Almond Production Estimates: Nuts and Bolts of Different Models
Almond Acreage, Yield, Production Estimates

Gary R. Keough, Director
USDA NASS Pacific Regional Office

December 12, 2019
Acreage

• Annual Almond Acreage Survey
  • Collect block level data from know growers
  • Block listings mailed in October
  • Data collection continues through February.
  • Data collected:
    • Crop, variety, year planted, acres, plant spacing

• Census of Agriculture
  • 5-year intervals
  • Collect whole farm data from all known farmers and potential farmers
  • Mandatory reporting
Almond Bearing Acres

The difference between ESTIMATED and REPORTED is the acres missing from the acreage survey.
Why the difference between estimated and reported?

- New growers may not be in the NASS database.
- Some growers don’t report because the acreage survey is voluntary.
- Growers may overlook the reporting of new parcels.
- If acres are harvested, then pulled out by the end of the year, they are removed from Reported Data.
Production Forecasts

• Subjective Forecast
  • Random sample of ~ 500 growers
  • Sample is stratified by size so all growers and areas are represented
  • Mail, phone follow-up in late April, early May
  • Opinion survey
Production Forecasts

• Objective Measurement Forecast
  • Based on actual counts and measurements
  • 940 randomly selected blocks selected from the results of the Almond Acreage Survey
  • Sample represents the population:
    • By age
    • By variety
    • By location (county)
Production Forecasts

• Objective Measurement Forecast
  • 2 trees in each orchard
  • Select count unit
    • Random limb with a cross sectional area greater than 0.5 square inch
  • Count nuts in the defined count unit
  • Measure weight, width, thickness and length of sample of nuts harvested from the count unit
Production Forecasts

• Objective Measurement Forecast
  • Linear Regression Model, $Y=\alpha + \beta X$
    • $Y$ is final production from receipts
    • $X$ input variable
    • $\alpha, \beta$ coefficients calculated from previous 15 years
  • $X=ab$ where:
    • $a=\text{Acres} \times \text{Trees per Acre} \times \text{Nuts per Tree} \times \text{Percent Sound}$
    • $b$ is either:
      • weight
      • cross suture
      • thickness
      • length
      • cross suture + thickness
Production Forecasts

United States Department of Agriculture
National Agricultural Statistics Service
Production Forecasts

• Objective Measurement Forecast
  • Models are designed to produce a forecast of all almond production at the state
  • Separate models for Nonpareil

• Analysis
  • Absolute Differences
  • Relative Differences (Percent)
Importance of Reporting/Cooperation

• Accuracy of production forecasts depends on grower participation on Acreage Survey and Subjective Forecast.

• Objective Measurement Survey relies on Acreage Survey for samples that represent each variety, age, and location.

• Block we don’t know about can’t be sampled.
Land IQ Almond Yield Estimating Tool

Joel Kimmelshue, PhD, CPSS
2019 Almond Acreage Update

• In-season estimate of almond acreage
  – May release: Initial bearing acreage and removals from the previous year
  – December release: Final bearing acreage and non-bearing estimate

<table>
<thead>
<tr>
<th>2019 Acreage</th>
<th>Final Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing</td>
<td>1,181,903</td>
</tr>
<tr>
<td>Non-Bearing</td>
<td>315,433</td>
</tr>
<tr>
<td>Total</td>
<td>1,497,336</td>
</tr>
</tbody>
</table>
Almond Mapping

• Bearing Acreage
  – Spatial representation of almond orchards
  – 98.8% accurate

• Non Bearing Acreage
  – Numerical estimate of non-bearing acreage
  – 95% accurate
  – Finalized two years after initial release

• Initial Estimate – April of each year
  – Current year spatial representation of bearing acreage
  – To be used by USDA-NASS

• Final Estimate – December of each year
  – Current year spatial representation of bearing acreage
  – Current year numerical estimate of non-bearing acreage
  – Current year total acreage estimate
• Note: In 2020, current year initial bearing estimate will be delivered in mid-April, with public release concurrent with NASS subjective forecast.
Almond Yield Forecasting

• Land IQ yield forecasting is based on four fundamental components:
  – Orchard Acreage
  – Orchard Location
  – Orchard Age
  – Yield Function
Almond Orchard Acreage

- Land IQ maps actual irrigated acreage of individual orchards
- Orchards that are 2 acres or larger
- Cuts out farm shops, homes and roads
- Field boundary positional accuracies are +/- 6 feet at a 95% confidence interval
Almond Orchard Location

- Yield varies by location (north = less, south = more)
- Land IQ has spatially mapped almond acreage for ABC since 2010.
- Mapping includes the following years:
  - 2010
  - 2012
  - 2014
  - 2016
  - 2018
  - 2019
  - Annually and within the production year moving forward
- Current spatial accuracy of bearing acreage is 98.8%
Almond Orchard Age

- In-season estimate of almond acreage also includes age analysis
  - A backwards looking approach (through 1984) at various imagery sources is conducted
  - Once the “signature” appears as open ground, a planting date can be established
  - Accuracy: 95% within +/- 1 year
Almond Yield Function

• Utilizes multiple lines of evidence to develop the yield model
• Calibrated to ABC receipts over the past 9 years with the difference between actual and predicted yield of 2% or less in any one year.
Land IQ Almond Yield Forecasting Tool
Land IQ Estimate for 2019 Yield

- Land IQ updates acreages following the initial release of acreage for ABC, taking into account removals.
- Land IQ yield estimate was available in June of 2018 and 2019

<table>
<thead>
<tr>
<th></th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land IQ Crop Volume</td>
<td>2,270,000,000</td>
<td>2,420,000,000</td>
</tr>
<tr>
<td>ABC Crop Volume (7/31)</td>
<td>2,269,570,776</td>
<td>TBD</td>
</tr>
<tr>
<td>Land IQ Difference</td>
<td>429,224</td>
<td>TBD</td>
</tr>
<tr>
<td>Land IQ % Difference</td>
<td>0.02%</td>
<td>TBD</td>
</tr>
</tbody>
</table>
Almond Production Estimates

Capturing the risk and its impacts

December 10, 2019

Roland Fumasi, Ph.D.
Senior Analyst
RaboResearch Food & Agribusiness
Yield & production are just puzzle pieces
The foundation: Acres by age & location

- Past Prices
- Existing almond acreage N C S
- Other factors i.e. water regulation N C S
- Change in acreage N C S
- Acreage Removed N C S
- Tree Age N C S
- Planted Acreage N C S

Diagram showing the relationship between these factors over time from 2020 to 2022.
### Yield risk estimation

<table>
<thead>
<tr>
<th>Region</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 3</td>
<td>Min</td>
<td>Mid</td>
<td>Max</td>
<td>etc</td>
<td>etc</td>
</tr>
<tr>
<td>Age 4</td>
<td>Min</td>
<td>Mid</td>
<td>Max</td>
<td>etc</td>
<td>etc</td>
</tr>
<tr>
<td>Age 5</td>
<td>Min</td>
<td>Mid</td>
<td>Max</td>
<td>etc</td>
<td>etc</td>
</tr>
<tr>
<td>Age 6</td>
<td>Min</td>
<td>Mid</td>
<td>Max</td>
<td>etc</td>
<td>etc</td>
</tr>
<tr>
<td>Age 7</td>
<td>Min</td>
<td>Mid</td>
<td>Max</td>
<td>etc</td>
<td>etc</td>
</tr>
<tr>
<td>Age 8+</td>
<td>Min</td>
<td>Mid</td>
<td>Max</td>
<td>etc</td>
<td>etc</td>
</tr>
</tbody>
</table>

**X 6 (tree age) X 5 (years) X 3 (regions) = 90 yield distributions**
Risk in estimates at every turn

Tree Age Blocks in Acres (3)

<table>
<thead>
<tr>
<th>Region</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 3</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Age 4</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Age 5</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Age 6</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Age 7</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Age 8+</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Yield Per Acre Blocks (3)

<table>
<thead>
<tr>
<th>Region</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 3</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Age 4</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Age 5</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Age 6</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Age 7</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Age 8+</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

X 3

Distributions are:
- Not all normal
- Not all symmetric
- Correlated
When combined with everything else

U.S. almond farm-level price 2008/09 – 2022/23e (as of March 2019)

Source: Rabo AgriFinance estimates March 2019
We fix this

Machine learning
Satellite data
Climate + Weather data
Vinsight
forecast error
20% -> 5%
Product Flow

Data Structuring & Cleaning → Feature Engineering → Vinsight modeling → Vinsight indices → Vinsight Forecast Range

Weather Imagery Physical data → Industry knowledge → Historical data → Crop Phenology

Index 1
Index 2
Index 3

input
vinsight
output
Modeling + Methodology

Over 100 different proprietary models developed

We forecast at the country, state, county, field

Forecasts from our proprietary models updated monthly

Our data collection happens hourly, daily, monthly, annually

We give forecast + context, the what and the why in speciality crops
## 2019 Forecasts - Almonds

<table>
<thead>
<tr>
<th>2019</th>
<th>Yield</th>
<th>Acreage</th>
<th>Production</th>
<th>Top Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>2,170</td>
<td>1,130,000</td>
<td>2,452,100,000</td>
<td>Growing degree days (Oct-Dec), solar radiation (Nov), NDVI (Oct-Dec)</td>
</tr>
<tr>
<td>May</td>
<td>2,216</td>
<td>1,130,000</td>
<td>2,504,080,000</td>
<td>NDVI, precipitation (Jan-Mar), Growing degree days, humidity (Oct-Dec), NDVI (Oct-Sept)</td>
</tr>
<tr>
<td>June</td>
<td>2,190</td>
<td>1,130,000</td>
<td>2,474,700,000</td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>2,143</td>
<td>1,130,000</td>
<td>2,421,590,000</td>
<td>NDVI, windspeed (Apr), NDVI (Oct-Dec), NDVI, windspeed (Oct)</td>
</tr>
<tr>
<td>Avg</td>
<td>2,180</td>
<td>1,130,000</td>
<td>2,463,117,500</td>
<td></td>
</tr>
</tbody>
</table>
Farmers in USA lose $11B on most valuable crops
Crops + AOIs

Grapes
Almonds
Pistachios
Walnuts
USA + Australia
Our Team

9 people
Agriculture experts
Machine Learning experts

[Logos of various institutions]
Thank you!
Let’s get in touch

461 2nd Street, Ste 207
San Francisco, CA 94107

e. megan@vinsight.co
Almond Crop Forecasting
Considerations and Repercussions
The Realities of Forecasting

- It’s an **Estimate**!!!
  - But the Consequences are Significant
- All Forecasts Are Wrong
  - It’s Just a Matter of Degrees
- There are a Lot of Variables
  - Precision is Implied
  - Reality is Variable
Historic Yields vs Crop Receipts
Crop Variables

- Macro & Micro-Climates
  - Sacramento Valley vs San Joaquin Valley
  - West side vs Eastern Foothills vs 99 Corridor
- Soil types
  - Pest & Disease Issues
  - Rootstock Limitations
- Orchard Architecture
  - Pre-1990’s “2 on 1” Plantings
  - Tree Density
  - Better Variety Matching
  - Low Volume Irrigation
- Self-Fertiles
- Water Availability and Quality
- Acreage Data
California Almond Acreage

Reported Acreage = 877,904
Estimated Acreage = 1,390,000
California Almond Acreage

1,347,273 Acres
Crop Share by Region

Crop NASS Yield/Acre

North Central South Crop

2007/08 1,383.6 1,611.0 1,402.6 1,626.6 2,017.2 1,884.1 2,006.9 1,869.7 1,892.1 2,130.6 2,263.0 2,268.0
2008/09 2,161 2,274 1,875 2,115 2,526 2,278 2,389 2,174 2,126 2,271 2,262 2,084
2009/10 2,161 2,274 1,875 2,115 2,526 2,278 2,389 2,174 2,126 2,271 2,262 2,084
2010/11 2,161 2,274 1,875 2,115 2,526 2,278 2,389 2,174 2,126 2,271 2,262 2,084
2011/12 2,161 2,274 1,875 2,115 2,526 2,278 2,389 2,174 2,126 2,271 2,262 2,084
2012/13 2,161 2,274 1,875 2,115 2,526 2,278 2,389 2,174 2,126 2,271 2,262 2,084
2013/14 2,161 2,274 1,875 2,115 2,526 2,278 2,389 2,174 2,126 2,271 2,262 2,084
2014/15 2,161 2,274 1,875 2,115 2,526 2,278 2,389 2,174 2,126 2,271 2,262 2,084
2015/16 2,161 2,274 1,875 2,115 2,526 2,278 2,389 2,174 2,126 2,271 2,262 2,084
2016/17 2,161 2,274 1,875 2,115 2,526 2,278 2,389 2,174 2,126 2,271 2,262 2,084
2017/18 2,161 2,274 1,875 2,115 2,526 2,278 2,389 2,174 2,126 2,271 2,262 2,084
2018/19 2,161 2,274 1,875 2,115 2,526 2,278 2,389 2,174 2,126 2,271 2,262 2,084
2018 Crop Yield by Region

2.268 Billion Pounds
Average Yield/Acre
2,084 Pounds

Sacramento Valley
13.3% of Crop
1,591 lbs/Acre
76.4% of Average

Northern San Joaquin Valley
31.5% of Crop
2,159 lbs/Acre
103.6% of Average

Southern San Joaquin Valley
55.2% of Crop
2,204 lbs/Acre
105.8% of Average
Turnout Percentages

21.0% → 2.291 B → -109.0 M

2.400 B → 22.0%

23.0% → 2.509 B → +109.0 M

- Stress
- Drought
- High Temperatures
- Other Unknown Environmental Factors
Almond Crop Forecasting Considerations and Repercussions
Almond Production Estimates: Nuts and Bolts of Different Models
Join the Conversation!

Use #AlmondConf to share highlights from The Almond Conference