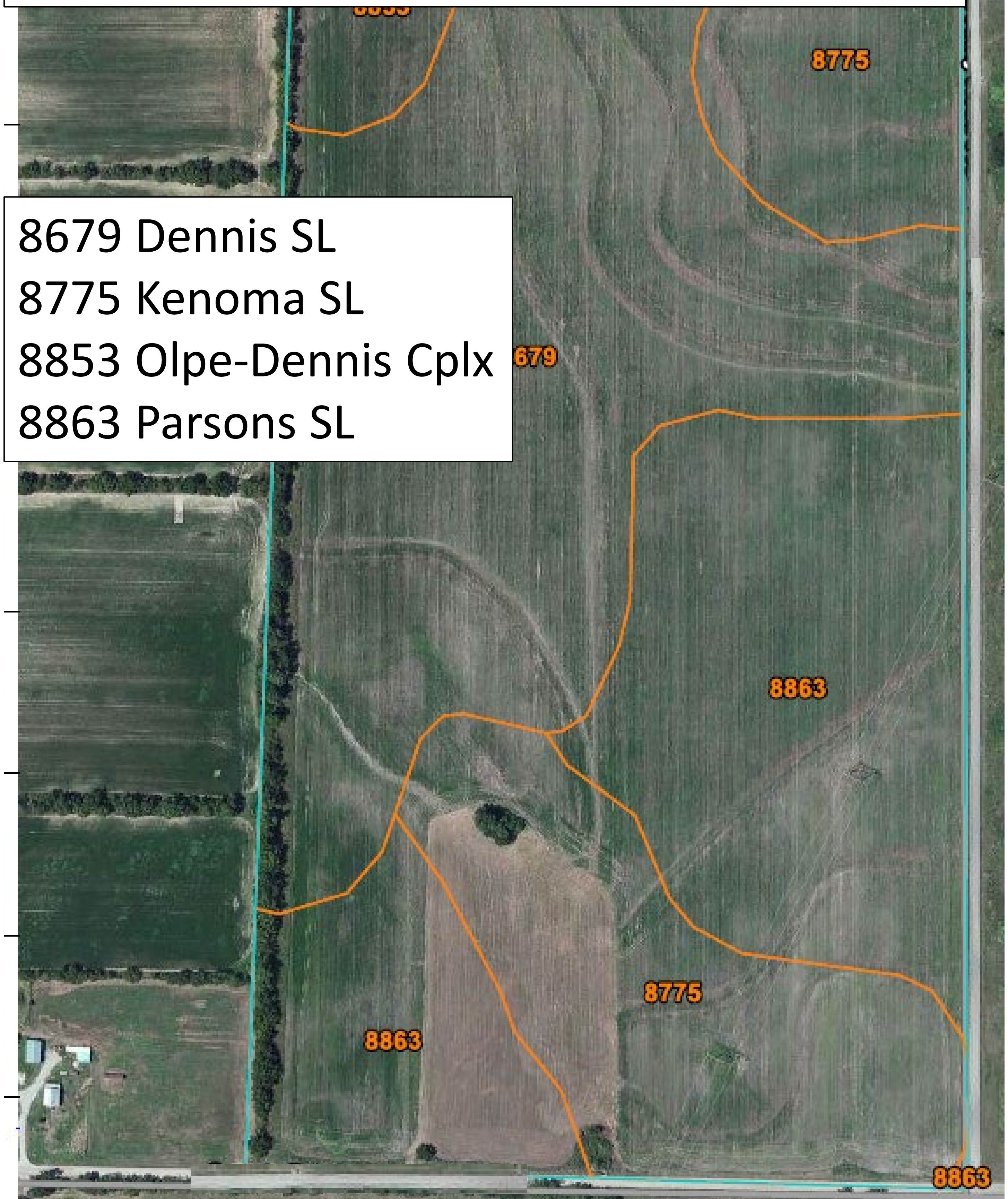
Soil Texture, Field 2
0 - 3"
3 - 6"
6 - 12"
12 - 18"
US Soil Texture Triangle
% Clay
% Silt
% Sand
Clay
Silty clay
Sandy clay
Clay loam
Silty clay loam
Sandy clay loam
Loam
Sandy loam
Silt loam
Loamy sand
Sand
Silt


Google Earth
1992

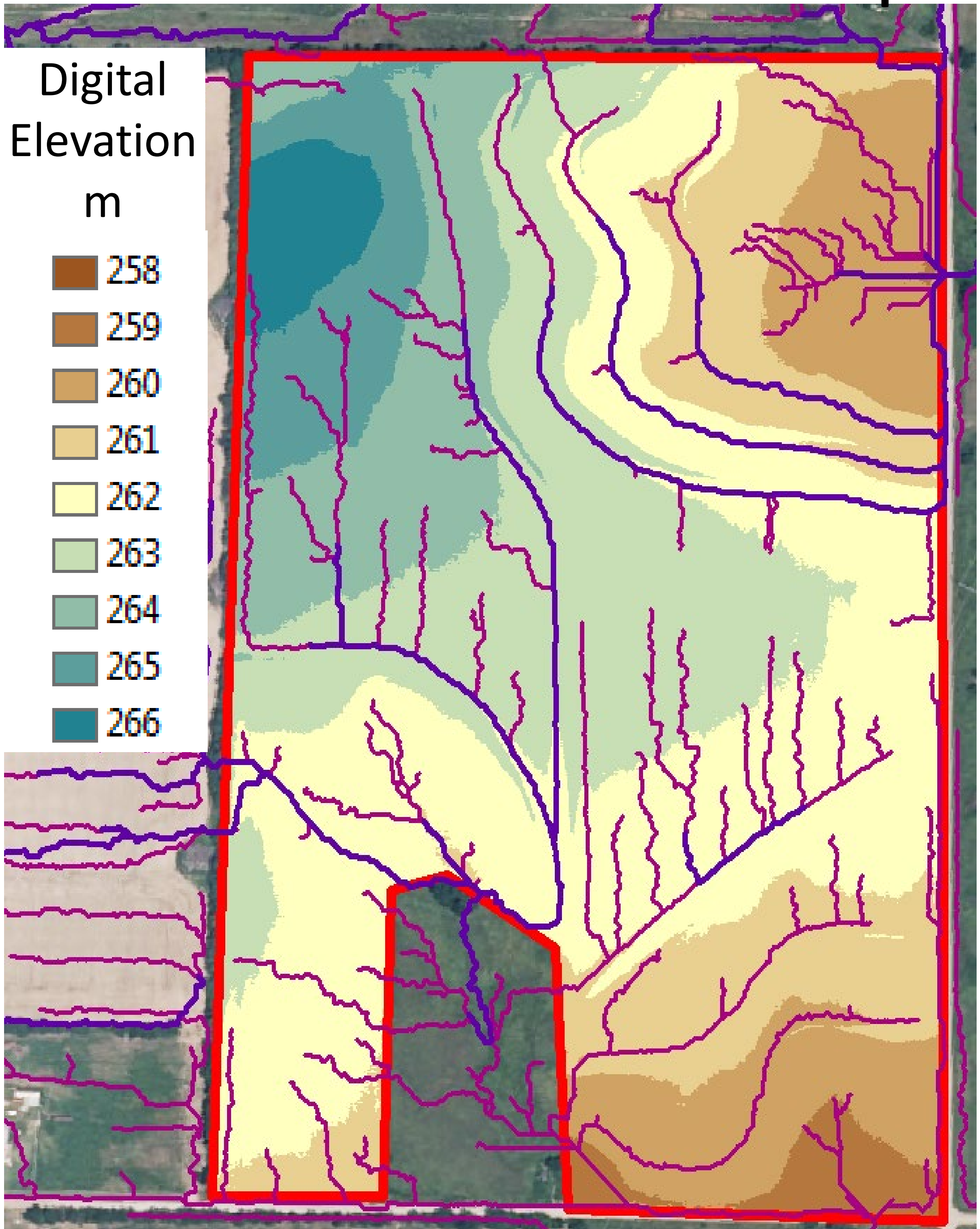
Web Soil Survey

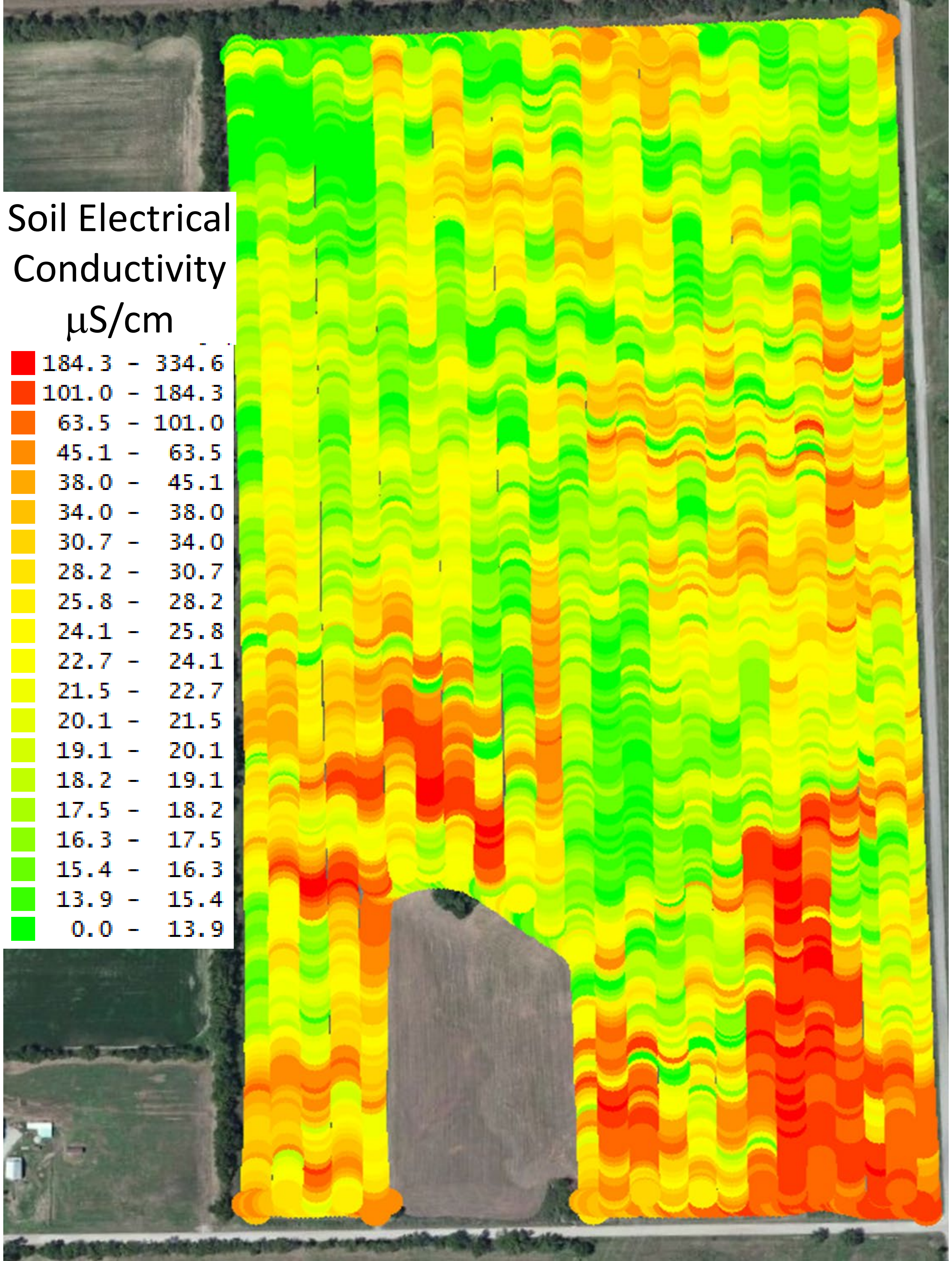
http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

8679 Dennis SL
8775 Kenoma SL
8853 Olpe-Dennis Cplx
8863 Parsons SL

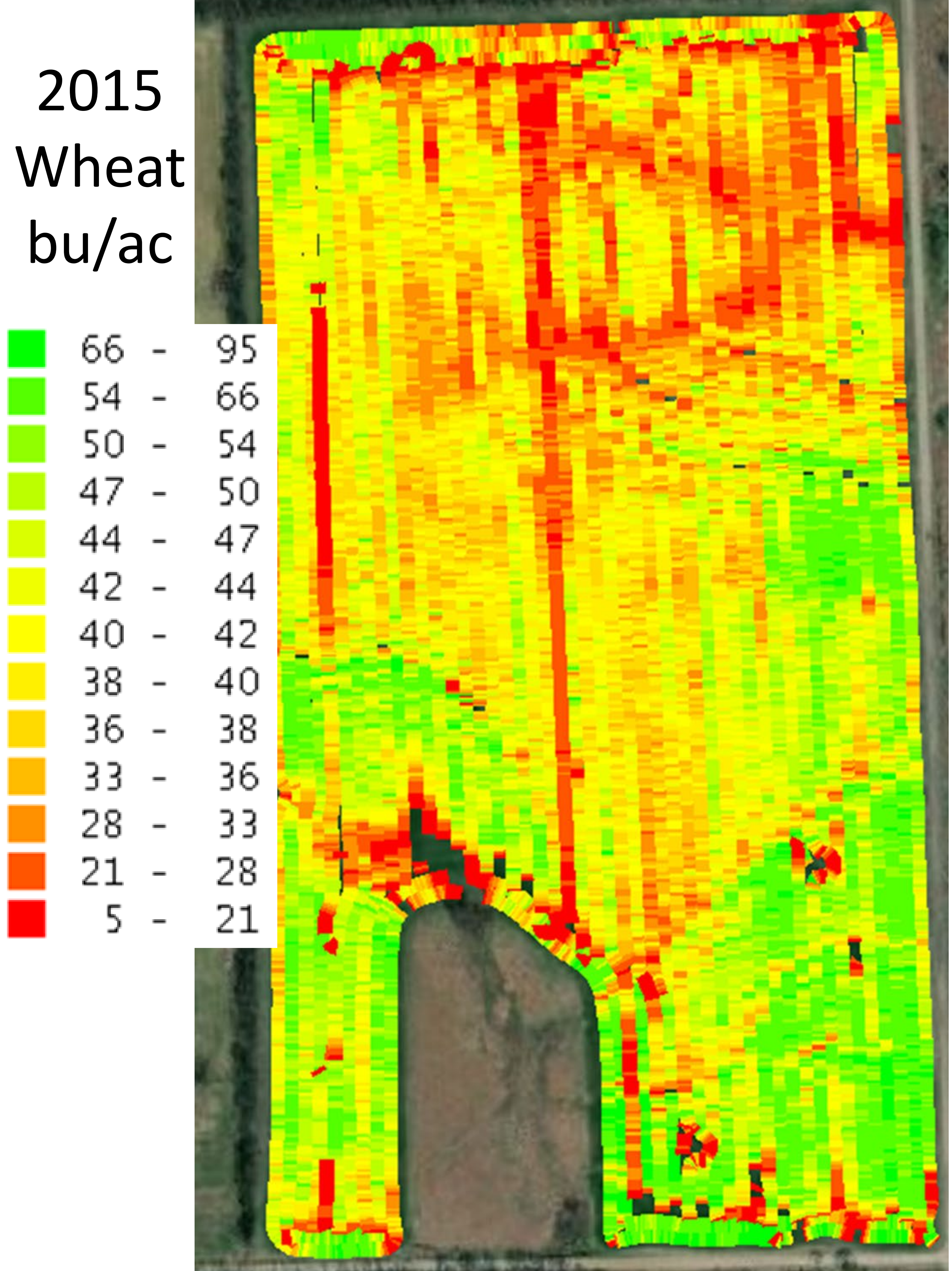


~1% slope



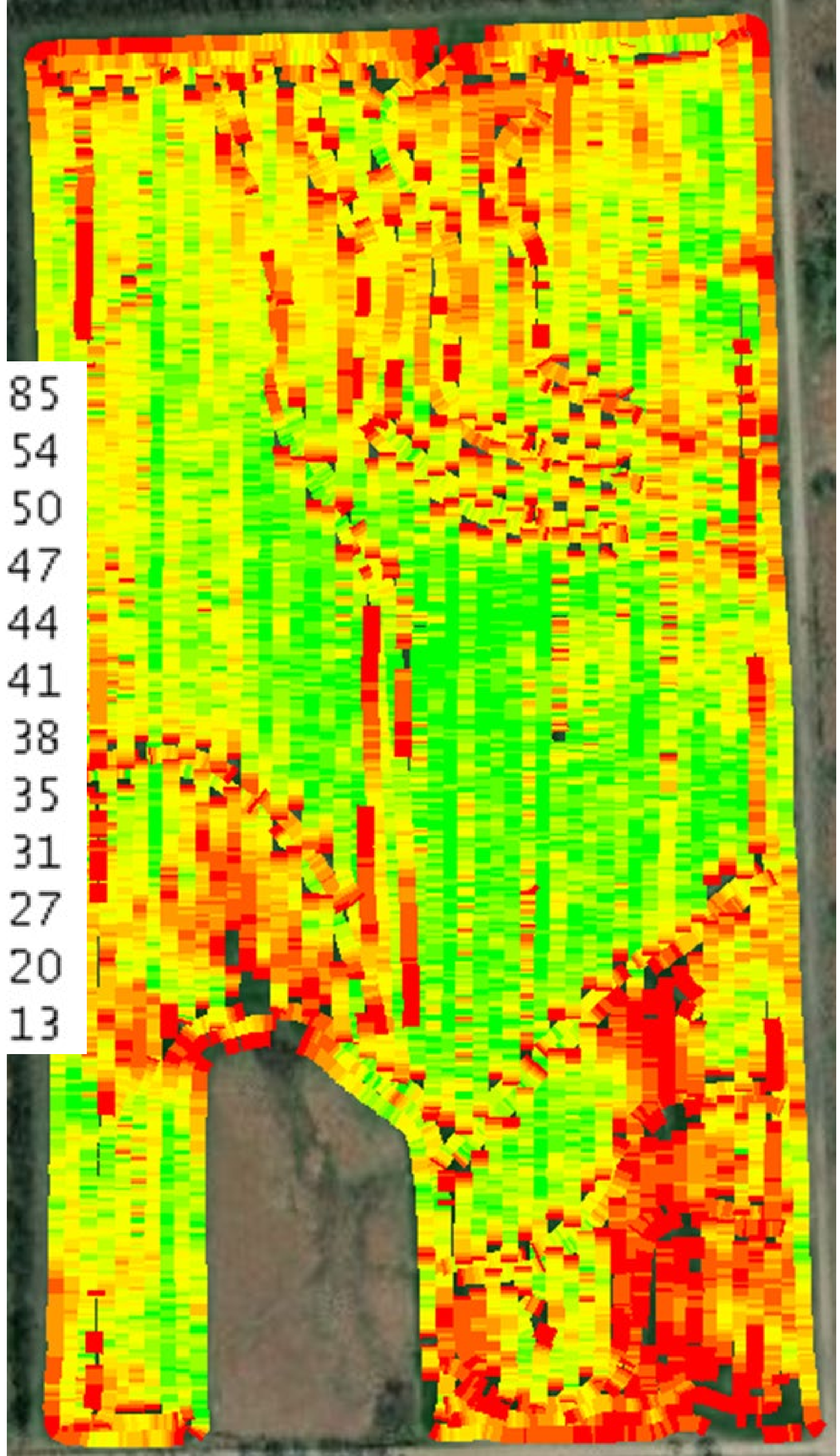

Soil Electrical Conductivity µS/cm
184.3 - 334.6
101.0 - 184.3
63.5 - 101.0
45.1 - 63.5
38.0 - 45.1
34.0 - 38.0
30.7 - 34.0
28.2 - 30.7
25.8 - 28.2
24.1 - 25.8
22.7 - 24.1
21.5 - 22.7
20.1 - 21.5
19.1 - 20.1
18.2 - 19.1
17.5 - 18.2
16.3 - 17.5
15.4 - 16.3
13.9 - 15.4
0.0 - 13.9

2015 Wheat bu/ac

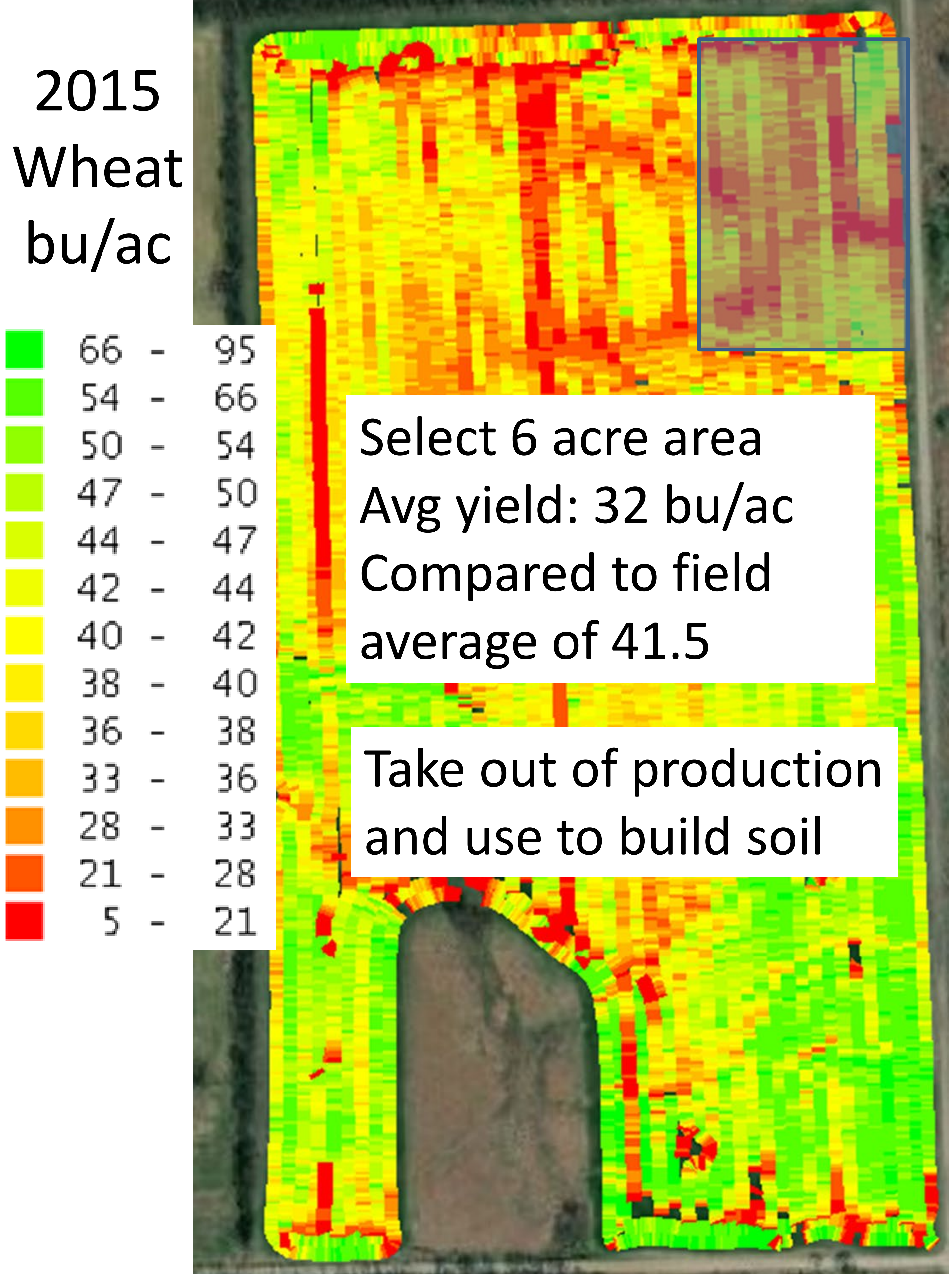


2015 Beans bu/ac

54	85
50	54
47	50
44	47
41	44
38	41
35	38
31	35
27	31
20	27
13	20
5	13



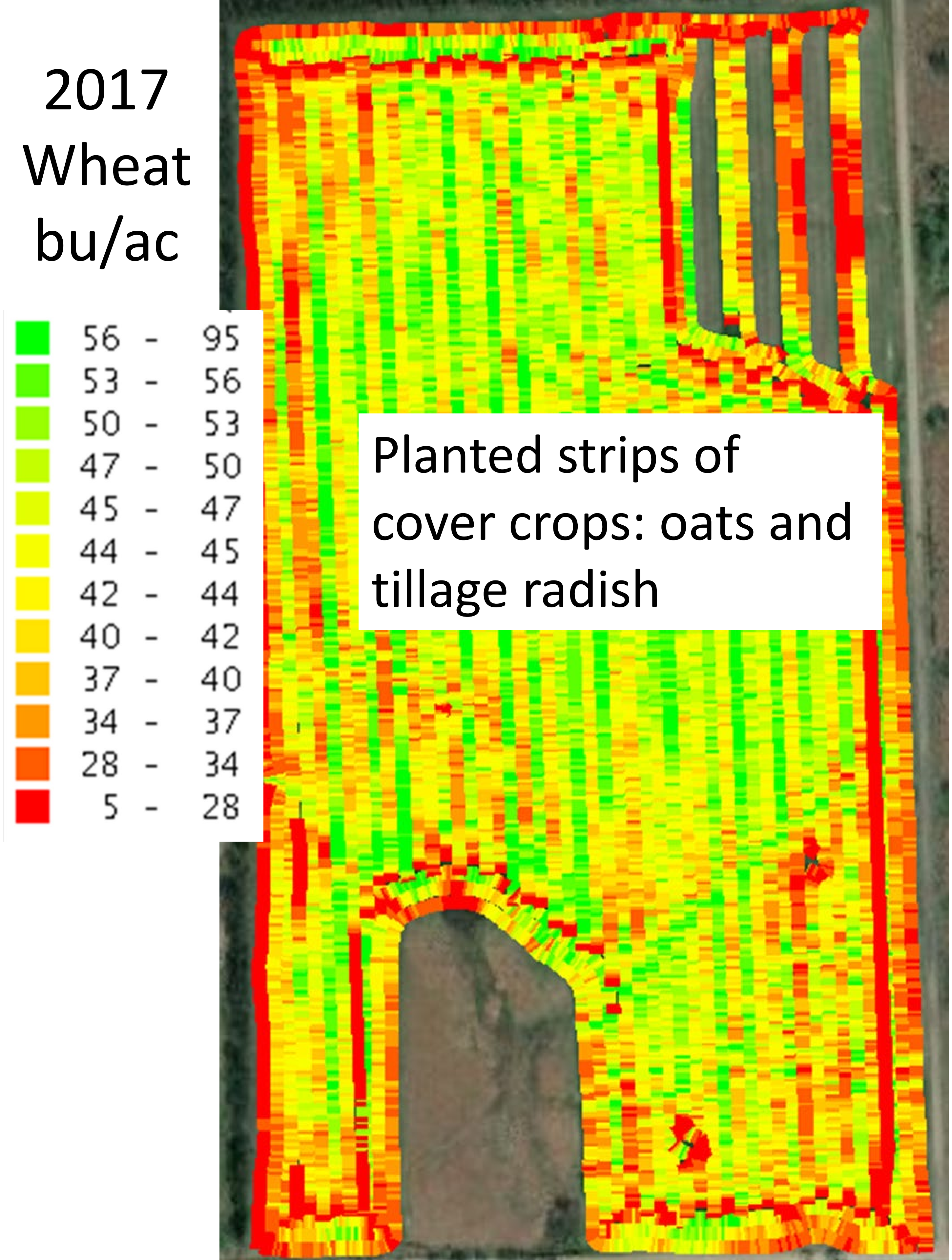
2015 Wheat bu/ac



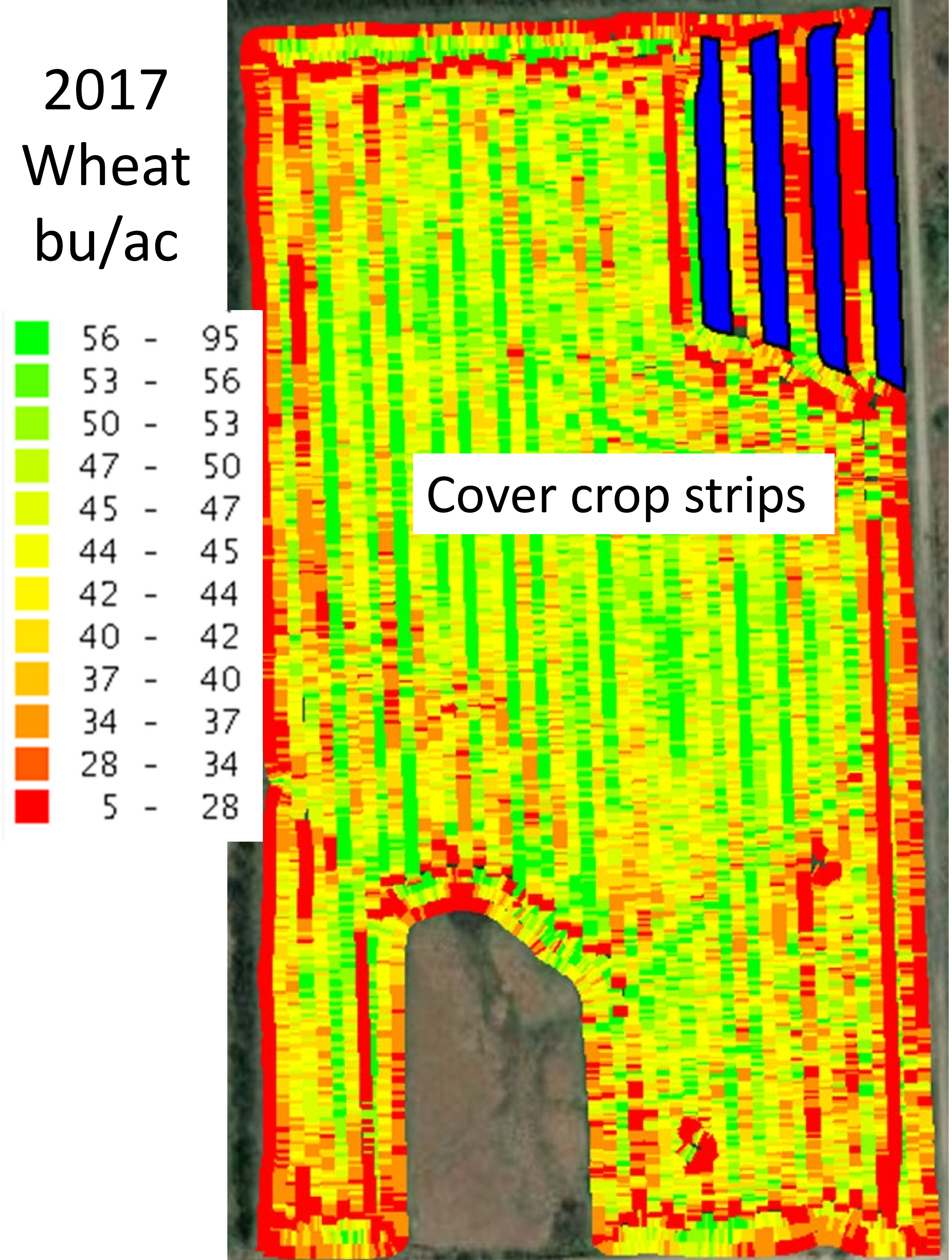
Select 6 acre area
Avg yield: 32 bu/ac
Compared to field average of 41.5

Take out of production and use to build soil

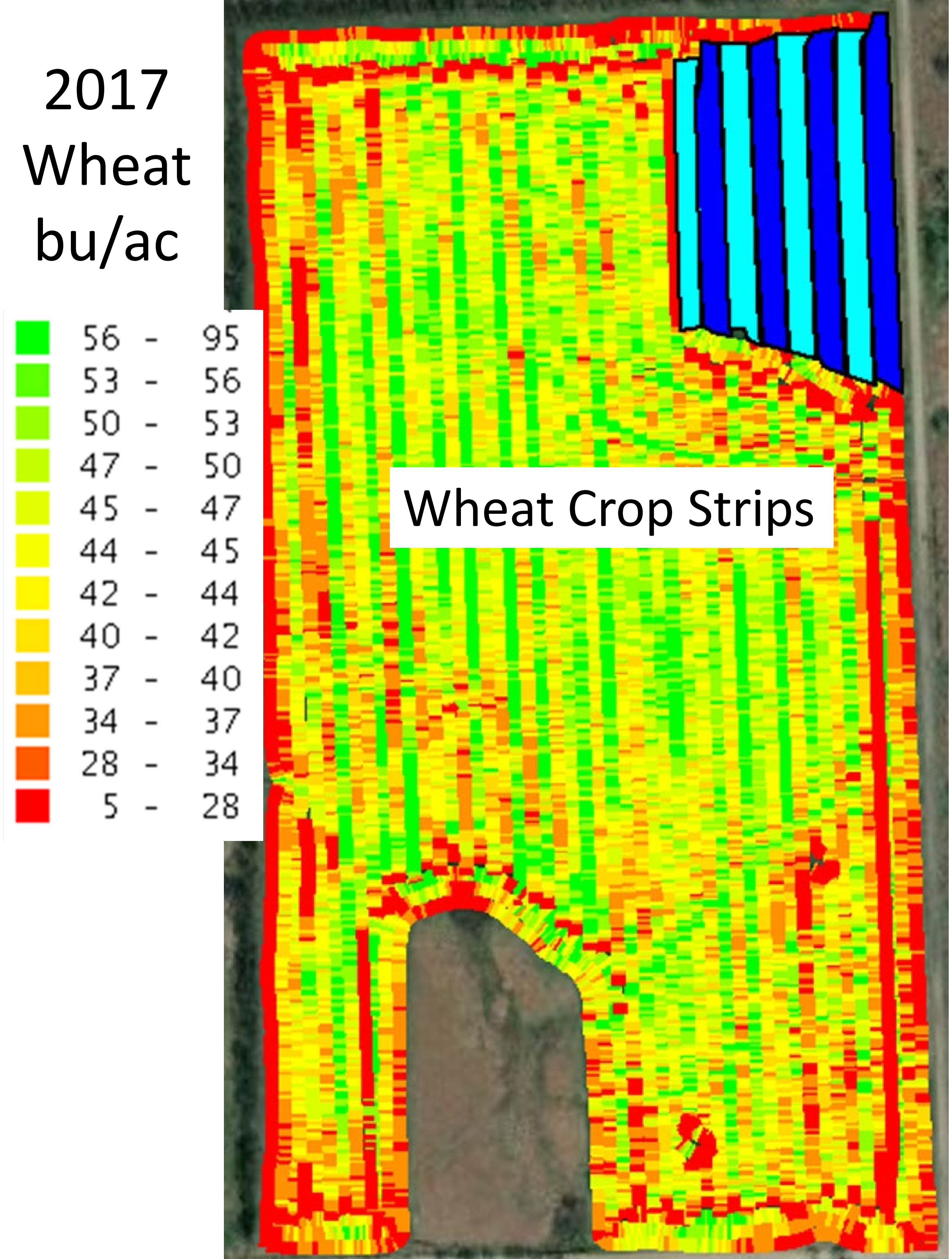
2017
Wheat
bu/ac



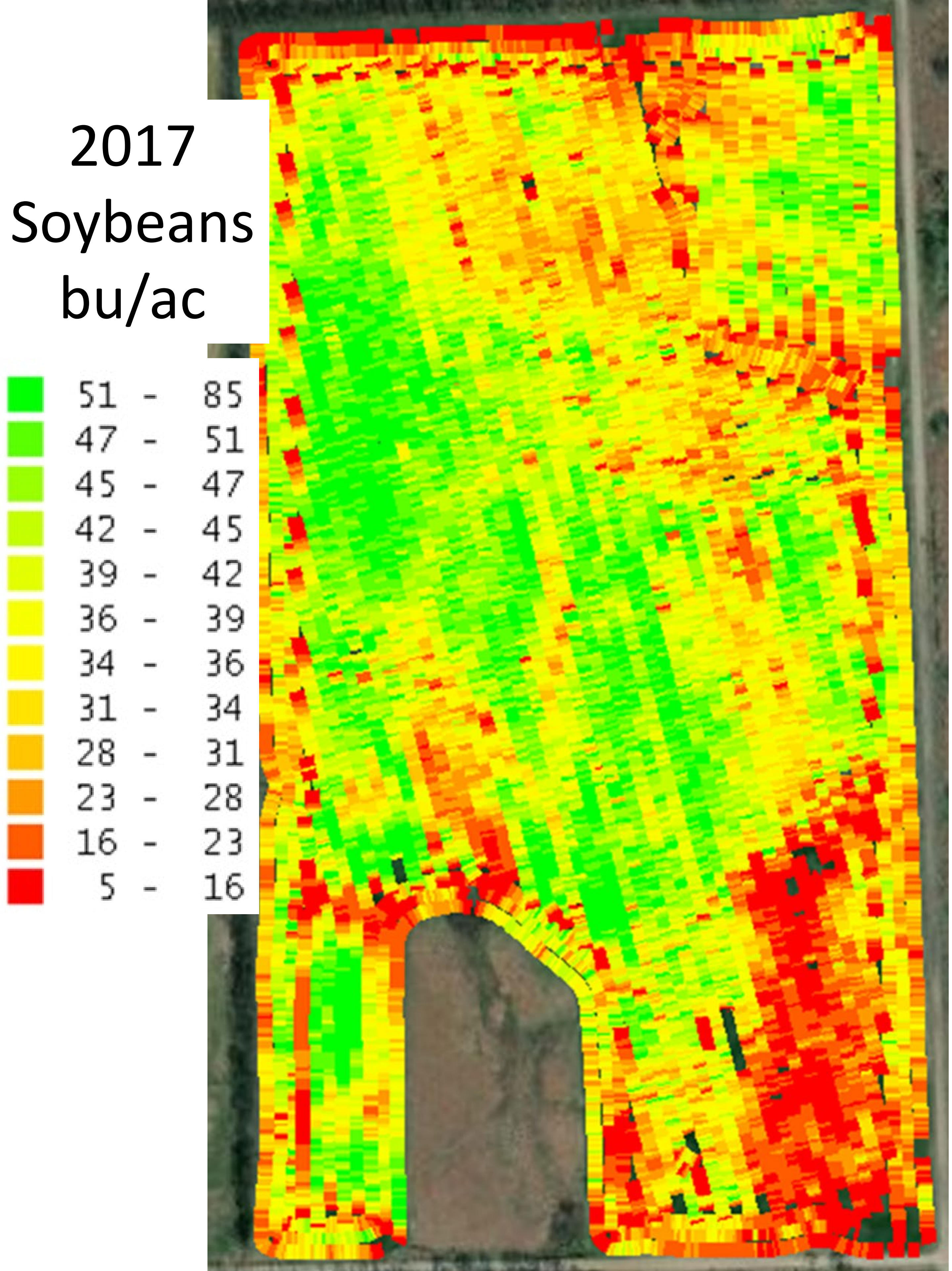
2017
Wheat
bu/ac

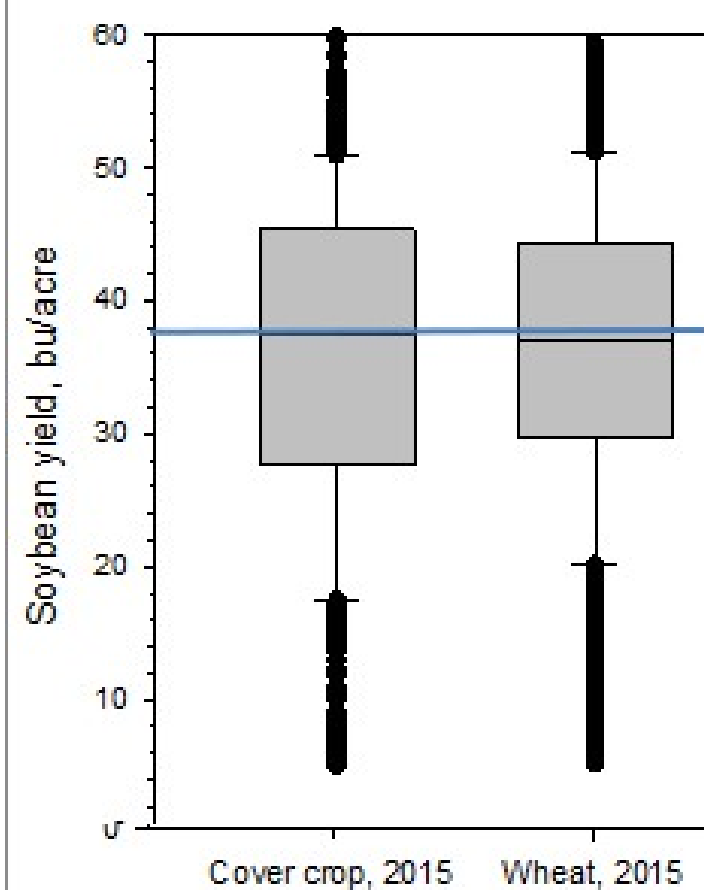


2017
Wheat
bu/ac

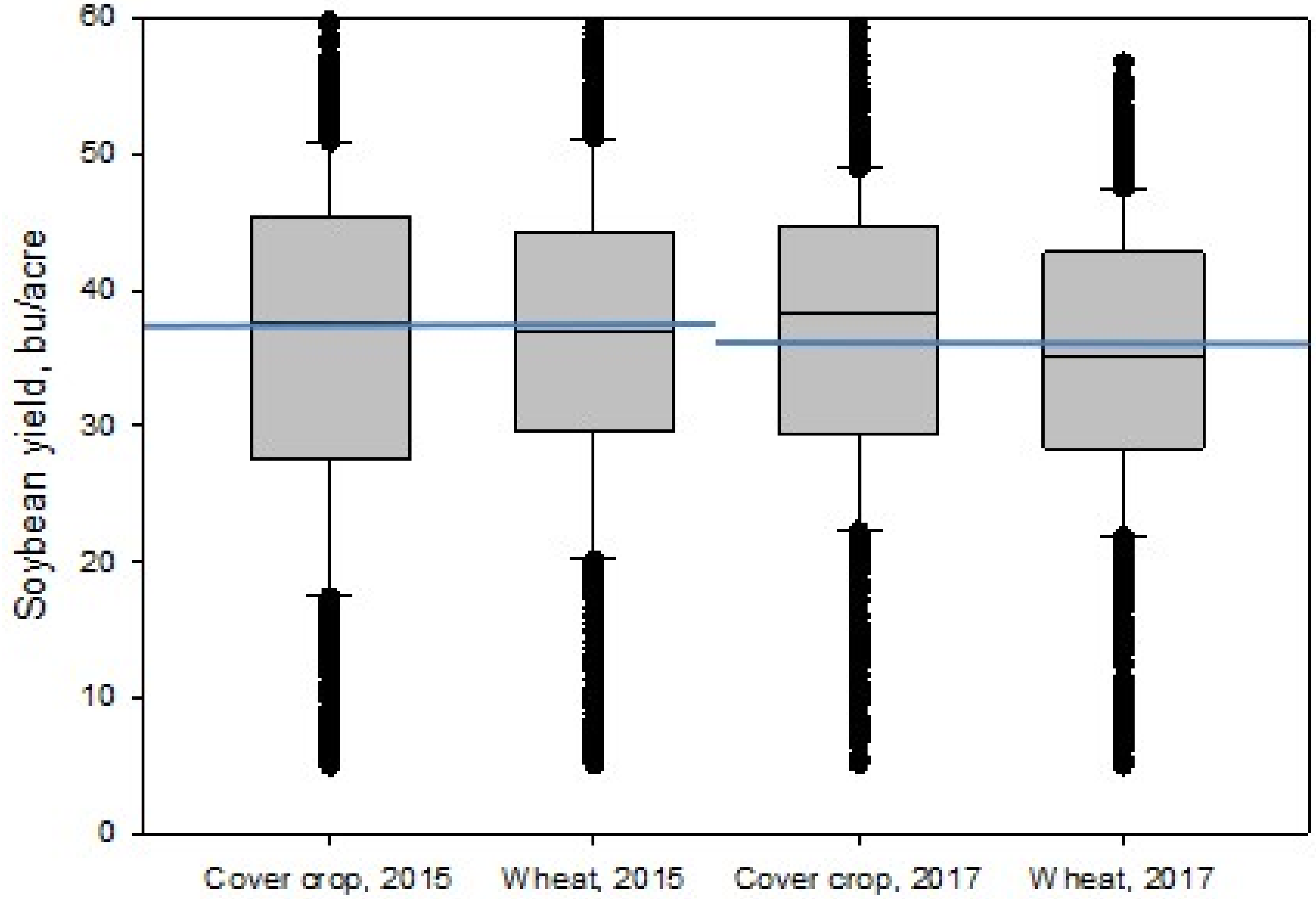


2017 Soybeans bu/ac

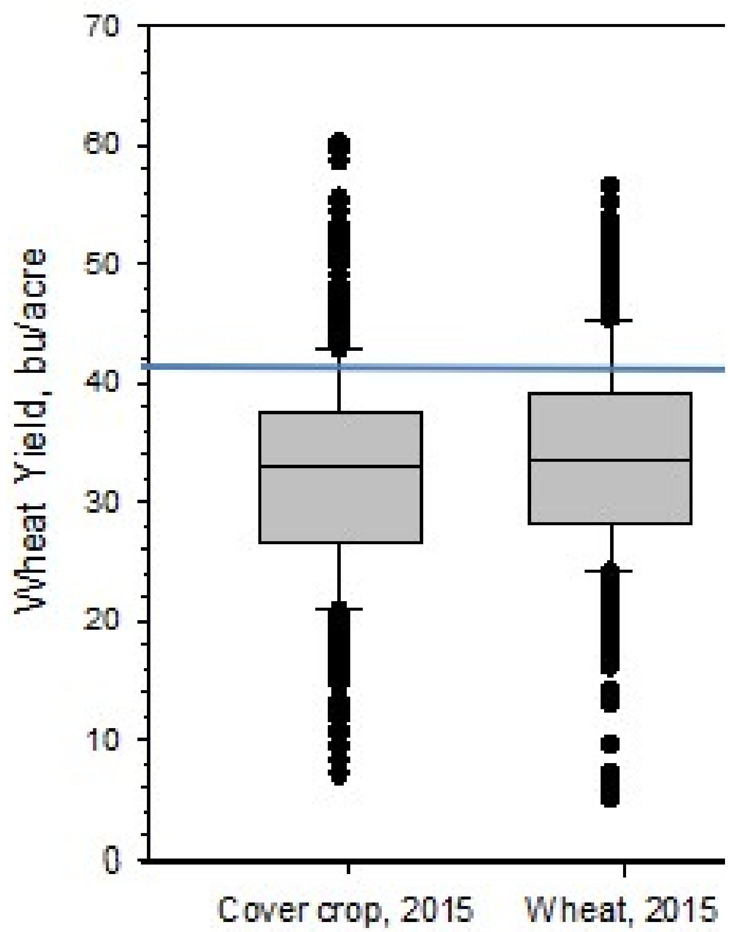




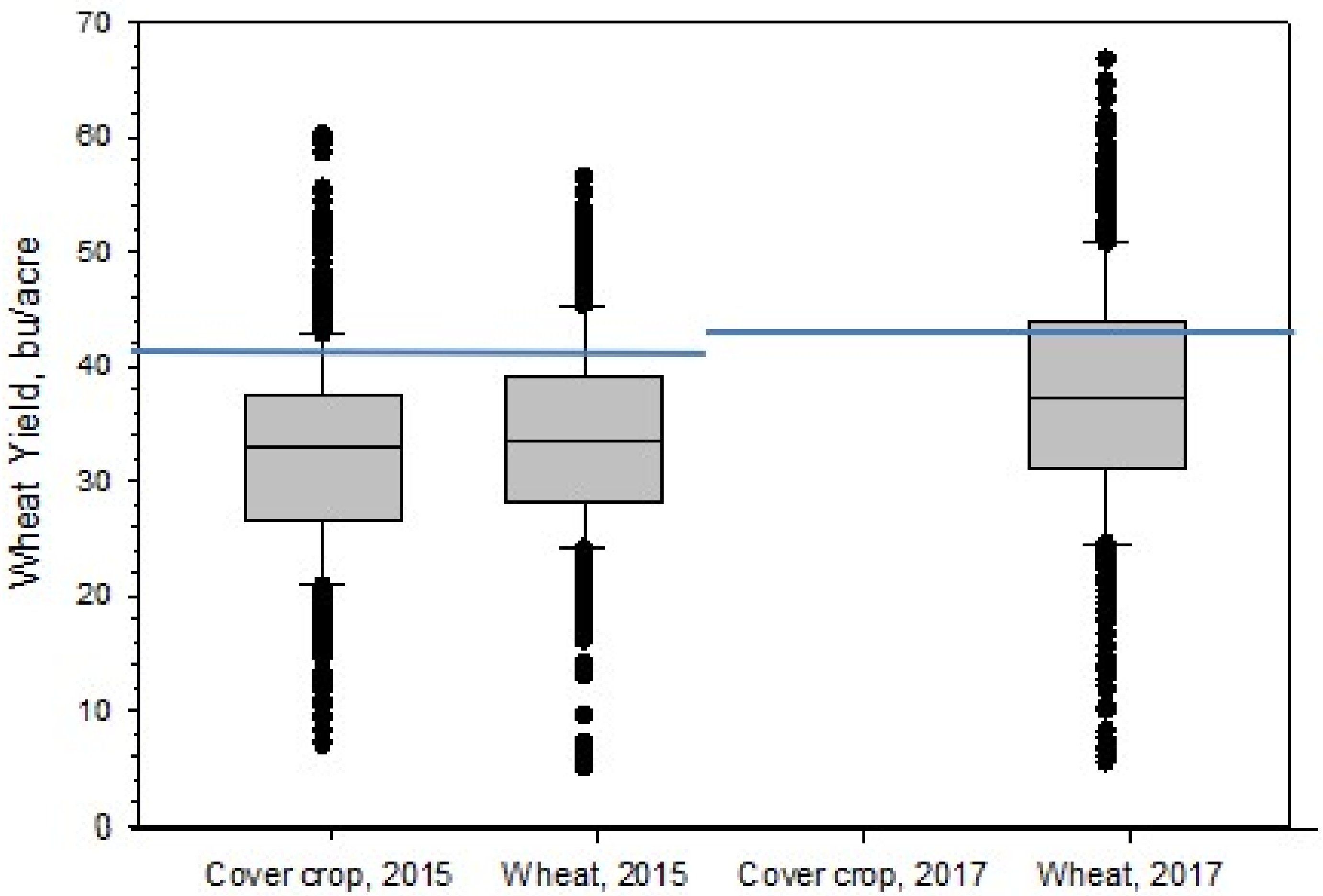
Soybean yield, bu/acre
60
50
40
30
20
10
0
Cover crop, 2015
Wheat, 2015



Soybean yield, bu/acre
60
50
40
30
20
10
0
Cover crop, 2015
Wheat, 2015
Cover crop, 2017
Wheat, 2017



Wheat Yield, bu/acre
70
60
50
40
30
20
10
0
Cover crop, 2015
Wheat, 2015


70
60
50
40
30
20
10
0
Wheat Yield, bu/acre
Cover crop, 2015
Wheat, 2015
Cover crop, 2017
Wheat, 2017

Making it pay

Soybean Cost Return Budget in Southeast Kansas

COST-RETURN PROJECTION — SOYBEANS — SOUTHEAST KANSAS

	Yield Level (bu/a)		
	27	**36**	**45**
INCOME PER ACRE			
A. Yield per acre	27	36	45
B. Price per bushel	$ 9.41	$ 9.41	$ 9.41
C. Net government payment	$	$	$
D. Indemnity payments	$	$	$
E. Miscellaneous income	$	$	$
F. Returns/acre ((A × B) + C + D + E)	$ 254.07	$ 338.76	$ 423.45
COSTS PER ACRE			
1. Seed	$ 58.50	$ 58.50	$ 63.00
2. Herbicide	28.72	28.72	28.72
3. Insecticide / Fungicide			
4. Fertilizer and Lime	31.40	39.48	48.64
5. Crop Consulting			
6. Crop Insurance*	4.84	8.40	11.95
7. Drying			
8. Miscellaneous	7.00	7.00	7.00
9. Custom Hire / Machinery Expense	76.85	108.09	112.14
10. Non-machinery Labor	7.50	7.50	7.50
11. Irrigation			
a. Labor			
b. Fuel and Oil			
c. Repairs and Maintenance			
d. Depreciation on Equipment and Well			
e. Interest on Equipment			
12. Land Charge / Rent	24.00	32.00	40.00
G. SUB TOTAL	$ 238.81	$ 289.68	$ 318.94
13. Interest on ½ Nonland Costs	6.98	8.37	9.07
H. TOTAL COSTS	$ 245.79	$ 298.06	$ 328.01
I. RETURNS OVER COSTS (F - H)	$ 8.28	$ 40.70	$ 95.44
J. TOTAL COSTS/BUSHEL (H ÷ A)	$ 9.10	$ 8.28	$ 7.29
K. RETURN TO ANNUAL COST (I + 13) ÷ G	6.39%	16.94%	32.77%

** Reflects expected net premium paid*

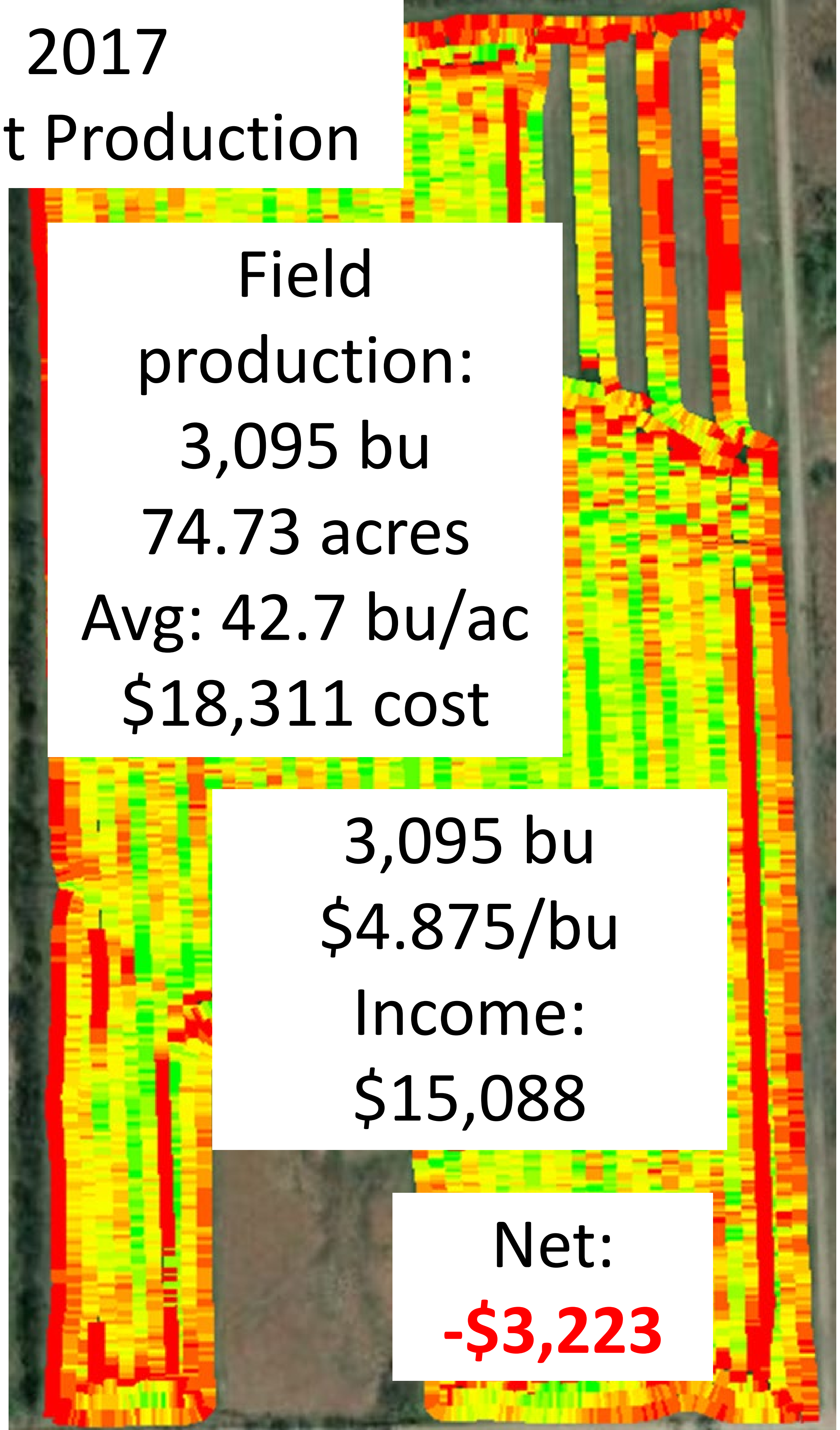
https://www.bookstore.ksre.ksu.edu/pubs/MF994.pdf

Per Acre Production Costs

Item	Cover Crop	Soybeans	Wheat
Seed	$28.00	$51.00	$21.60
Herbicide		$7.76	$4.48
Insect/Fungicide			$6.69
Fertilizer		$15.77	$45.39
Machinery	15.11*	$76.39	$87.11
Miscellaneous		$67.13	$79.76
Total	**$43.11**	**$218.05**	**$245.03**

Production information from Cost-Return Budgets for Southeast Kansas, Kansas State University
*Planting costs

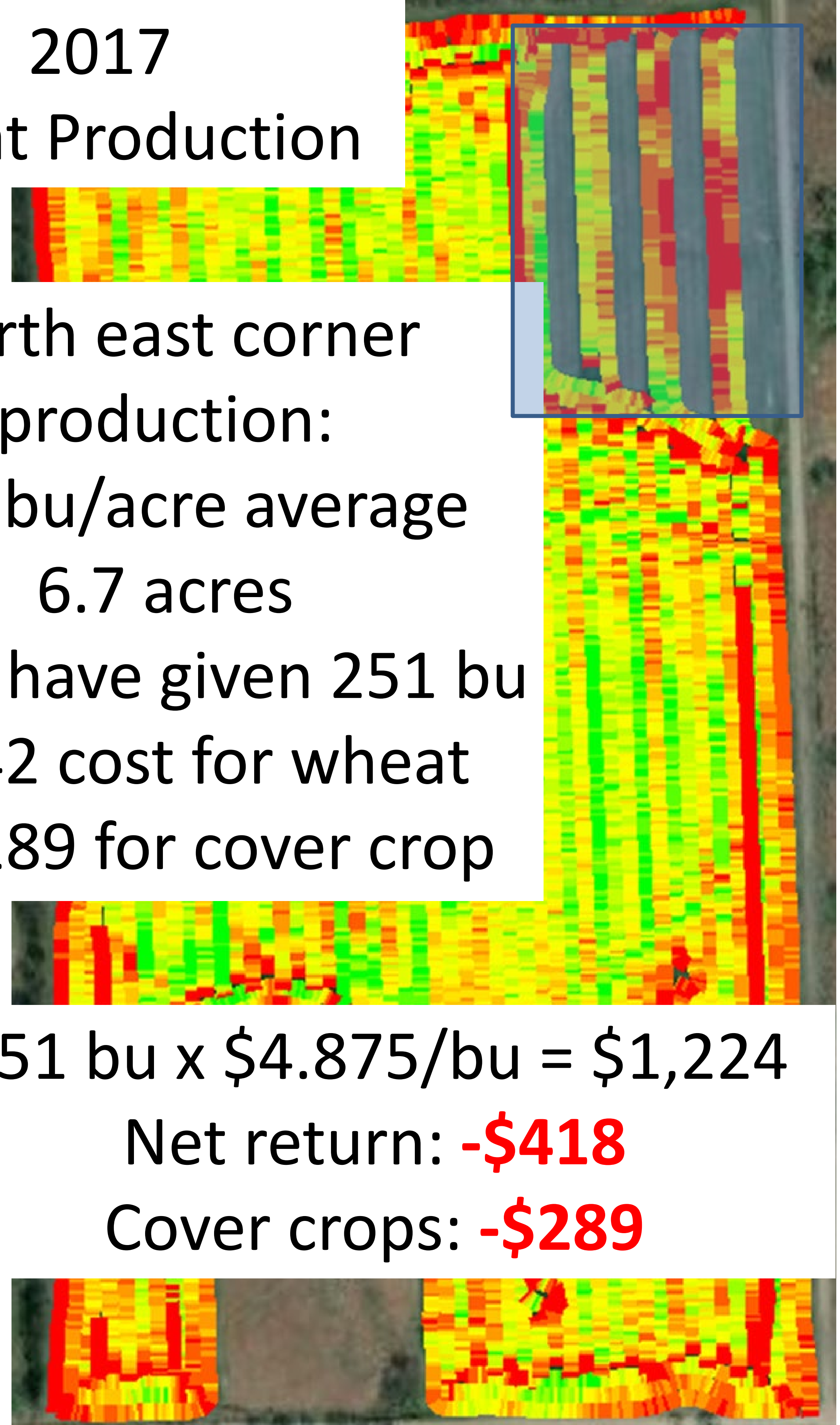
2017
Wheat Production



Field production:
3,095 bu
74.73 acres
Avg: 42.7 bu/ac
$18,311 cost

3,095 bu
$4.875/bu
Income:
$15,088

Net:
-$3,223



2017
Wheat Production

North east corner production:
37.4 bu/acre average
6.7 acres
Would have given 251 bu
$1642 cost for wheat
Vs. $289 for cover crop

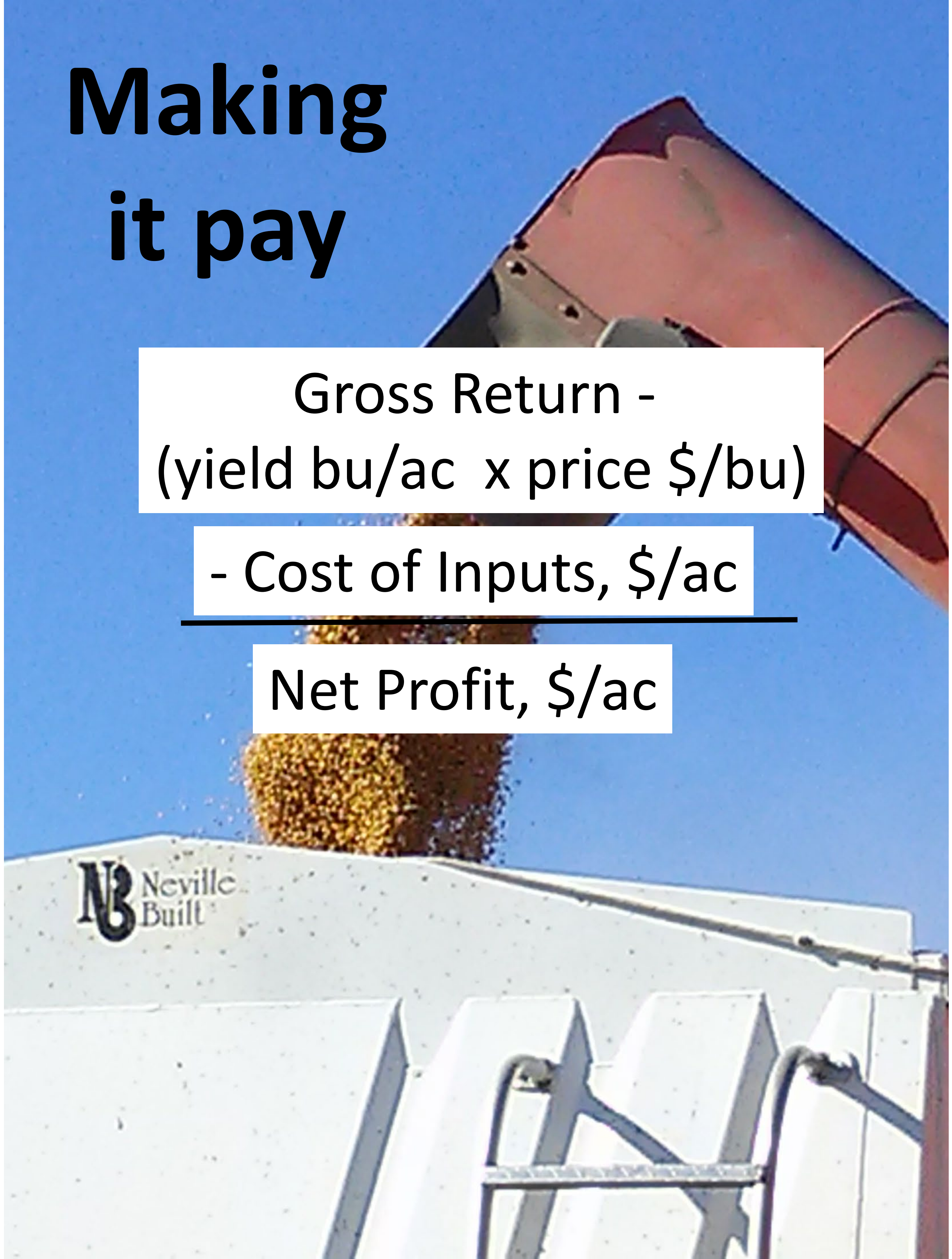
251 bu x $4.875/bu = $1,224
Net return: **-$418**
Cover crops: **-$289**

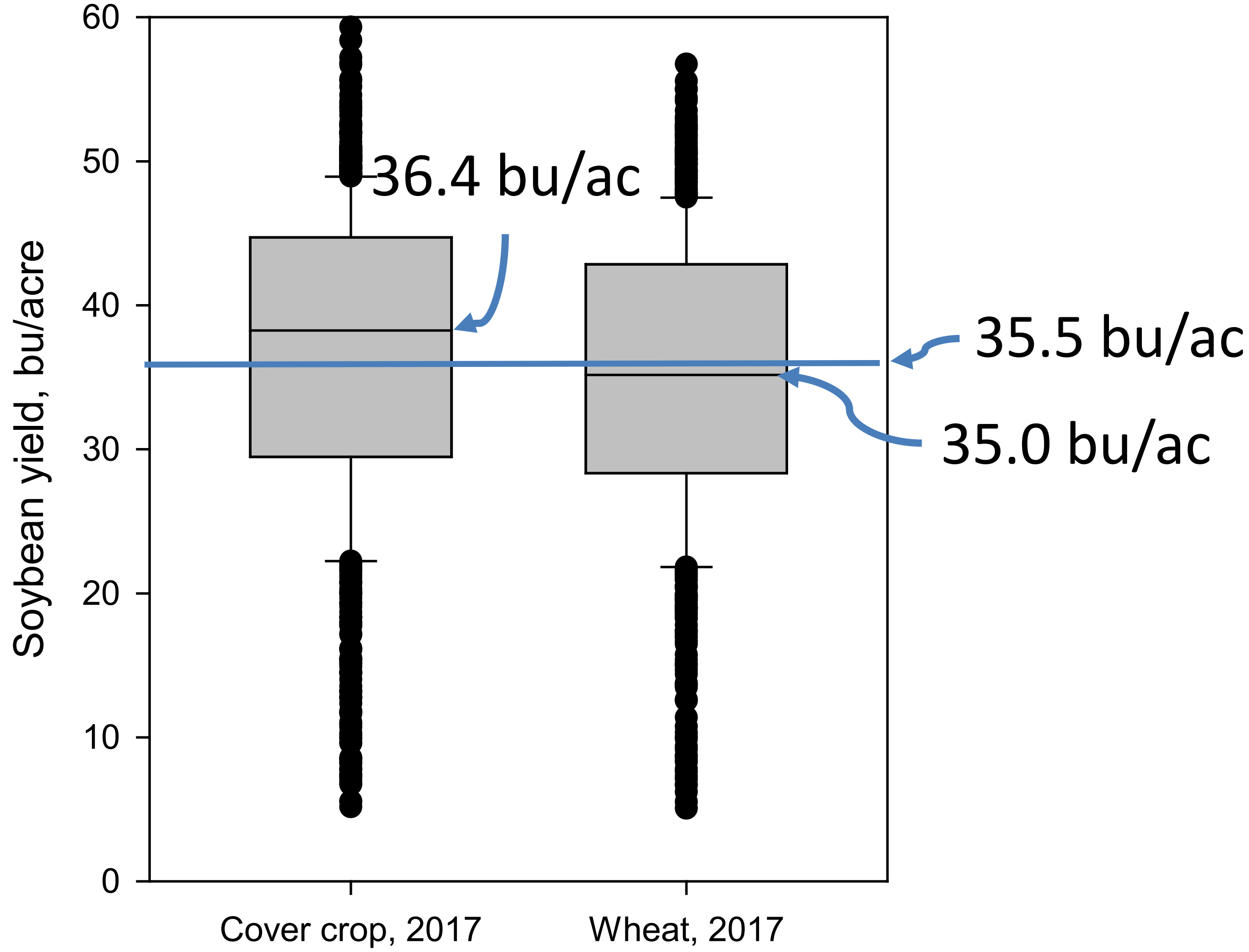
Making it pay

Gross Return -
(yield bu/ac x price $/bu)

- Cost of Inputs, $/ac

Net Profit, $/ac





60
50
40
30
20
10
0
Soybean yield, bu/acre
36.4 bu/ac
35.5 bu/ac
35.0 bu/ac
Cover crop, 2017
Wheat, 2017

Soybean production

	Yield Bu/ac	Income $/acre*	Net Return $/acre**
Field Average	35.5	$302.46	$84.41

*$8.52/bu
**$218.05/acre

Soybean production

	Yield Bu/ac	Income $/acre*	Net Return $/acre**
Field Average	35.5	$302.46	$84.41
Cover Crop Area	36.4	$310.13	$92.08

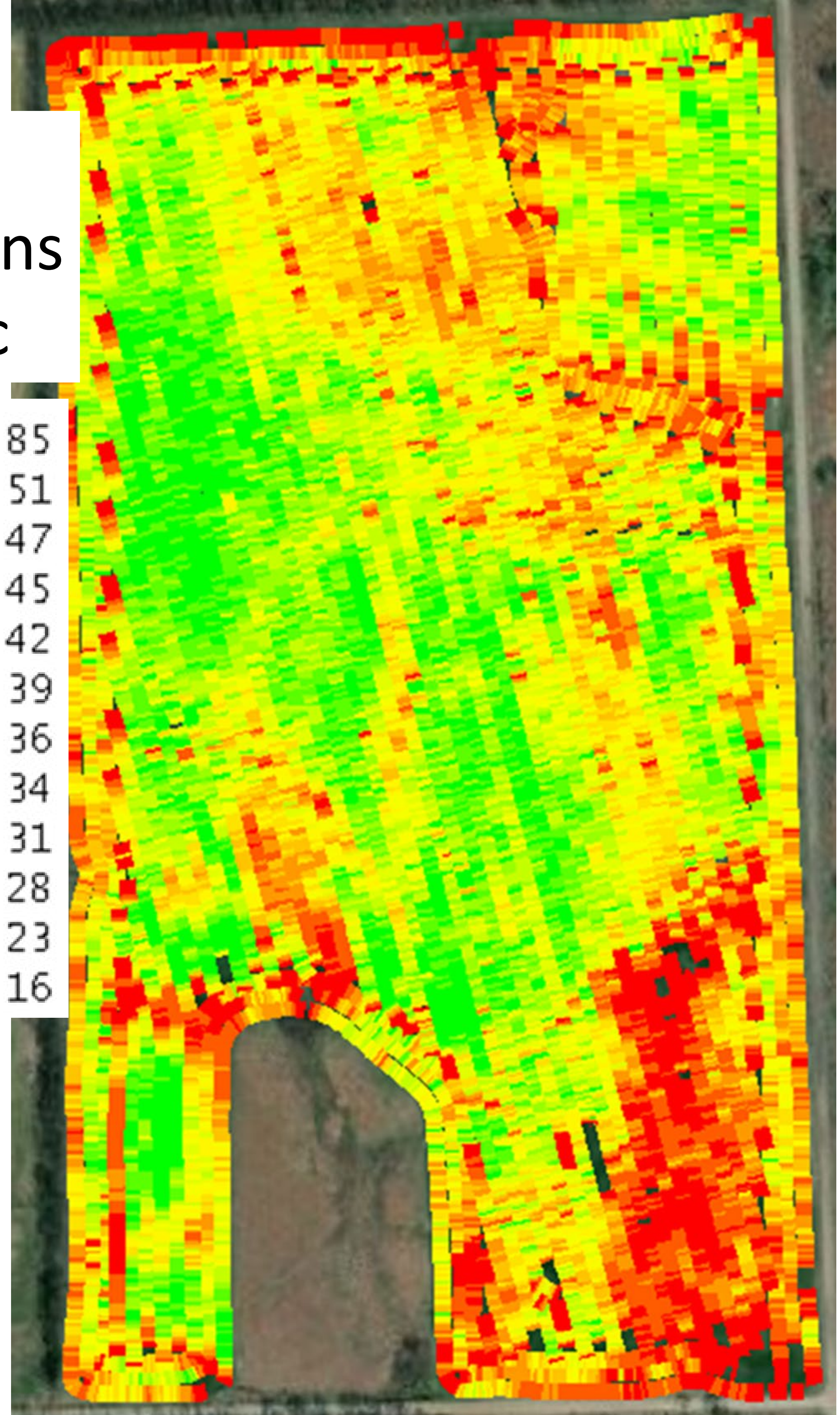
*$8.52/bu
**$218.05/acre

Soybean production

	Yield Bu/ac	Income $/acre*	Net Return $/acre**
Field Average	35.5	$302.46	$84.41
Cover Crop Area	36.4	$310.13	$92.08
Wheat Area	35.0	$298.20	$80.15

*$8.52/bu
**$218.05/acre

2017 Soybeans bu/ac

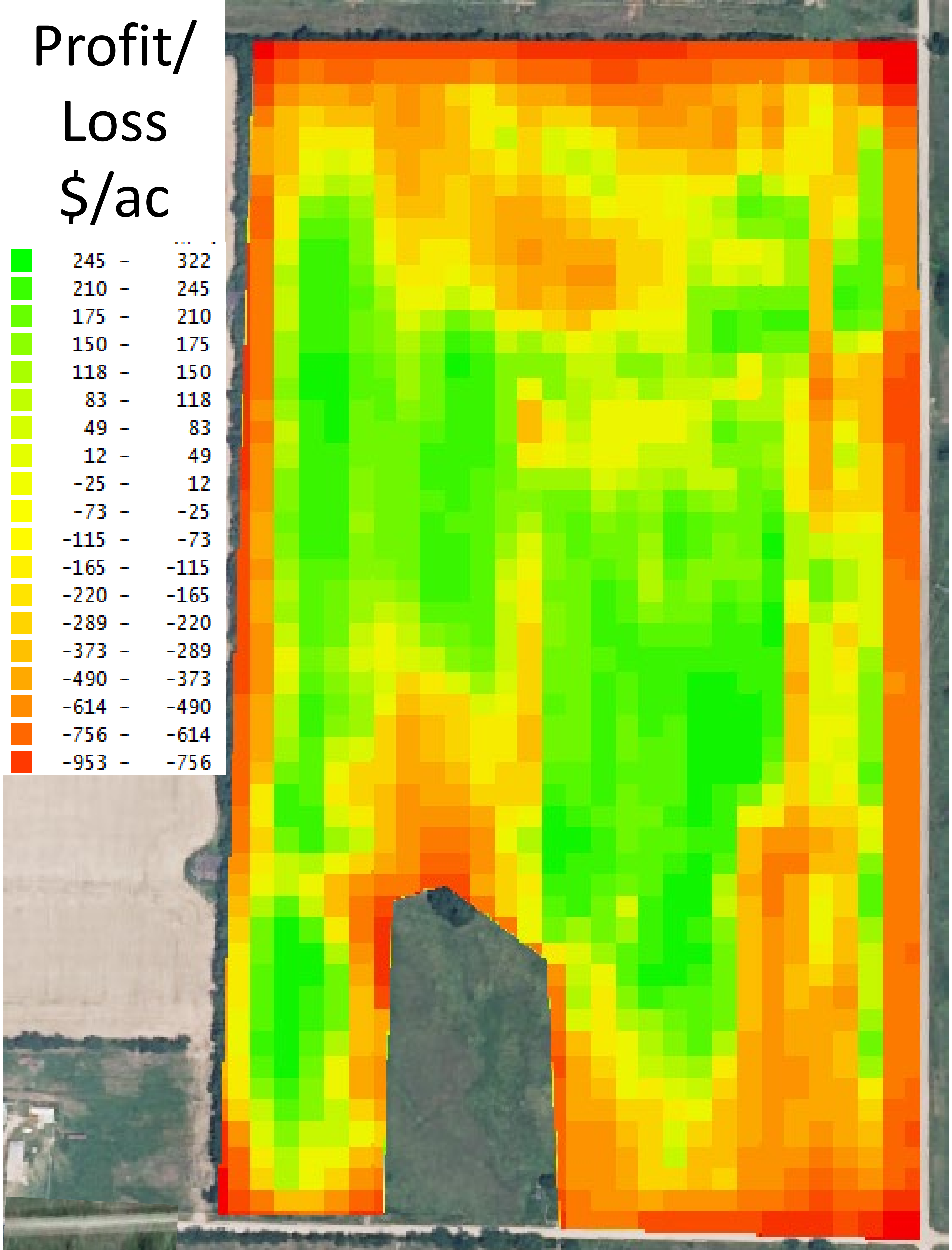


		Input Costs	Income	Net Return
Wheat	Wheat	$245.03	$182.33	-$62.70
	Cover Crop	$ 43.11	$ 0.00	-$43.11

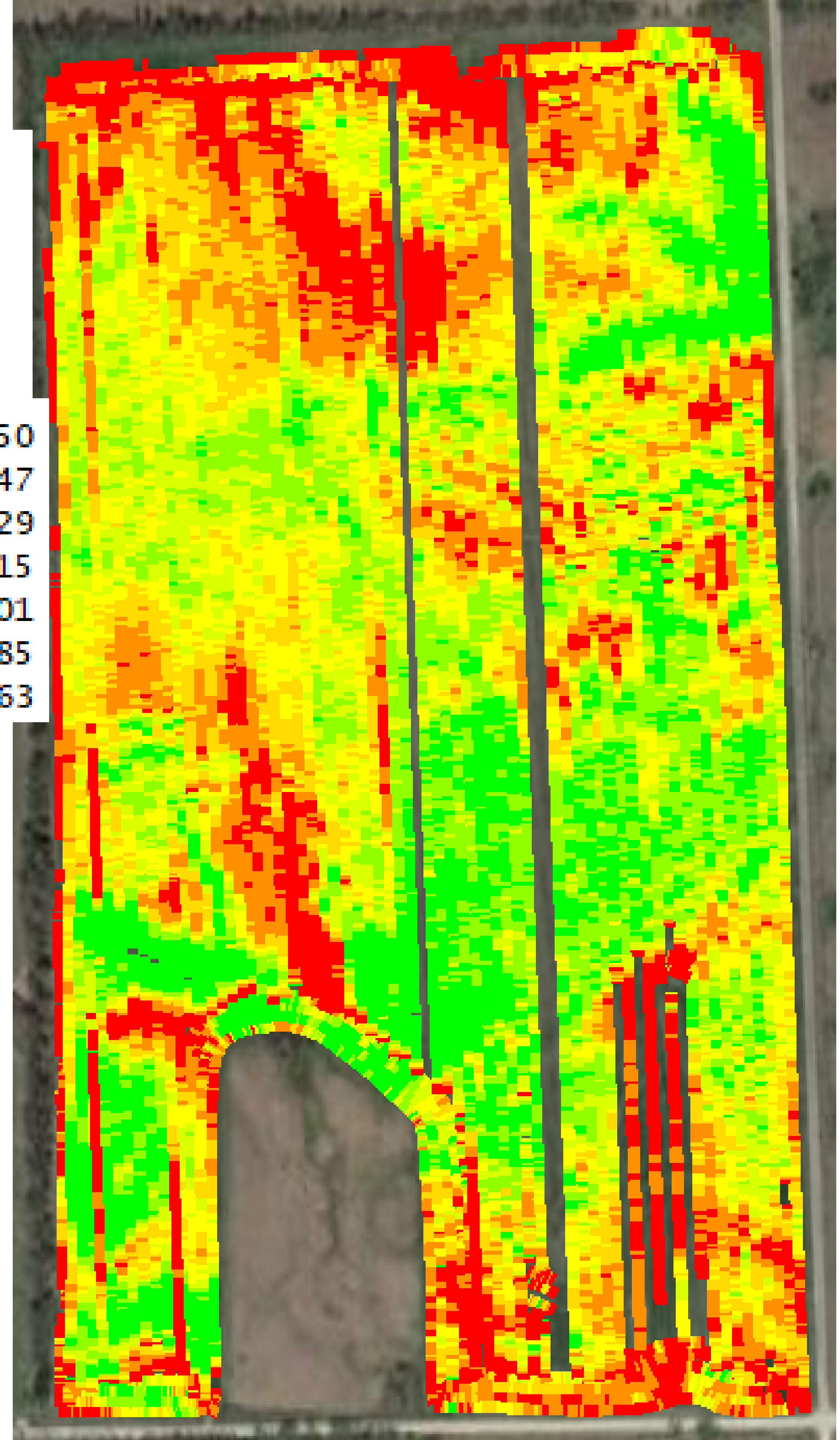
		Input Costs	Income	Net Return
Wheat	Wheat	$245.03	$182.33	-$62.70
	Cover Crop	$ 43.11	$ 0.00	-$43.11
Soybean	Wheat	$218.05	$298.20	$80.15
	Cover Crop	$218.05	$310.13	$92.08

		Input Costs	Income	Net Return
Wheat	Wheat	$245.03	$182.33	-$62.70
	Cover Crop	$ 43.11	$ 0.00	-$43.11
Soybean	Wheat	$218.05	$298.20	$80.15
	Cover Crop	$218.05	$310.13	$92.08
Wheat/ Soybean	Wheat	$463.08	$480.53	$17.45
	Cover Crop	$261.16	$310.13	$48.97

$31.52/acre net return more
with cover crops than with wheat


Profit/
Loss
$/ac
245 - 322
210 - 245
175 - 210
150 - 175
118 - 150
83 - 118
49 - 83
12 - 49
-25 - 12
-73 - -25
-115 - -73
-165 - -115
-220 - -165
-289 - -220
-373 - -289
-490 - -373
-614 - -490
-756 - -614
-953 - -756

2018 Corn bu/ac



Questions?

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