Almond Production Estimates: Nuts and Bolts of Different Models

california almonds®
Almond Board of California

Almond Acreage, Yield, Production Estimates

Gary R. Keough, Director
USDA NASS Pacific Regional Office

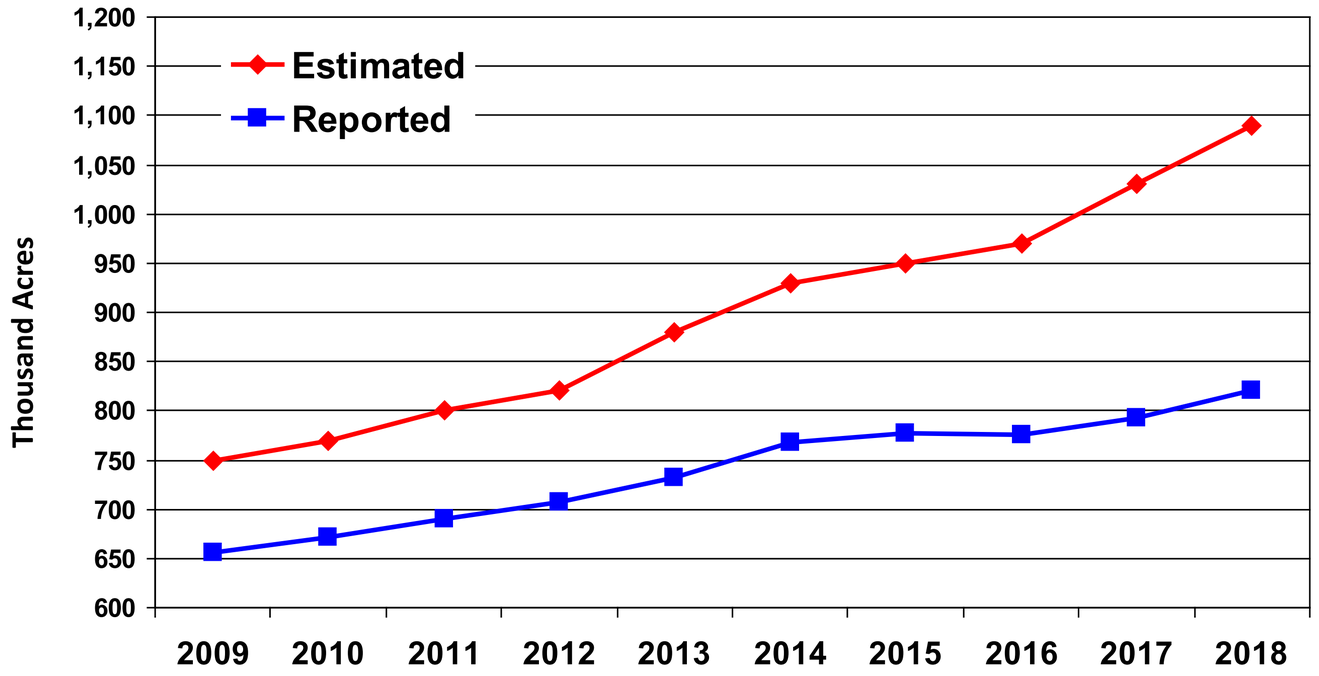
December 12, 2019

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.

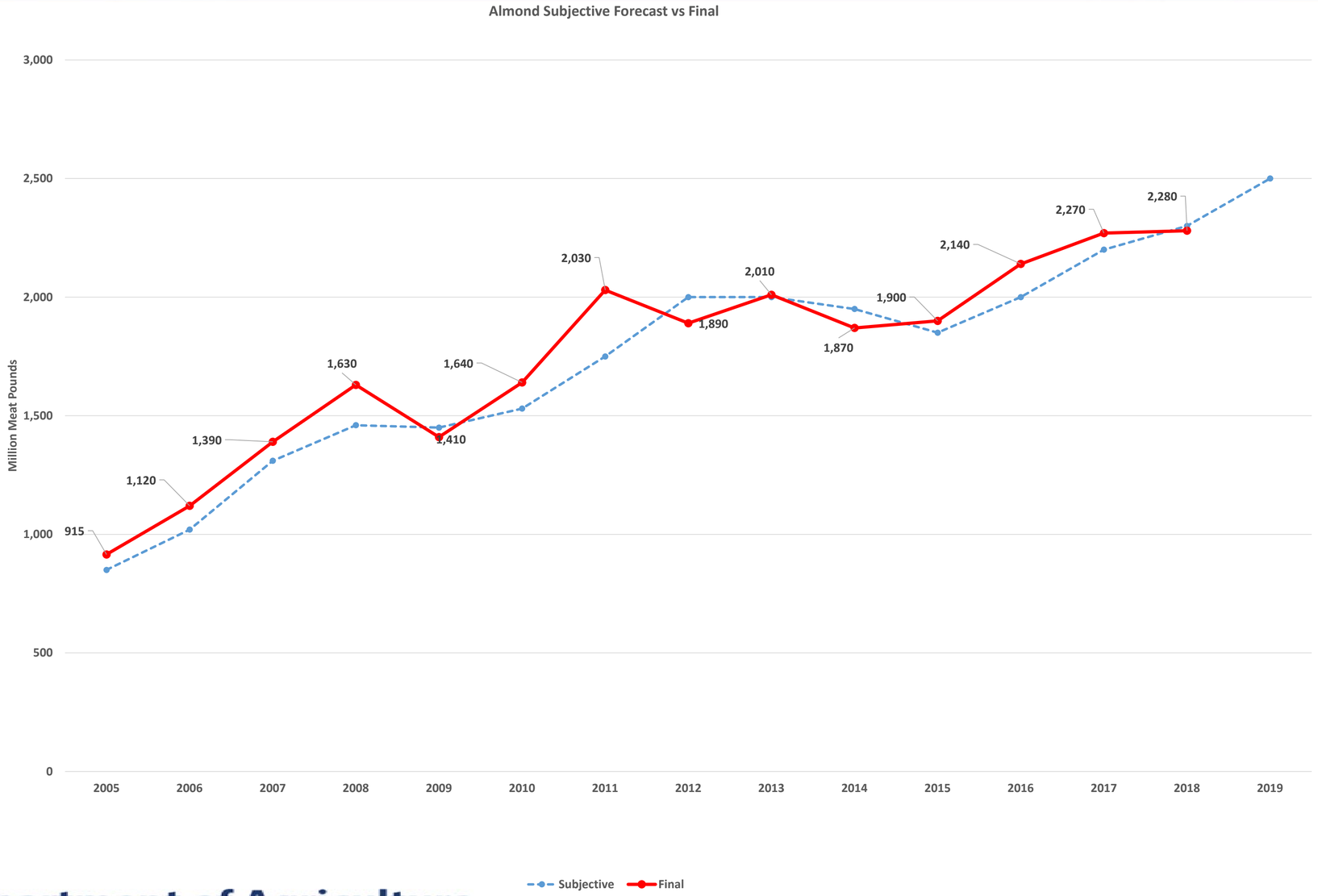


Why the difference between estimated and reported?

- 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


Almond Subjective Forecast vs Final
Million Meat Pounds
3,000
2,500
2,000
1,500
1,000
500
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
915
1,120
1,390
1,630
1,410
1,640
2,030
1,890
2,010
1,870
1,900
2,140
2,270
2,280
Subjective
Final

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

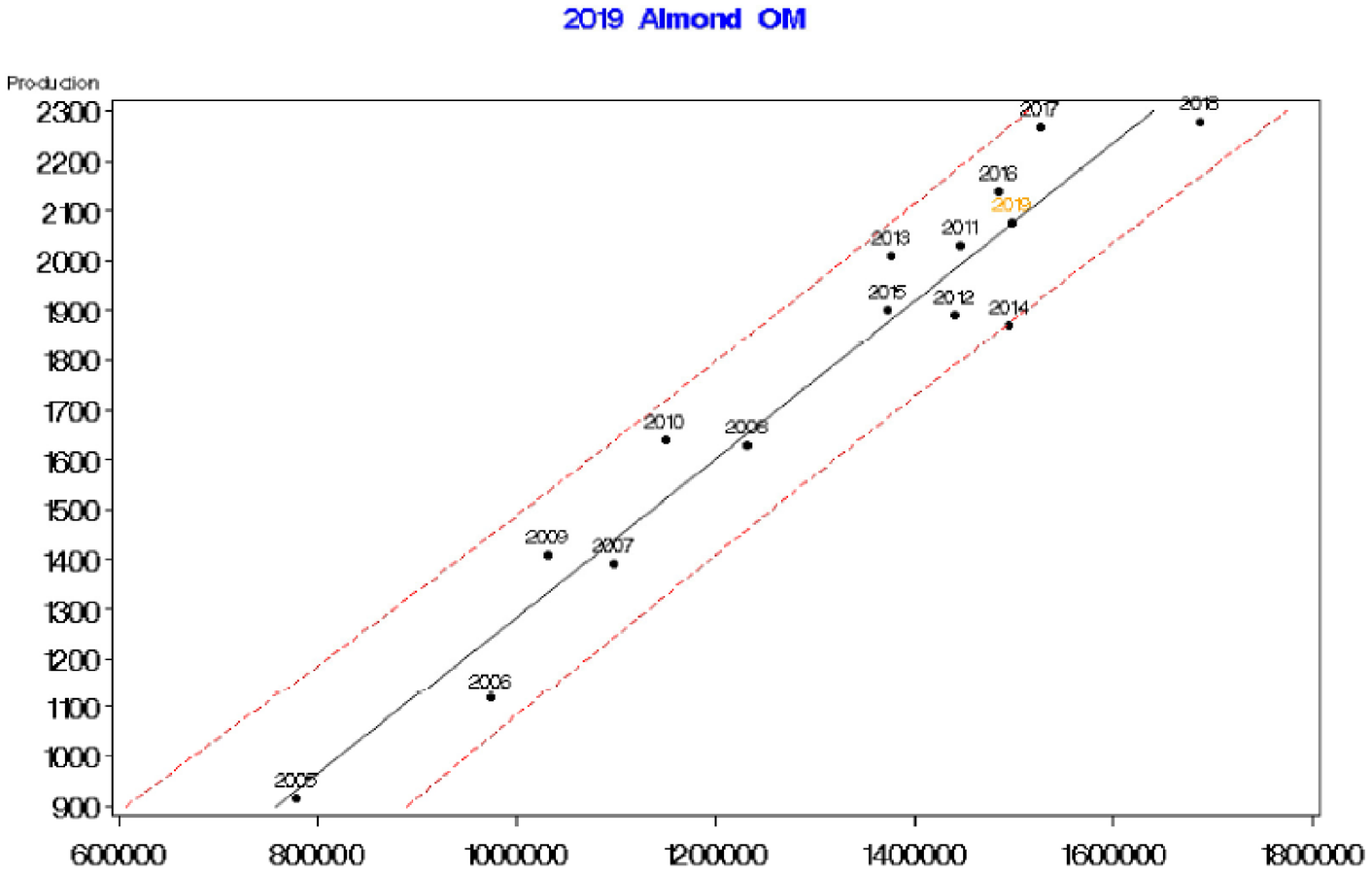
Production Forecasts

- 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

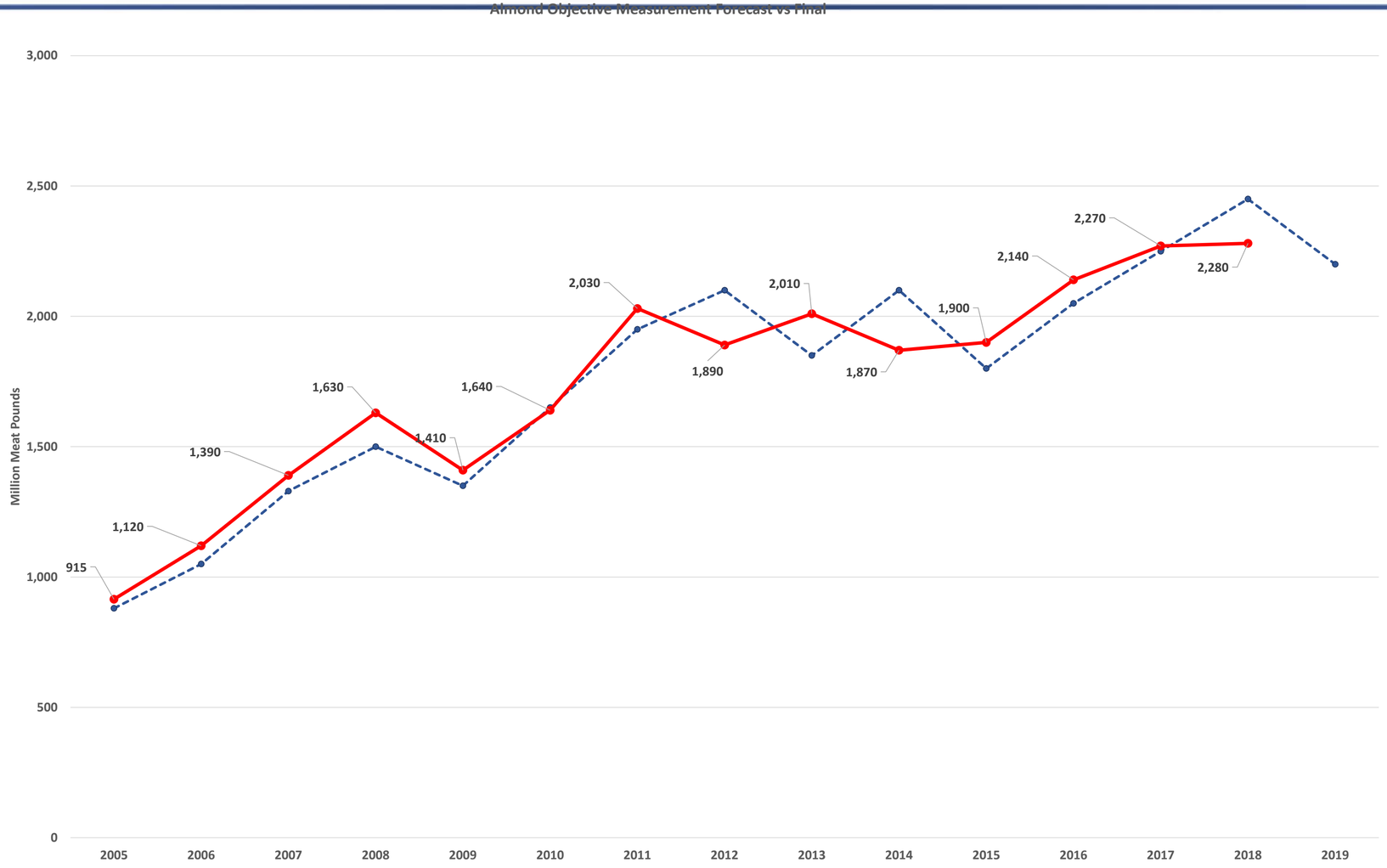
- Objective Measurement Forecast
  - Linear Regression Model, $Y=\alpha + \beta X$
    - Y is final production from receipts
    - X input variable
    - α, β coefficients calculated from previous 15 years
  - X=ab where:
  - a=Acres x Trees per Acre x Nuts per Tree x Percent Sound
  - b is either:
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

Production Forecasts



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)


Almond Objective Measurement Forecast vs Final
Million Meat Pounds
3,000
2,500
2,000
1,500
1,000
500
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
915
1,120
1,390
1,630
1,410
1,640
2,030
1,890
2,010
1,870
1,900
2,140
2,270
2,280
OM
Final

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

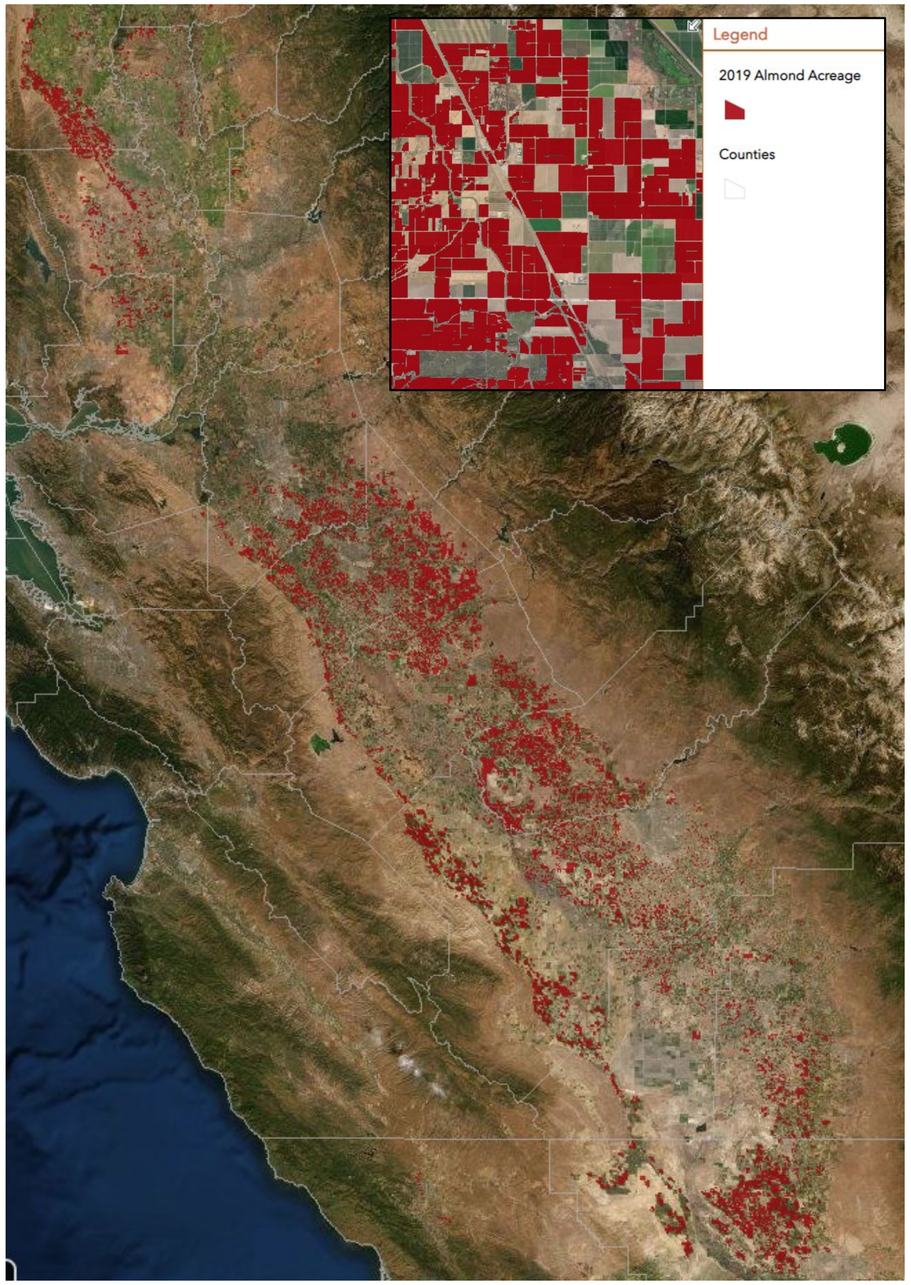
LAND IQ

california almonds
Almond Board of California

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

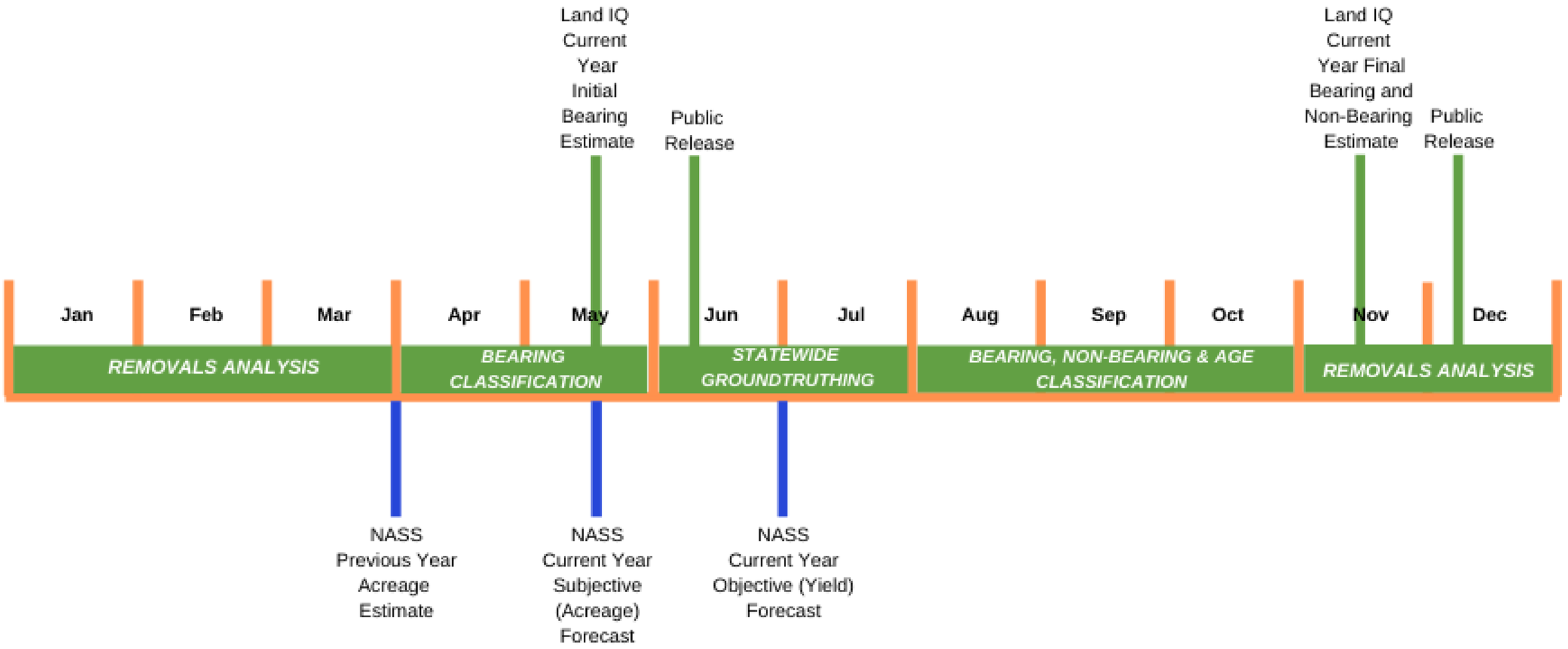
2019 Acreage	Final Estimate
Bearing	1,181,903
Non-Bearing	315,433
Total	1,497,336



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

Land IQ Mapping Timeline - 2019



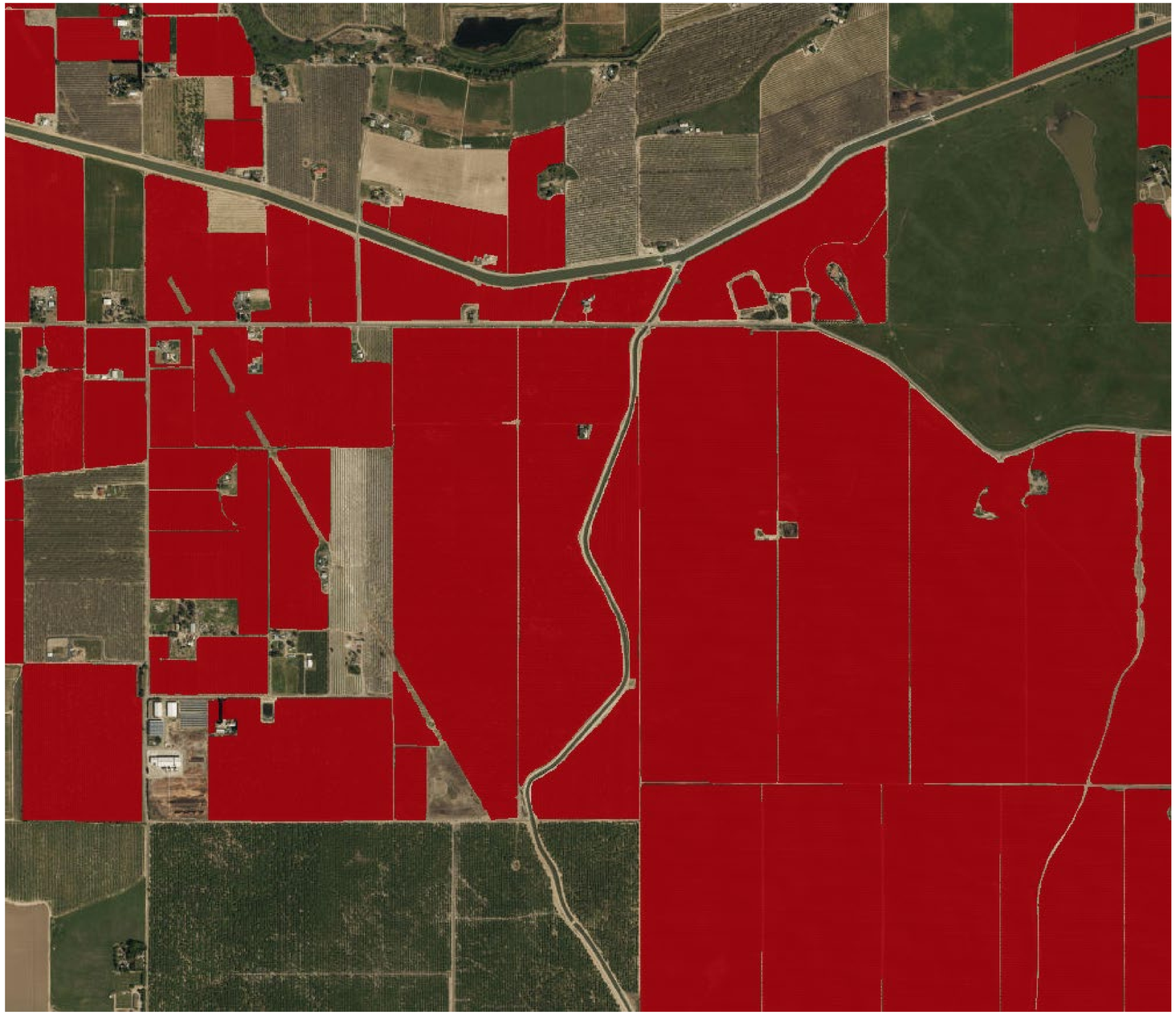
- Note: In 2020, current year initial bearing estimate will be delivered in mid-April, with public release concurrent with NASS subjective forecast

Almond Yield Forecasting

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

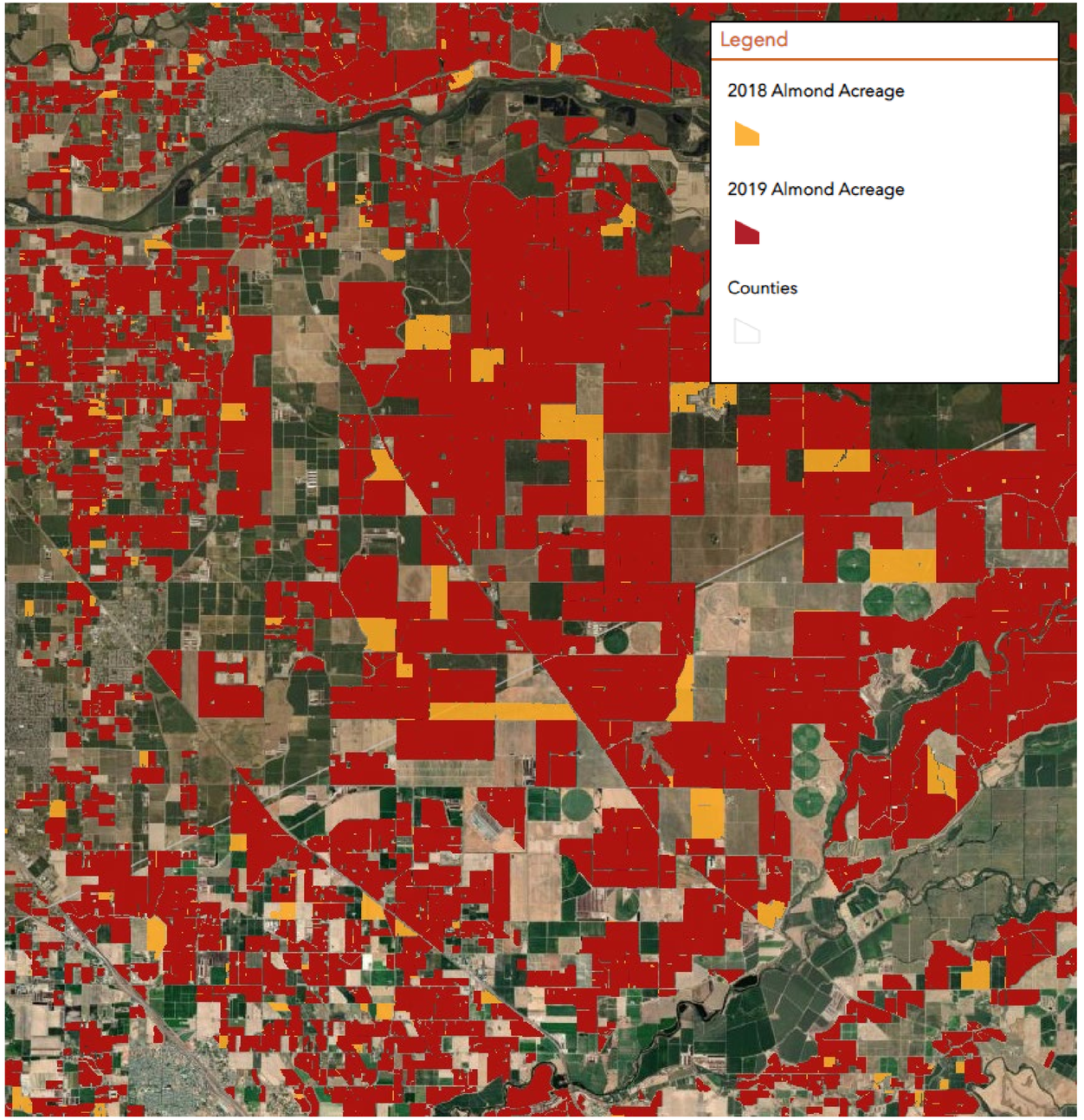
Almond Orchard Acreage

- 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



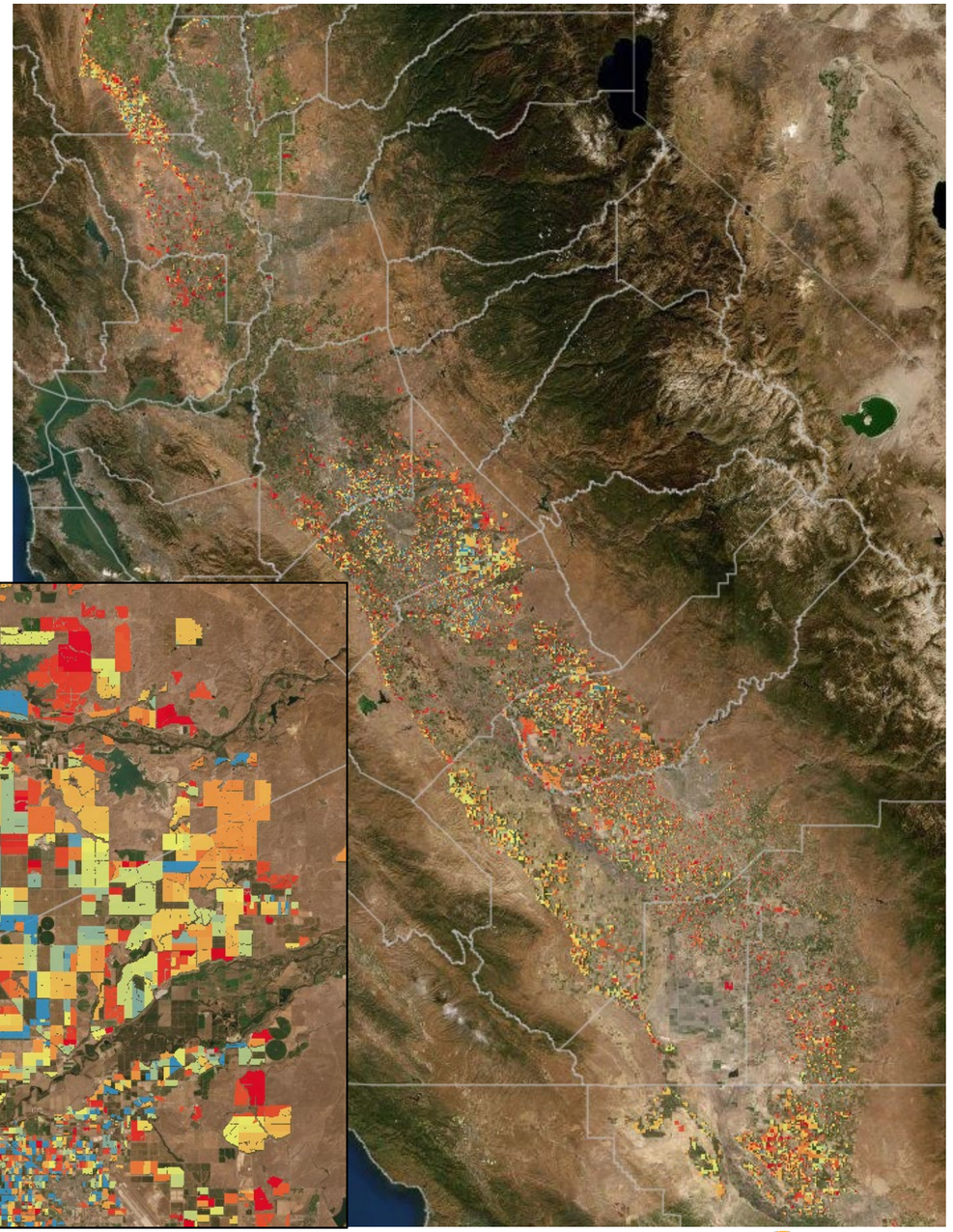
Almond Orchard Location

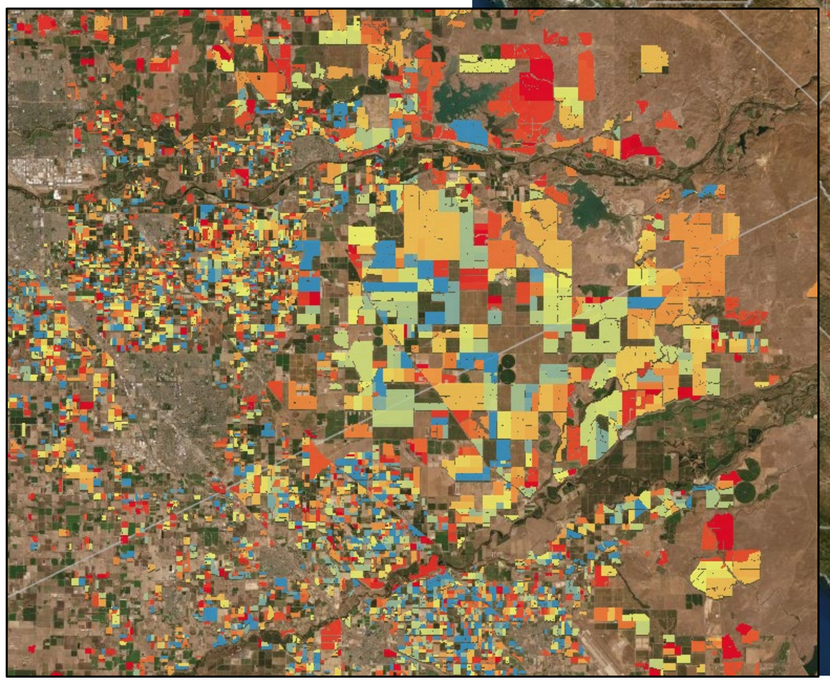
- Yield varies by location (north = less, south = more)
- Land IQ has spatially mapped almond acreage for ABC since 2010.
- Mapping includes the following years:
  - 2010
  - 2012
  - 2014
  - 2016
  - 2018
  - 2019
  - Annually and within the production year moving forward
- Current spatial accuracy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

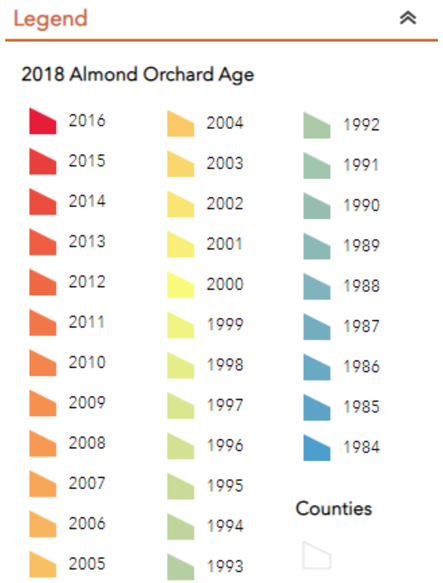


Almond Orchard Age

- 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

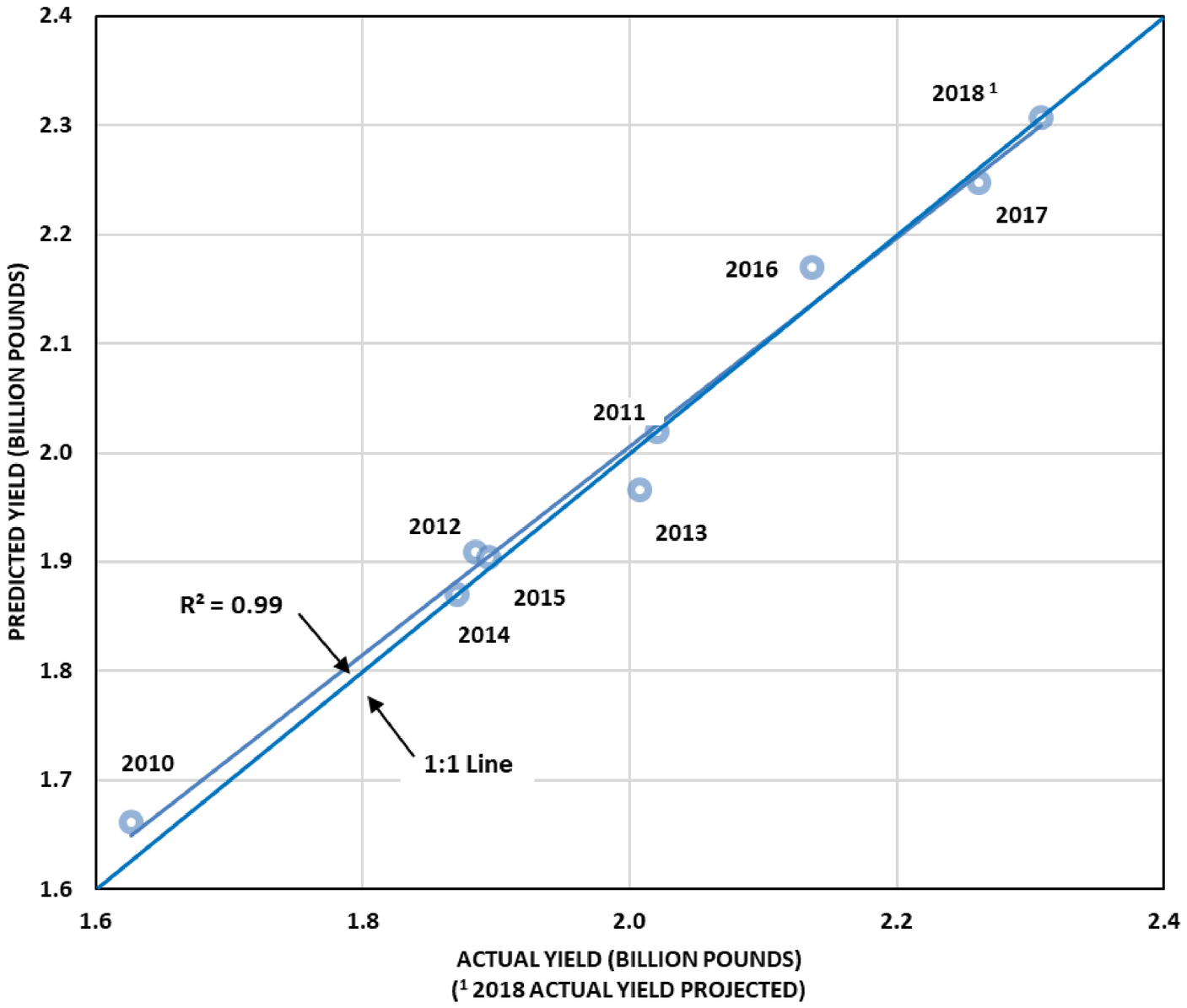




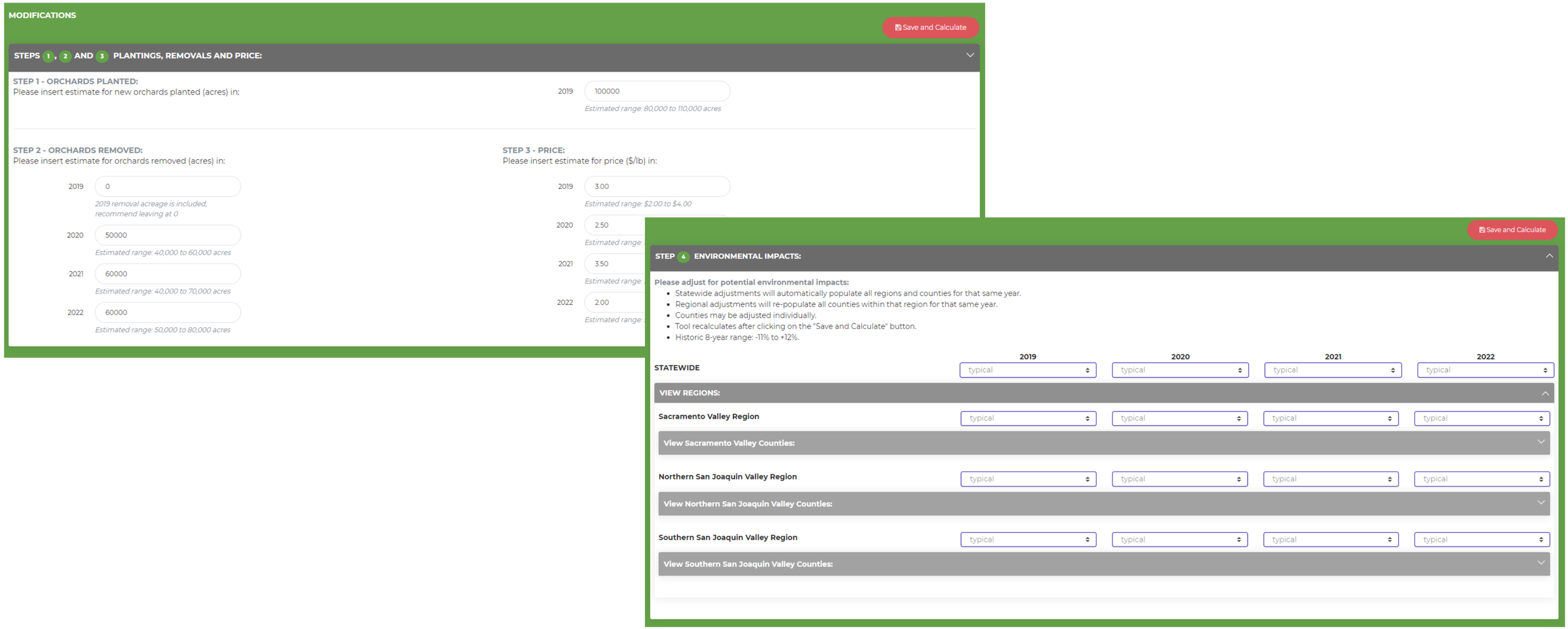


Almond Yield Function

- 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

	2018	2019
Land IQ Crop Volume	2,270,000,000	2,420,000,000
ABC Crop Volume (7/31)	2,269,570,776	TBD
Land IQ Difference	429,224	TBD
Land IQ % Difference	0.02%	TBD

Almond Production Estimates

Capturing the risk and its impacts

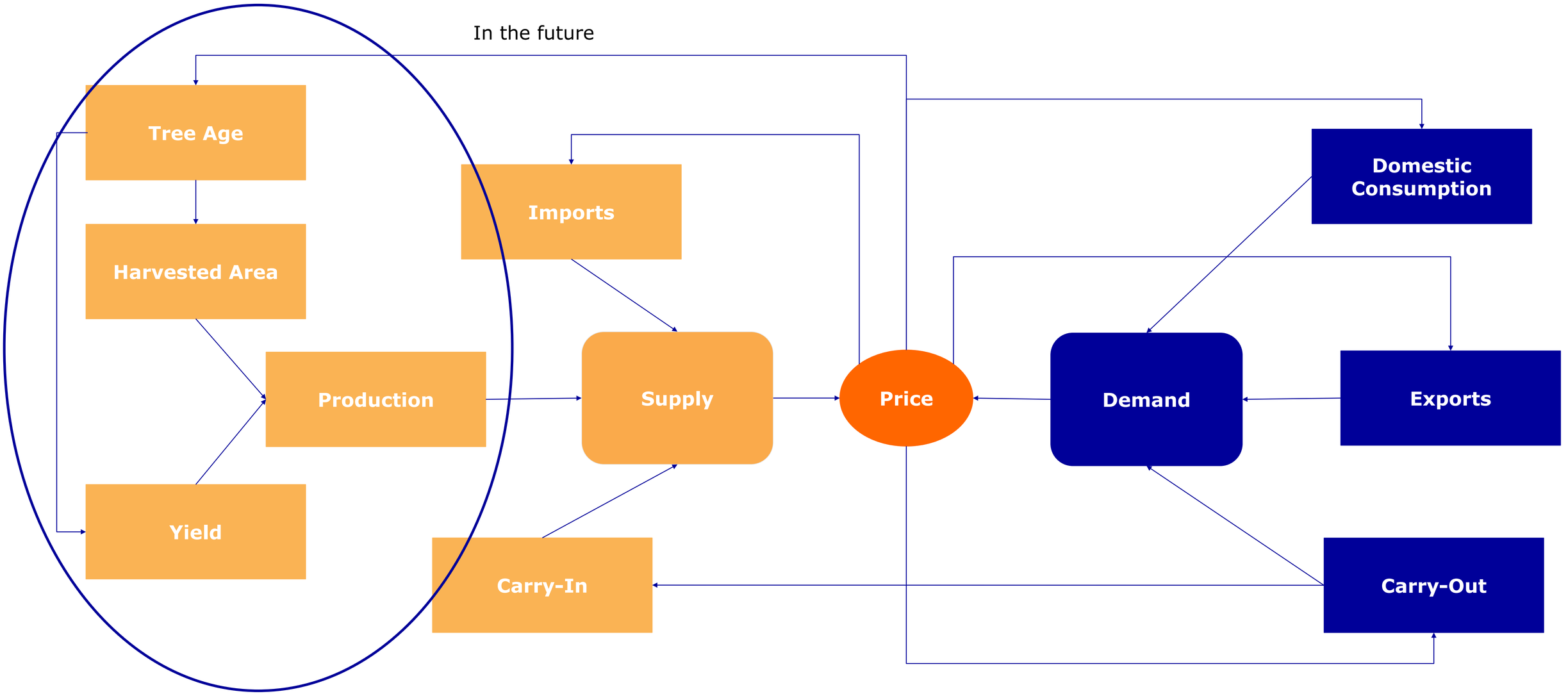
December 10, 2019

Roland Fumasi, Ph.D.
Senior Analyst
RaboResearch Food & Agribusiness

california almonds
Almond Board of California

Rabo AgriFinance

Yield & production are just puzzle pieces



The foundation: Acres by age & location

Rabo AgriFinance

Past Prices

Existing almond acreage
N C S

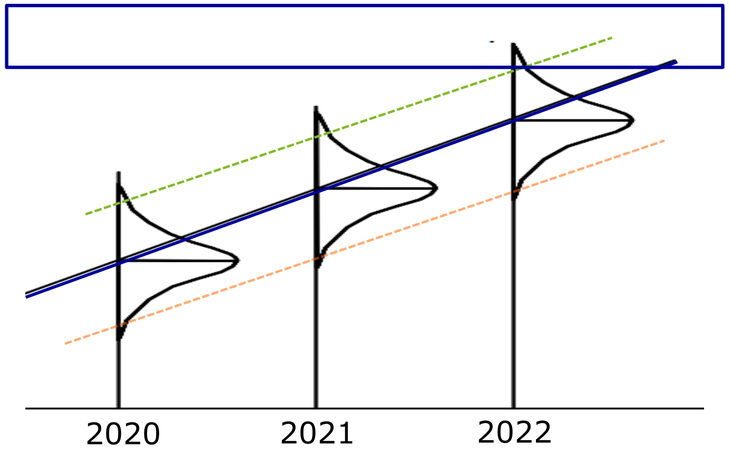
Other factors i.e. water regulation
N C S

Change in acreage
N C S

Acreage Removed
N C S

Tree Age
N C S

Planted Acreage
N C S

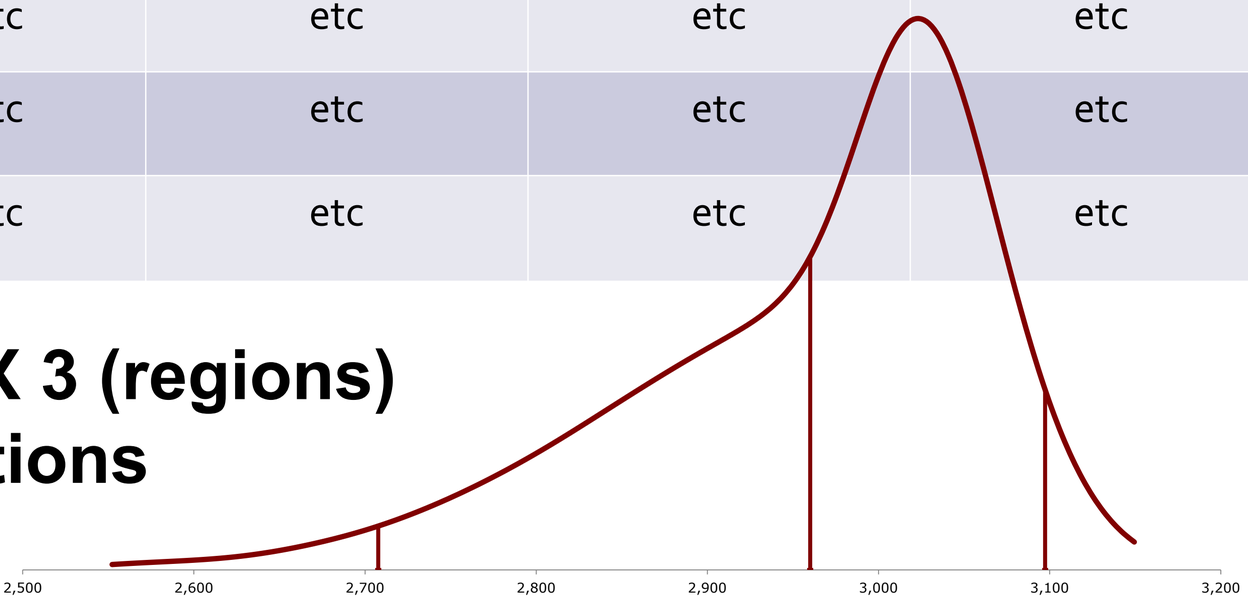


Yield risk estimation

X 3

Region	2020			2021	2022	2023	2024
Age 3	Min	Mid	Max	etc	etc	etc	etc
Age 4	Min	Mid	Max	etc	etc	etc	etc
Age 5	Min	Mid	Max	etc	etc	etc	etc
Age 6	Min	Mid	Max	etc	etc	etc	etc
Age 7	Min	Mid	Max	etc	etc	etc	etc
Age 8+	Min	Mid	Max	etc	etc	etc	etc

X 6 (tree age) X 5 (years) X 3 (regions)
= 90 yield distributions



Risk in estimates at every turn

Rabo AgriFinance

Tree Age Blocks in Acres (3)

Region	2020	2021	2022	2023	2024
Age 3					
Age 4					
Age 5					
Age 6					
Age 7					
Age 8+					

X 3

Yield Per Acre Blocks (3)

Region	2020	2021	2022	2023	2024
Age 3					
Age 4					
Age 5					
Age 6					
Age 7					
Age 8+					

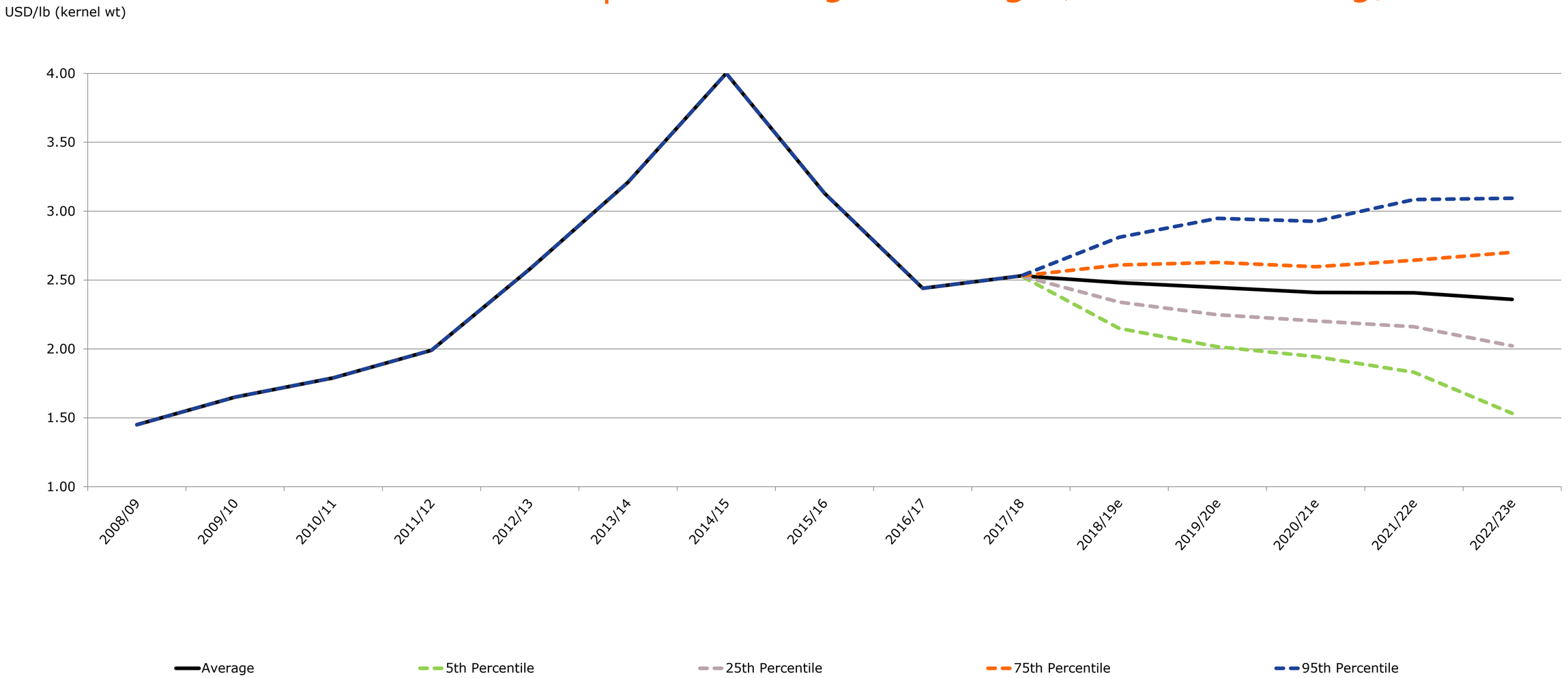
X 3

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

Thank you for your attention

roland.fumasi@raboag.com

Banking for Food

Rabo AgriFinance

VINSIGHT

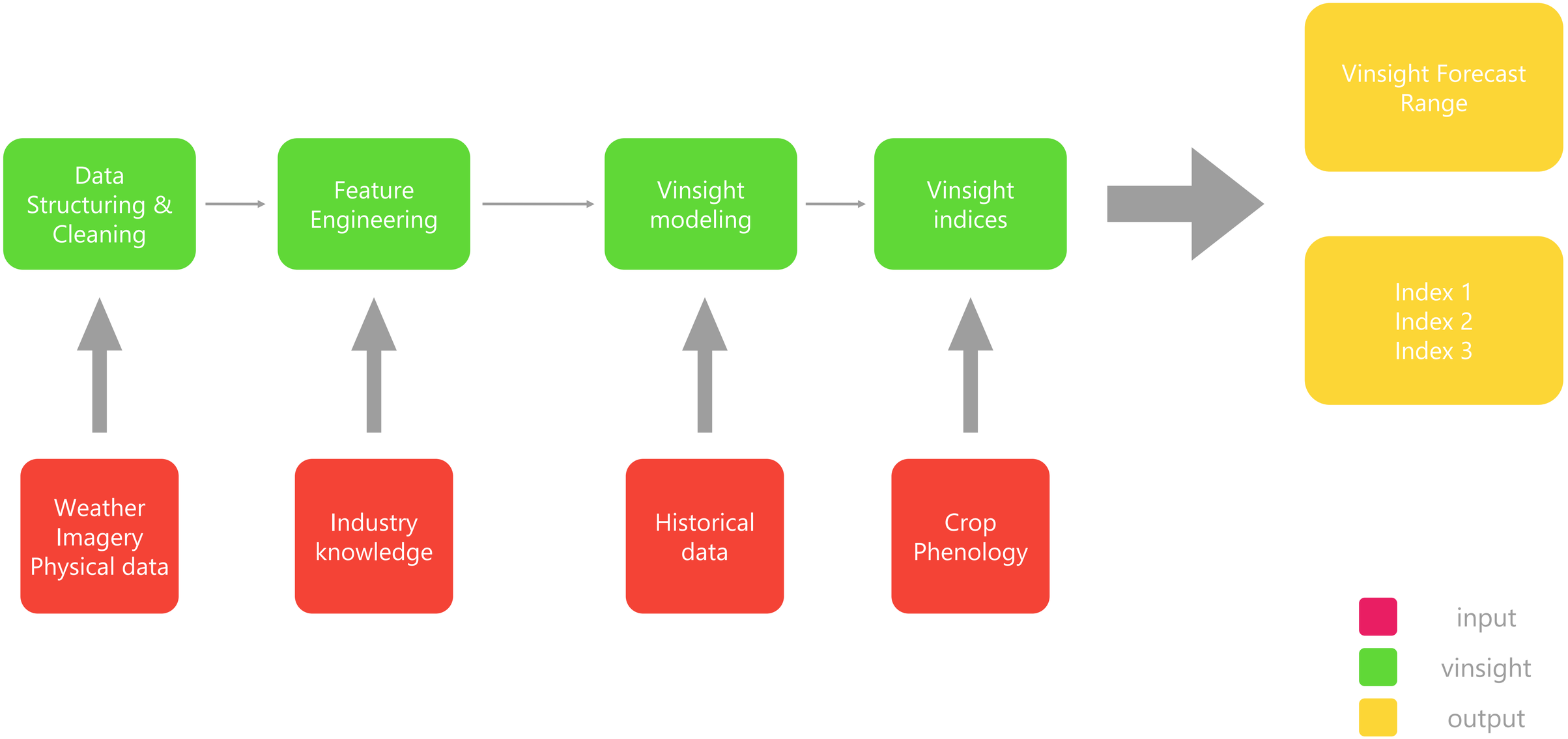
Forecasting for agriculture

We fix this

Machine learning
Satellite data
Climate + Weather data

Vinsight forecast error 20% -> 5%

Product Flow



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

2019	Yield	Acreage	Production	Top Features
April	2,170	1,130,000	2,452,100,000	Growing degree days (Oct-Dec) solar radiation (Nov)NDVI (Oct-Dec)
May	2,216	1,130,000	2,504,080,000	NDVI, precipitation (Jan-Mar), Growing degree days, humidity (Oct-Dec)NDVI (Oct-Sept)
June	2,190	1,130,000	2,474,700,000	
July	2,143	1,130,000	2,421,590,000	NDVI, windspeed (Apr)NDVI (Oct-Dec)NDVI, windspeed (Oct)

Avg	2,180	1,130,000	2,463,117,500

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

PennState

CAL POLY
SAN LUIS OBISPO

NASA

Caltech

Cornell University

Berkeley
UNIVERSITY OF CALIFORNIA

VINSIGHT

Thank you!
Let's get in touch

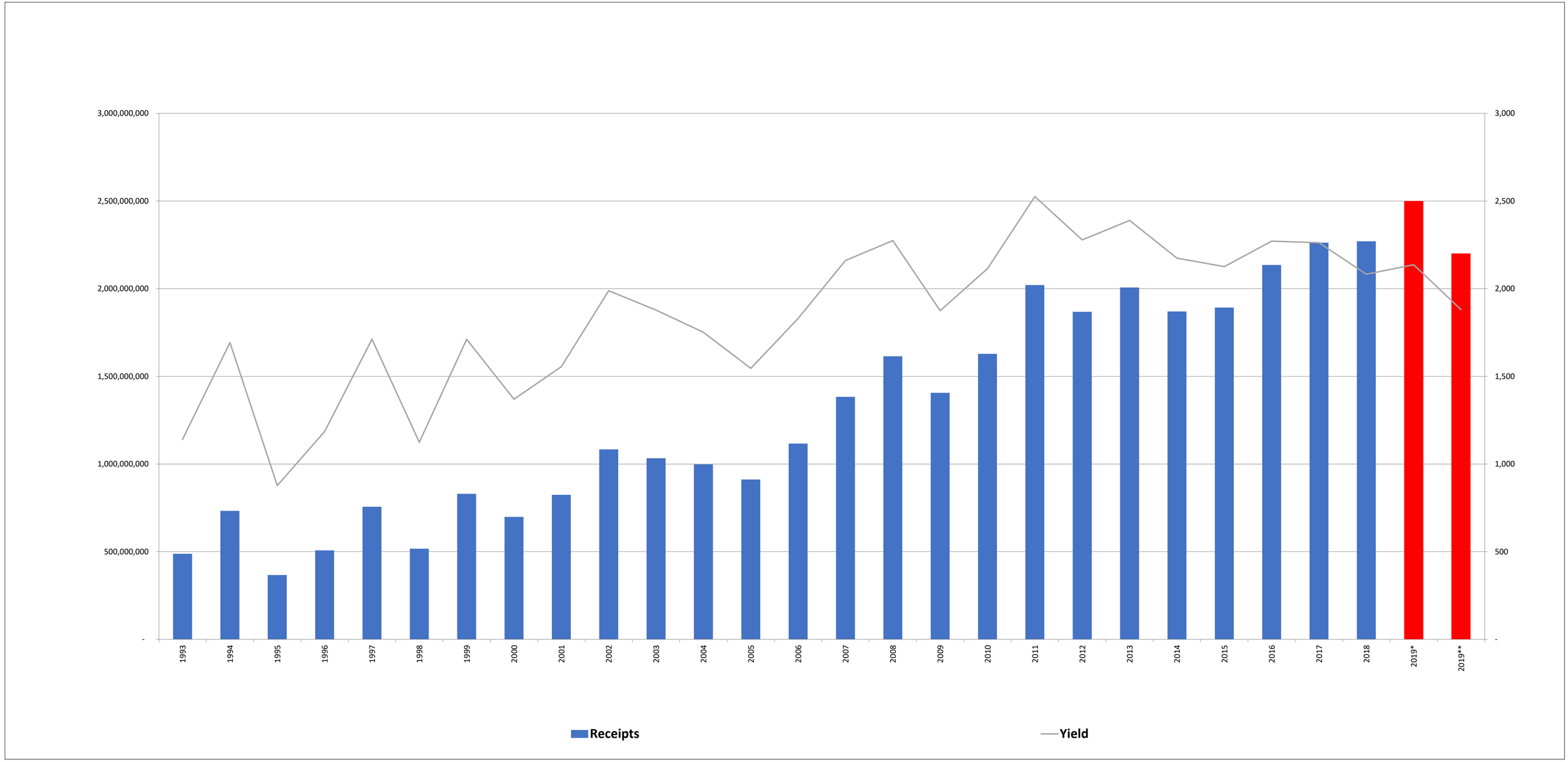
461 2nd Street, Ste 207
San Francisco, CA 94107
e. megan@vinsight.co

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

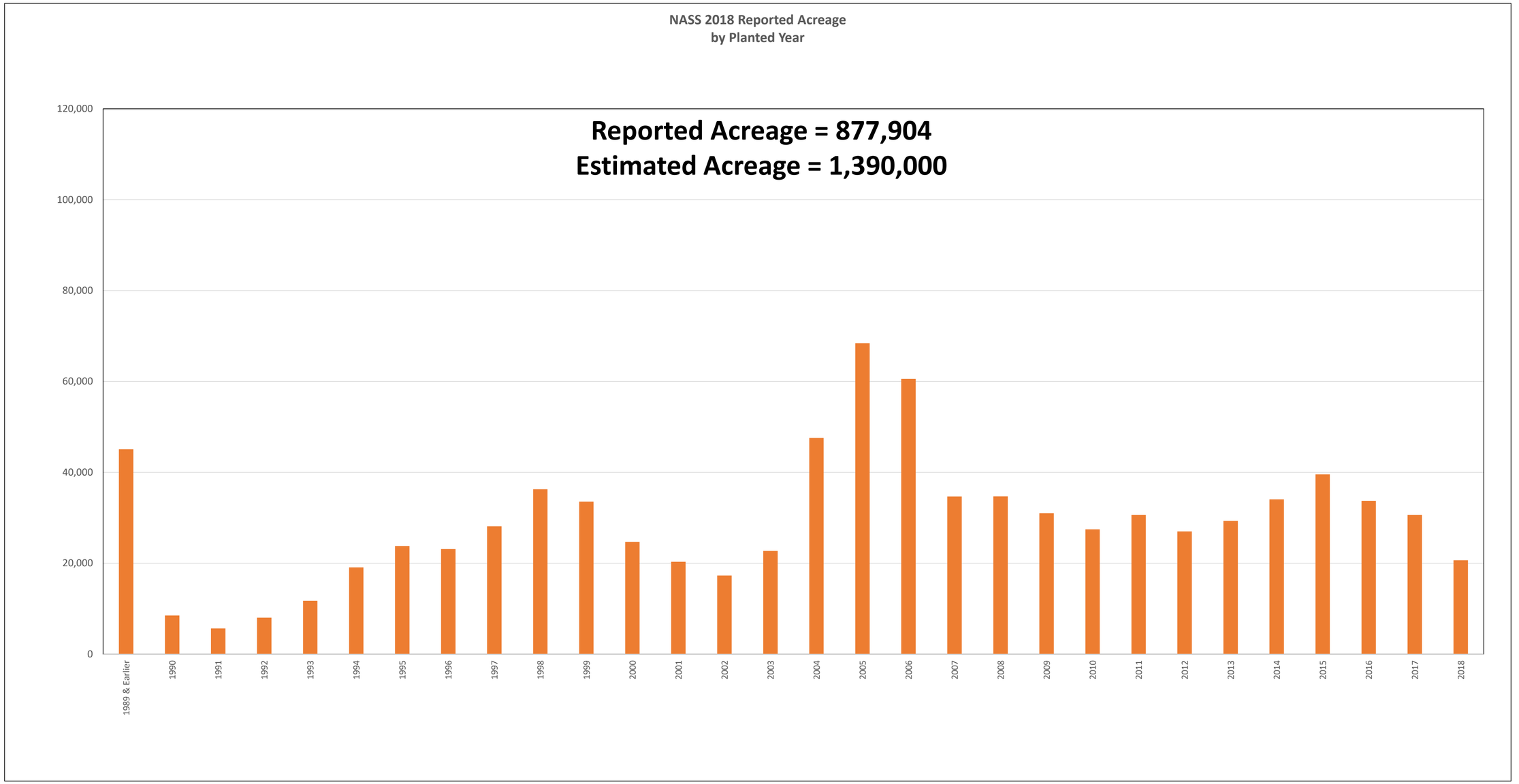
Historic Yields vs Crop Receipts



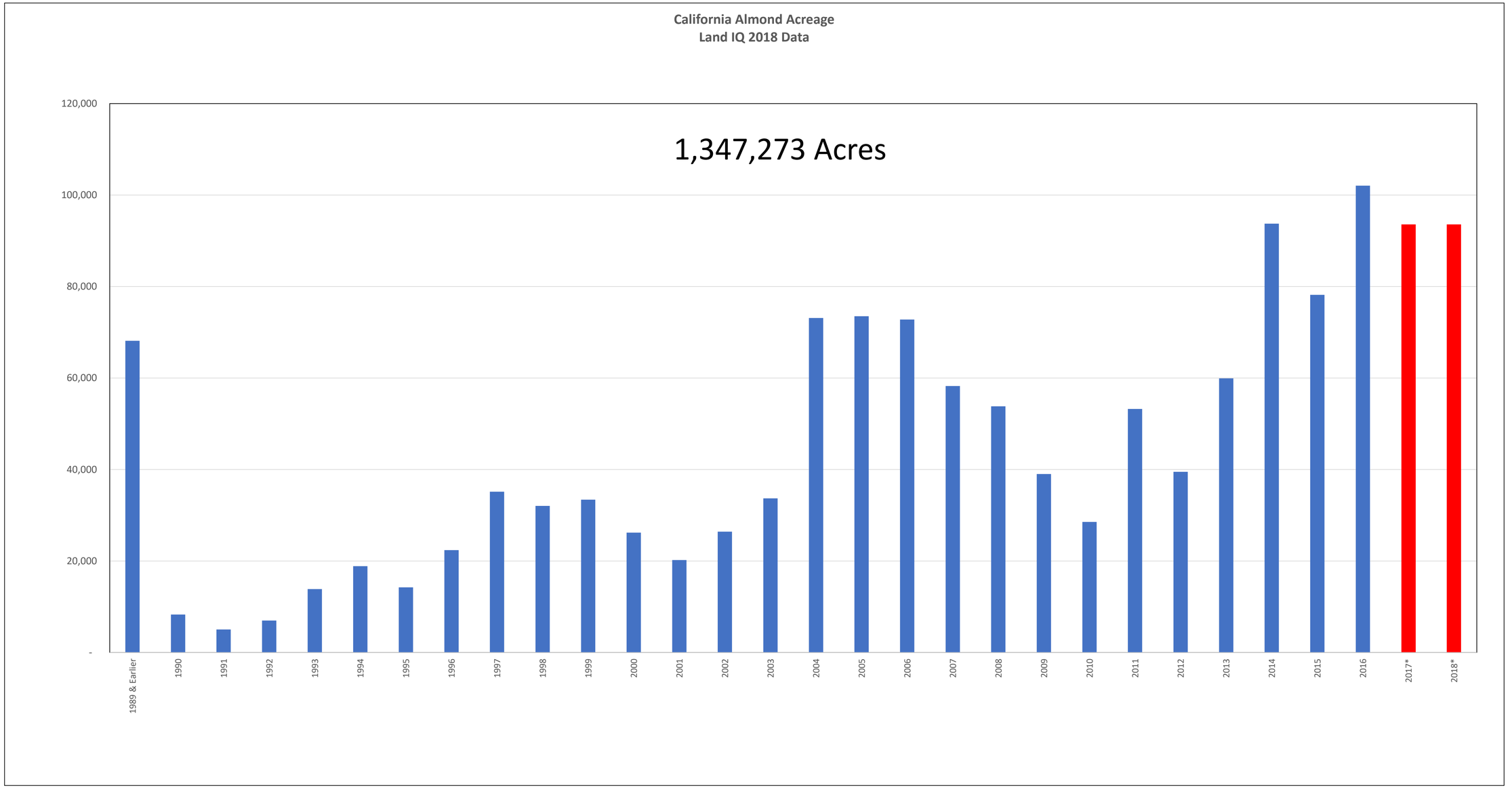
Crop Variables

- 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

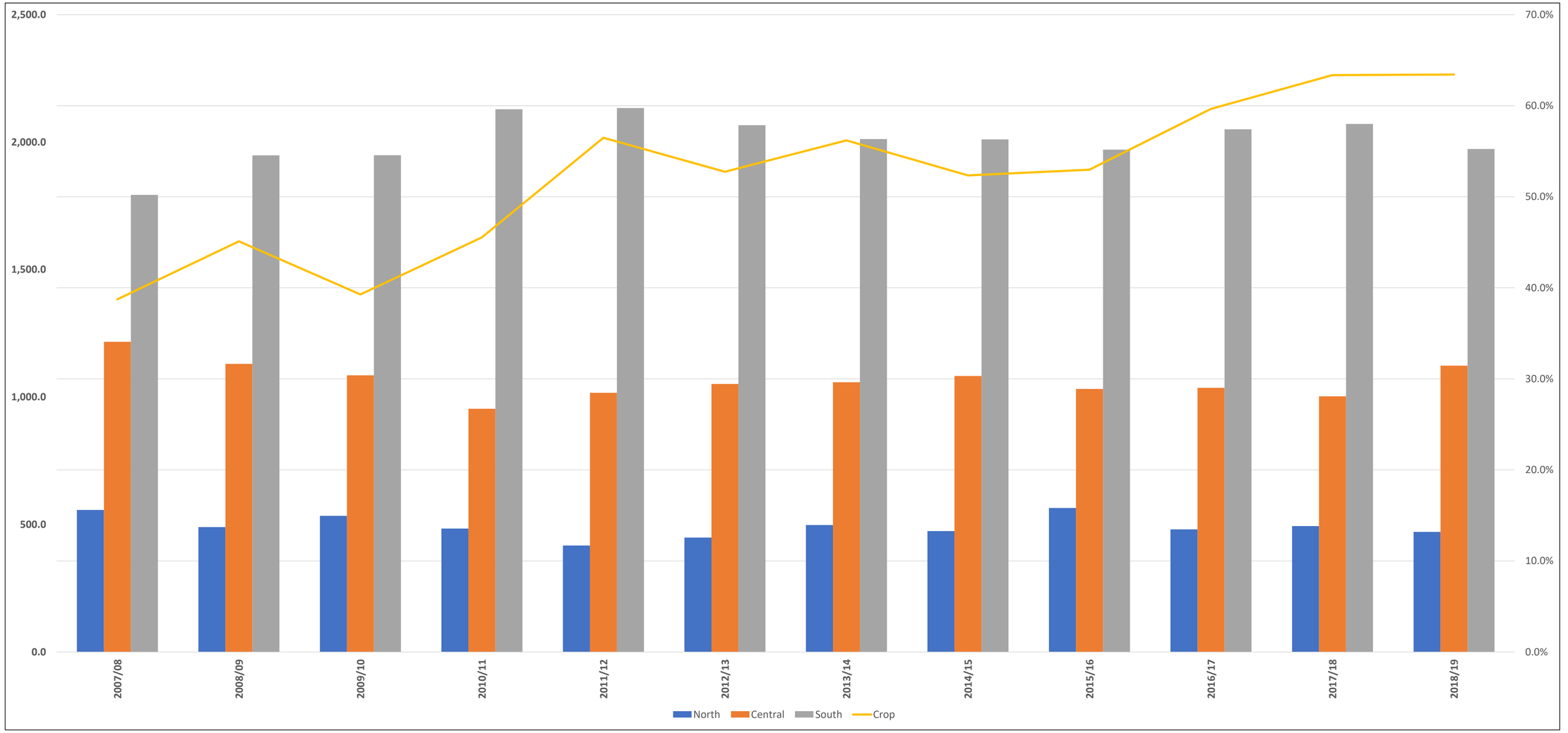
California Almond Acreage



California Almond Acreage



Crop Share by Region



Crop	**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**
NASS Yield/Acre	**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

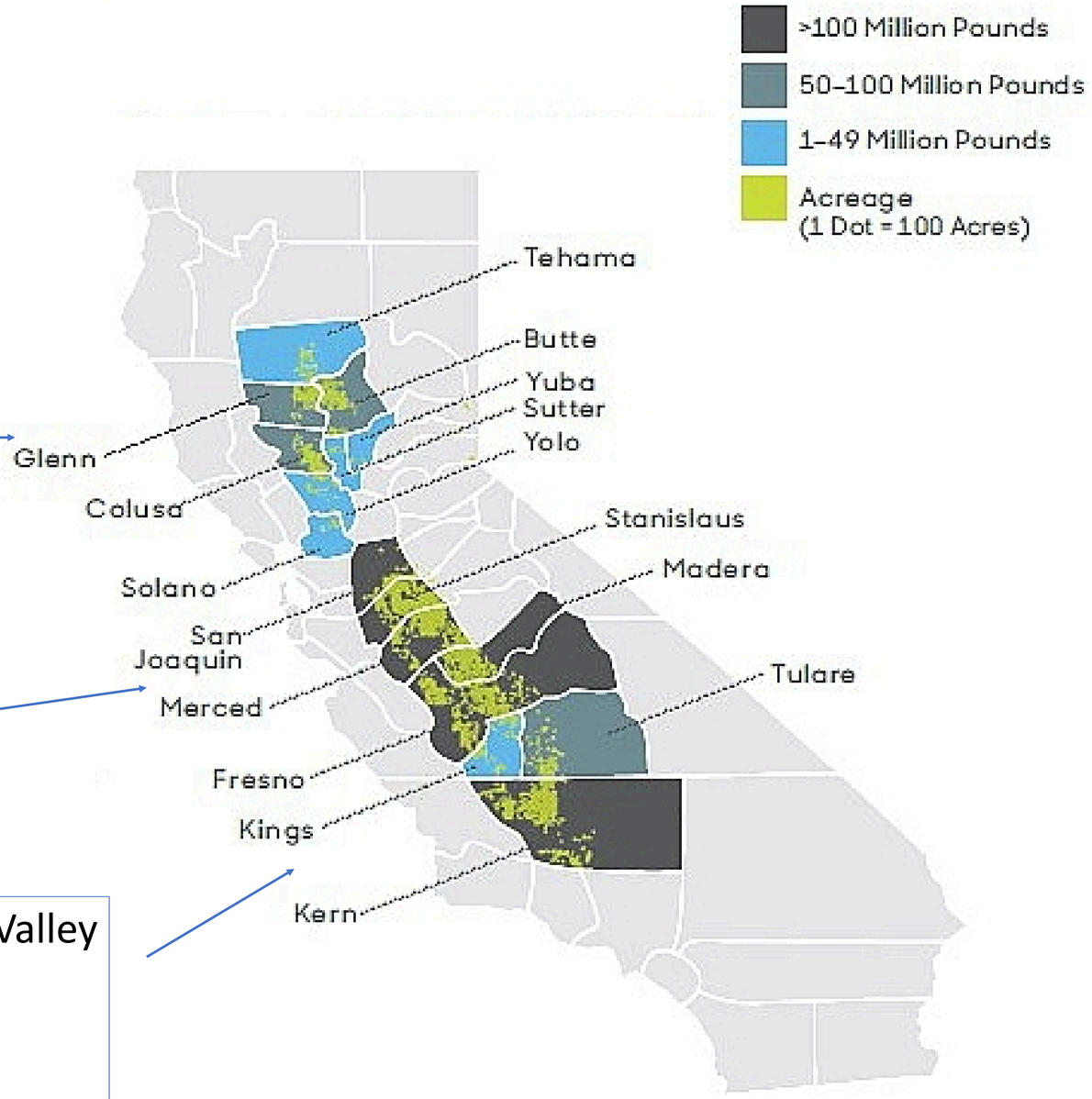
76.4% of Average

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

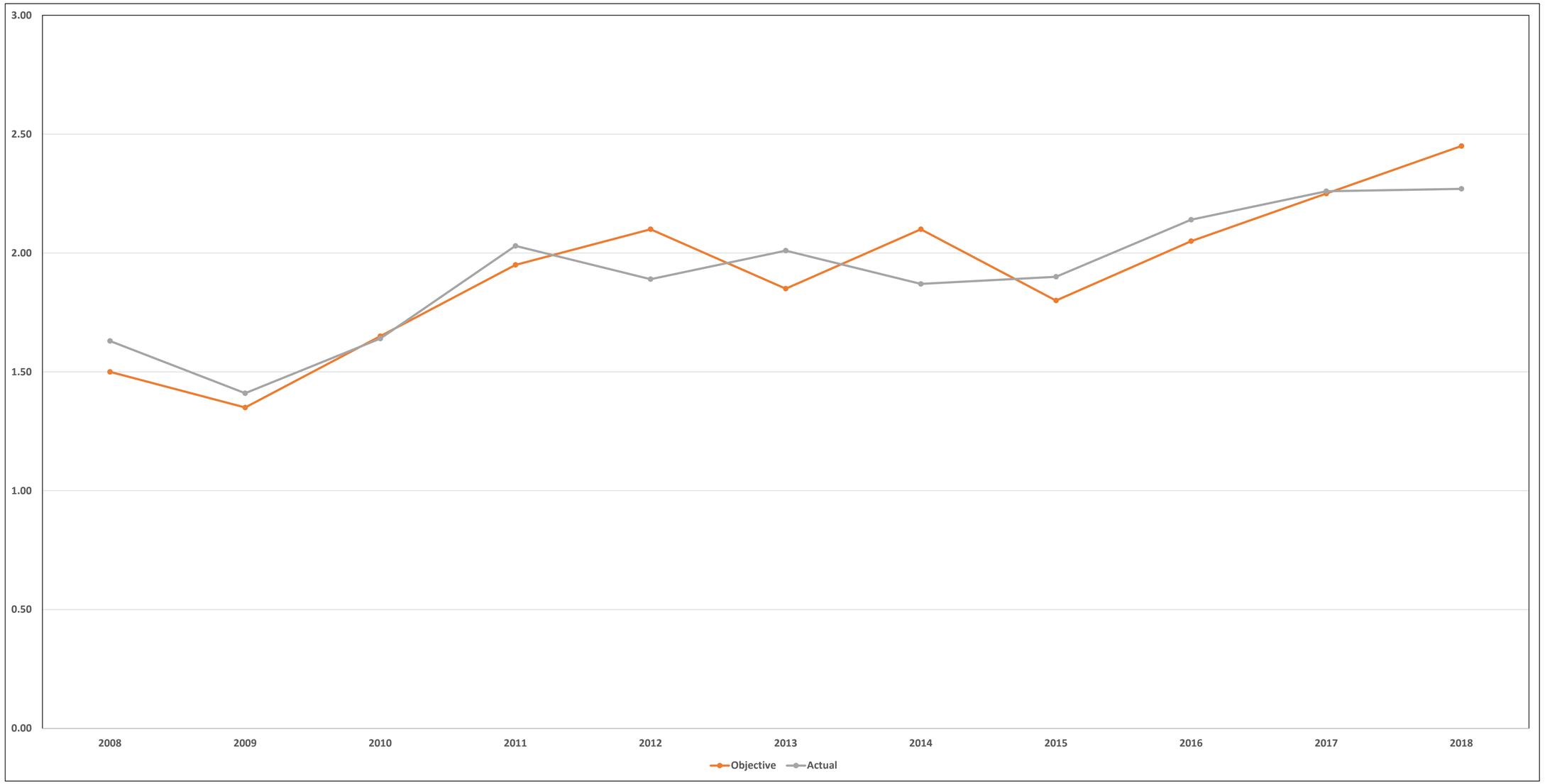
21.0% → 2.291 B → -109.0 M

2.400 B → 22.0%

23.0% → 2.509 B → +109.0 M

- Stress
  - Drought
  - High Temperatures
- Other Unknown Environmental Factors

Variation From Actual

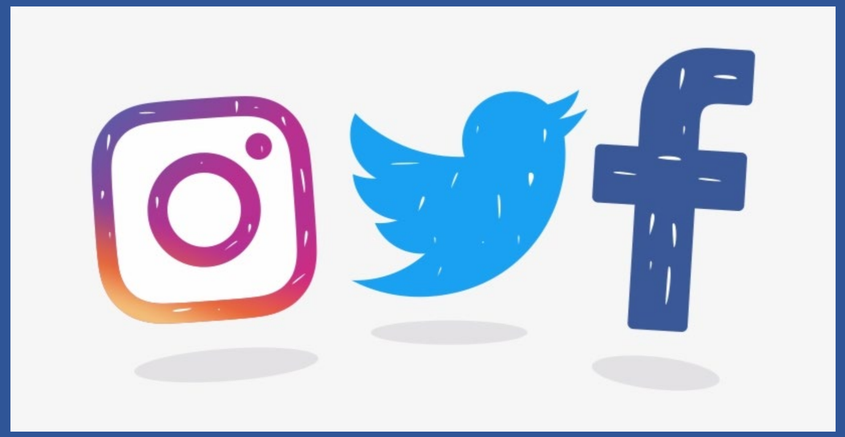


Almond Crop Forecasting Considerations and Repercussions

Almond Production Estimates: Nuts and Bolts of Different Models

california almonds®
Almond Board of California

Join the Conversation!



Use #AlmondConf to share highlights from The Almond Conference