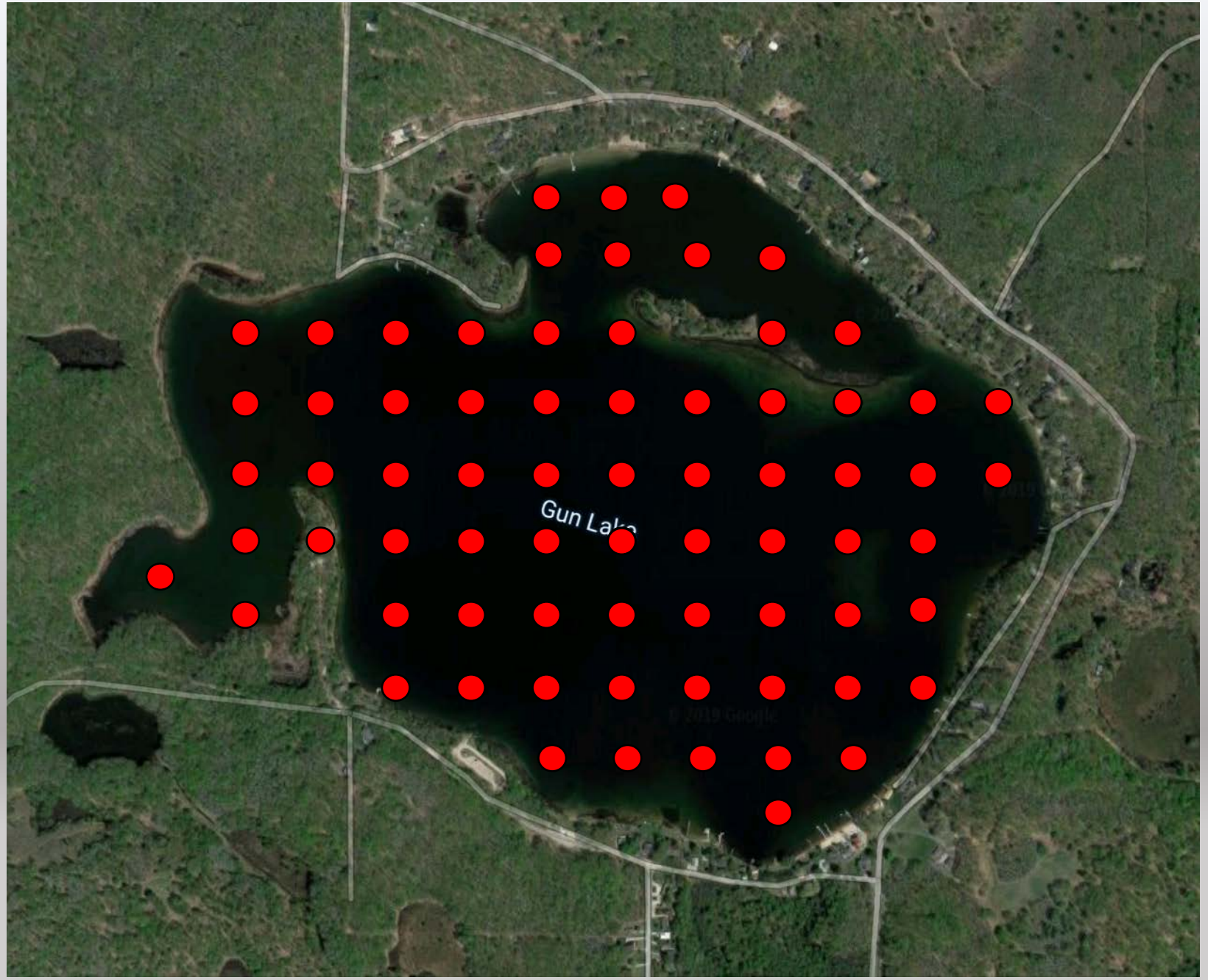
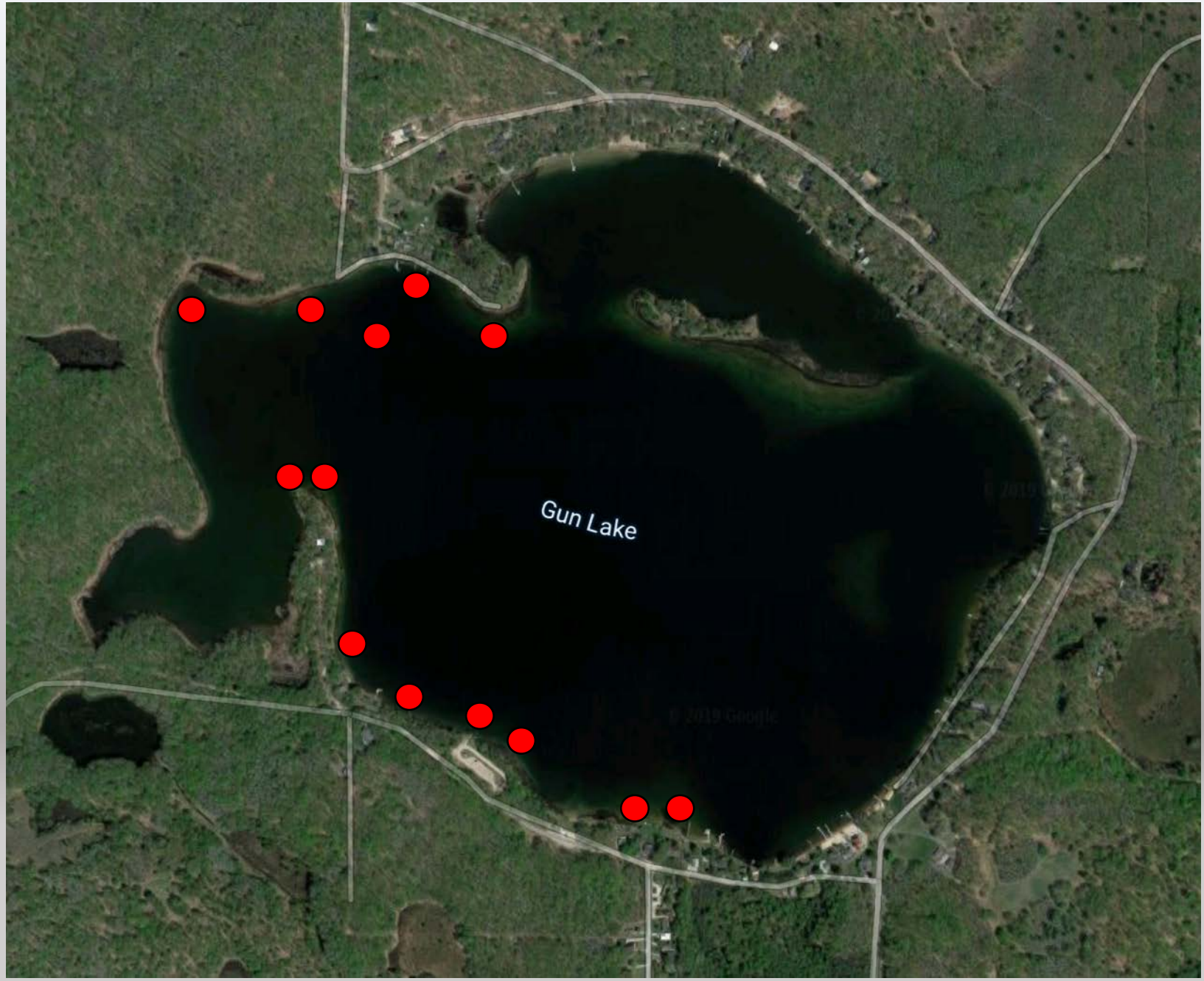
Using spatial information to improve soil sampling

Dr. Jason Ackerson
Assistant Professor of Soil Science
Purdue University
Email: jackers@purdue.edu
Twitter: @purdue_soil


Gun Lake


Gun Lake

How do we improve our fishing trip?

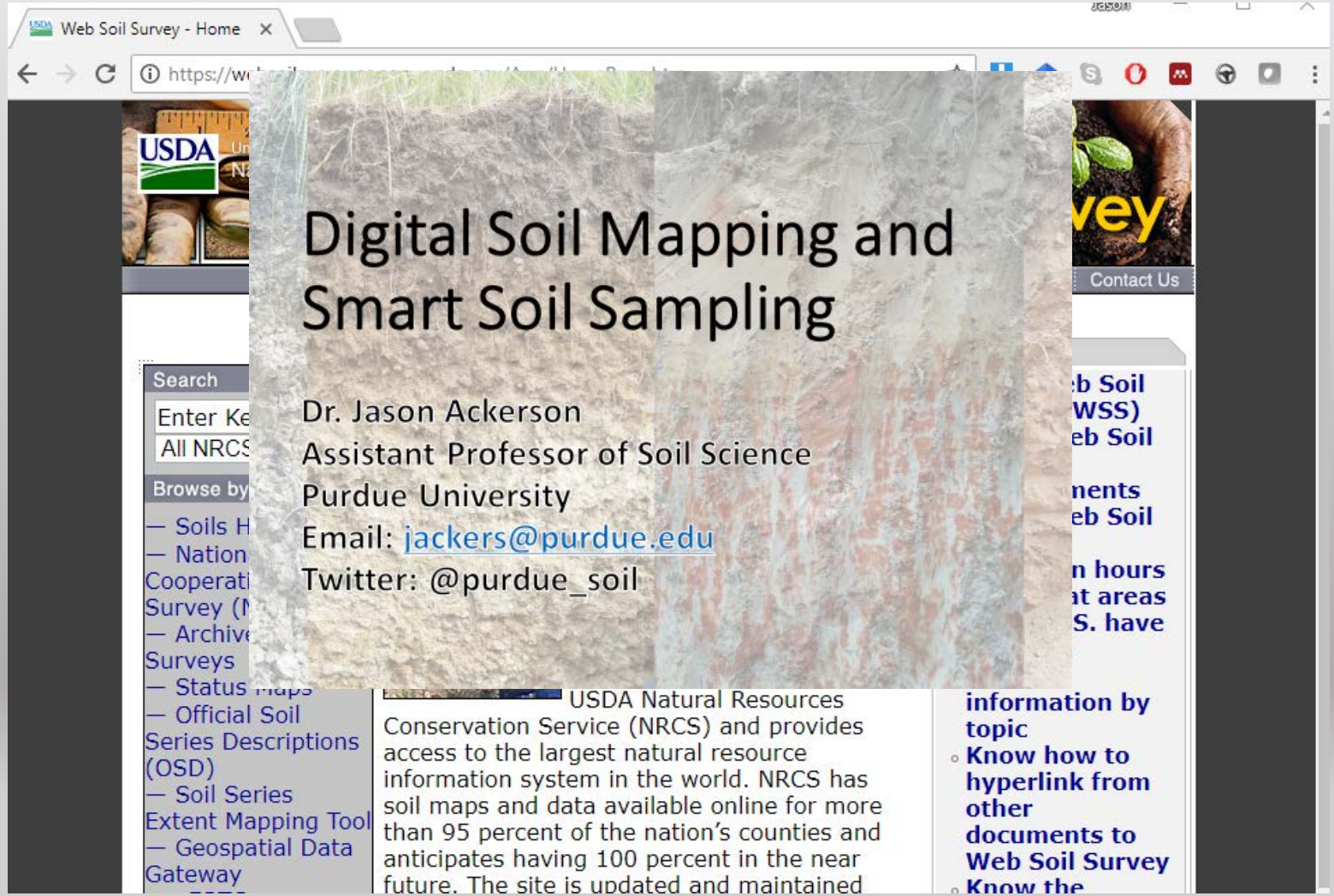

Gun Lake

What does fishing have to do with soil sampling?

- “Fishing” expeditions are inefficient
- Grid sampling is like fishing
- We want to cast where the fish are
  - Using knowledge of fish ecology to target our search

- ***We can use soil information to direct sampling/management***

Web Soil Survey

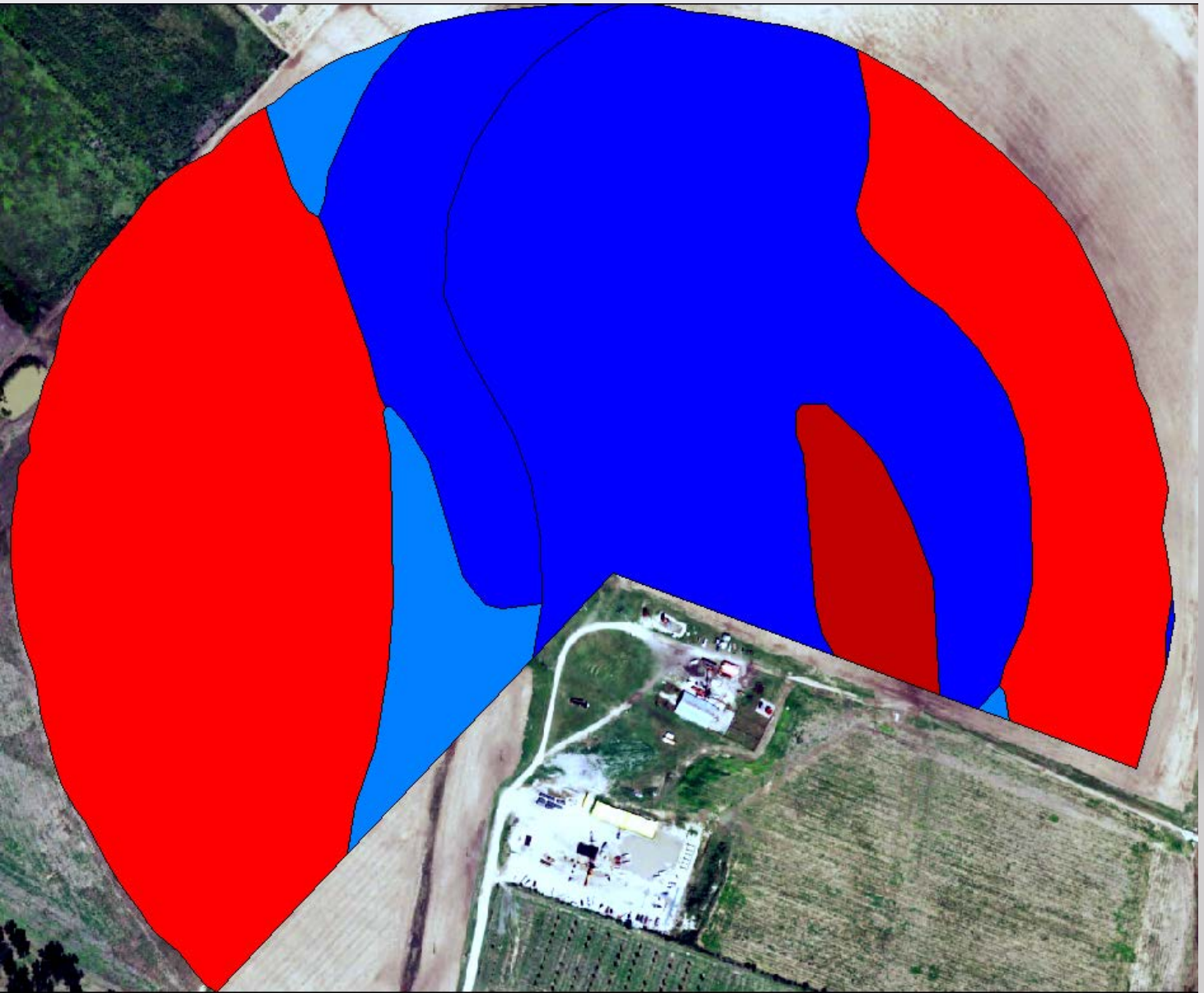


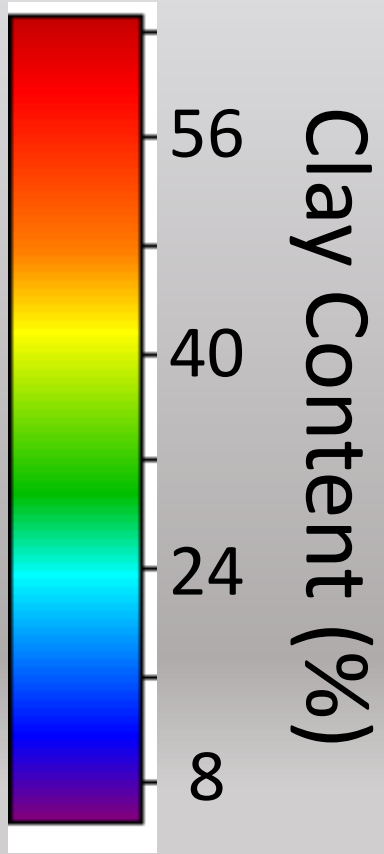
Soil Map

Scale 1:6,000 ± 1 %

⚠ *Warning: Soil Map may not be valid at this scale.*

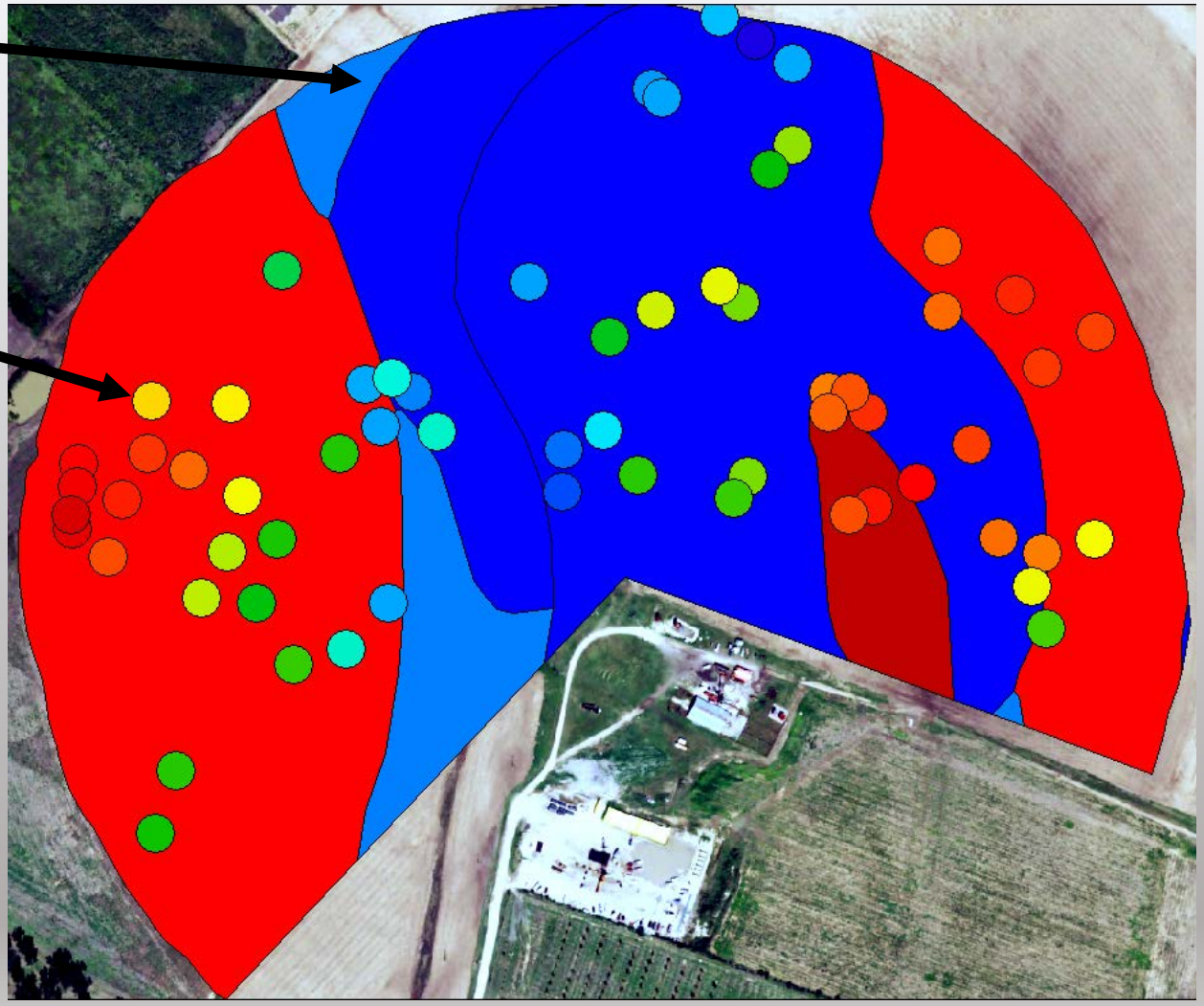
SSURGO: Clay 0-50 cm

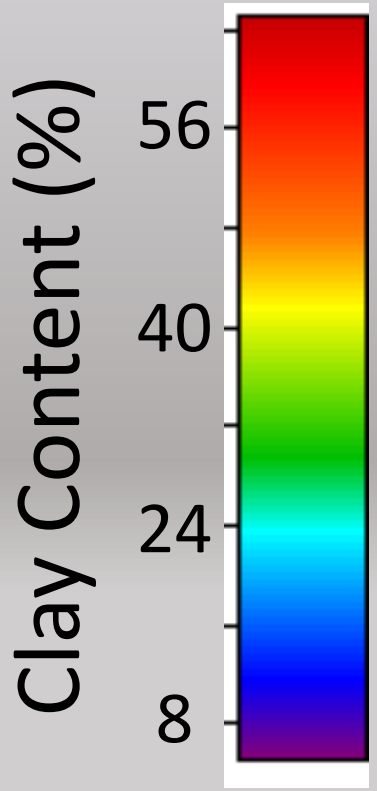




Web Soil Survey

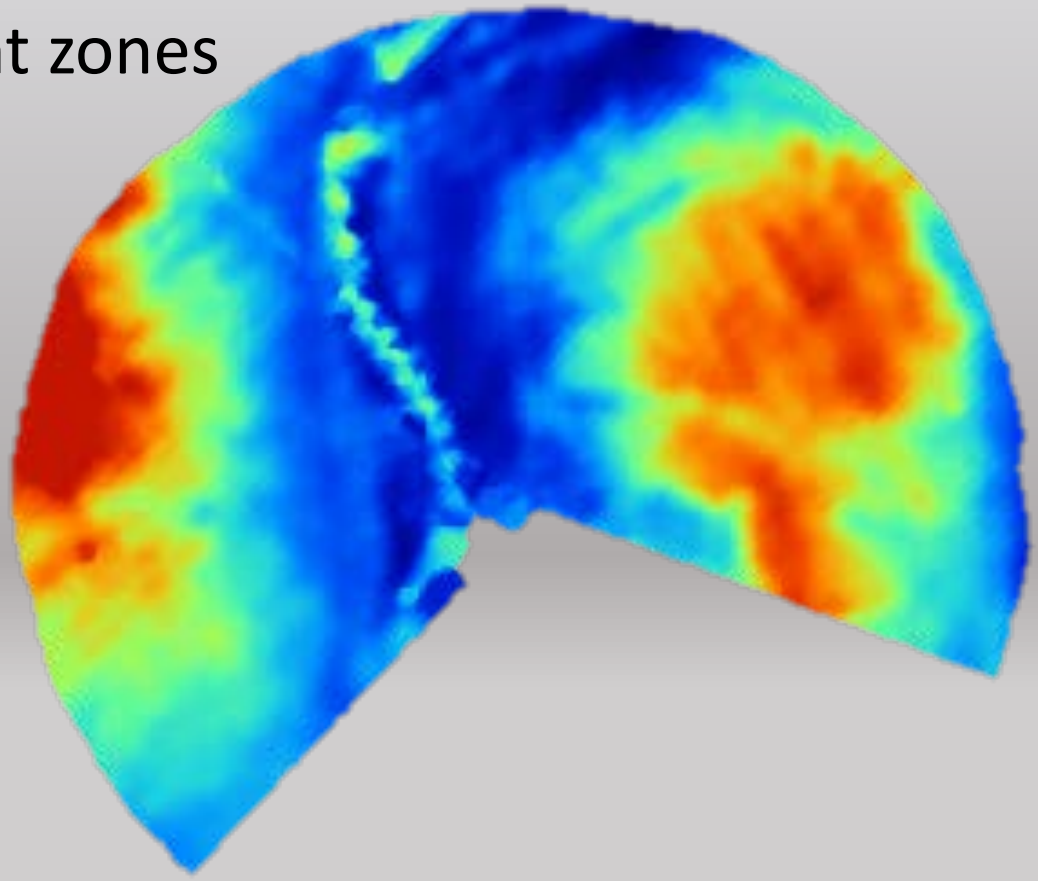
Measured





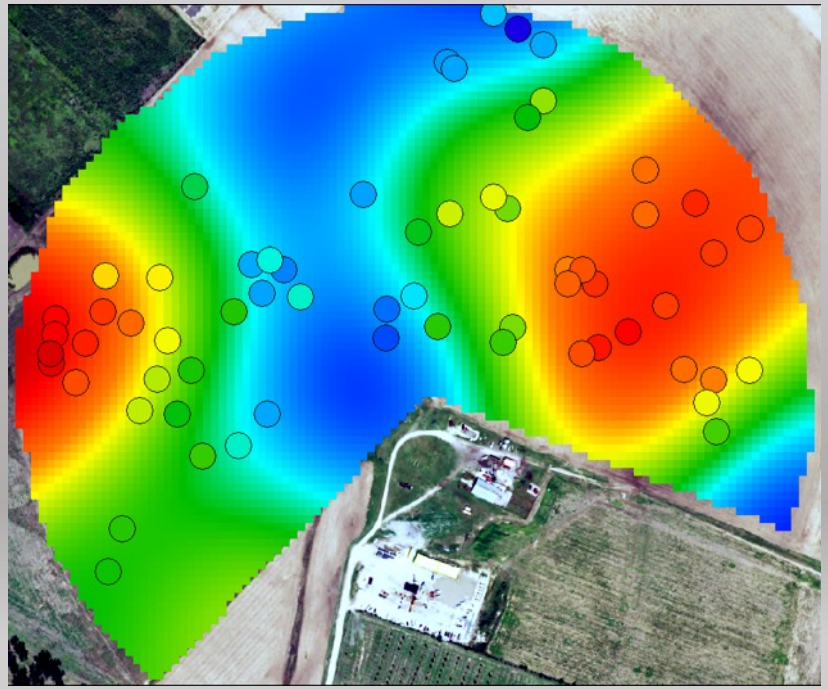
Need *precision* soil maps

- Variable rate (fertilizer, lime, seeding, etc.)
- Soil-based management zones
- Precision conservation

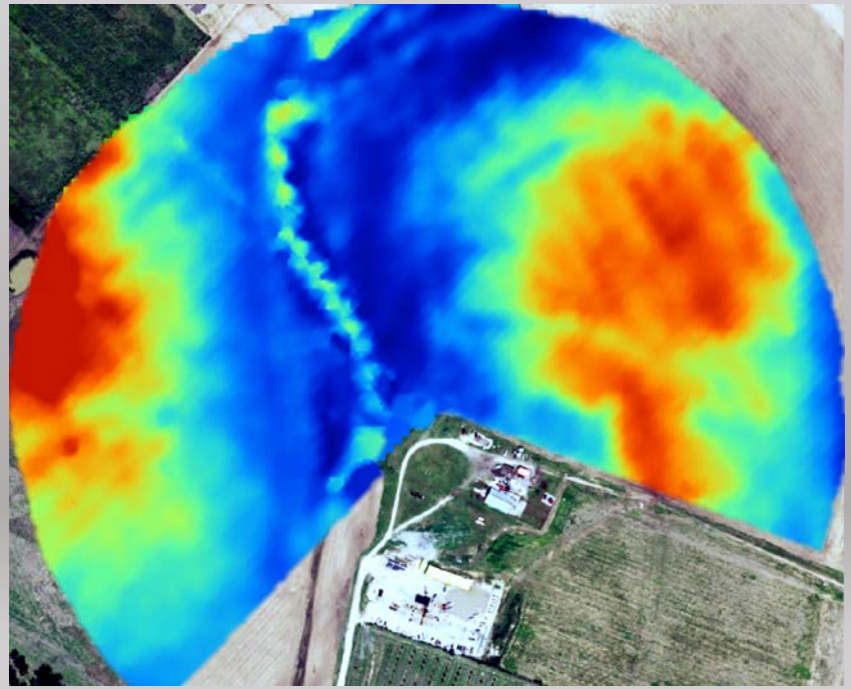


Making precision soil maps

Interpolation



Digital Soil Mapping



Making precision soil maps

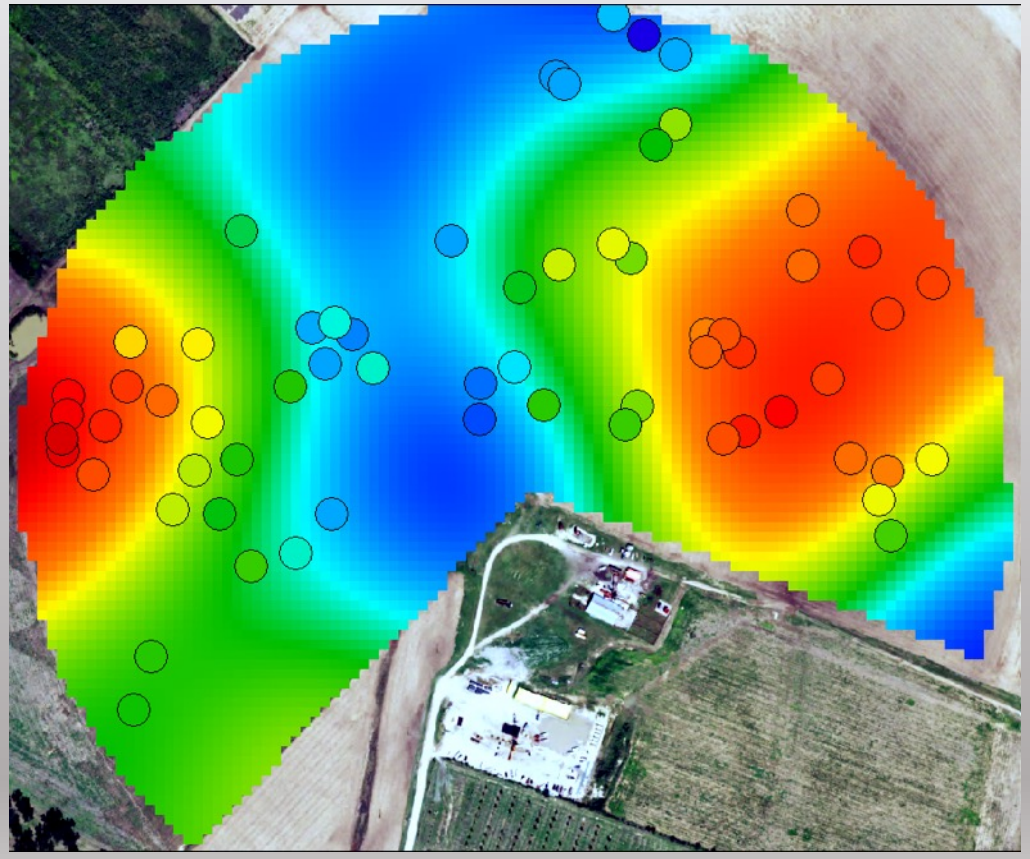
Interpolation

- Uses soil observations and their separation distance only
- Statistical “guessing”

Digital Soil Mapping

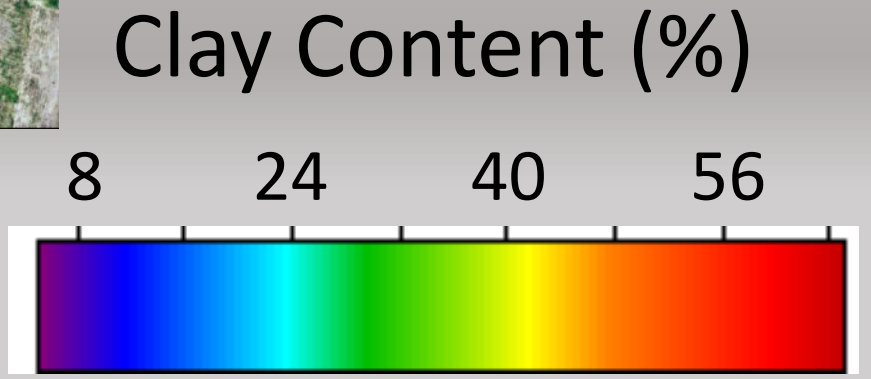
- Uses relationships between soil and environment
- Statistical prediction

Interpolation:

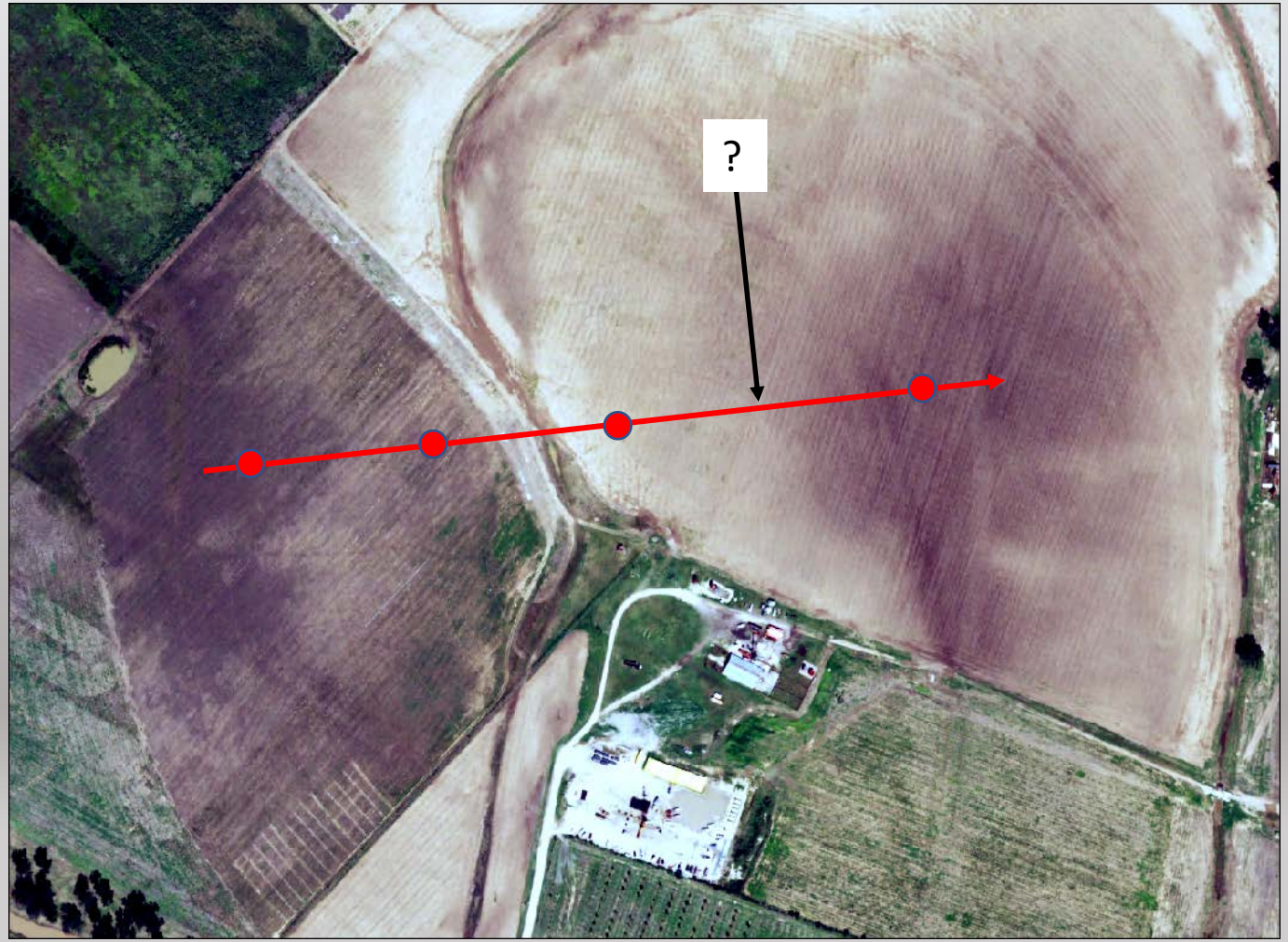


Predicts property at new locations using *only observations of that property*

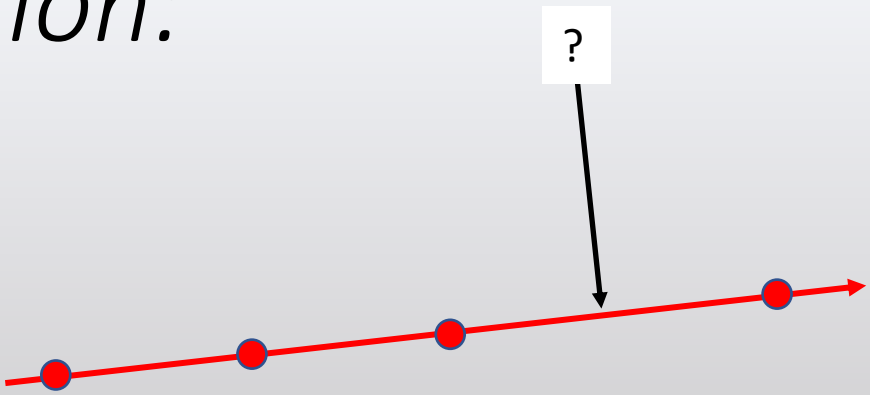
Ex. Inverse Distance, Kriging, Nearest Neighbor, etc.

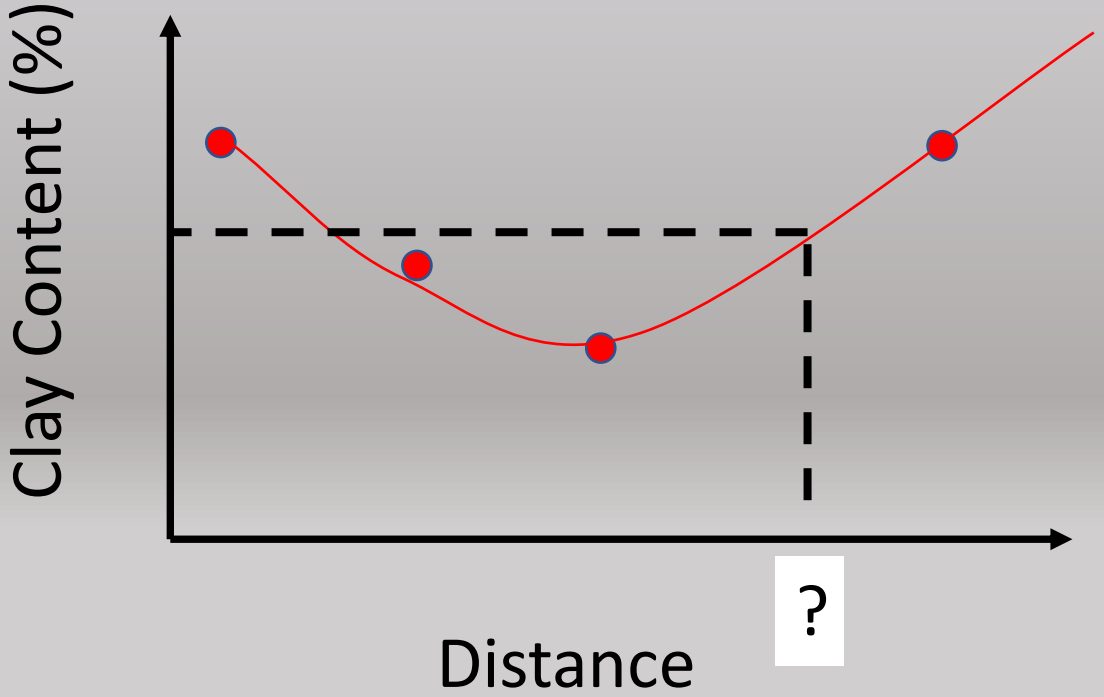


Interpolation:

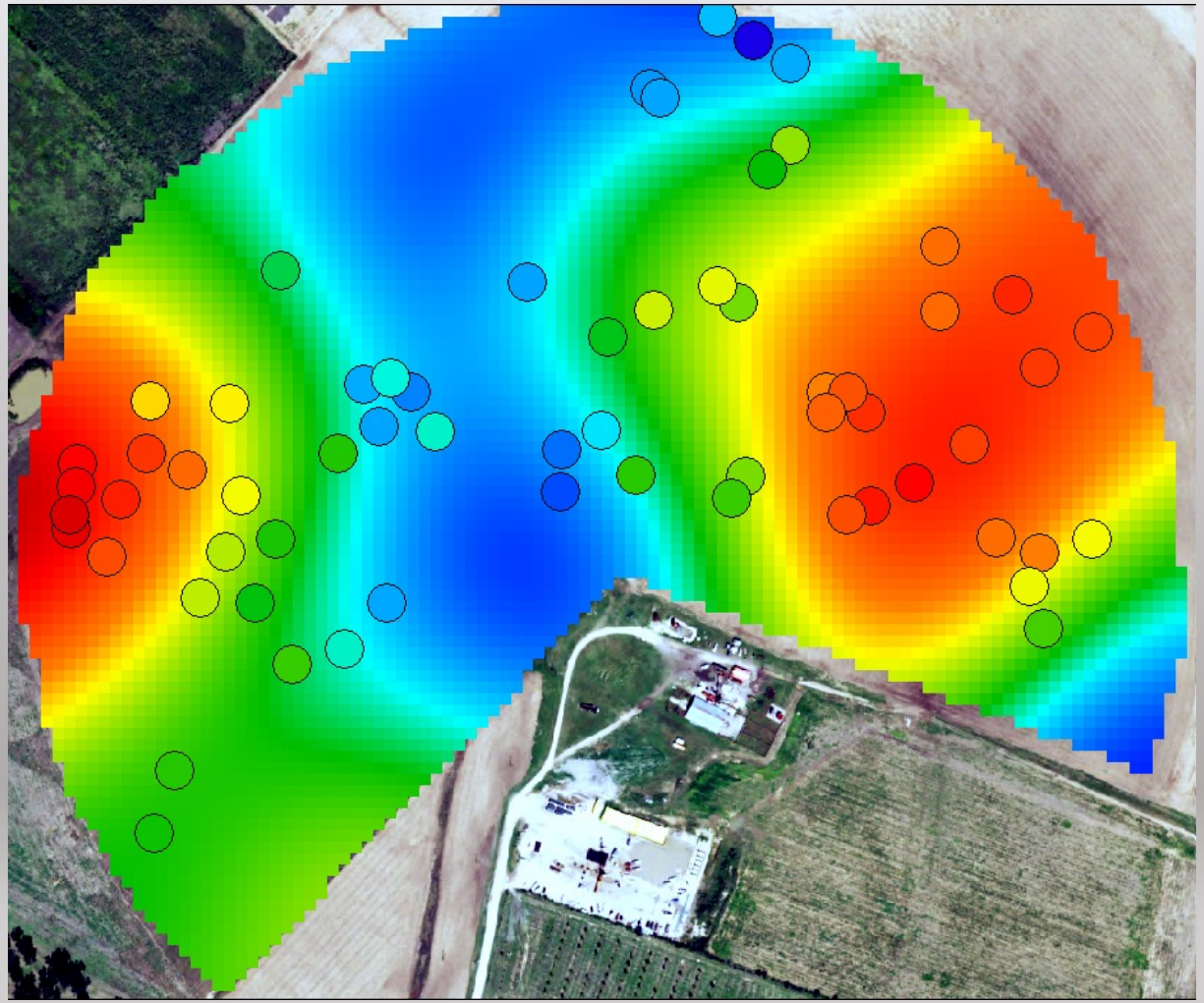


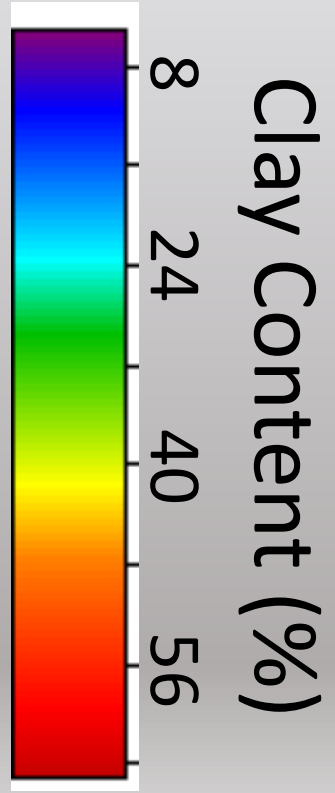
Interpolation:



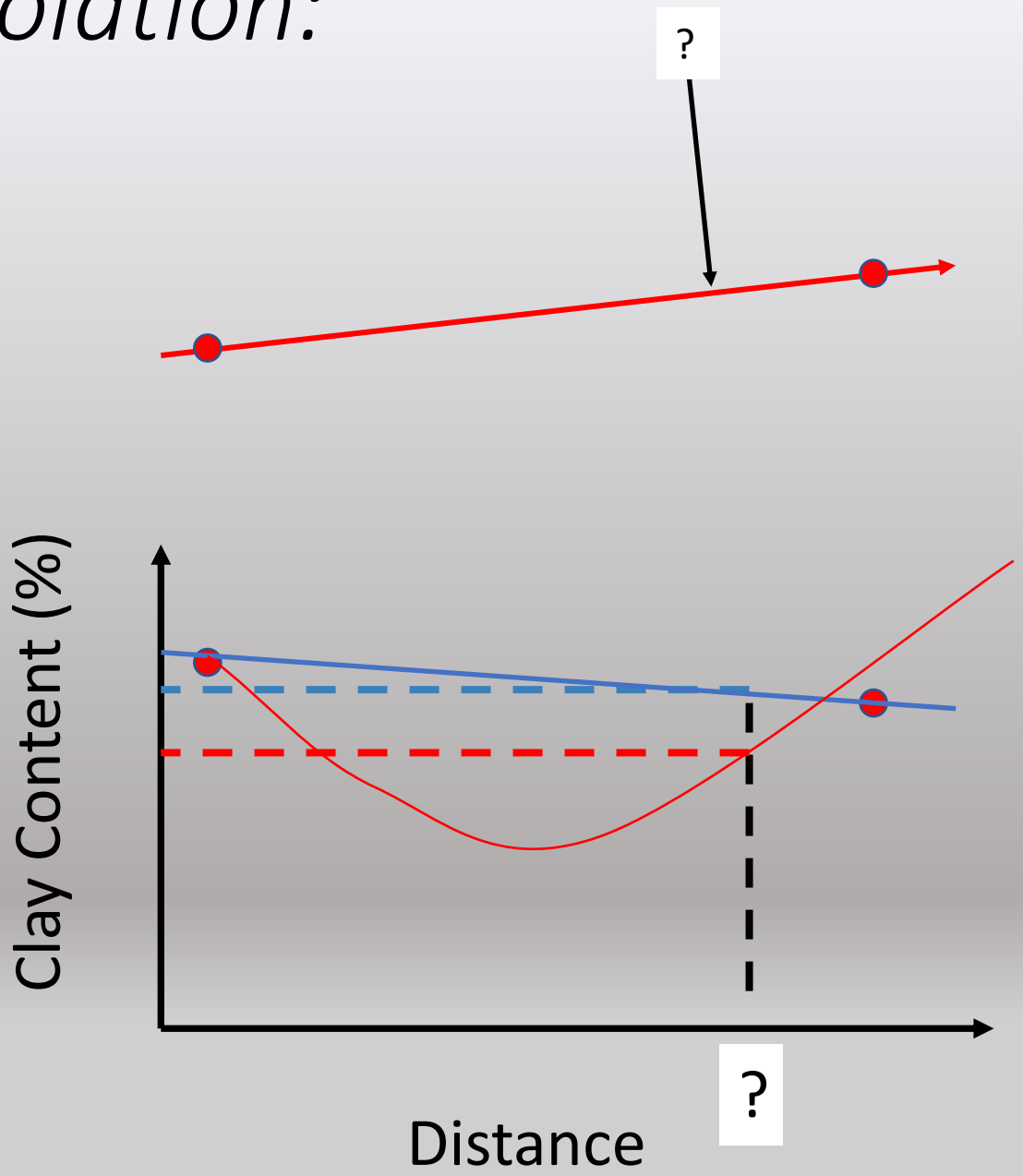


Interpolation:



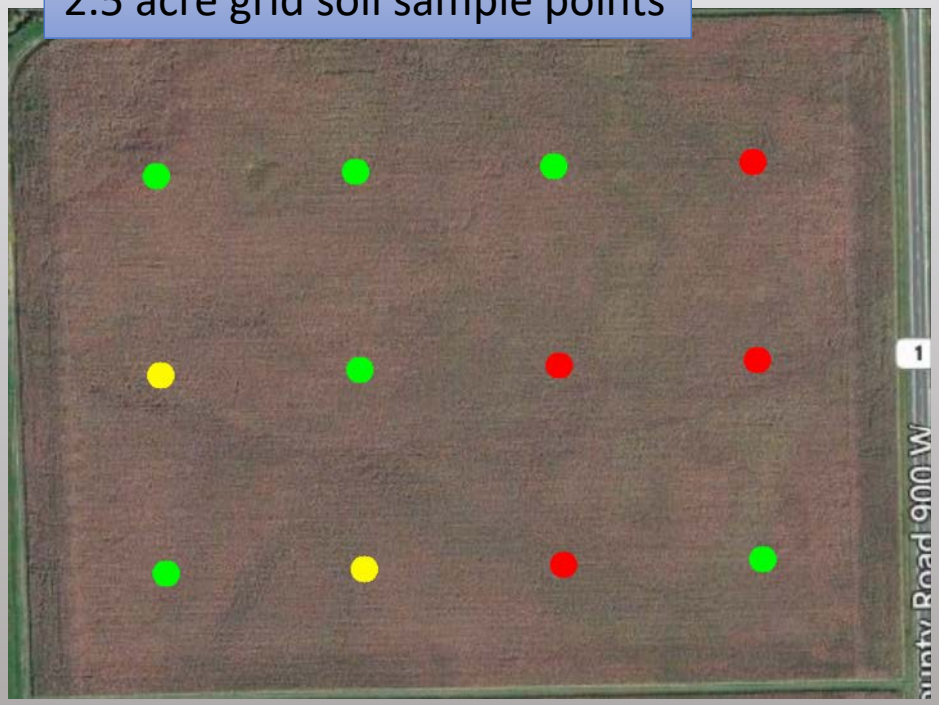


Interpolation:

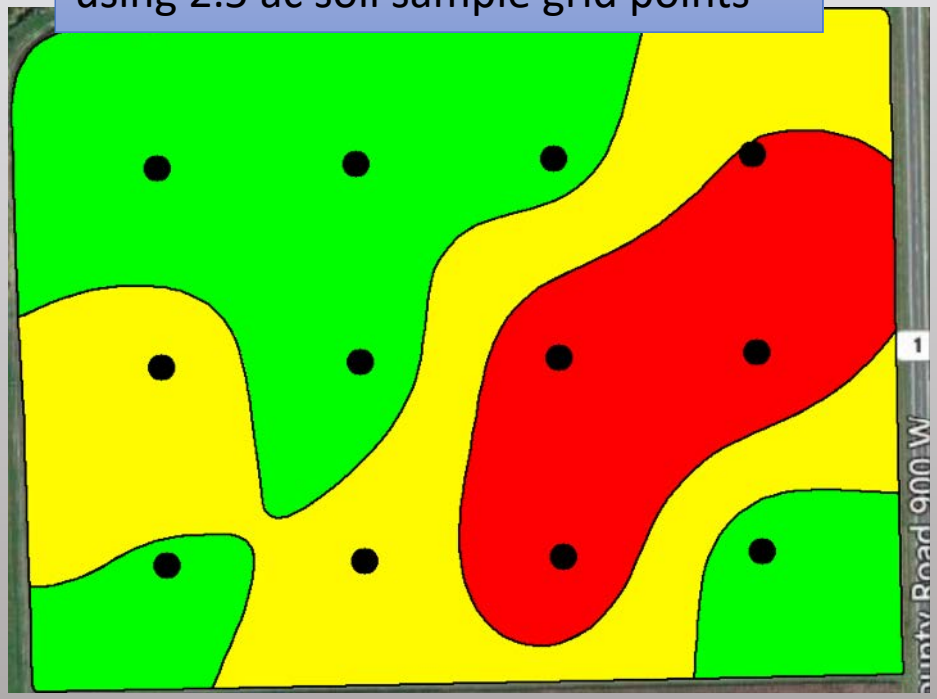


Bray-1 phosphorus – 2.5 ac grid

2.5 acre grid soil sample points



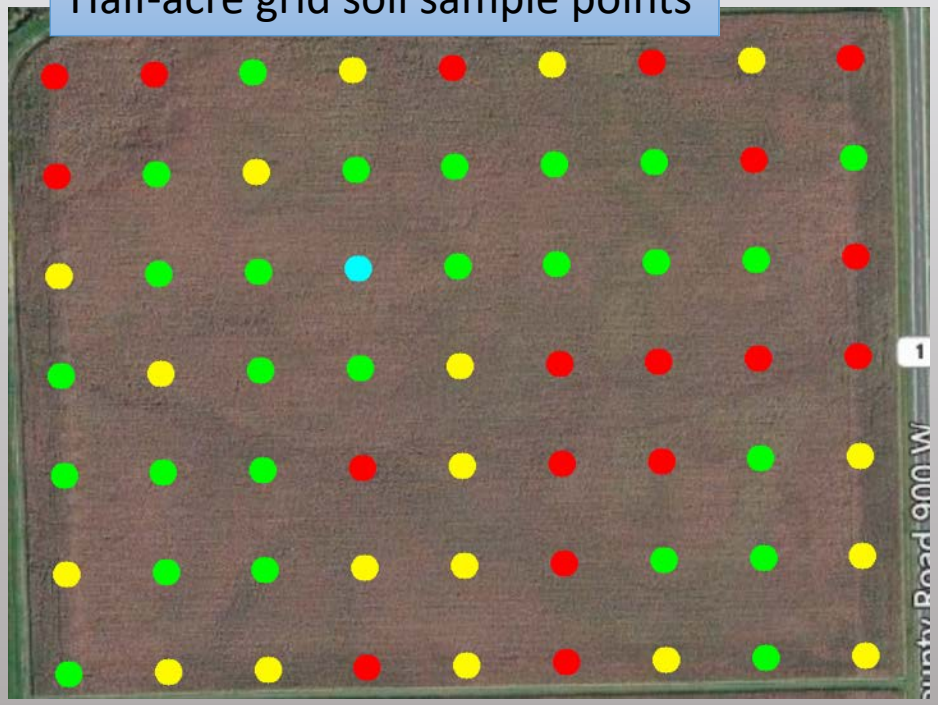
Rasterized Bray-P1 map interpolated using 2.5 ac soil sample grid points



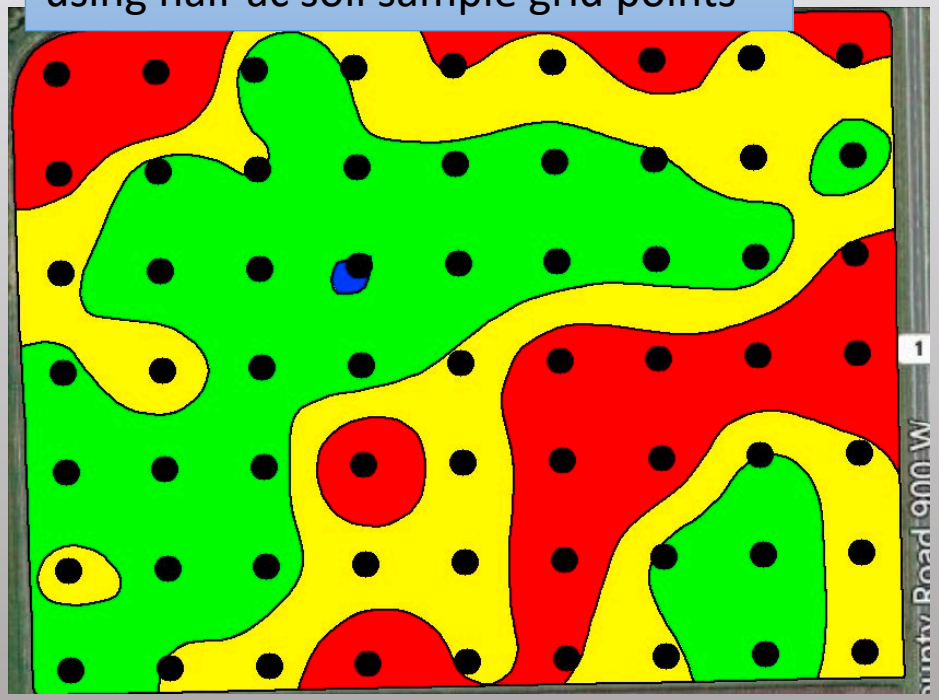
Red = Greater than 40 ppm
Yellow = Betw 30 & 40 ppm
Green = Betw 15 & 30 ppm
Blue = Less than 15 ppm

Bray-1 phosphorus – Half-ac grid

Half-acre grid soil sample points



Rasterized Bray-P1 map interpolated using half-ac soil sample grid points

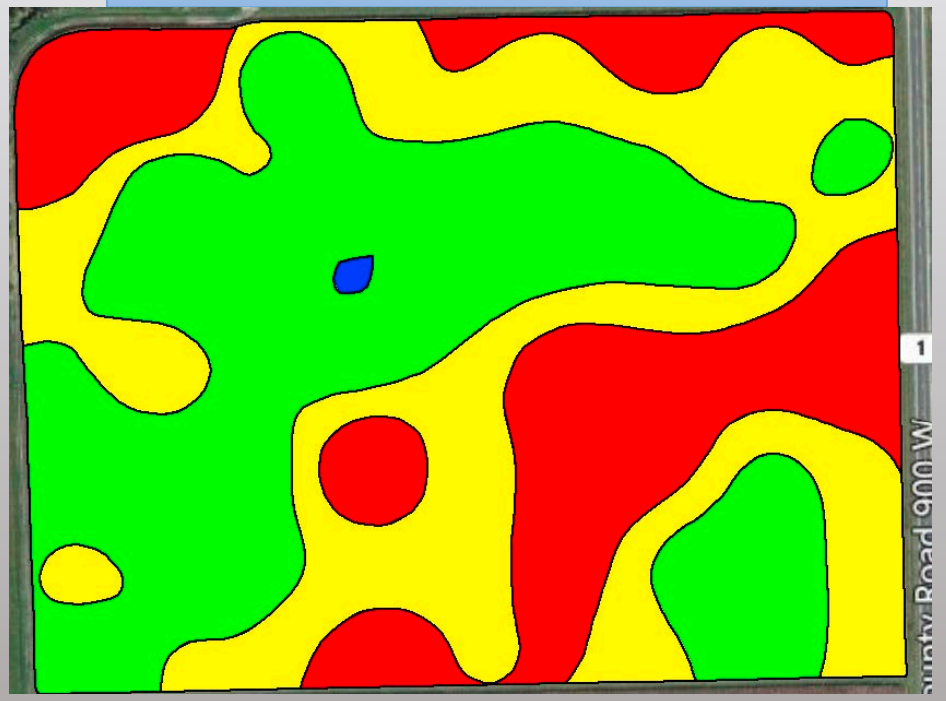


Red = Greater than 40 ppm
Yellow = Betw 30 & 40 ppm
Green = Betw 15 & 30 ppm
Blue = Less than 15 ppm

Difference in P_2O_5 Spread Maps

Spread map based on 2.5 ac samples

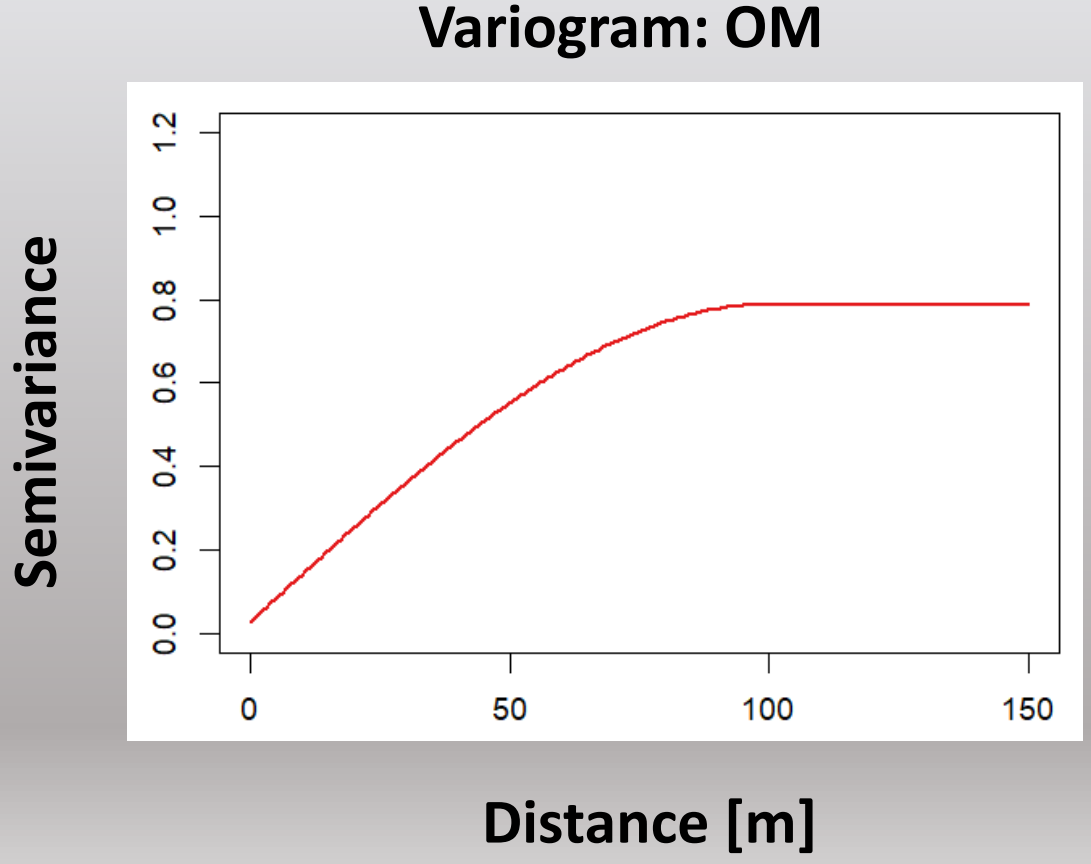
Spread map based on half-ac samples



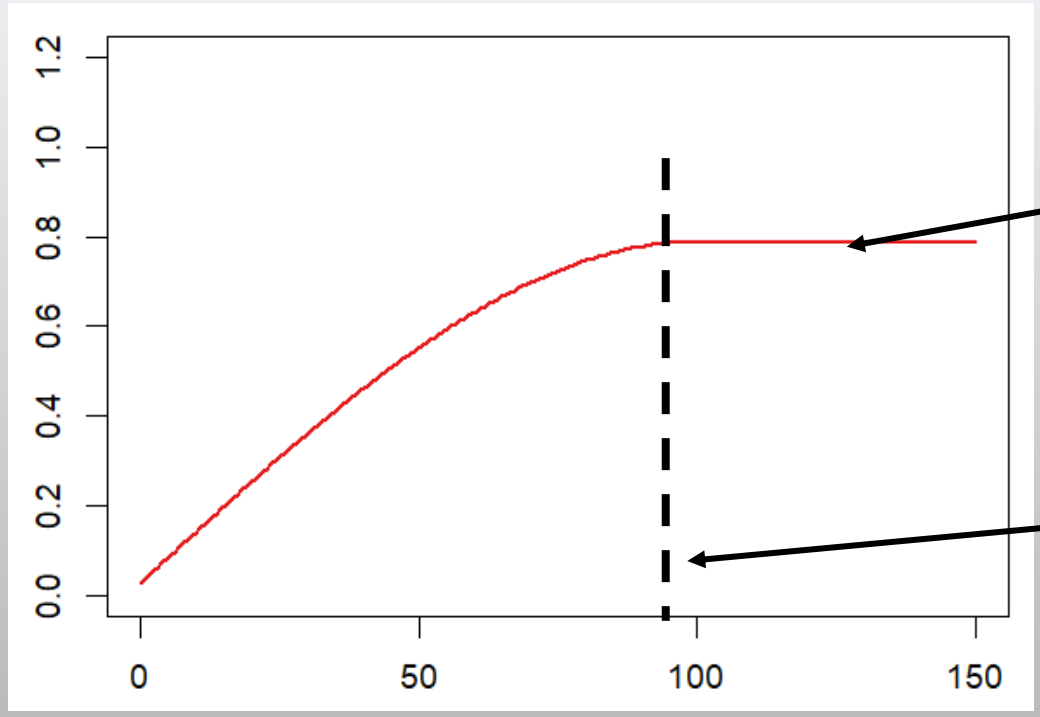
Red = No P_2O_5 recommended
Yellow = Drawdown P_2O_5 application rates
Green= Replacement of crop removal
Blue = Crop removal + buildup application rates

Semivariance: Spatial Dissimilarity

Increasing distance between points = increasing *dissimilarity*



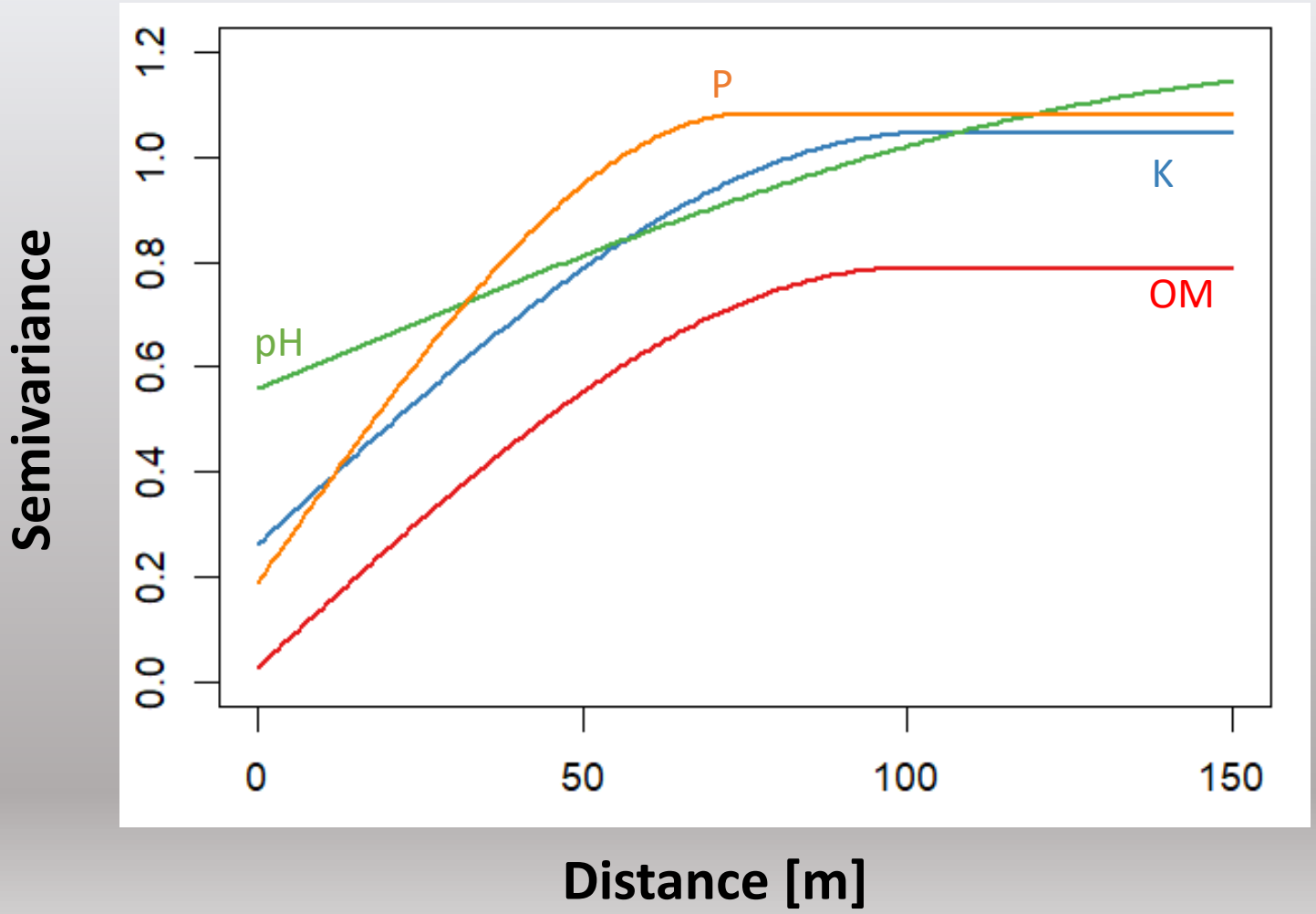
Variogram: OM



Sill: Maximum dissimilarity (sample deviation)

Range: separation distance where maximum dissimilarity is reached

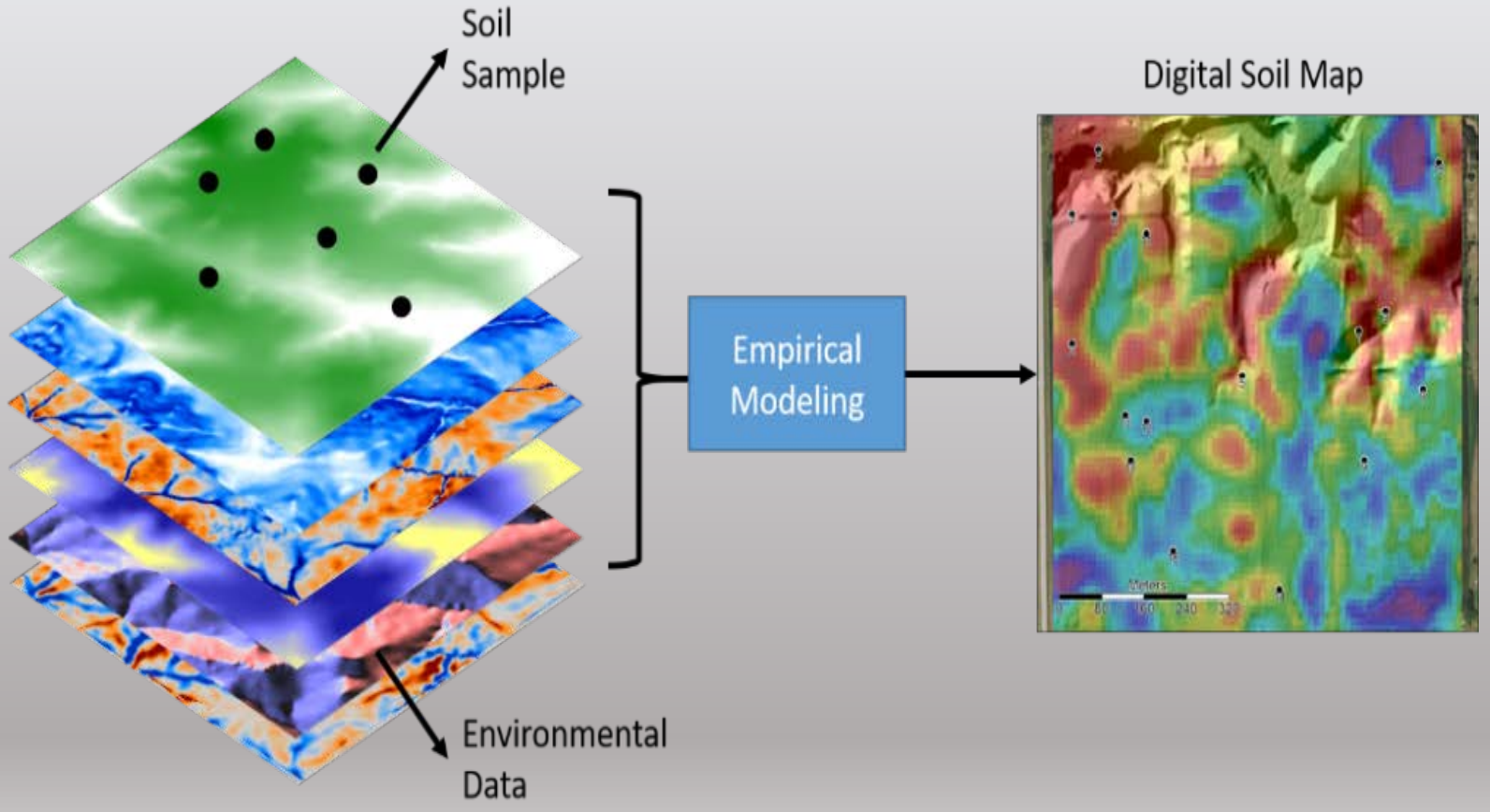
- Points separated by distances greater than the range are spatially uncorrelated
- Spatially uncorrelated points lead to erroneous interpolations


Semivariance
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
50
100
150
Distance [m]
P
K
OM
pH

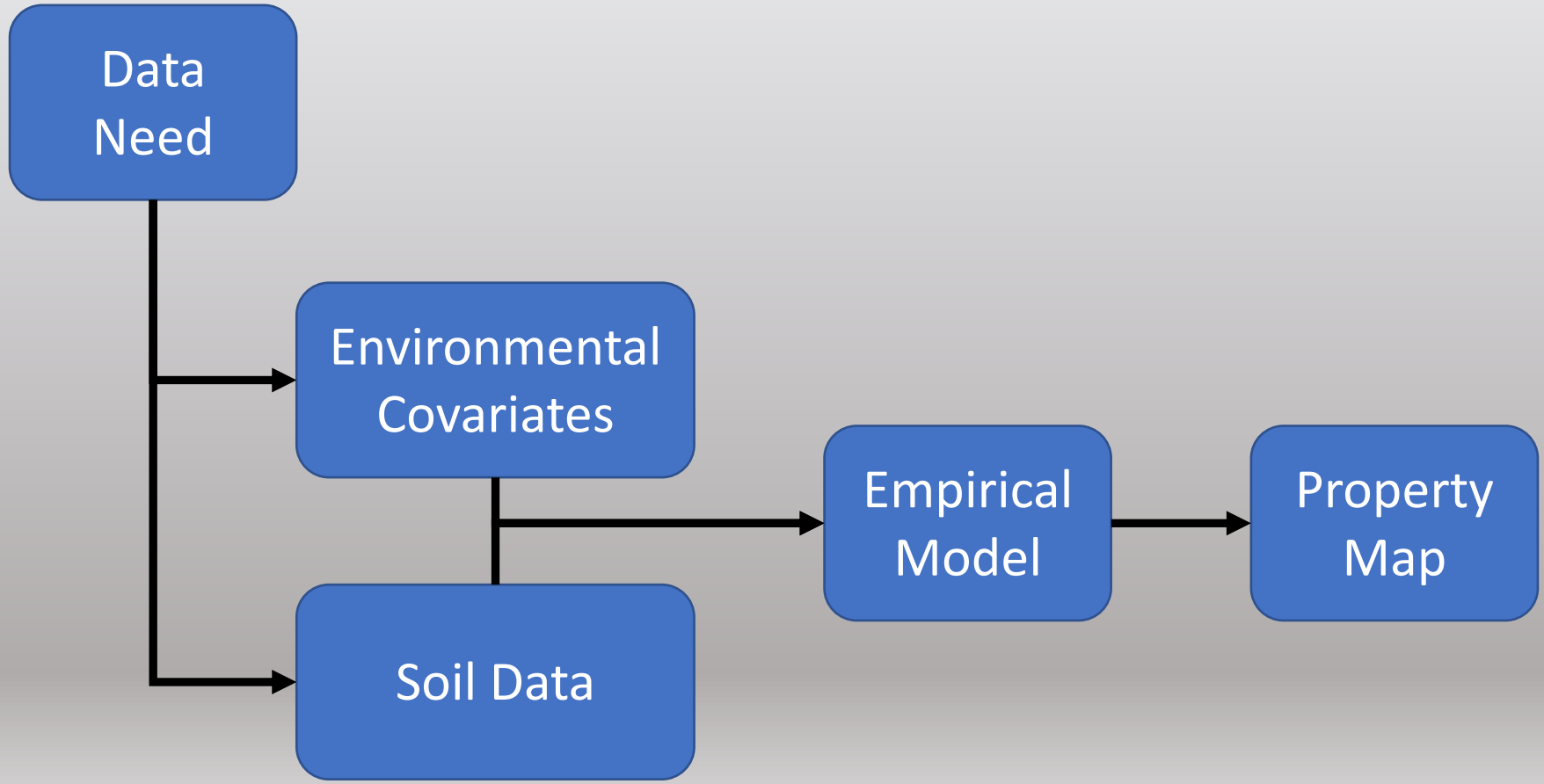
Recap: Interpolation

- Interpolation uses the spatial relationships between points to generate maps
- A statistical best guess, smooth maps
- The quality of interpolated maps is subject to the spatial correlation and separation distance between points
- Typically, samples separated by > 100m are very poorly correlated

Digital Soil Mapping

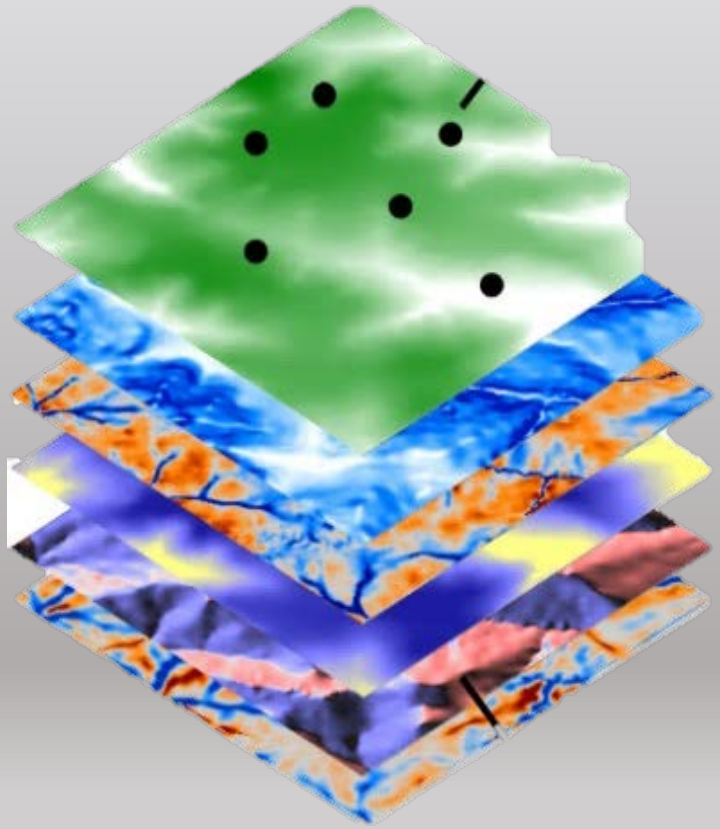


Digital Soil Mapping



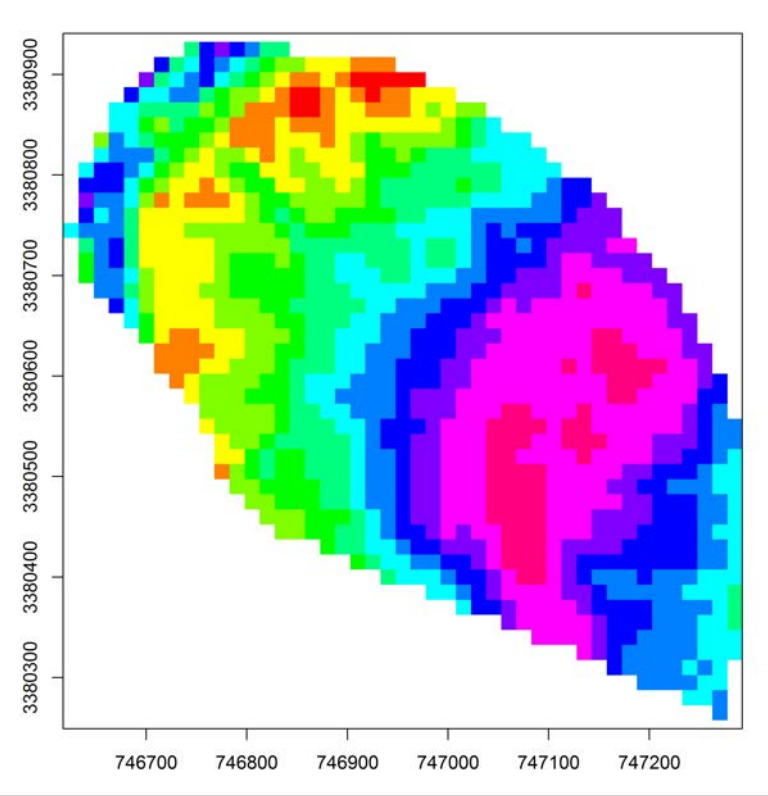
Spatial data layers: Environmental Covariates

- Easy to measure
- Cover large areas (i.e. entire fields)
- Raster data; not point data
- Correlated to soil

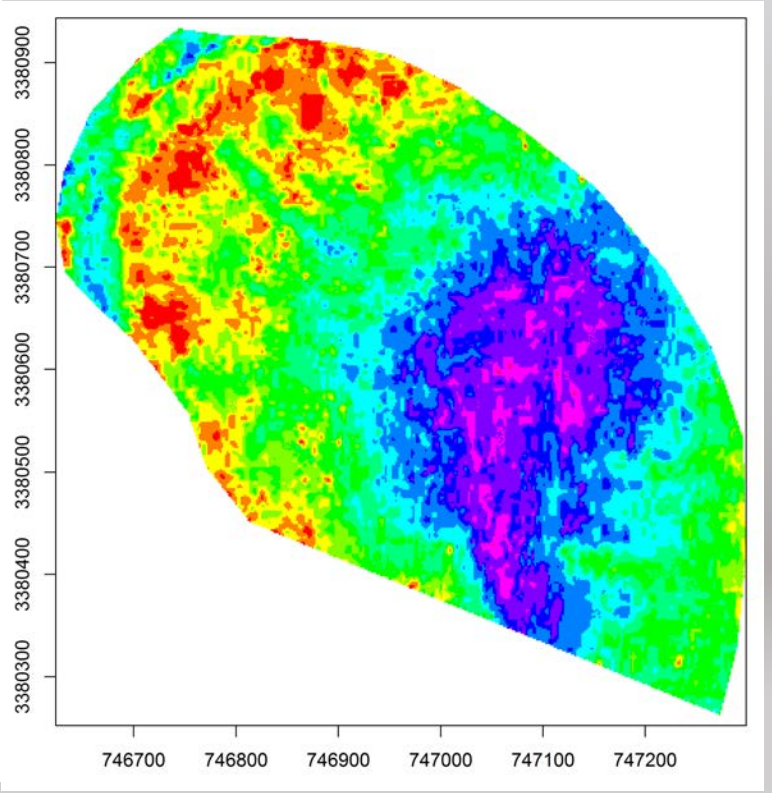


Potential Covariates: Satellite Imagery

Land Sat



Google Earth



Potential Covariates: UAV's

Photo:
John Scott

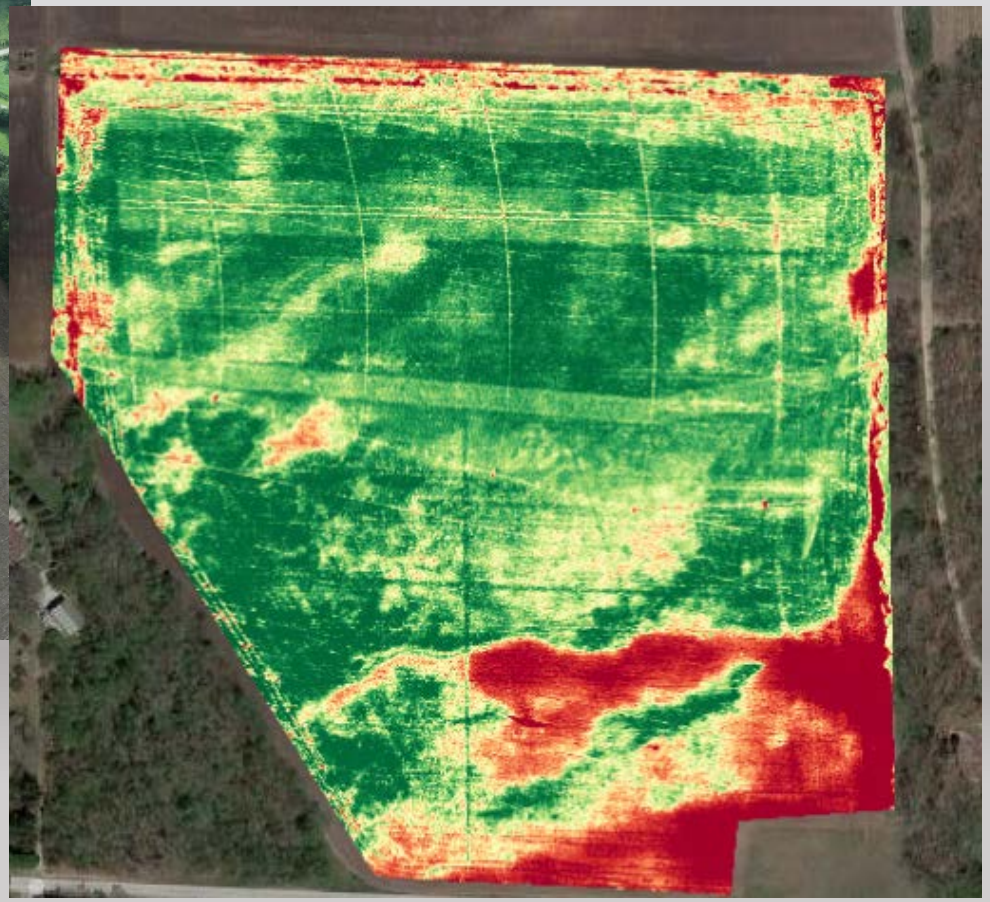
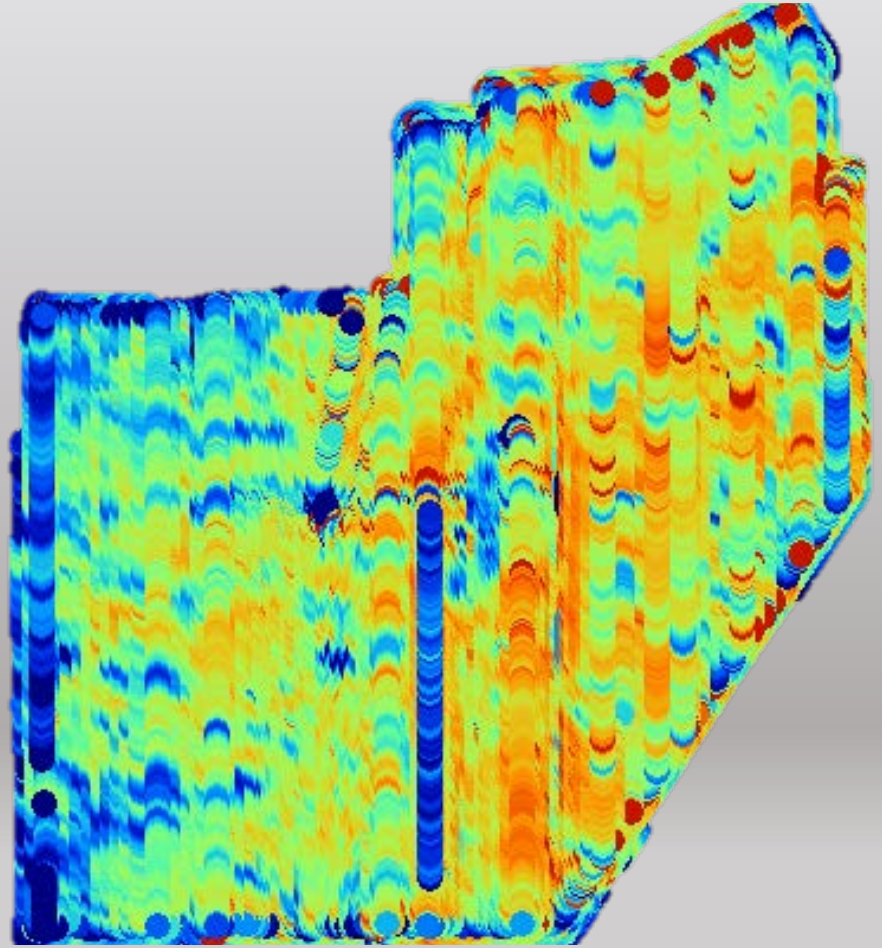


Photo: Brian Overstreet

Potential Covariates: Yield Monitors

- Need to be cleaned and processed
- May have many years of data

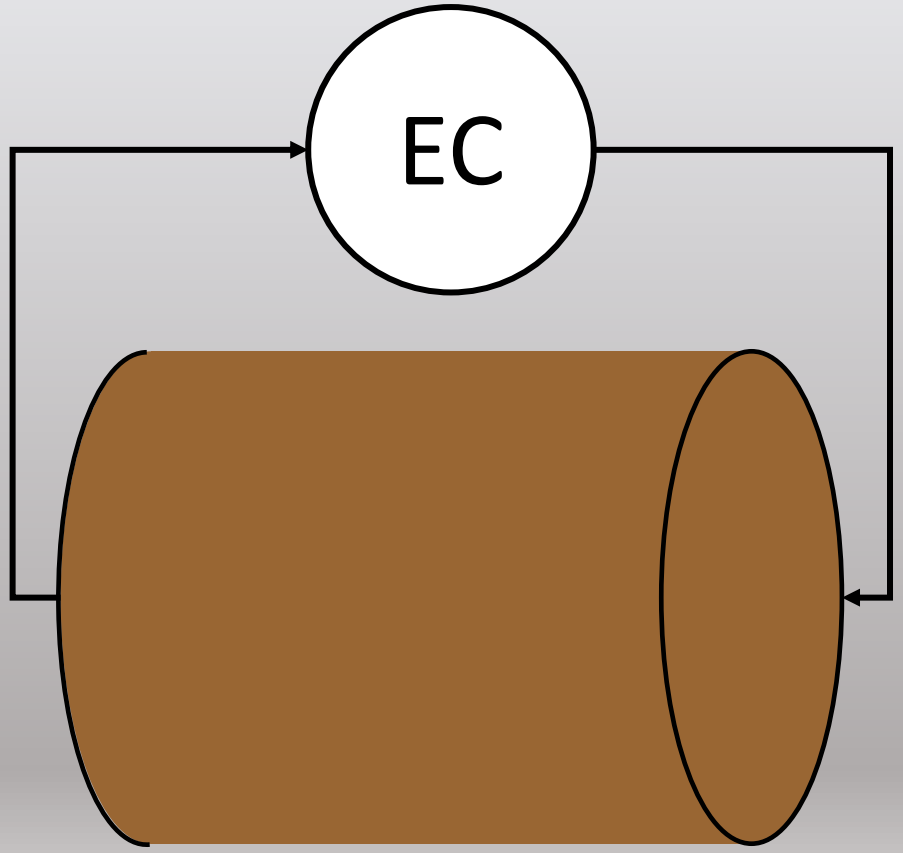


Potential Covariates:
LiDAR

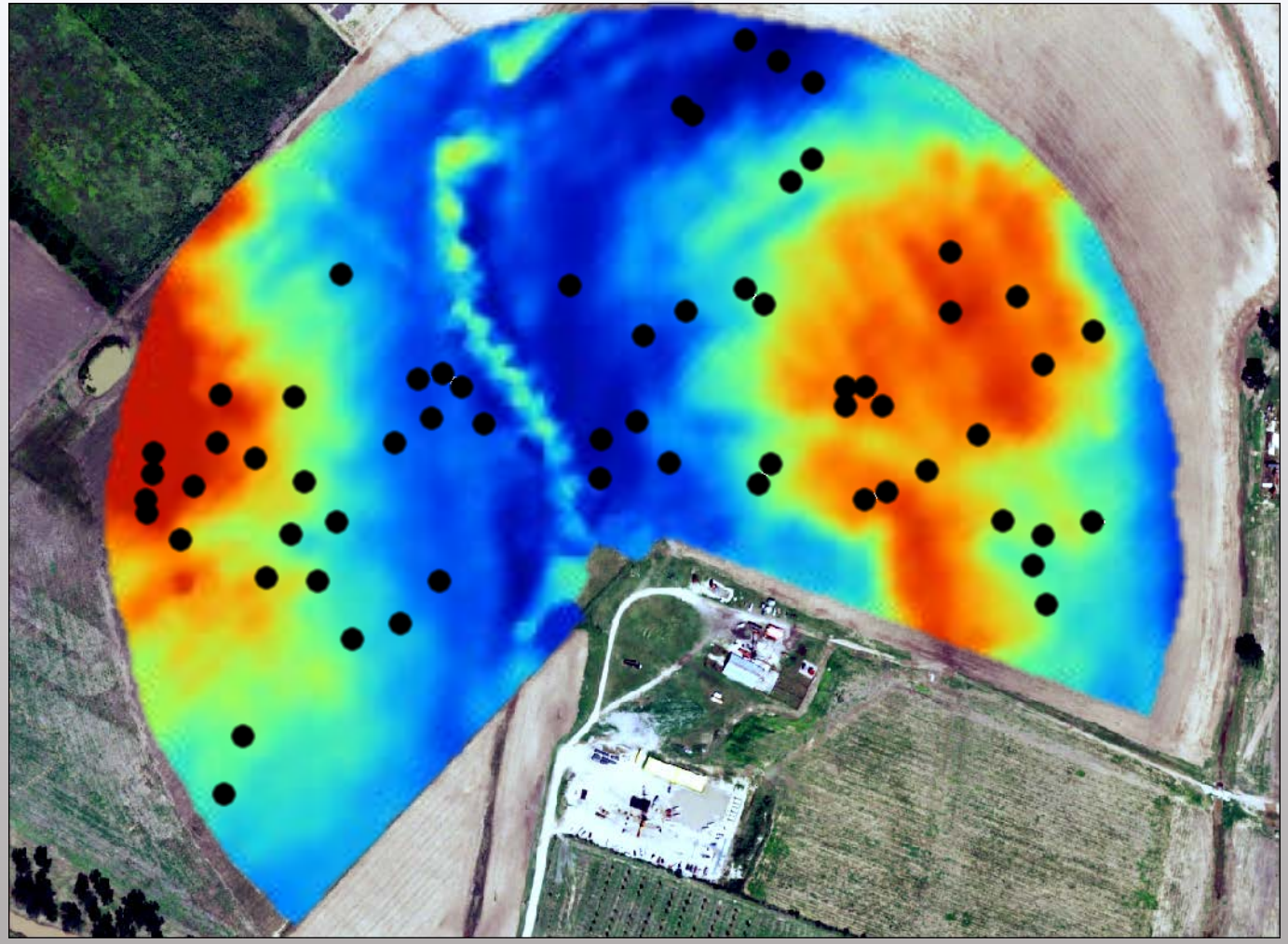
Electrical Conductivity:

How easily soil can move electricity

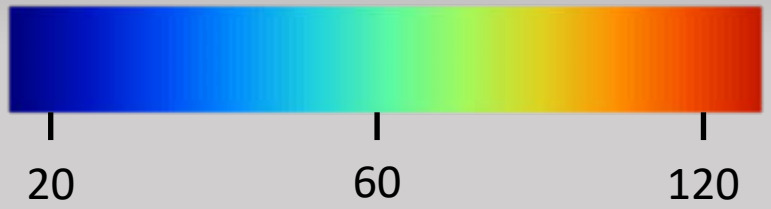
- Soil Water Content
- Salinity (Salts)
- Clay Content

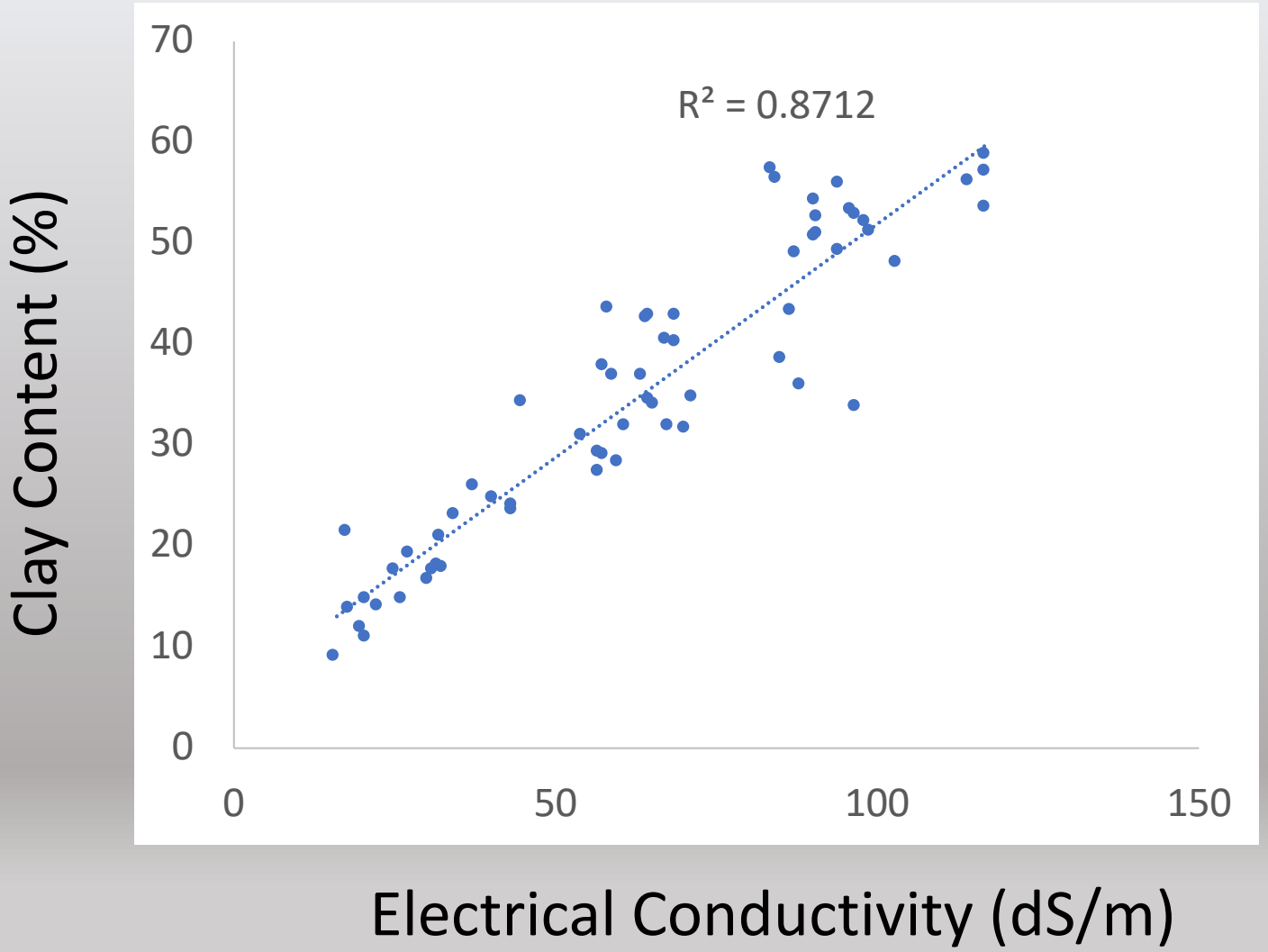


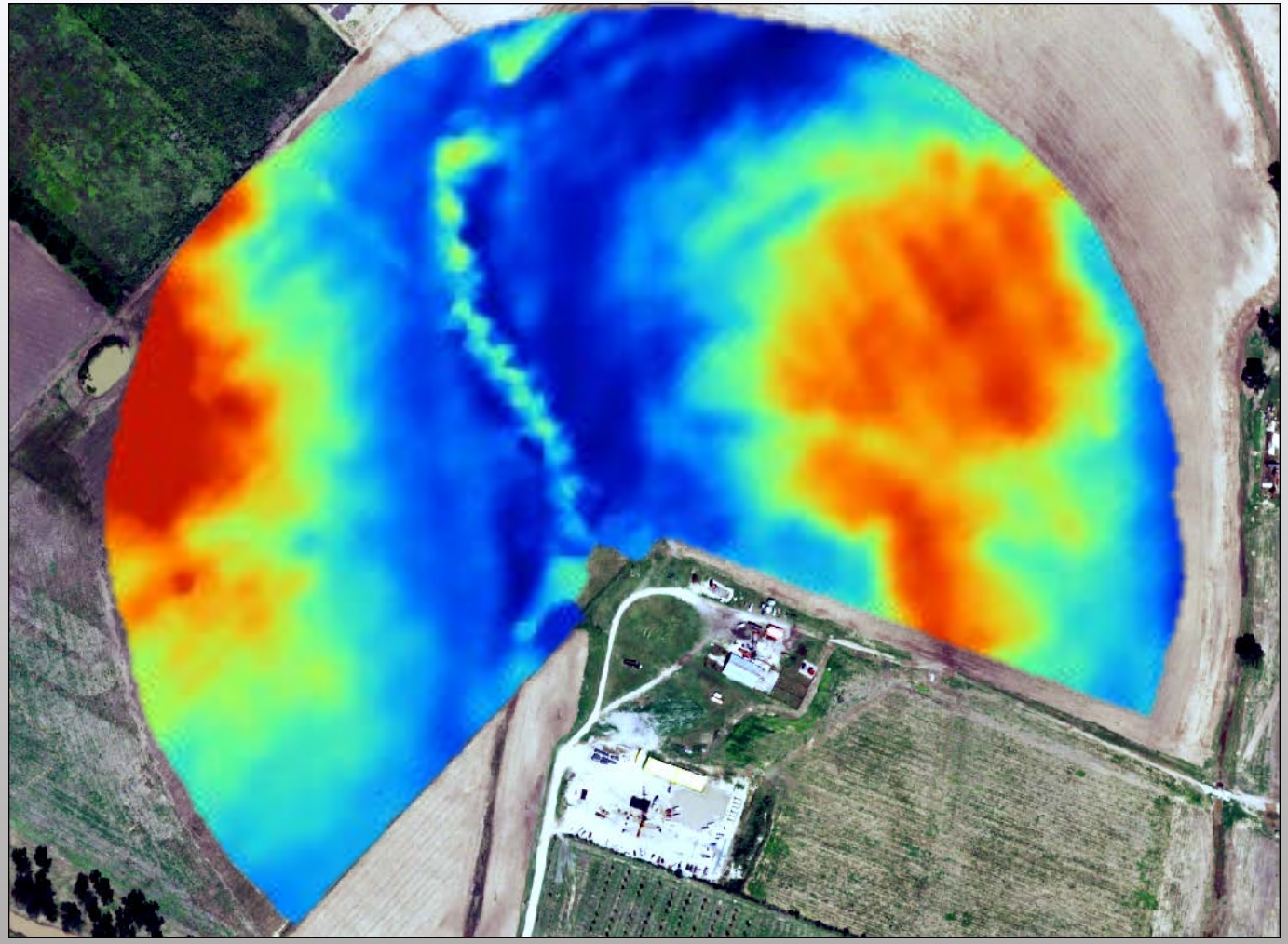
Electrical Conductivity

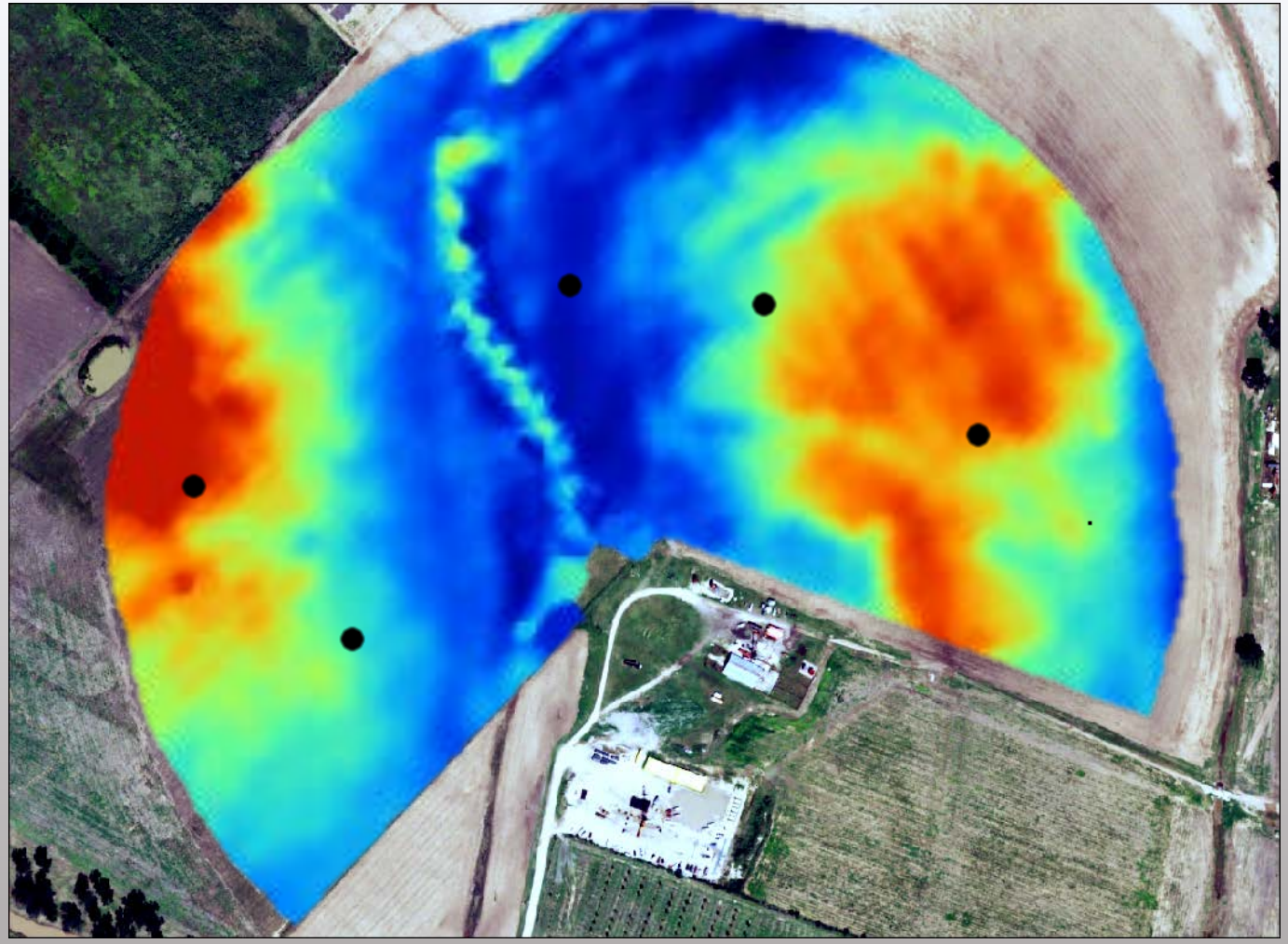


Electrical Conductivity (dS/m)

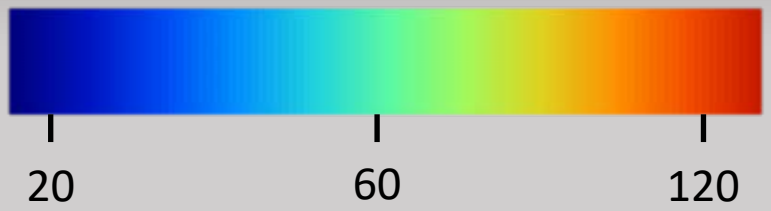


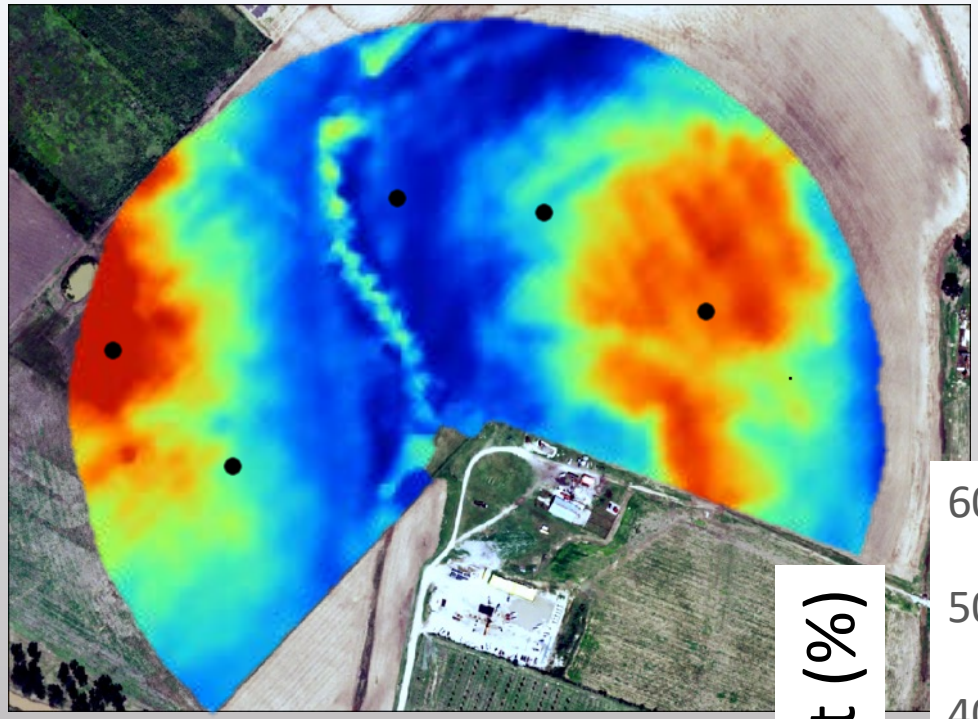

Clay Content (%)
70
60
50
40
30
20
10
0
R^2 = 0.8712
0
50
100
150
Electrical Conductivity (dS/m)


Clay Content (%)
10
35
60

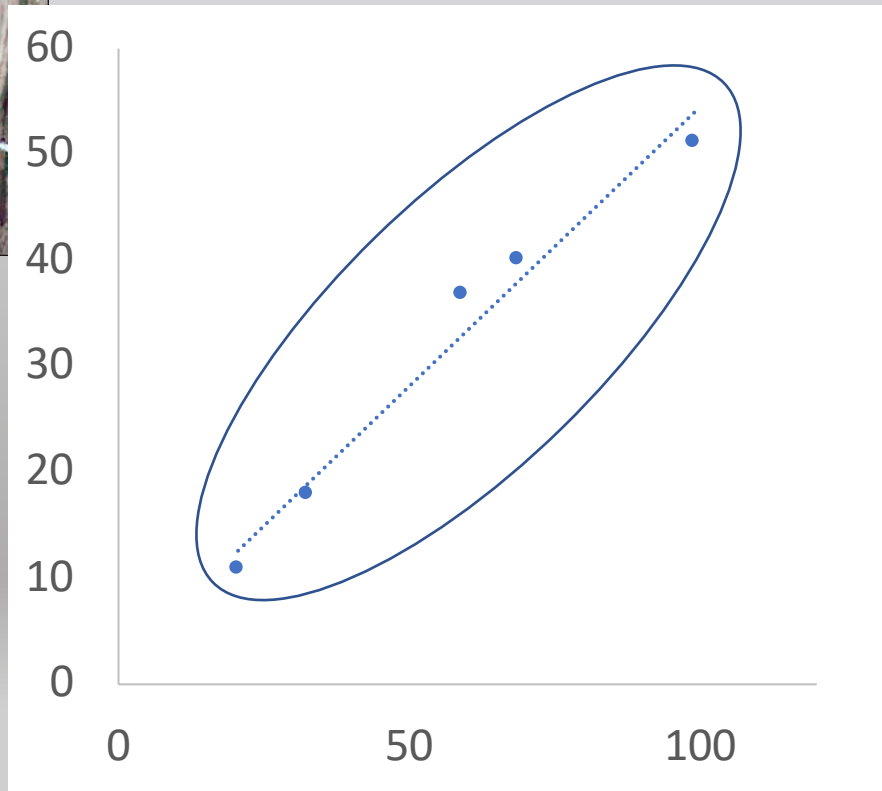


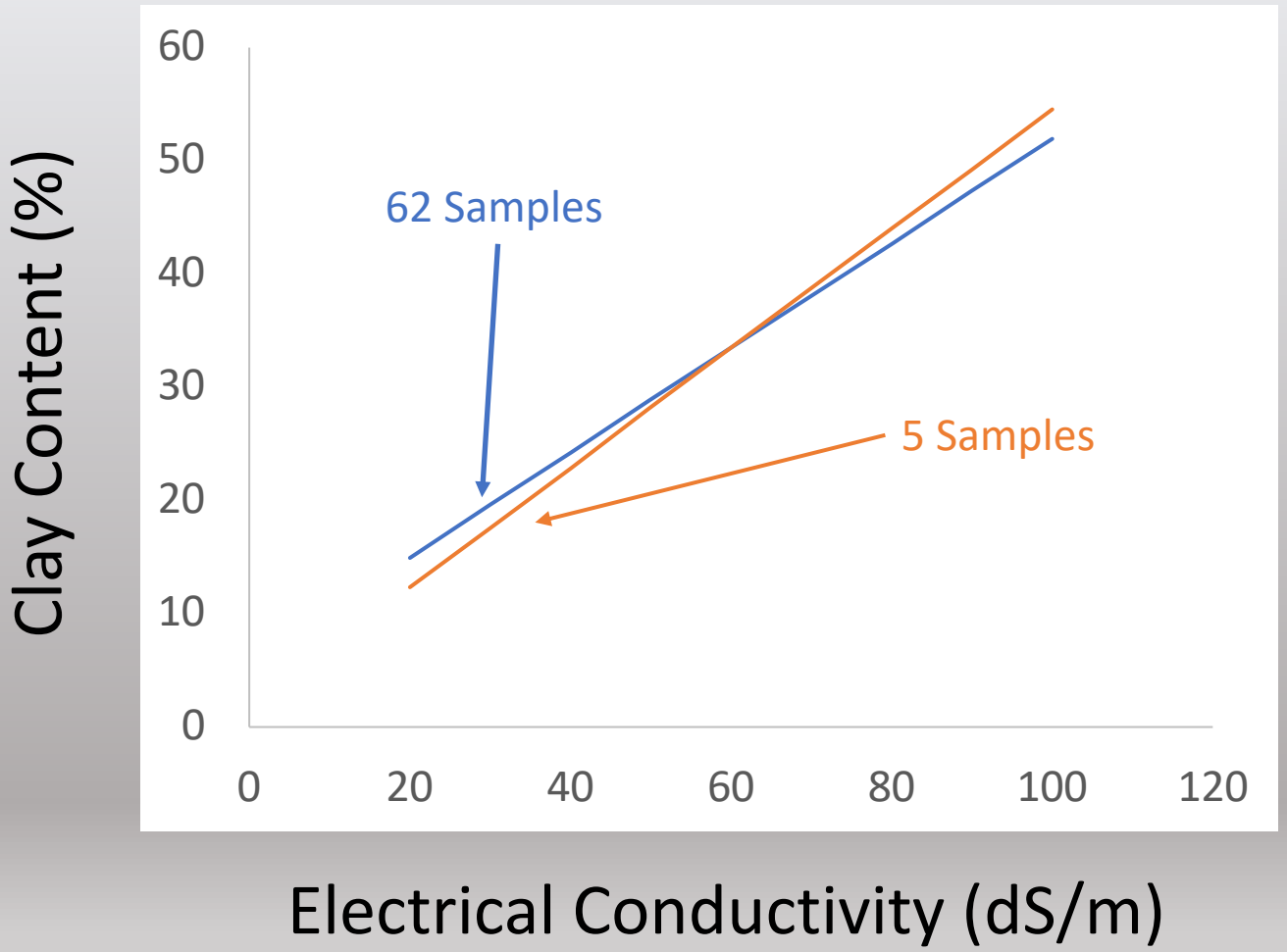
Electrical Conductivity (dS/m)





“Stratified Sample”




Clay Content (%)
60
50
40
30
20
10
0
62 Samples
5 Samples
0
20
40
60
80
100
120
Electrical Conductivity (dS/m)

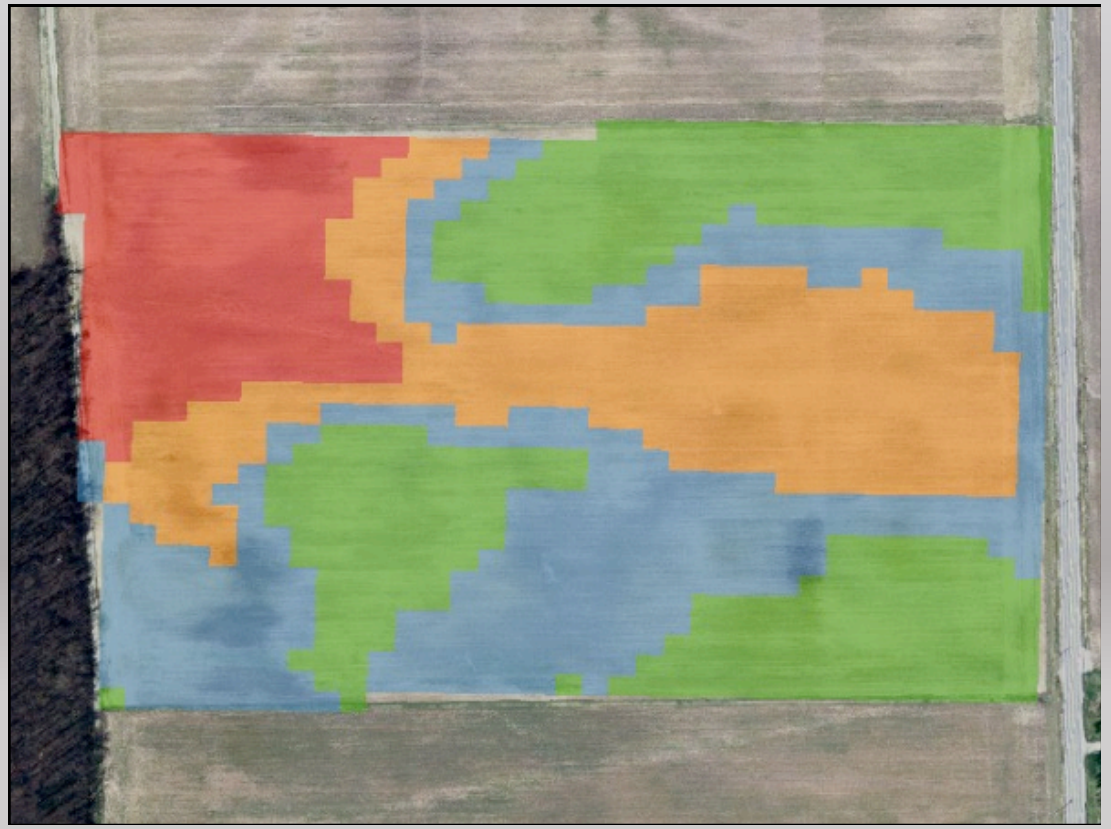
Lessons from DSM:

- Can produce high resolution maps
- Samples number *can* be small
  - Need to collect stratified sample
  - Samples representative of variability in the field
- Property needs to be correlated to covariate

Applying DSM lessons: Zone Sampling -> AKA stratified sampling

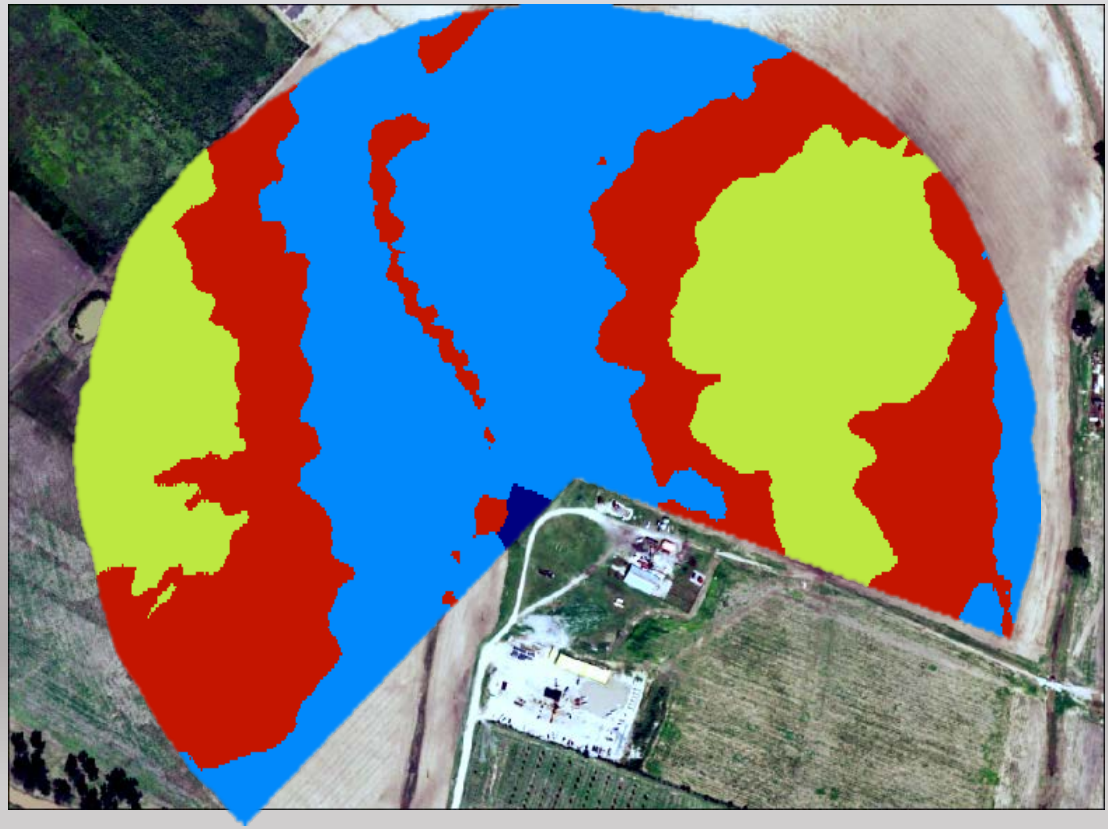
- Sample soil from zones (2-10 Acres)
- Combine all cores from each zone (can't be used for DSM, do provide better more representative sample)

Zone Map

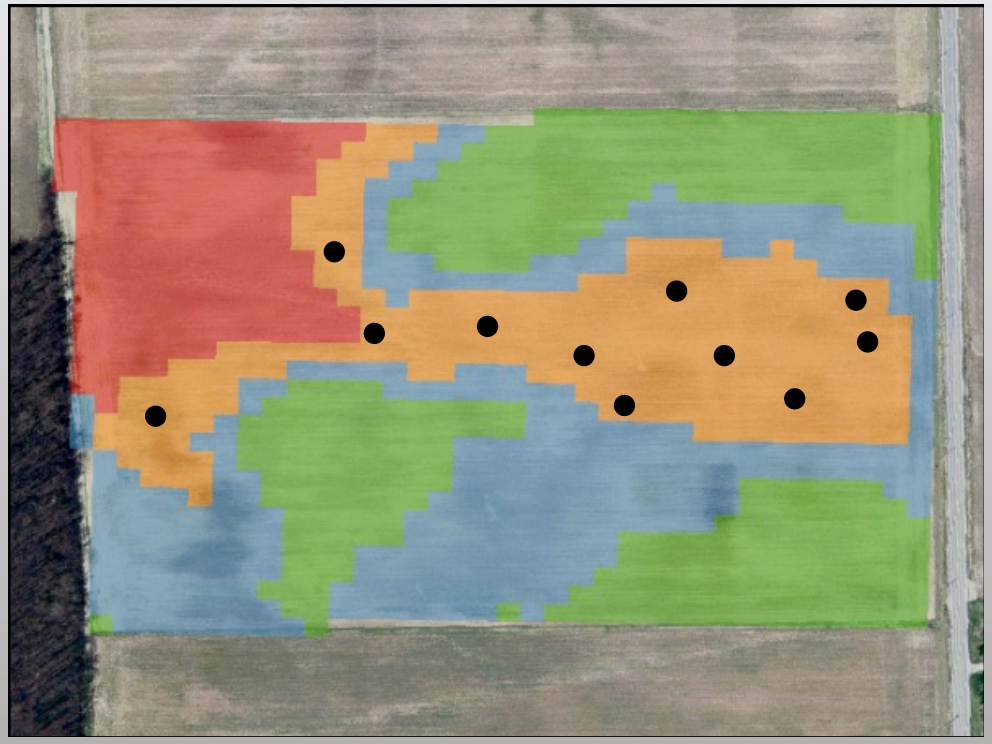


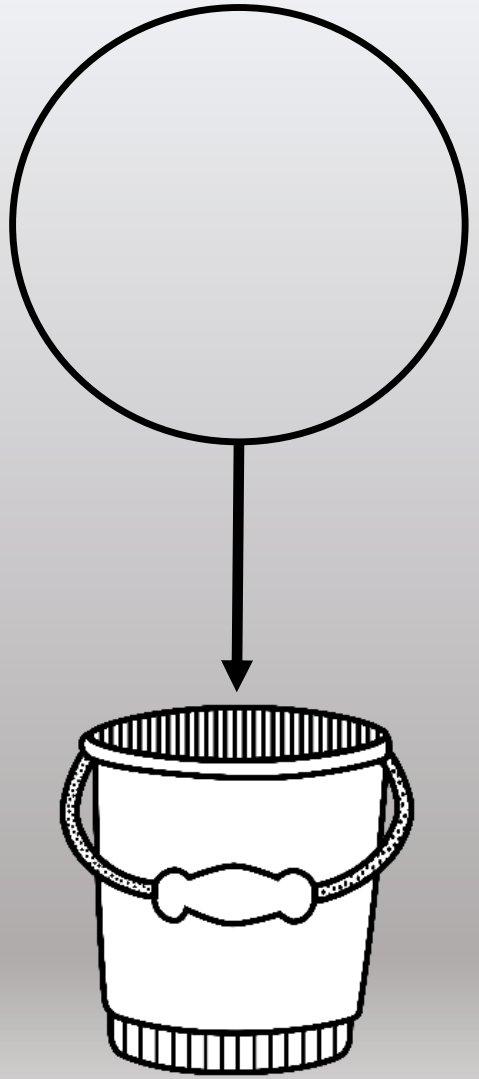
Establishing zones

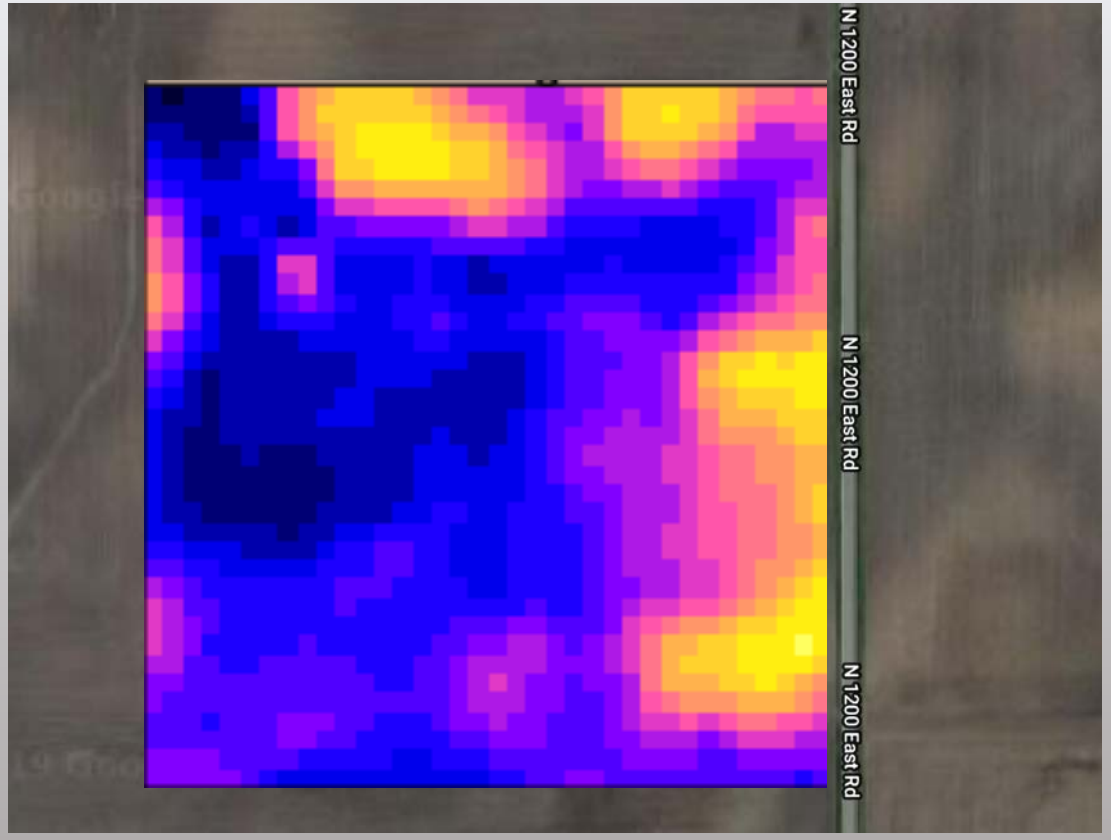
- Yield monitor data
- Soil map
- Sensor data (electrical conductivity)
- Aerial imagery



Zone Map





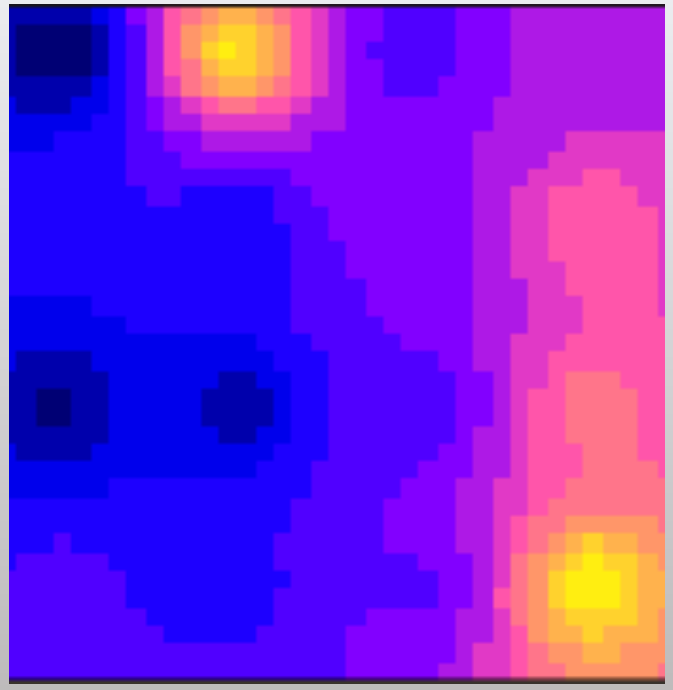


- 40 acre field in Central IL
- Sampled on a 40 ft. grid

pH

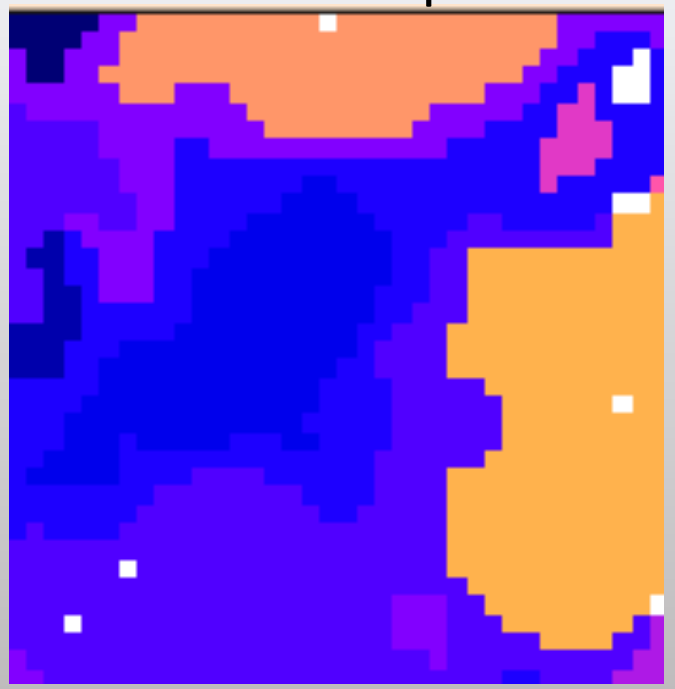
8 6.5 5.5

2.5 Acre Map



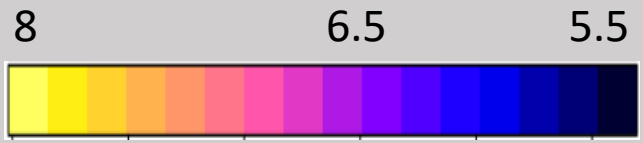
Error = 0.29
16 samples

Zone-based Map



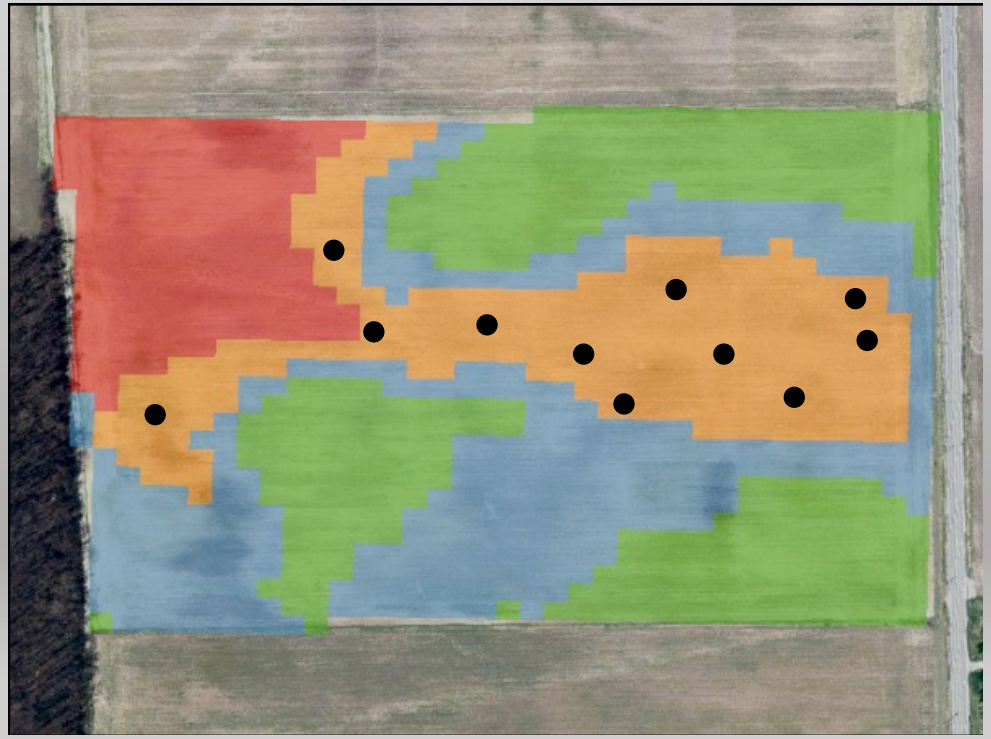
Error = 0.26
10 samples

pH



Zone soil sampling:
i.e. Stratified random sampling

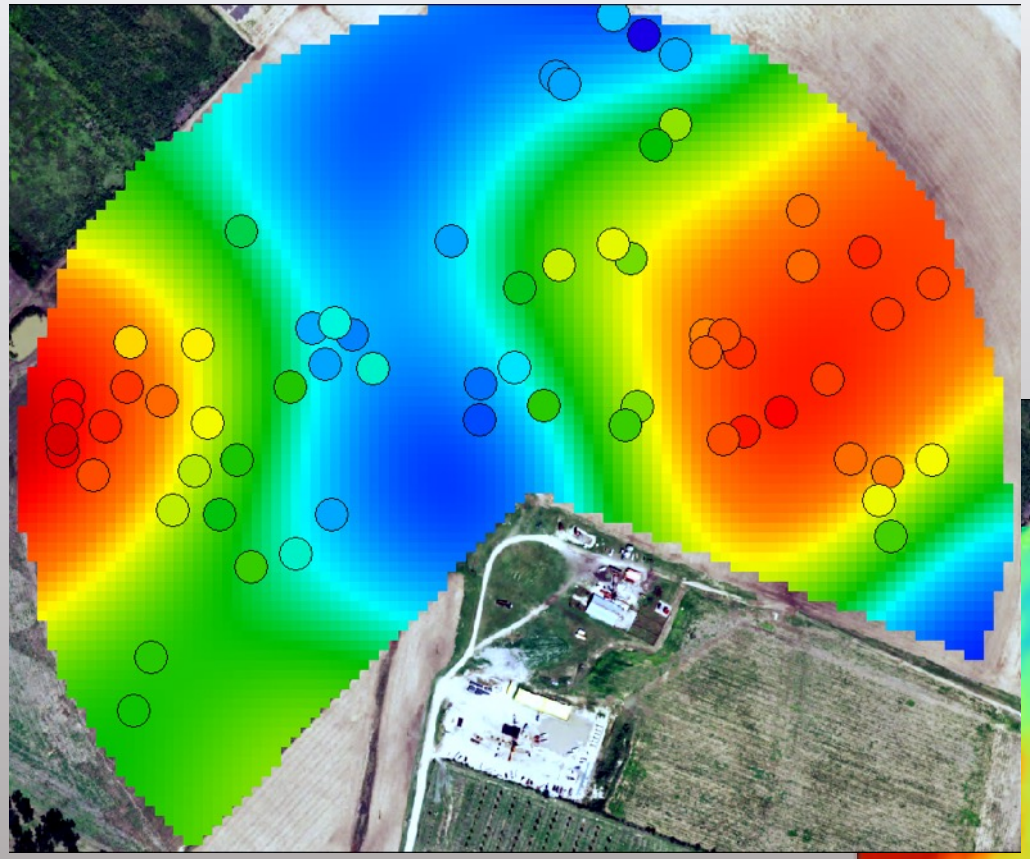
- May reduce sample number over grids
- Leverages spatial data to improve soil sampling

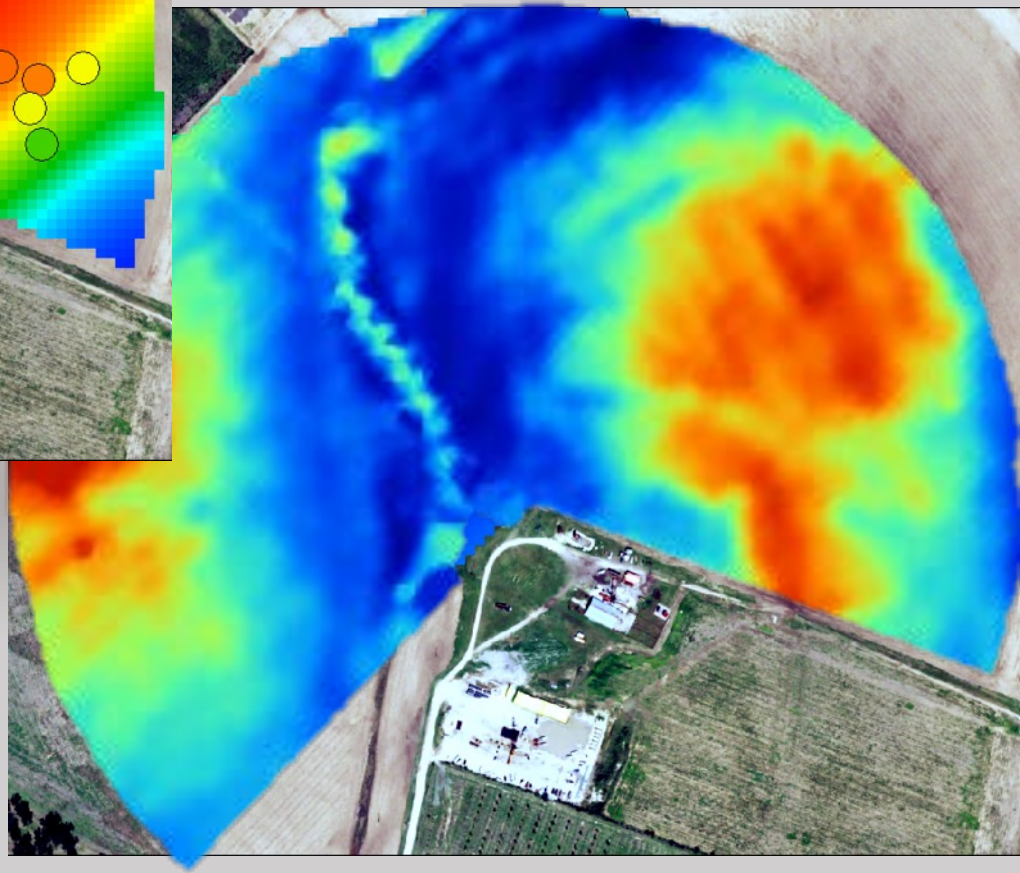


Take away's:

- Concepts from DSM can improve soil sampling
  - Stratified/targeted sampling
- DSM can provide more useful maps than interpolation alone
  - DSM requires more data wrangling but fewer samples

Interpolation vs. DSM:





DSM

- Requires covariates
- Requires statistical modeling
- Can use fewer samples
- Can make very detailed maps

Interpolation

- Uses sample data only
- Can be done in most GIS
- Needs many samples
- Makes smooth maps

Which soil properties are easily/accurately mapped?

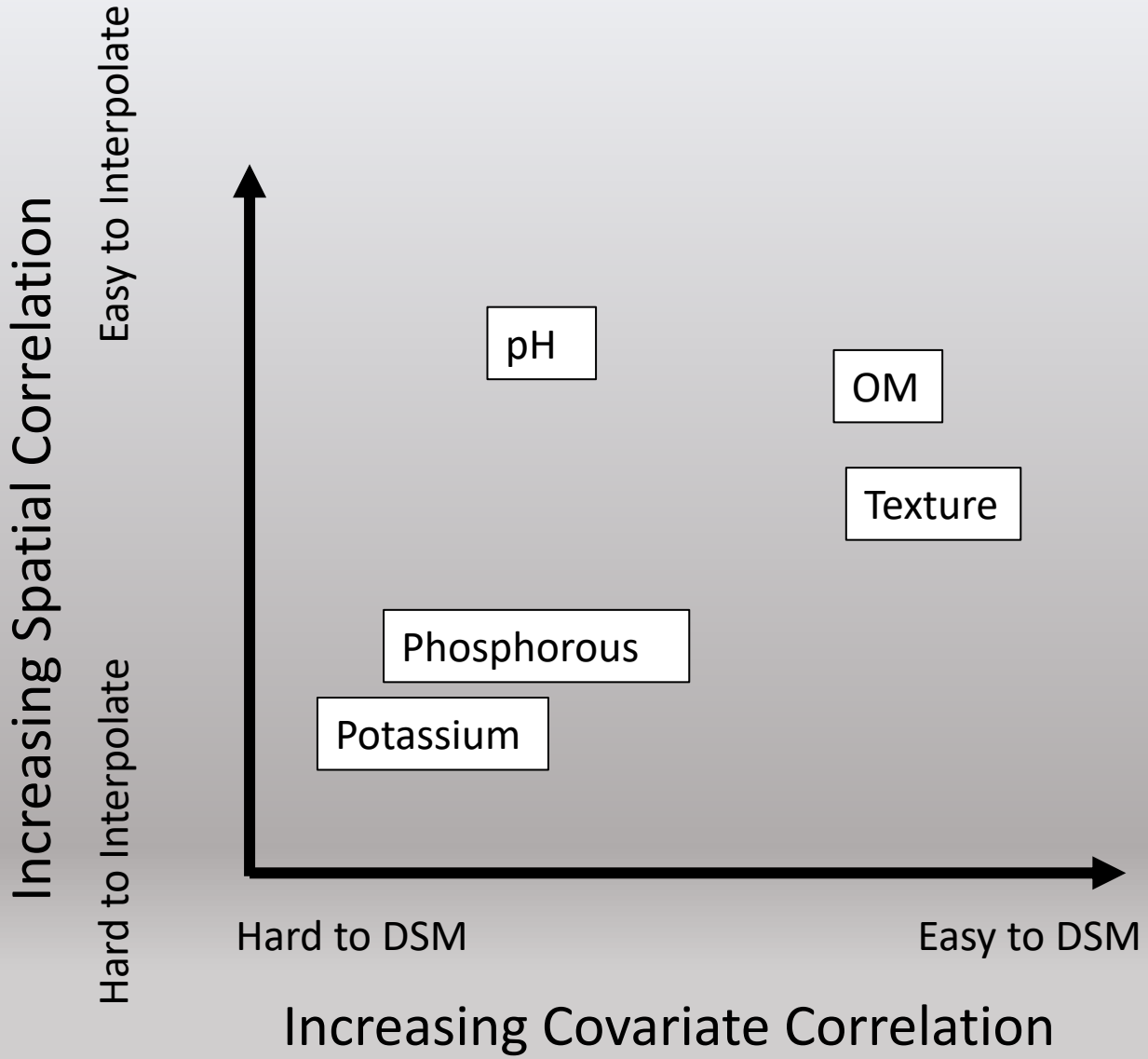
Interpolation

- Sampling points need to be correlated to one another

Digital soil mapping

- Properties need to be correlated to covariates

Each of these factors depends on the specific field, soil type, and property


Increasing Spatial Correlation
Easy to Interpolate
Hard to Interpolate
pH
OM
Texture
Phosphorous
Potassium
Hard to DSM
Easy to DSM
Increasing Covariate Correlation

Summary

- Precision soil maps can be made using Interpolation or digital soil mapping
- Interpolation relies on spatial correlation between points/samples
  - Need observations to be closely spaced *or* samples to be highly spatially correlated
- DSM relies on correlation between soil and environment
  - Can use fewer points *if* property is correlated to the environment

Questions?

Dr. Jason Ackerson
Assistant Professor of Soil Science
Purdue University
Email: jackers@purdue.edu
Twitter: @purdue_soil

Analog Soil Maps

Analog Soil Maps

1905: 34 pgs.

SOIL SURVEY OF TIPPECANOE COUNTY, INDIANA.

By N. P. NEILL and W. E. THARP.

LOCATION AND BOUNDARIES OF THE AREA.

Tippecanoe County is situated in the west central part of Indiana. It is bounded on the north by White and Carroll counties; on the east by Carroll and Clinton counties; on the south by Montgomery County, and on the west by Fountain, Warren, and Benton counties. The county comprises approximately 320,000 acres, or 500 square miles.

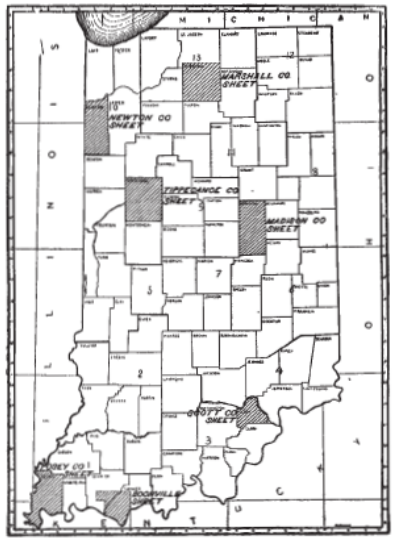


FIG. 33.—Sketch map showing location of the Tippecanoe County area, Indiana.

1959: 124 pgs.

Series 1945, No. 22 — Issued January 1959

SOIL SURVEY

Tippecanoe County Indiana

OUR SOIL • OUR STRENGTH

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION

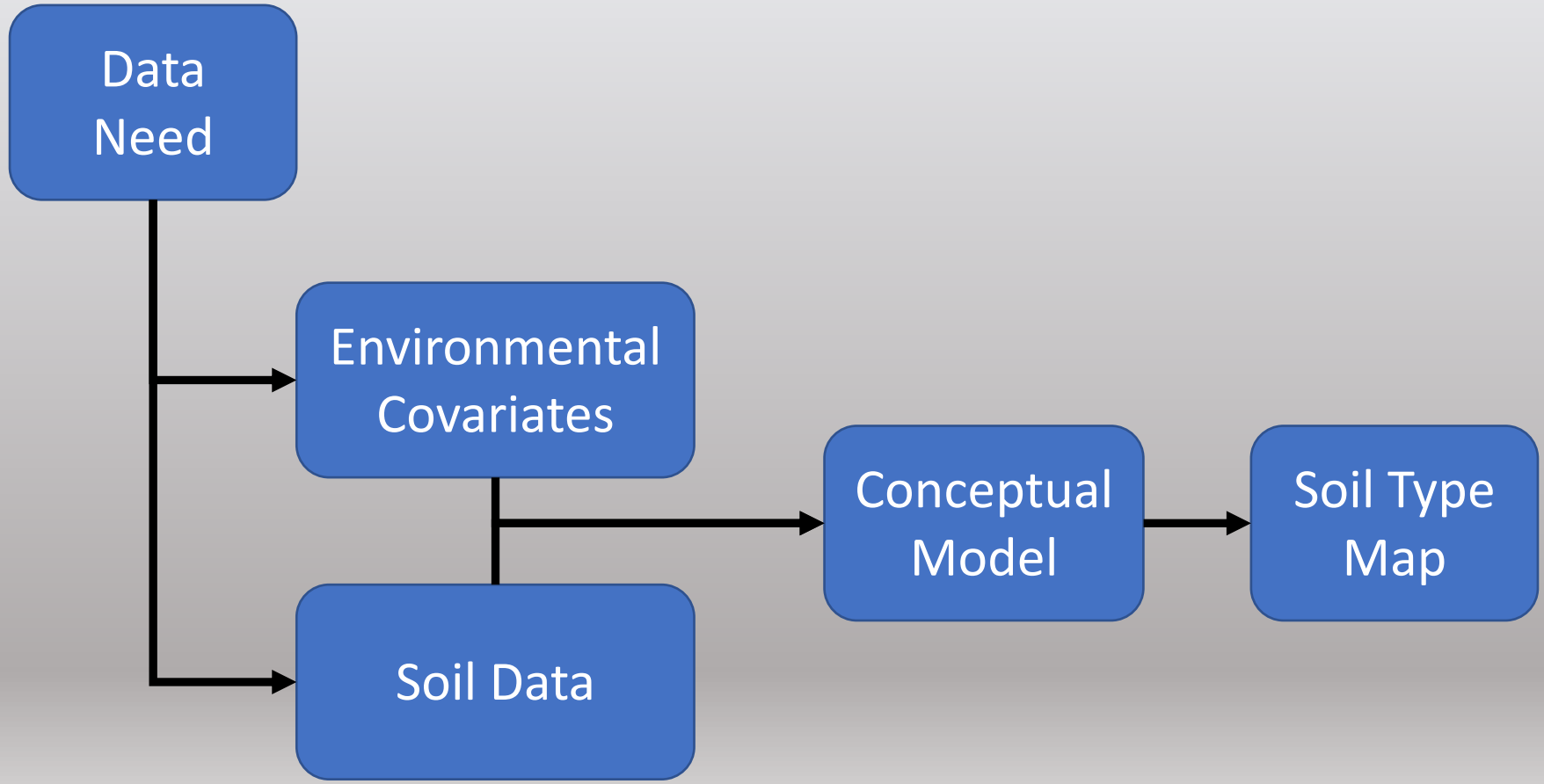
1998: 342 pgs.

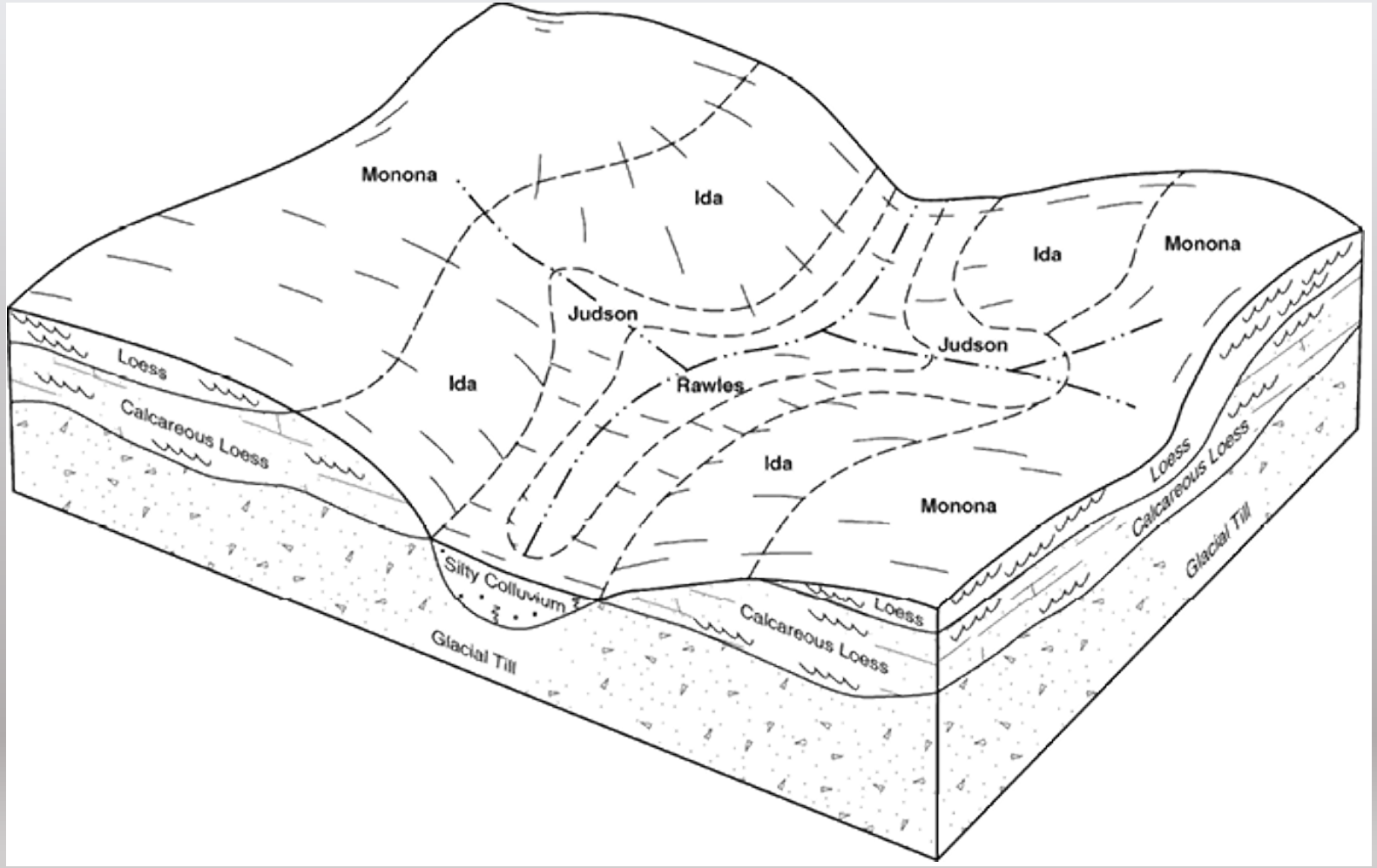
USDA United States Department of Agriculture
Natural Resources Conservation Service

In cooperation with Purdue University Agricultural Experiment Station and the Indiana Department of Natural Resources, State Soil Conservation Board and Division of Soil Conservation

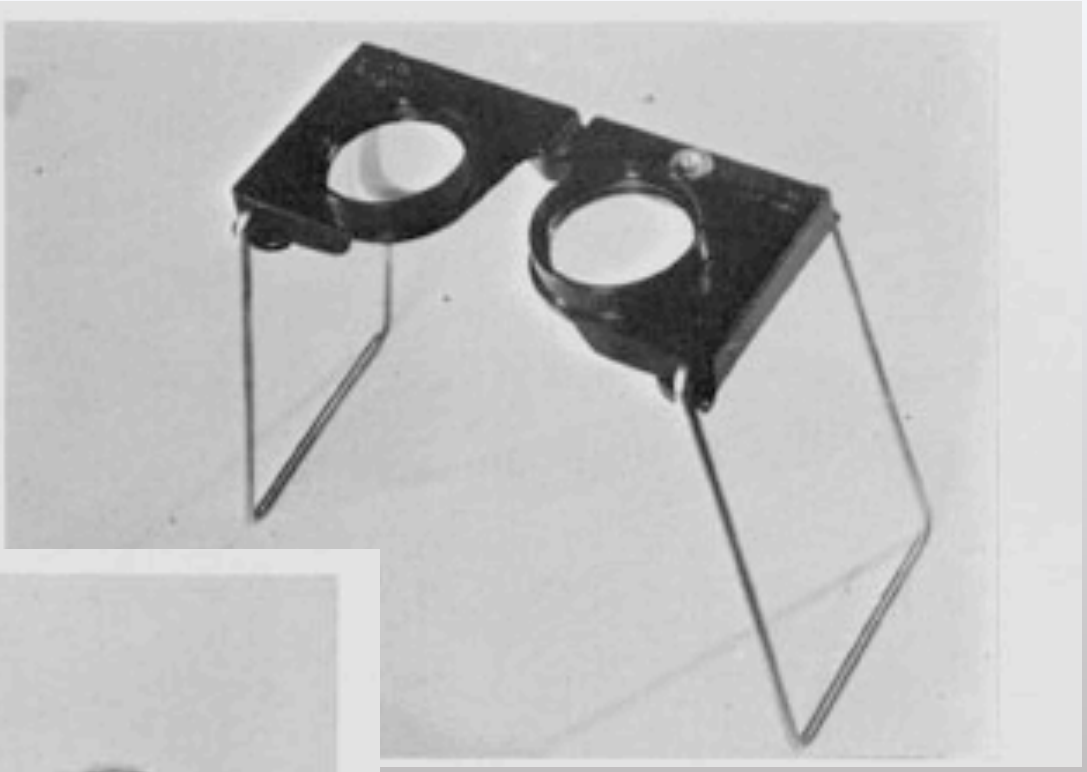
Soil Survey of Tippecanoe County, Indiana

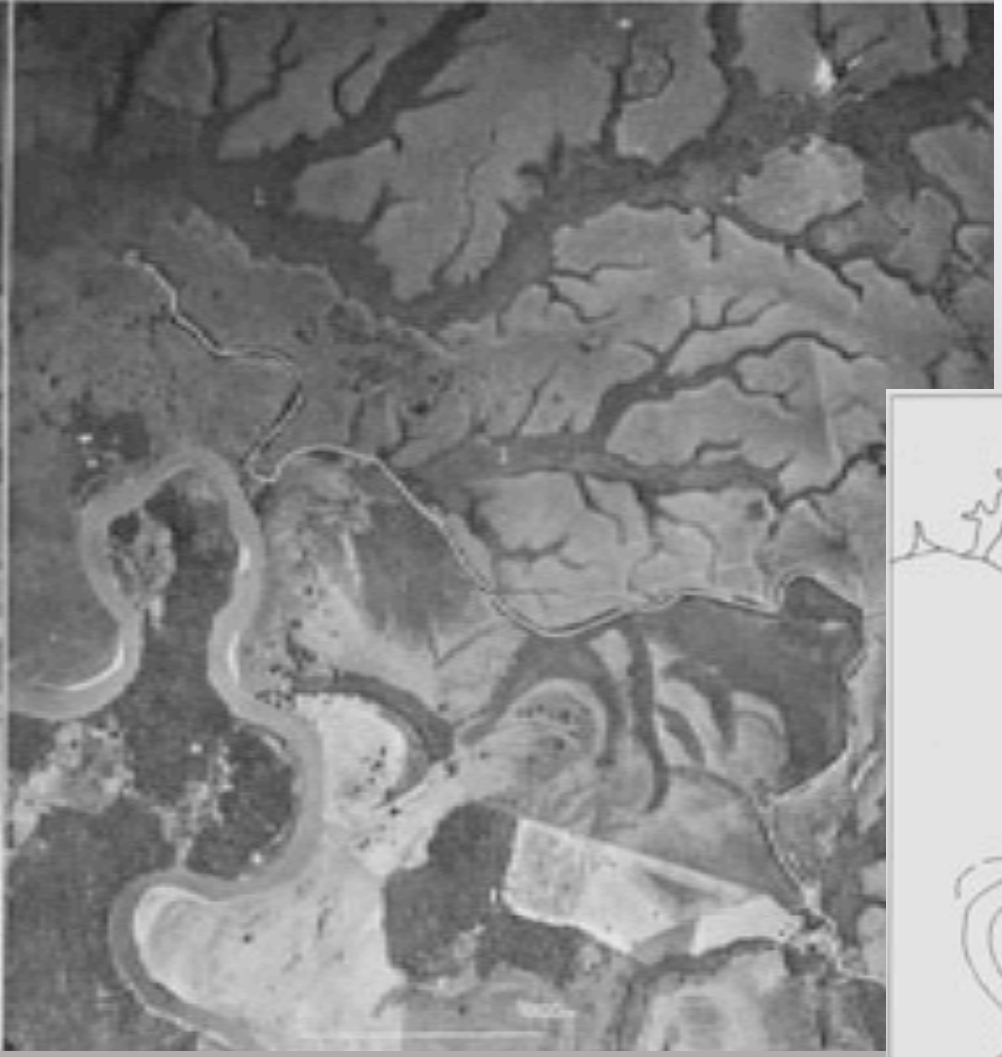
Analog Soil Mapping

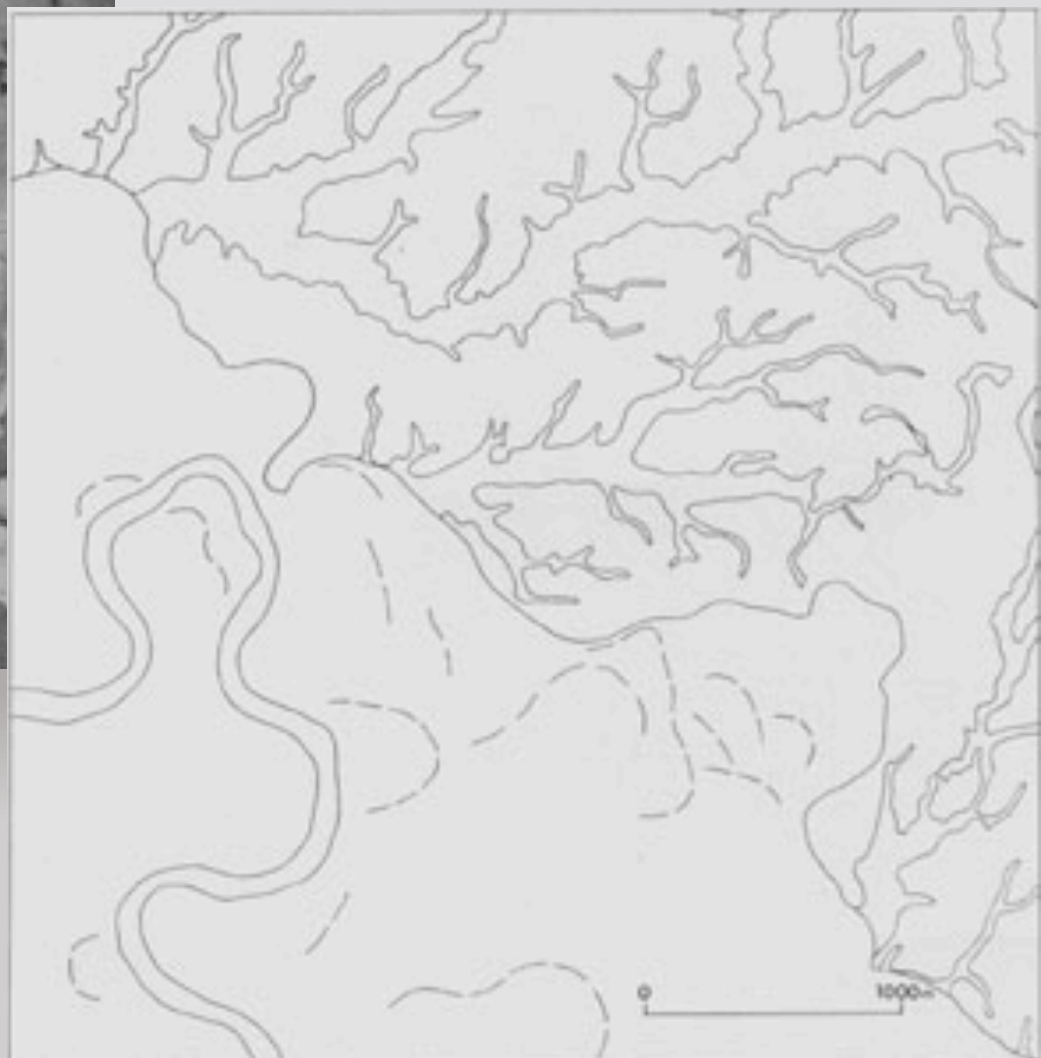



Monona
Ida
Judson
Ida
Rawles
Ida
Monona
Ida
Monona
Judson
Loess
Calcareous Loess
Silty Colluvium
Glacial Till
Loess
Calcareous Loess
Glacial Till
Loess
Calcareous Loess
Glacial Till

Analog tools of soil survey

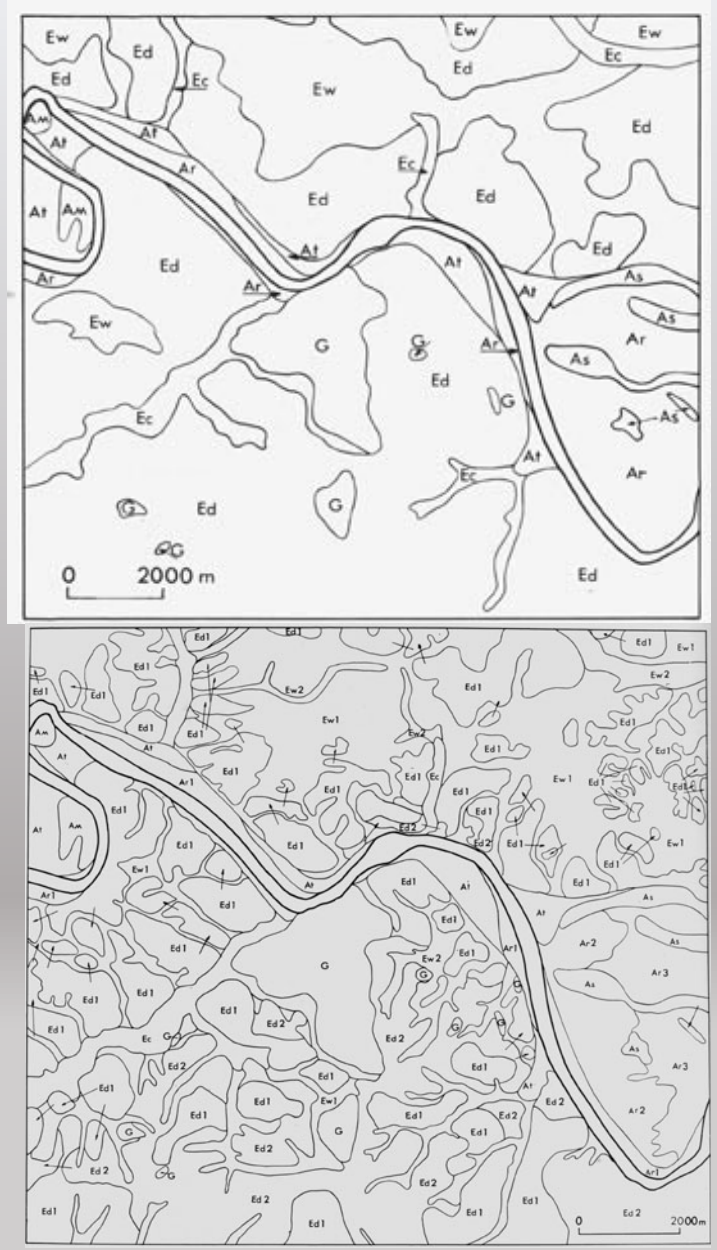





0
1000m

You can only draw so many lines and still have a readable map.

Map detail was linked to map scale (size of the paper)



Future Activities at Purdue

- Online tutorials on GIS for precision ag. -> 2020
- DSM Toolbox for QGIS
  - Free software plugin to help make digital soil maps using agronomic data
  - Open source
  - Spring/Summer of 2021