

# **Climate Change, Policy and Economics of California Agriculture**

**May 30, 2019**

**CLIMATE ACTION AND AGRICULTURE SYMPOSIUM**

**California State University-San Marcos  
San Diego County, UCCE**

**Daniel A. Sumner**

**University of California Agricultural Issues Center and  
Agricultural and Resource Economics, UC Davis**



University of California  
Agricultural Issues Center

■ University of California Agriculture and Natural Resources

# Major Points in the Presentation (1)

- **Global climate has been changing in ways relevant to agriculture and that is likely to continue**
  - **Temperature trends are well documented**
  - **Some climate models suggest more future variability, and harm in vulnerable regions – especially nearer the equator**
- **Warming trends are clear other climate shifts, such as shift in precipitation patterns and weather variability are less so**
- **Down-scaled data and models show relevant climate shifts in California especially warming of winter-time lows**
- **Relevant climate shifts and their agricultural implications depend on what changes, what crops are best suited and market relationships.**

## **Four topics:**

- 1. Climate change and implications for production**
- 2. Contributions of agriculture to GHG emissions**
- 3. Adaptions of farms and markets to climate change**
- 4. Adaptations to climate policy—taxes, subsidies, regulations and and cap &trade**

## Major Points in the Presentation (2)

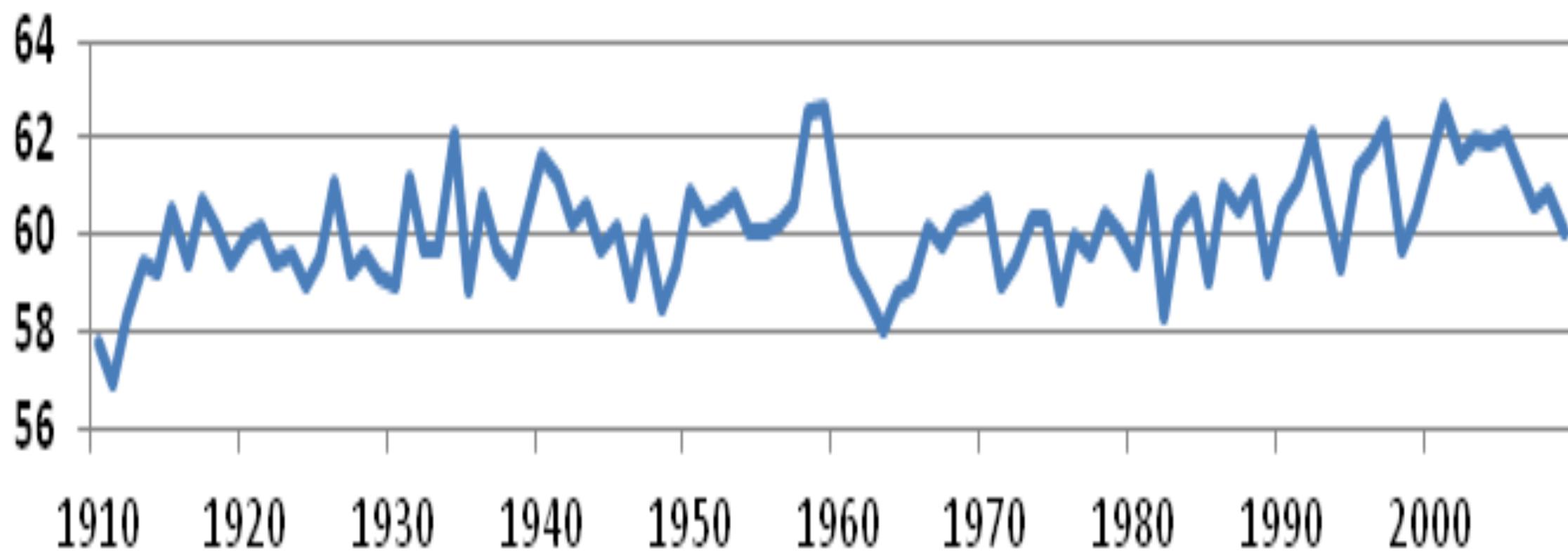
- **Climate policy may have bigger effects in California than climate change**
- **Warming causing a change in the form of precipitation seems to be most important, given rigidity of institutions and infrastructure**
- **Markets matter to climate impacts, but quantification is hard**
- **Climate shifts outside California affect agriculture here directly through global markets—prices facing California agriculture will change**
- **Adaptations to climate changes, including variability**
  - **Storage and other devices for inter-temporal smoothing**
  - **Trade and other devices for spatial smoothing**
  - **Adjusting what and how crops and livestock are grown and where**
  - **Adjusting in infra-structure and institutions such as for irrigation**
  - **Direct efforts to mitigate climate flux with technology such as tolerant varieties or flexible planting and harvesting**
  - **Diversification across commodities and locations**

# Economic Implications from Climate Change Affecting Global Markets

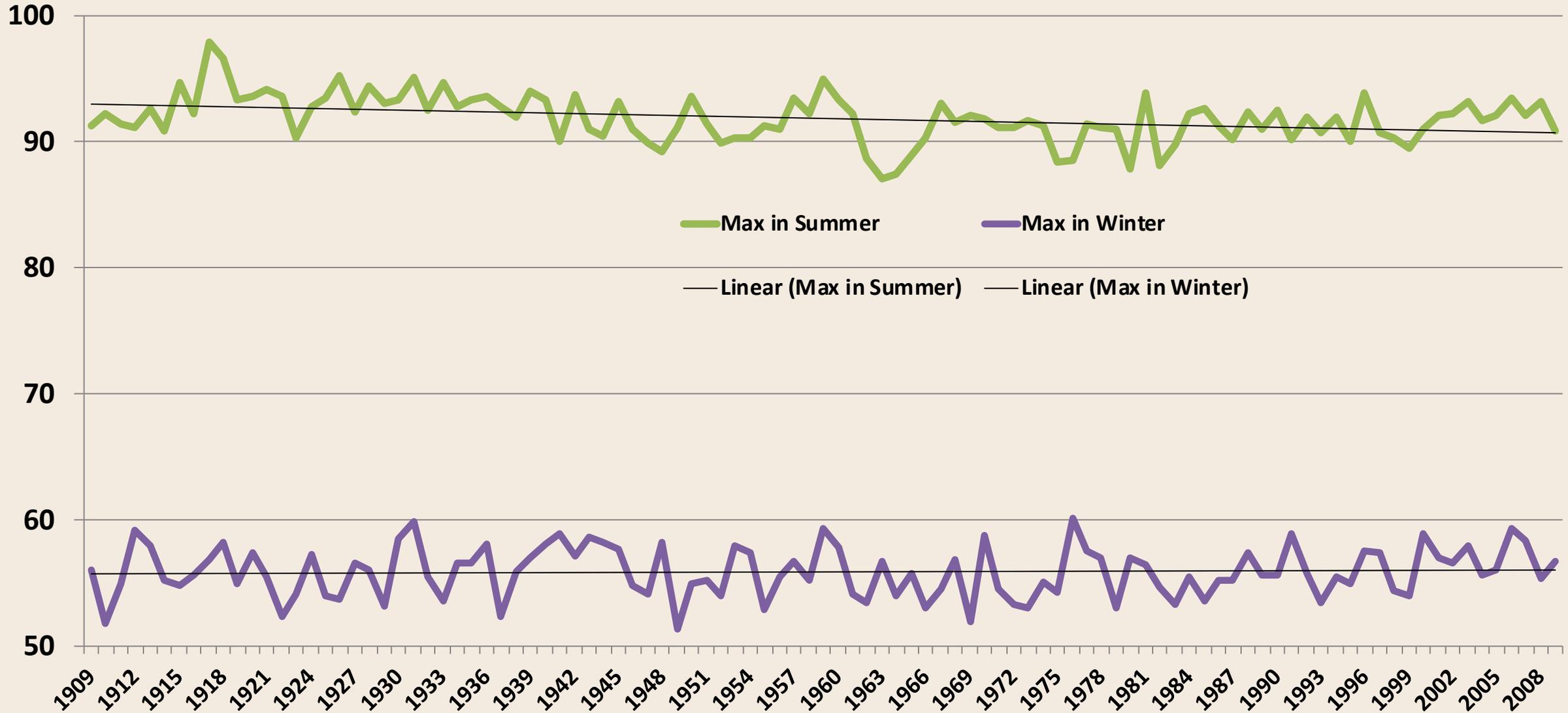
- It is easy to focus too much on the local when climate and market implications are global.
- Just as California emissions affect the global climate, California economic relationships in agriculture are global.
- That means our modeling of adaptation to climate must incorporate global **market** implications.
- It also means climate **elsewhere** affects adjustments in California.
- When adaptation elsewhere affects the global supply & demand balance, California farms and ranchers adjustments to those **market** changes may outweigh changing climate here!

# Annual Average Temperature in Yolo County, California: 1910-2009

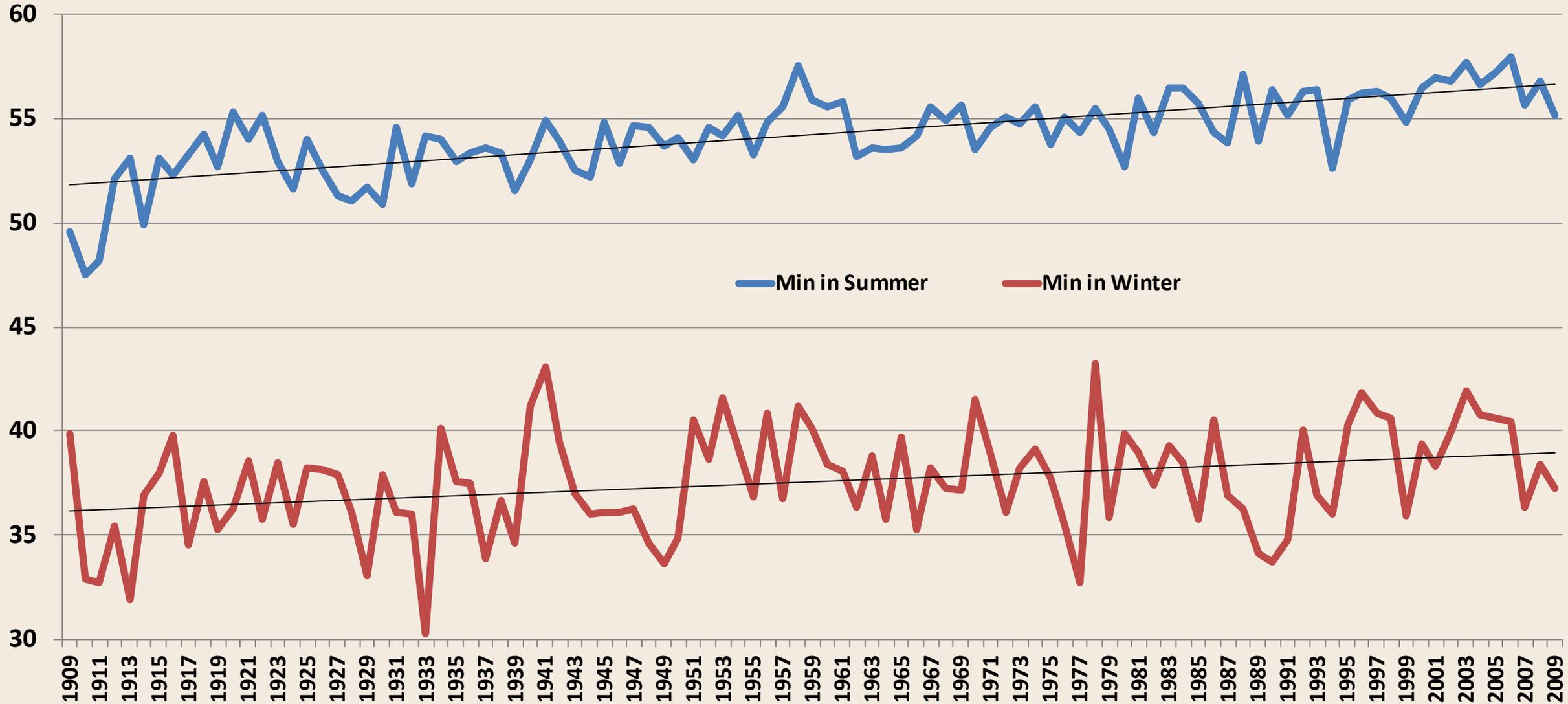
Degrees, F



# Historical maximum average temperature in summer and winter months for the period of 1909-2008 for Davis, CA



# Historical minimum average temperature in summer and winter months for the period of 1909-2008 for Davis, CA



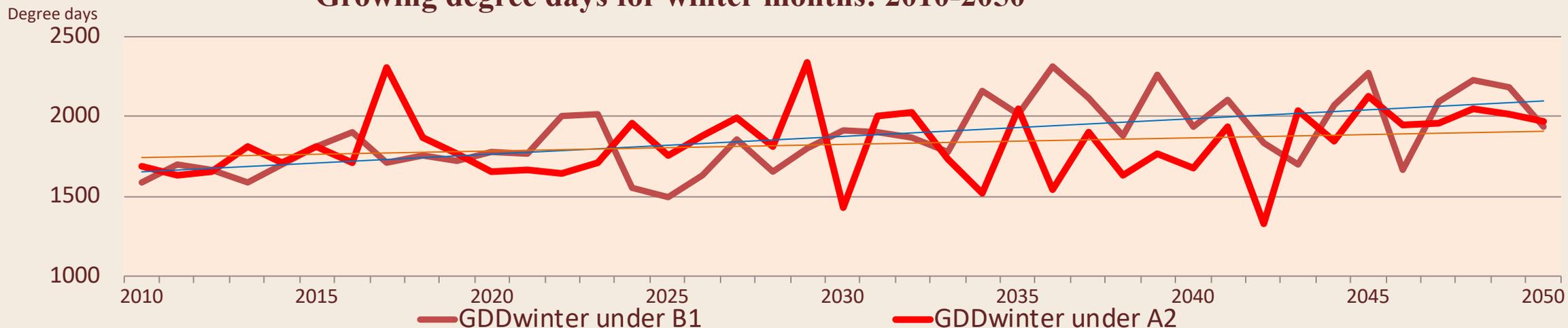
# Projections of GDDs

- IPCC Scenarios for low emission (B1) and moderate emissions (A2) climate projections differ and show ups and downs though 2050, but winter GDD rises especially under B1 after about 2035.

## Growing degree days for summer months: 2010-2050



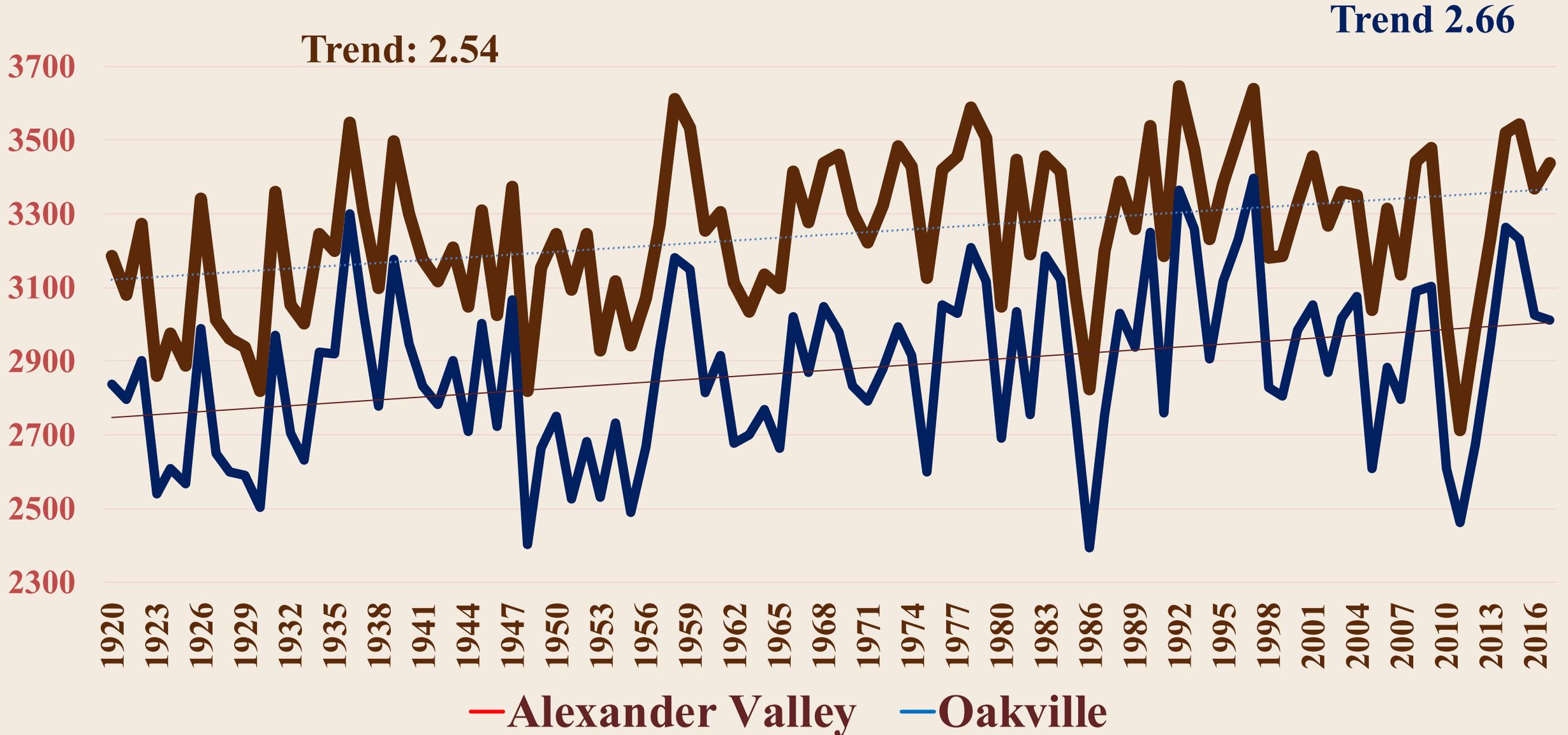
## Growing degree days for winter months: 2010-2050



## **Consider Wine with Climate Change**

- a) Weather and climate affect wine practices and prices**
- b) Relationships are complex, ...vineyard and winery adaptation**
- c) Weather and climate matter within a region for local practices and outcomes including grape quantities and qualities**
- d) Conditions outside the region affect market conditions and may be even more important than local conditions**
- e) We examine data for impacts on price (and indicators of wine qualities) of a few likely weather measurements**
- f) Implications of climate change for wine prices must incorporate adaptations...implemented over decades rather than a single year**

# Historical GDD in Alexander Valley and Oakville (1920-2017)



# GDD and related weather variables

- **Going back to Winkler, GDD has been used to related weather to grape production in California**
- **GDD = average daily temperature – 50 degrees F summed over a period**
- **Recall our interest is in the wine prices and ratings not yields or specific grape attributes**
- **Maybe daily highs and lows are important separately**
- **Maybe full growing season GDD matters or maybe certain months**
- **We explore a few specifications, but do not attempt to search the data for possibly spurious correlations**

## Average Wine Prices by Appellation, (2014 \$)

<b>Napa Valley</b>	<b>103</b>	<b>Knights Valley</b>	<b>71</b>
<b>Oakville</b>	<b>133</b>	<b>Calistoga</b>	<b>91</b>
<b>Rutherford</b>	<b>110</b>	<b>Drycreek Valley</b>	<b>64</b>
<b>Alexander Valley</b>	<b>48</b>	<b>Chalk Hill</b>	<b>73</b>
<b>Howell Mountain</b>	<b>99</b>	<b>Coombsville</b>	<b>143</b>
<b>Sonoma County</b>	<b>52</b>	<b>Atlas Peak</b>	<b>102</b>
<b>Stags Leap</b>	<b>101</b>	<b>Sonoma Mountain</b>	<b>54</b>
<b>St. Helena</b>	<b>103</b>	<b>Oak Knoll</b>	<b>105</b>
<b>Spring Mountain</b>	<b>90</b>	<b>Napa County</b>	<b>28</b>
<b>Diamond Mountain</b>	<b>91</b>	<b>Russian River</b>	<b>28</b>
<b>Mount Veeder</b>	<b>75</b>	<b>Moon Mountain</b>	<b>67</b>
<b>Yountville</b>	<b>111</b>	<b>Pine Mountain</b>	<b>37</b>
<b>Sonoma Valley</b>	<b>57</b>	<b>Northern Sonoma</b>	<b>95</b>

# Economic Reasoning and Relationships

- **Supply and demand drive prices and so we put weather and climate in this context**
- **For commodities, weather-driven quantities drive prices**
- **For fancy wine, qualities of the grapes drive prices and the weather impacts are more subtle**
- **Climate and weather changes are global and so are markets**
- **Climate and weather elsewhere also matters to local grapes prices (Calanit Bar Am)**
- **Vineyard managers and winemakers are active in response to weather and climate, but limitations are real**
- **More heat, more sugar, more alcohol...has climate driven hotter wine (Alston, Lapsley and others)**

# **Wine Price and Ratings Data**

- **Information on prices and ratings from Spectator Magazine listings through early 2017**
- **Vintages 2000 through 2014 for Napa and Sonoma Cabernet Sauvignon**
- **Almost 2000 wines represented for a total of 4870 observations across 26 appellations**
- **Many wines appear only once or twice; a few are in most years**
- **Almost 60% “Napa Valley” Appellation**
- **Oakville, Rutherford and Alexander Valley each have between 200 and 400 observations**
- **Sonoma County and a few others have more than 100 observations**

# Average growing degree days in Lodi, Davis and Firebaugh from 2000 to 2014

<b>Regions</b>	<b>County</b>	<b>GDD</b>
Lodi	San Joaquin	3861.1
Davis	Yolo	4171.5
Firebaugh	Fresno	4787.6

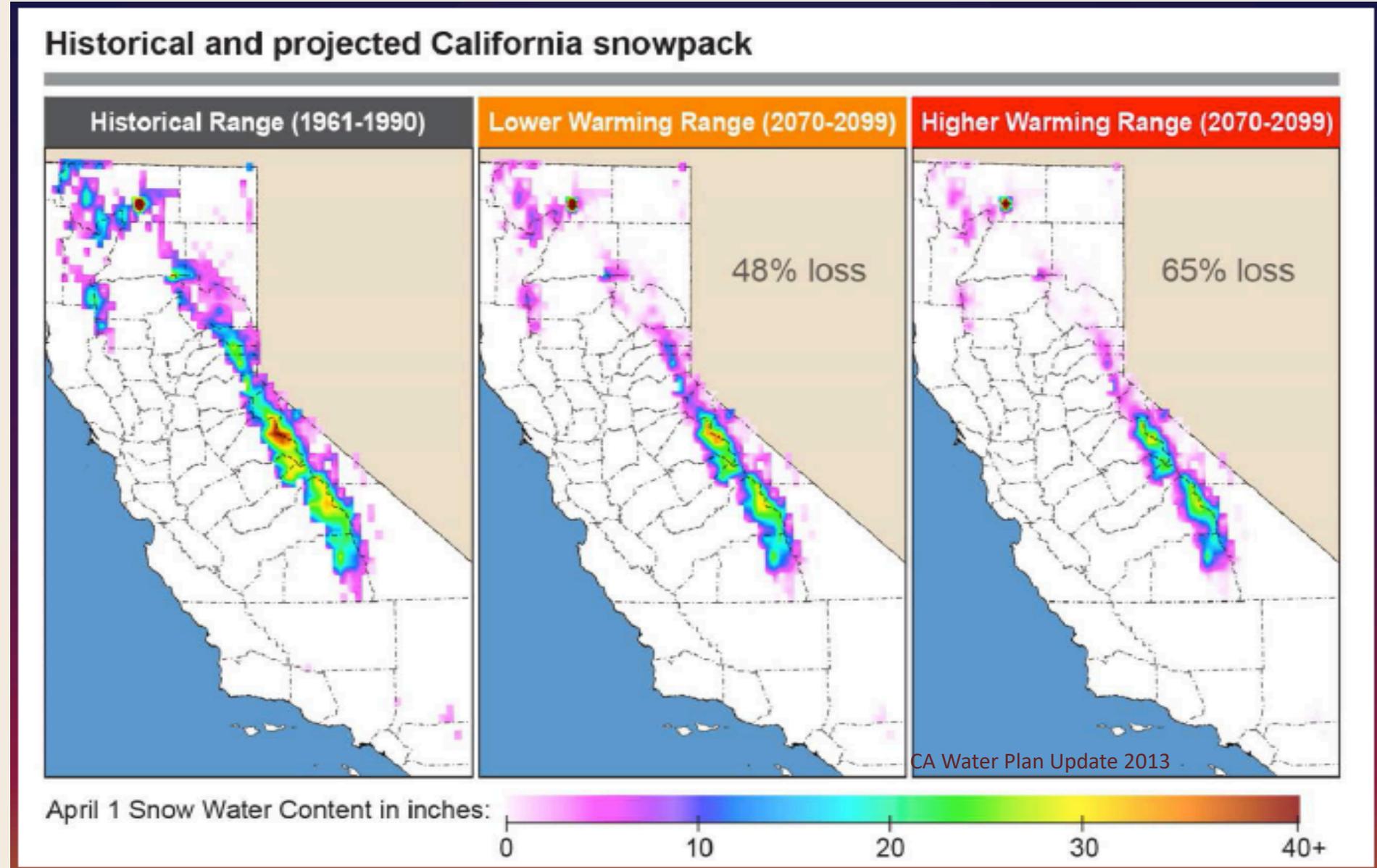
Notes: the growing degree days are based on growing season from April 1 to October 31

# California snowpack has a big impact on California agriculture

- Snowpack is relied upon as the primary source for the summer water supply for irrigated farming.
- California faces a warming climate which may have three big consequences:
  - Smaller snowpack ~ less water available for irrigation during dry season
  - Earlier snowpack melting date ~ longer, warmer pasture plant growing season
  - Smaller snowpack area ~ land exposed for other use: land for grazing
- The first has been extensively discussed but not the next two!
- We try to answer how climate change affects forage availability and beef cattle supply in California and western US.

# Impact on Cattle, especially pasture-based herds

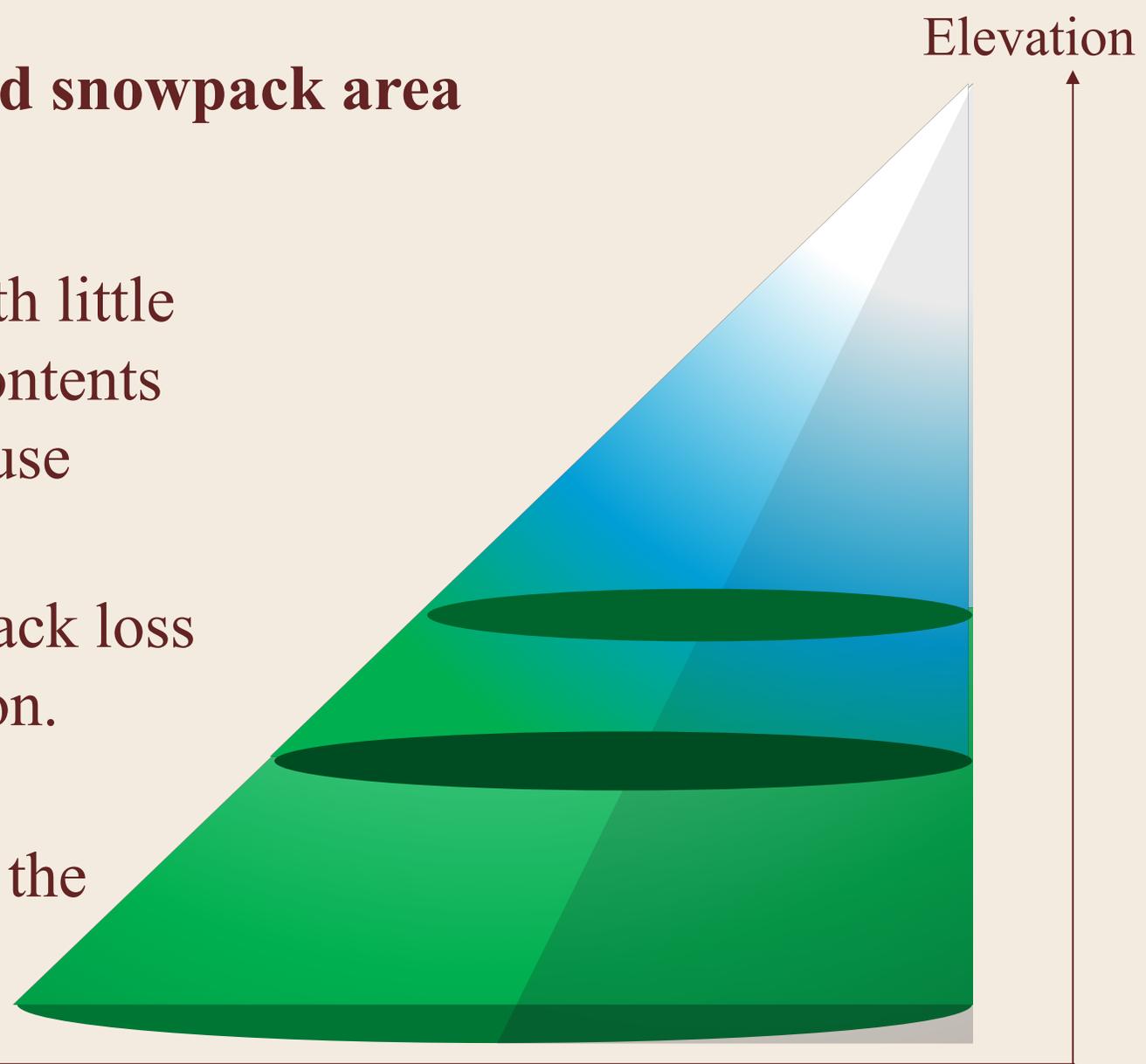
- Changes in area of pasture
- Less snowpack may allow more rangeland for pasture
- This may imply a shift in land use and more cattle in California



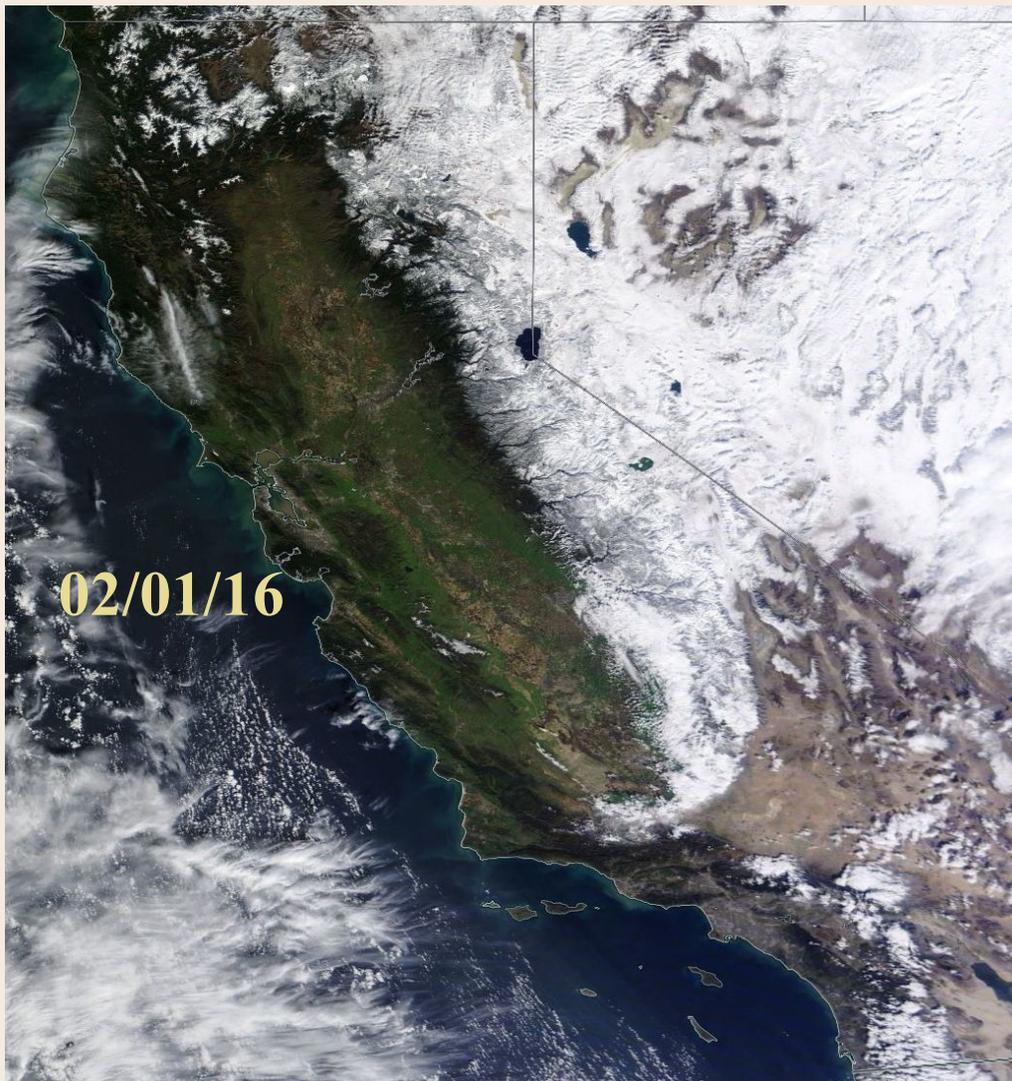
## Elevation and snowpack area

- Snowpack with warming climate
  - Low level snowpack storage. With little snowmelt runoff, the reservoir contents will be the amount available for use during summer.
  - Early snowmelt causes in snowpack loss and longer pasture growing season.
  - Higher snow line results in more pastureland available throughout the year.

← Surface area



# California Snowpack (cont.)



# Adaptation to Variability

- **On farm**
  - **Diversification across timing, season and location**
  - **Specific cultivars of crops that respond differently**
- **Within agriculture**
  - **Inter-regional trade, hay from Shasta or Fresno**
  - **International trade, corn from USA or Argentina**
  - **Inter-seasonal and annual storage**
- **Improved forecasts:**
  - **We are better with El Niño planning.**
  - **Farmers will plant differently as well as store and trade**
  - **(Builds on ideas from Hallstrom (Davis PhD. 1998) and Lybbert, Smith and Sumner, 2016)**

## **Agricultural impacts of cap and trade policy applied to energy and food manufacturing the lower price of California farm output**

- AB 32 has been regulating GHG emissions in California with Cap and Trade for more than a decade.
- Food processing among most energy intensive industries in California
  - Only transport and agro-chemicals are higher
  - Milk is among most energy intensive within food processing
- When other, complementary, input costs rise in processing and marketing, the price for raw materials falls
  - GHG regulation of milk processing plants lowers the price of milk paid to California farms
  - Impact may encourage shifts out of state where feasible, especially for livestock industries ...This is happening in California
- Regulation of processing causes shifts across crops and, if widespread, a lower price of land or and lower prices and quantities of other resources specific to farming.

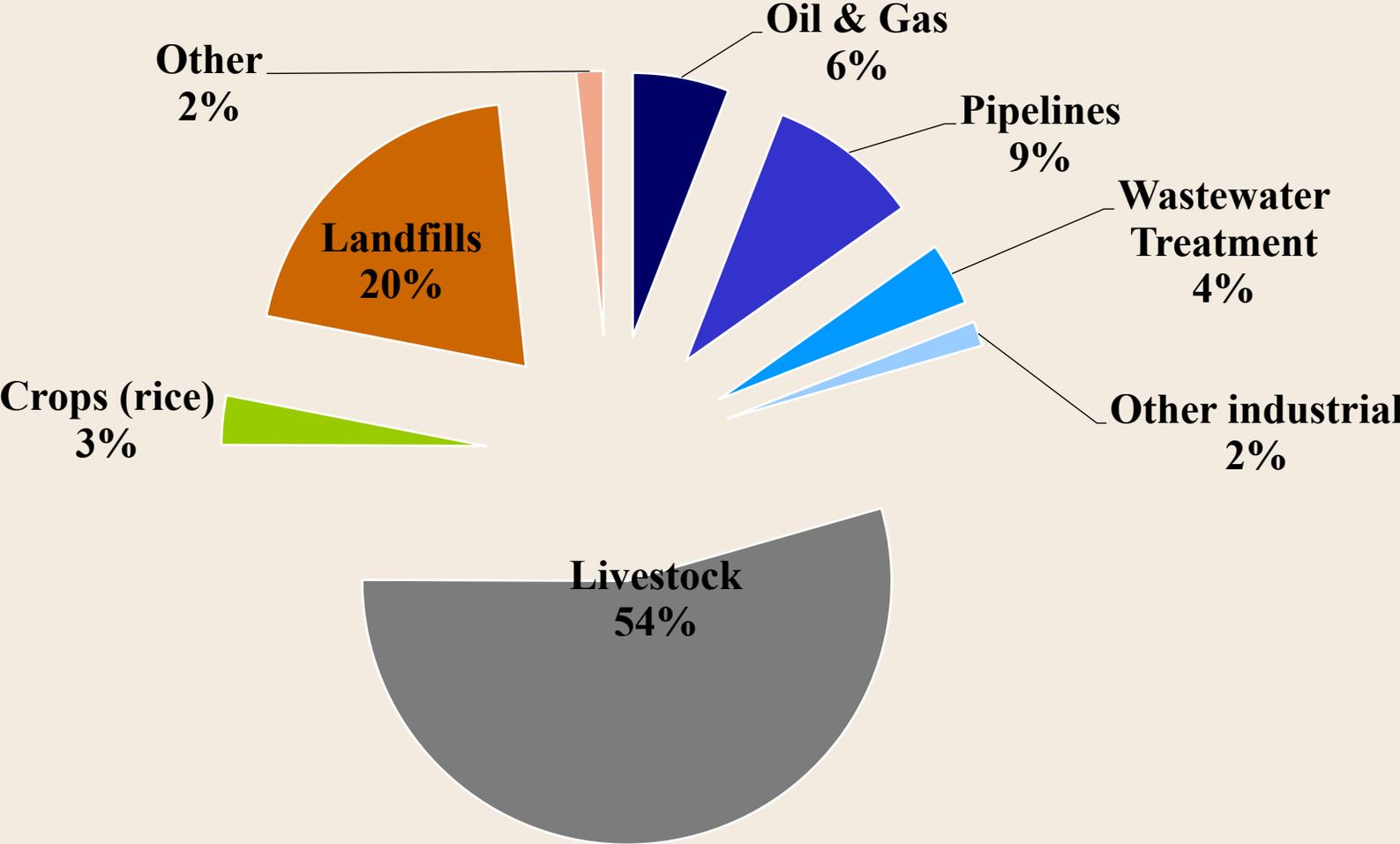
## Now we have SB 1383

- On Sept 19, 2016, Governor Brown signed into law Senate Bill (SB) 1383, the latest California state government effort to set policies that will allow California to meet its greenhouse gas (GHG) reduction targets.
- Senate Bill 1383 authorizes the state to regulate the releases of short-lived climate pollutants (SLCP) such as methane, black carbon and fluorinated gases. These substances remain in the atmosphere for much shorter periods than carbon dioxide.
- The state realized it could not meet its short term emissions targets and allow farms to remain unregulated.

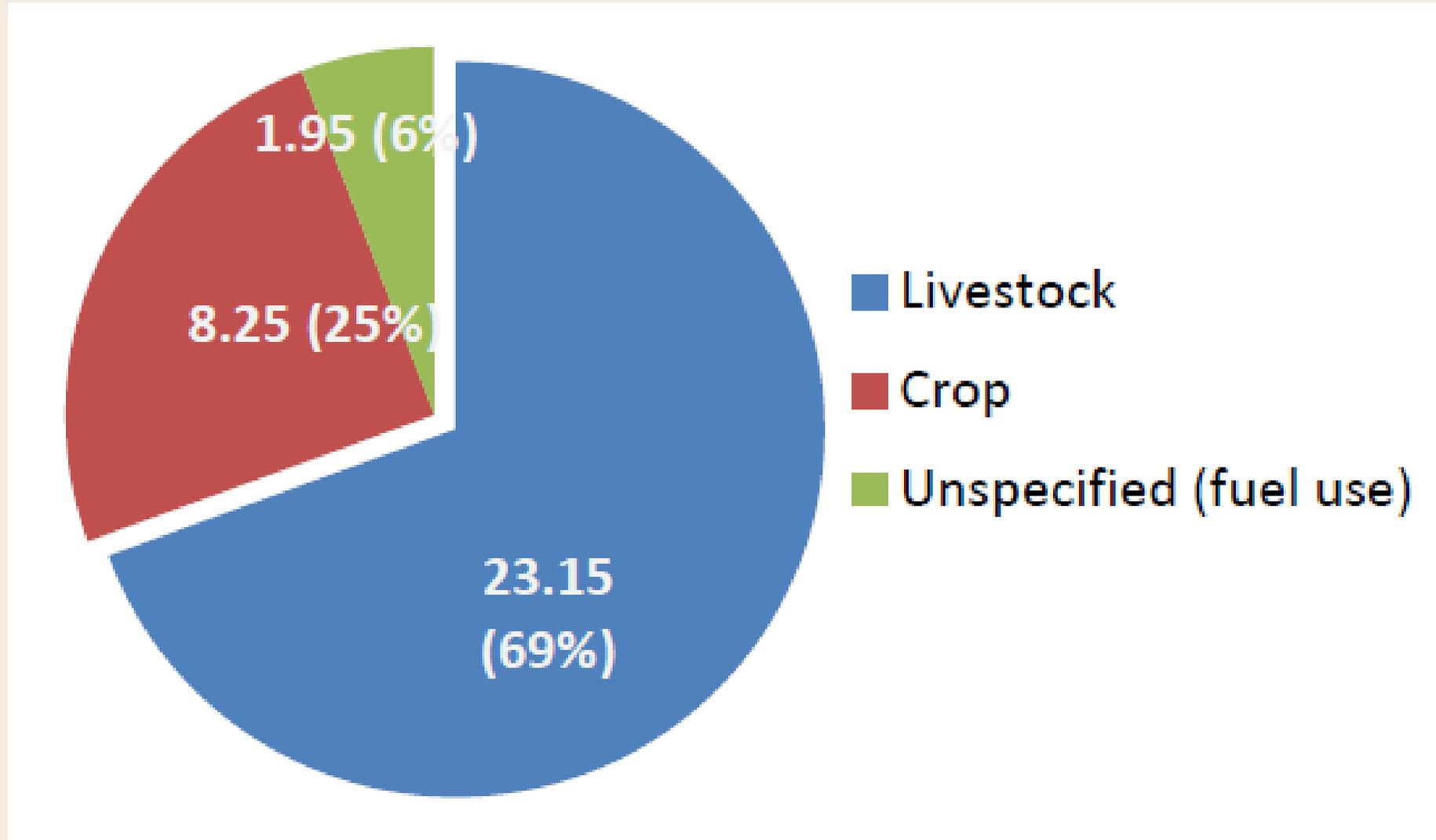
# Sources of Short Lived Climate Pollutants

- SB 1383 deals with short lived climate pollutants (SLCPs) across many sectors of the economy.
- The major emission sources of SLCPs include:
  - diesel combustion for black carbon,
  - leaks of fluorinated gases in refrigeration and air-conditioning systems for hydrofluorocarbons, and
  - **livestock operations**, waste treatment, oil and natural gas systems for methane.
- Of these three pollutants, **methane has the largest share of carbon-equivalent GHG emissions, accounting for 60% of the total.** SB 1383 targets emission reductions of **40 percent for methane**, 40 percent for hydrofluorocarbon and 50 percent for black carbon **by 2030 from their 2013 levels.**

# California Methane by source



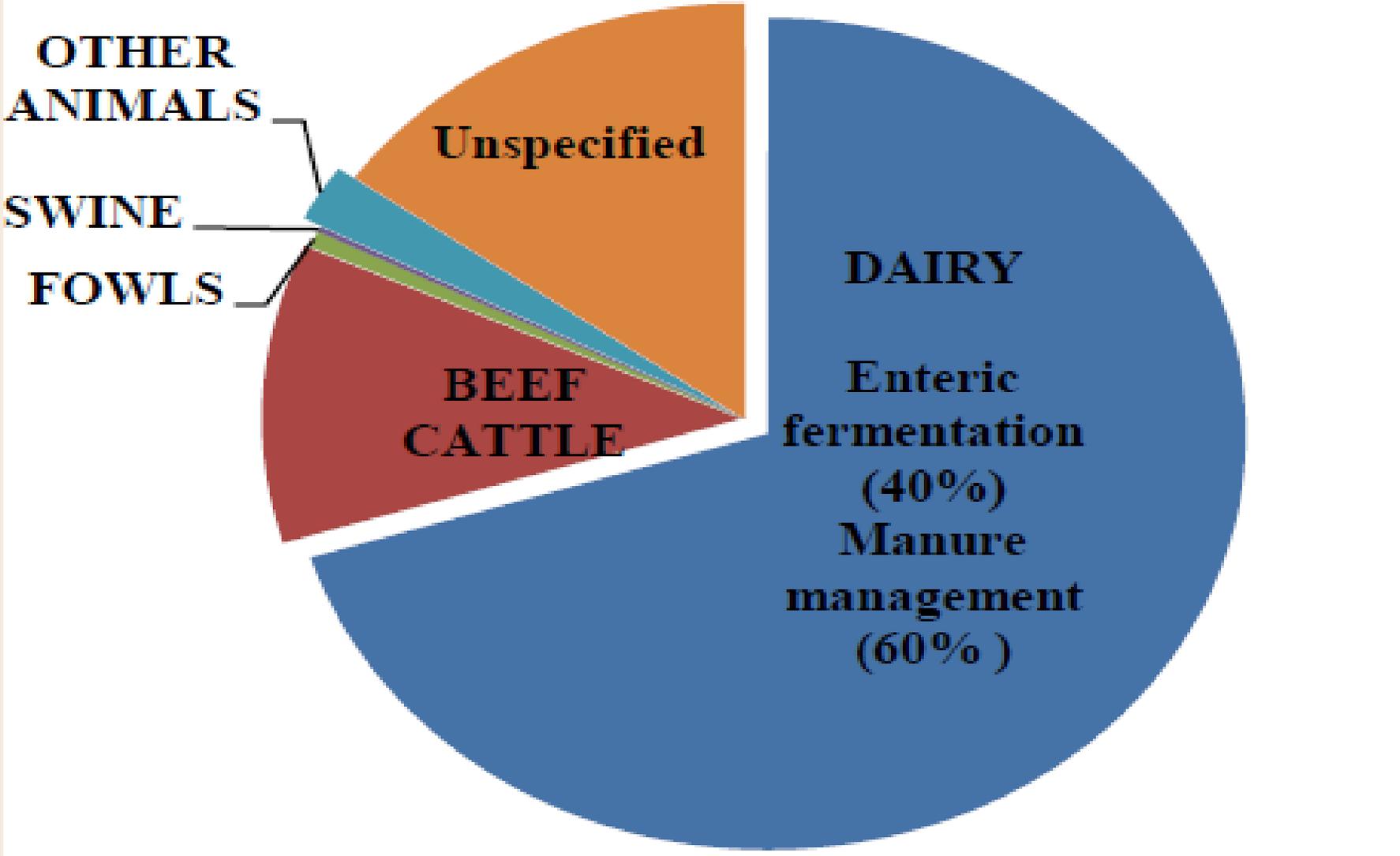
# Distribution of Agricultural GHG in California



# Implications for Dairies

- Dairies are significant emitters of methane in agriculture.
- CA dairies will be regulated on their methane emissions beginning in 2024.
- Dairy emissions can be mitigated via digester technology.
- Economics of digester technology
- Implications and challenges

# GHG from Livestock in California



# Dairy lagoon waste management



# Covered lagoon



## California digesters 2006 - 18

<b>Year</b>	<b>New</b>	<b>Shut down</b>	<b>Existing</b>
2006	2	0	12
2007	1	1	12
2008	4	1	15
2009	2	6	11
2010	0	1	10
2011	0	0	10
2012	0	1	9
2013	5	0	14
2014	2	0	16
2015	1	3	14
2016	2	1	15
2017	2	0	17
2018	3	0	20

# Complete Mix Digesters



# Manure scraping system



# Digester costs and cost comparison

*500 farms with 2,000 cows each*

## ❑ PER FARM DIGESTER COSTS:

- ❑ The initial capital costs include conversion to a manure scrape system and the farm's share related to the central operation which includes trucks, the digester, a pipeline, interconnection, etc. According to CARB calculations, these add up to about \$3 million per farm.
- ❑ The annual operating and maintenance costs (O&M) for the farm share of the centralized digester are about \$0.315 million.

# Digester costs and cost comparison

- ❑ To put the numbers in context,
  - ❑ Per farm asset value= \$5.6 million (CDFA)
  - ❑ Per farm production=500,000cwt (@250 cwt/cow/year).
  - ❑ Per farm revenue= \$7.5 million/yr (\$15/cwt)
  - ❑ (In 2015 and 2016, a typical dairy in California had operating cost above milk revenue.)
  
- ❑ A \$3 million capital investment in manure handling alone would be a substantial investment relative to the investment in the dairy operations themselves.

# Implications

- ❑ Compliance with new regulations on manure handling is likely to become a major factor determining dairy economics in California. Important questions are: will methane emission rules raise milk production costs or generate new revenue, and will this help or hinder efforts of the California dairy industry to remain competitive?
- ❑ The California dairy industry is under economic pressure.
  - ❑ California's milk production and processing costs used to be below those of industries in most other states because of scale economies and high-quality management.
  - ❑ However, as dairy operation in other states has become larger and cost reductions in California have not kept pace, California's advantage has eroded.
- ❑ If new methane regulations further erode the economic position of dairy farms in California, we would expect substantial exit from the industry with resultant reduction in economic activity, especially in the San Joaquin Valley.

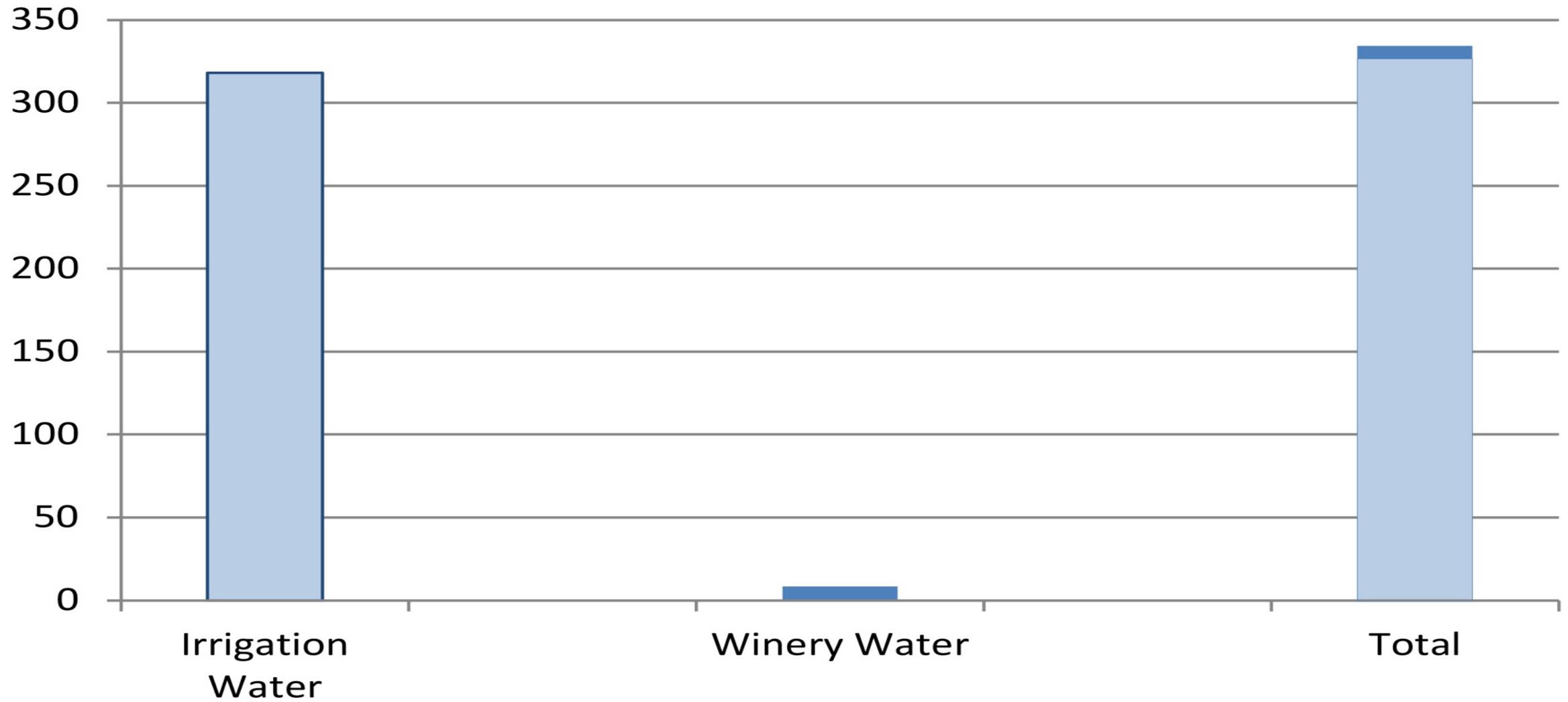
# Climate Points and Reminders about Water

- 1. California has the most variable precipitation in the US**
- 2. Often abundant snowfall “near” growing areas ... better than any Mediterranean competitor.**
- 3. For the Central Valley and the South surface water (shipped in the from Sierra Nevada Mountains) became the base water supply for irrigation**
- 4. Groundwater became the bank we have drawn from in dry years.**
- 5. Then: More environmental use, more urban use, more perennial crops, more total farm demand and use of drip technology have all led to less recharge.**
- 6. A sustainable system of recharge with mountain snow in “normal” years and draw down only in dry years became drawdown almost every year.**
- 7. The Sustainable Groundwater Management Act is a response to prepare for the long term including climate change.**

# **A few facts for irrigation water in California**

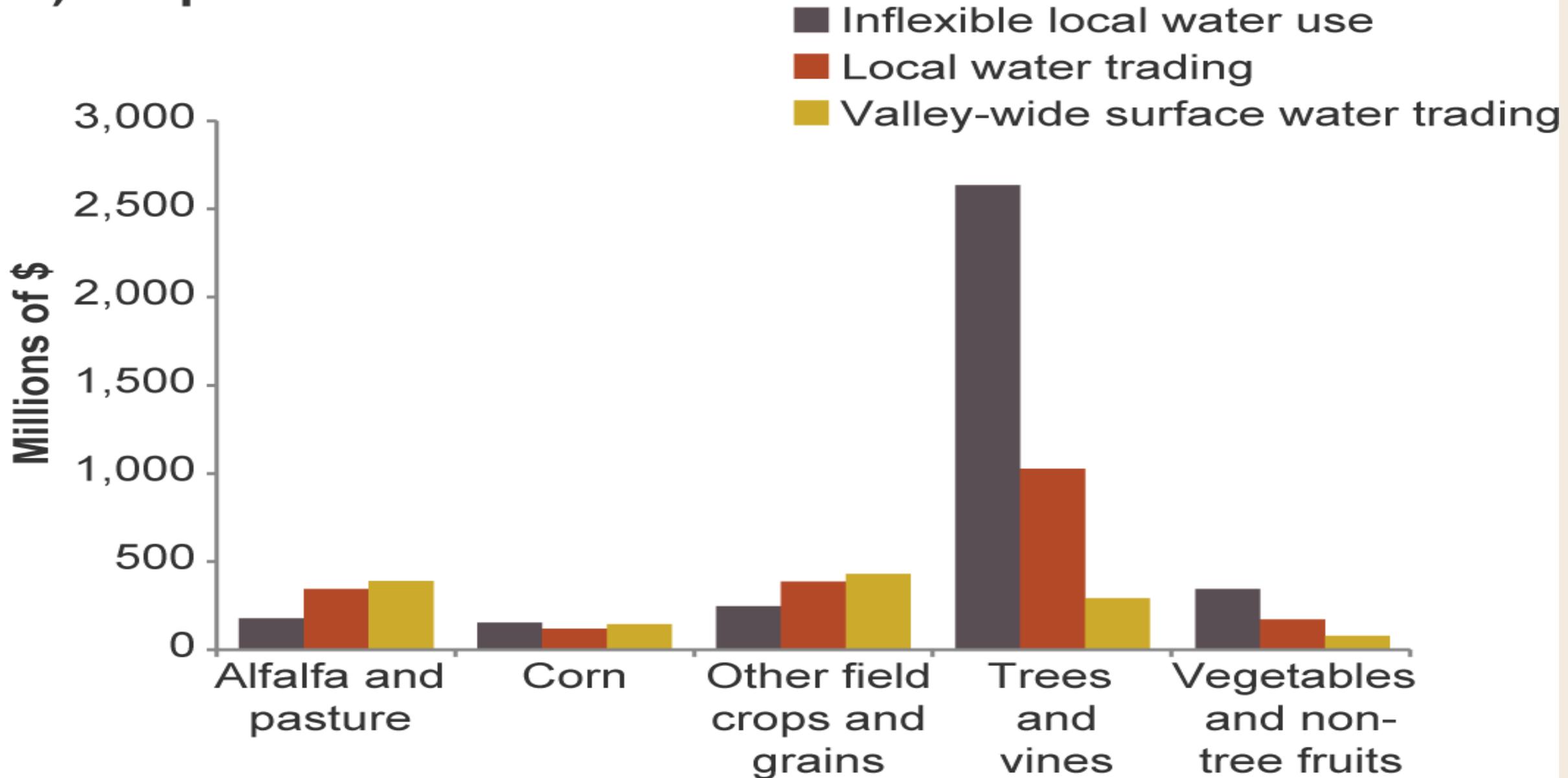
- **California has lots of water on an ongoing long term basis**
- **We have plumbing move water from where it landed to where it is demanded**
- **Year to year and seasonal variability demands storage and plumbing.**
- **Climate projections imply more rain rather than so much snow,**
- **But not less precipitation**
- **Precipitation is harder to project than temperature**
- **Geographically specific projections of the form of precipitation is what we need**

# Average Gallons of Water per Gallon of Wine



# Water Trading Impacts for Crops

## B) Crop revenue losses



# Ownership of California Groundwater

- **Trust in the secure ownership of an asset is crucial for any reasonable economic decisions.**
- **Establishing ownership is key. Security of ownership is even more important.**
- **If ownership can be shifted to another party, say a fish or a bird, or their representatives then investment cannot be securely made.**
- **Will groundwater become like surface water?**
- **Diverted to environmental uses when claims are made?**

# Much work on the Hydrology and Plant Physiology of Groundwater Recharge

- Efforts to recharge are complicated. Research is underway on:
  - Where to focus recharge efforts? Where does the soil make it easy? How do crops react, especially trees, vines and alfalfa? How interconnected are the aquifers?
  - Helen Dahlke is a key researcher in this area and has several plant science coauthors.
  - For example, Dahlke and Dan Putnam have explored the use of alfalfa fields as places for groundwater recharge.

# Ownership and Trading of California Groundwater Overtime

- **When we have secure property rights in groundwater, then:**
  - **Those with suitable land can recharge in the winter when there is little evaporation loss from flooding and delivery costs are low.**
  - **During wet winters have water delivered from canals of rivers, just as they would irrigate in the summer. To “own” this water underground they would need to measure and document the recharge quantity.**

# Ownership and Trading of California Groundwater

- **Much of the analysis has ignored storage and trading of groundwater over time.**
- **Will you have an incentive to “save” groundwater? Do you still own for next year, what you do not pump it this year?**
- **Can you put water into the groundwater basin to store it, and still own it?**
- **Can you sell to a neighbor what you would have pumped five years from now?**
- **Or, do the fish and birds own the water in any drought?**

# Economic Implications from Climate Change Affecting Global Markets

- It is easy to focus too much on the local when climate and market implications are global.
- Just as California emissions affect the global climate, California economic relationships in agriculture are global.
- That means our modeling of adaptation to climate must incorporate global **market** implications.
- It also means climate **elsewhere** affects adjustments in California.
- When adaptation elsewhere affects the global supply & demand balance, California farms and ranchers adjustments to those **market** changes may outweigh changing climate here!

## **Policy Priorities Relevant for Climate Change in California**

- **Invest in public agricultural R&D**
- **Harness agricultural biotechnology as a potentially important option**
- **Encourage complementarities between public and private agricultural research**
- **Invest in better information & forecasts**

**Thank you**

