Soil Sensibility And Data Utility

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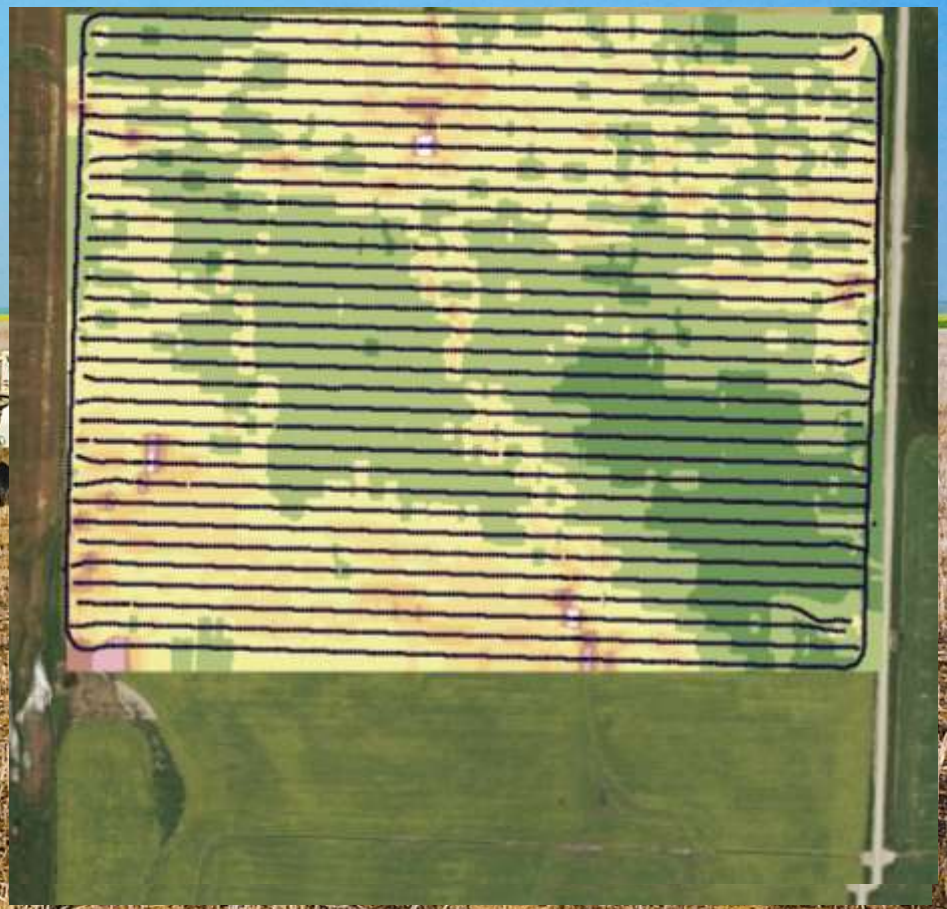
FARMING SMARTER

Grid Soil Samples

- 32 data points (sparse)
- Cost: ~$1600/field ($10/acre)
  - Soil Nutrients NPKS top 15cm
- High cost, low density

Electrical Conductivity Sensor

- 49,152 data points (dense)
- Cost: ~$880/field ($5.50/acre)
  - EC (clay and moisture content)
- Low cost, high density



Research Questions

1. What can soil sensors tell us?
2. How can this information create zones?
3. Are these zones useful or meaningful?

The Soil Sensors

Veris MSP3

- Electrical Conductivity (Resistance)
- On the go pH measurements
- Organic Matter

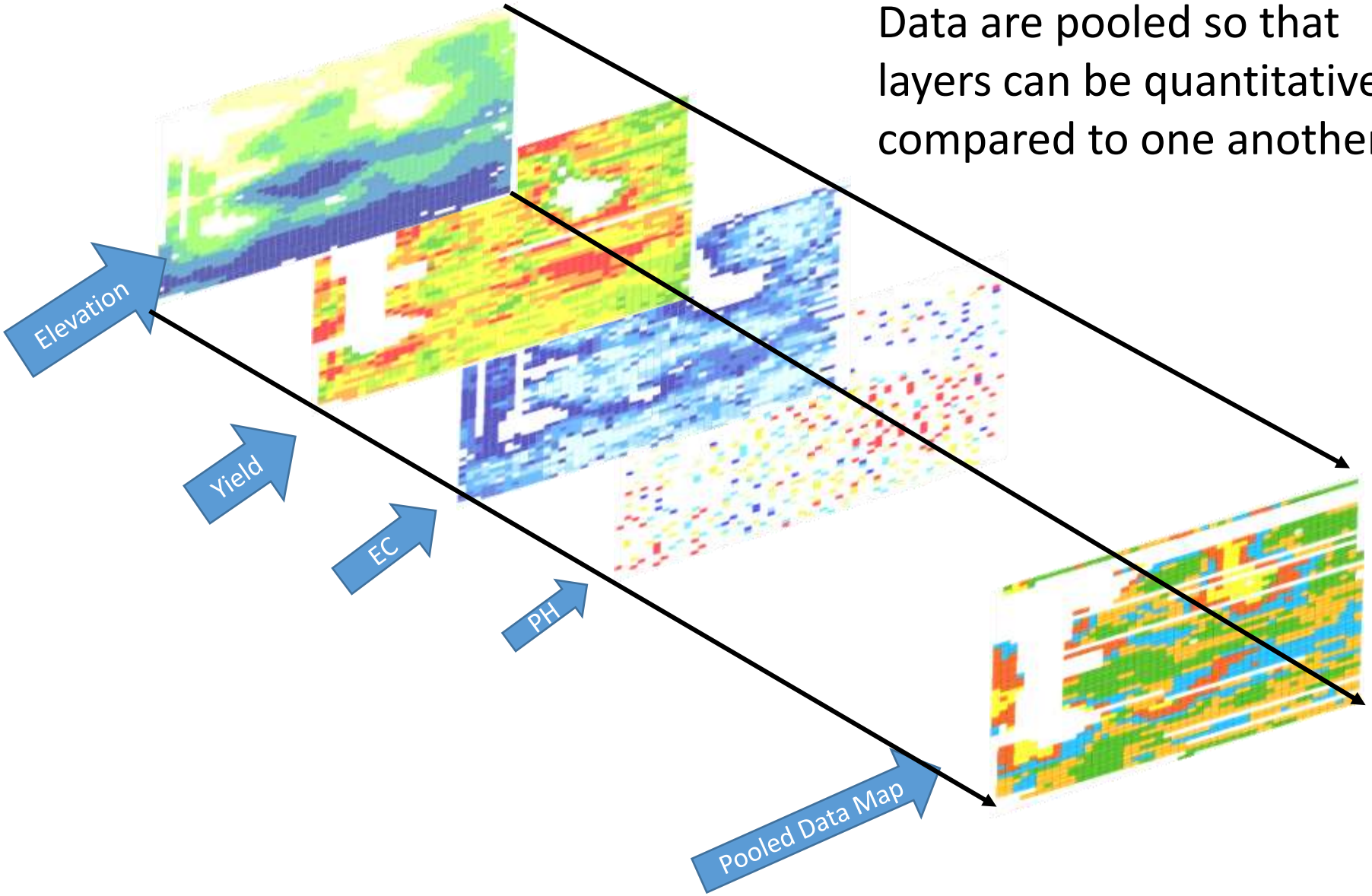
EM38-MK2

- Electrical Conductivity (EM Induction)

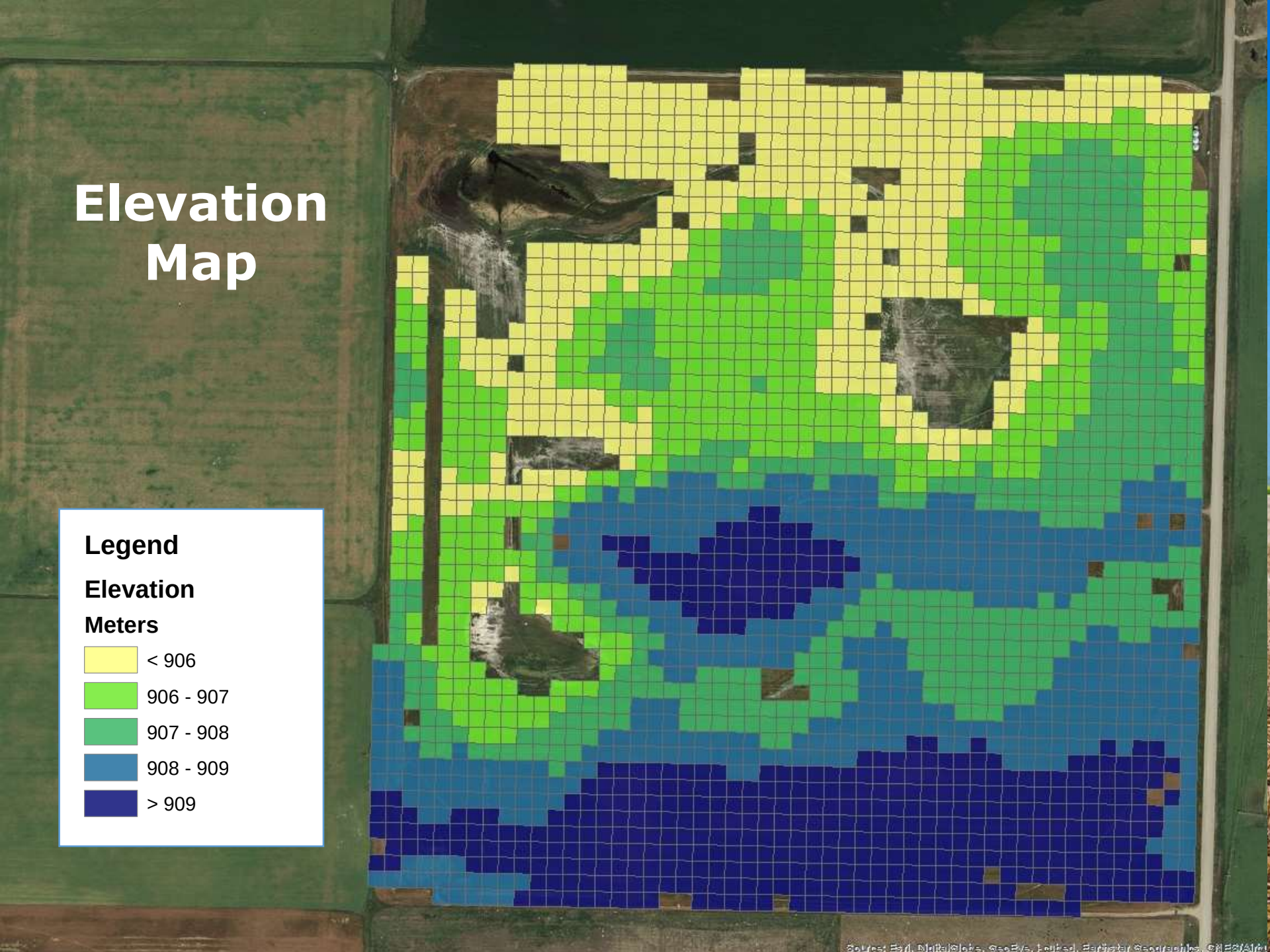
1. What can soil sensors tell us?

- **Account for in-field variability**
- **Give insight into soil properties**

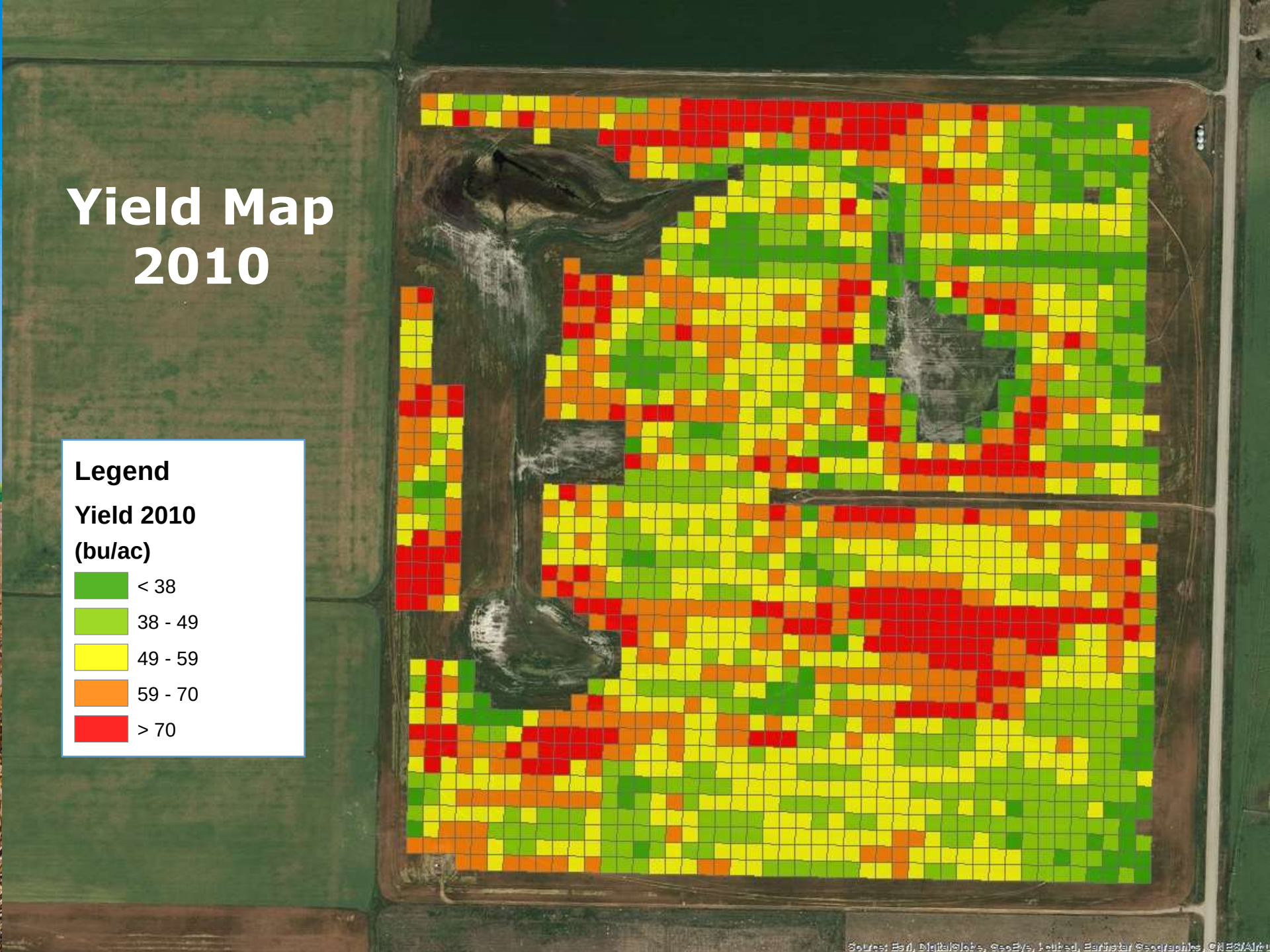
Data are pooled so that layers can be quantitatively compared to one another



Elevation Map

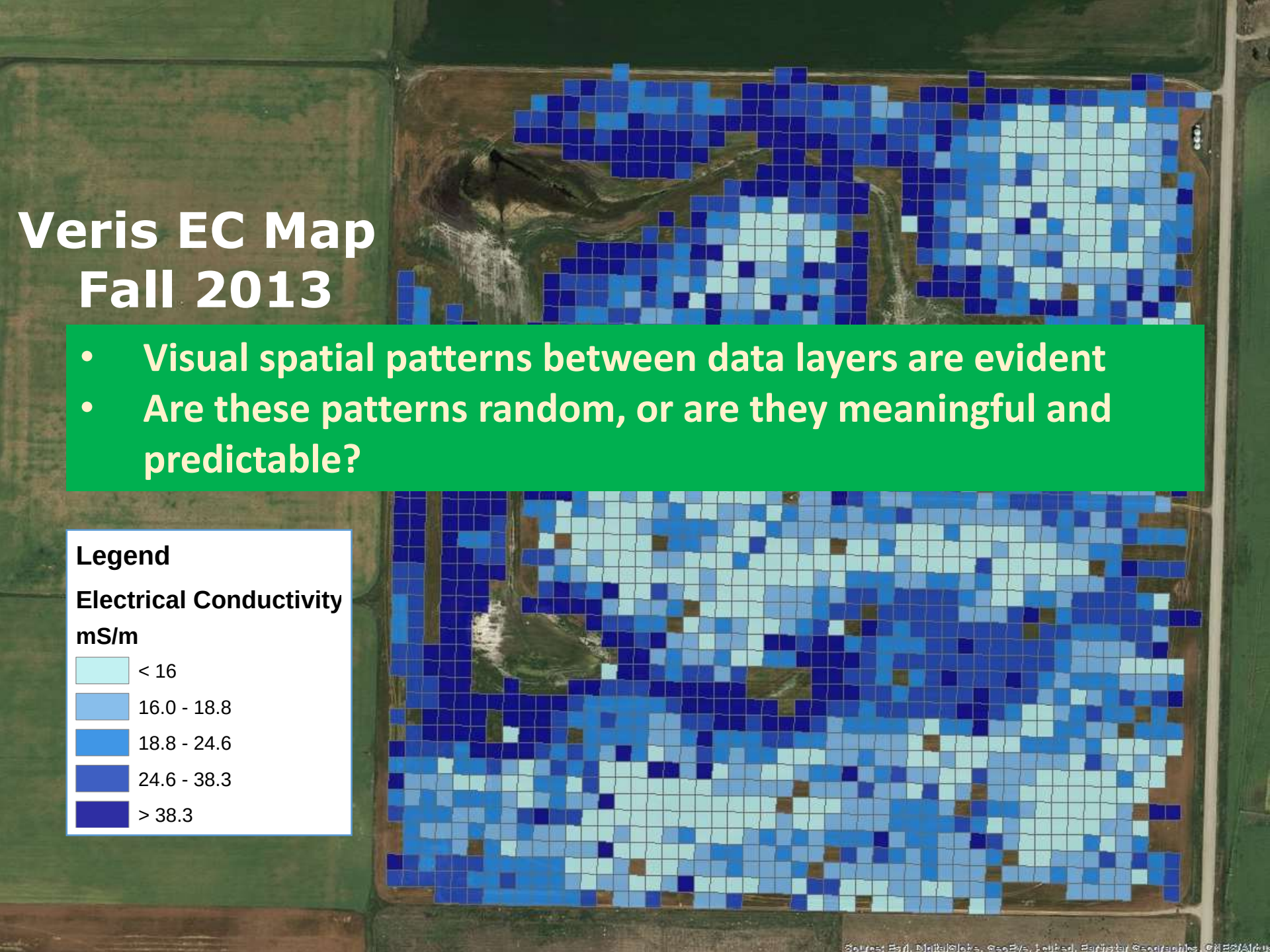


Yield Map 2010



Veris EC Map Fall 2013

- Visual spatial patterns between data layers are evident
- Are these patterns random, or are they meaningful and predictable?



How do different layers of data relate to one another?

- Correlation Matrix
  - Statistically measures relationships between data layers
- Green indicates positive correlation
- Red indicates negative correlation

1. **EC data patterns were statistically similar to one another**
   - Consistent over space
   - Consistent over time
   - Consistent from one sensor to another

2. **Yield patterns were statistically quite variable**
   - Relationship between yield and sensor data changes over time
   - Yield patterns over time are more dynamic than we might expect

How do different layers of data relate to measured soil data?

- Correlation Matrix
  - Statistically measures relationships between mapped data layers and measured soil samples
- Green indicates strong correlation

Correlation of																
Silt		0.4 (39)		0.4 (44)	0.5 (44)	0.5 (44)	0.4 (44)			-0.4 (39)	-0.4 (39)	0.5 (21)	0.5 (33)	0.4 (29)		0.3 (40)
Sand		-0.4 (43)	-0.4 (25)	-0.4 (48)	-0.5 (48)	-0.6 (48)	-0.6 (48)			0.5 (43)	0.6 (43)	-0.6 (25)	-0.6 (35)			-0.4 (44)
EC		0.5 (26)	0.5 (26)	0.9 (29)	0.8 (29)	0.6 (29)	0.5 (29)				-0.5 (26)	0.5 (26)	0.7 (22)			0.7 (28)

1. EC patterns were often related to measured soil texture and soil moisture
2. EC patterns often did not relate strongly to soil nutrients (NPKS)

1 What can soil sensors tell us?

- EC readings are highly consistent
- EC is a strong indicator of the presence of clay and soil moisture
- Very few strong correlations between EC and either yield or soil nutrients
- Yield patterns can be quite variable

2 How can this information create zones?

- What data should we use to create zones?
- How many zones?
- What are the boundaries between zones?

Principal Component Analysis

- Uses statistics to reduce many data layers into a few **Factors**
- Examines relationships between data layers
- Identifies the 'key variables' that best account for variability

Factor 1: EC

Factor 2: Yield/OM

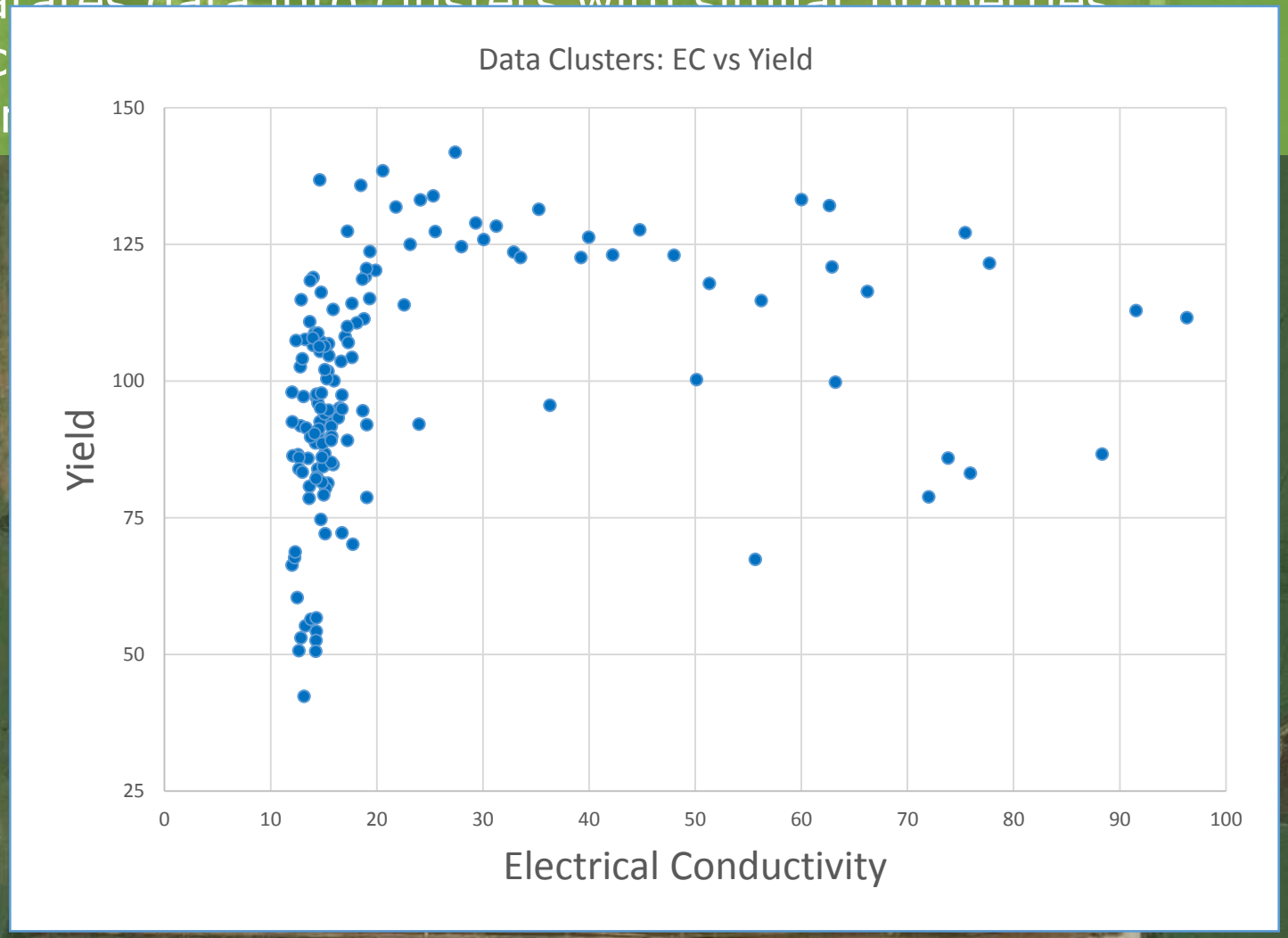
Principal Component Analysis Results				
	Primary Factor		Secondary Factor	
EM38_Deep_Fall2012	87	*	33	
EM38_Shallow_Fall2012	90	*	28	
VerisEC_Deep_Fall2013	94	*	14	
VerisEC_Shallow_Fall2013	82	*	7	
Veris_IR_Spring2014	-29		-89	*
Veris_OM_Spring2014	29		89	*
Yield_2010	33		75	*
Yield_2011	-20		45	*
Yield_2013_Ntrial	6		74	*

Printed values are multiplied by 100 and rounded to the nearest integer.
Values greater than 0.4 are flagged by an '*'.

Identified EC and Yield as key data layers

K-means Cluster Analysis

- A mathematical process for grouping of complex data
- Separates data into clusters with similar properties
- Effec
- Comr



K-means Cluster Analysis

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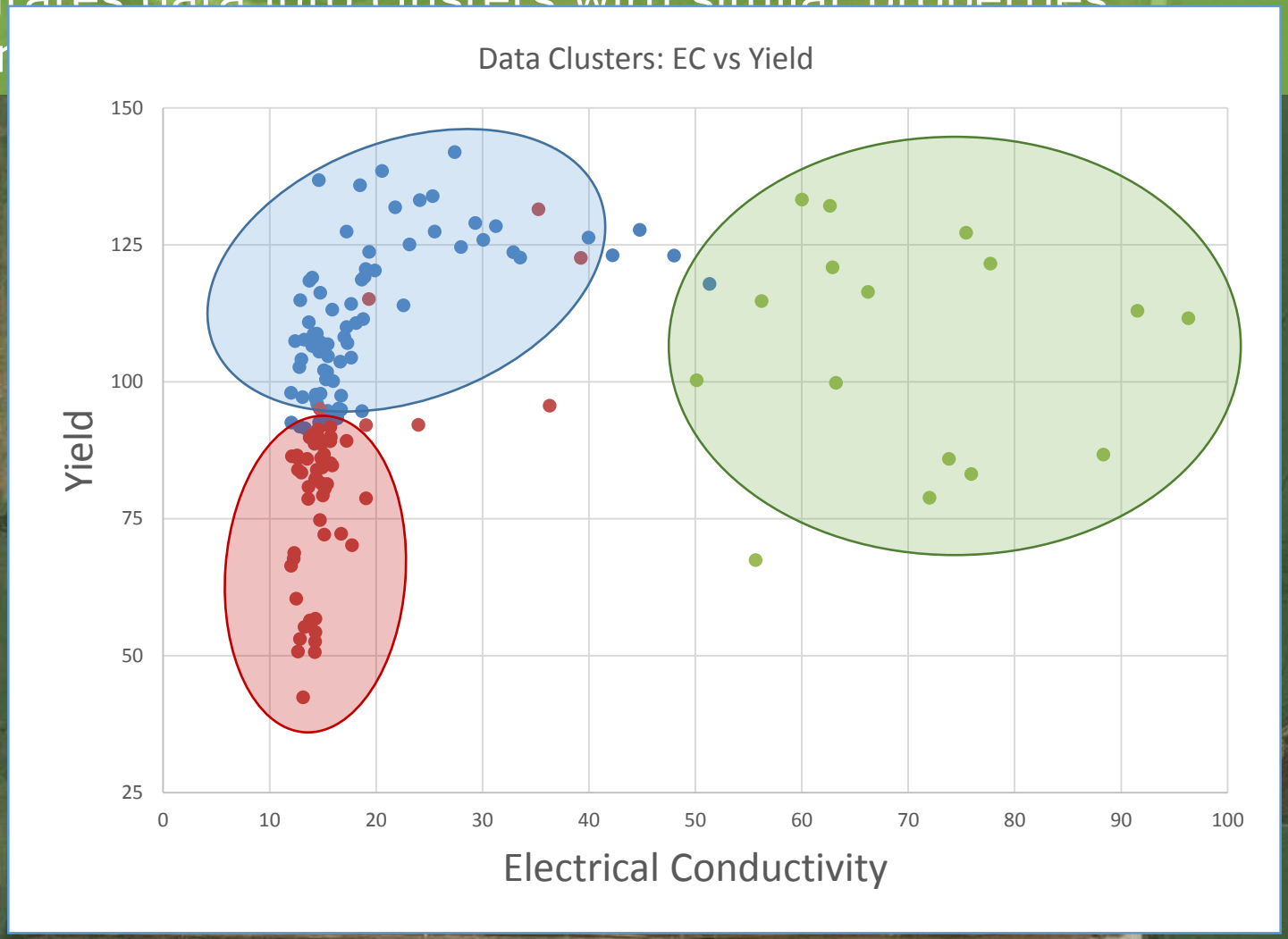
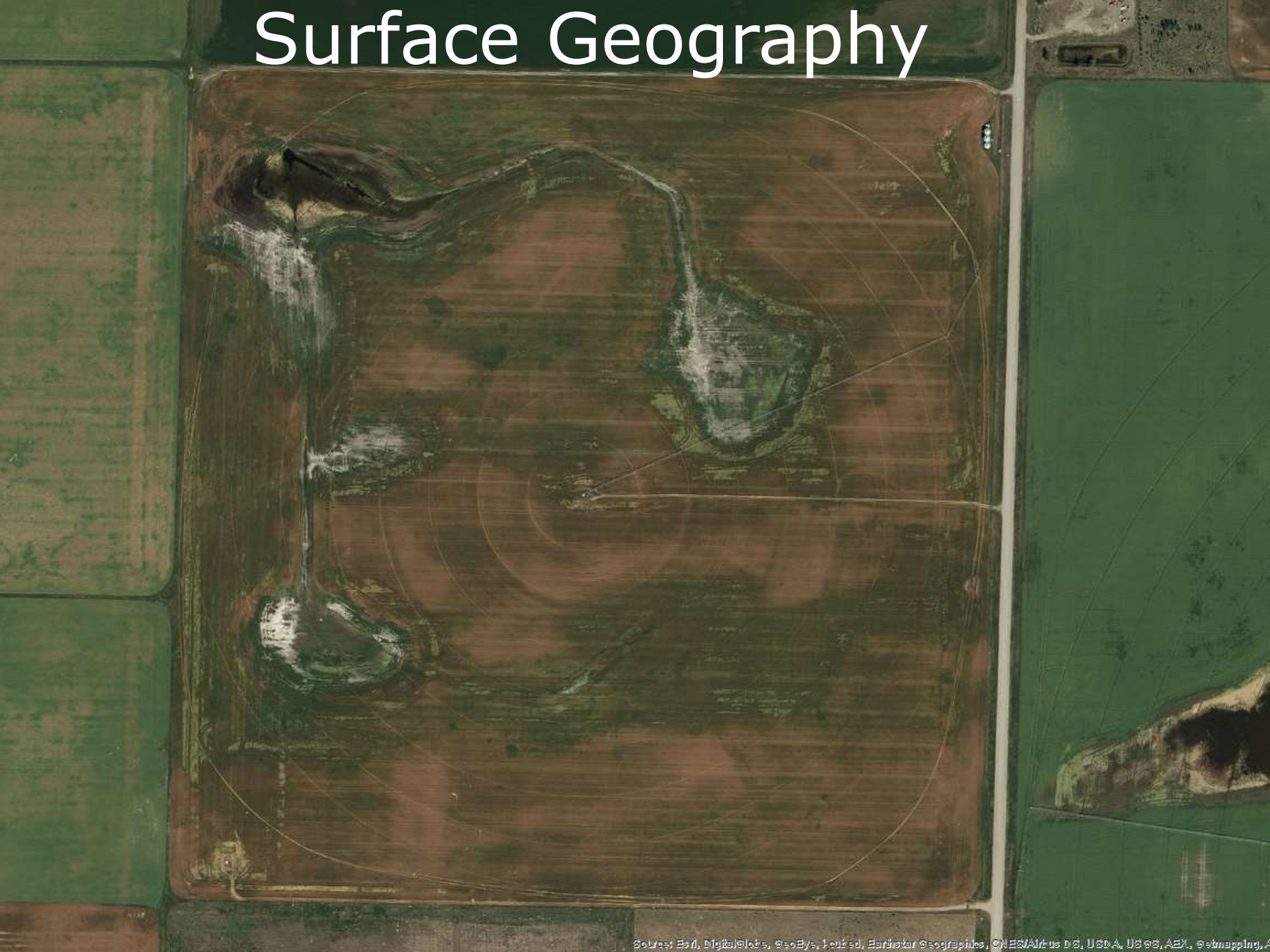


Surface Geography



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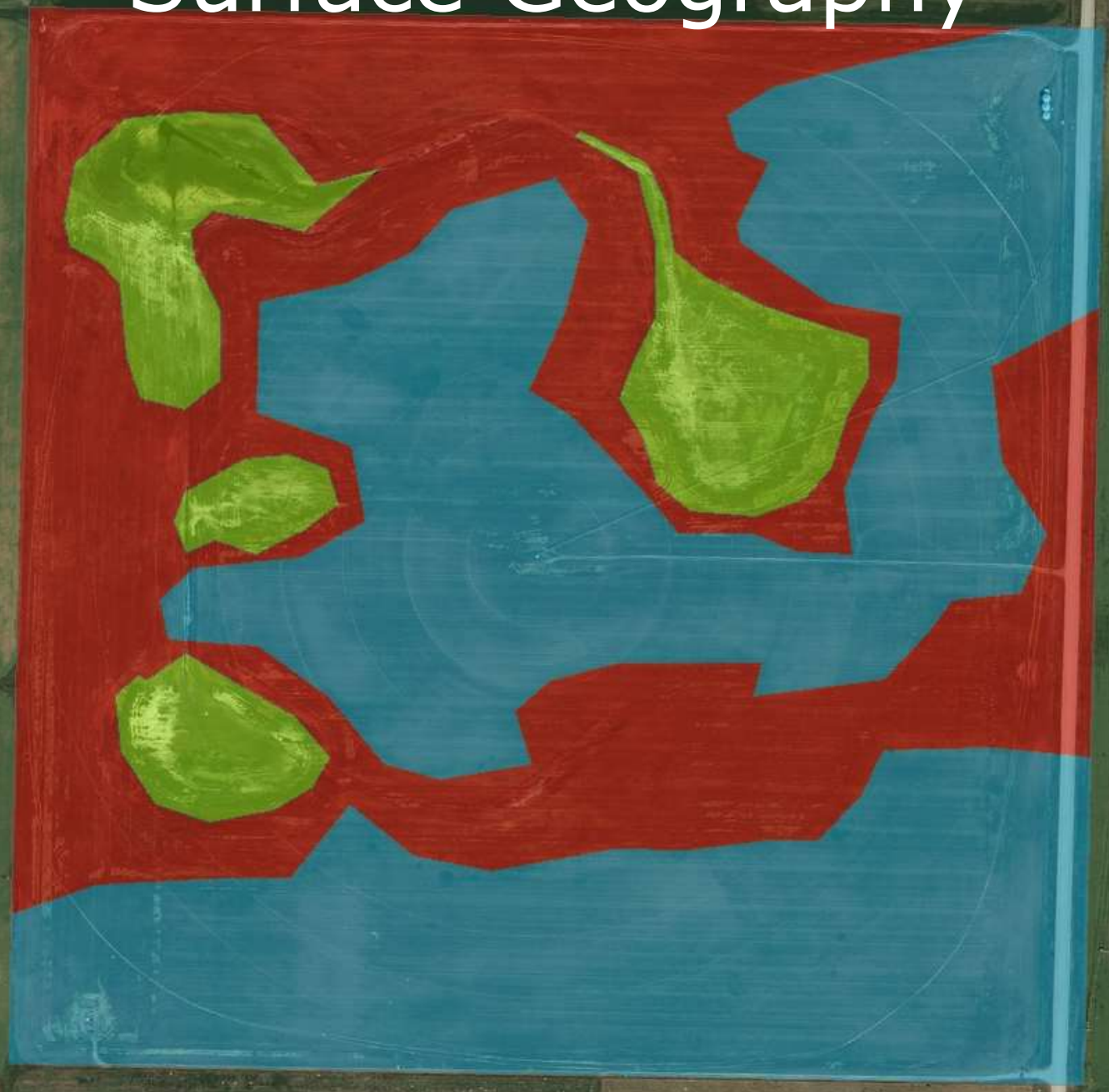

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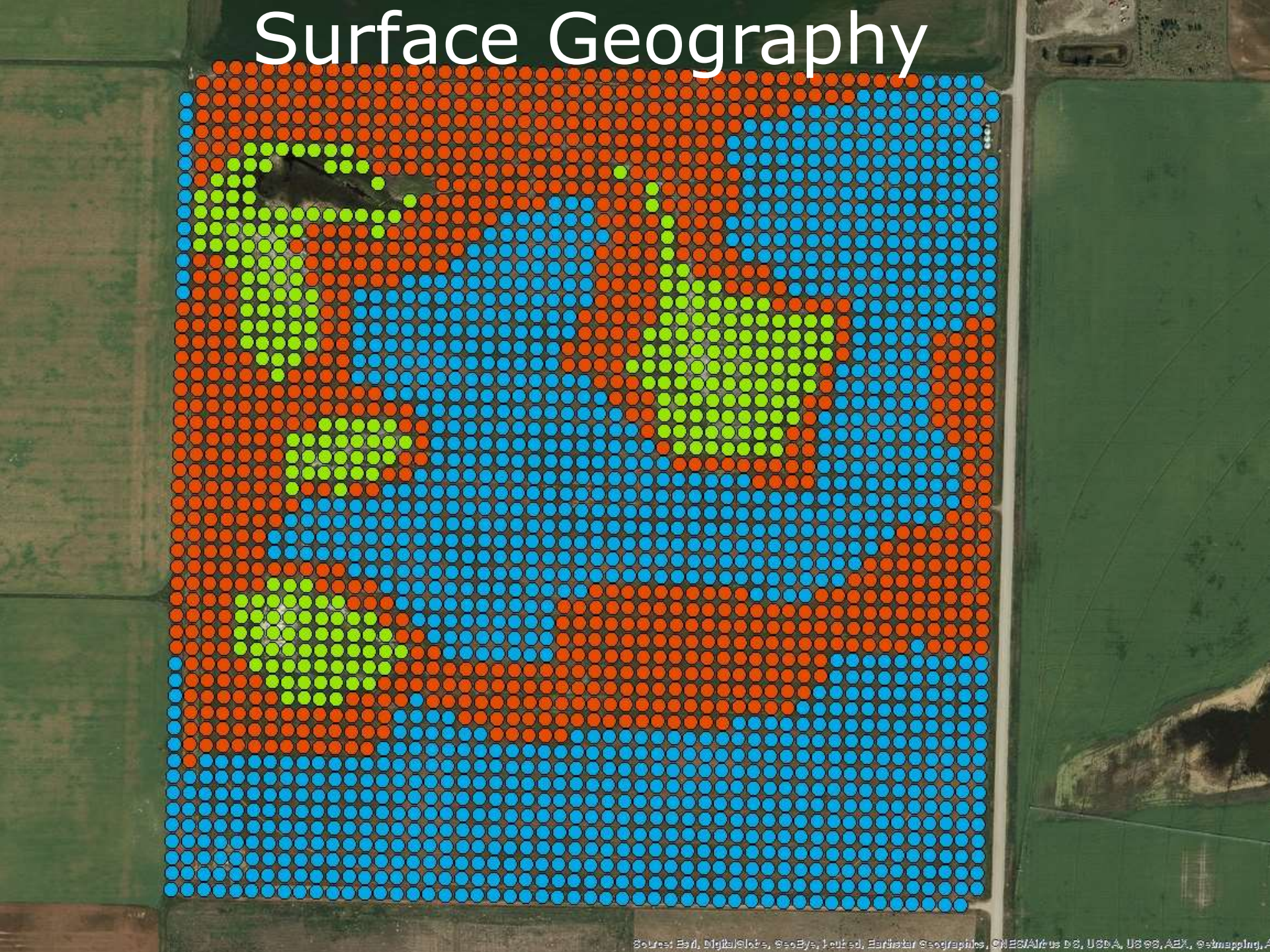
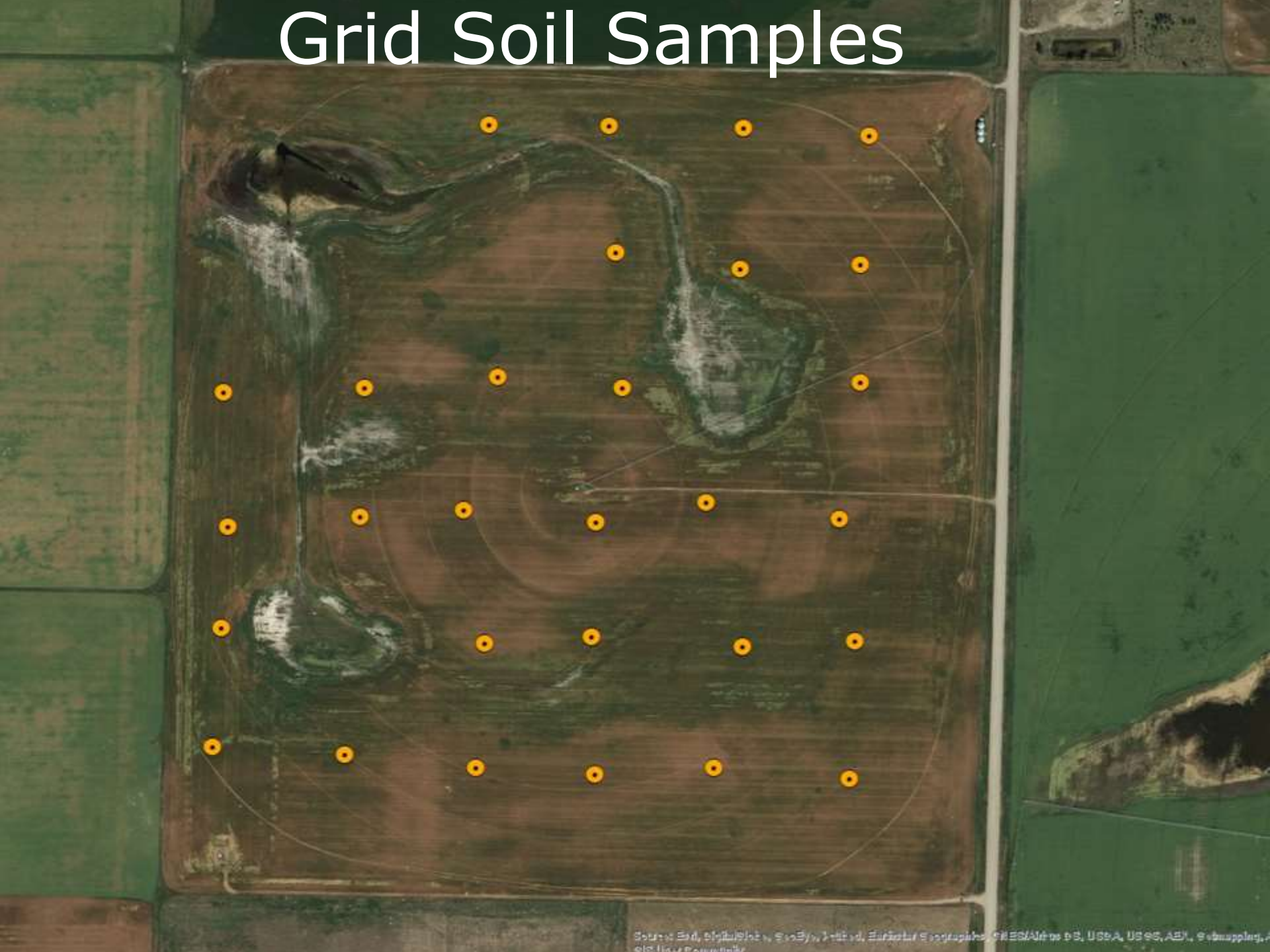


Grid Soil Samples



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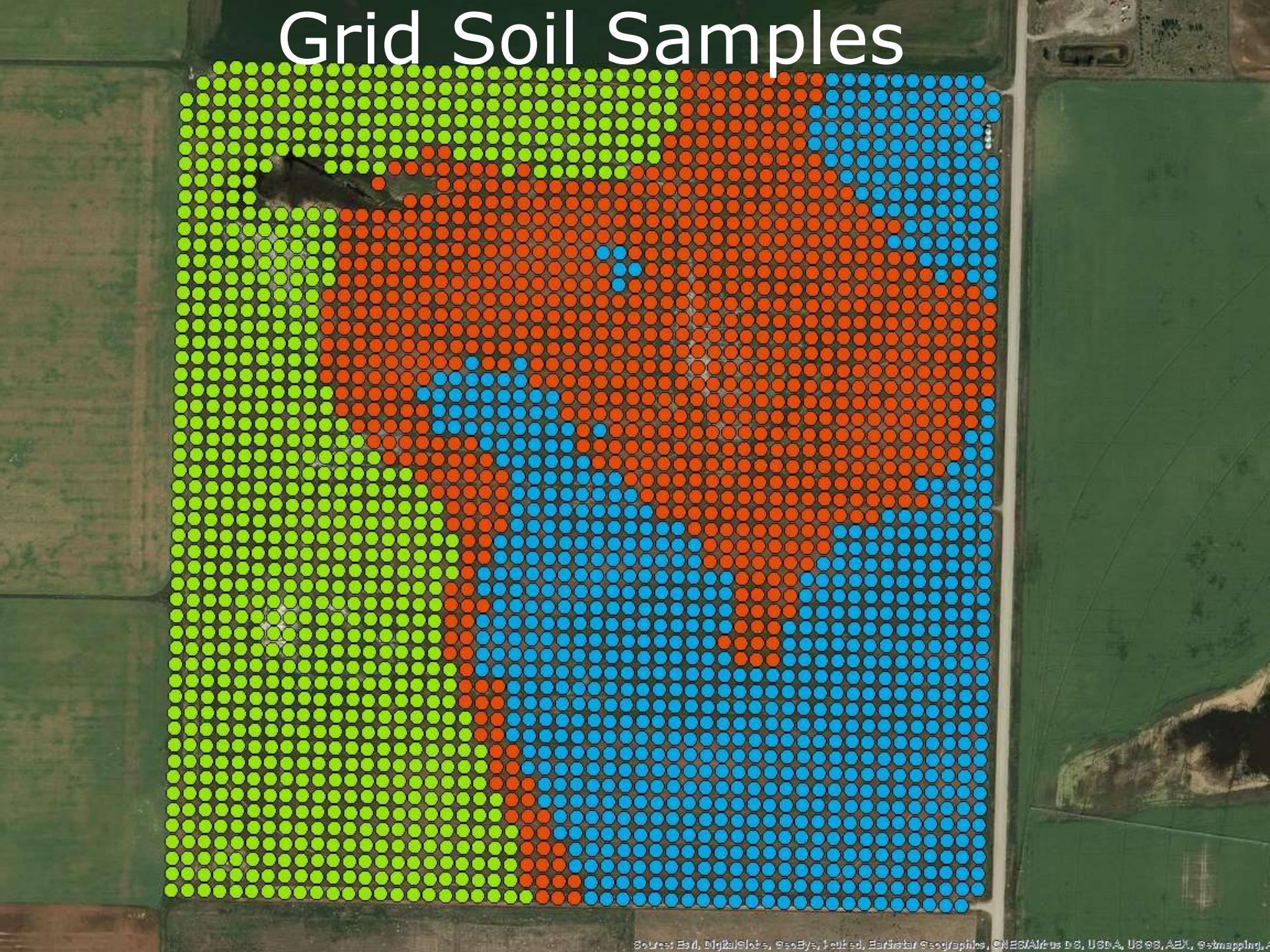
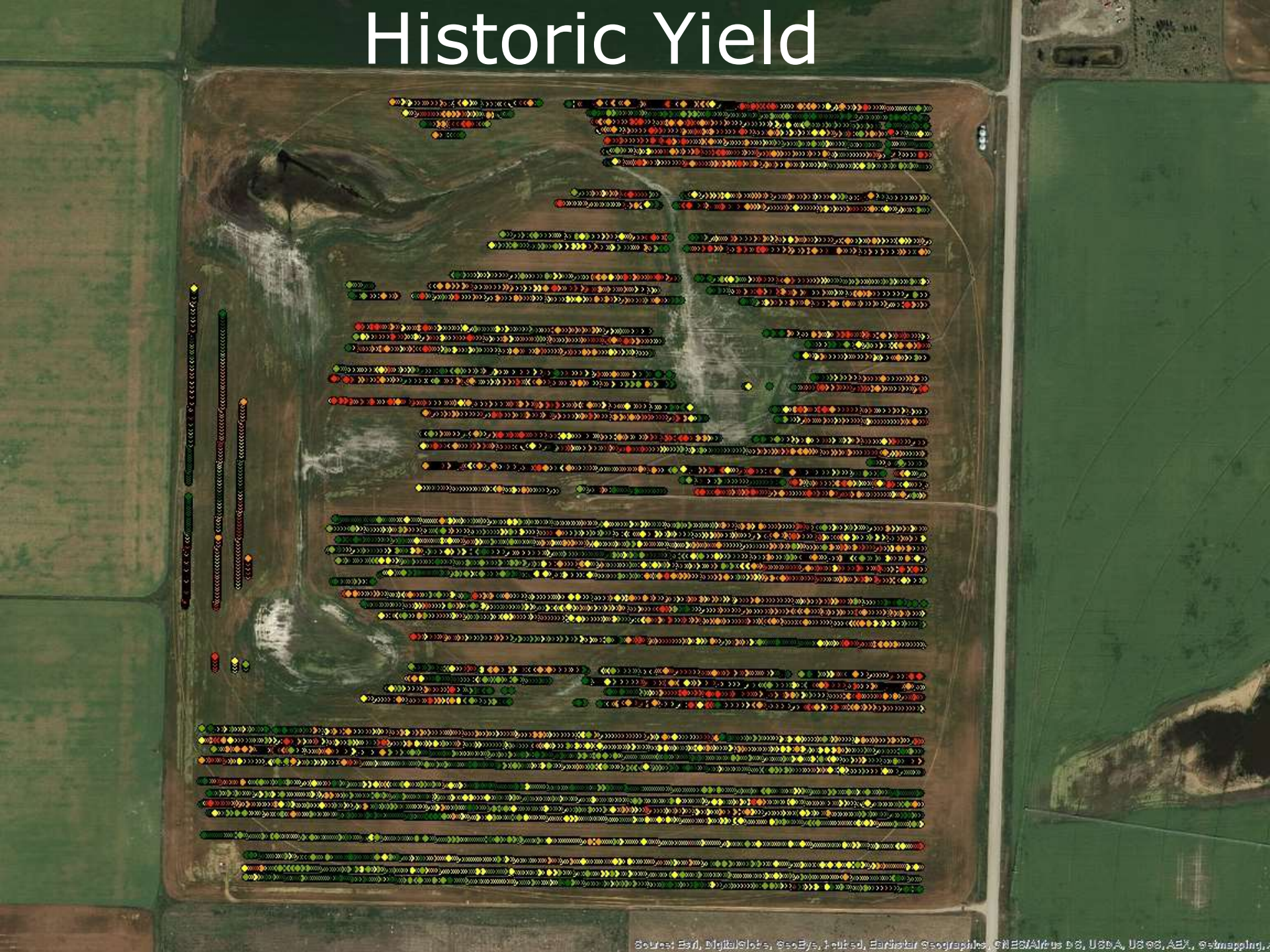
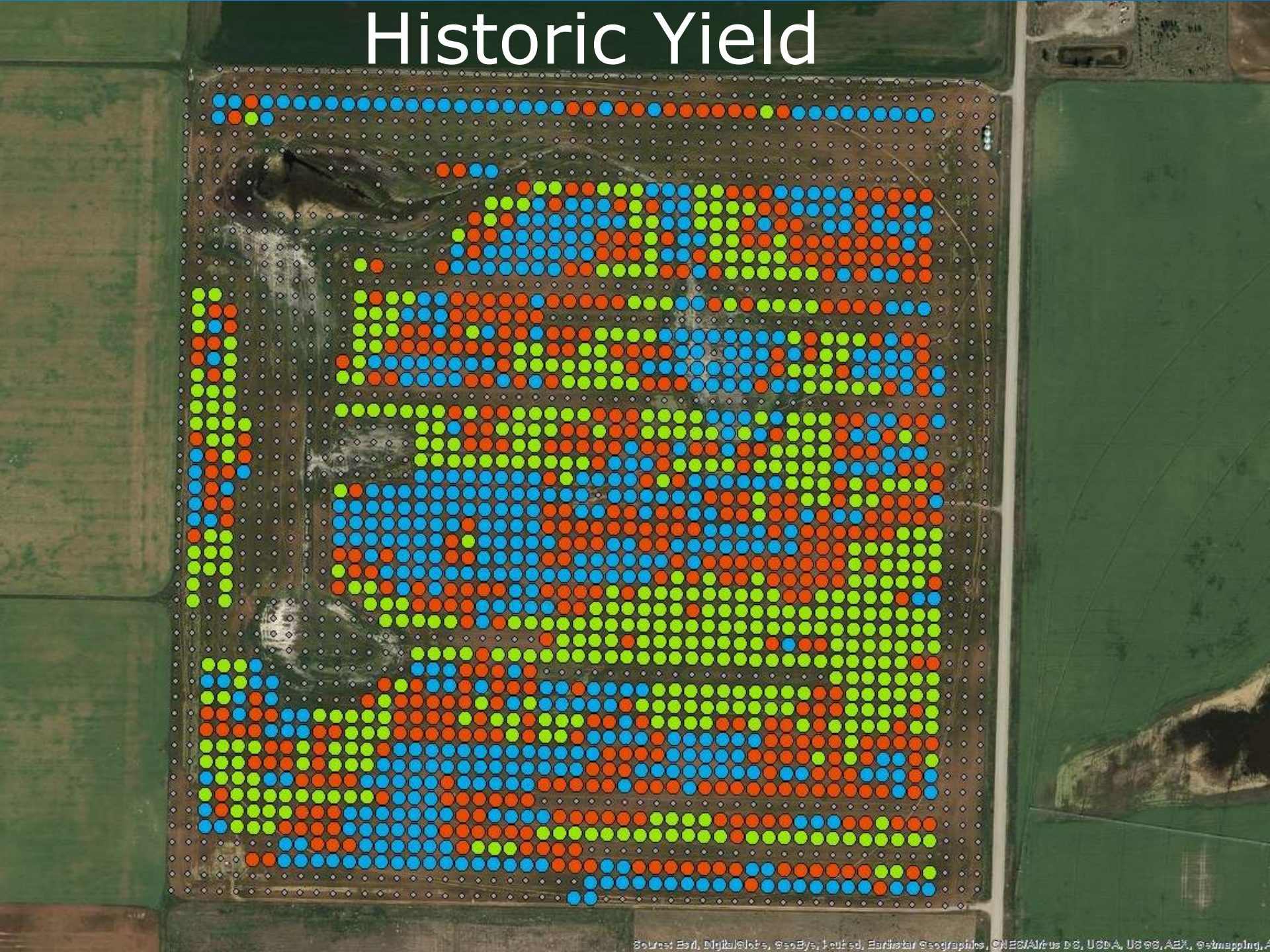


Historic Yield

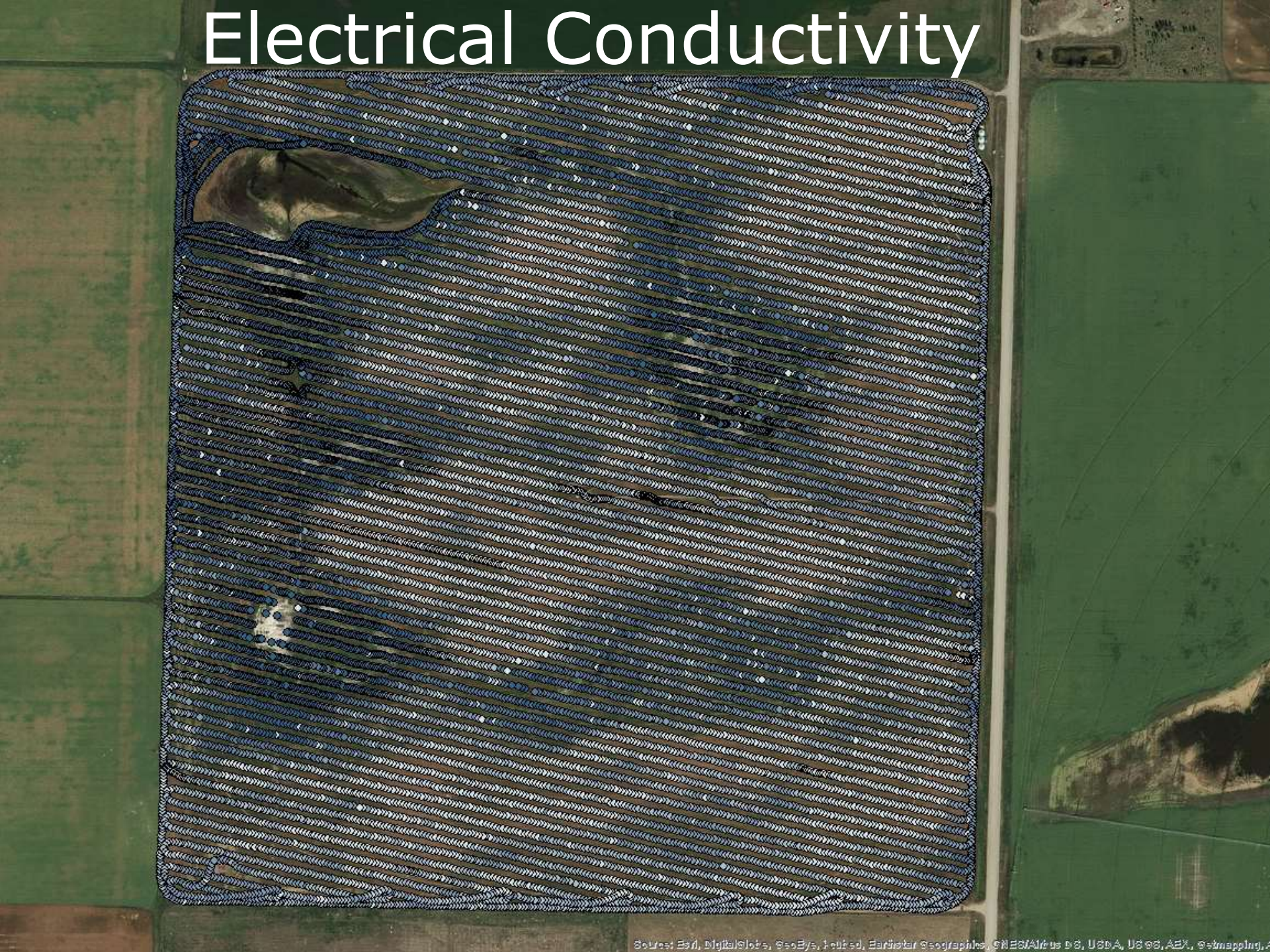
Historic Yield



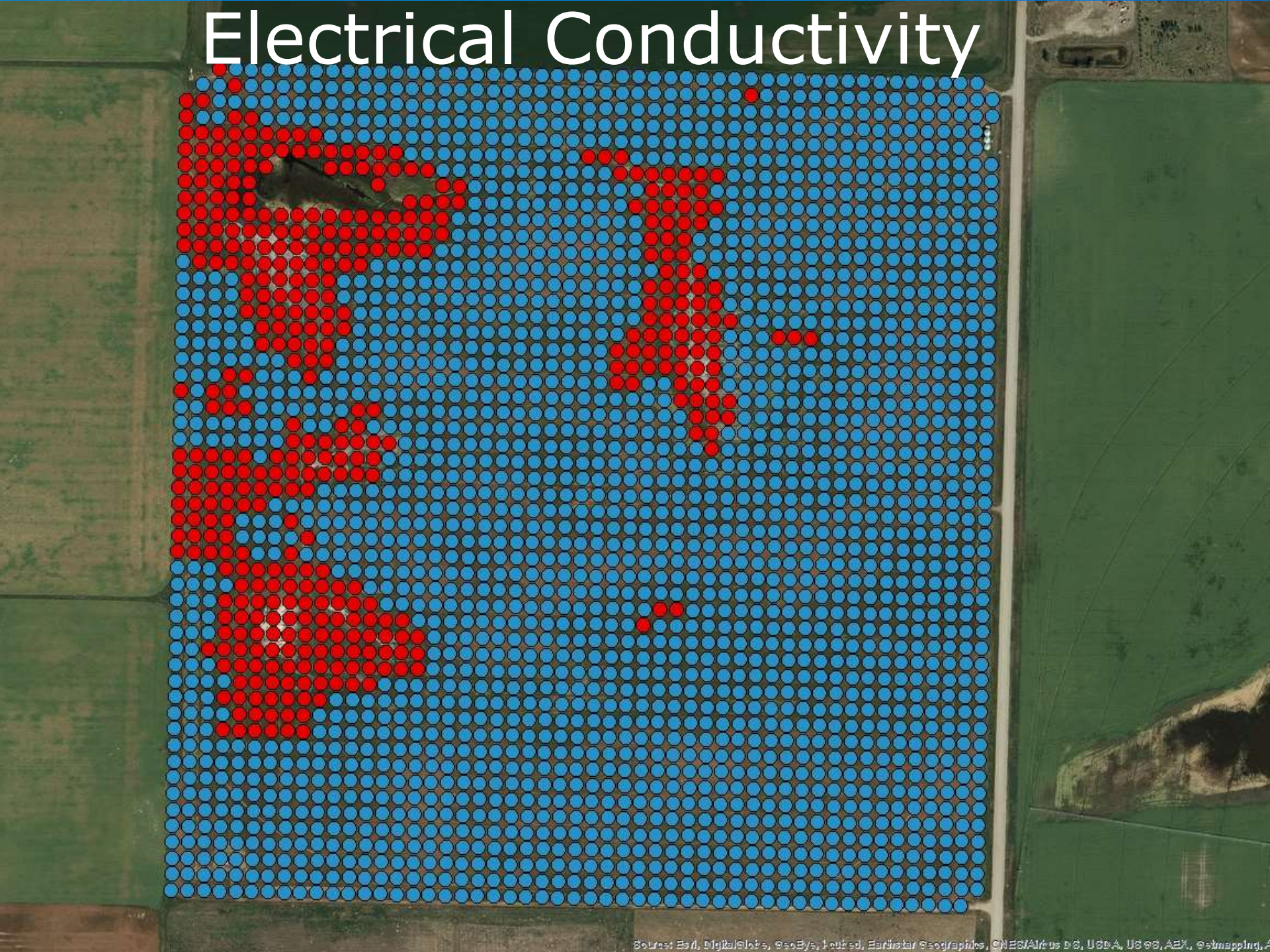
Historic Yield



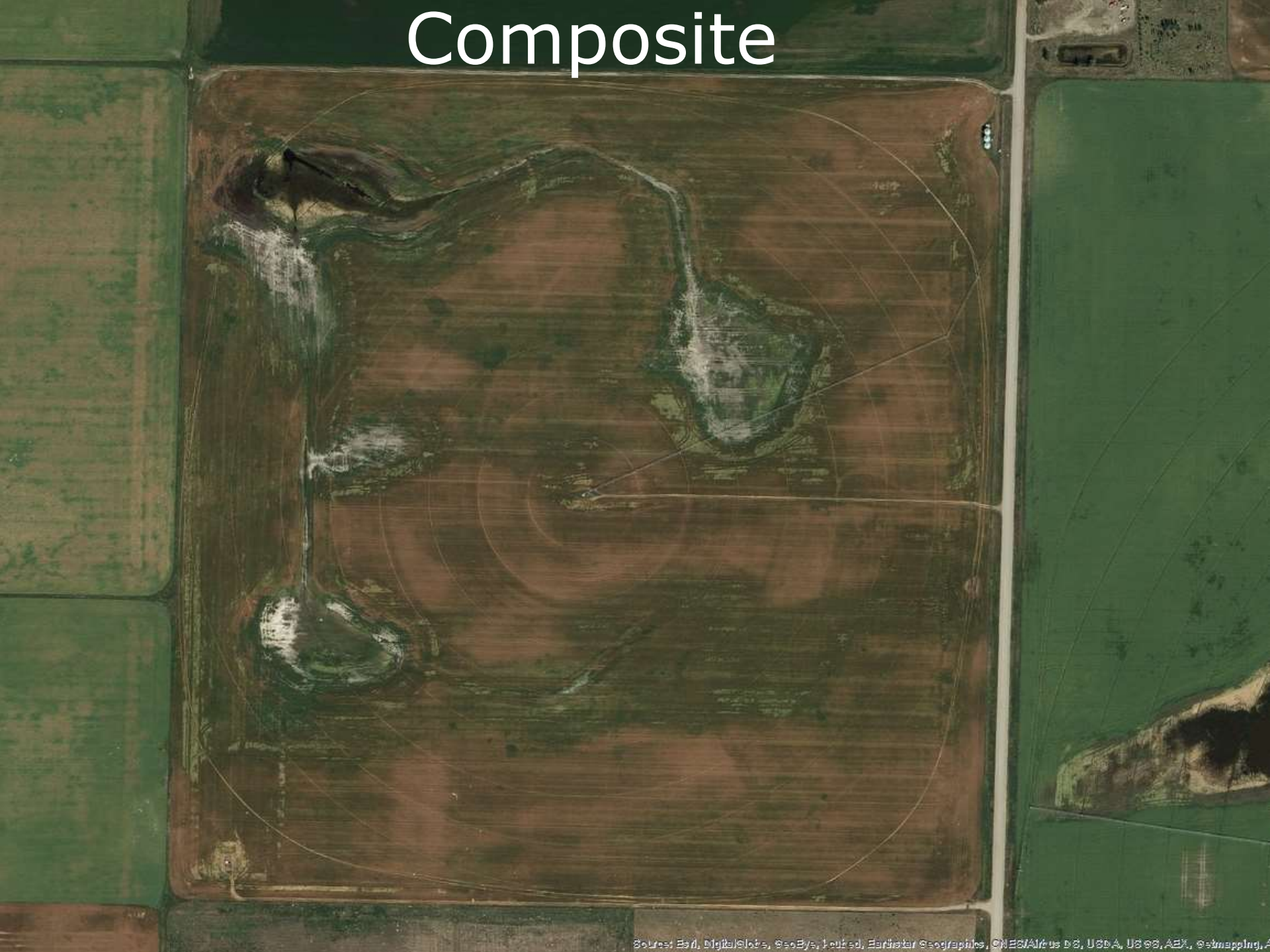
Electrical Conductivity



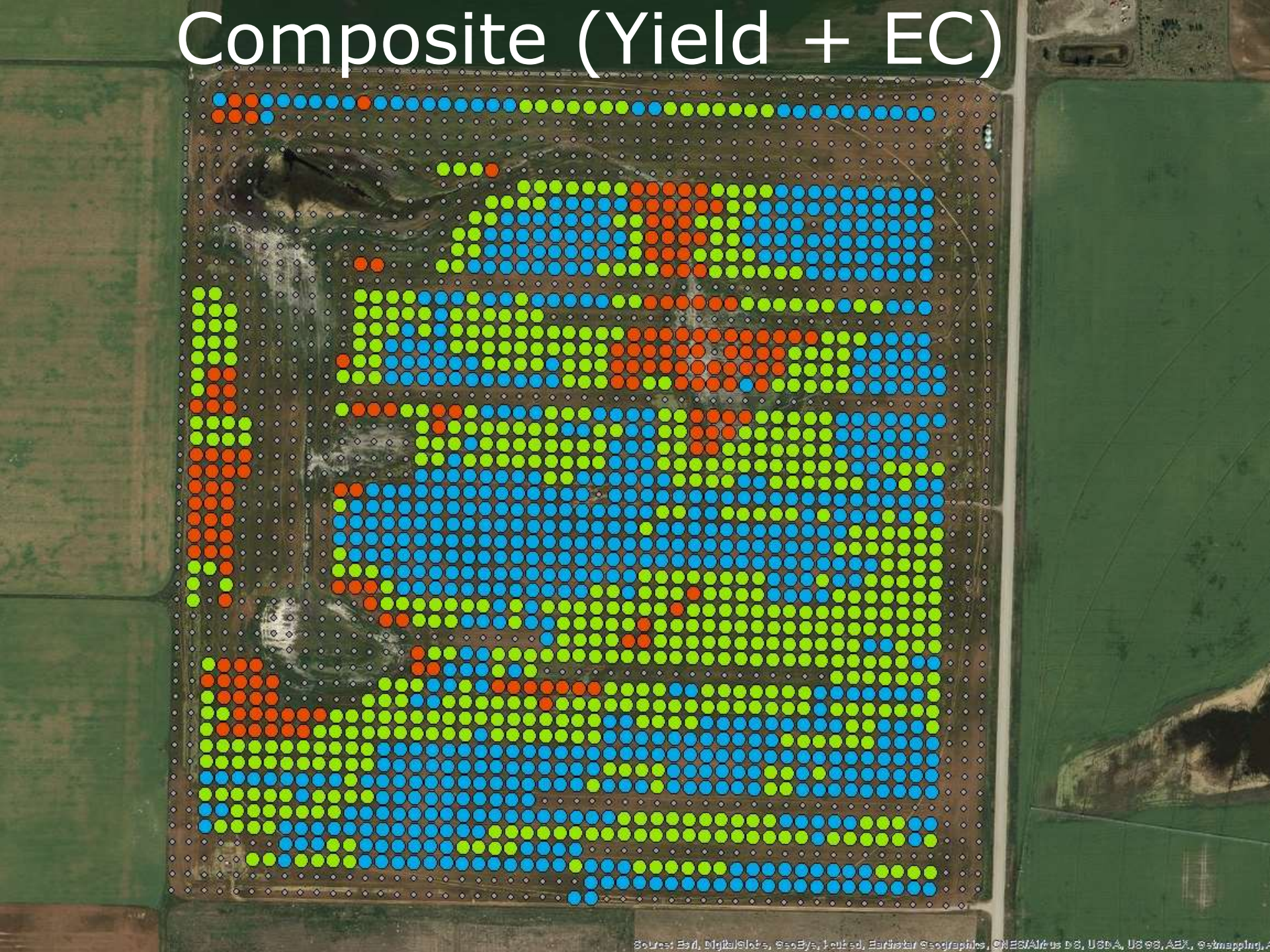
Electrical Conductivity



Composite


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping,

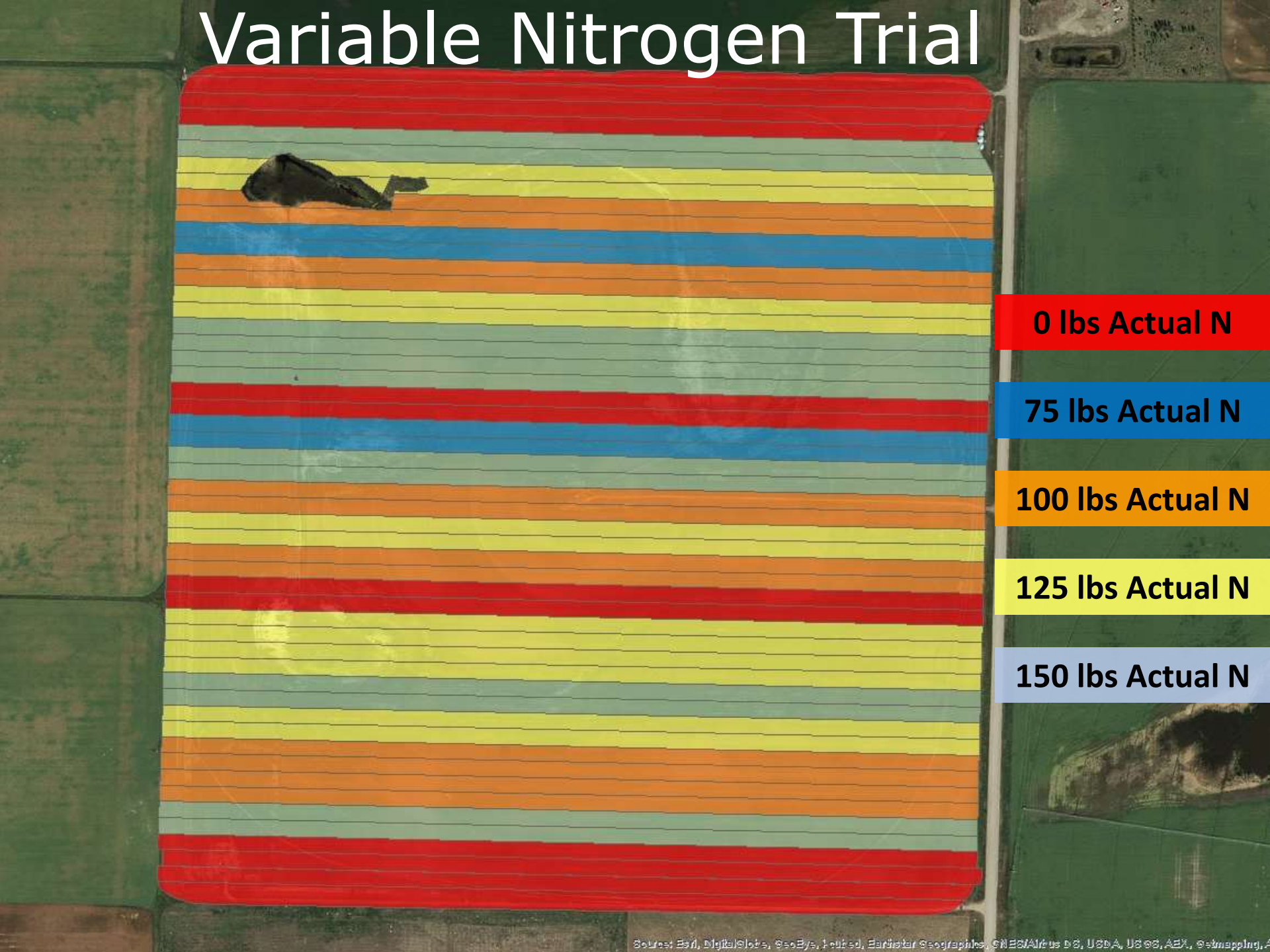
Composite (Yield + EC)



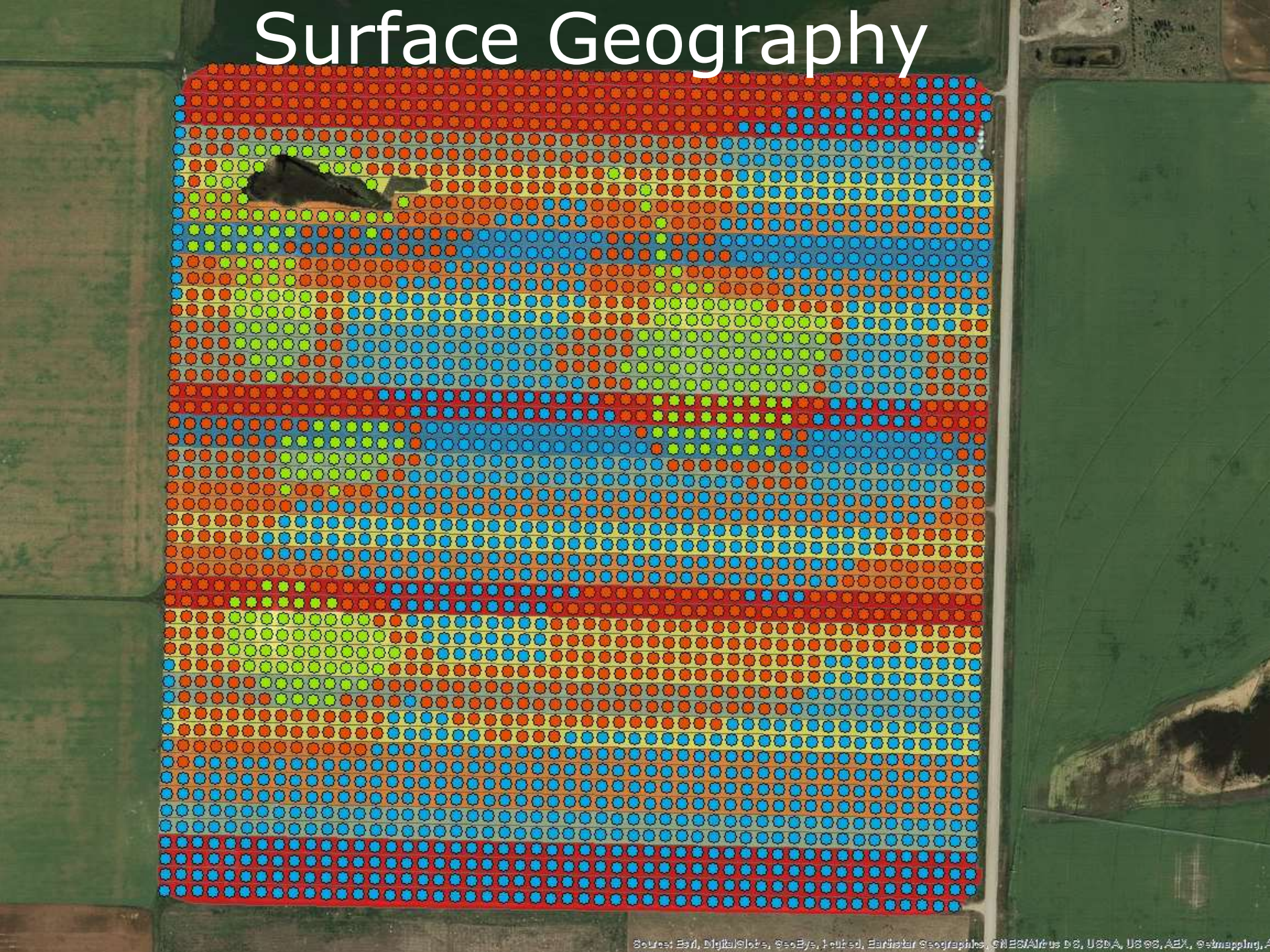
3. Are these zones useful or meaningful?

- Do zones yield differently?
- Can zones be managed differently?

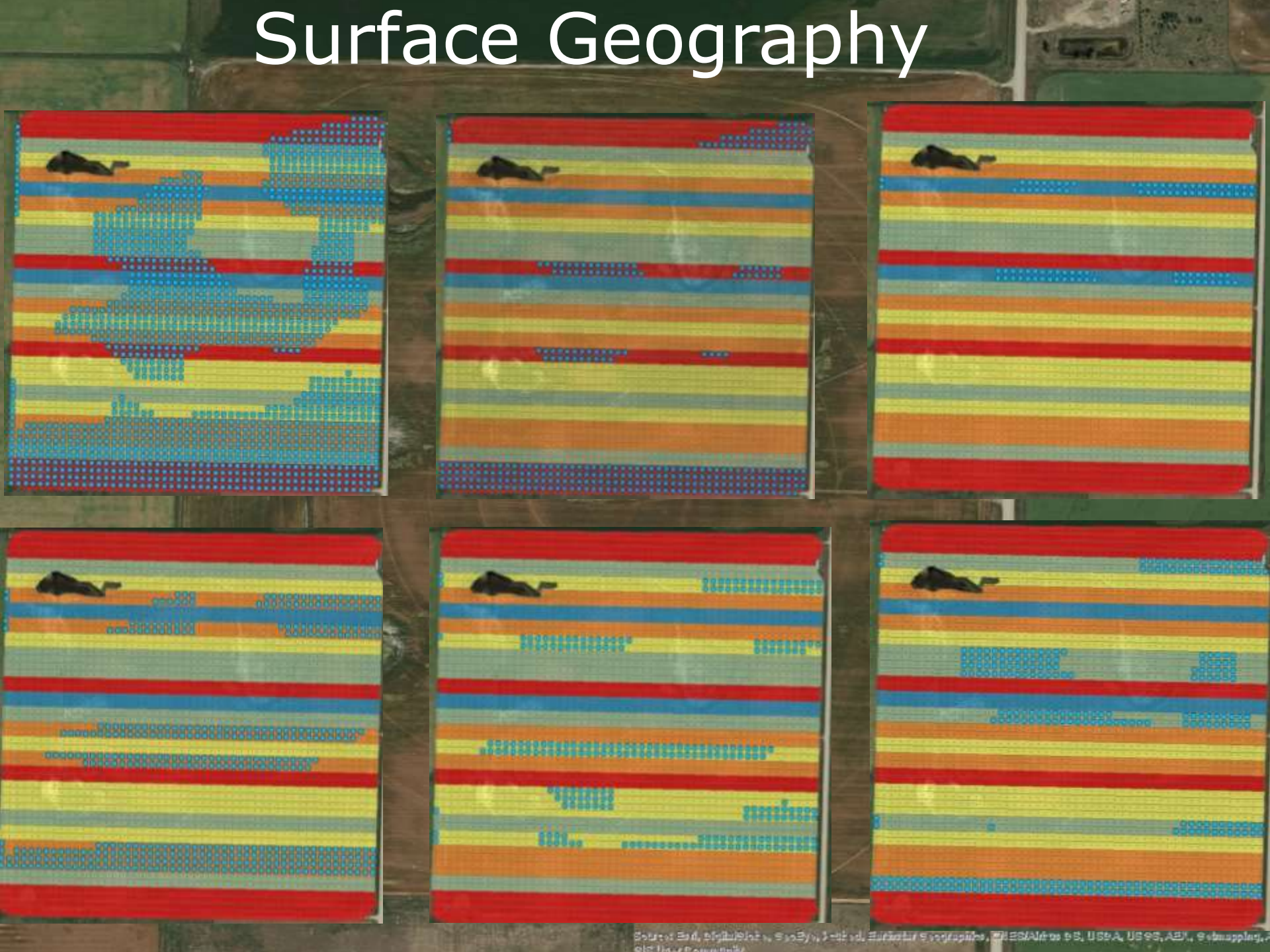
Variable Nitrogen Trial

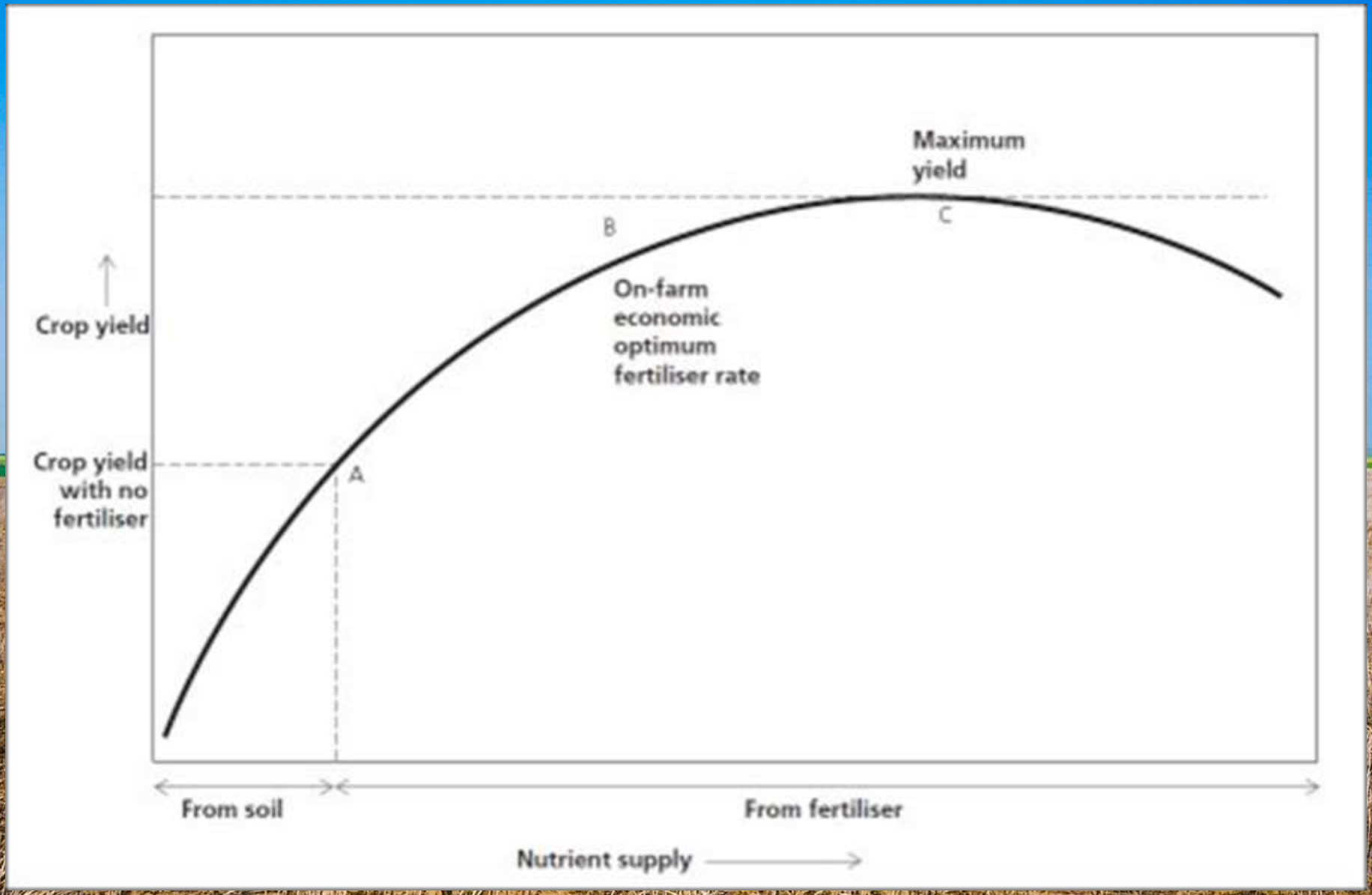


Surface Geography

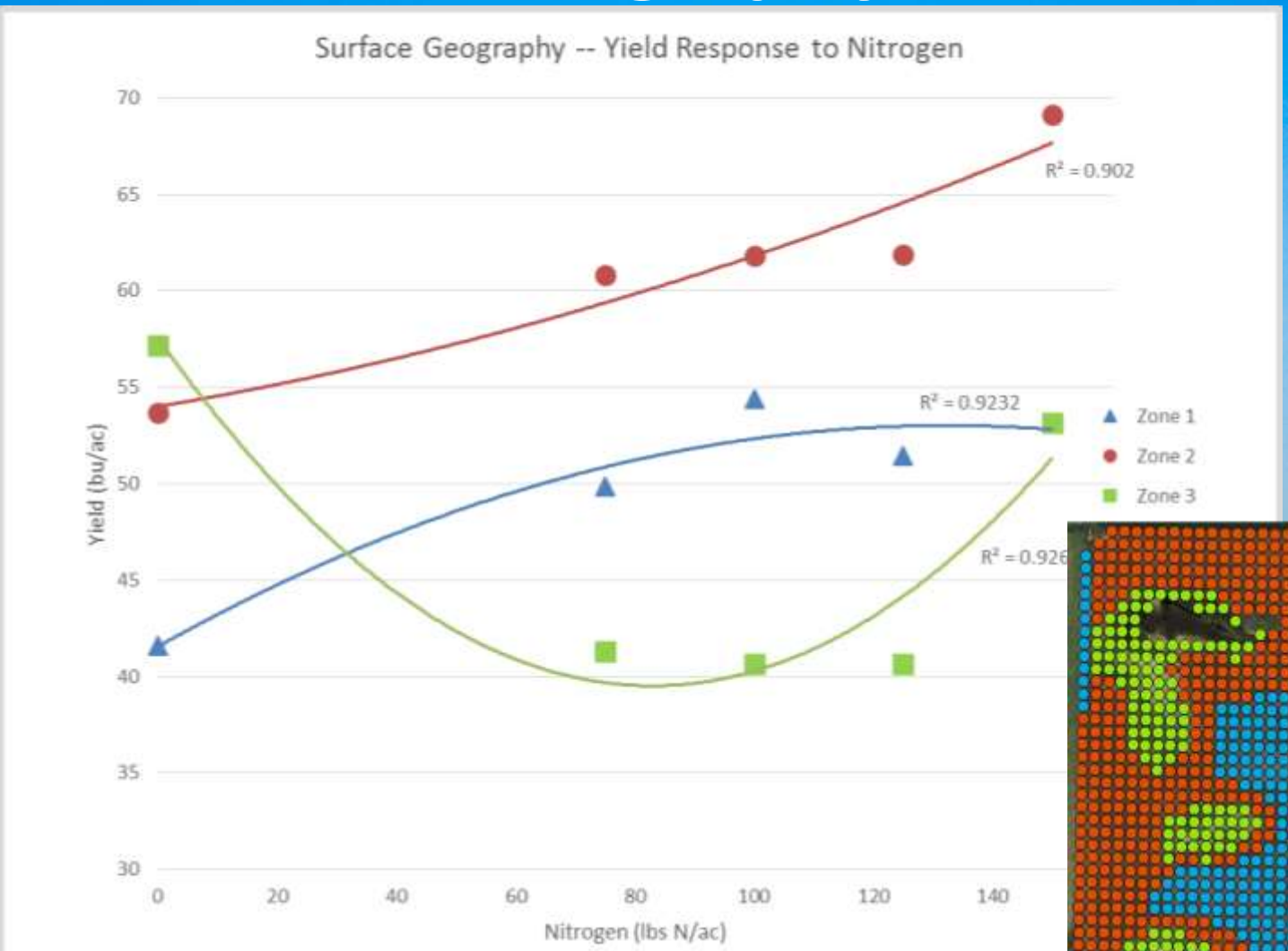


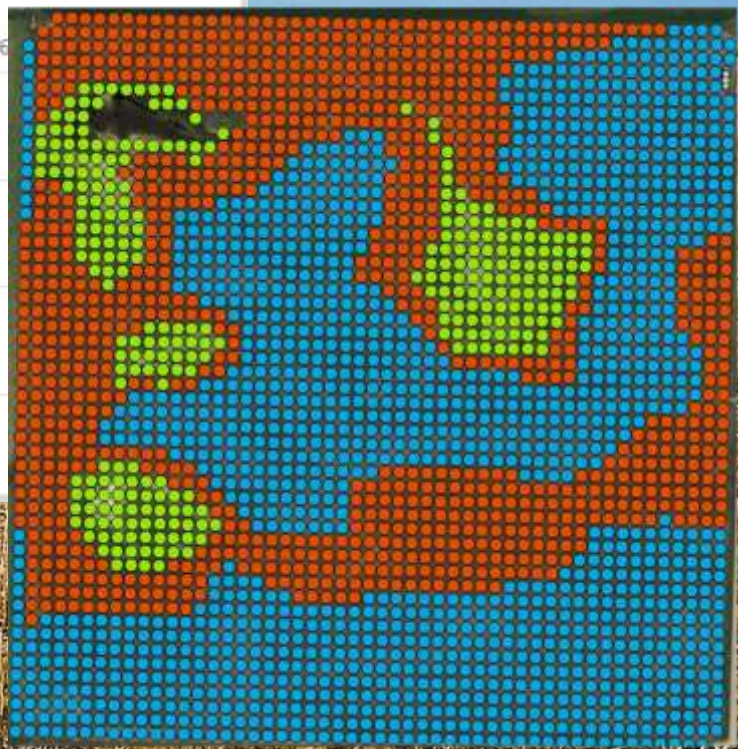
Surface Geography



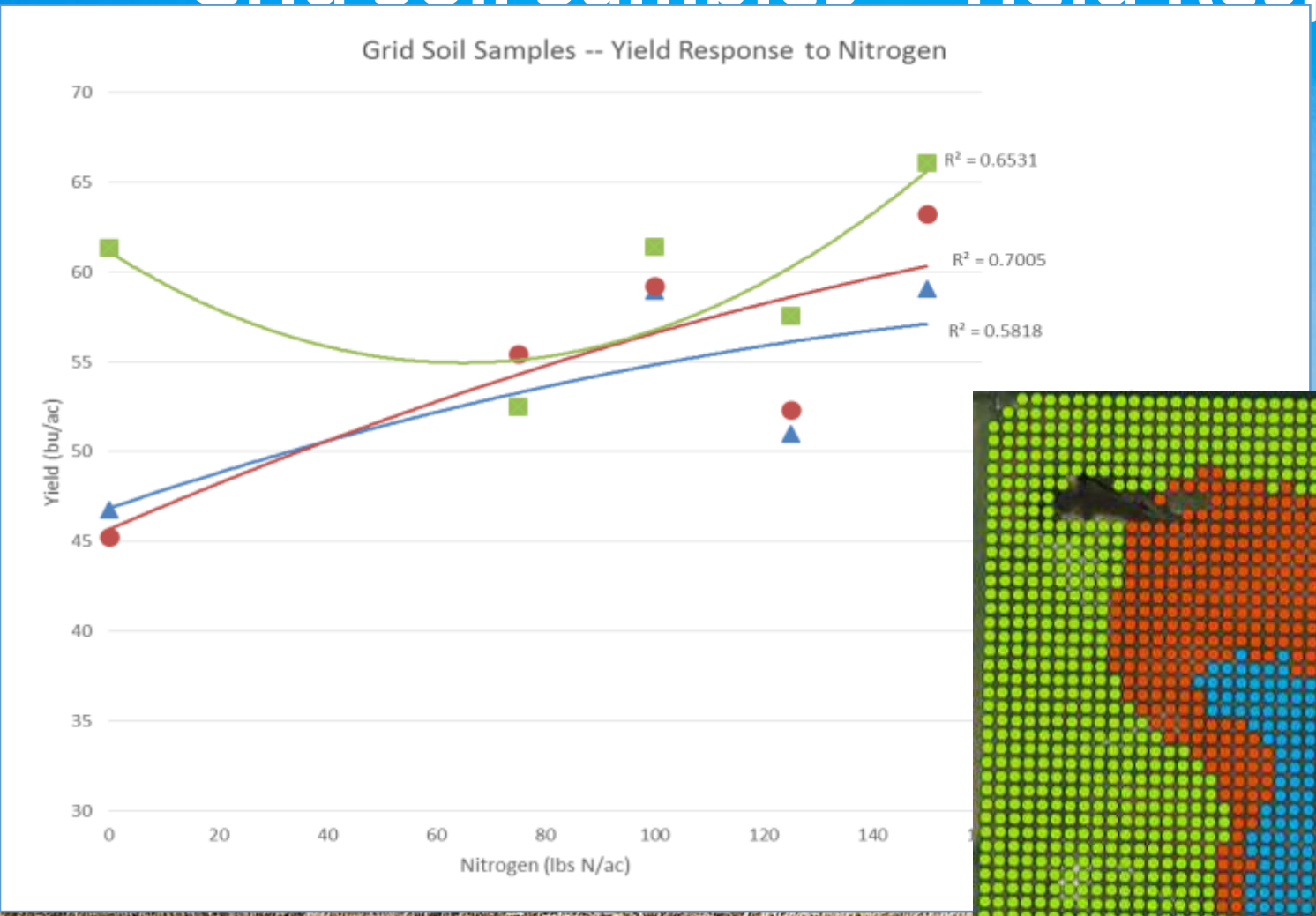

Maximum yield
B
C
On-farm economic optimum fertiliser rate
Crop yield
Crop yield with no fertiliser
A
From soil
From fertiliser
Nutrient supply

Surface Geography – Yield Response

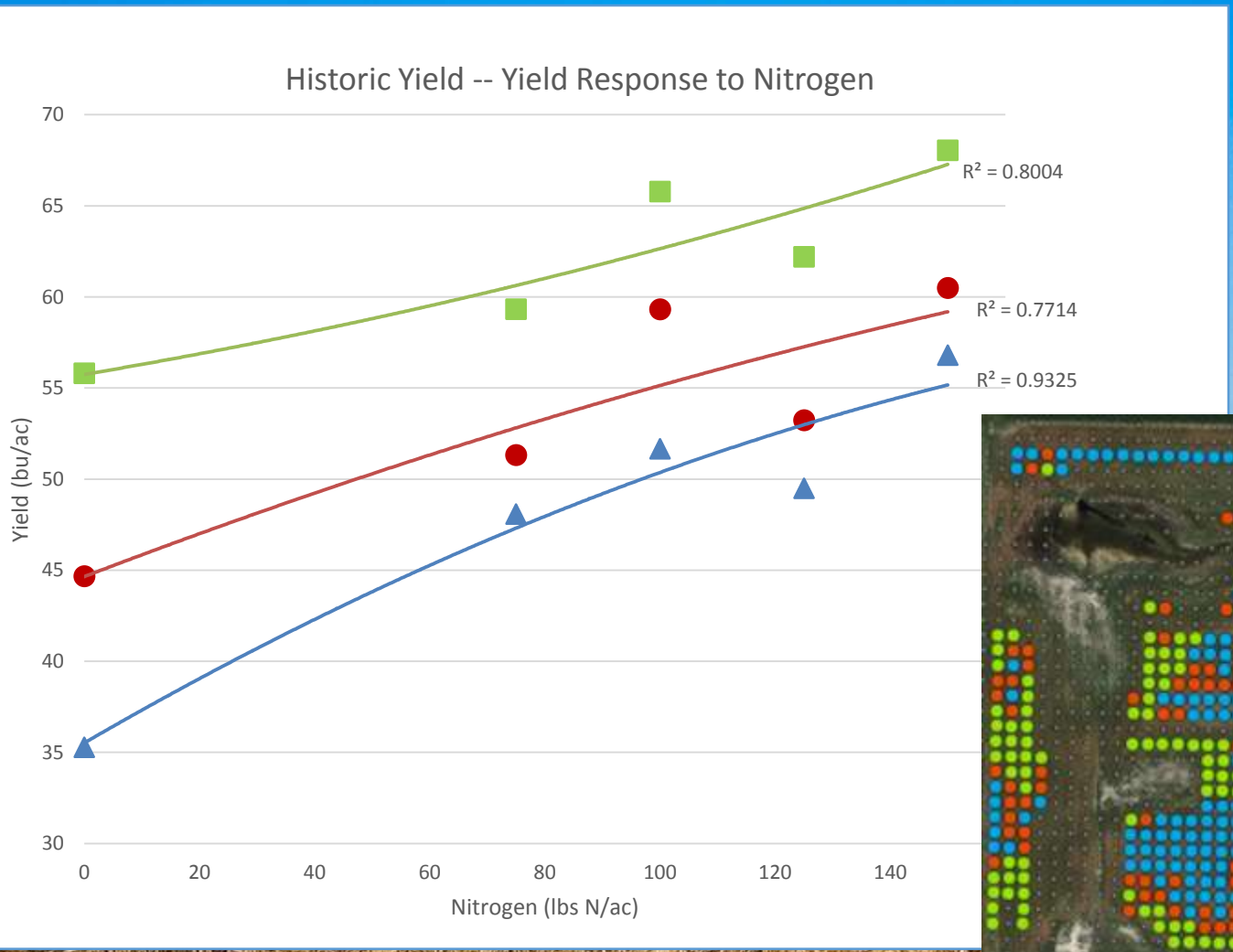


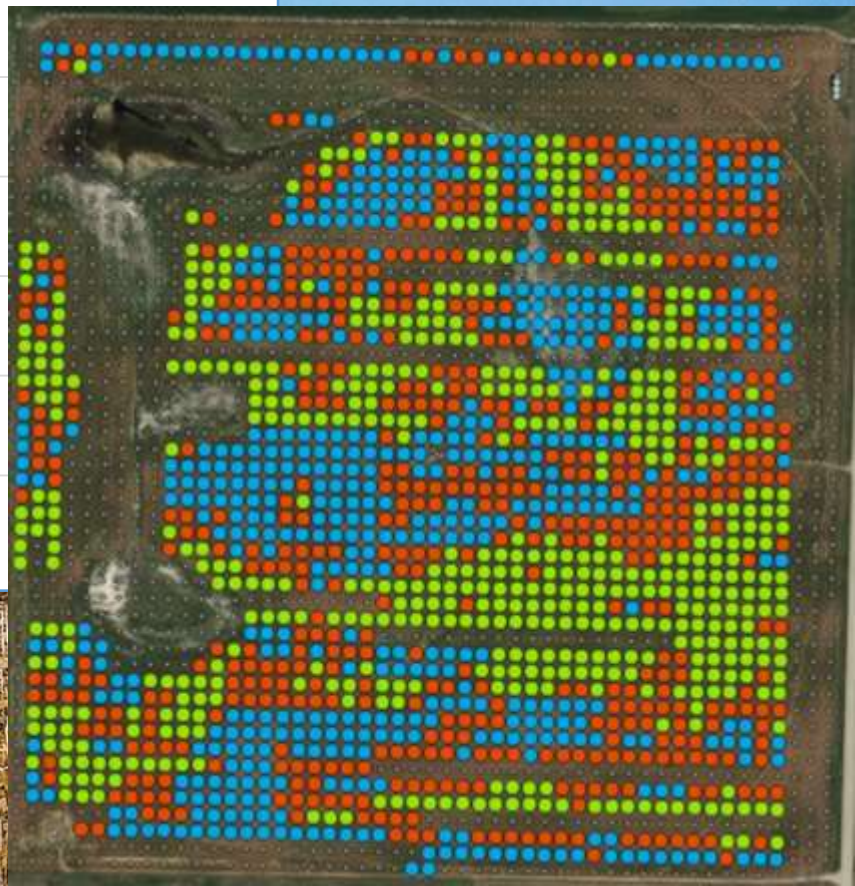


Grid Soil Samples – Yield Response

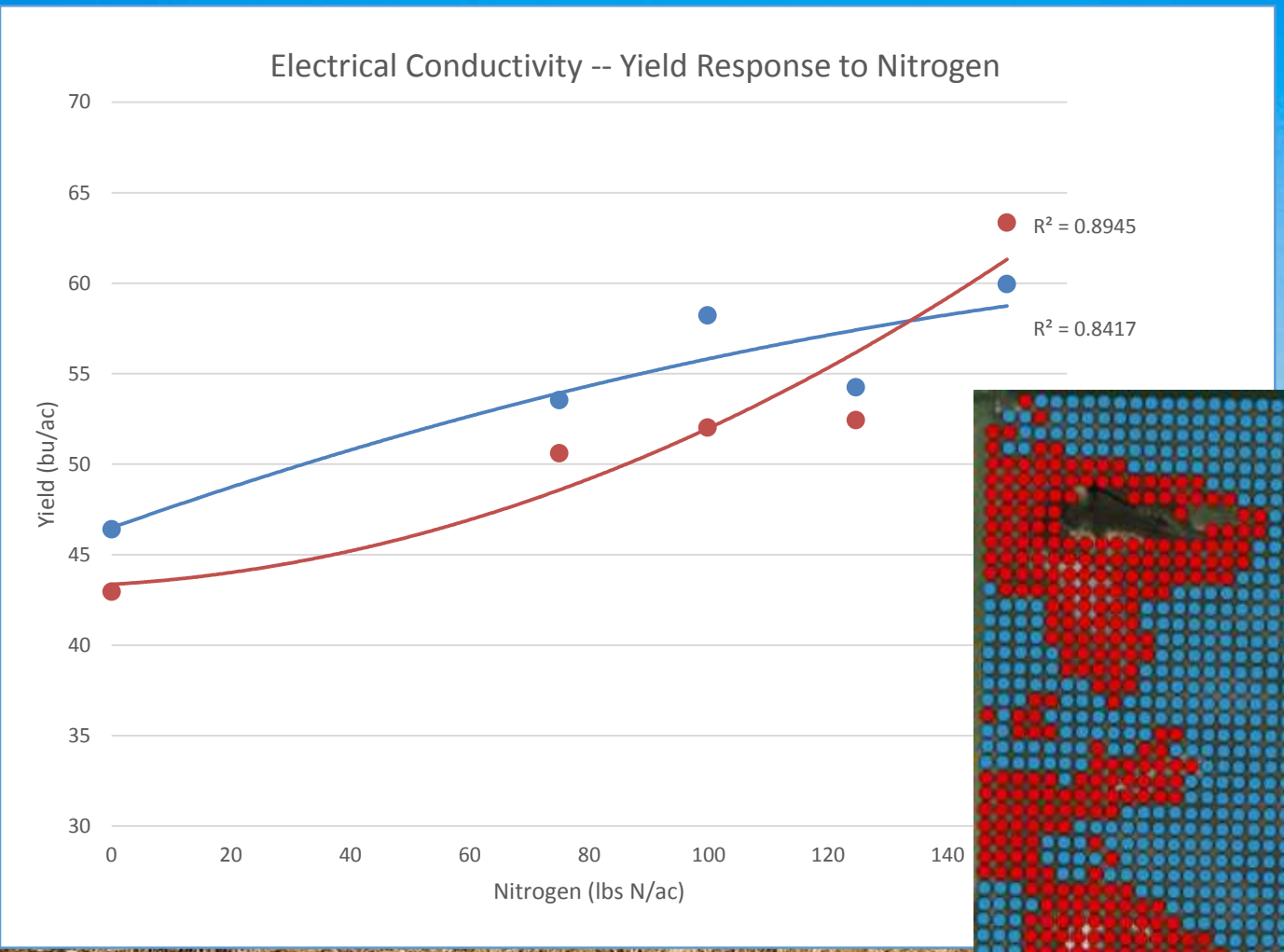


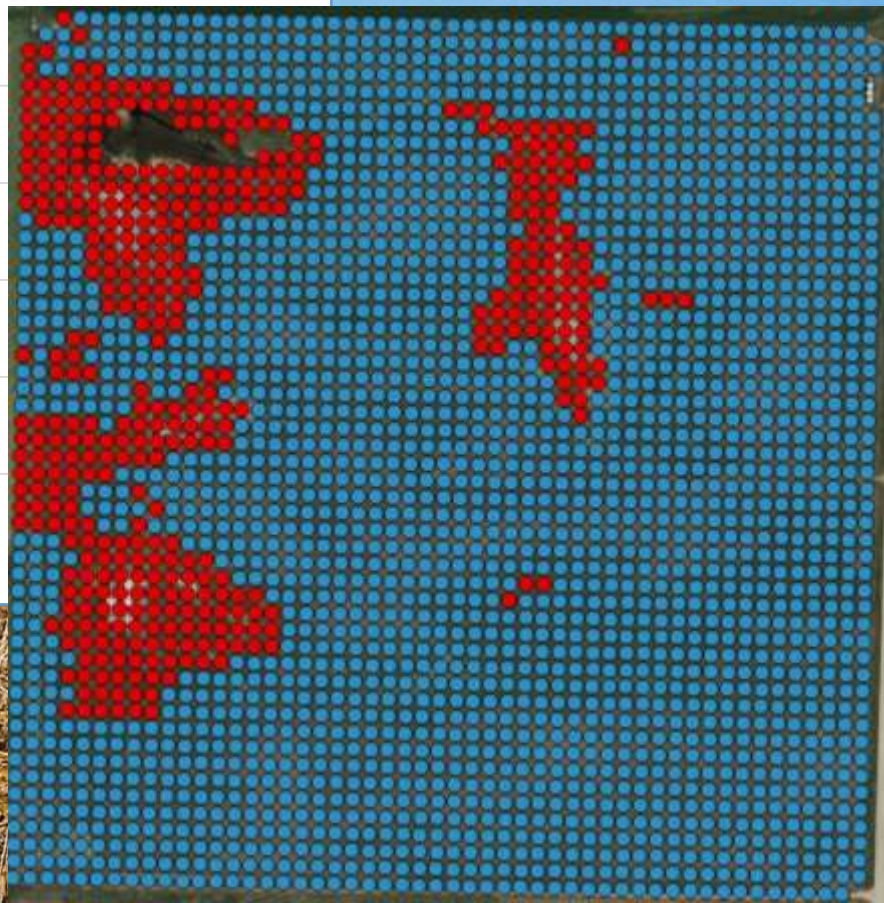
Historic Yield – Yield Response



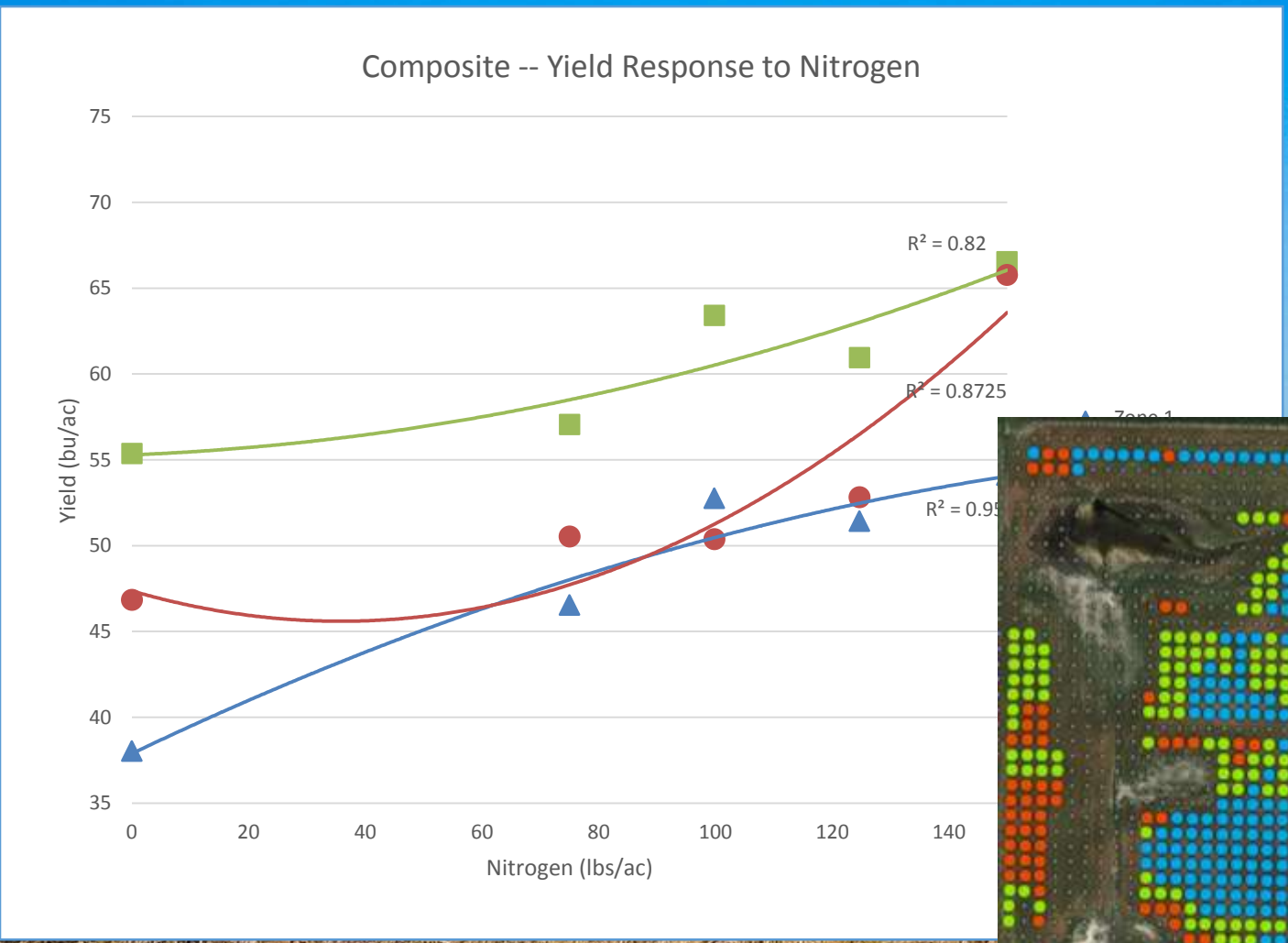


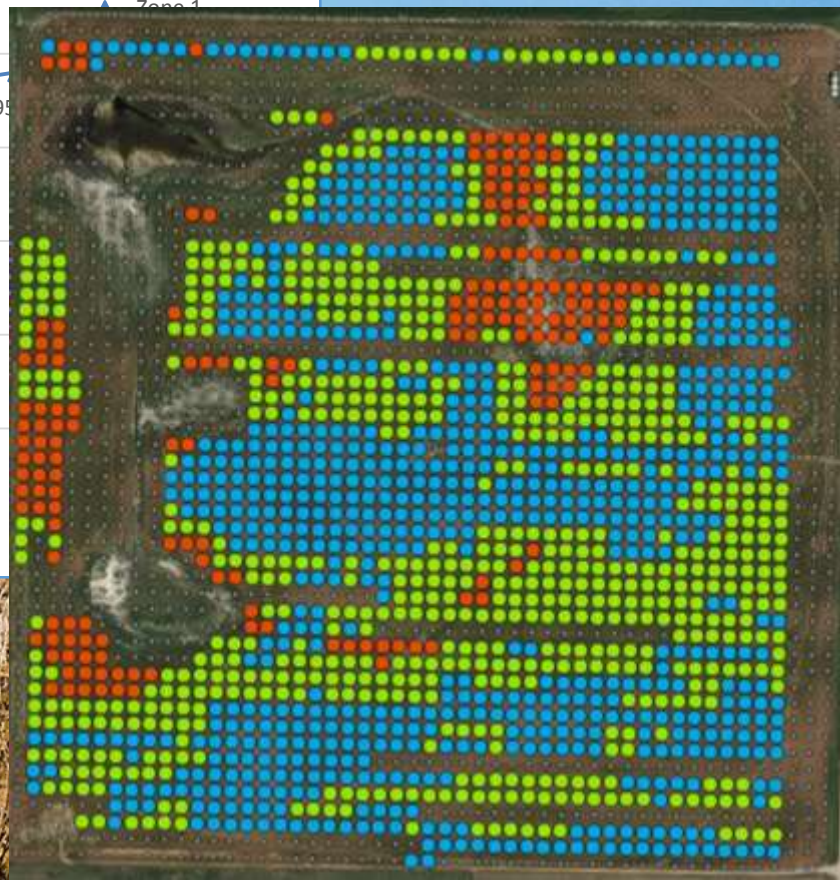
Electrical Conductivity – Yield Response





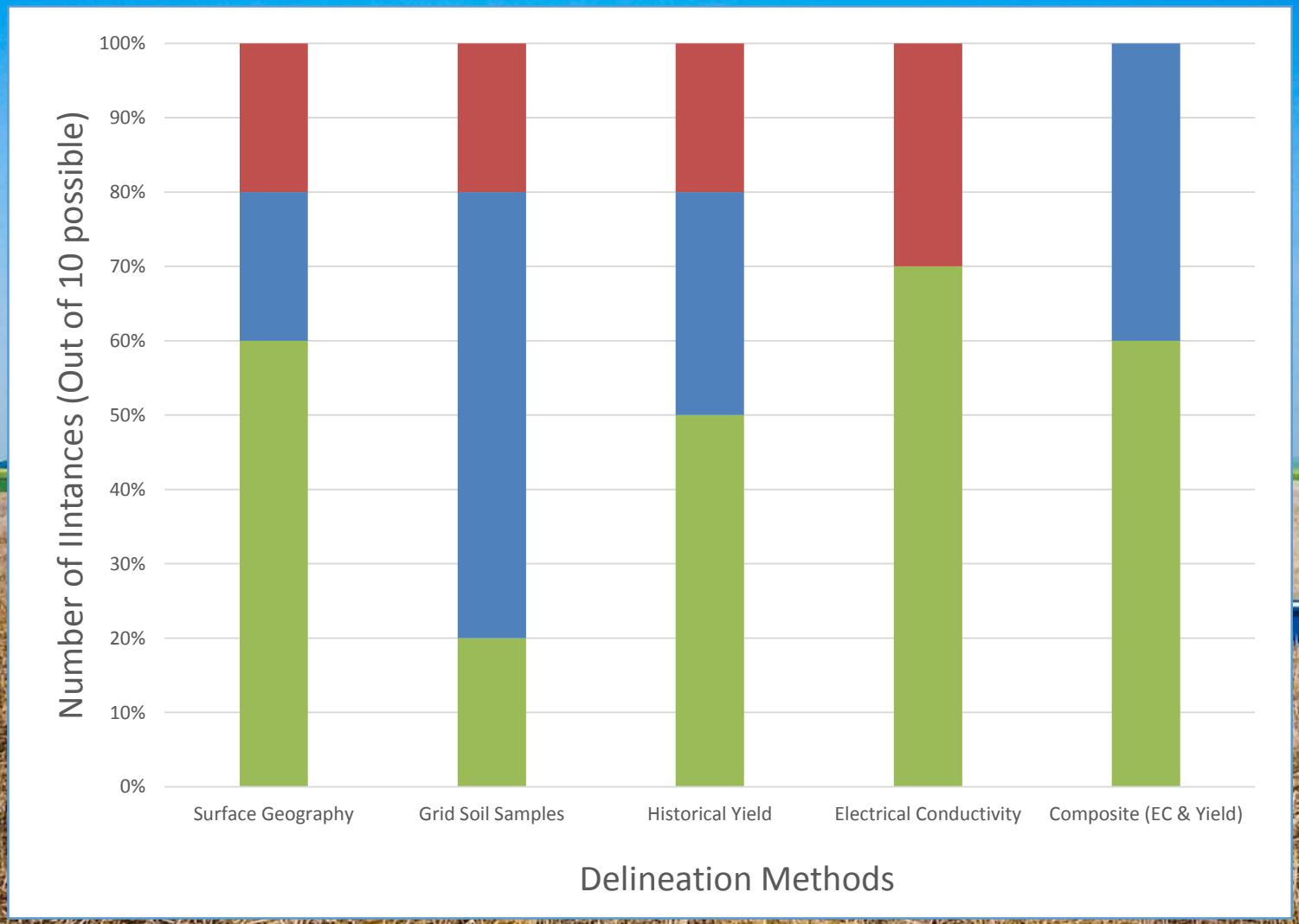
Composite – Yield Response





Did zones yield differently?

Statistically significant difference of means project-wide



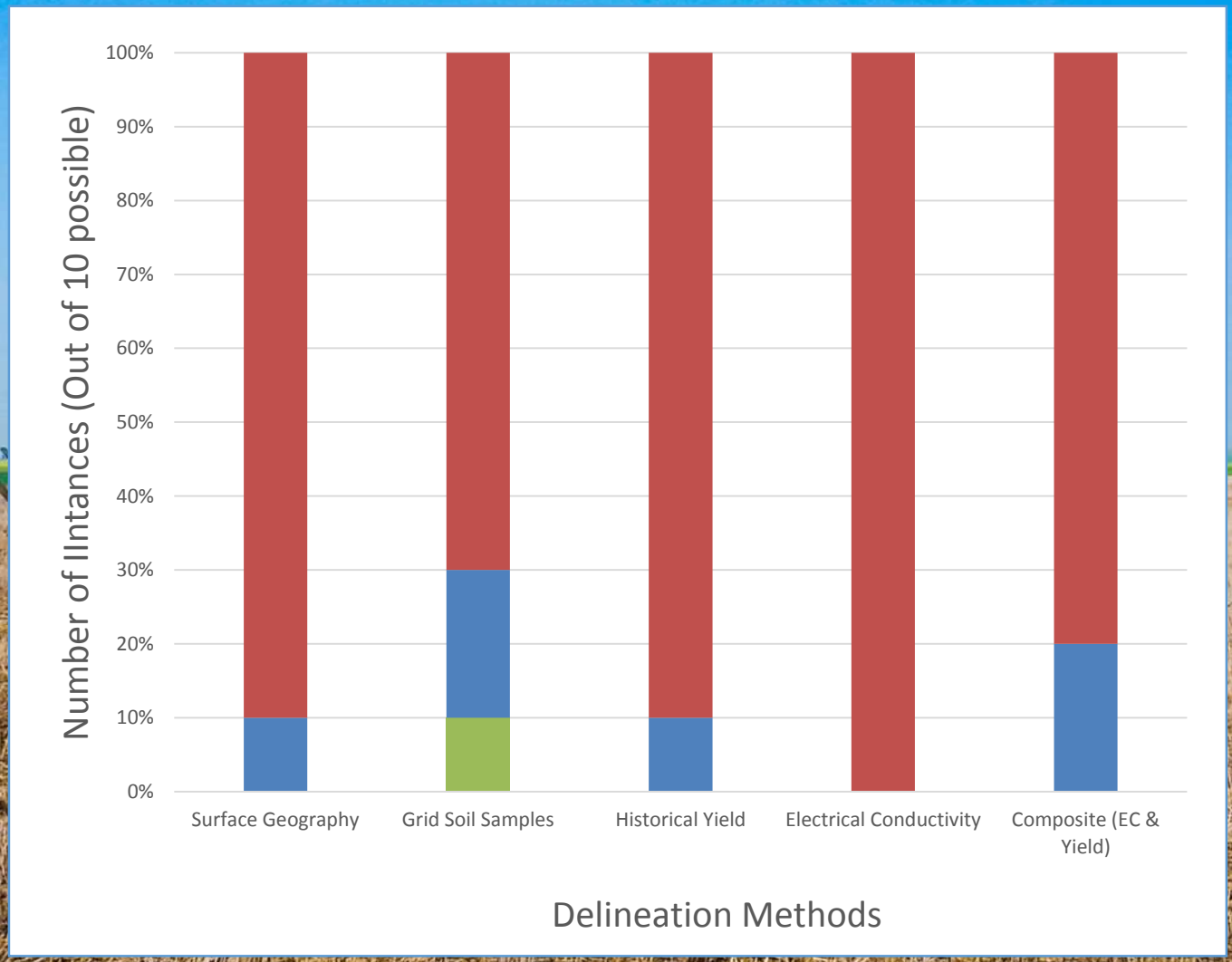
Complete Success
(All zones yielded differently)

Some Success
(Some zones yielded differently)

No Success
(No zones yielded differently)

Could zones be managed differently?

Statistically significant difference between response curves



Complete Success
(All zones yielded differently)

Some Success
(Some zones yielded differently)

No Success
(No zones yielded differently)

3. Are these zones meaningful?

- Success in differentiating zones of productivity
- Limited success in differentiating optimal nitrogen rates for zones identified

Conclusion

- Soil sensor measurements were found to be highly consistent
- EC is good tool to better understand soil variability
- No obvious correlations between EC and soil nutrient properties
- EC is just one piece of a complex puzzle

Conclusion

- Every field is different, and the relationship between soil sensor data and soil properties, and yield can vary over space and time
- **Variable Rate Technology** requires a **Variable approach**
- Be prepared to tailor a specific VR strategy for specific fields
- The process is as important as the results
  - VR strategies are not universal, but they are testable

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