# Big Data and the Productivity Challenge for Wine Grapes

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**Agricultural Outlook Forum**

**February 2016**

# Big Data and the Productivity Challenge for Wine Grapes

## Outline

- Current production challenges
- Lessons learned from annual crops
- How will we utilize Big Data to meet our challenges?
  - Measure
  - Model
  - Manage
- Summary

# The Productivity Challenge for Wine Grapes

- Suitable land, labor and water for agriculture are becoming more scarce and expensive
- Need to increase grape supply without increasing production area and environmental impact
- Must increase *both* yield and quality simultaneously
- Similar challenges are faced by nearly all agricultural commodities worldwide

# How are annual crops addressing these challenges?

Dramatic increases in the productivity of agronomic crops have been achieved during the past century via:

- Genetics – traditional breeding and genomics
- Improved agronomic practices and resource management
- Application of remote sensing and other technologies

# How are perennial crops different in their approach?

Progress has been much slower in wine grapes and other perennial crops:

- Critical mass – limited acres = limited attention despite farm-gate value
- Genetics – research, breeding cycle and market tradition
- Production cycle and innovation adoption
- Yield – quality relationships

# Integrated systems are required for improving productivity *and* quality

| Germplasm Improvement | Systems Biology | Precision Agriculture |
| --- | --- | --- |
| • Clonal selection<br>• Cultivar and rootstock improvement via traditional breeding<br>• Pest/disease resistance | • Elucidate the regulation of key yield and fruit quality pathways<br>• Functional genomics – linking genes to key traits | • Characterize the parameters regulating vine productivity and quality<br>• Model key relationships<br>• Variable rate management |

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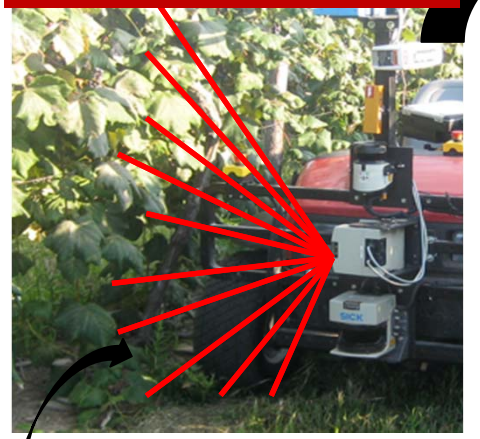
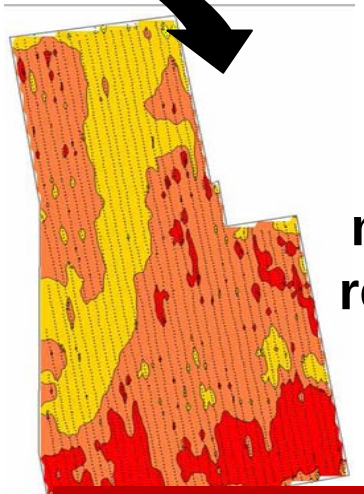
# The Future of Grape Growing

## MEASURE

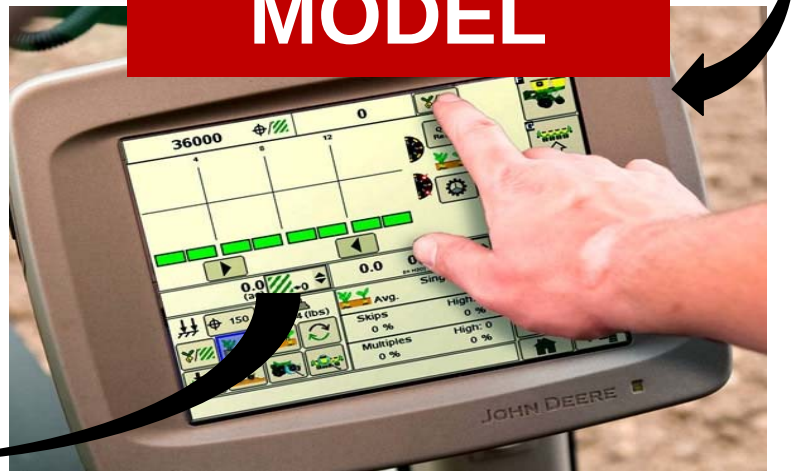


Automated sensors measuring intra-field variability – crop load, canopy size, irrigation requirements



Measures used to construct geospatial maps of key relationships

## MODEL

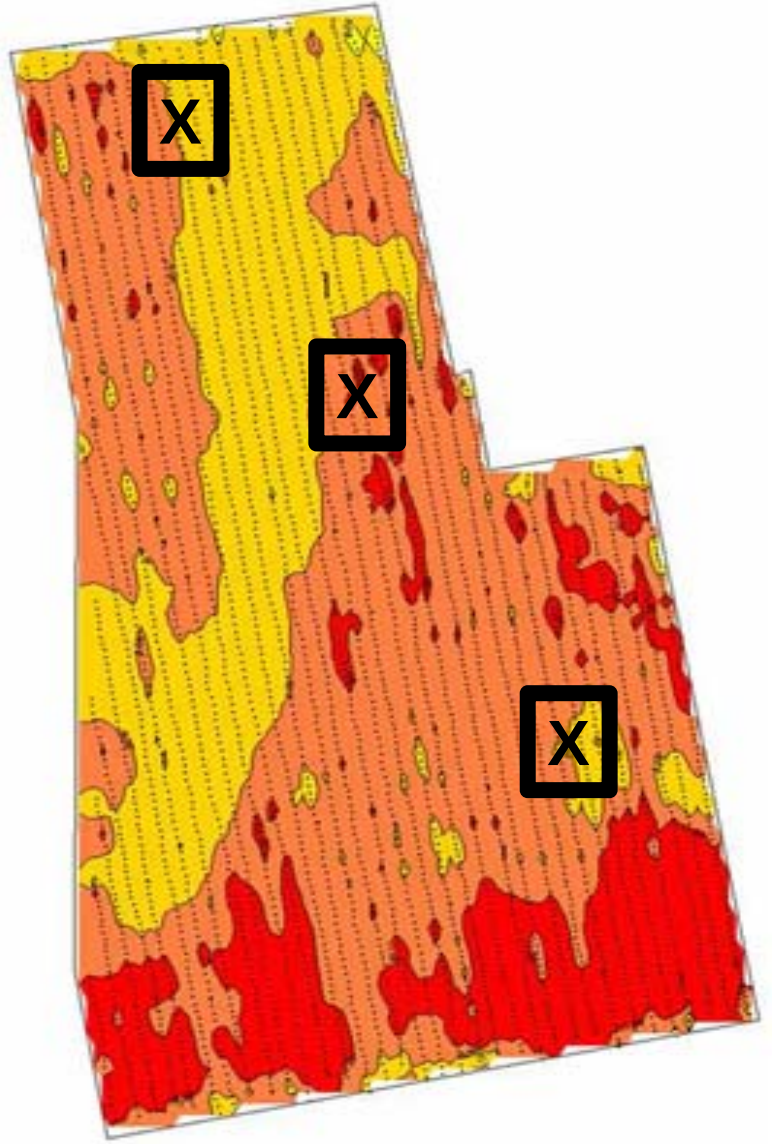



## MANAGE

Information used to spatially alter cultural practices

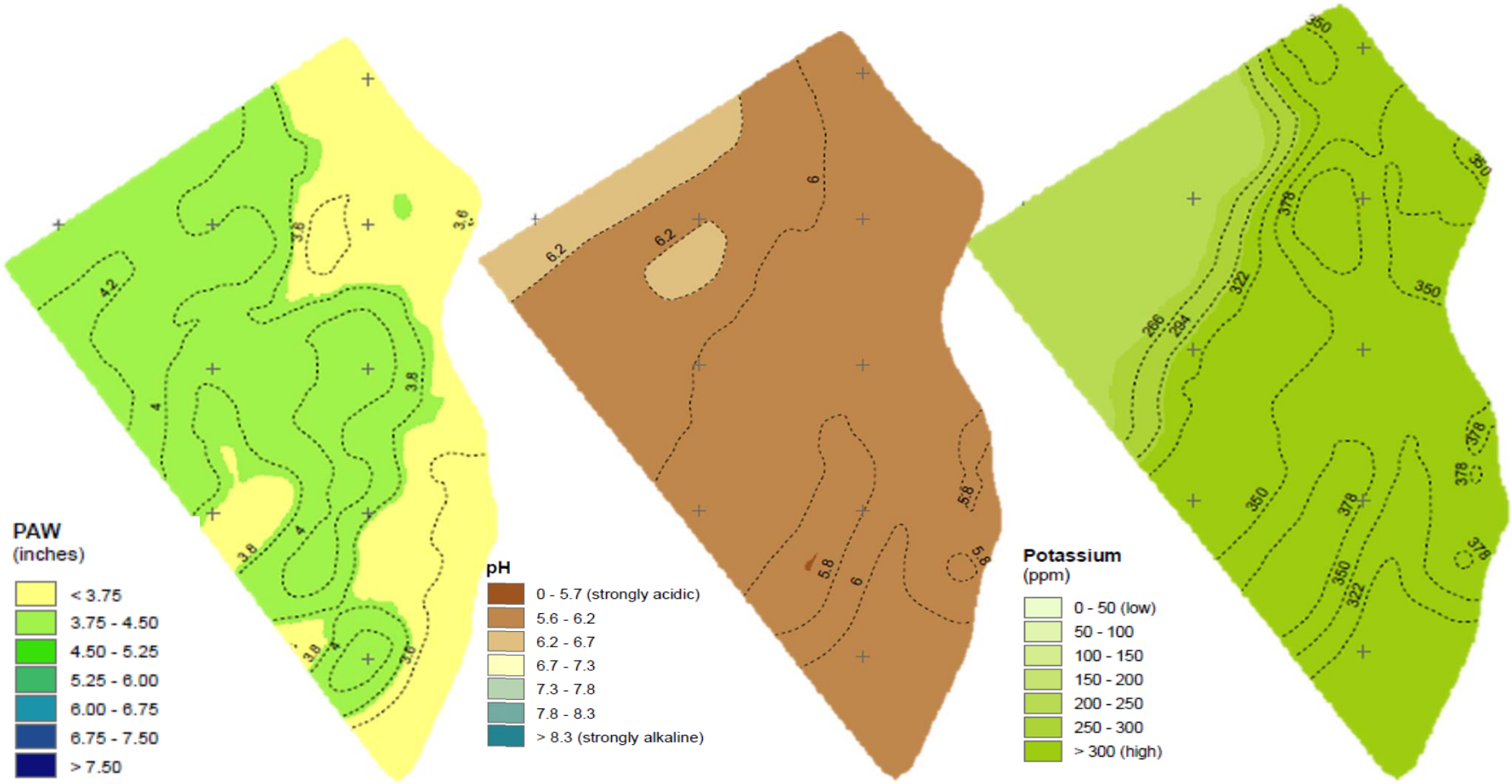
# Historical sensors are site specific


# Historical soil measures



# Sensors provide high density soil information

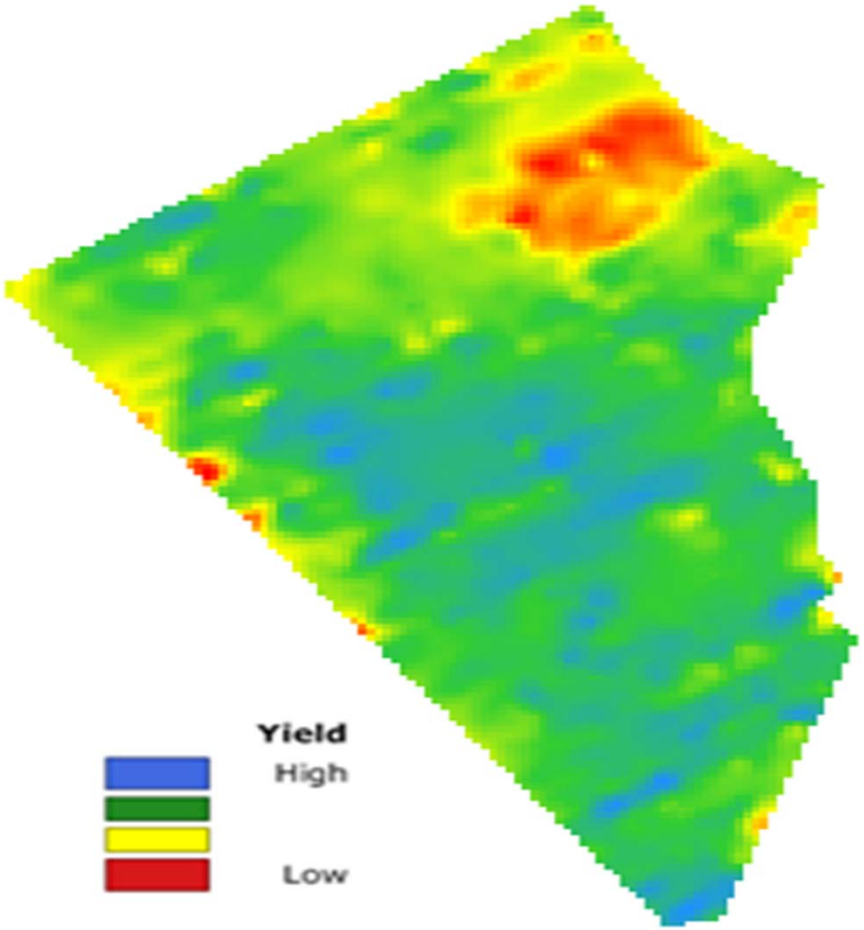
# High Resolution Maps - EM Sensor



# Characterizing Yield Variability

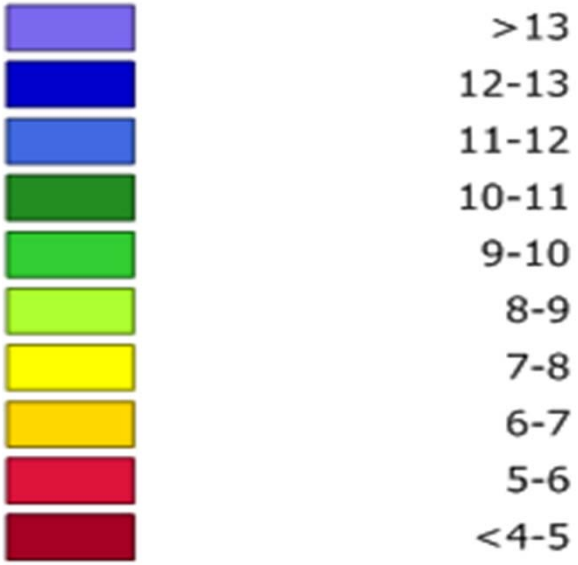

DANGER

# Why does variability matter?




**Cabernet Sauvignon**

**9.2 tons/acre**
**22.7 tons/ha**



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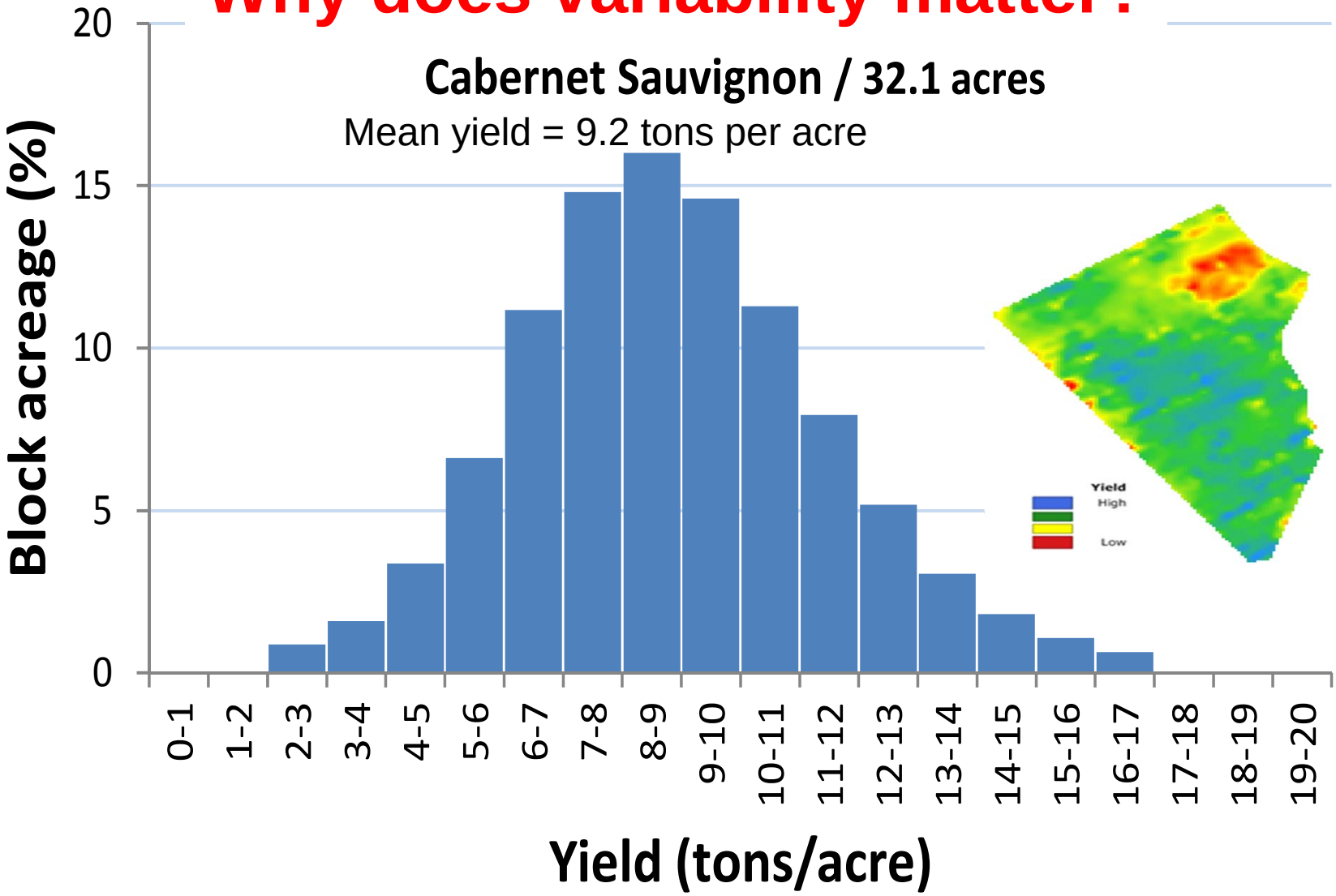

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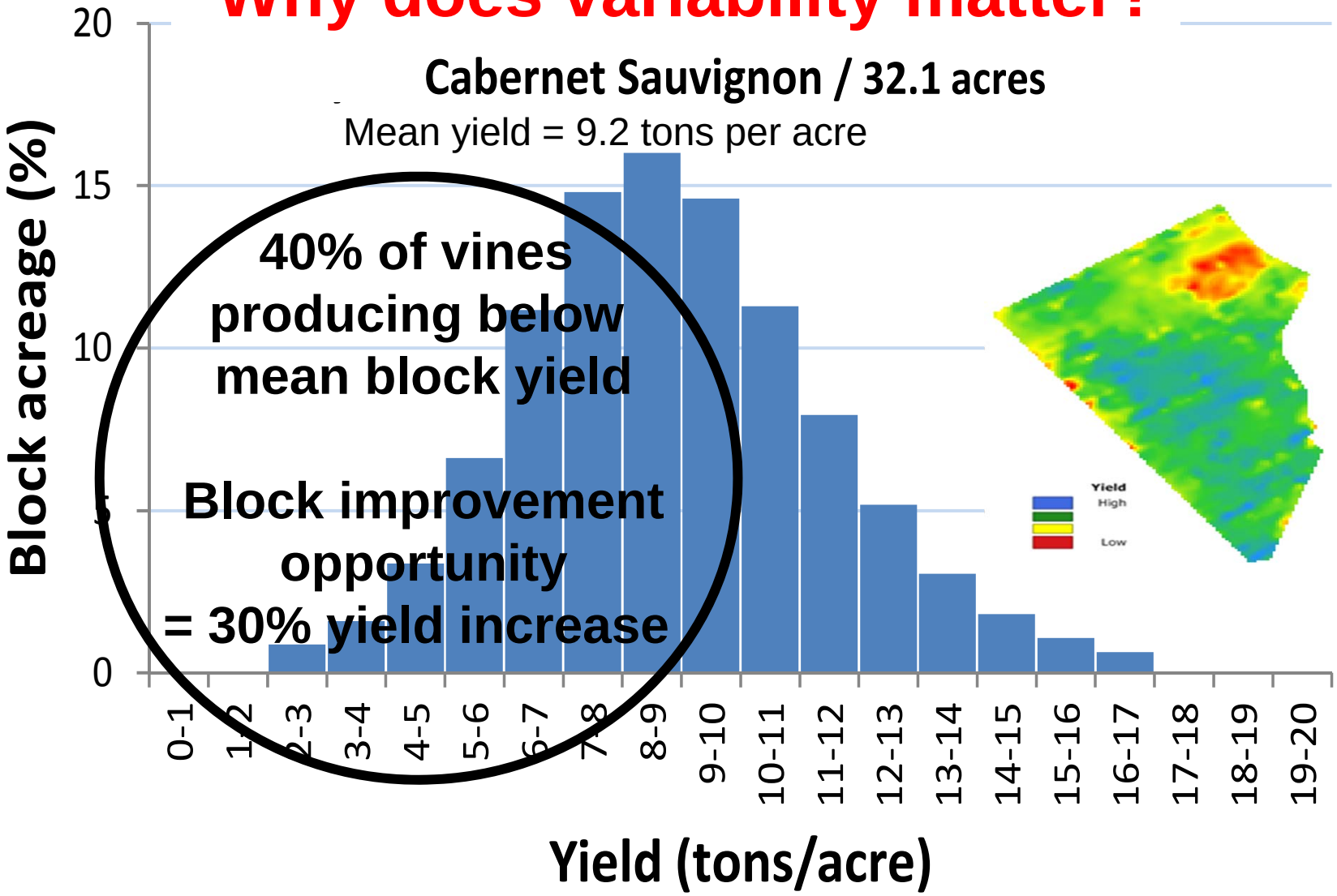

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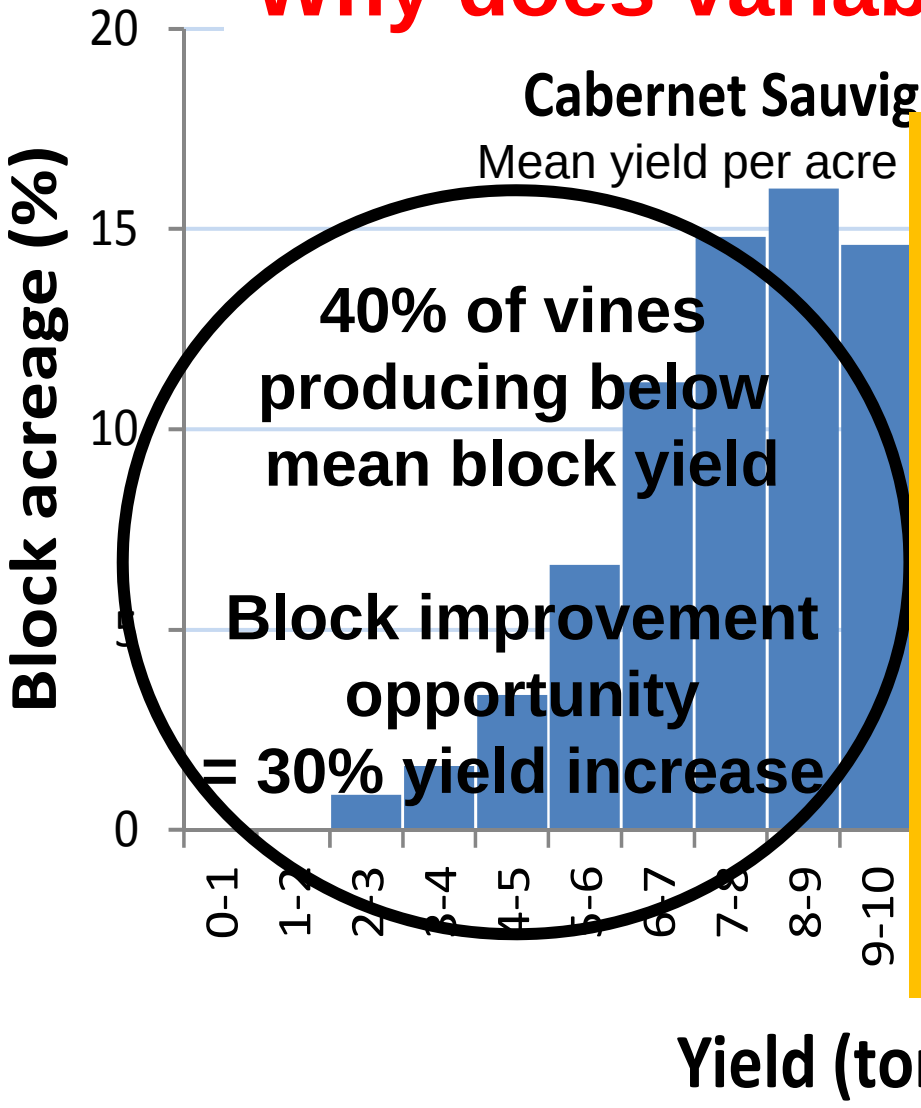
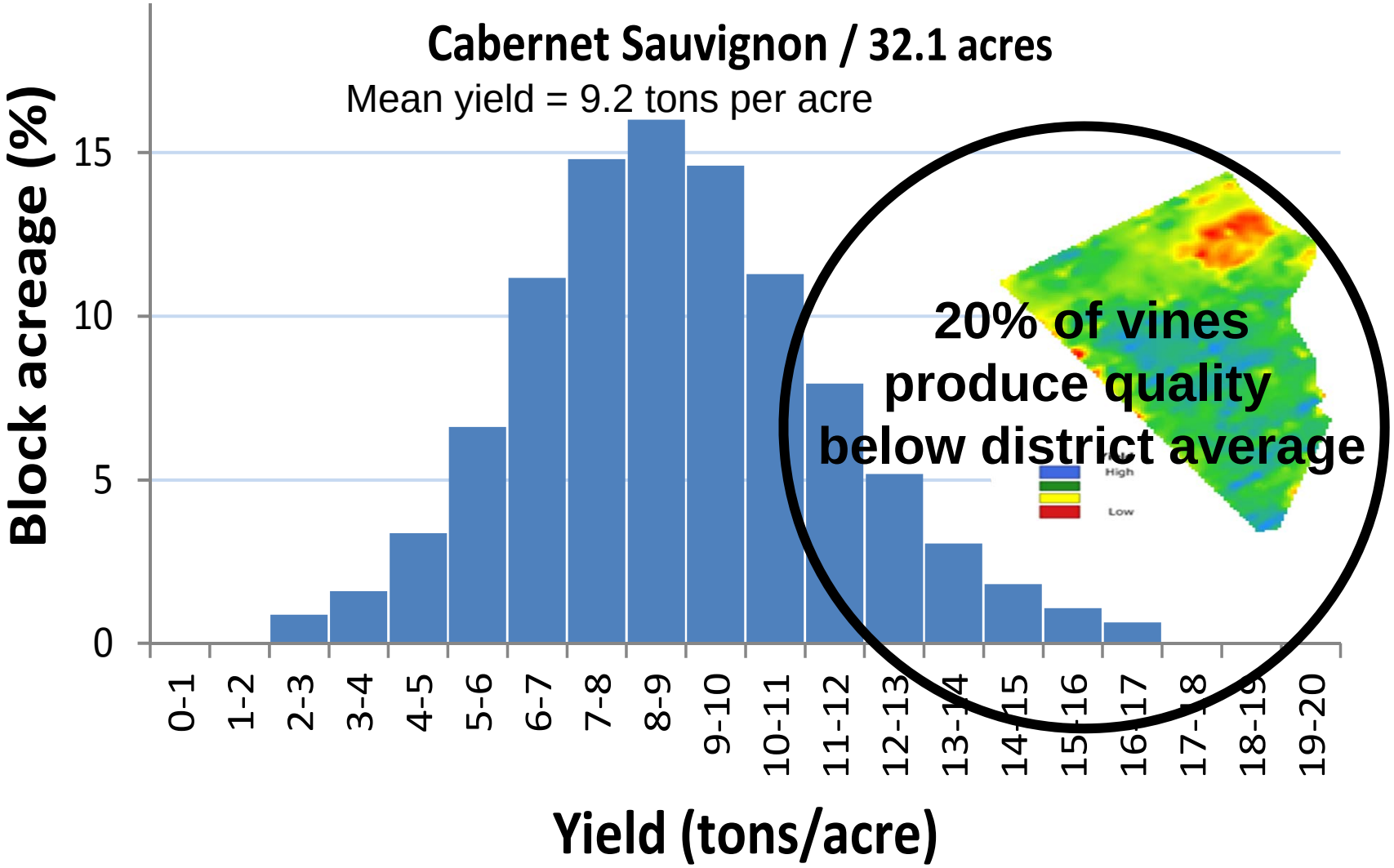



- **Annual increase in revenue = $900/acre**
- **Estimated cost = $100/acre**
- **30% yield increase without planting additional acreage**

**<u>Capital avoidance/acre</u>**
**Land - $50,000**
**Establishment - $35,000**

# What is the size of the prize for Big Data?



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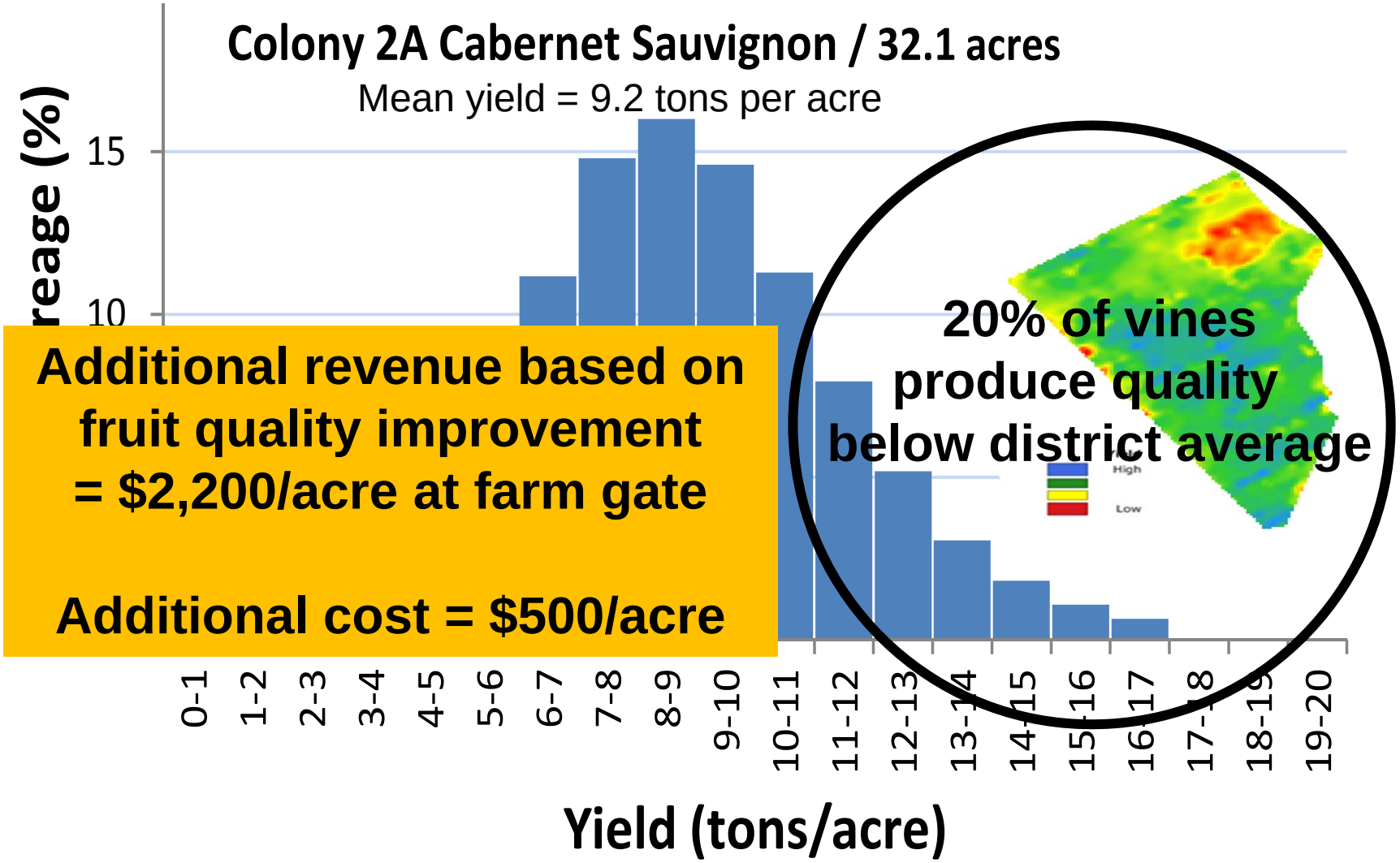
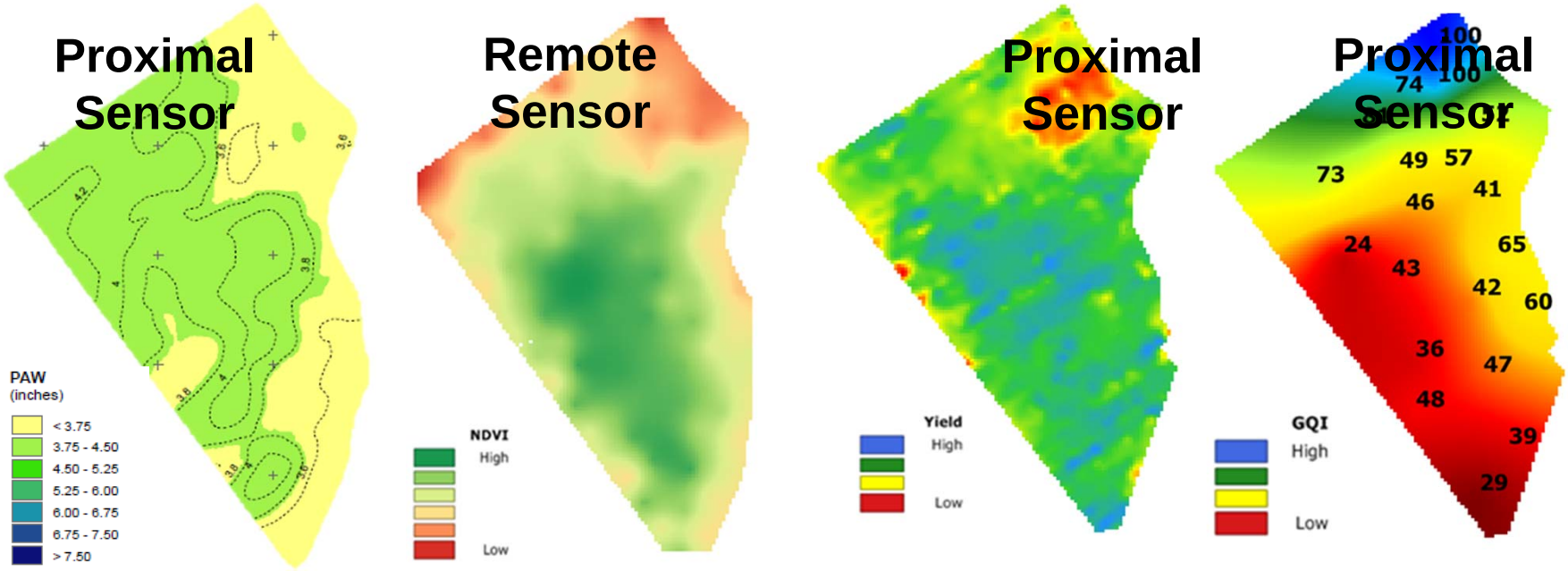


# Integrated systems - analytics




Plant available water in soil → Vegetation Index (NDVI) → Yield → Fruit Quality

# Modeling Yield and Fruit Quality Data with Soil Parameters

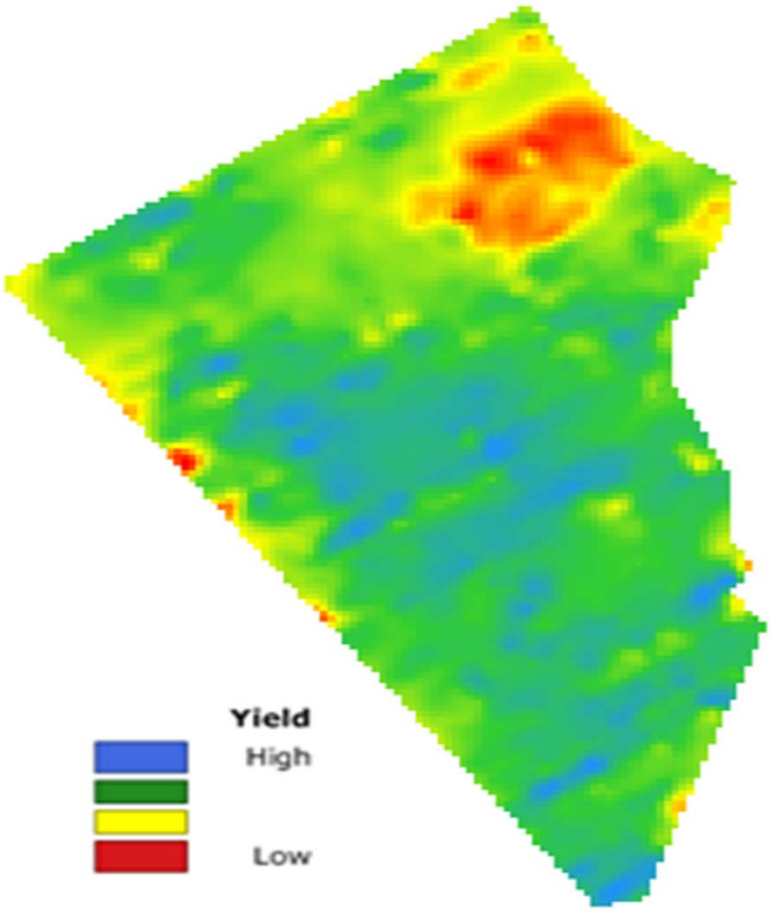
## Significant Correlations with Fruit Yield

| Parameter | Correlation ($r^2$) |
|---|---|
| Subsurface $K^+$ | 0.903 |
| **Soil rooting depth** | **0.774** |
| Subsurface pH | – 0.805 |
| Subsurface P | – 0.805 |
| Subsurface organic matter | – 0.882 |
| Subsurface K/Mg ratio | – 0.890 |

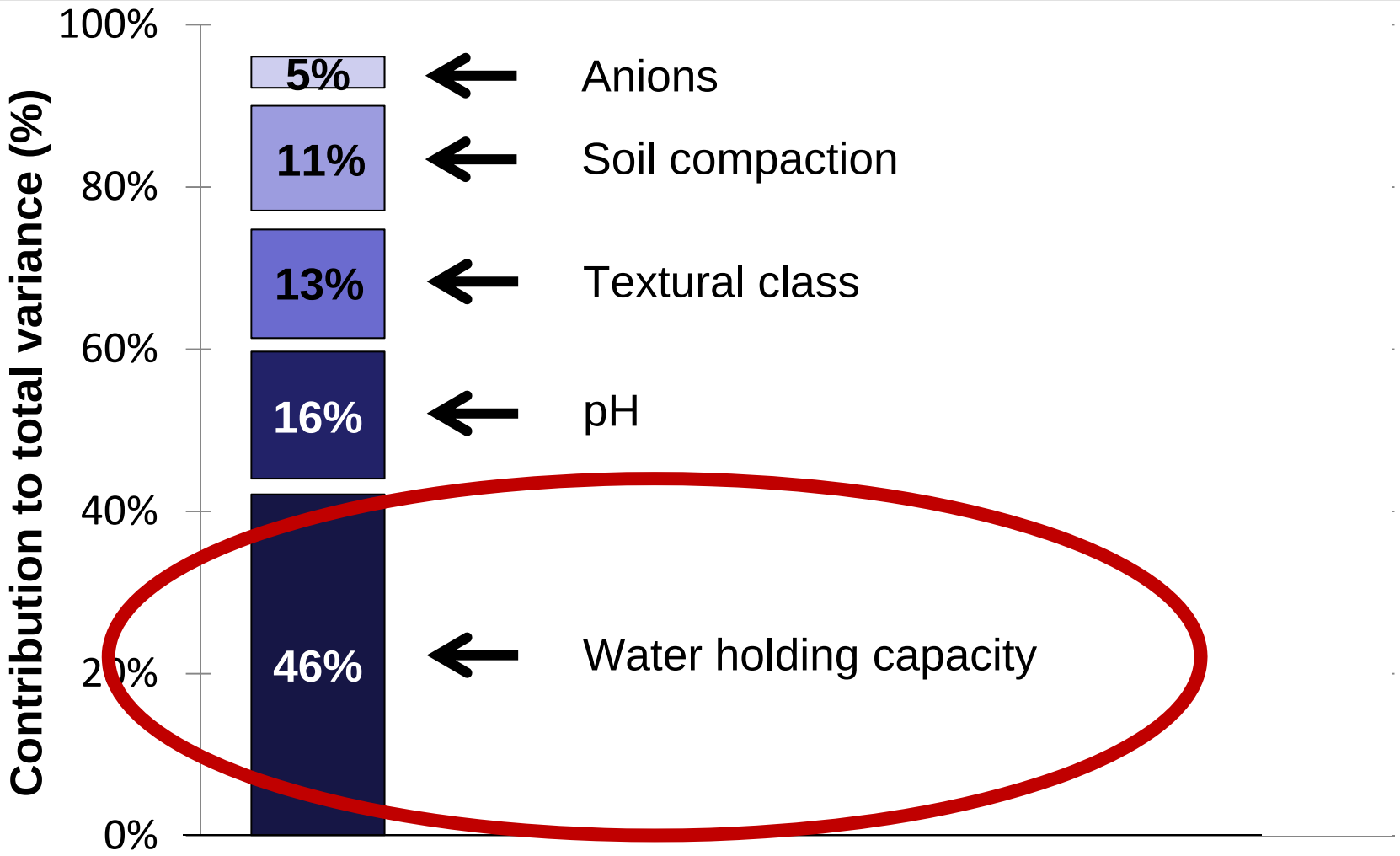
## Significant Correlations with Fruit Quality

| Parameter | Correlation ($r^2$) |
|---|---|
| **Soil rooting depth** | **– 0.673** |
| Surface CA | – 0.506 |
| Subsurface CA / Mg ratio | – 0.510 |
| Surface CEC | – 0.554 |

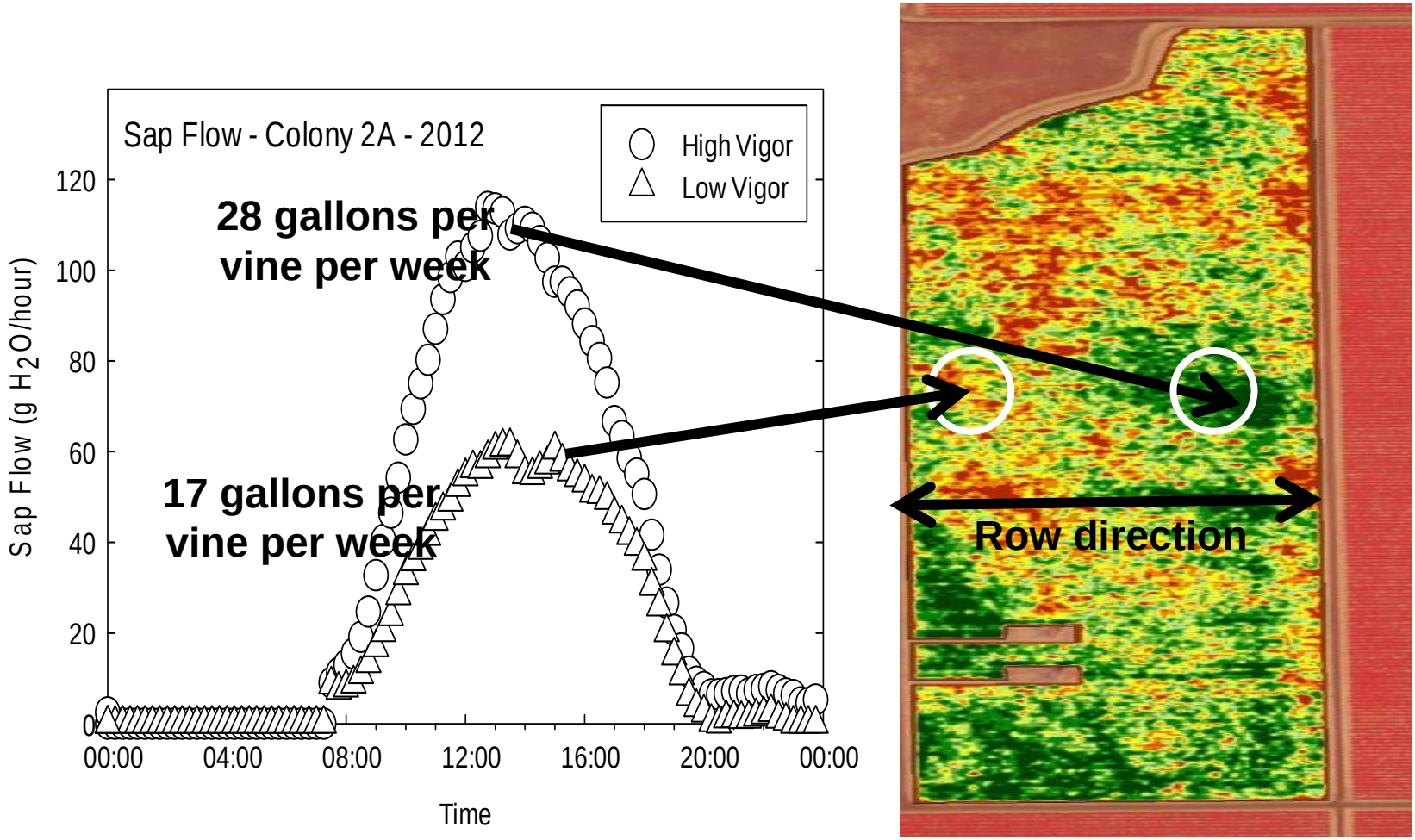
# Variable rate management



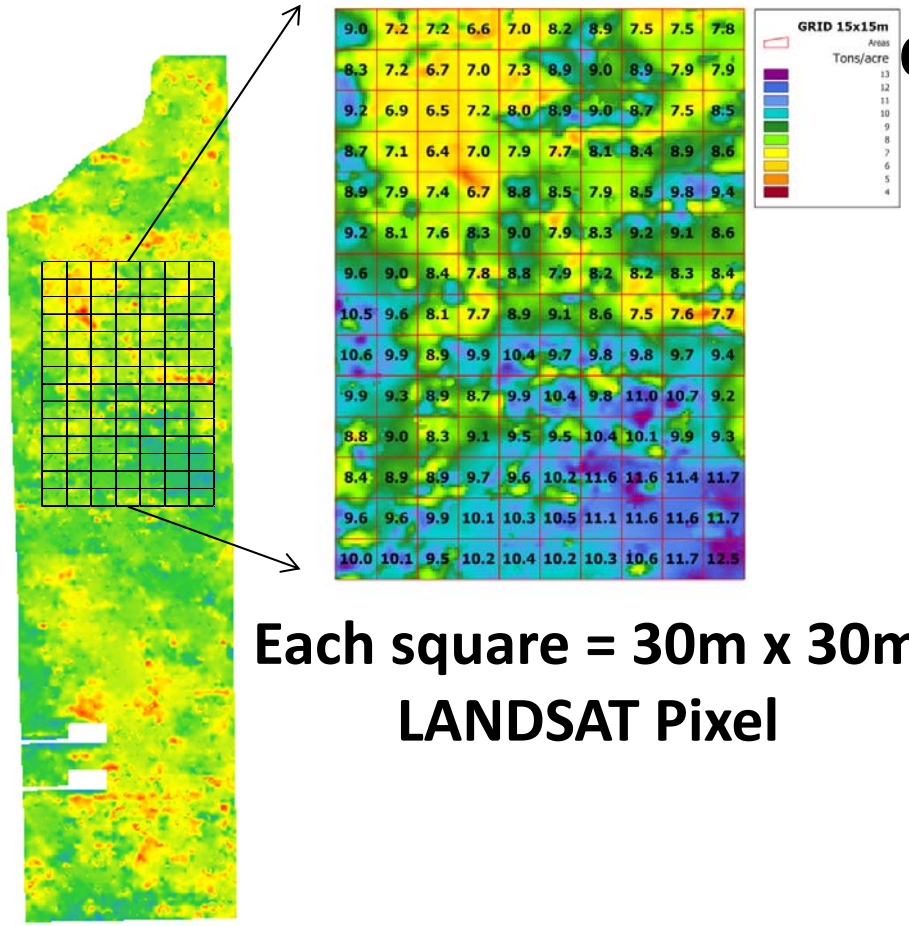

# Relative importance of soil parameters to block yield variability



# Vine water use is variable based on canopy size

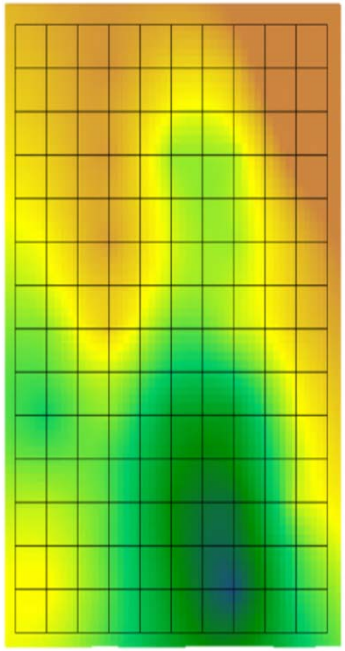


# Variable Rate Drip Irrigation

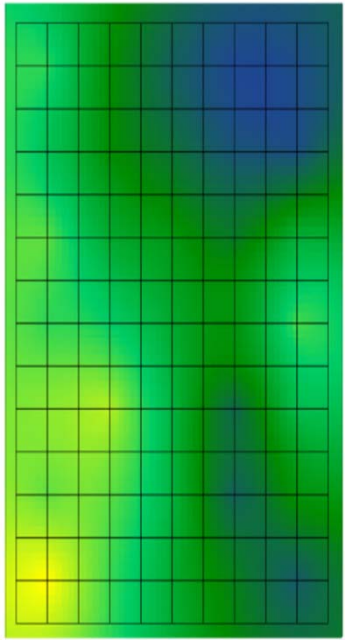



**Each square = 30m x 30m LANDSAT Pixel**

**Changes in canopy vigor (NDVI)**



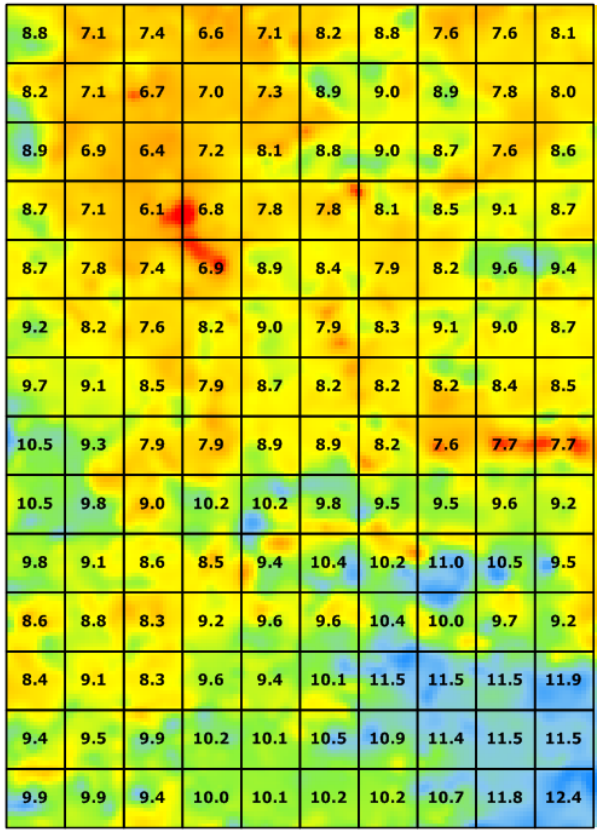
**Before variable rate irrigation**



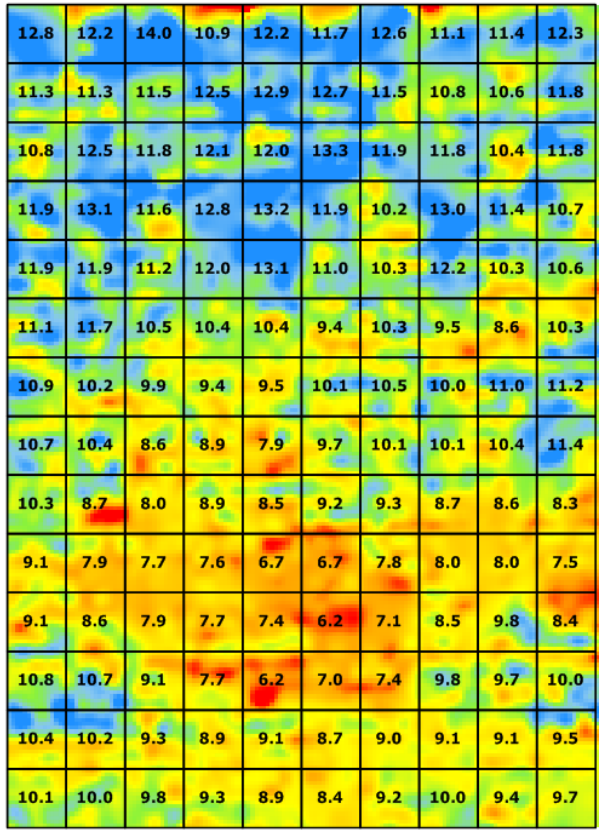
**After variable rate irrigation**

## Pixel level management based on canopy size

# Impact of Precision Irrigation




**2012 Block Yield**
**8.1 tons/ac**




**2015 Block Yield**
**10.2 tons/ac**

**Yield improved 20%; Water use efficiency improved 30%**

# Summary and future challenges

- Sensor technology has advanced real-time, high density data collection
  - Geospatial analytics for characterizing vineyard variables – environment, growth, yield and quality
- Our ability to measure exceeds our ability to interpret
  - Understand what is important and actionable
- Large gaps exist in variable rate application technologies for geospatial management
  - Example: Variable rate drip irrigation
- Research collaboration (USDA - ARS) and industry partnership are essential to advance