



*the Almond*  
**CONFERENCE**  
2019

# Almond Production Estimates: Nuts and Bolts of Different Models



california  
**almonds**<sup>®</sup>  
Almond Board of California



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# **Almond Acreage, Yield, Production Estimates**

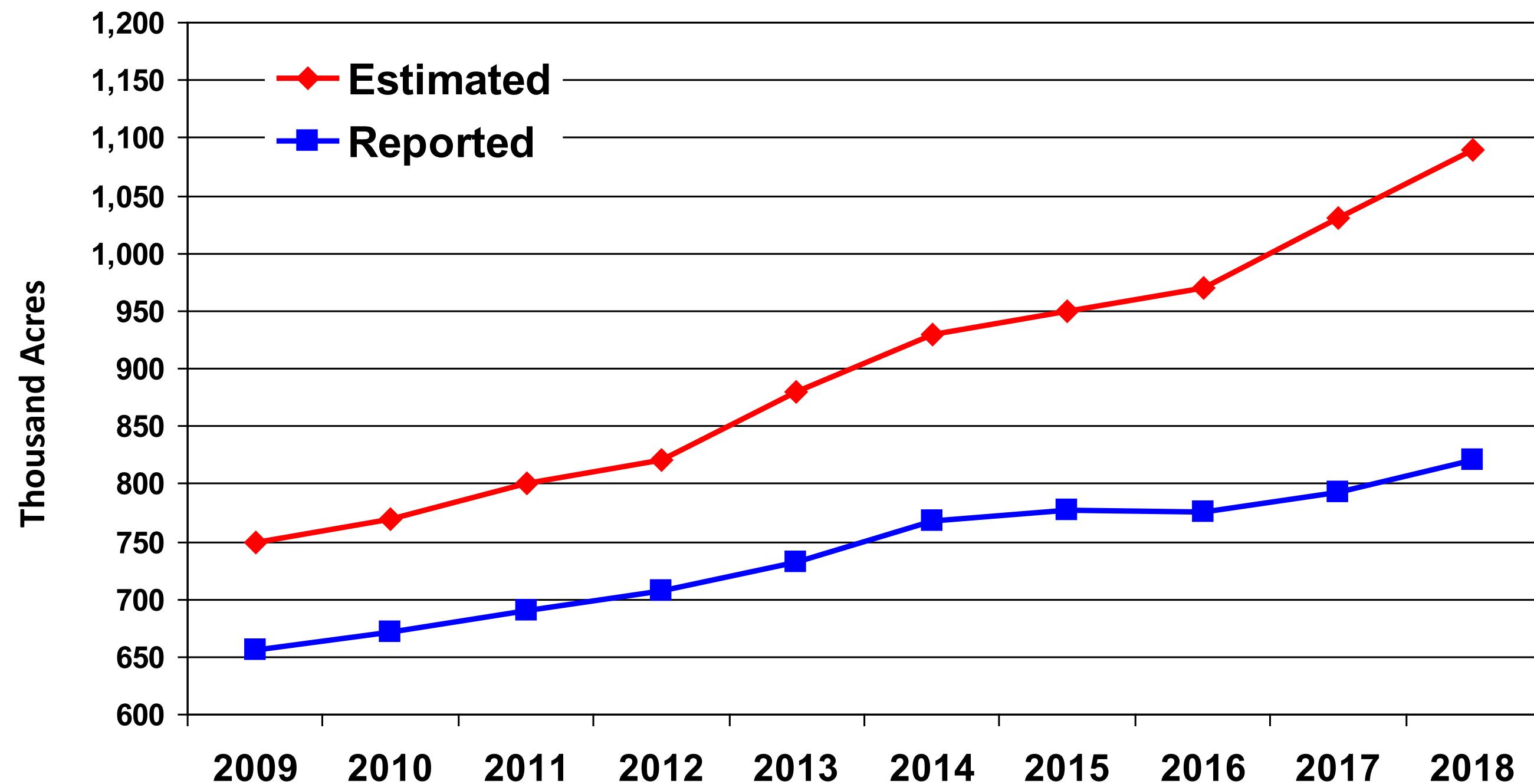
Gary R. Keough, Director  
USDA NASS Pacific Regional Office

December 12, 2019

- Annual Almond Acreage Survey
  - Collect block level data from known 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.



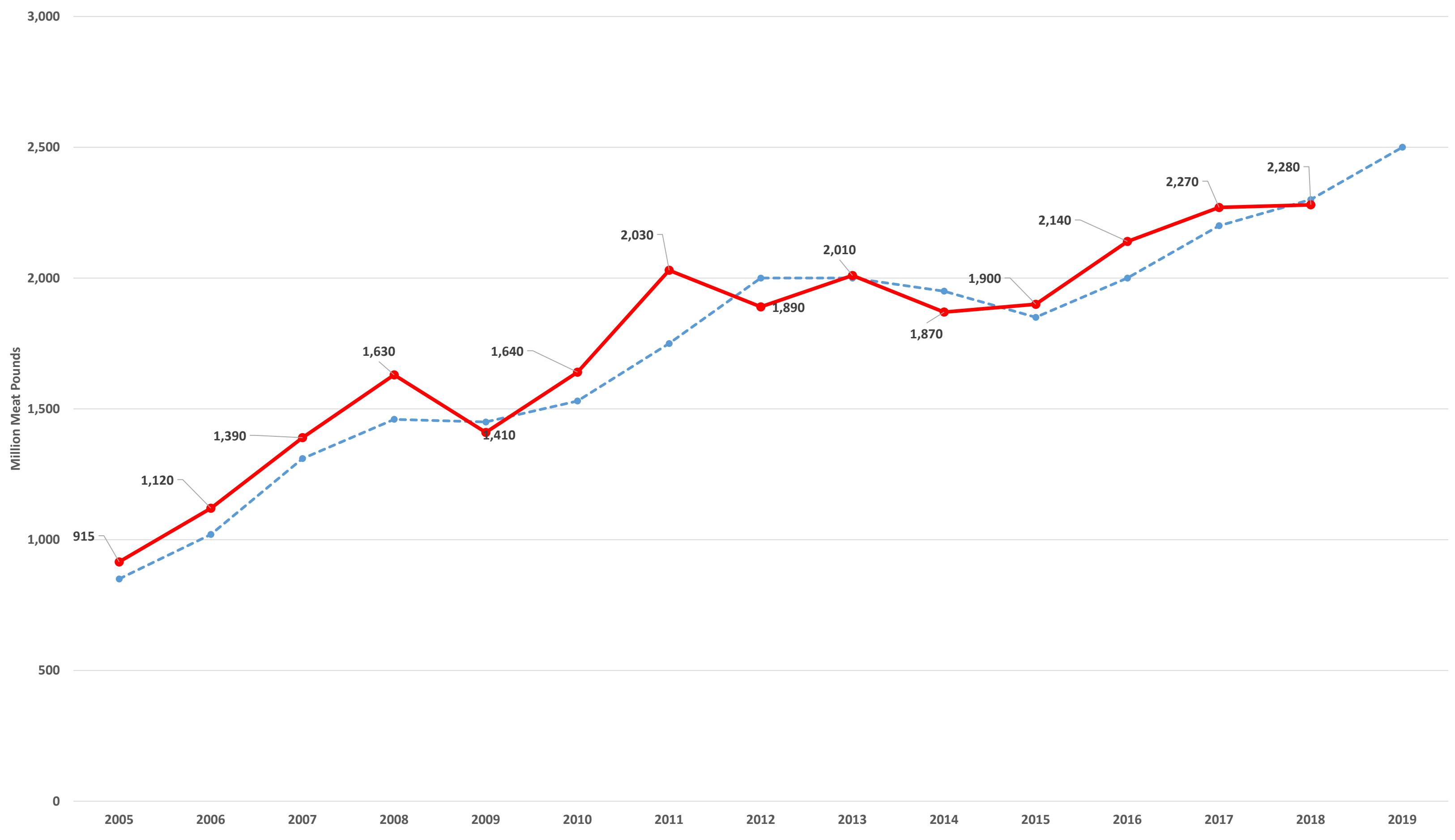
# Why the difference between estimated and reported?

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- 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.

- 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

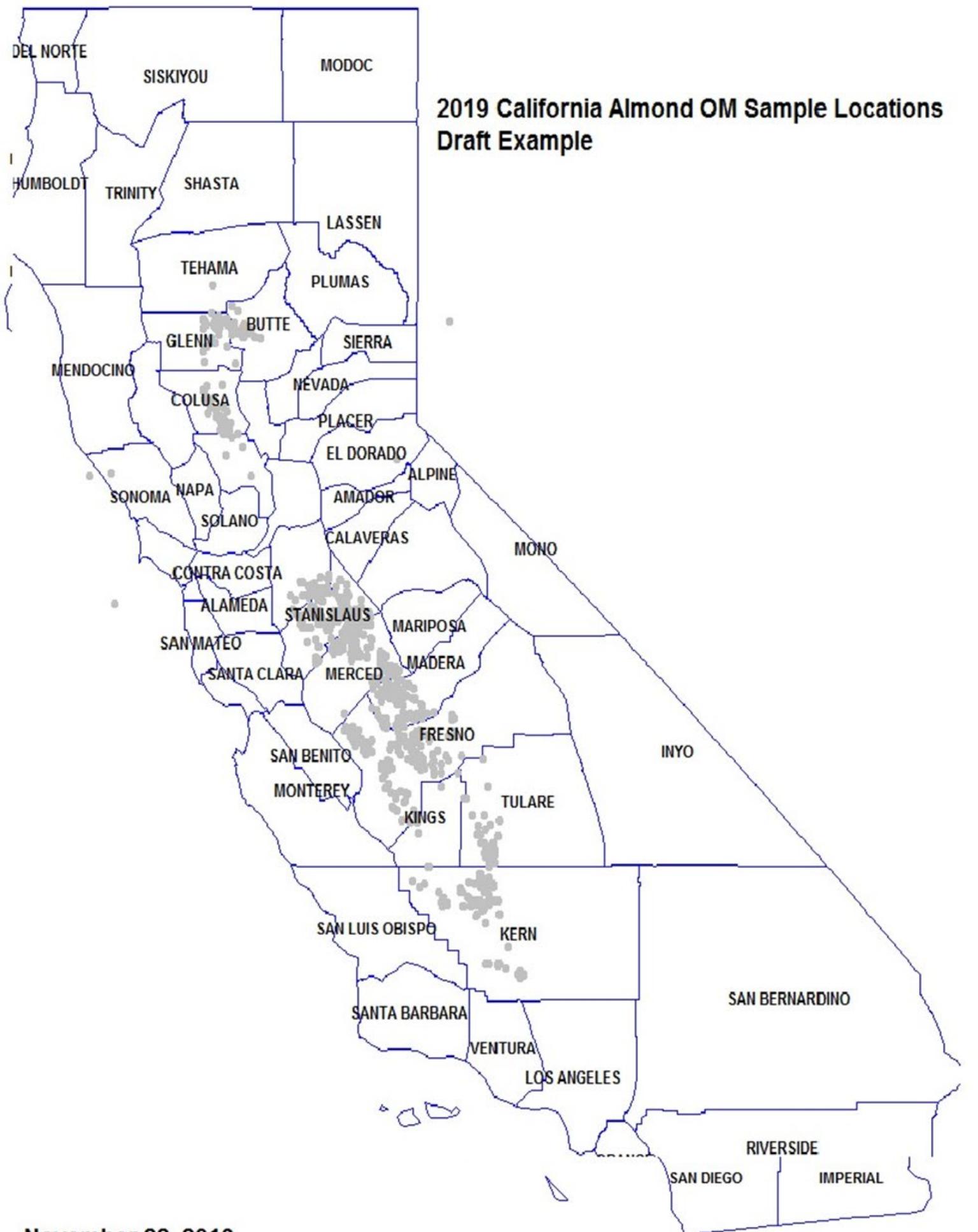
### Almond Subjective Forecast vs Final



• Subjective    ● Final

- 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

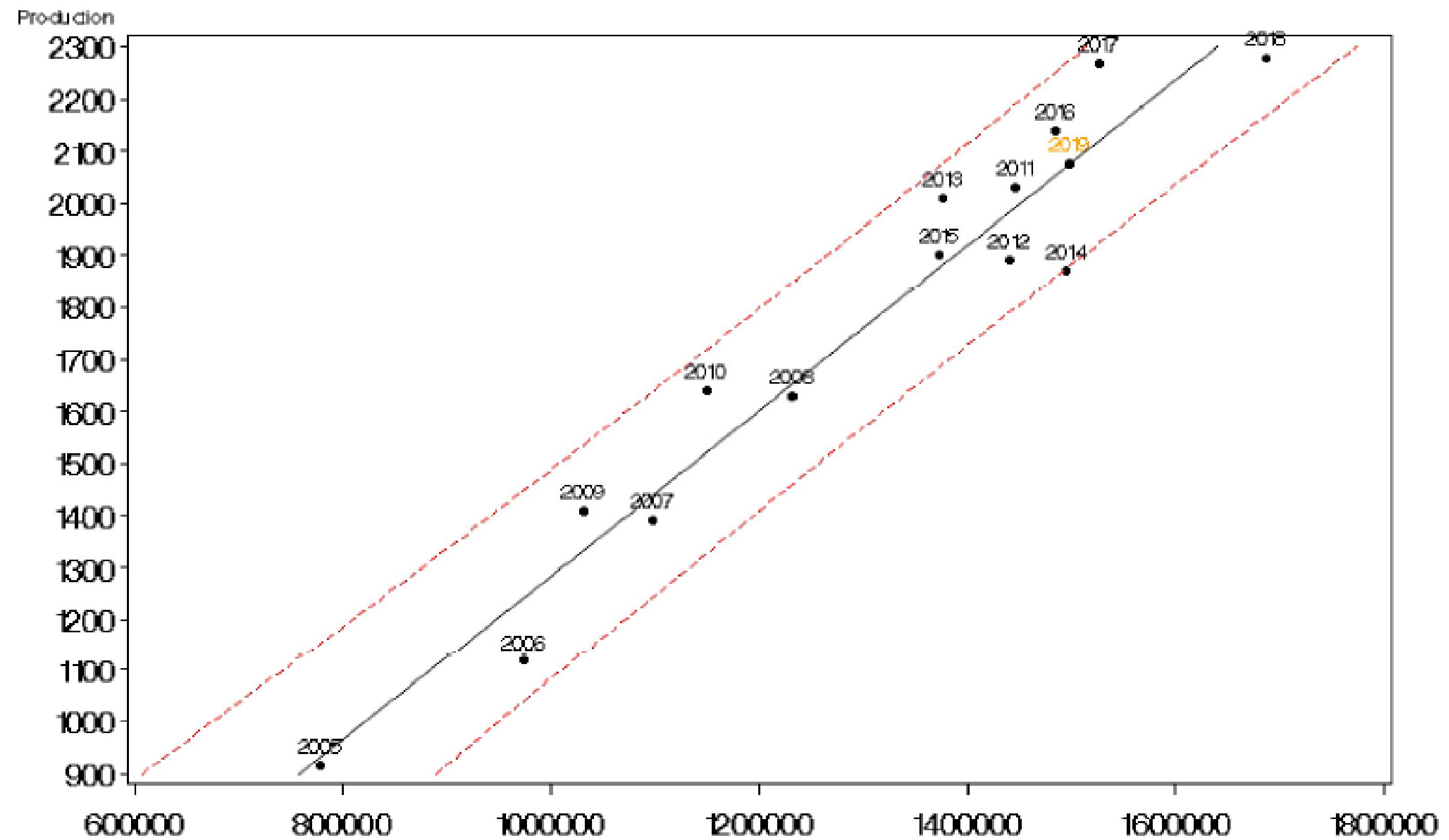


- Objective Measurement Forecast
  - 2 trees in each orchard
  - Select count unit
    - Random limb with a cross sectional area greater than 0.5 square inch
  - Count nuts in the defined count unit
  - Measure weight, width, thickness and length of sample of nuts harvested from the count unit

- 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=Acres x Trees per Acre x Nuts per Tree x Percent Sound
    - b is either:
      - weight
      - cross suture
      - thickness
      - length
      - cross suture + thickness

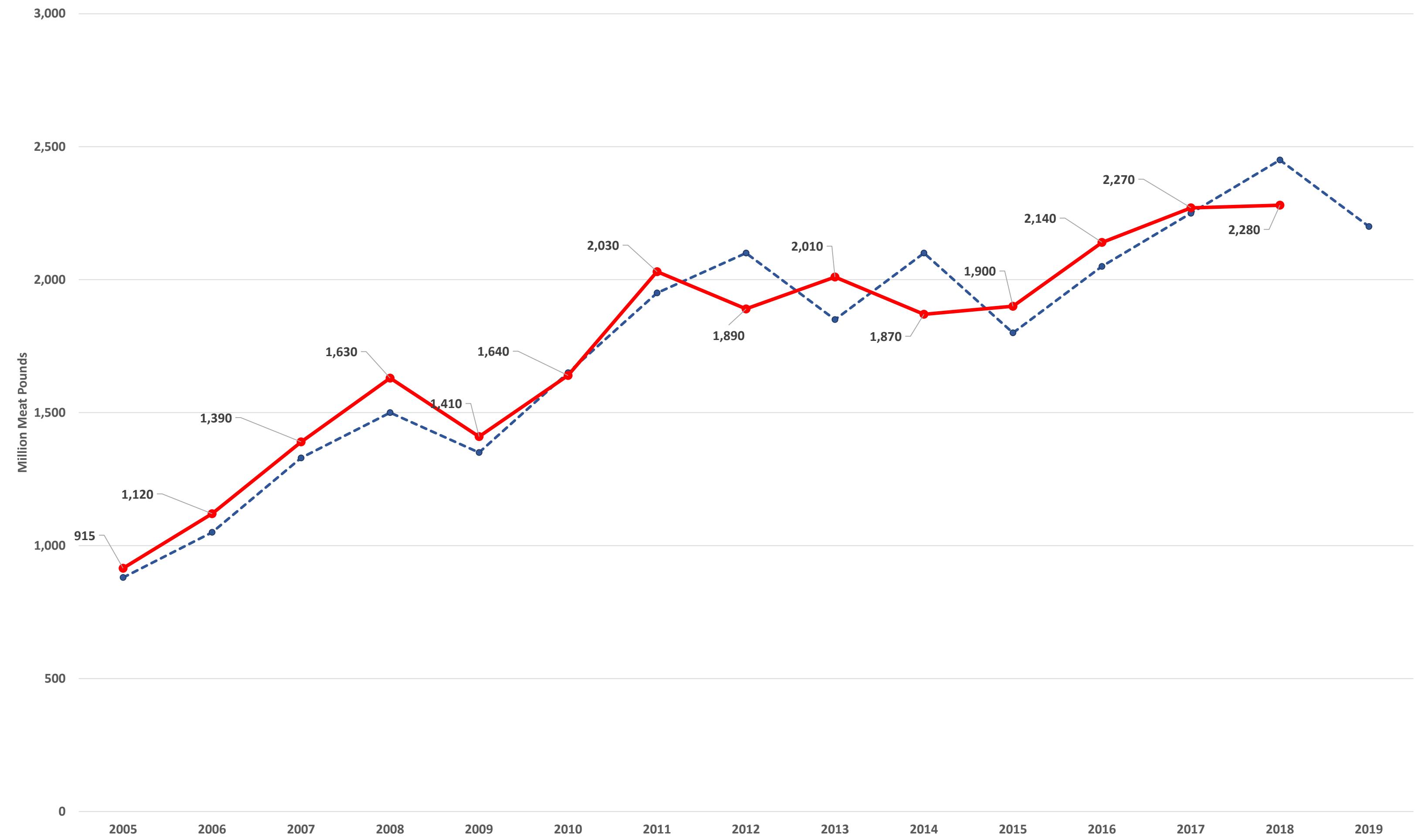
# Production Forecasts

2019 Almond OM



- 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



# Importance of Reporting/Cooperation

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- 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

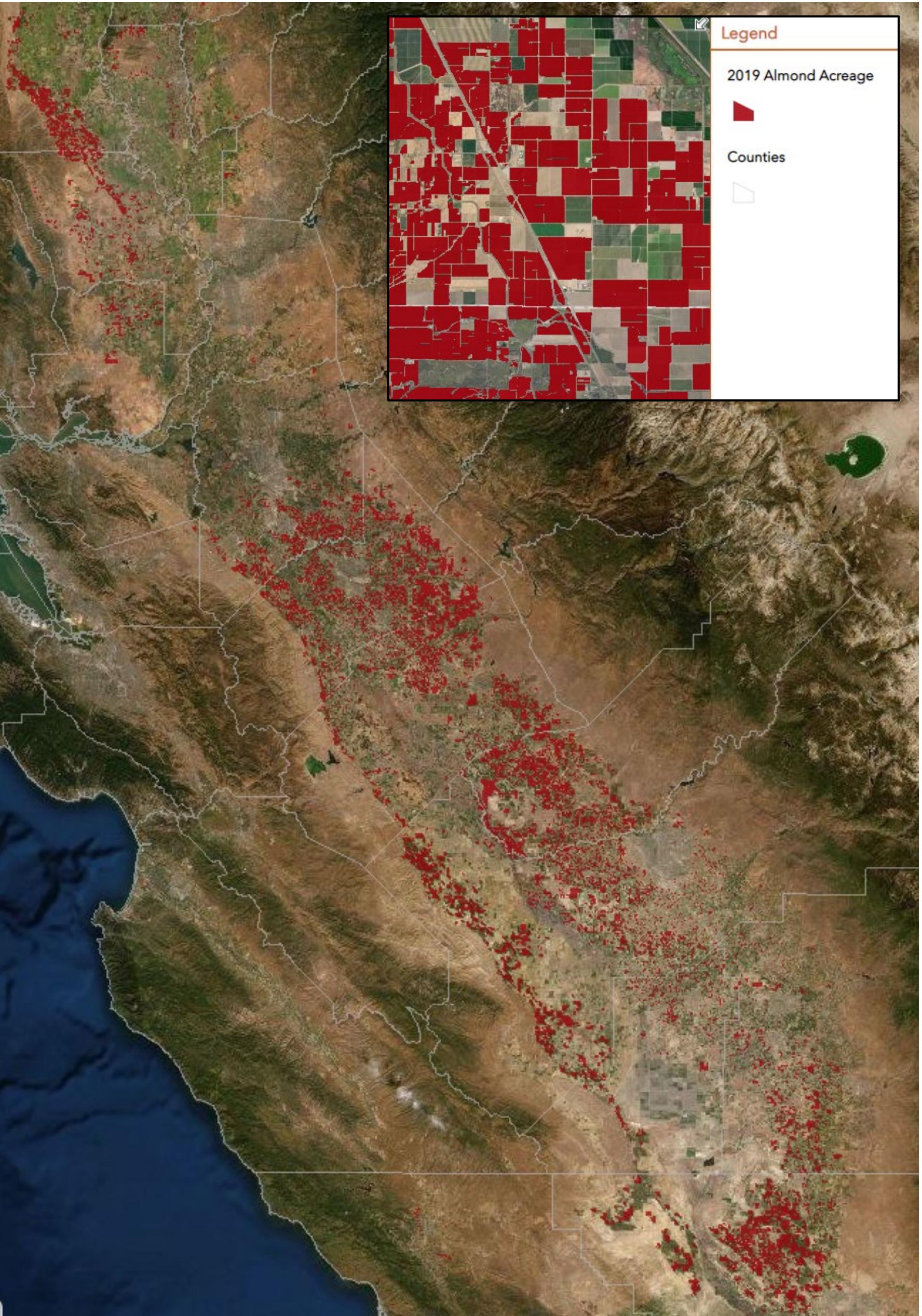
Joel Kimmelshue, PhD, CPSS



# 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

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

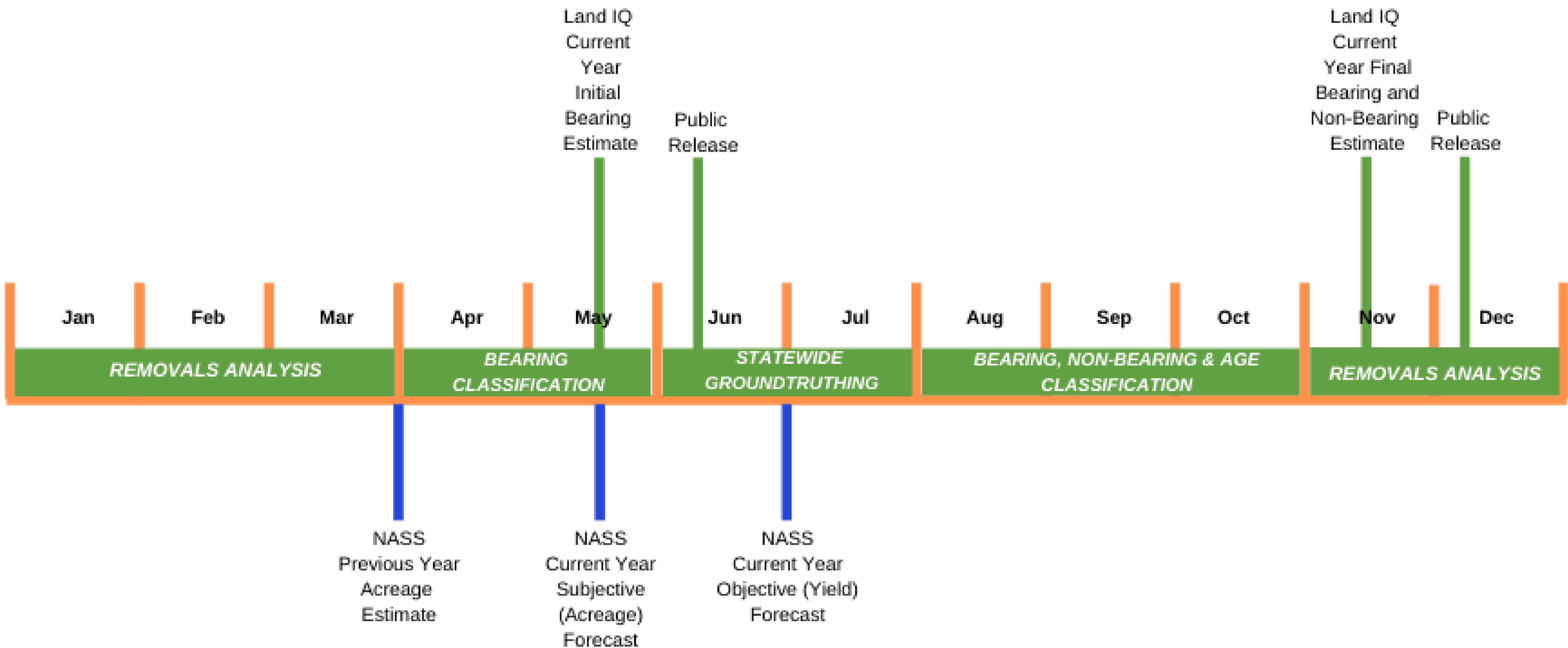


# Almond Mapping

- 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

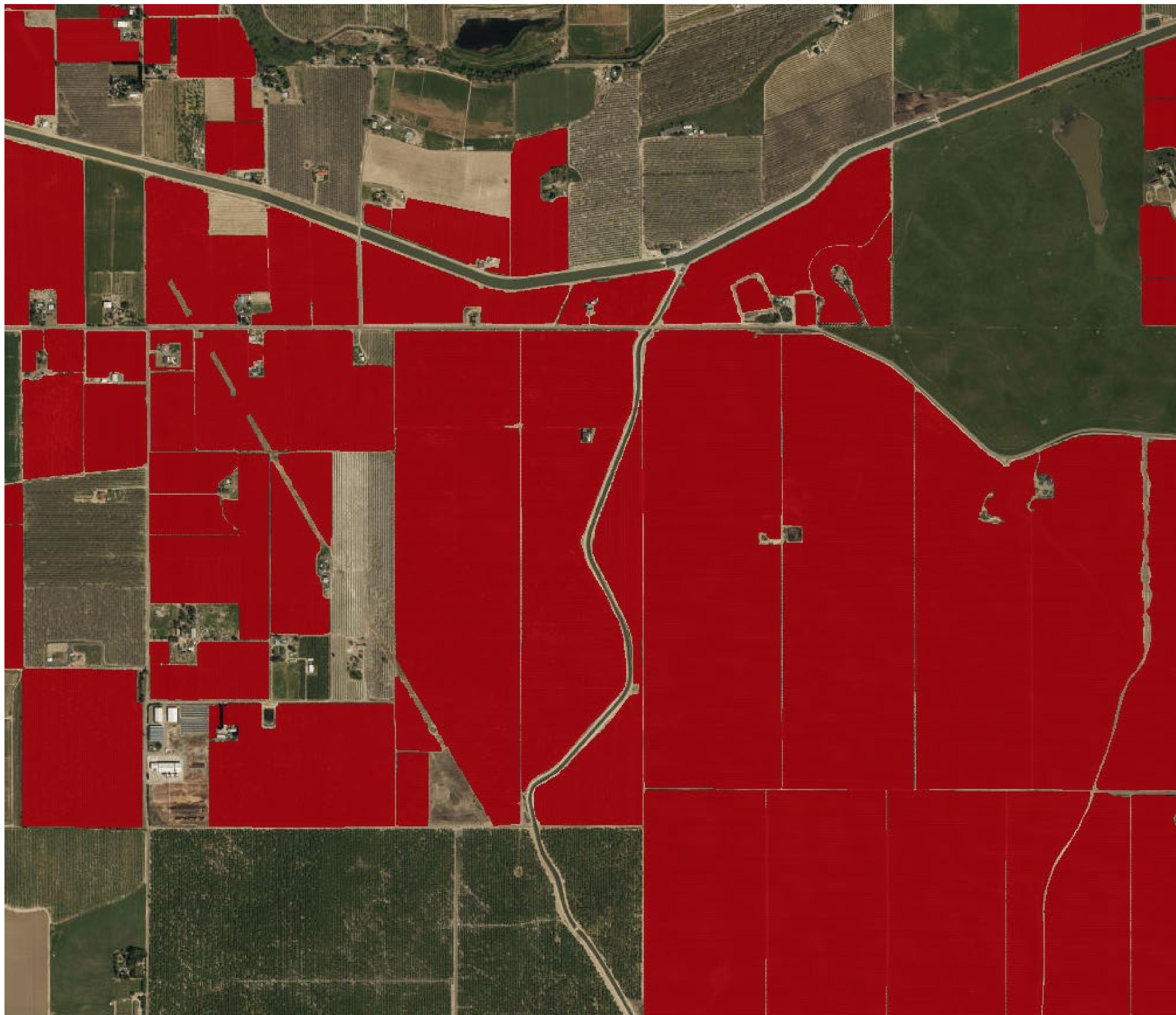
# Almond Yield Forecasting

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



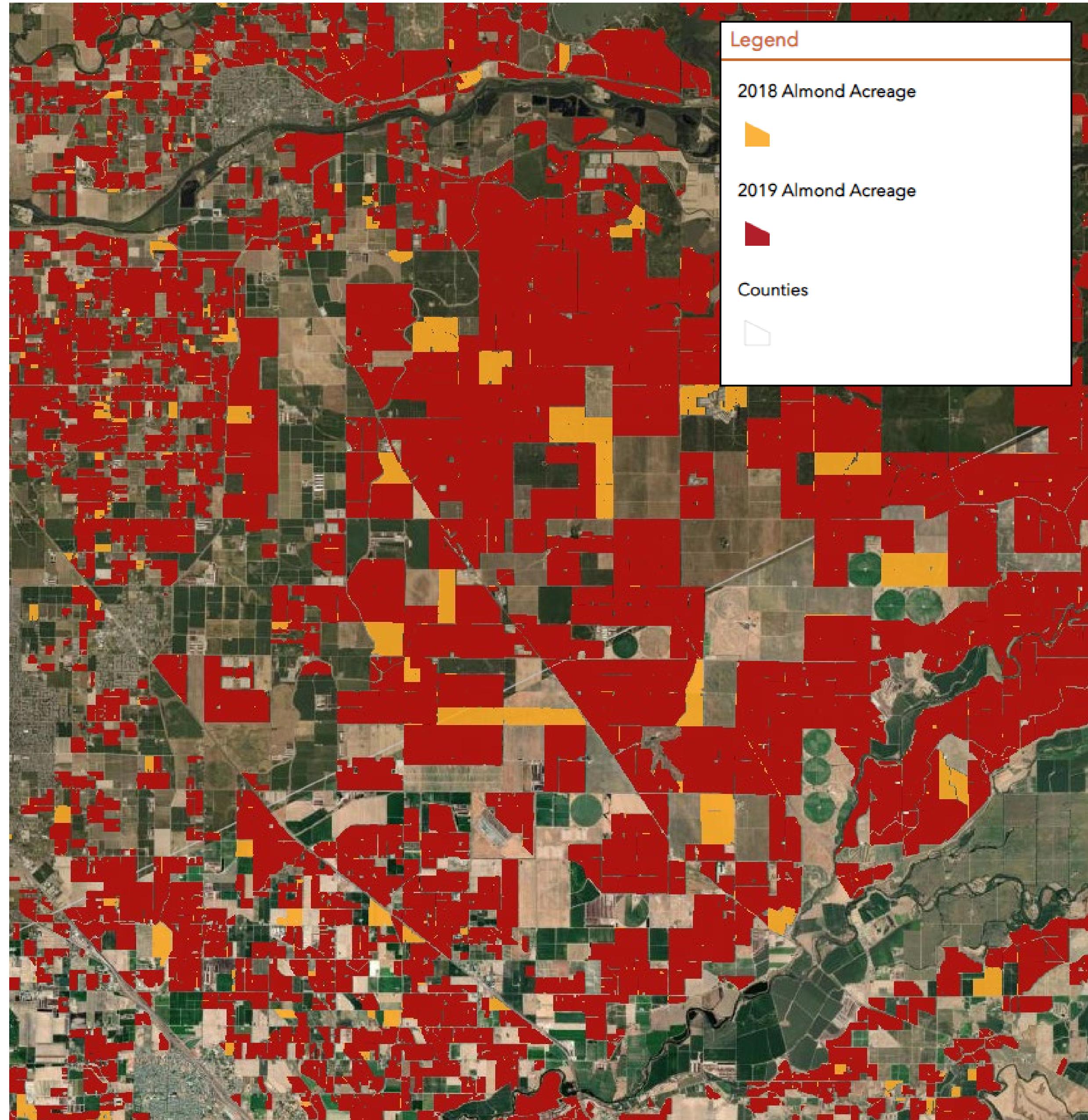
# Almond Orchard Acreage

- 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  $\pm$  6 feet at a 95% confidence interval



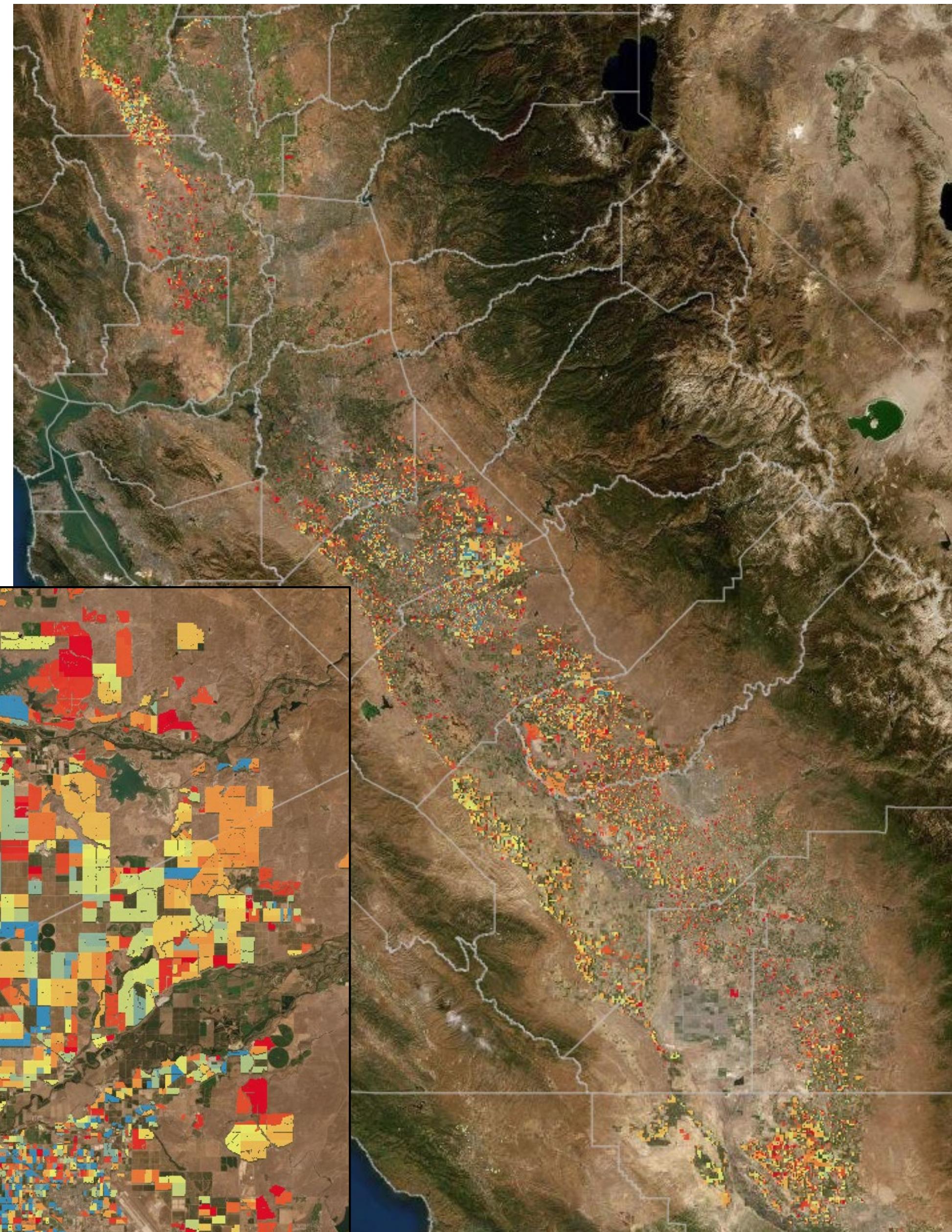
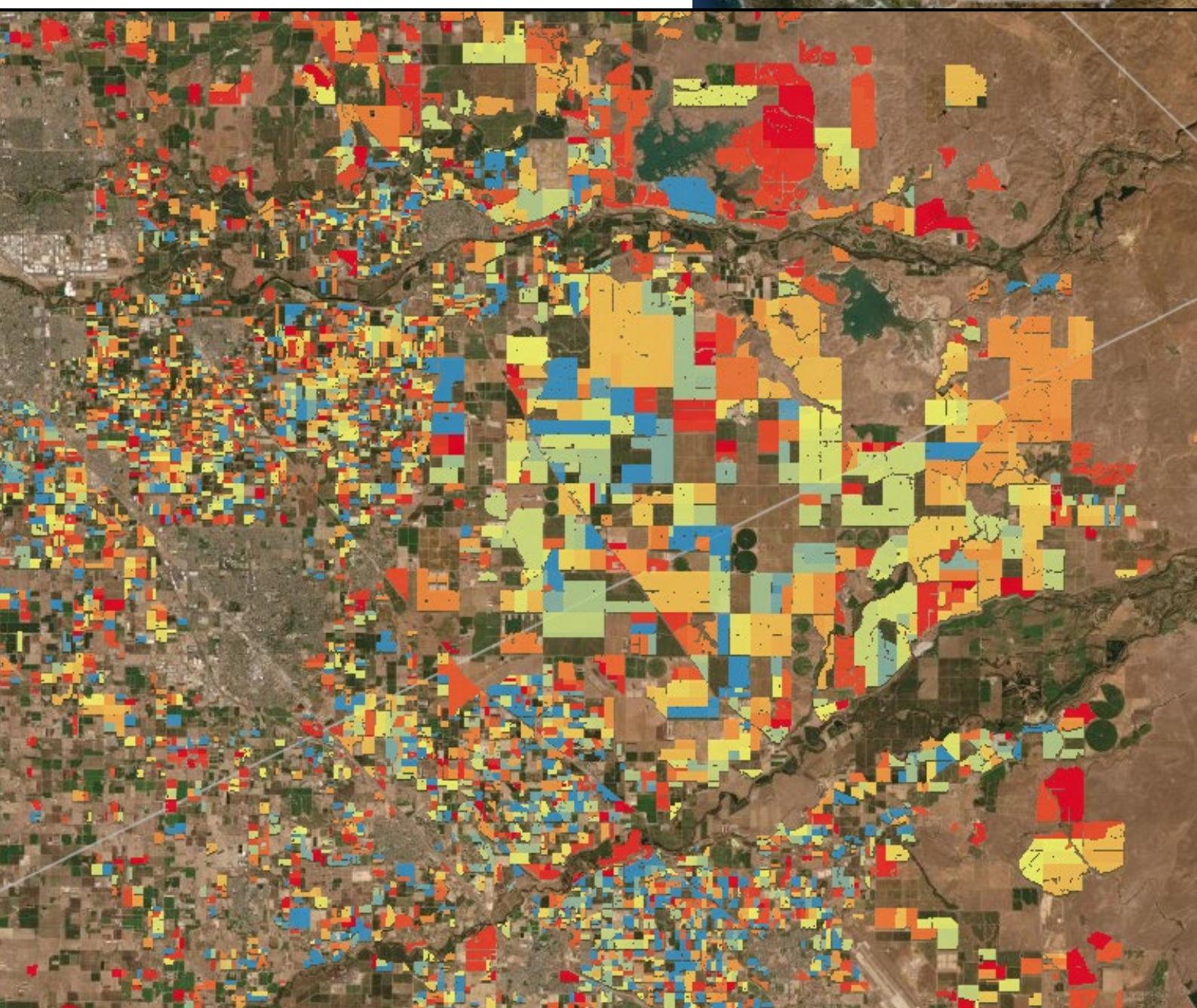
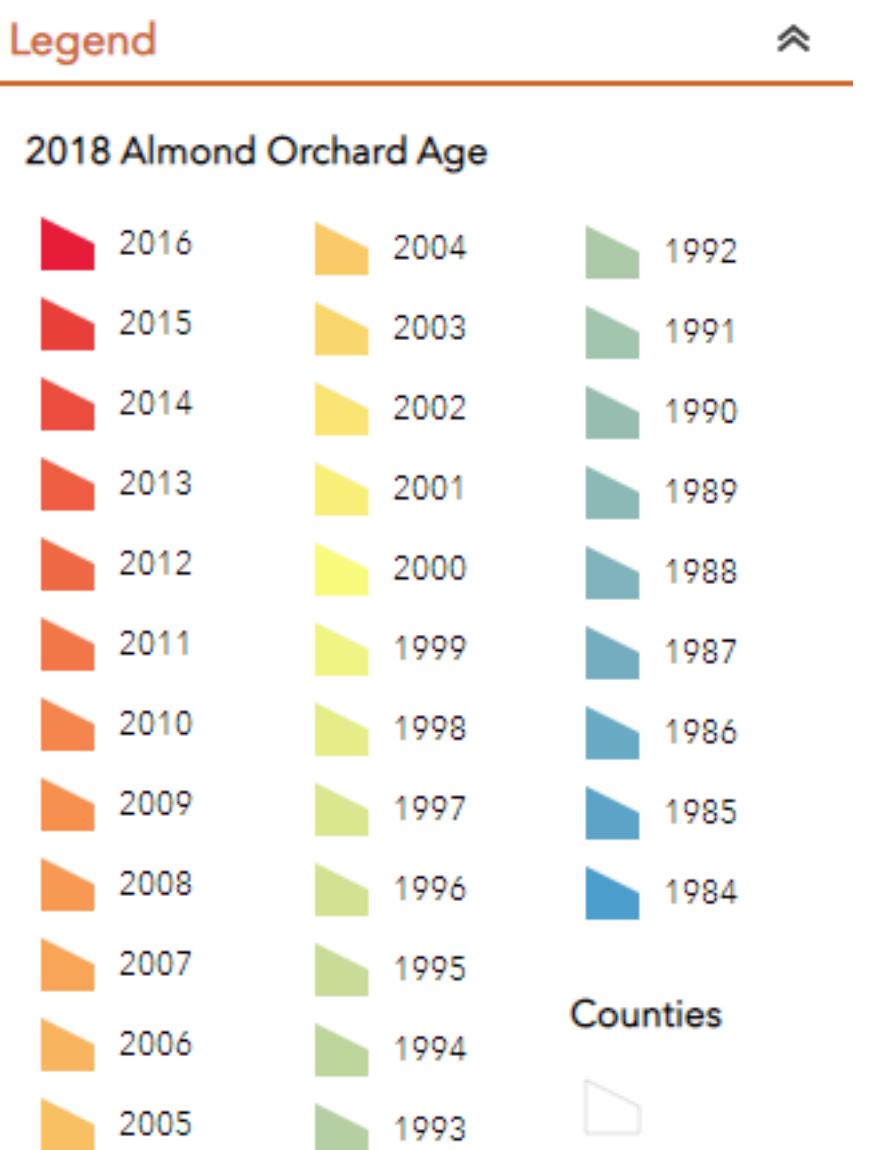
# Almond Orchard Location

- 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%**



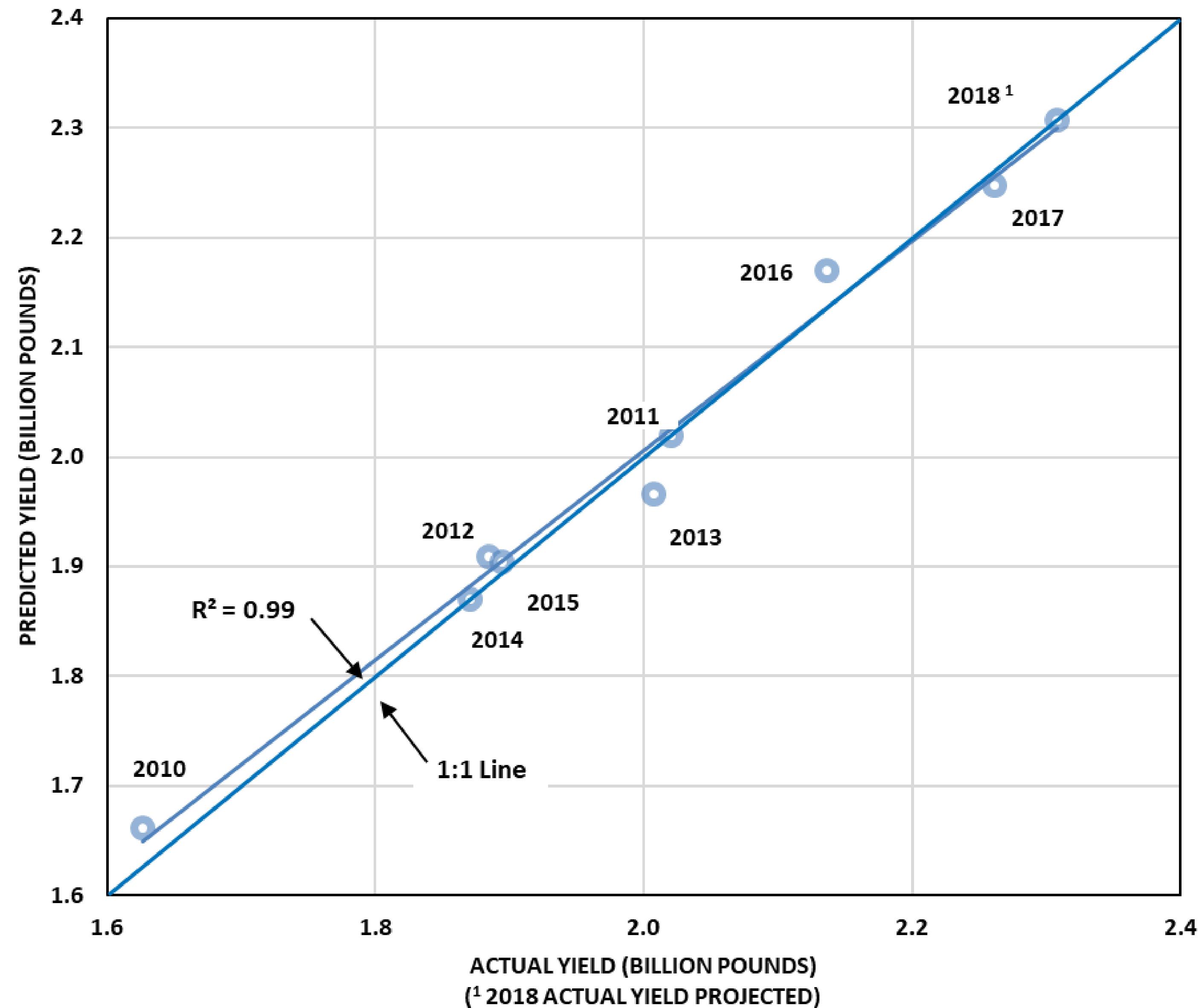
# Almond Orchard Age

- 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

**MODIFICATIONS**

**STEPS 1, 2 AND 3 PLANTINGS, REMOVALS AND PRICE:**

**STEP 1 - ORCHARDS PLANTED:**  
Please insert estimate for new orchards planted (acres) in:

2019 100000  
Estimated range: 80,000 to 110,000 acres

**STEP 2 - ORCHARDS REMOVED:**  
Please insert estimate for orchards removed (acres) in:

2019 0  
2019 removal acreage is included, recommend leaving at 0

2020 50000  
Estimated range: 40,000 to 60,000 acres

2021 60000  
Estimated range: 40,000 to 70,000 acres

2022 60000  
Estimated range: 50,000 to 80,000 acres

**STEP 3 - PRICE:**  
Please insert estimate for price (\$/lb) in:

2019 3.00  
Estimated range: \$2.00 to \$4.00

2020 2.50  
Estimated range: \$2.00 to \$4.00

2021 3.50  
Estimated range: \$2.00 to \$4.00

2022 2.00  
Estimated range: \$2.00 to \$4.00

**STEP 4 ENVIRONMENTAL IMPACTS:**

Please adjust for potential environmental impacts:

- Statewide adjustments will automatically populate all regions and counties for that same year.
- Regional adjustments will re-populate all counties within that region for that same year.
- Counties may be adjusted individually.
- Tool recalculates after clicking on the "Save and Calculate" button.
- Historic 8-year range: -11% to +12%.

**STATEWIDE**

2019 typical 2020 typical 2021 typical 2022 typical

**VIEW REGIONS:**

**Sacramento Valley Region** typical typical typical typical

**View Sacramento Valley Counties:**

**Northern San Joaquin Valley Region** typical typical typical typical

**View Northern San Joaquin Valley Counties:**

**Southern San Joaquin Valley Region** typical typical typical typical

**View Southern San Joaquin Valley Counties:**

**Save and Calculate**

# 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*

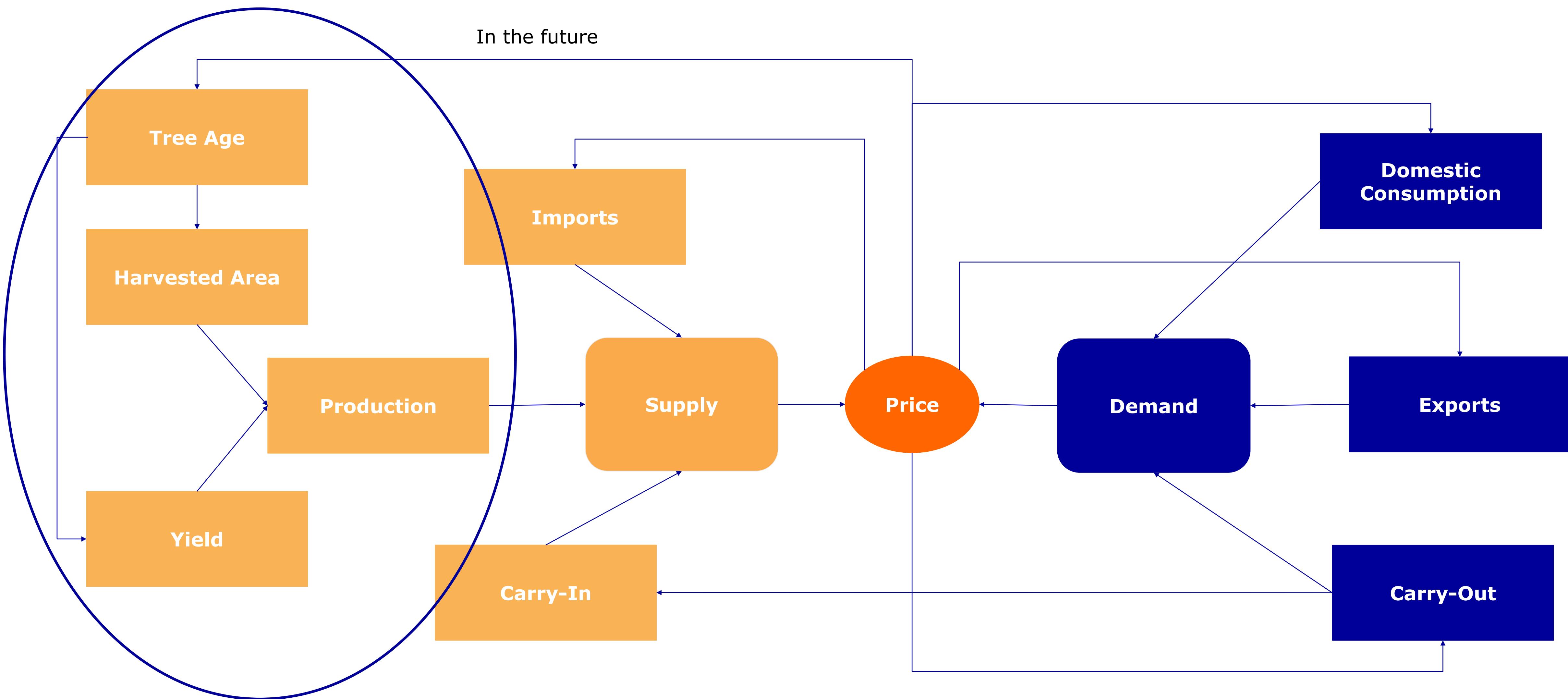
December 10, 2019



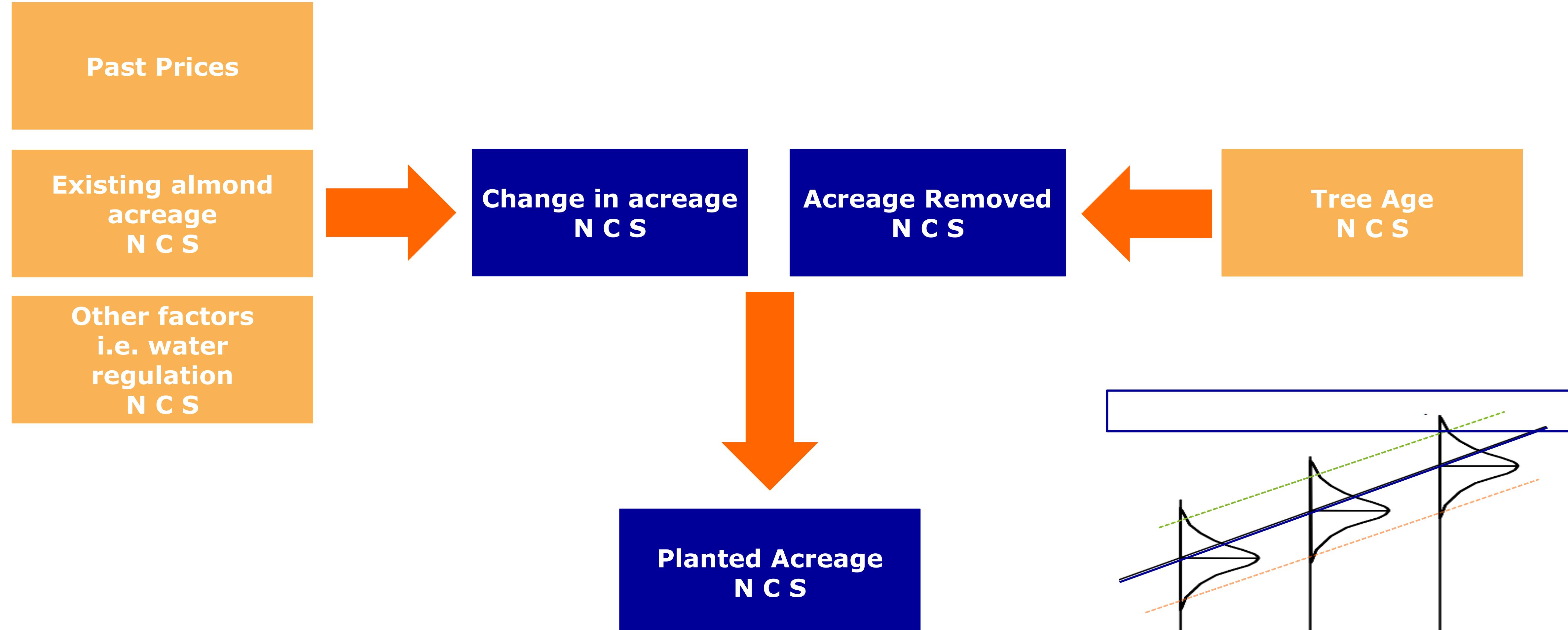
*Roland Fumasi, Ph.D.*  
Senior Analyst  
RaboResearch Food & Agribusiness



# Yield & production are just puzzle pieces



# The foundation: Acres by age & location



2020 2021 2022

# 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

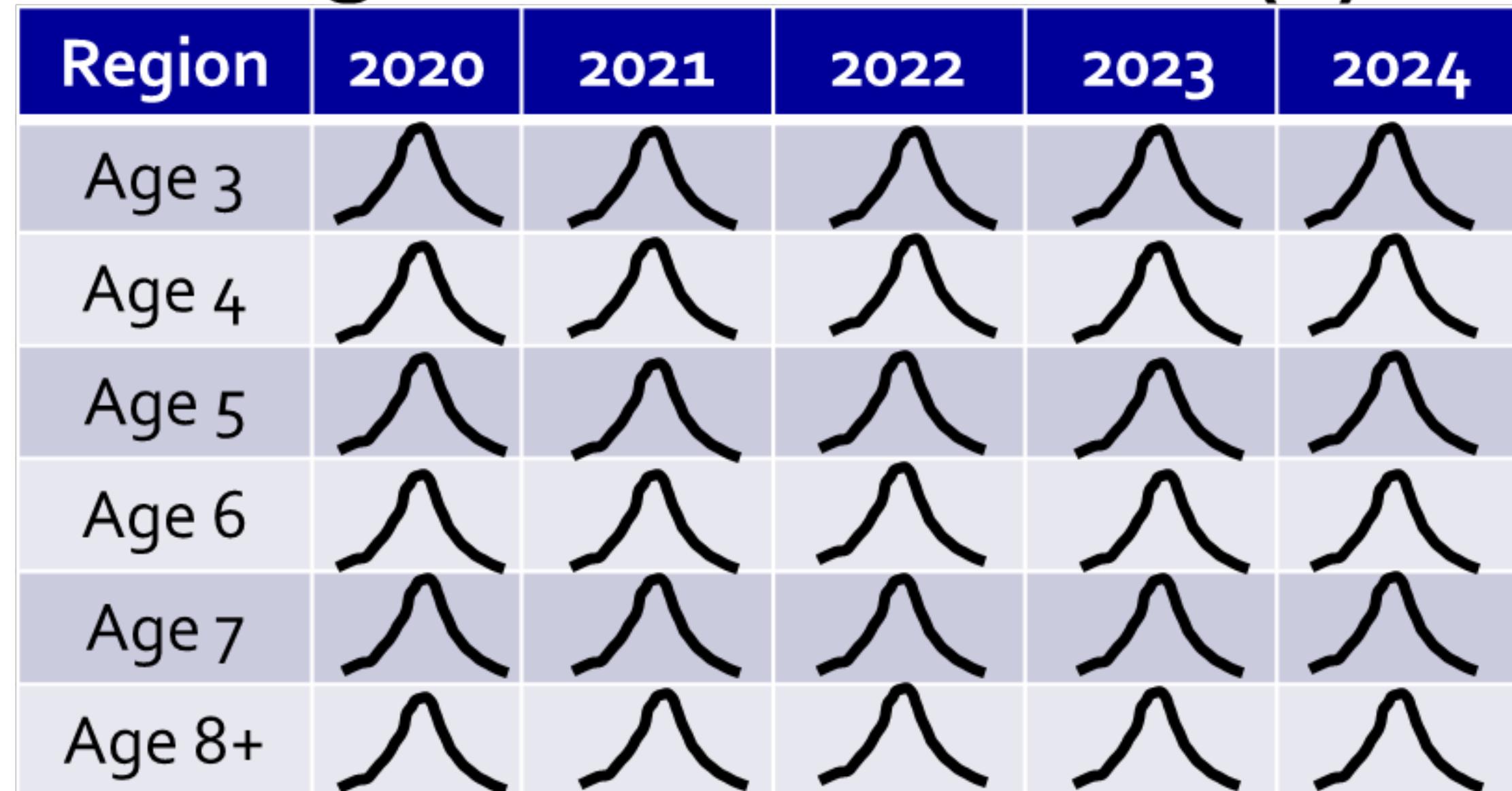
X 6 (tree age) X 5 (years) X 3 (regions)  
= 90 yield distributions



# Risk in estimates at every turn

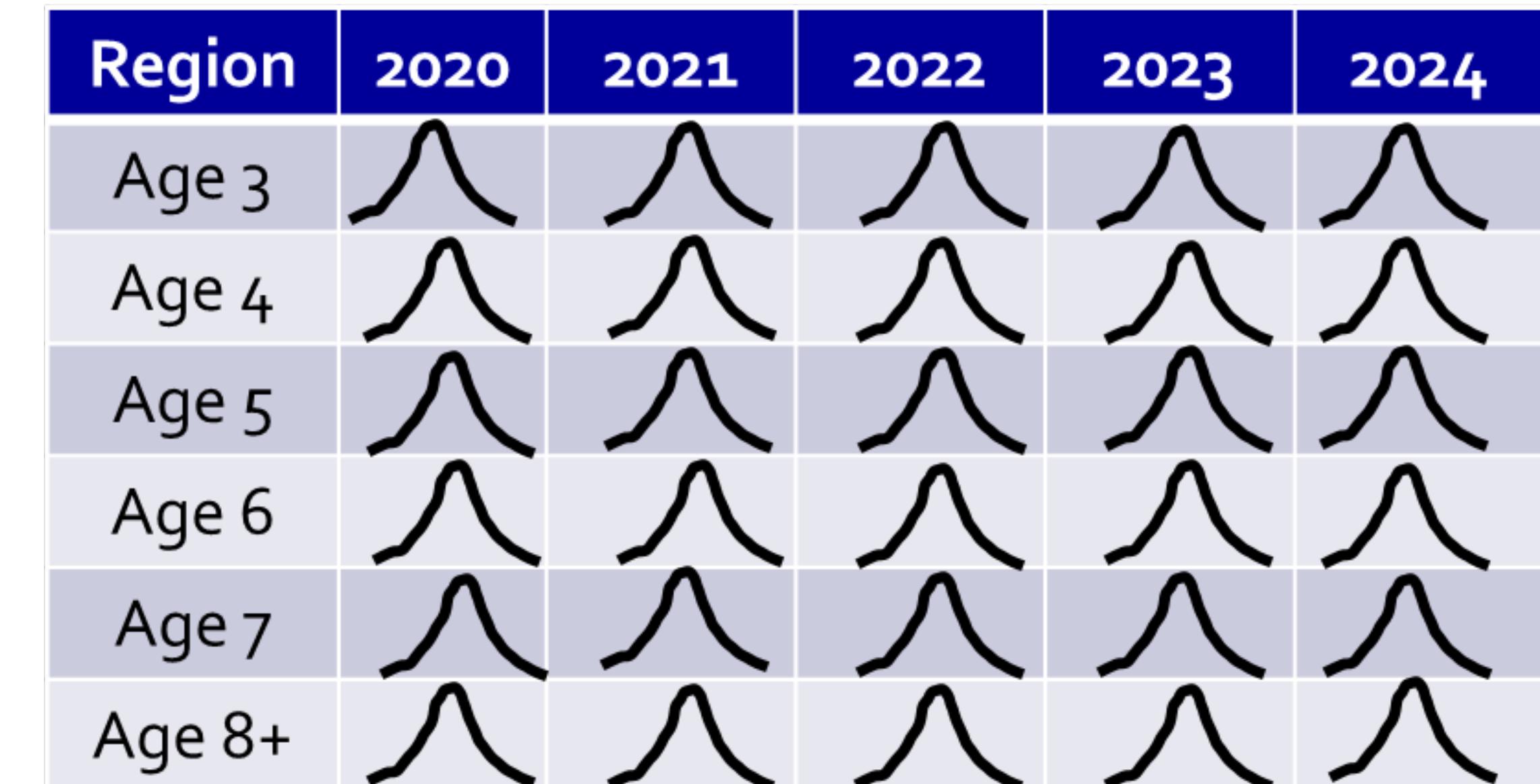


## Tree Age Blocks in Acres (3)



X 3

## Yield Per Acre Blocks (3)



X 3

**Distributions are:**

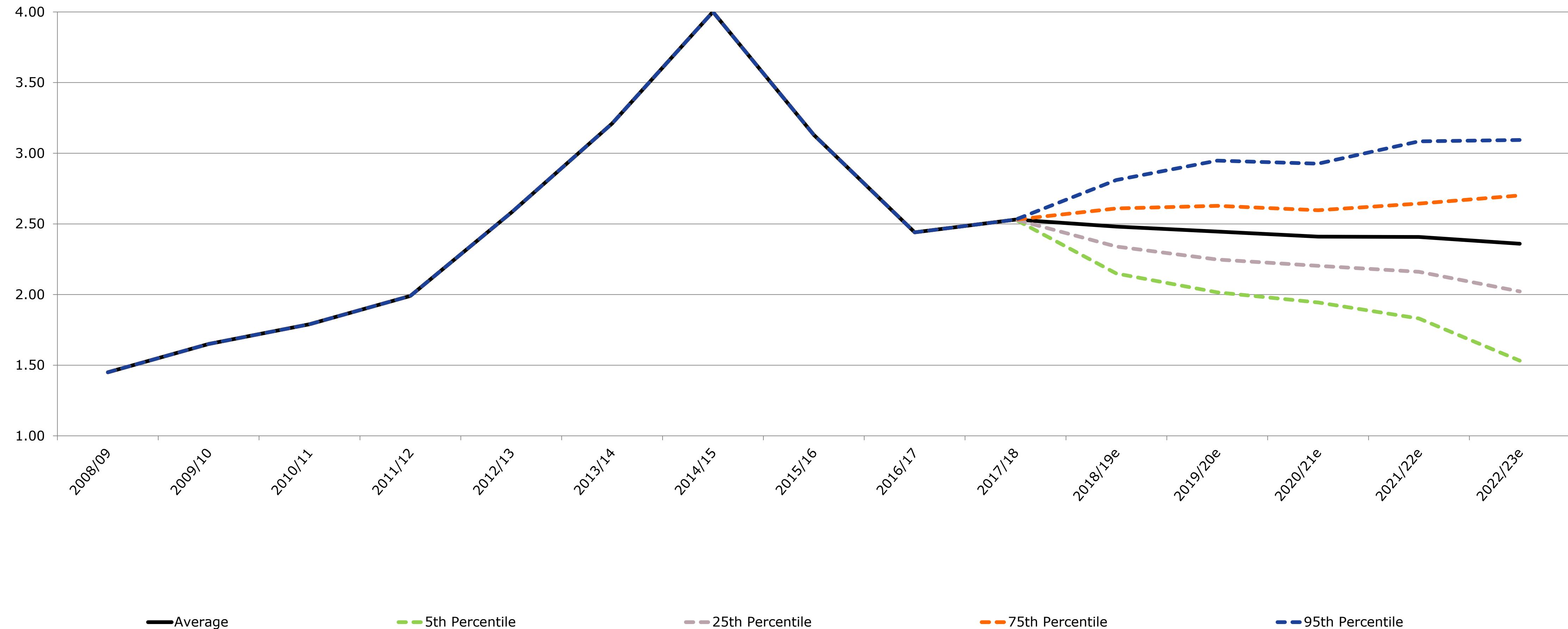
- **Not all normal**
- **Not all symmetric**
- **Correlated**

# When combined with everything else



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

USD/lb (kernel wt)



Source: Rabo AgriFinance estimates March 2019



# Thank you for your attention

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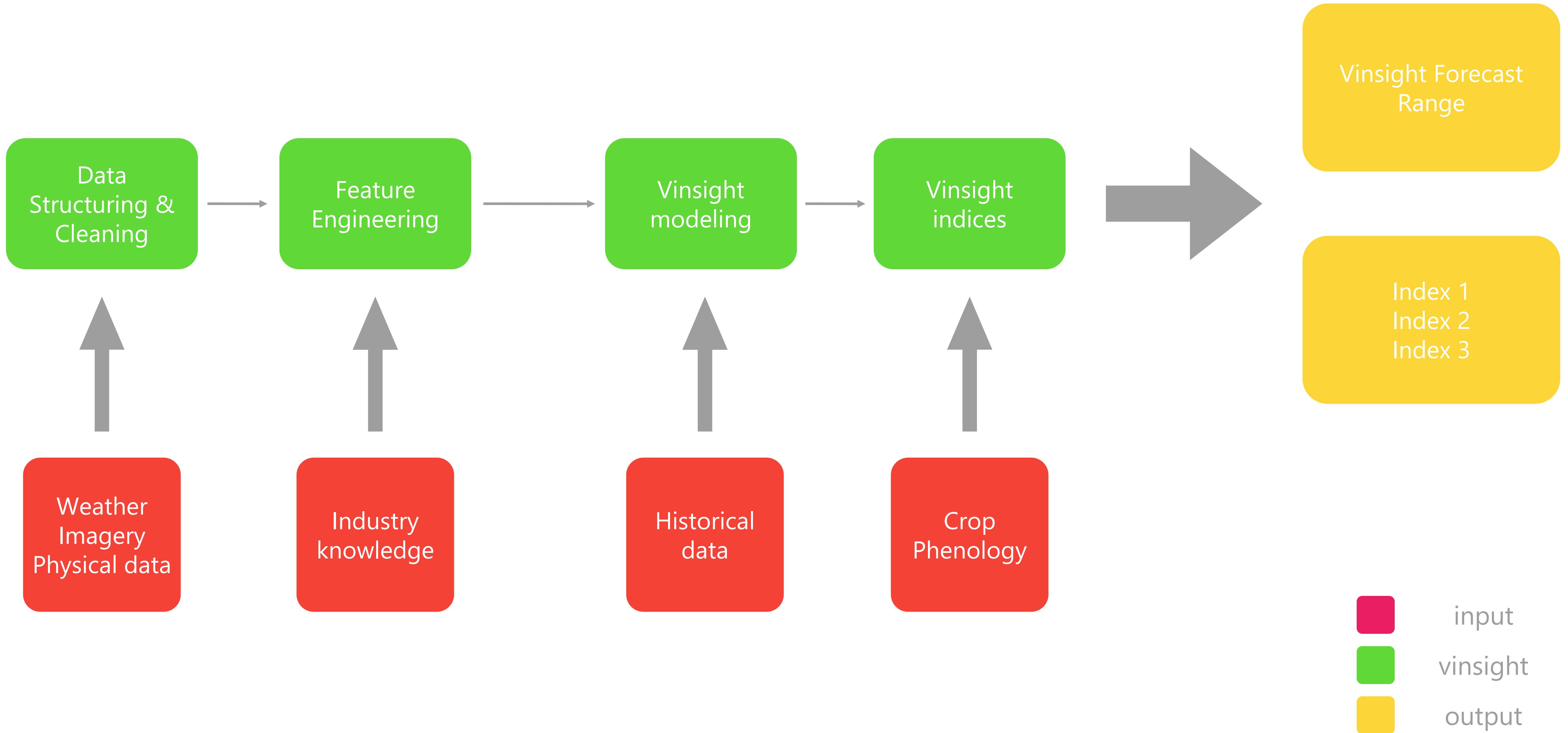
**VINSIGHT**  
Forecasting for agriculture

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

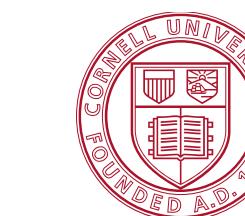


PennState

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Caltech



Cornell University

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Thank you!  
Let's get in touch

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# Almond Crop Forecasting Considerations and Repercussions

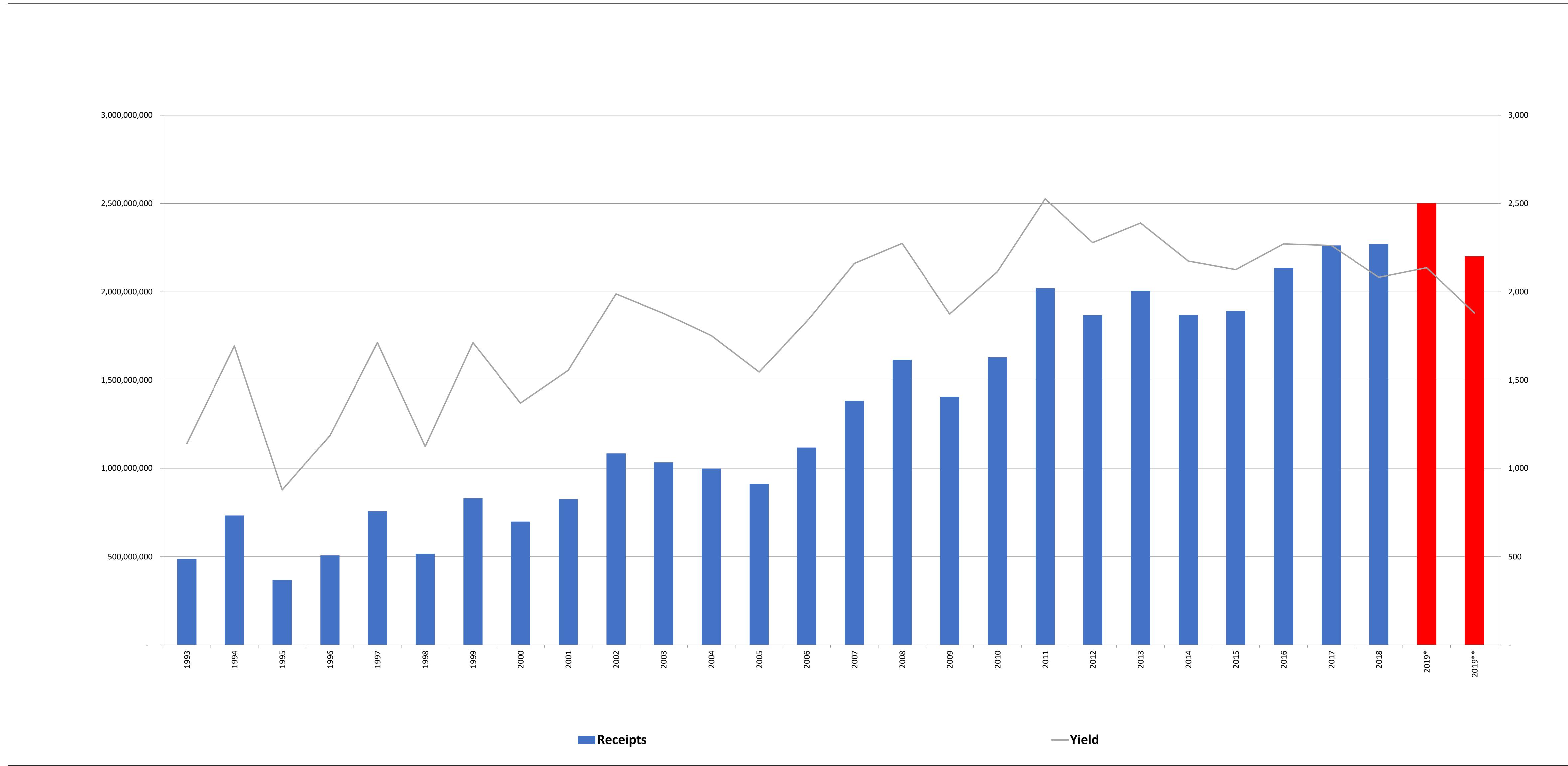


# The Realities of Forecasting

- ❖ 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



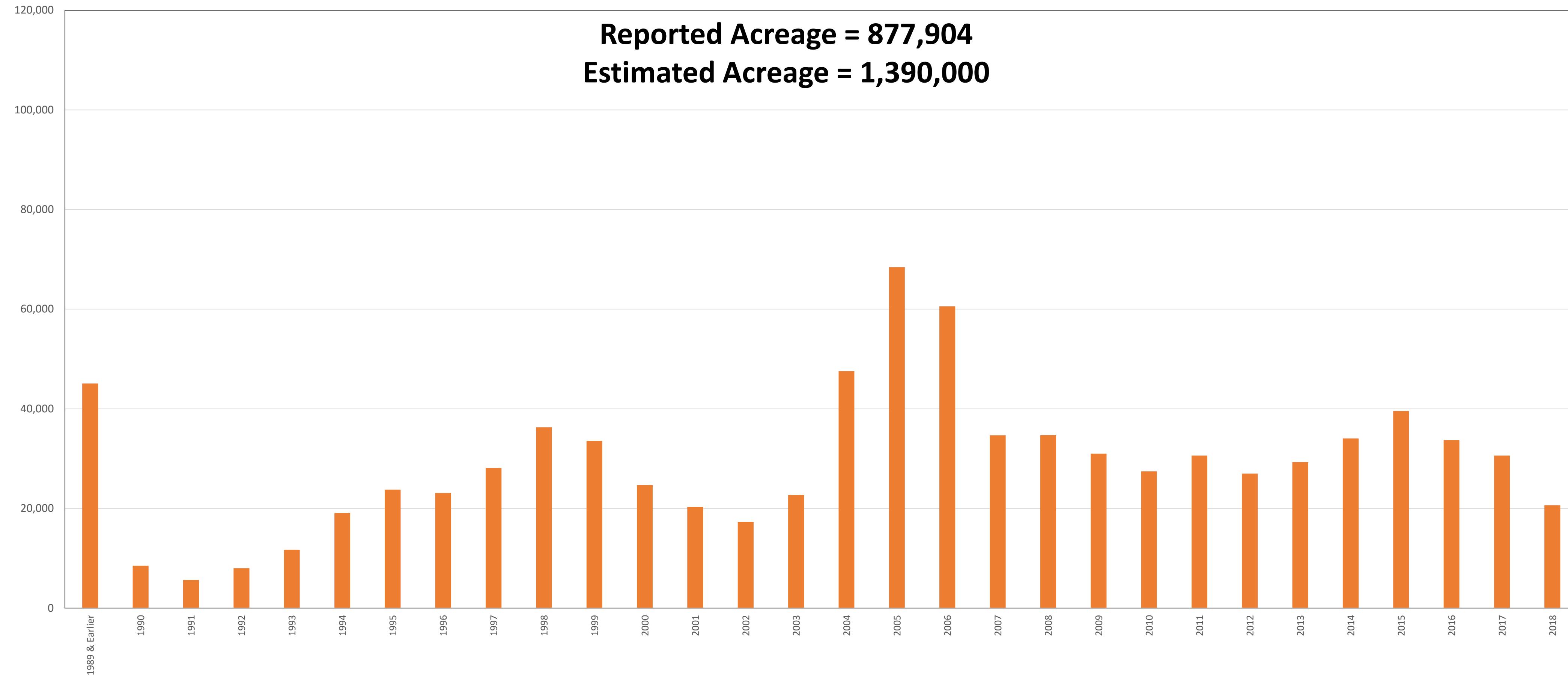
# Crop Variables

- ❖ 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

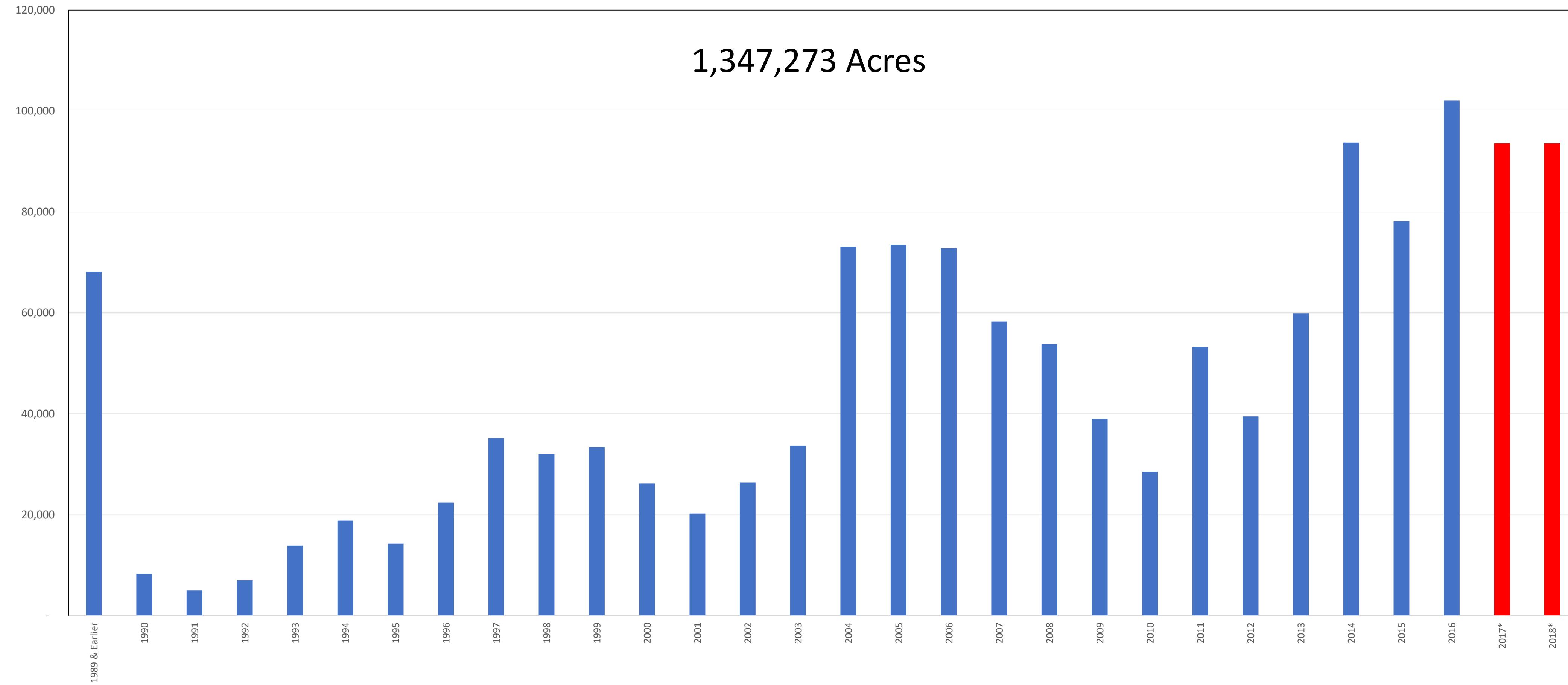
NASS 2018 Reported Acreage  
by Planted Year



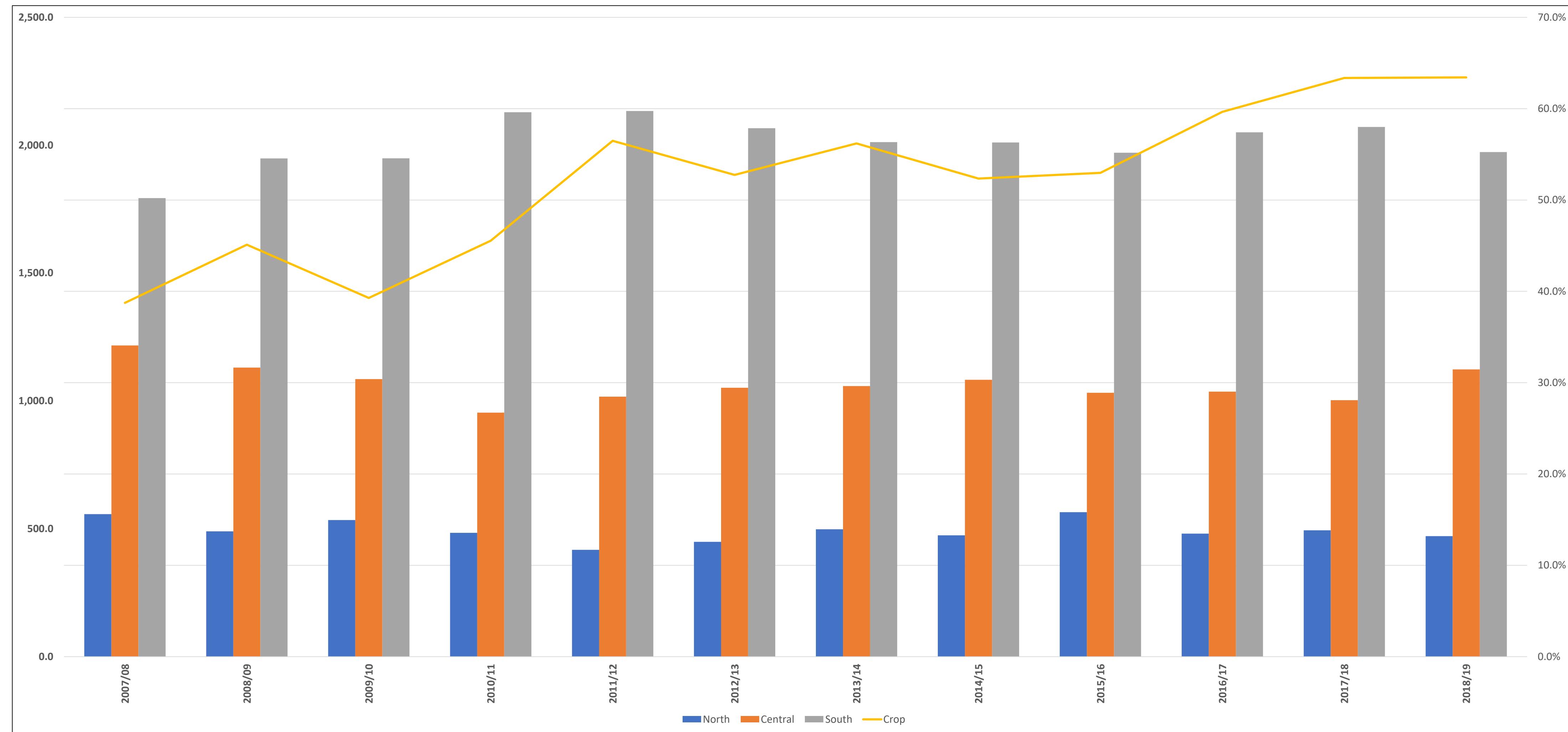
# California Almond Acreage

California Almond Acreage  
Land IQ 2018 Data

1,347,273 Acres



# 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

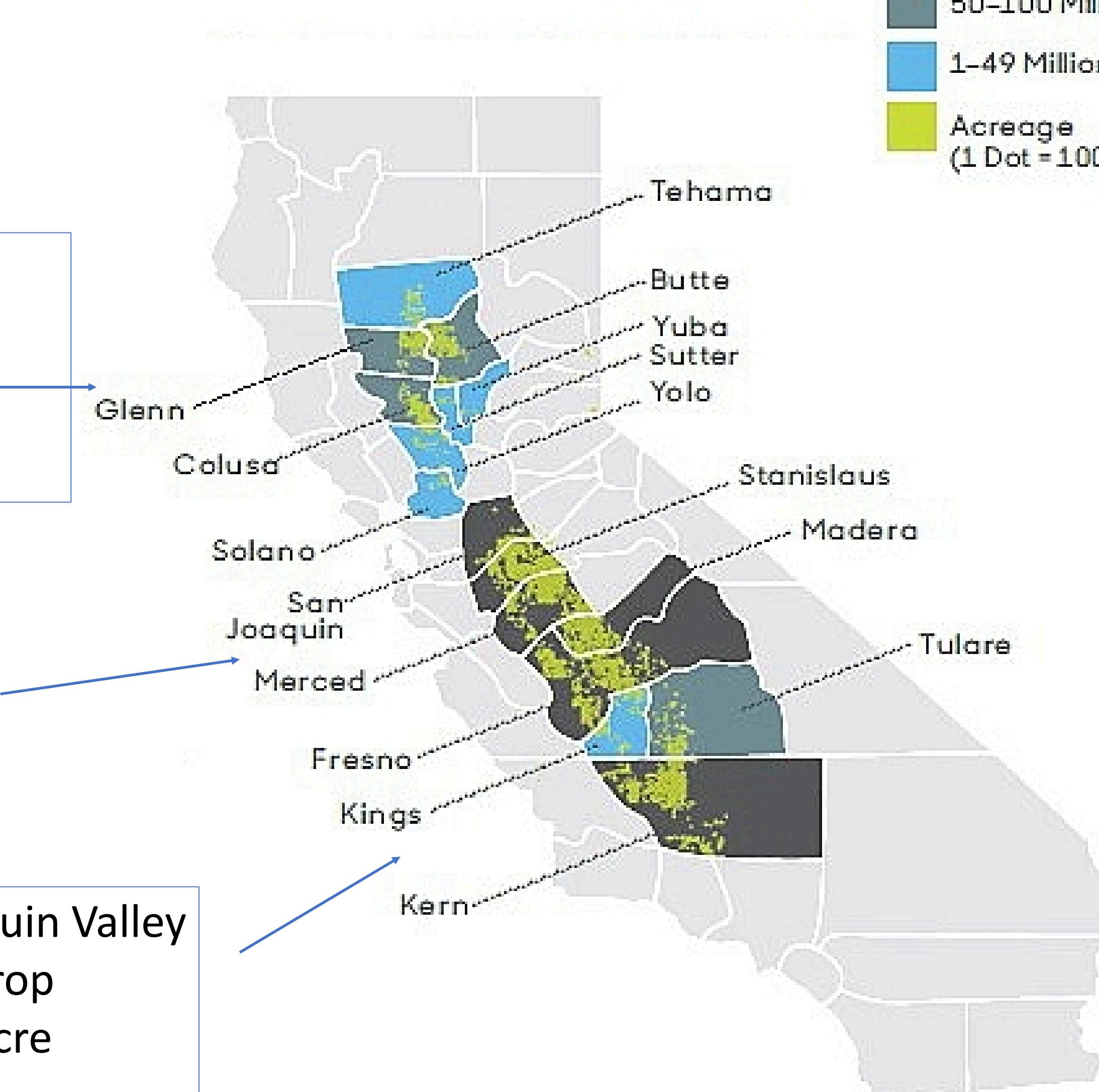
**2.268 Billion Pounds**  
**Average Yield/Acre**  
**2,084 Pounds**

>100 Million Pounds  
50-100 Million Pounds  
1-49 Million Pounds  
Acreage  
(1 Dot = 100 Acres)

**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

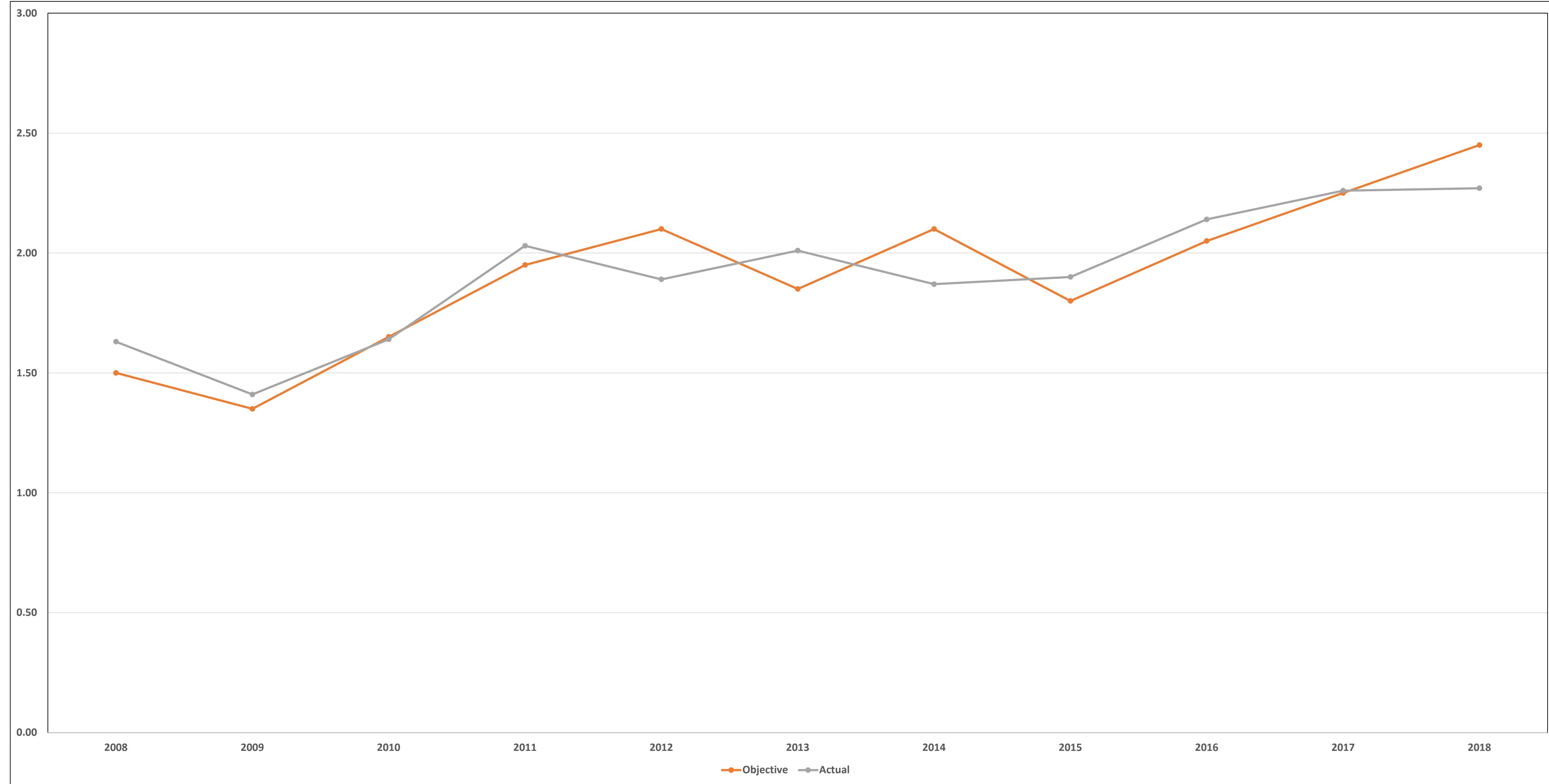
21.0%  $\longrightarrow$  2.291 B  $\longrightarrow$  -109.0 M

2.400 B  $\longrightarrow$  22.0%

23.0%  $\longrightarrow$  2.509 B  $\longrightarrow$  +109.0 M

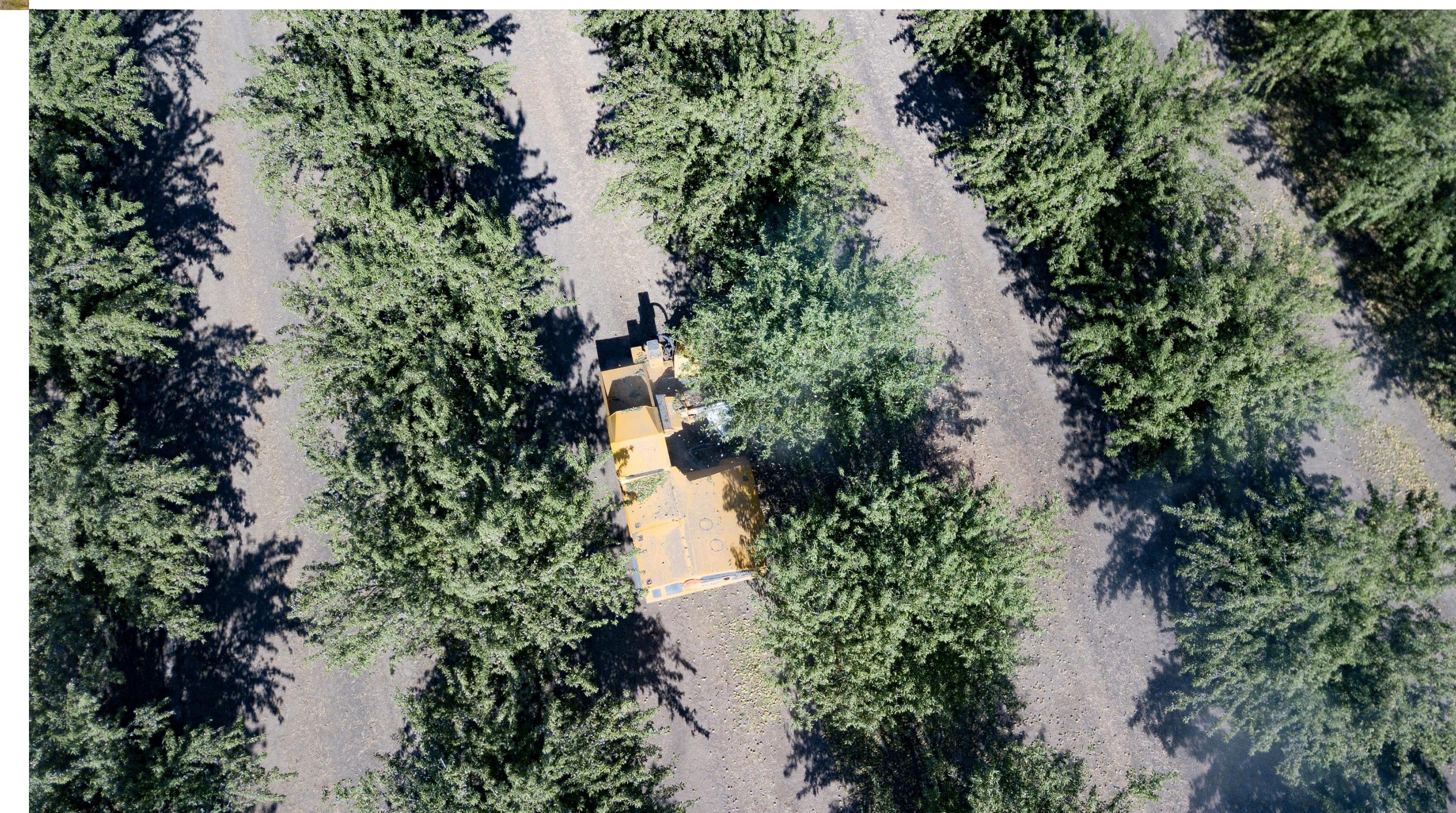
- ❖ Stress
- ❖ Drought
- ❖ High Temperatures
- ❖ Other Unknown Environmental Factors

# Variation From Actual





# Almond Crop Forecasting Considerations and Repercussions





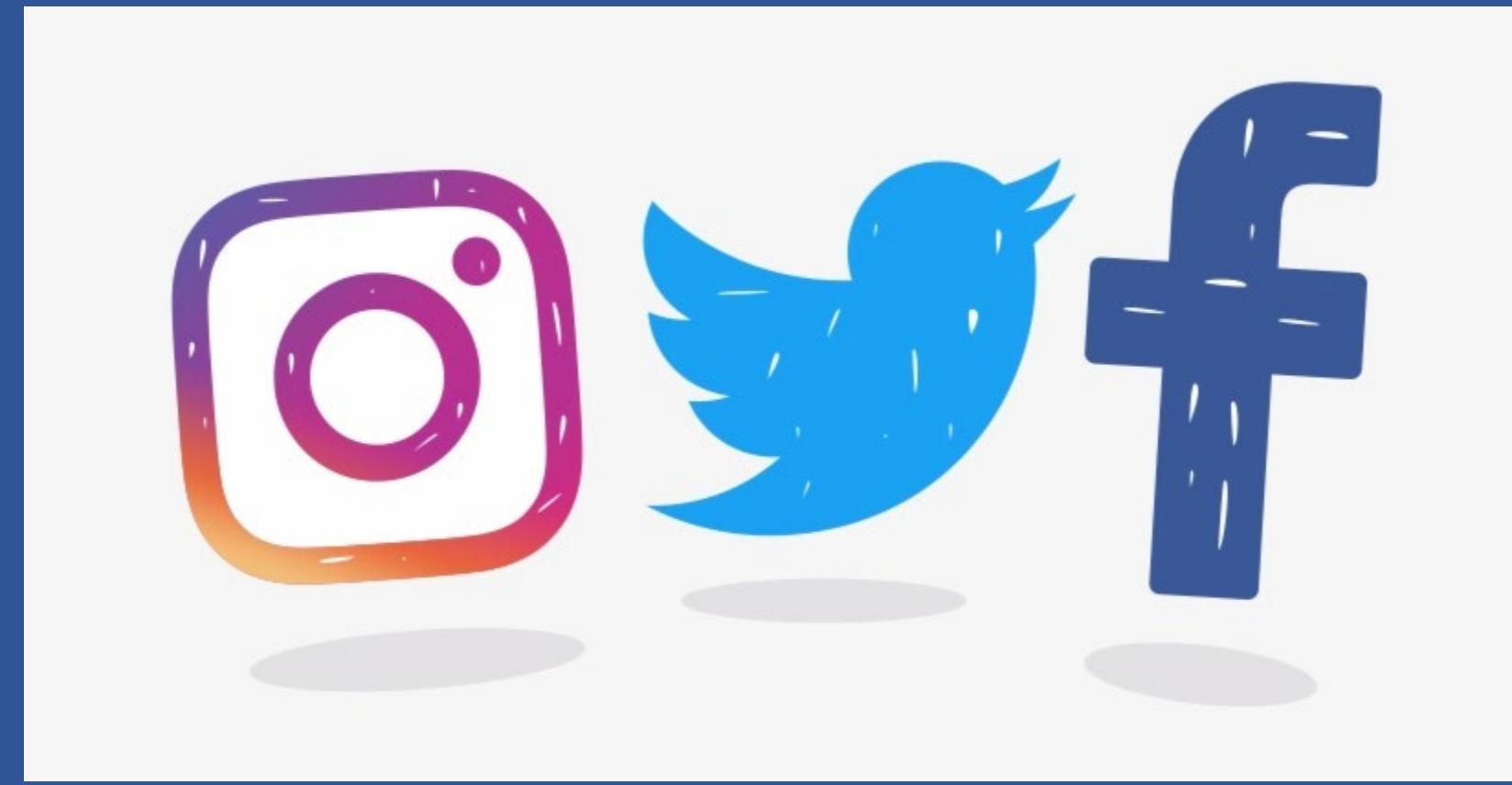
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# Almond Production Estimates: Nuts and Bolts of Different Models



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