Big Data and the Productivity Challenge for Wine Grapes

Nick Dokoozlian
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
- Clonal selection
- Cultivar and rootstock improvement via traditional breeding
- Pest/disease resistance

Systems Biology
- Elucidate the regulation of key yield and fruit quality pathways
- Functional genomics – linking genes to key traits

Precision Agriculture
- Characterize the parameters regulating vine productivity and quality
- Model key relationships
- Variable rate management
Integrated systems are required for improving productivity **and** quality

**Germplasm Improvement**
- Clonal selection
- Cultivar and rootstock improvement via traditional breeding
- Pest/disease resistance

**Systems Biology**
- Elucidate the regulation of key yield and fruit quality pathways
- Functional genomics – linking genes to key traits

**Precision Agriculture**
- Characterize the parameters regulating vine productivity and quality
- Model key relationships
- Variable rate management
The Future of Grape Growing

**MEASURE**

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

**MANAGE**

Information used to spatially alter cultural practices

**MODEL**

Measures used to construct geospatial maps of key relationships
Historical sensors are site specific
Historical soil measures
Sensors provide high density soil information
High Resolution Maps - EM Sensor

PAW (inches)
- < 3.75
- 3.75 - 4.50
- 4.50 - 5.25
- 5.25 - 6.00
- 6.00 - 6.75
- 6.75 - 7.50
- > 7.50

pH
- 0 - 5.7 (strongly acidic)
- 5.6 - 6.2
- 6.2 - 6.7
- 6.7 - 7.3
- 7.3 - 7.8
- 7.8 - 8.3
- > 8.3 (strongly alkaline)

Potassium (ppm)
- 0 - 50 (low)
- 50 - 100
- 100 - 150
- 150 - 200
- 200 - 250
- 250 - 300
- > 300 (high)
Characterizing Yield Variability

[Image of a tractor in a vineyard]

- Characterizing Yield Variability
Why does variability matter?

Cabernet Sauvignon

9.2 tons/acre
22.7 tons/ha
Why does variability matter?

Cabernet Sauvignon / 32.1 acres
Mean yield = 9.2 tons per acre

Block acreage (%)

Yield (tons/acre)

Mean yield = 9.2 tons per acre
Why does variability matter?

Cabernet Sauvignon / 32.1 acres
Mean yield = 9.2 tons per acre

40% of vines producing below mean block yield
Block improvement opportunity = 30% yield increase

What is the size of the prize?
Why does variability matter?
Why does variability matter?

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

Capital avoidance/acre
- Land - $50,000
- Establishment - $35,000
What is the size of the prize for Big Data?

<table>
<thead>
<tr>
<th>Colony</th>
<th>Block acreage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A Cabernet Sauvignon / 32.1 acres</td>
<td>Mean yield = 9.2 tons per acre</td>
</tr>
</tbody>
</table>

20% of vines produce quality below district average.
What is the size of the prize for Big Data?

Colony 2A Cabernet Sauvignon / 32.1 acres
Mean yield = 9.2 tons per acre

Additional revenue based on fruit quality improvement = $2,200/acre at farm gate
Additional cost = $500/acre

20% of vines produce quality below district average
Integrated systems - analytics

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

Integrated systems - analytics
### Significant Correlations with Fruit Yield

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Correlation (r²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsurface K⁺</td>
<td>0.903</td>
</tr>
<tr>
<td><strong>Soil rooting depth</strong></td>
<td><strong>0.774</strong></td>
</tr>
<tr>
<td>Subsurface pH</td>
<td>– 0.805</td>
</tr>
<tr>
<td>Subsurface P</td>
<td>– 0.805</td>
</tr>
<tr>
<td>Subsurface organic matter</td>
<td>– 0.882</td>
</tr>
<tr>
<td>Subsurface K/Mg ratio</td>
<td>– 0.890</td>
</tr>
</tbody>
</table>

### Significant Correlations with Fruit Quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Correlation (r²)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil rooting depth</strong></td>
<td><strong>– 0.673</strong></td>
</tr>
<tr>
<td>Surface CA</td>
<td>– 0.506</td>
</tr>
<tr>
<td>Subsurface CA / Mg ratio</td>
<td>– 0.510</td>
</tr>
<tr>
<td>Surface CEC</td>
<td>– 0.554</td>
</tr>
</tbody>
</table>
Variable rate management
Relative importance of soil parameters to block yield variability

- Anions: 5%
- Soil compaction: 11%
- Textural class: 13%
- pH: 16%
- Water holding capacity: 46%
Vine water use is variable based on canopy size

- **28 gallons per vine per week** for High Vigor vines
- **17 gallons per vine per week** for Low Vigor vines

Graph shows sap flow over time with high and low vigor vine data points marked by circles and triangles respectively.
Variable Rate Drip Irrigation

Changes in canopy vigor (NDVI)

Before variable rate irrigation

After variable rate irrigation

Pixel level management based on canopy size

Each square = 30m x 30m LANDSAT Pixel
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