

# Estimación Económica de la Sequía en California

**Josué Medellín-Azuara**

*Profesor Asociado, Ingeniería Civil y Ambiental*

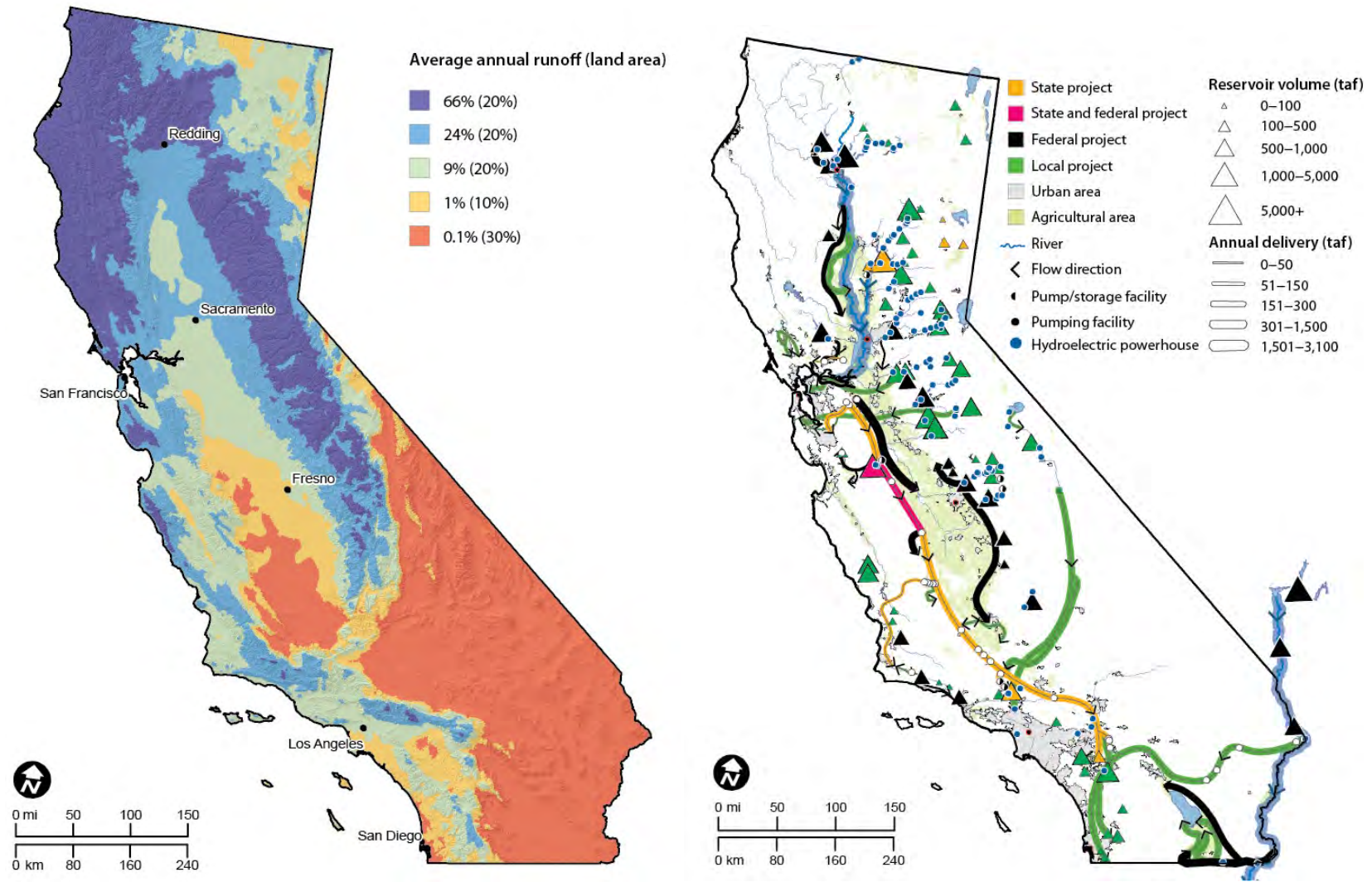
*Director Asociado, UC Agricultural Issues Center,*

*Director Asociado, Center Watershed Sciences,*

Ciclo de Seminarios: Evaluación Económica de la Mega-Sequía

Universidad de Chile, Santiago de Chile, Abril 27, 2021

# Rercursos Hídricos en California



Hanak et al. (2011) *Managing California's Water*





Josue Medellin-Azuara, UC Merced



.. and floods!





# Whiplash weather in California

nature climate change

[Explore content](#) ▾ [Journal information](#) ▾ [Publish with us](#) ▾ [Subscribe](#)

[nature](#) > [nature climate change](#) > [articles](#) > [article](#)

Article | Published: 23 April 2018

## Increasing precipitation volatility in twenty-first-century California

Daniel L. Swain [✉](#), Baird Langenbrunner, J. David Neelin & Alex Hall

*Nature Climate Change* **8**, 427–433(2018) | [Cite this article](#)

**6134** Accesses | **233** Citations | **1951** Altmetric | [Metrics](#)

### Abstract

Mediterranean climate regimes are particularly susceptible to rapid shifts between drought and flood—of which, California’s rapid transition from record multi-year dryness between 2012 and 2016 to extreme wetness during the 2016–2017 winter provides a dramatic example. Projected future changes in such dry-to-wet events, however, remain inadequately

Josue Medellin-Azuara, UC Merced

Oroville dam spillway



Monticello dam spillway



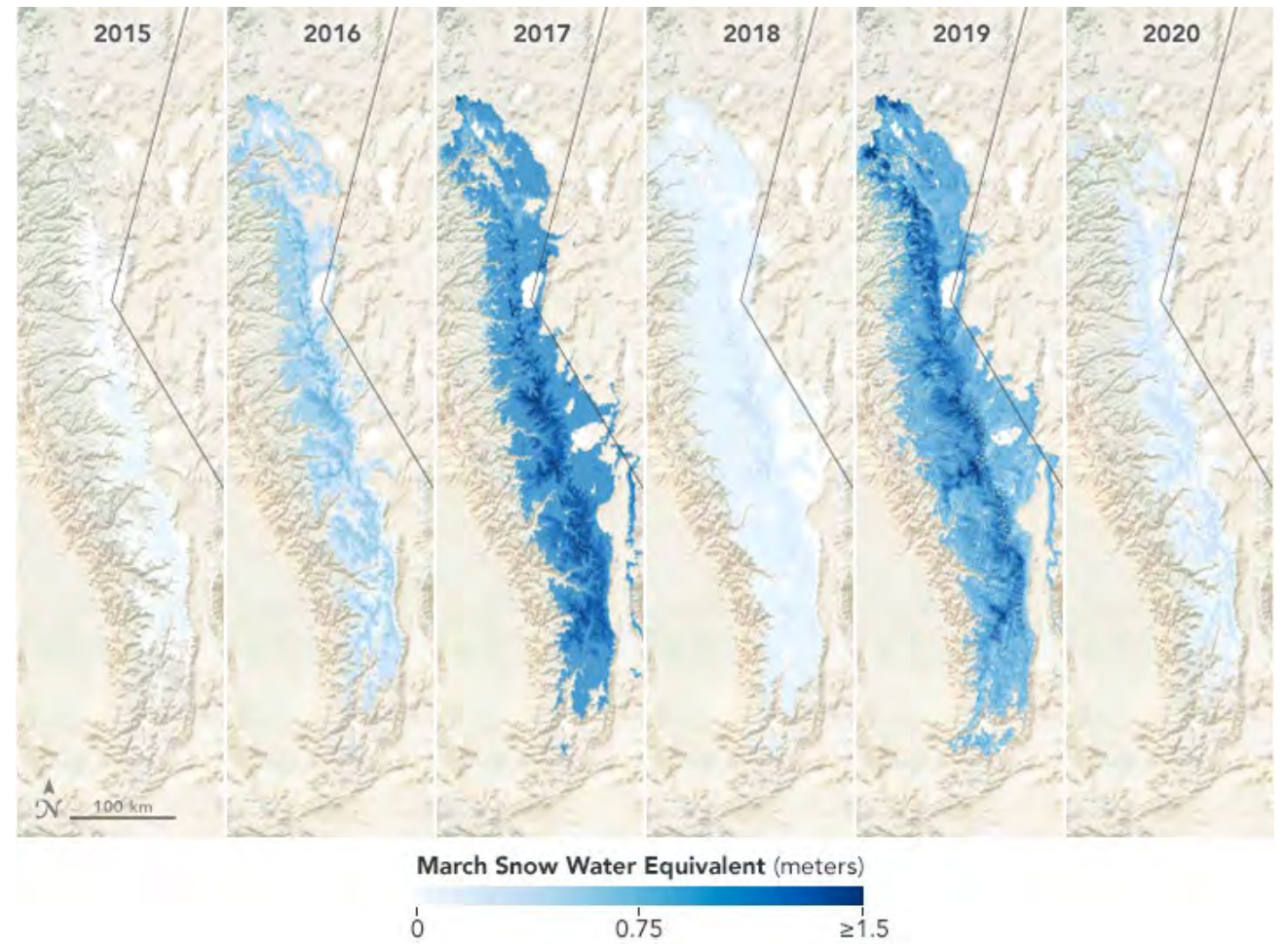




2017



2020



# Sierra Nevada Snow Cover and Snow Water Equivalent

Source: <https://earthobservatory.nasa.gov/images/146424/thin-snow-cover-in-the-sierra-nevada>

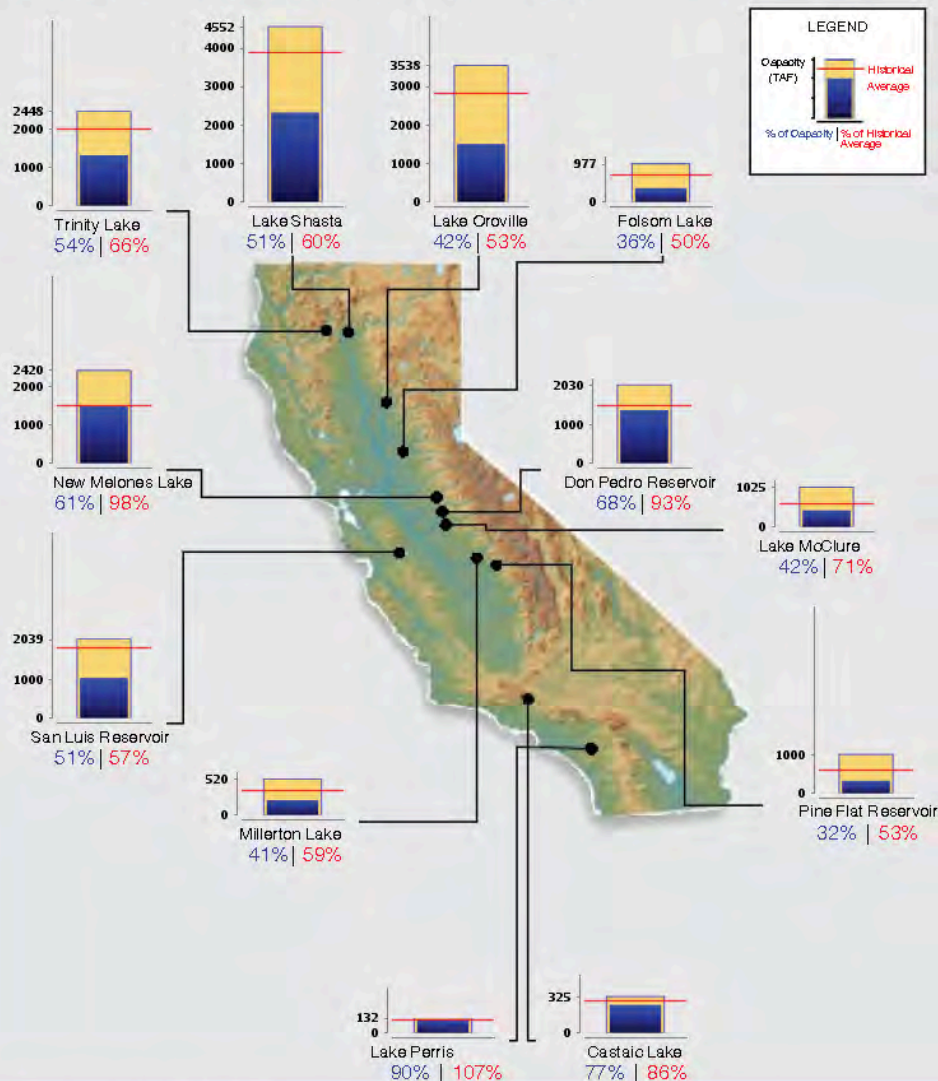




# Reservoir Conditions

Ending At Midnight - April 25, 2021

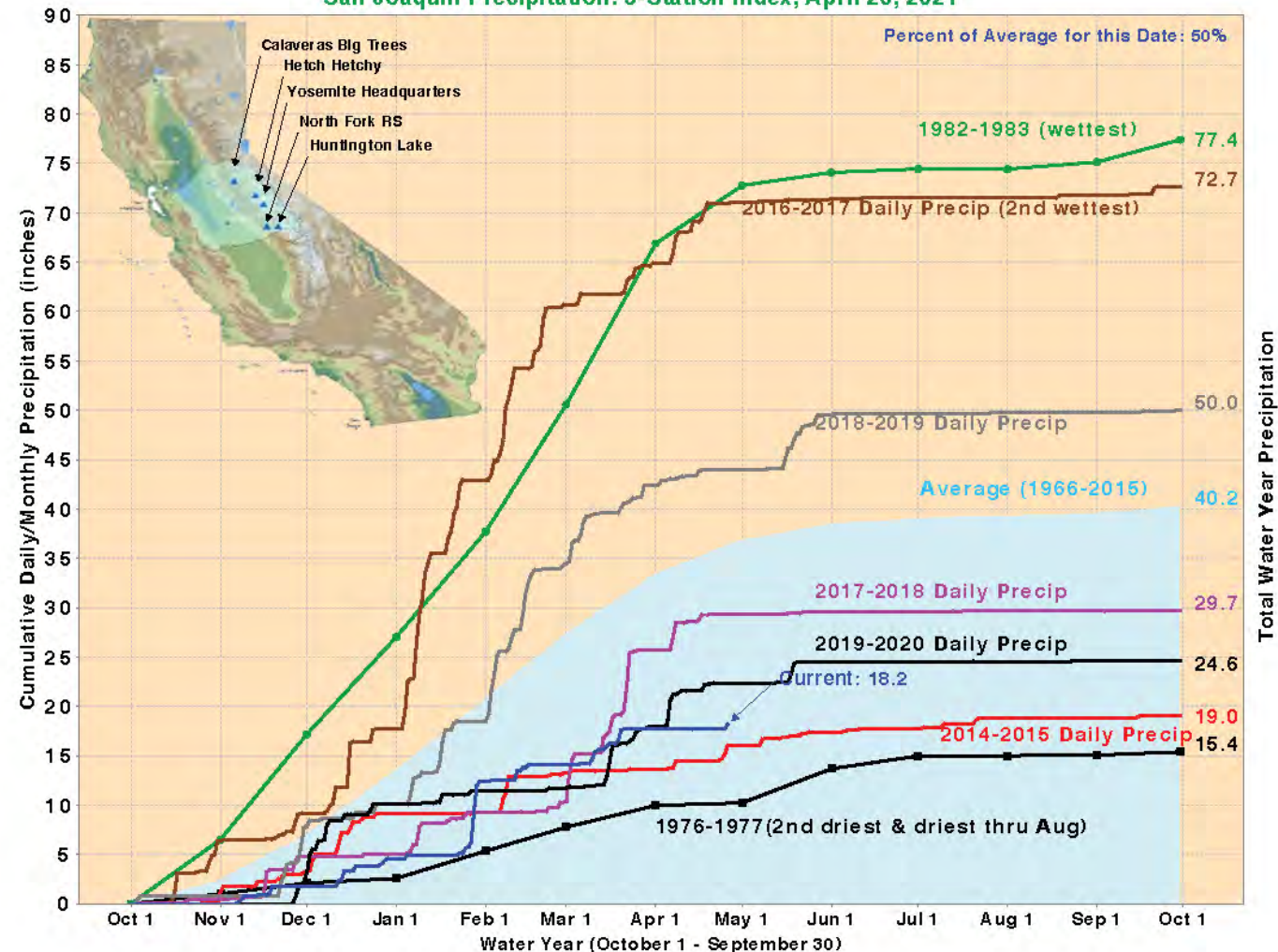
## CURRENT RESERVOIR CONDITIONS



Graph Updated 04/26/2021 04:48 PM

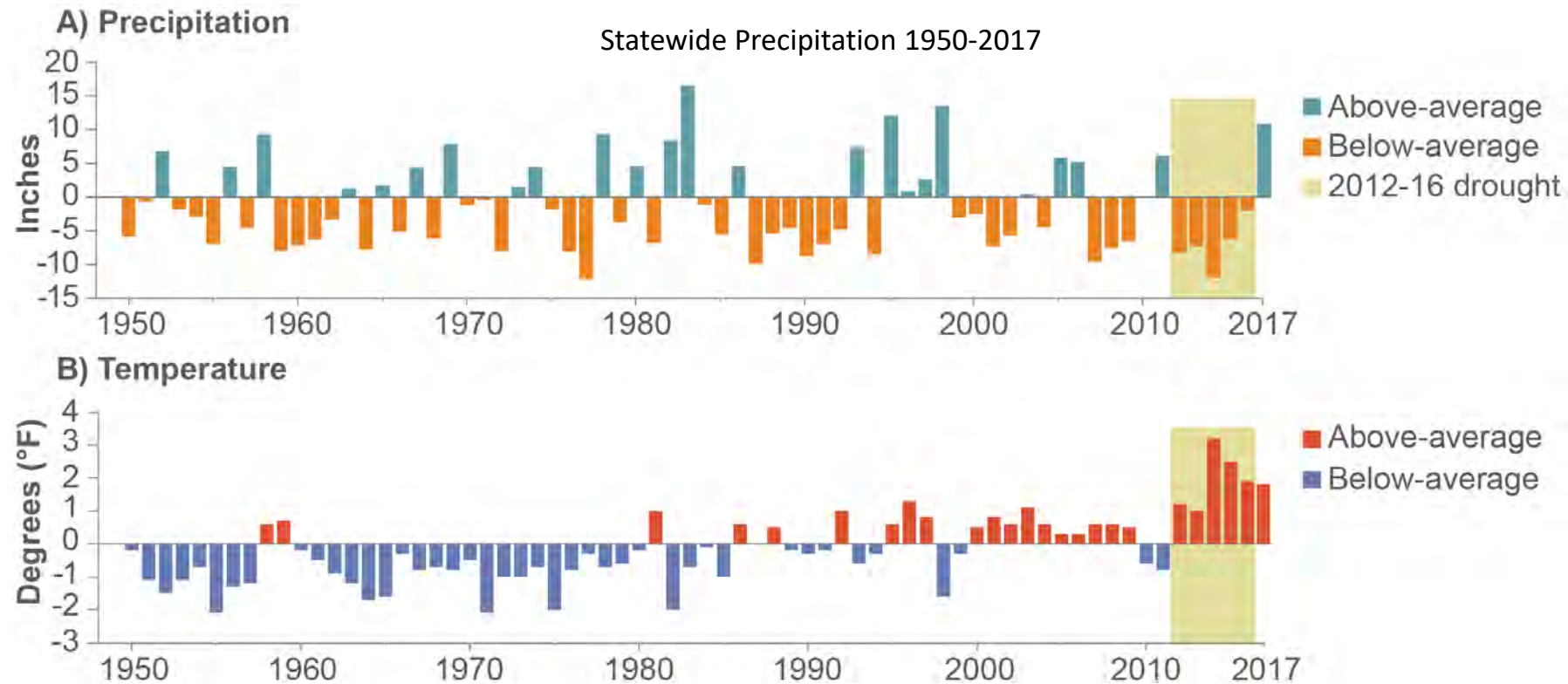
# Current Conditions

## San Joaquin Precipitation: 5-Station Index, April 26, 2021



Josue Medellin-Azuara, UC Merced

# Managing for extremes became the new normal





# 2015 Drought Emergency Declaration

Triggers funds  
for assessments  
and response

APRIL 2, 2015

## Record-low snowpack: Bad news for California, say Stanford experts

*The snowpack in California's mountains is at the lowest level ever recorded. The long-term effects of the drought could be devastating.*



This week California water officials performed one of their regular measurements of the state's snowpack and confirmed it is a startling 5 percent of normal – the lowest April 1 total on record. That accumulation of snow in the state's mountains – specifically the Sierra Nevada – serves as natural “frozen storage” for surface water supplies. Its runoff feeds streams, rivers and reservoirs throughout the year and provides about 30 percent of the water Californians depend on for drinking, growing food and other uses in a typical year.

The California snowpack is historically at its peak by this time of the year, but has been hindered



Frank Gehrke, left, chief of the California Cooperative Snow Surveys Program for the Department of Water Resources, points to a mark on the snow pack measuring pole that was the lowest previous snow pack level, as Gov. Jerry Brown, center, and Mark Cowin, director of the Department of Water Resources, look on at a news conference near Echo Summit, California, on April 1, 2015. (Image credit: AP Photo/Rich Pedroncelli)

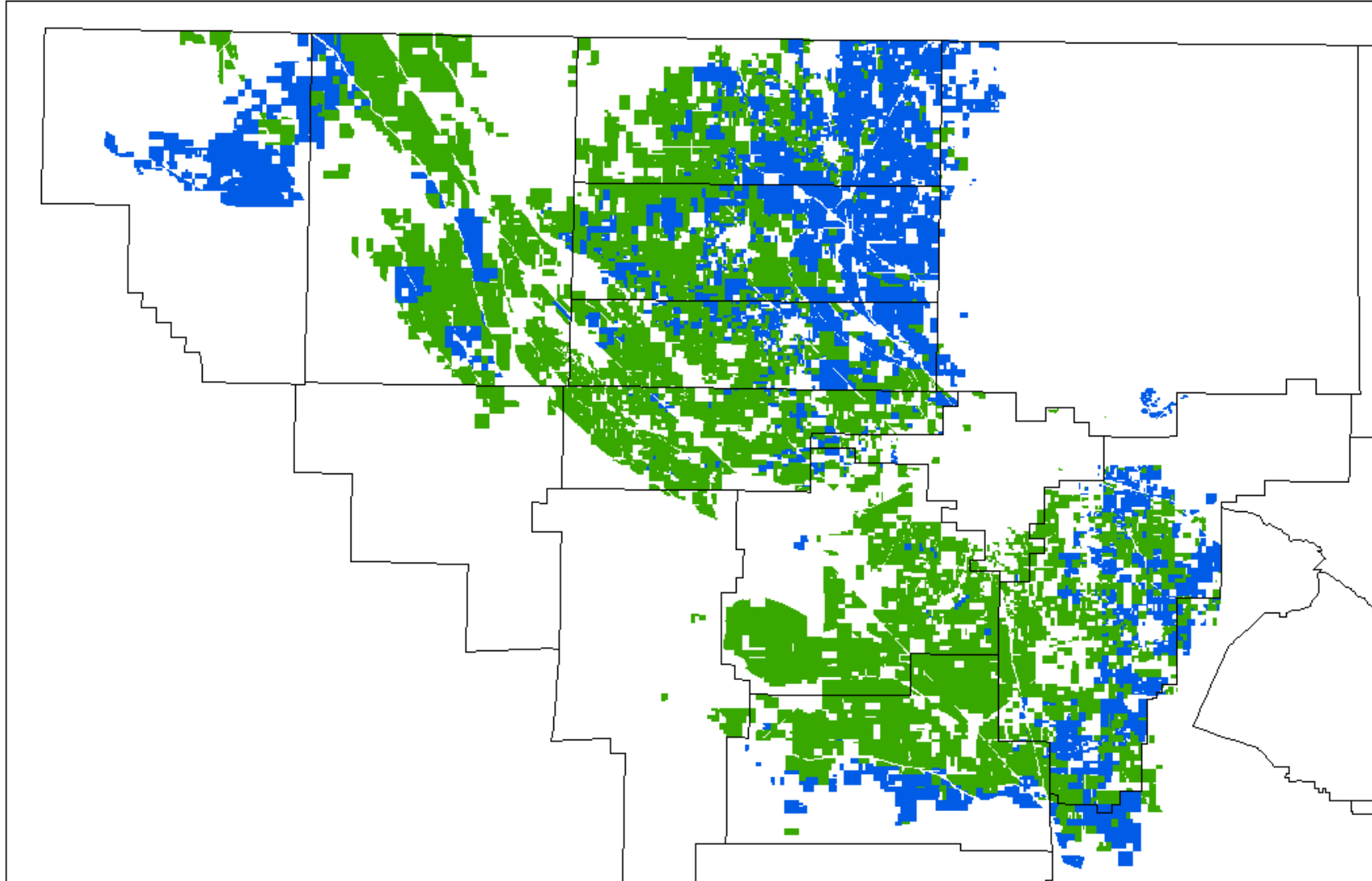
# What have we learned from recent droughts: Agriculture, Cities, Environmental Systems and Rural Water Systems?



# Califor Power

- \$54+ B
- 300+ c
- 9+ M a
- 450,00
- Large
- More
- (75-80
- Trend

1997



Perennial
  Annual

Josue Medellin-Azuara, UC Merced

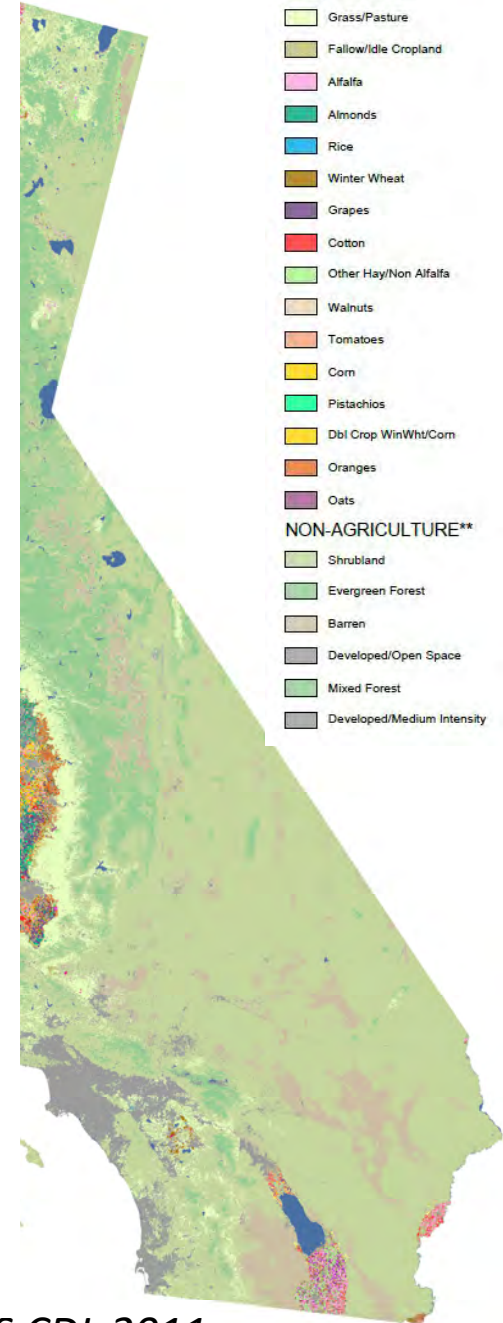
Land Cover Categories  
(by decreasing acreage)

## AGRICULTURE\*

- Grass/Pasture
- Fallow/Idle Cropland
- Alfalfa
- Almonds
- Rice
- Winter Wheat
- Grapes
- Cotton
- Other Hay/Non Alfalfa
- Walnuts
- Tomatoes
- Corn
- Pistachios
- Dist Crop WinWht/Corn
- Oranges
- Oats

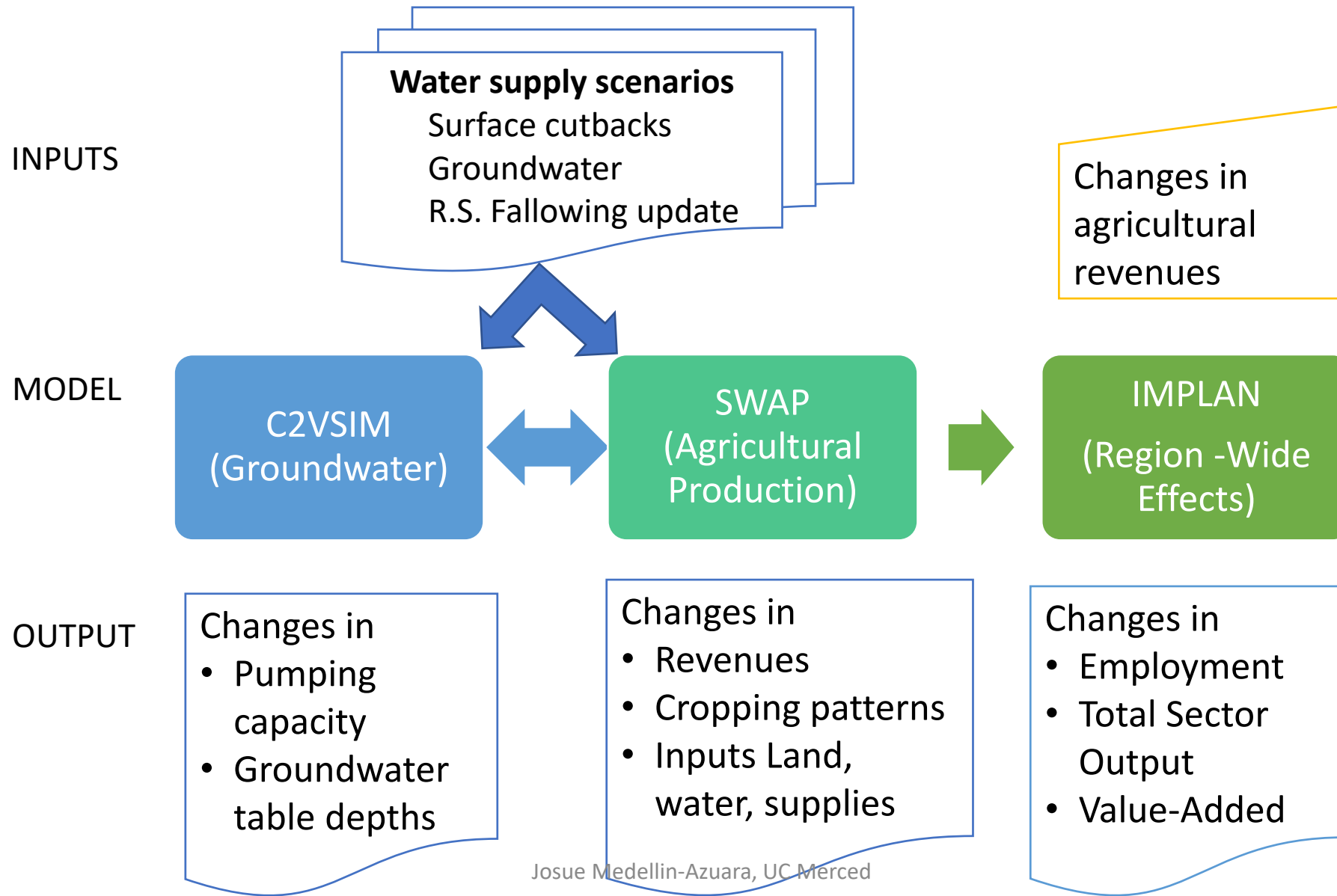
## NON-AGRICULTURE\*\*

- Shrubland
- Evergreen Forest
- Barren
- Developed/Open Space
- Mixed Forest
- Developed/Medium Intensity



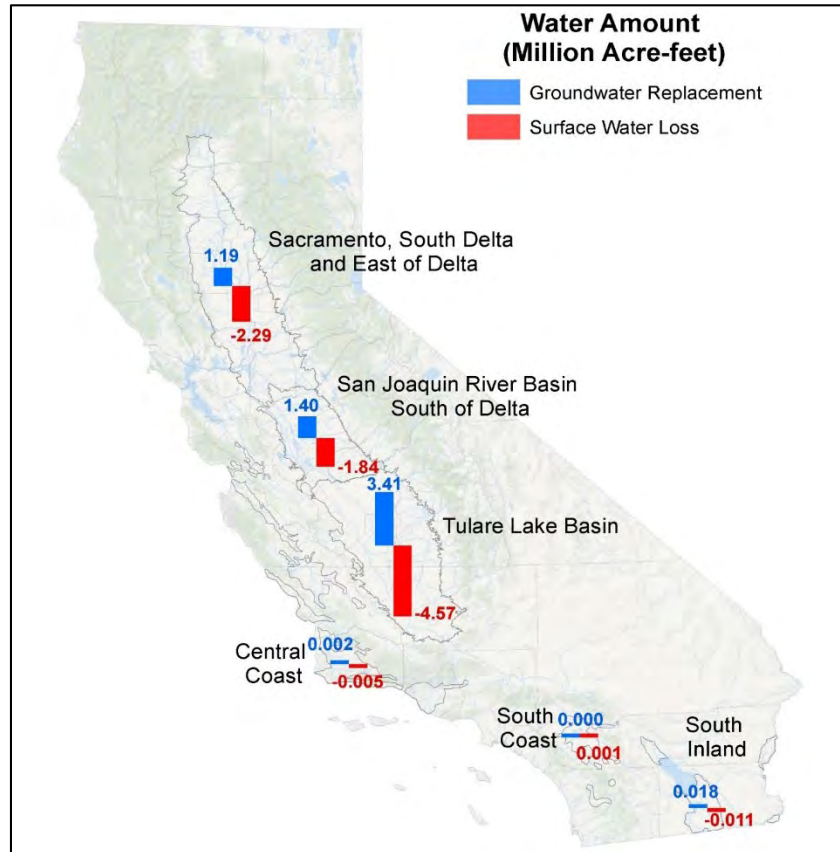
Source: NASS CDL 2011

# Models integrate physical and socioeconomic aspects in agricultural production to investigate drought impacts



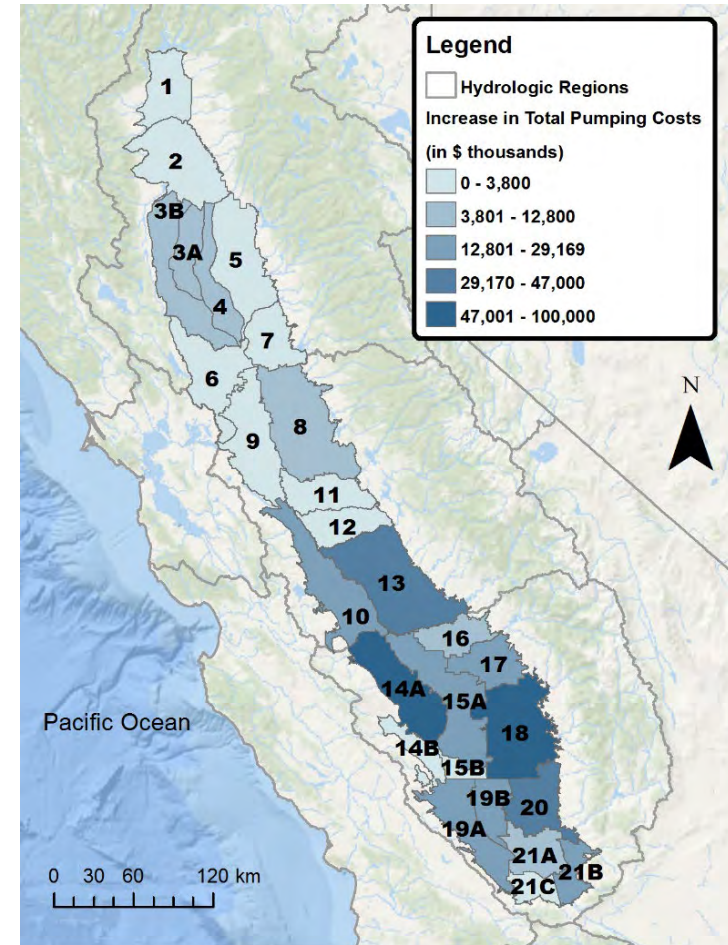


# Study of recent droughts highlight the role of groundwater in agriculture



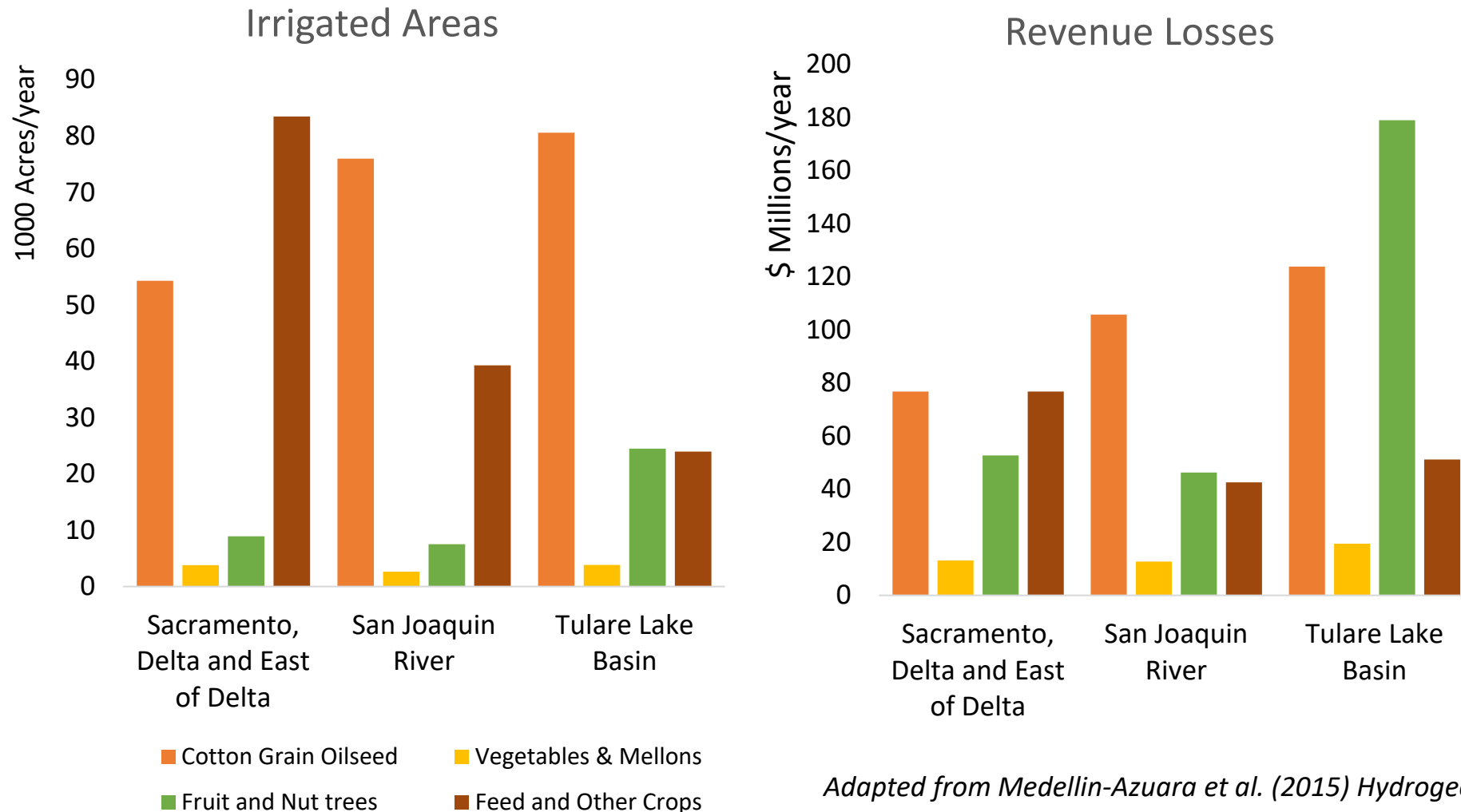
<http://droughtimpacts.ucdavis.edu>

[Also see: Why California needs better groundwater management](#)



*Medellin-Azuara et al. (2015) Hydrogeology Journal*

During droughts affected irrigated areas vary by crop and region. Field, grain, and feed crops are more vulnerable



*Adapted from Medellin-Azuara et al. (2015) Hydrogeology Journal*

Josue Medellin-Azuara, UC Merced



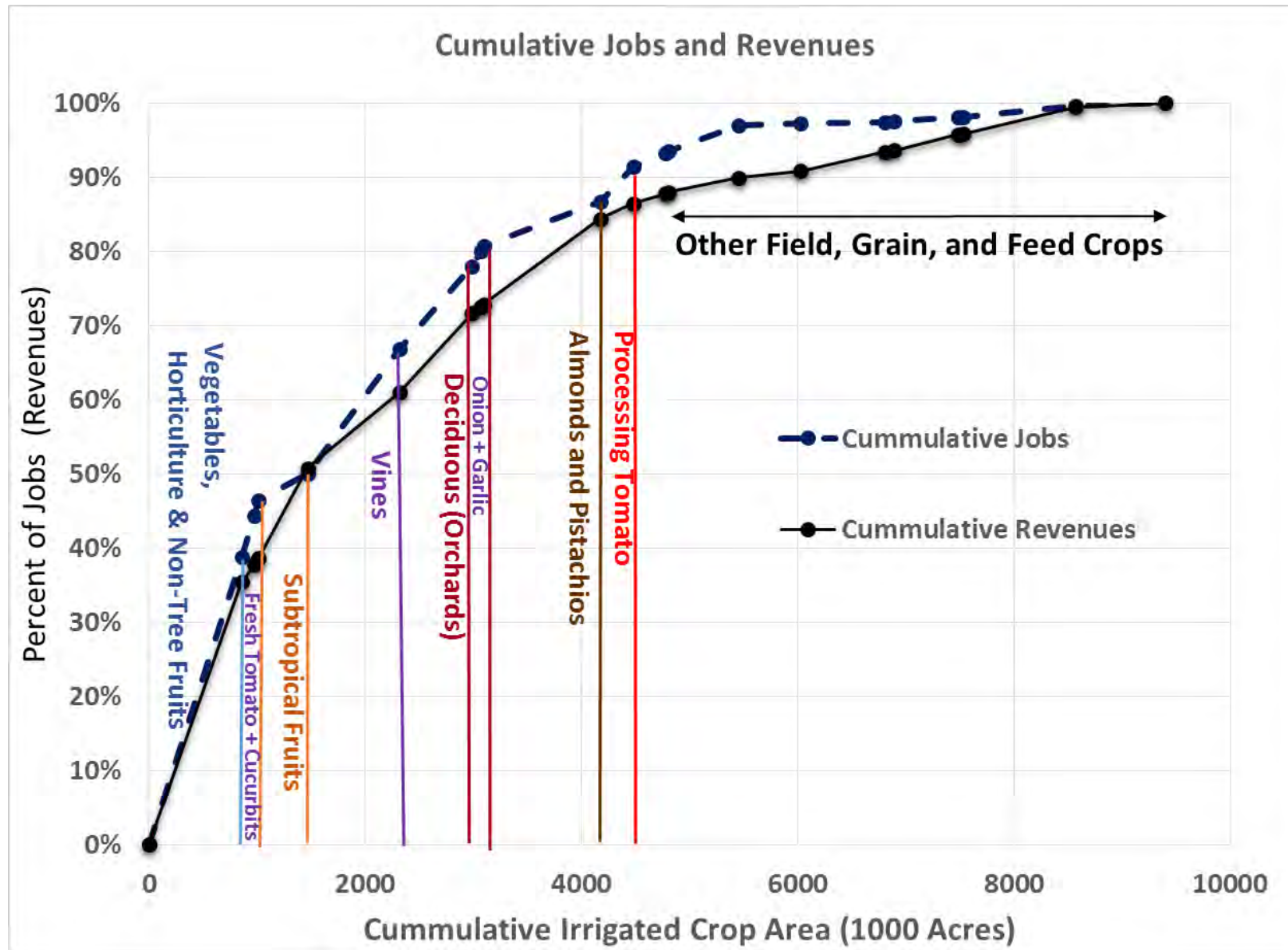
# Overall 2015 Drought Economic Impact

Impact	Quantity	
Water supply, 2015 drought	Percent Change	
Surface water reduction	8.7 MAF/yr	-48%
Groundwater pumping increase	6.0 MAF/yr	72%
Net water shortage	2.7 MAF/yr	-10%
Statewide Agriculture Economic Impacts		
Total fallow ( Irrigated crop area 9.3 million acres)	540,000 acres	-5.8%
Crop revenue loss	\$900 million	-2.6%
Additional groundwater pumping cost	\$590 million	75.5%
Livestock and dairy revenue loss	\$350 million	-2.8%
Total direct costs	<b>\$1.8 billion</b>	
Total agriculture economic costs	\$2.7 billion	
Direct job losses	<b>10,100</b>	<b>-2.5%*</b>
Total job losses	21,000	

Josue Medellin-Azuara, UC Merced

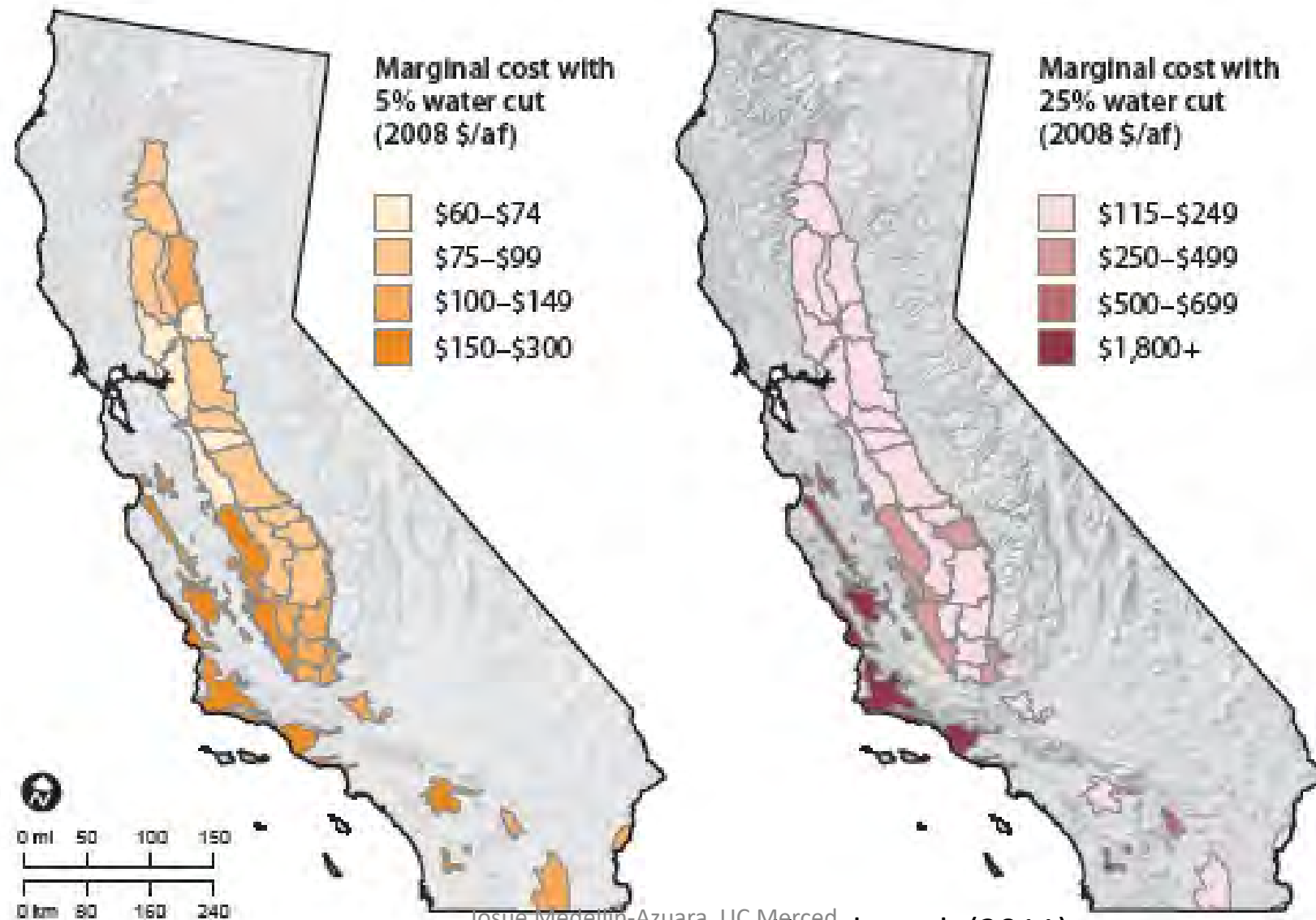
\*considering undocumented work force <http://droughtimpacts.ucdavis.edu>

In crop farming, most employment and economic value is in fruits, nuts and vegetables





# There is a wide range of value in agricultural water use



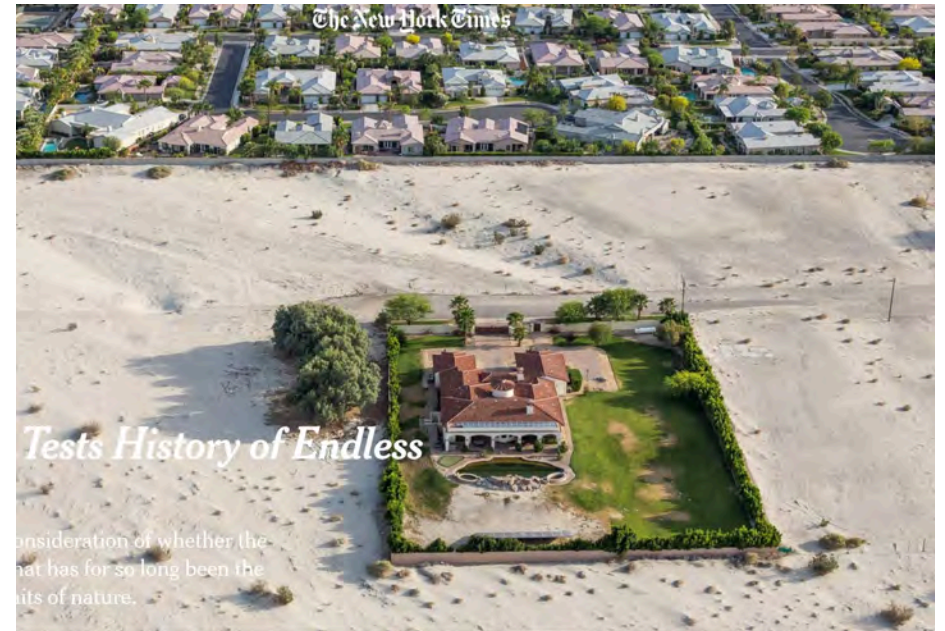
Josue Medellin-Azuara, UC Merced

Hanak et al. (2011)

# Other Sectors Weathering Droughts: Large Urban Systems



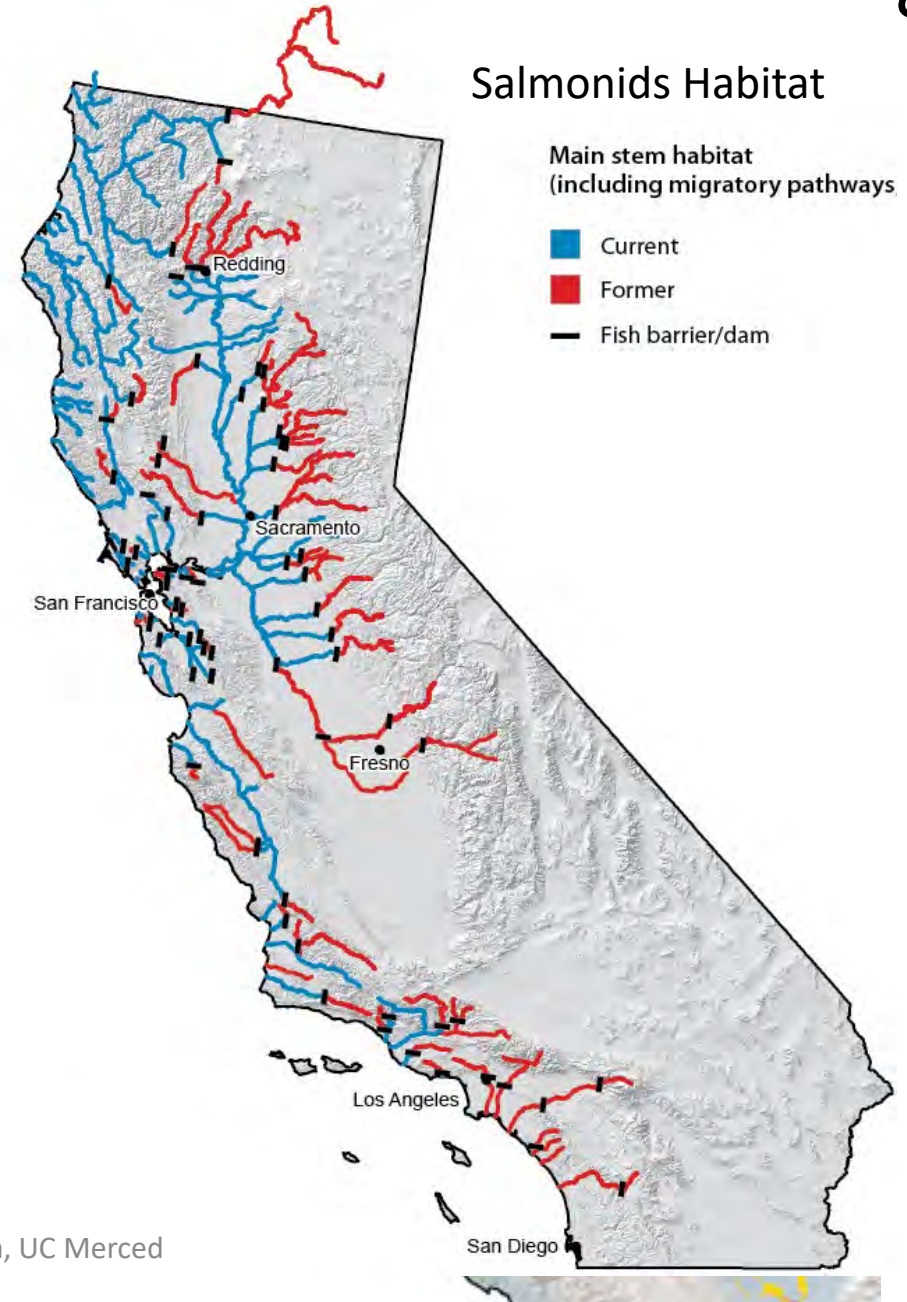
- A Portfolio Approach
- Water Markets
- Conservation Programs
- Investments Paying Off
- Some exceptions: Santa Cruz
- Challenges to maintain operating and fixed costs





# Ecosystems are often more vulnerable to droughts

- No price signals
- Disruption in the natural landscape
- Reduced control of farm inputs and outputs
- Decline in native species, and establishment of invasive species
- Disturbance of natural pollination and other insect interaction

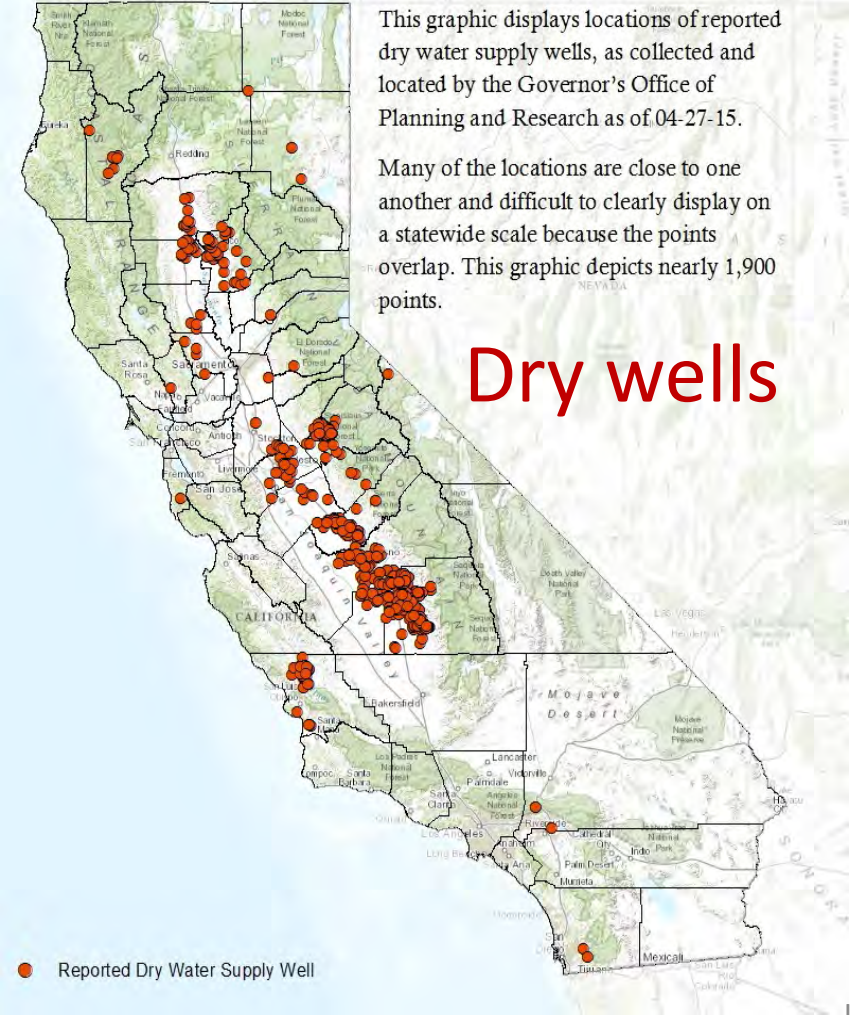


*Hanak et al. (2011) Managing California's Water*

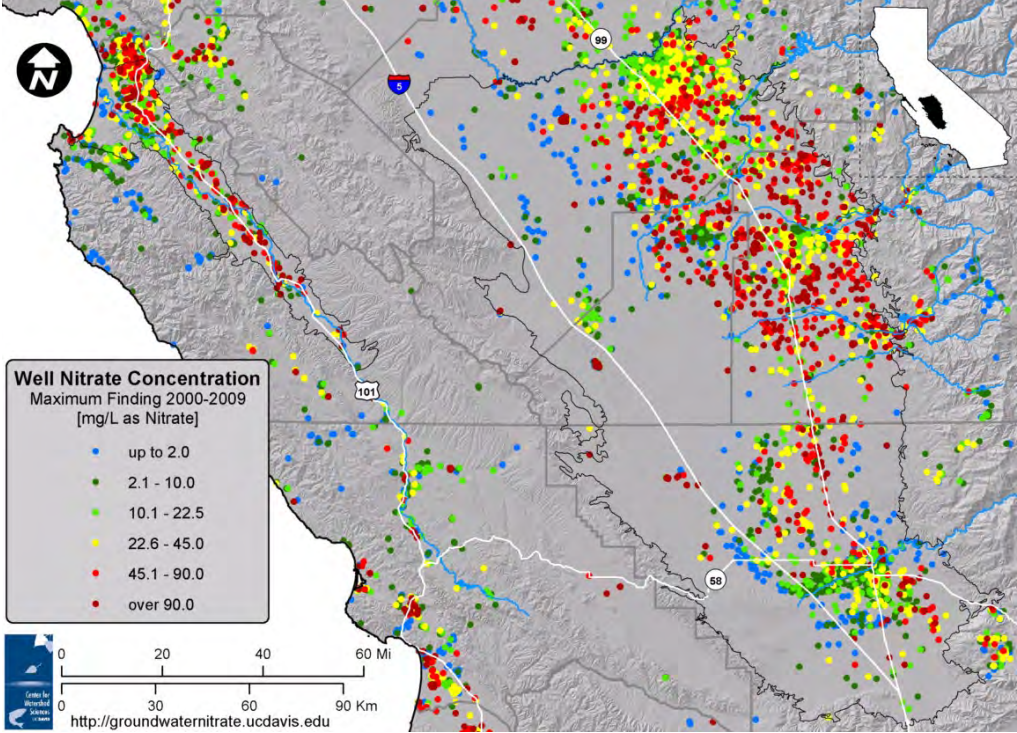
*Null, Medellin-Azuara, Escrivá-Bou, Lent, Lund (2014) Optimizing the Dammed, JEMA*

Josue Medellin-Azuara, UC Merced

# Water Quantity and Quality Issues in Small Rural Water Systems



## Concentration of Pollutants



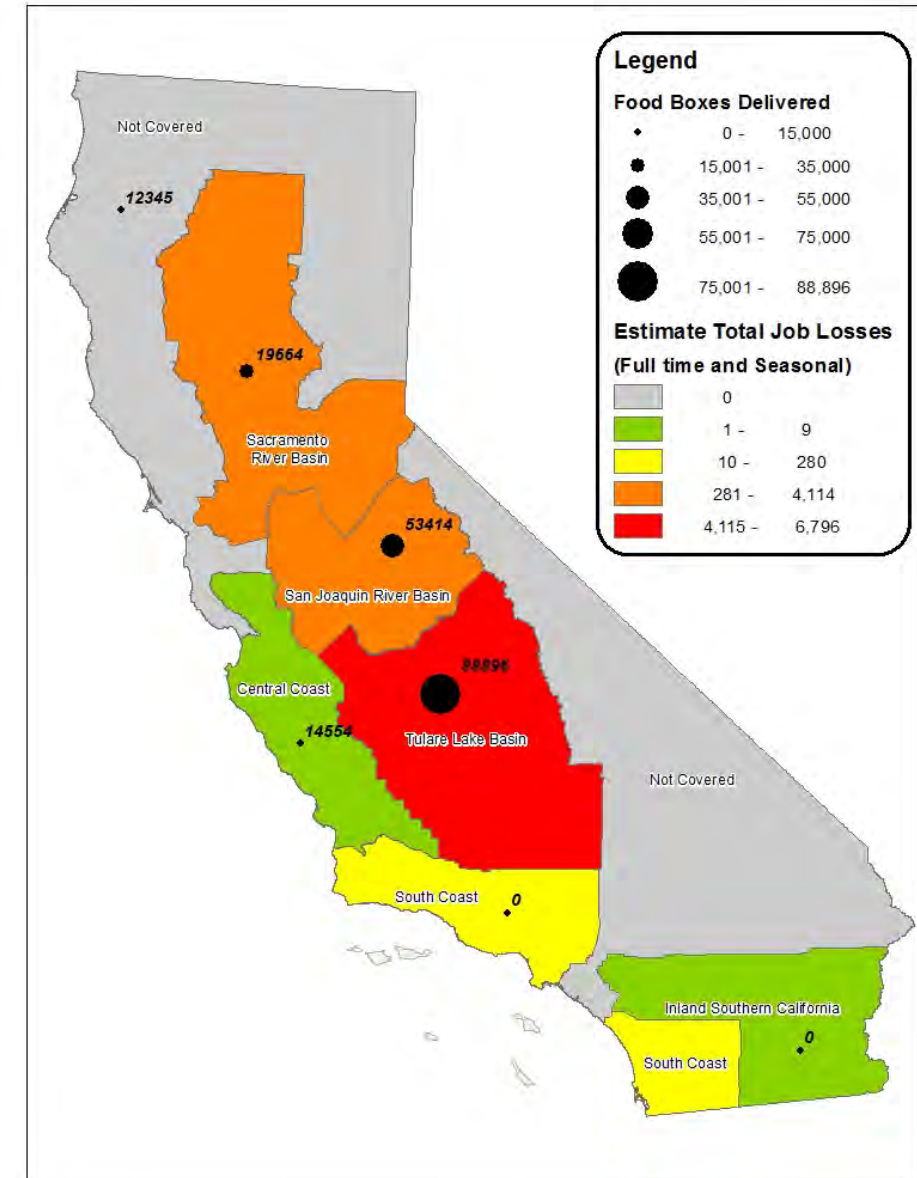


# Job Losses and Boxes Delivered by Emergency Services

- Food boxes were delivered to regions with job losses
- Tulare Lake Basin is the most seriously affected

## Migrant & Seasonal Farm Worker Emergency Drought Relief Needs Assessment Report

Prepared for: California Department of Community Services & Development  
Prepared by: La Cooperativa de Campesina, Profile Research & Marketing, Inc.  
Date: November, 2015



# Some Lessons from Recent Droughts

- Droughts focus attention and encourage improvement in water management
- A diversified economy with deep global connections significantly buffers economic effects of droughts
- Major drought and climate change have much less impacts on irrigated water systems with diversified supply
- Ecosystems were the most affected by the drought
- Small rural water systems are particularly vulnerable to drought
- Every drought is different



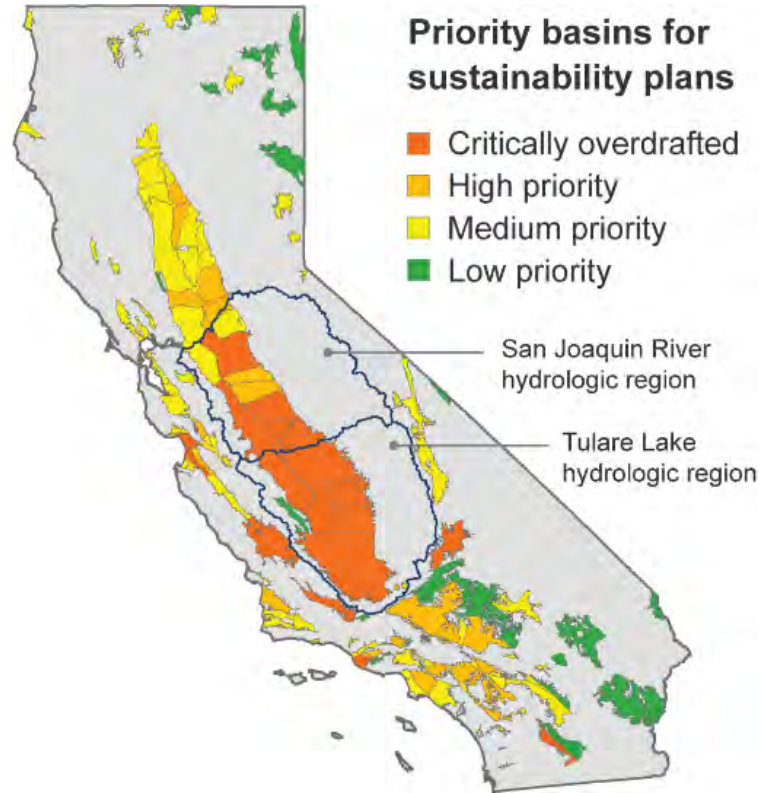
Lund et al. (2018) JWRPM

Josue Medellin-Azuara, UC Merced

Photo Credit: DWR



# Challenges for Future Drought: Sustainable Groundwater Management Act of 2014



- Most of the San Joaquin Valley groundwater basins are critically overdrafted
- Consequences are dry wells, sinking lands, reduced supplies for droughts
- Most basins must adopt plans by 2020, achieve sustainability by 2040
- Attaining balance means more recharge, less water use, or both
- Impacts will vary across the region



MARCH 2017

Ellen Hanak,  
Jay Lund,  
Brad Arnold,  
Alvar Escriva-Bou,  
Brian Gray,  
Sarge Green,  
Thomas Harter,  
Richard Howitt,  
Duncan MacEwan,  
Josué Medellín-Azuara,  
Peter Moyle,  
Nathaniel Seavy  
with research support  
from Jelena  
Jezdimirovic

*Supported with funding  
from the S. D. Bechtel,  
Jr. Foundation, the  
TomKat Foundation,  
and the US  
Environmental  
Protection Agency*

## Water Stress and a Changing San Joaquin Valley

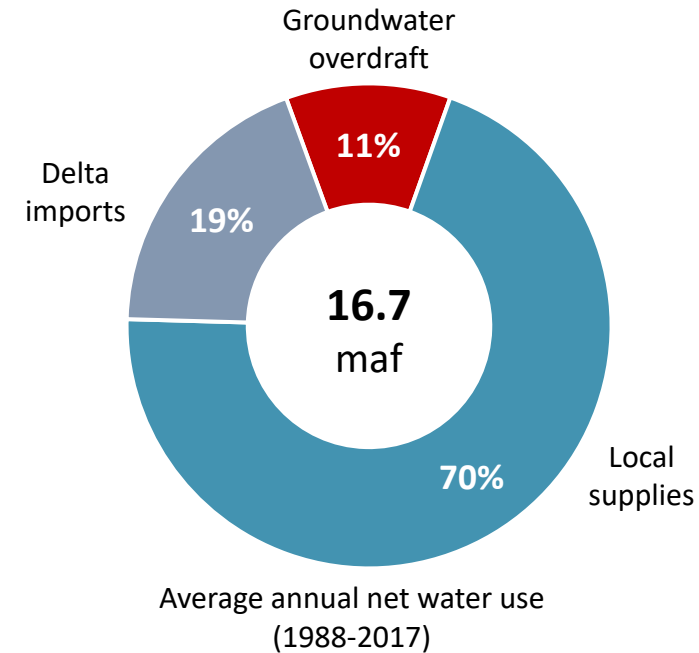
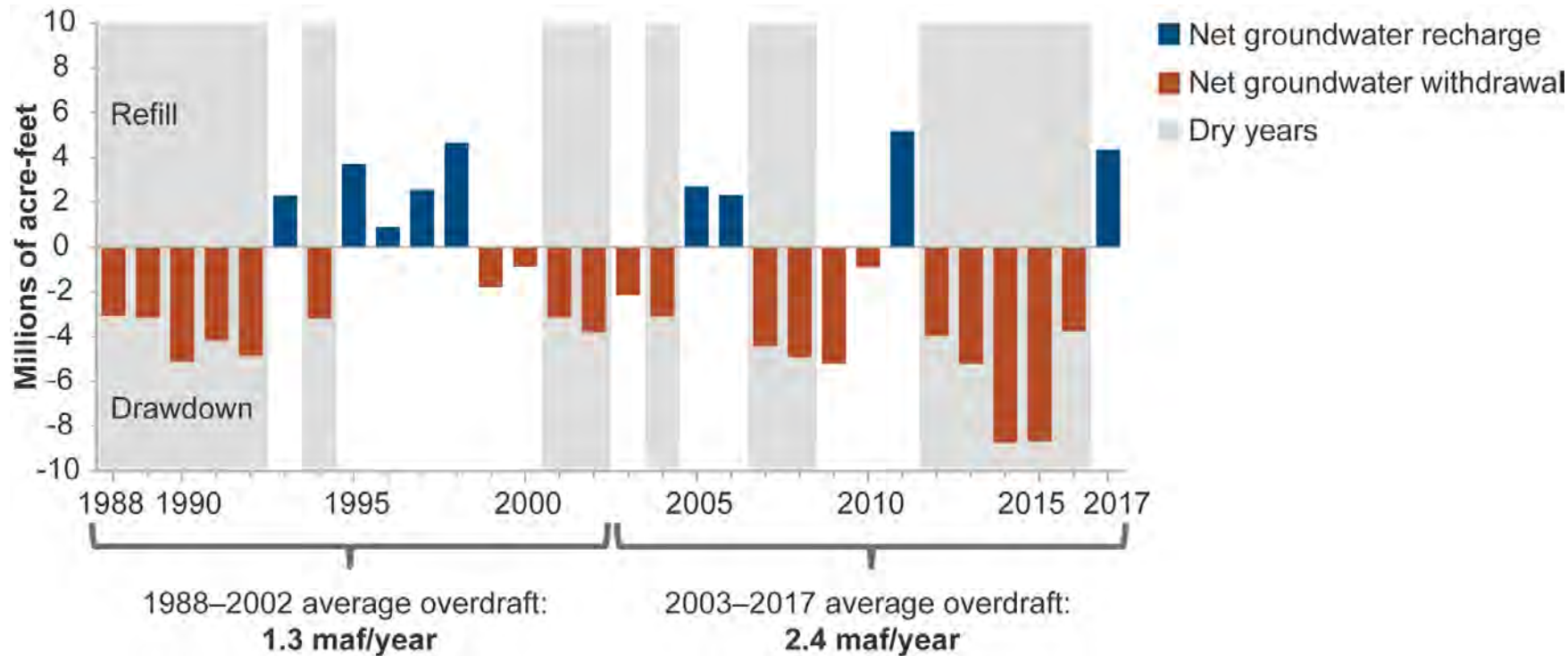


FIGURE A16  
Average water balance in the San Joaquin Valley, 1986–2015



# The San Joaquin Valley relies on groundwater overdraft to deal with its long-term water imbalance

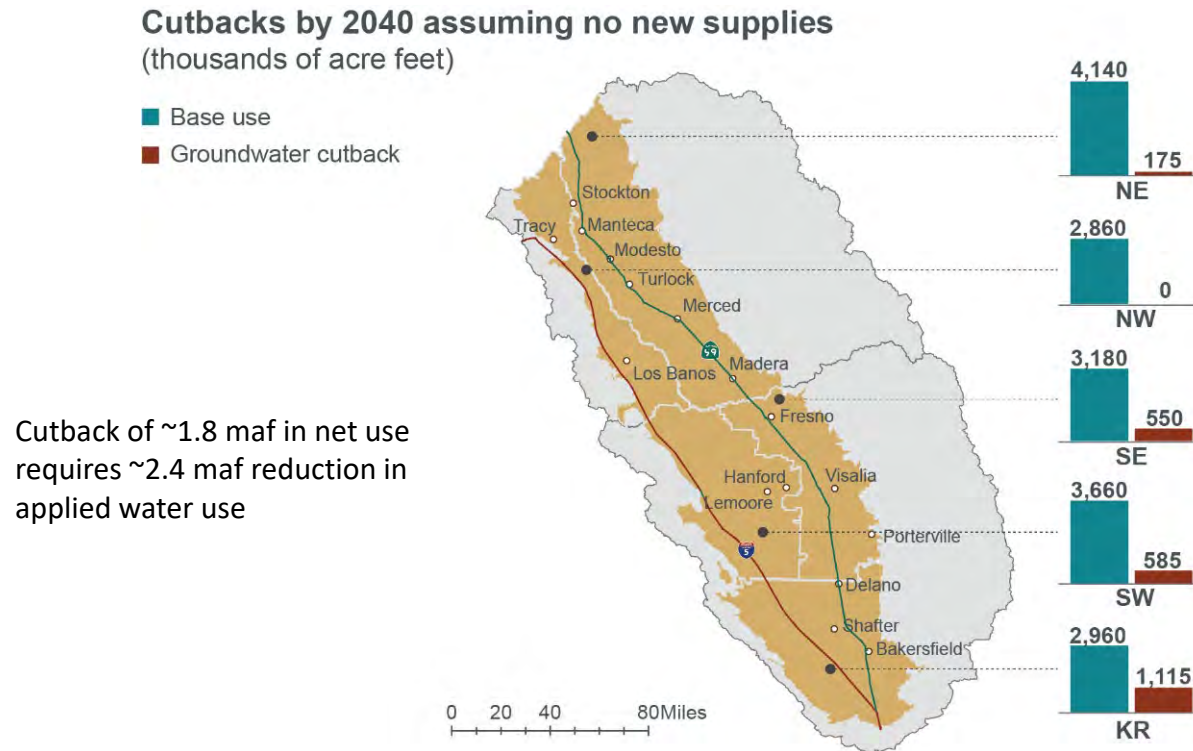
- 30-year valley-wide deficit (1988-2017): 1.8 maf/year



Hanak *et al.* (2019)

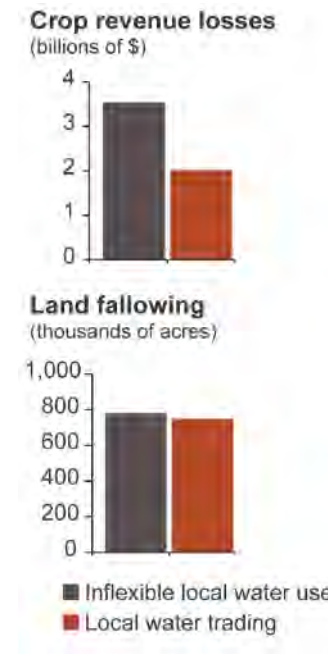


# Long-term groundwater balance in the SJV will require pumping cutbacks in some locations



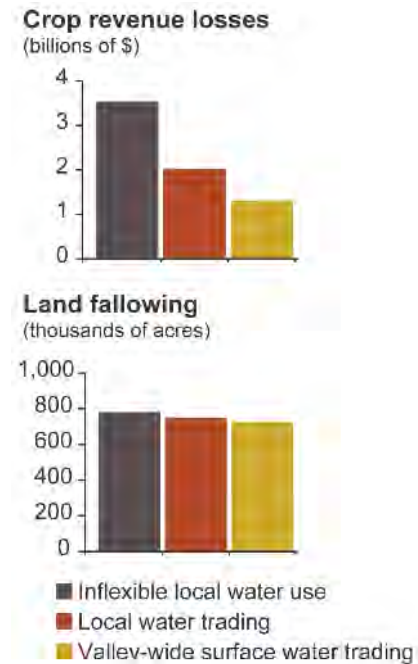
# Flexibility is key to managing farm water demand

- Inflexible water use is very costly
- Local water trading slashes costs



# Flexibility is key to managing farm water demand

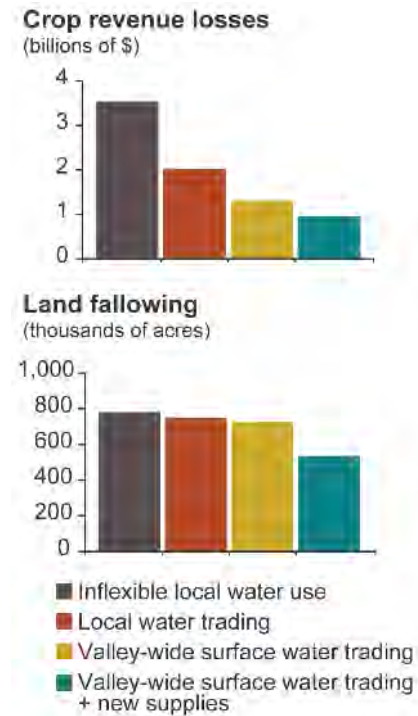
- Inflexible water use is very costly
- Local water trading slashes costs
- Valley-wide surface water trading cuts costs further



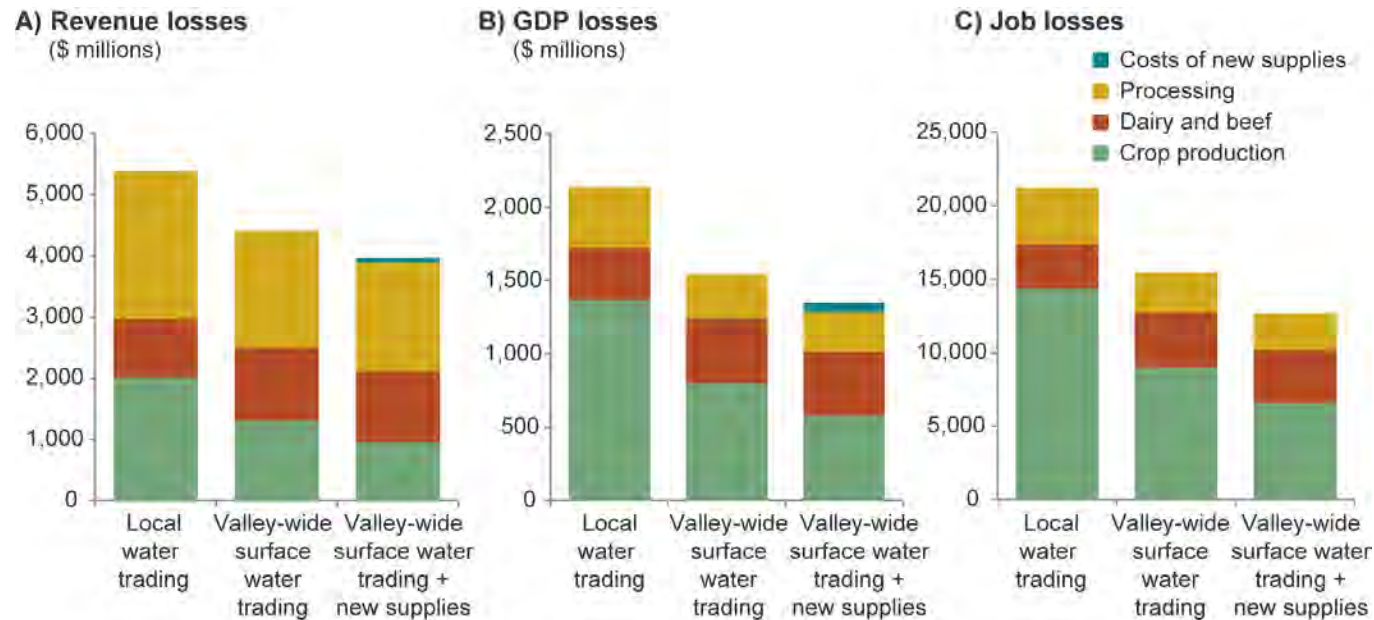


# Flexibility is key to managing farm water demand

- Inflexible water use is very costly
- Local water trading slashes costs
- Valley-wide surface water trading cuts costs further
- Trading + new supplies also cuts land fallowing



# A portfolio approach can minimize regional economic losses



- Gradually ending overdraft (“glide path”) can also help

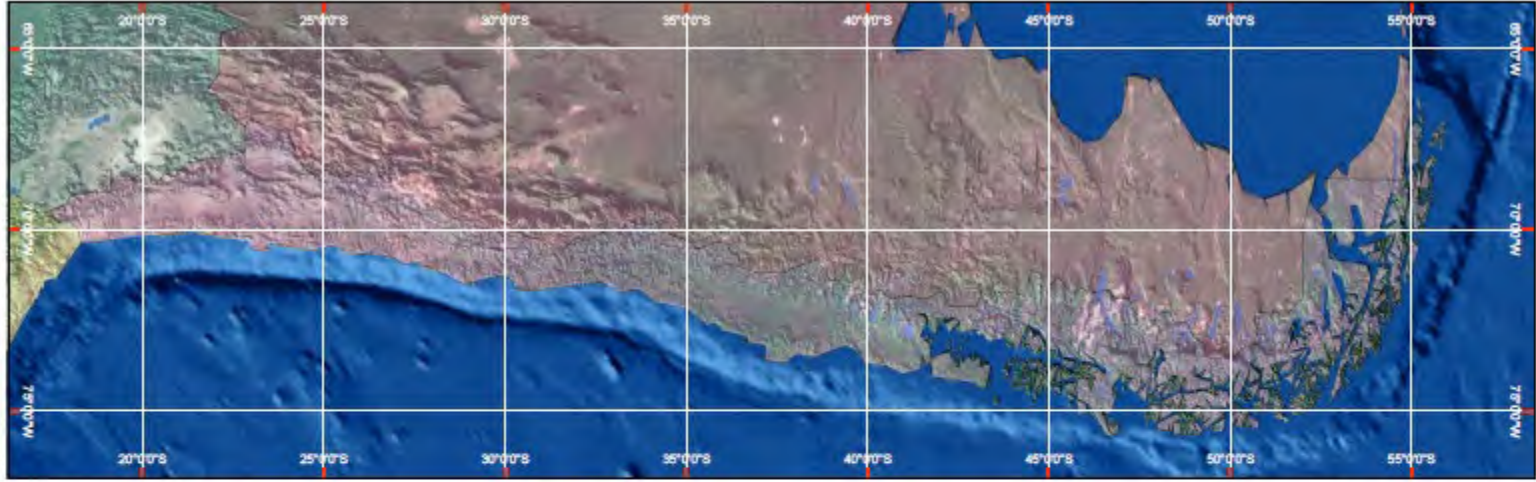


# Additional Concluding Remarks

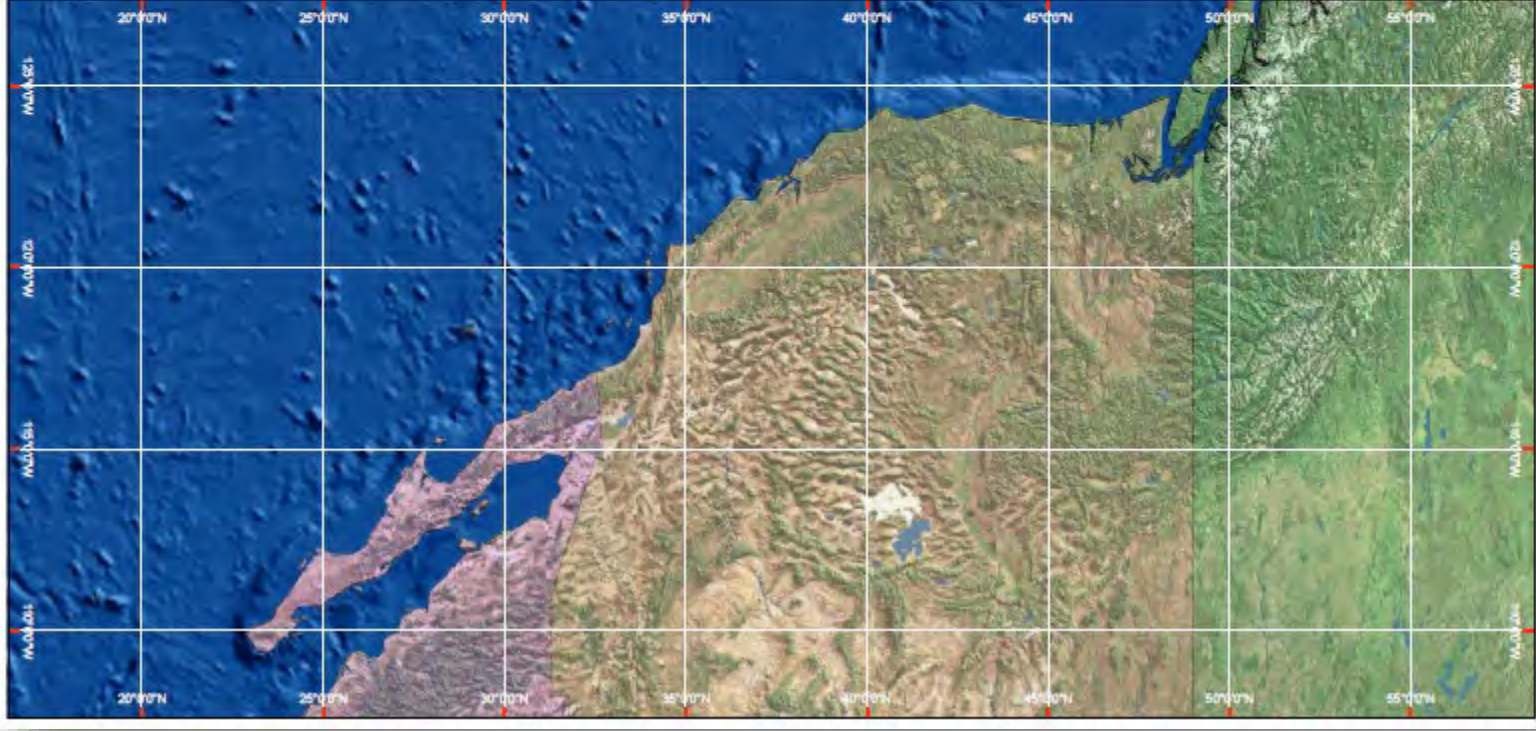
- The 2014 CA Sustainable Groundwater Management Act (SGMA) brings challenges and forces creativity and cooperation to reduce basin-scale water imbalance
- Hydro-economic models are useful to explore both demand and supply management alternatives
- In demand management, increased water allocation flexibility can dampen economic costs of achieving sustainability
- Supply management actions can also vary widely in costs. Increased local runoff capture is the most affordable alternative to farmers



Chile



California







# iGracias!

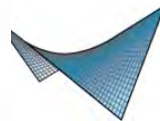
I am grateful for current and past collaboration my many colleagues at UC Davis and other institutions, in particular: Jay Lund, Ellen Hanak, Richard Howitt, Alvar Escriva-Bou and Daniel Sumner

Contact information: [jmedellin@ucmerced](mailto:jmedellin@ucmerced).



**PPIC**

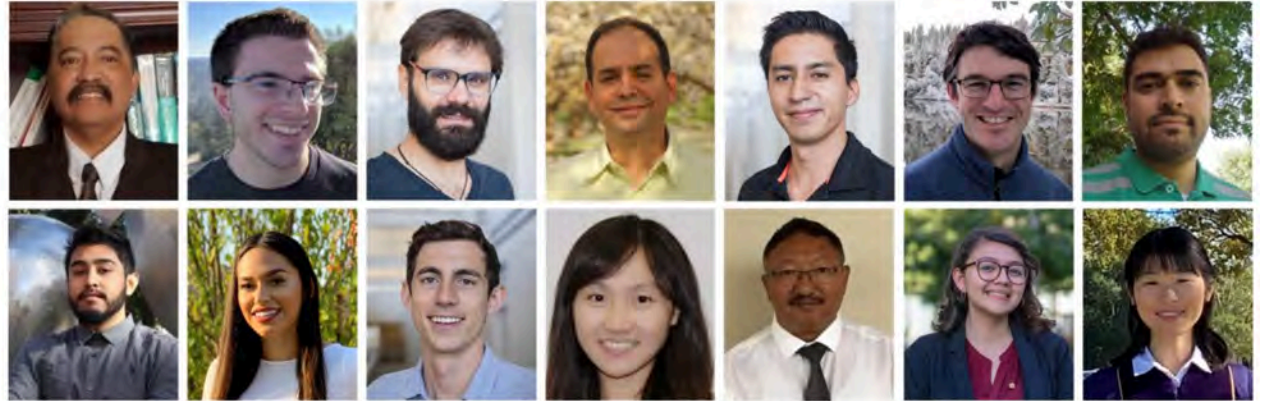
PUBLIC POLICY  
INSTITUTE OF CALIFORNIA



**eraeconomics**  
environment • resources • agriculture

# UNIVERSITY OF CALIFORNIA MERCED

## Water Systems Management Lab



We study **water economics**, **agricultural production**, **water consumptive use**, **hydro-economic simulations**, **environmental justice**, and **water-informatics**

[WSM.UCMERCED.EDU](http://WSM.UCMERCED.EDU)

