## Horticultural Crop Value

<table>
<thead>
<tr>
<th>Crop</th>
<th>Acres</th>
<th>Farm Gate Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grapes</td>
<td>1,000,000</td>
<td>6 Billion</td>
</tr>
<tr>
<td>Nuts</td>
<td>1,300,000</td>
<td>6 Billion</td>
</tr>
<tr>
<td>Citrus</td>
<td>800,000</td>
<td>3.5 Billion</td>
</tr>
<tr>
<td>Tree fruit</td>
<td>250,000</td>
<td>1.0 Billion</td>
</tr>
</tbody>
</table>
Drive research to maximize productivity, sustainability and competitiveness of US horticultural crops

**Genomics**
- Gene identification and function
- Gene regulation
- Traditional breeding
- Molecular breeding

**Resources & Environment**
- Air
- Water
- Land
- Labor
- Sustainability

**Precision Management**
- Remote sensing
- Proximal sensing
- Automation
- Mechanization
- Big data and informatics
Drive research to maximize productivity, sustainability and competitiveness of US horticultural crops.

**Horticulture Research Roadmap**

- **Genomics**
  - Gene identification
- **Resources & Environment**
  - Air
- **Precision Management**
  - Remote sensing

**Next Generation Water Management**

- Traditional breeding
- Molecular breeding
- Labor
- Sustainability
- Mechanization
- Big data and informatics

**Genome x Environment x Management**
Current Methods for Water Management

- Standard, discrete methods for monitoring plant water and soil moisture status have significant limitations for production
  - Subjective
  - Location specific
  - Labor intensive and expensive
  - Too few measurements are collected
Next Generation Water Management

Remote sensing allows an integrated look at the vineyard

Remote sensing

- Multispectral, hyperspectral, thermal provide measures of plant water use and status
- Vegetation indices provide measures of canopy development and size
- Integration of remote sensing provides our most accurate assessment of whole-block water use and crop irrigation requirements
METRIC (Mapping evapotranspiration at high resolution and internalized calibration)

• ET residual of surface energy balance
  \[ Rn + LE + G + H = 0 \]

• Inputs
  – Landsat (visible & infrared)
  – CIMIS weather data

• Outputs
  – ETc
  – Kc (f/NDVI)

• Watering of each zone:
  \[ ETc = ETref \times Kc \times Km \]
Building robust models based on remote sensing requires ground truthing.
Integrated data analytics

Plant available water in soil

Vegetation Index (NDVI)

Yield

Fruit Quality
Variable rate drip irrigation

Vines using 17 gallons per week

Vines using 28 gallons per week

Row direction
Variable Rate Irrigation

Changes in canopy vigor (NDVI)

Colony 2A
Cabernet Sauvignon

July 2012 → July 2013
Precision Irrigation

2012 Block Yield
8.9 t/ac

2013 Block Yield
10.2 t/ac
20% less water applied
Next Generation Water Management

**MEASURE**
soil and plant water status

Develop integrated, block level measures to monitor plant water and soil moisture status

**MODEL**
remote and proximal sensor data

Correlate relationships among remote sensing, proximal sensing, traditional measures and other data sources and plant water and soil moisture status

**MANAGE**
Irrigation to maximize water use efficiency

Develop precision irrigation systems for variable rate irrigation management, including Best Practices for irrigation amount, timing and frequency to optimize water use efficiency
Summary

- Increased focus on specialty crops
  - Modern tools to measure, model and manage water and improve water use efficiency
- Commodity group collaboration to extend ARS efforts
  - Potential source of funding
  - Link to extension of information to grower community
- Establish Grape LTAR in California
  - Focus on water agro-ecosystem and management