Conjunctive Management and Potential Role of FIRO

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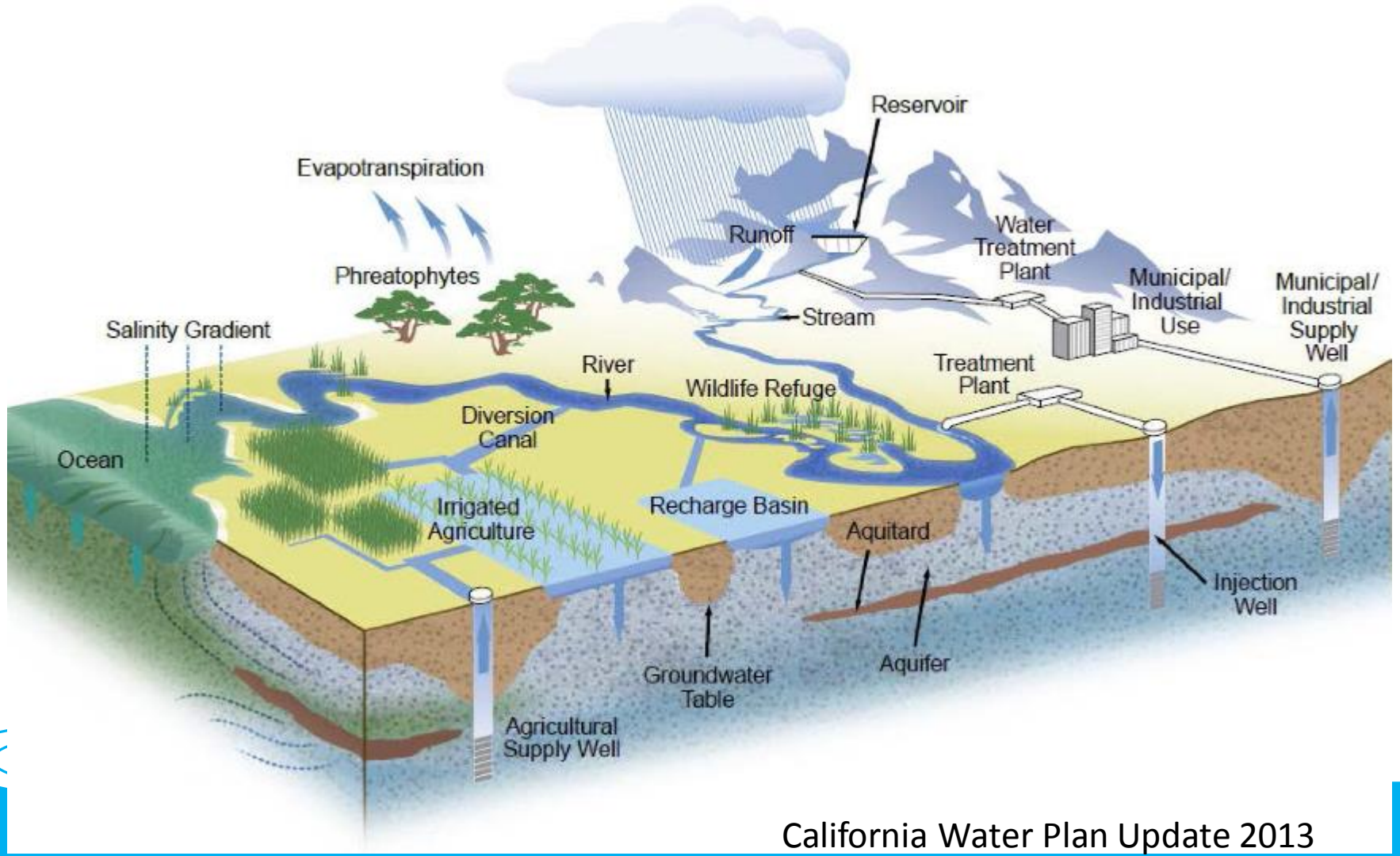
Main Ideas

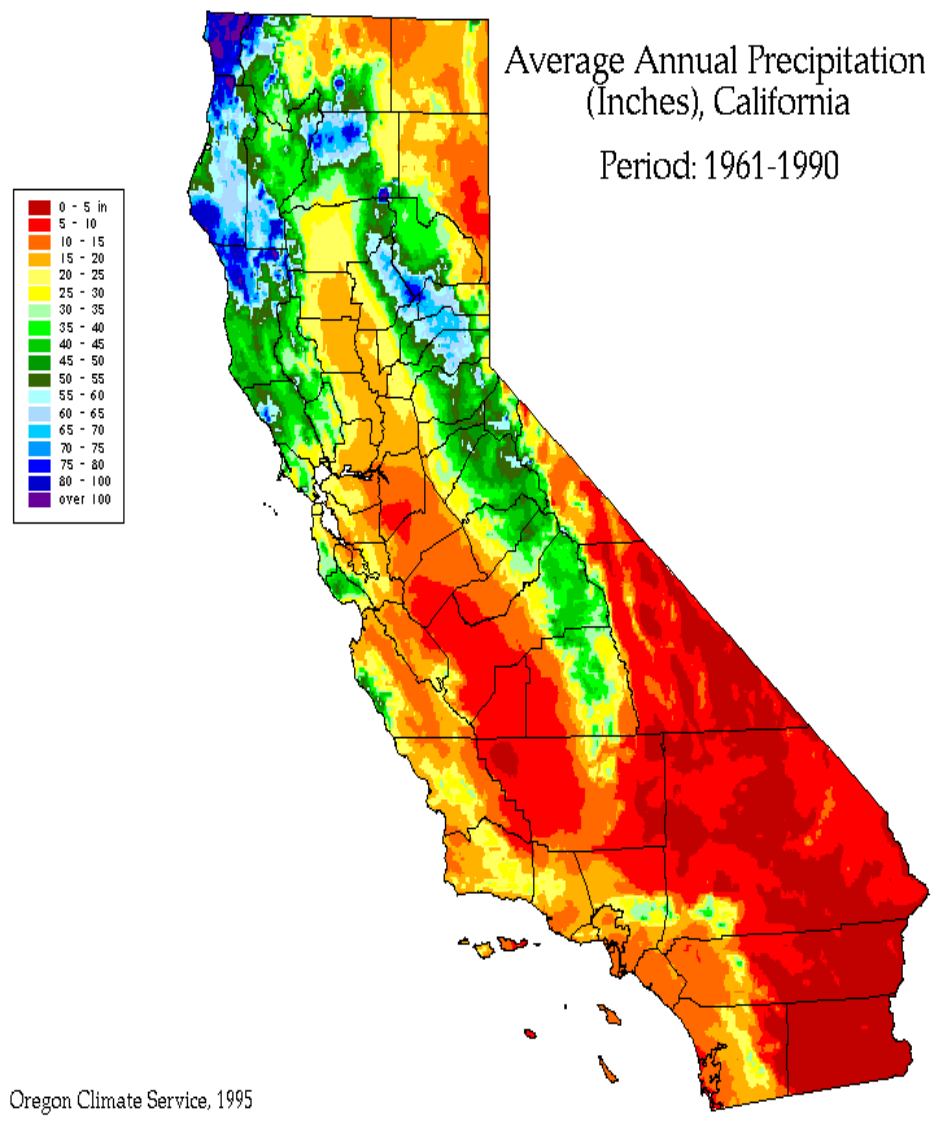
- Water Storage in California
- Improved Surface and Groundwater Integration
- Recent Policy Efforts for Groundwater Sustainability
- Pilot for Decadal-Scale Predictions
- Potential Applications of FIRO for Conjunctive Management

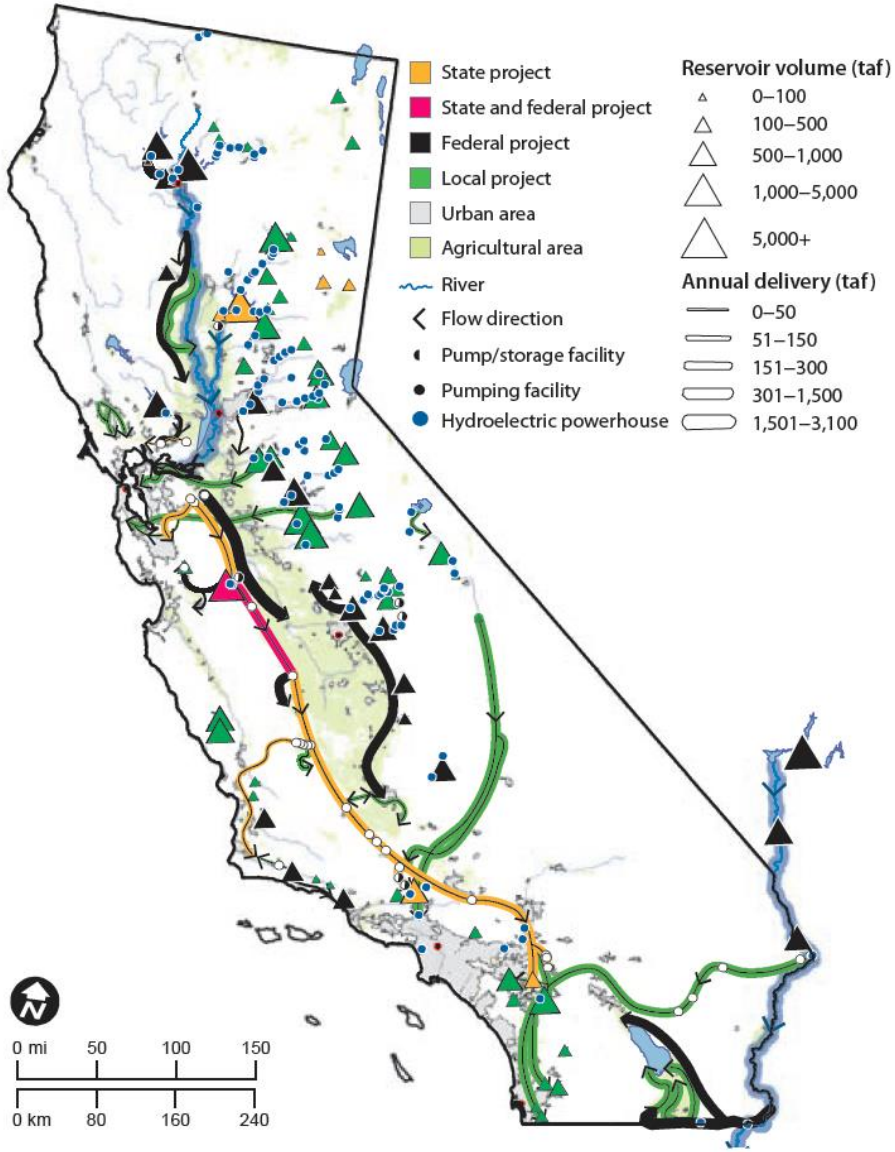
Water Supply is Part of an Intensely Integrated Hydrologic System



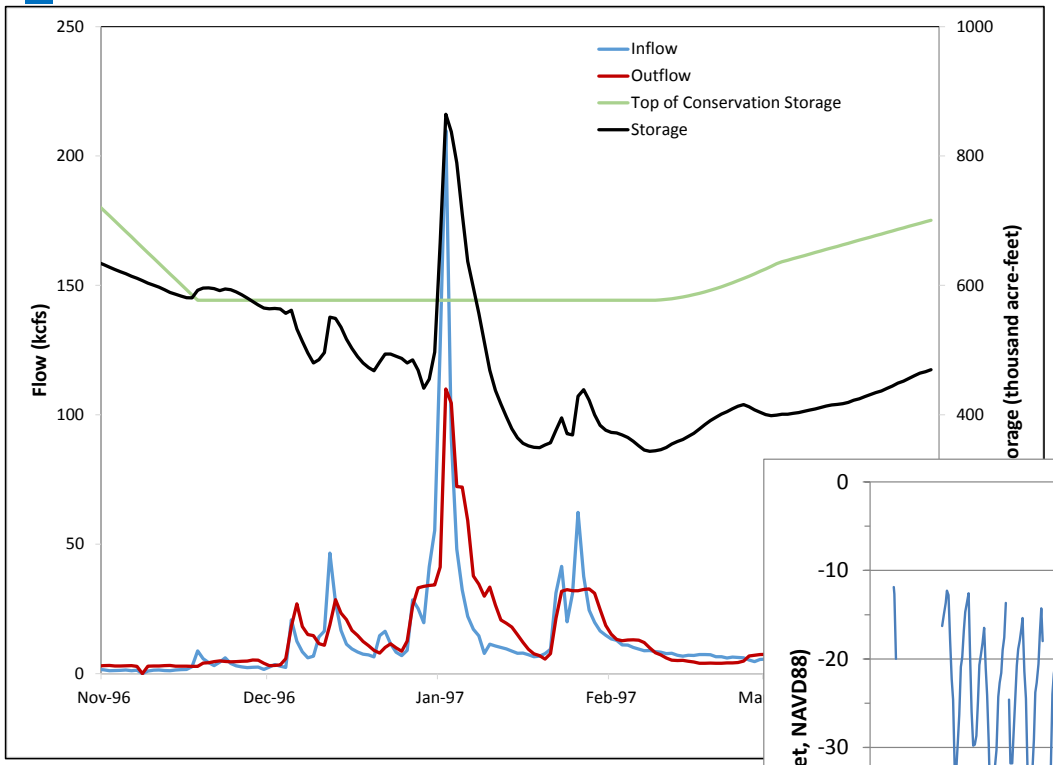
California Water Plan Update 2013

… and an Intertied Water System

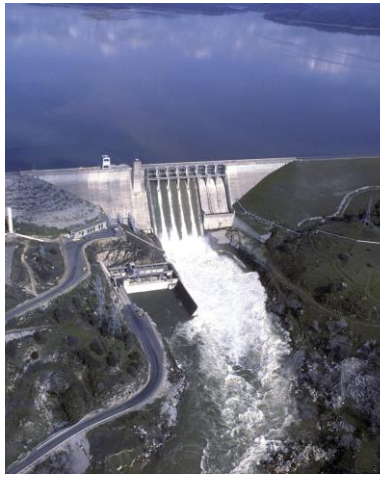




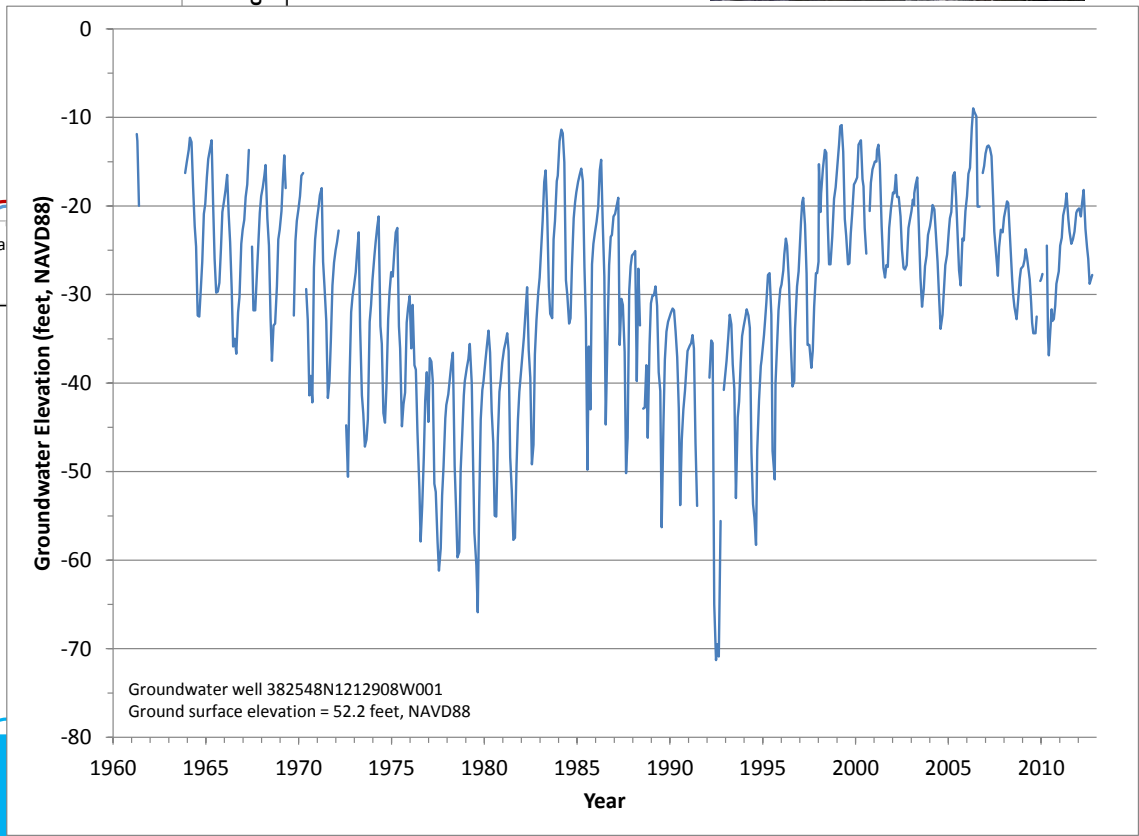
Storage Moves Water in Time



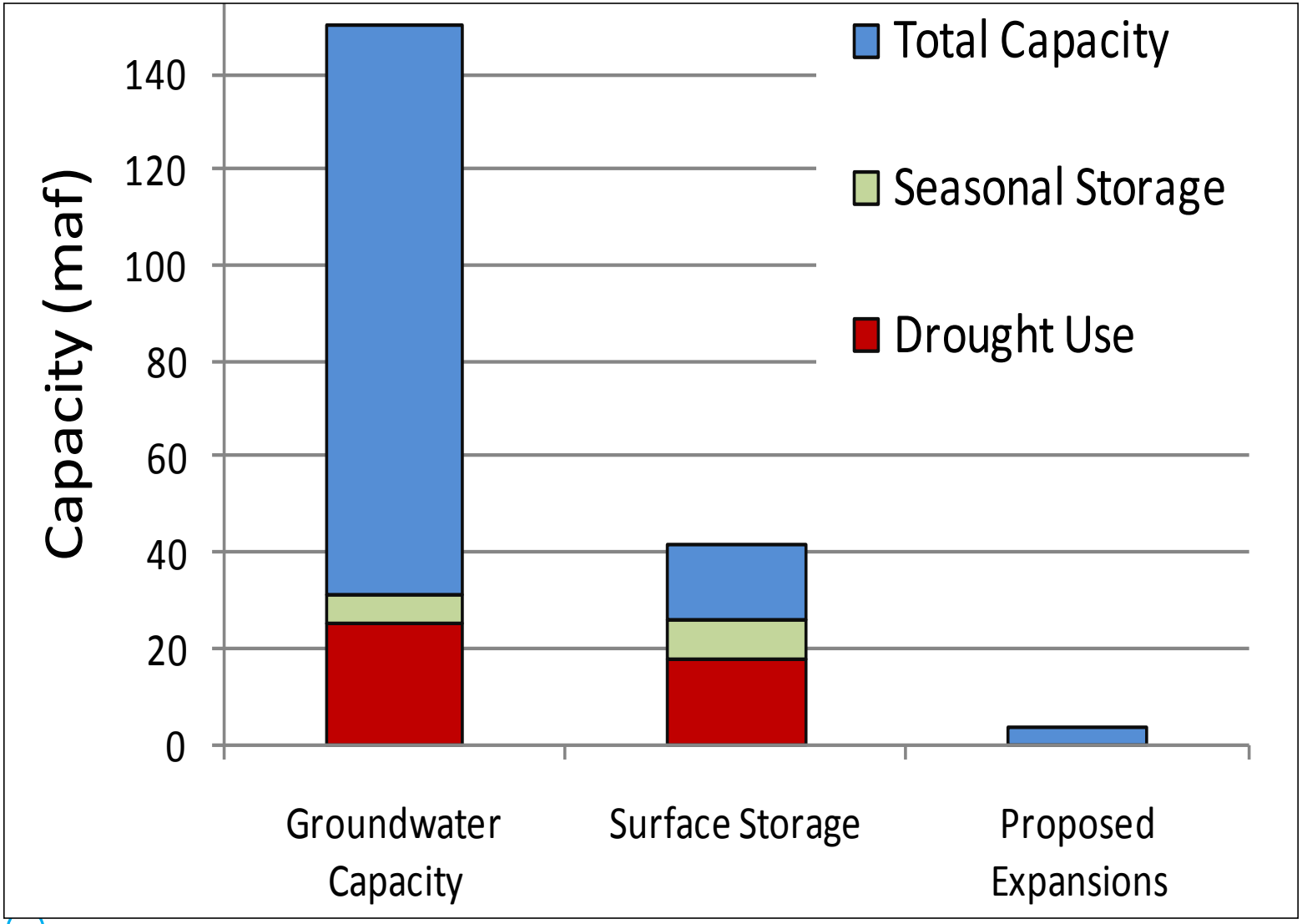
1997 flood storage at Folsom



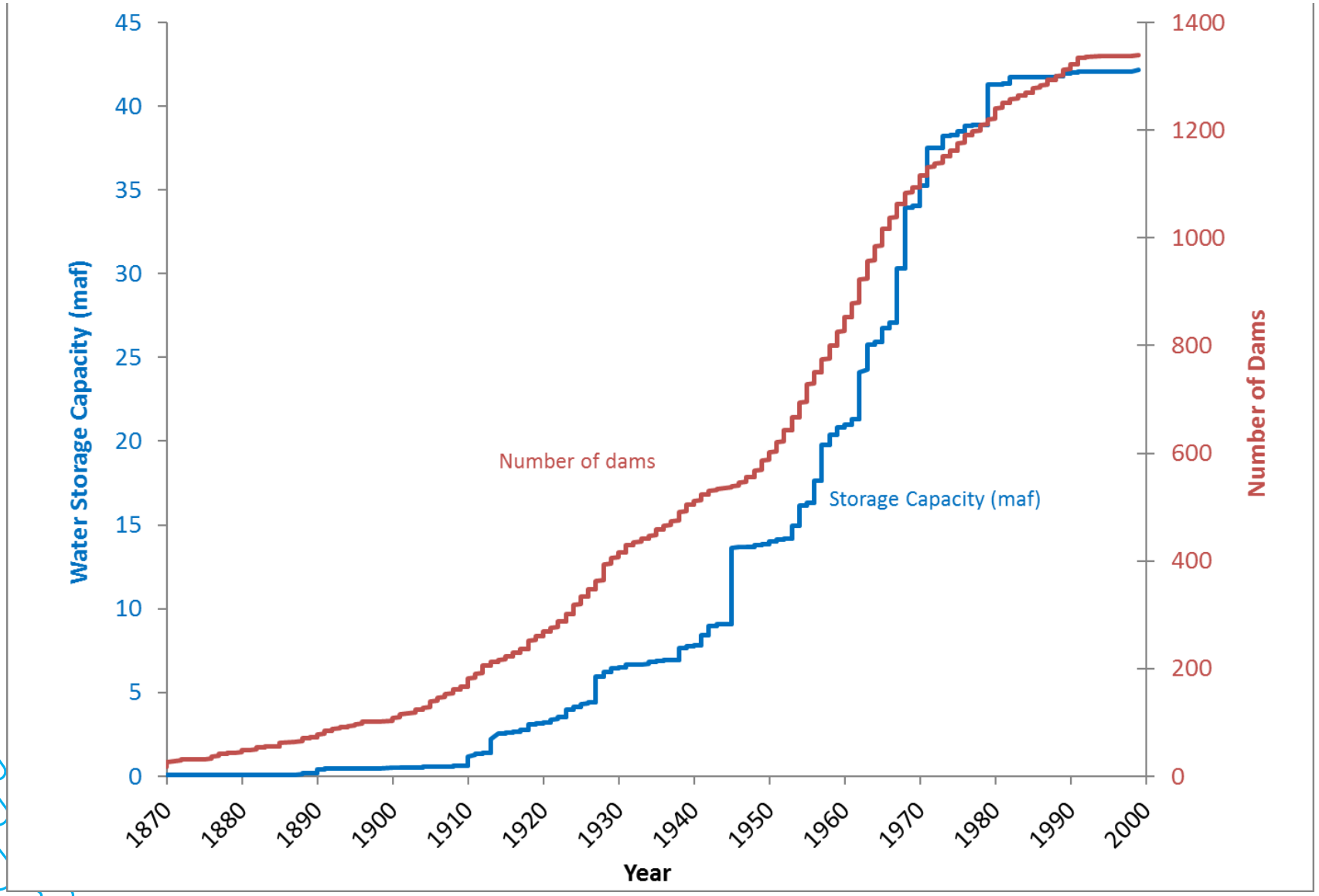
Seasonal and drought groundwater storage (Galt, CA)



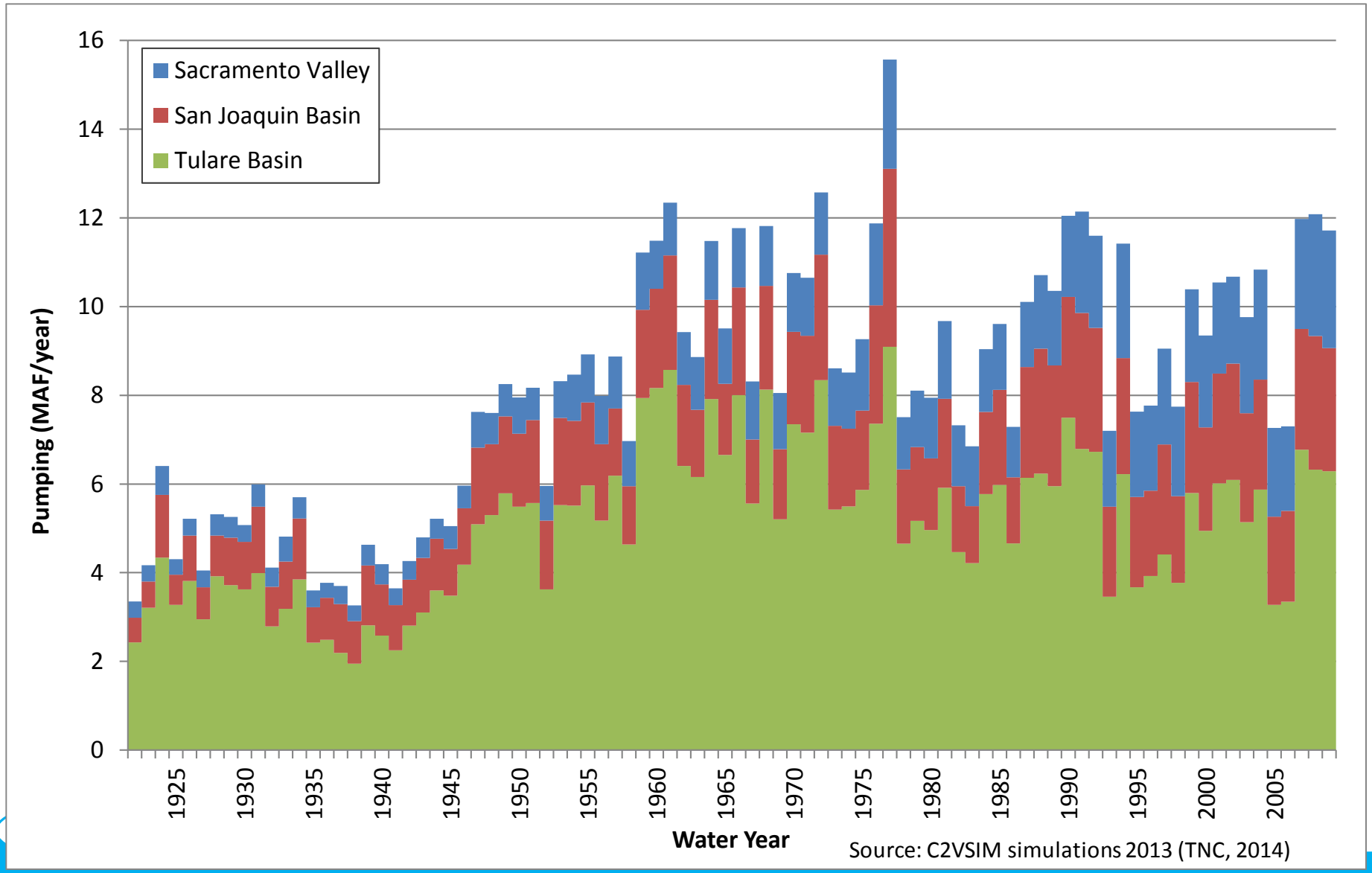
Water Storage Capacity and Uses in California



Surface Storage Development in CA



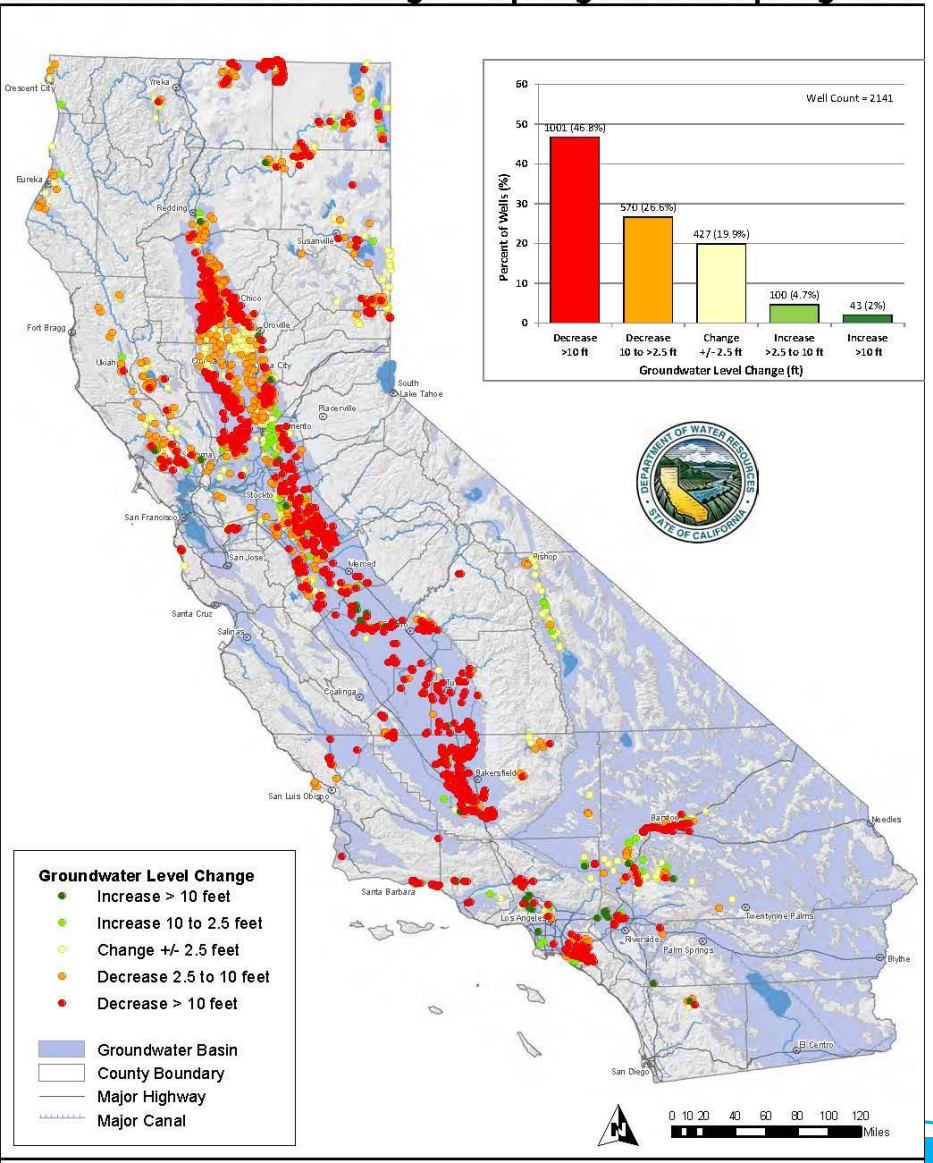
Historical Central Valley Pumping



Source: C2VSIM simulations 2013 (TNC, 2014)

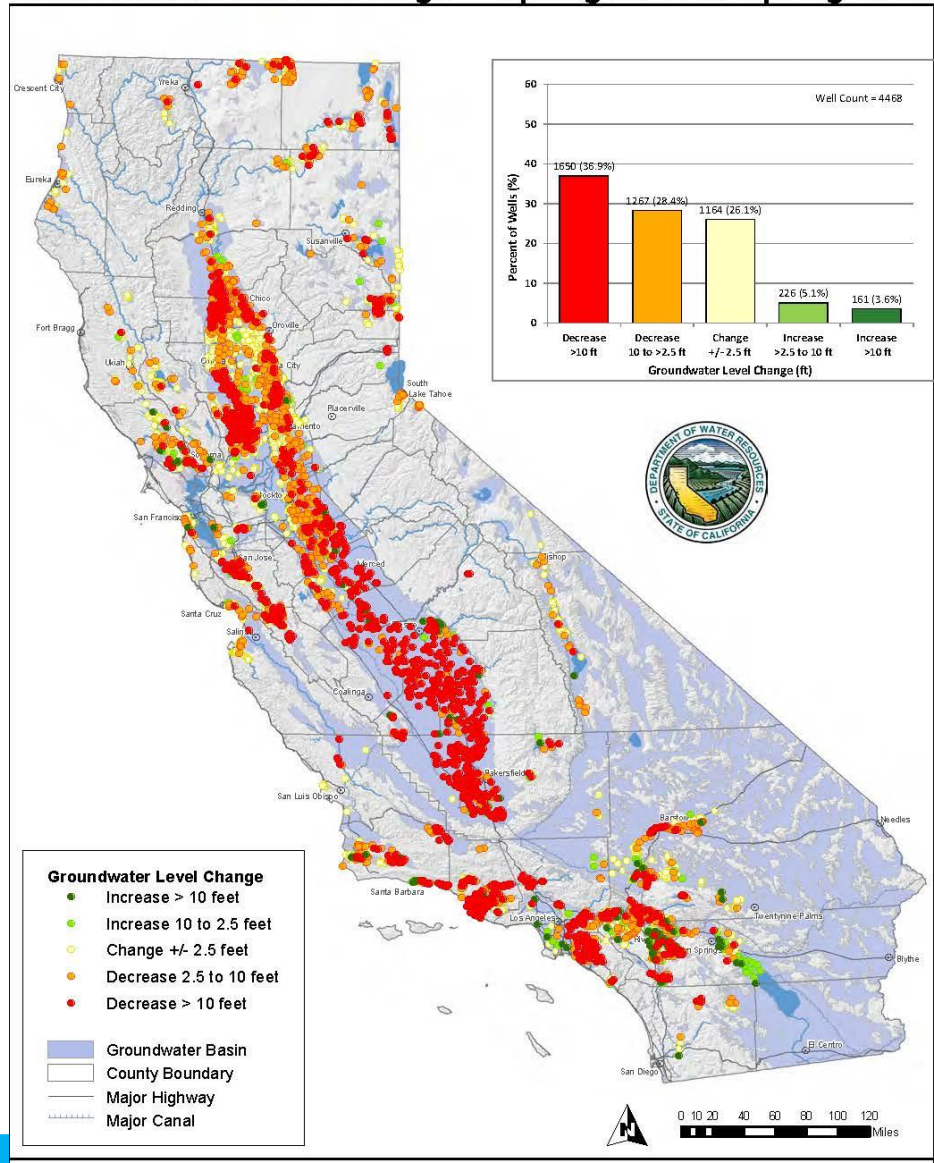
Change in Groundwater Levels in Wells

Groundwater Level Change* - Spring 2005 to Spring 2015



*Groundwater level change determined from water level measurements in wells. Map and chart based on available data from the DWR Water Data Library as of 07/15/2015. Document Name: S2015_S2005_DM_20150717 Updated: 07/17/2015 Data subject to change without notice.

Groundwater Level Change* - Spring 2012 to Spring 2015



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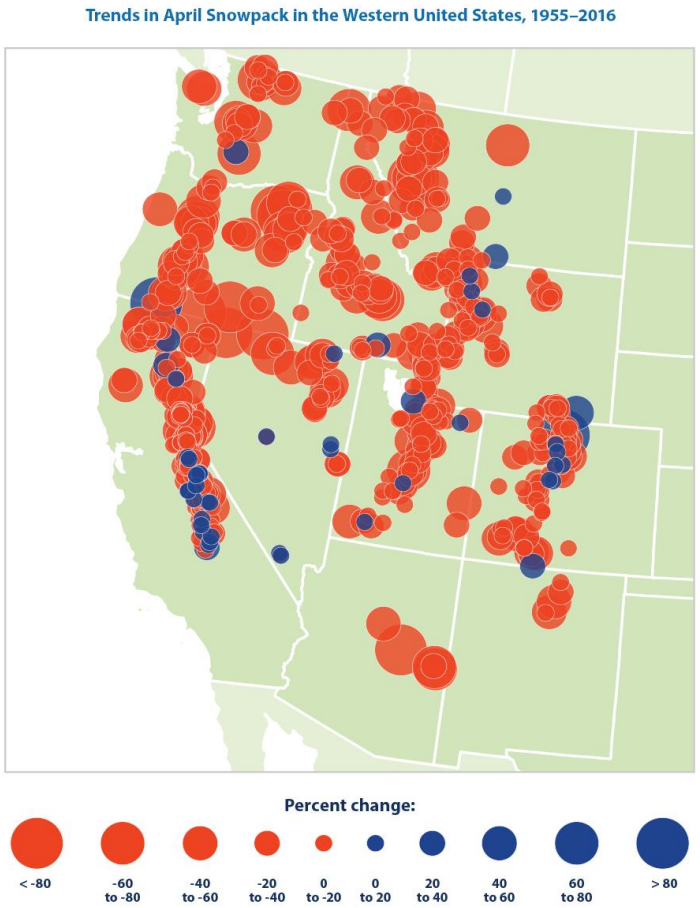
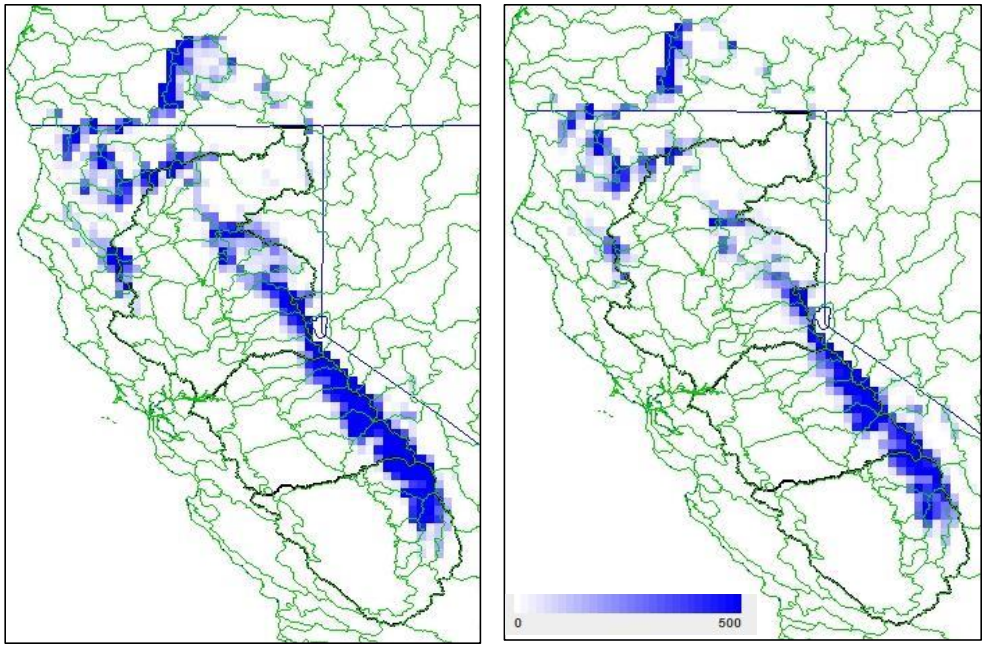
Compounded by Decreasing Snowpack Storage

- **Historical declining trends in snowpack**



Source: Mote and Sharp 2016

- **Projected continued declines in snowpack**



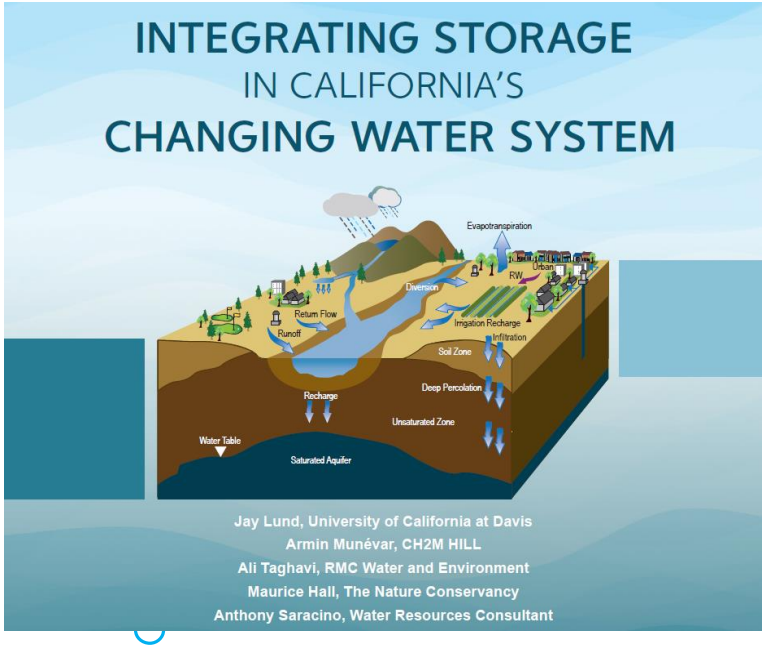
1981-2010: ~ 23.0 maf

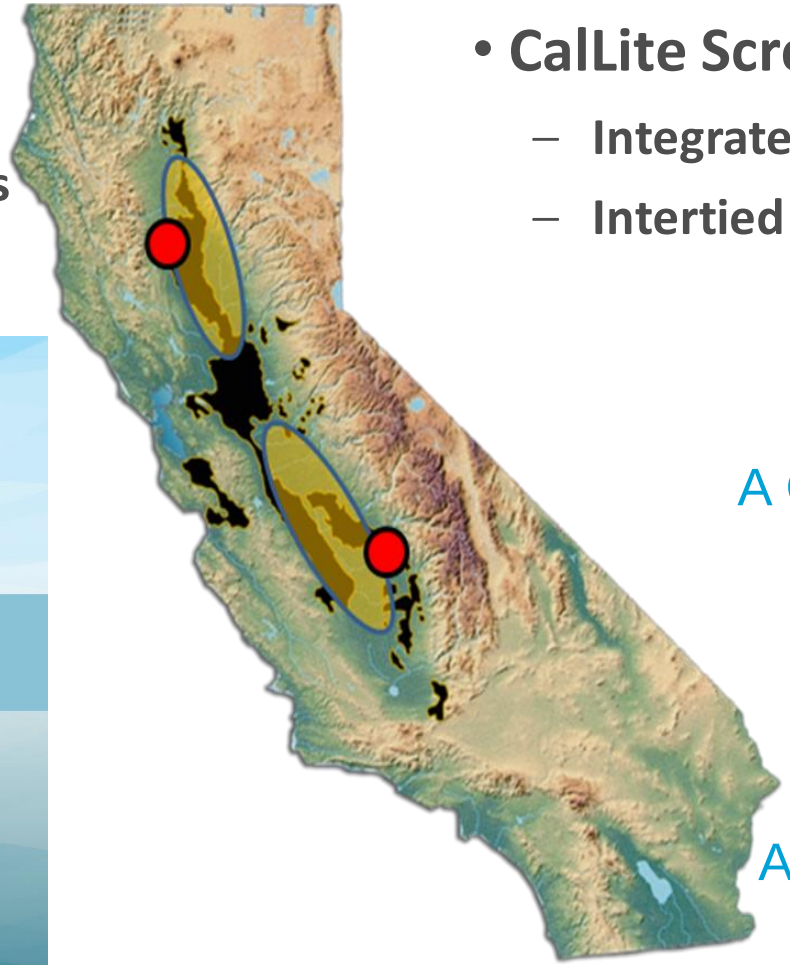
2041-2069: ~11.7 maf

Source: Historical and future VIC hydrological model simulations (CH2M 2014)

Pilot Integrated Storage Analysis

- **4 Storage Programs**
  - **2 groundwater storage**
  - **2 surface storage locations**
  - **2 maf capacity each**





- **CalLite Screening Model**
  - **Integrated hydrology**
  - **Intertied system**

A Collaboration of:
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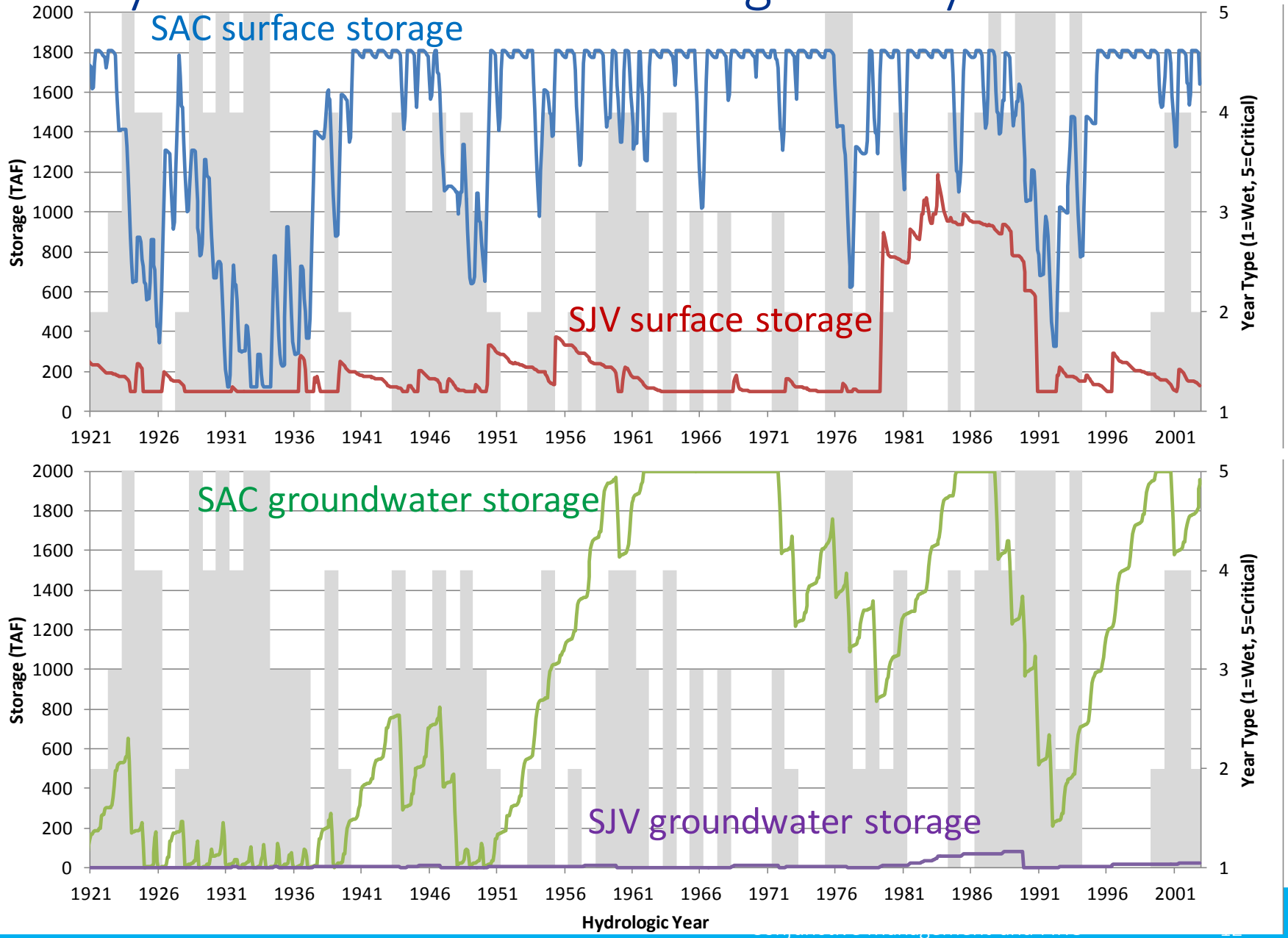
Armin Munévar
Ali Taghavi
Maurice Hall
Anthony Saracino

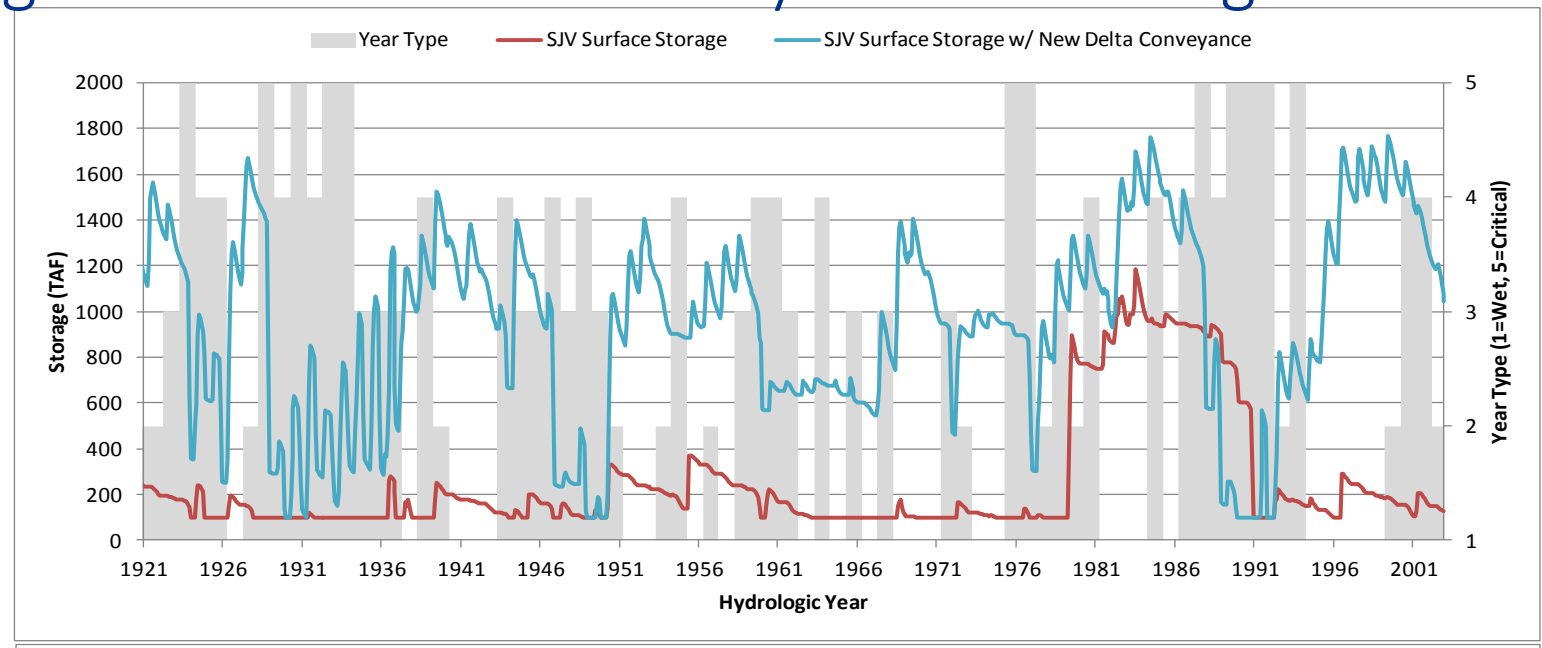
Supported by TNC; funded by the S.D. Bechtel, Jr. Foundation
https://watershed.ucdavis.edu/files/biblio/Storage_White_Paper_20Nov2014.pdf

Ability to Use Additional Storage Today

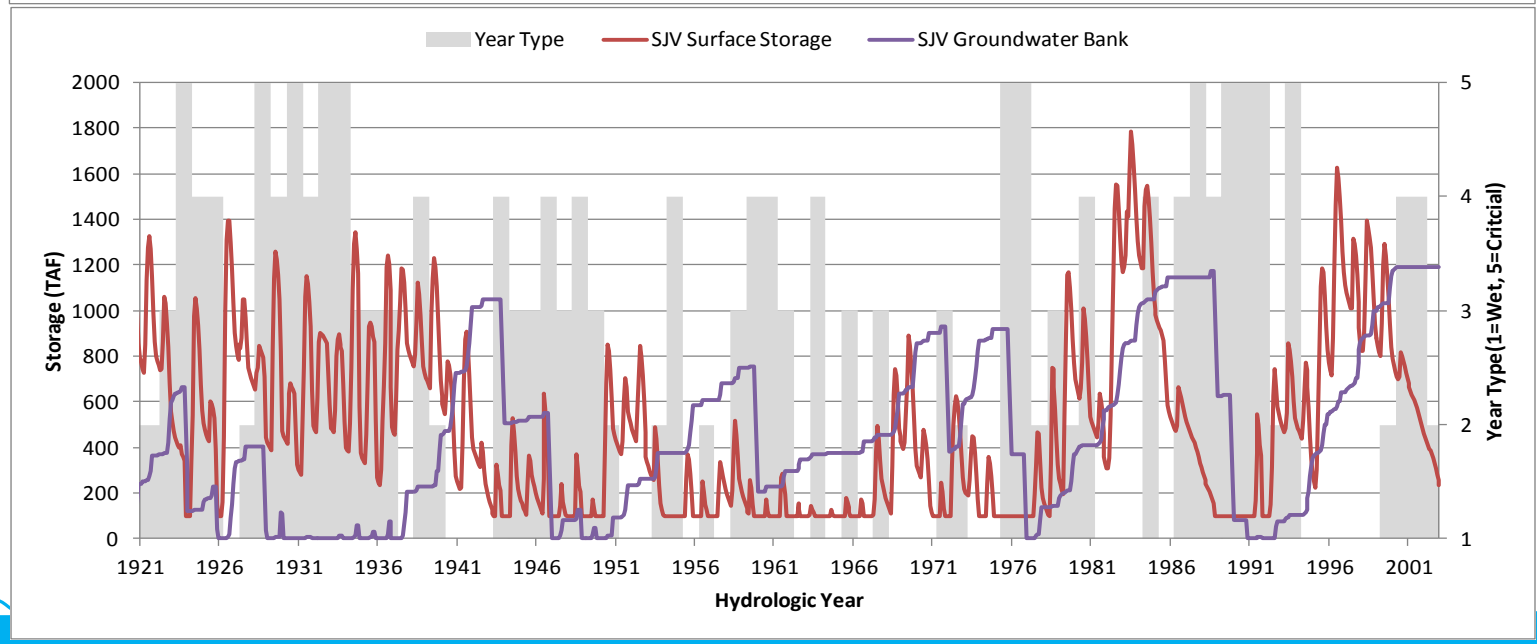


SJV Storage Utilization with Conveyance and Integration

SJV surface storage



SJV surface and groundwater storage

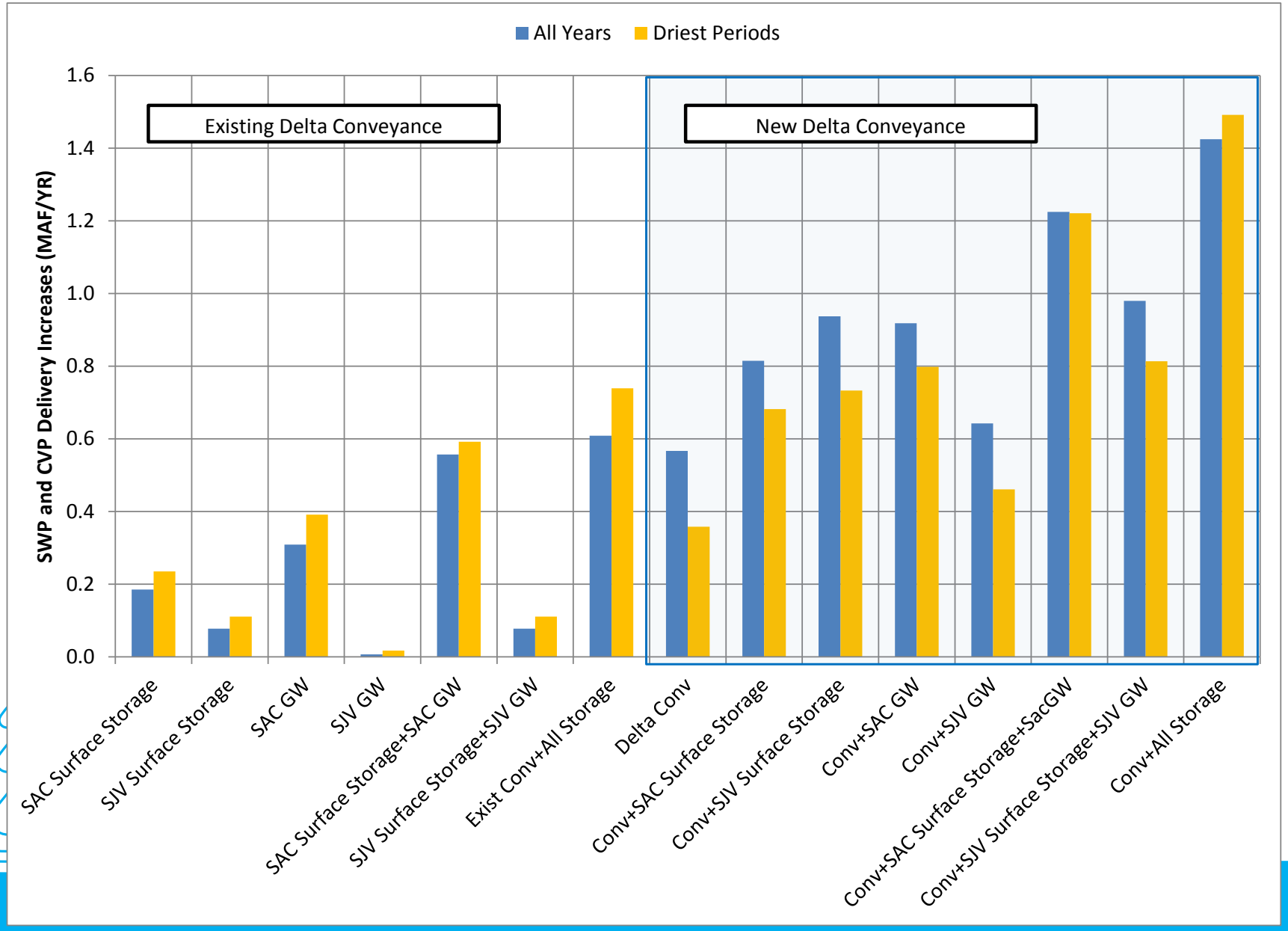


Total Storage Utilization

Storage	Existing Delta Conveyance	Integrated SW and GW Operations w/ Existing Delta Conveyance	New Delta Conveyance	Integrated SW and GW Operations with New Delta Conveyance
Sacramento Valley				
Surface Storage	1.8 maf (1.8 maf)	1.8 maf (1.8 maf)	1.8 maf (1.8 maf)	1.8 maf (1.8 maf)
Groundwater	2.0 maf (2.0 maf)	2.0 maf (2.0 maf)	2.0 maf (2.0 maf)	2.0 maf (2.0 maf)
San Joaquin Valley				
Surface Storage	1.2 maf (800 taf)	900 taf (100 taf)*	1.8 maf (1.5 maf)	1.4 maf (1.0 maf)
Groundwater	< 50 taf (<50 taf)	<200 taf (<200 taf)	<200 taf (<100 taf)	1.1 maf (1.0 maf)
Total				
Total Storage Utilization	5.0 maf (4.6 maf)	4.9 maf (4.1 maf)	5.8 maf (5.4 maf)	6.3 maf (5.8 maf)

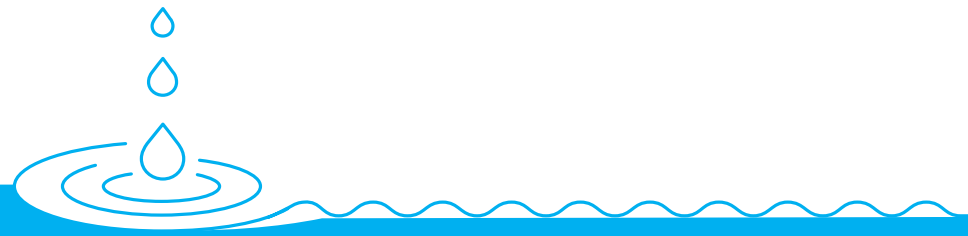
No more than 5-6 maf of additional could be utilized, due to insufficient streamflow.

Water Delivery Improvements With Integration



Main Conclusions

- **Surface and groundwater storage need to be viewed as part of water management "systems"**
- **Integration of surface and groundwater storage through conjunctive operations substantially increases reliability benefits**
- **Large hydrological variability, combined with limited groundwater recharge rates, requires surface storage to regulate peaks**
- **Conjunctive management is a significant climate adaptation strategy in the water sector**

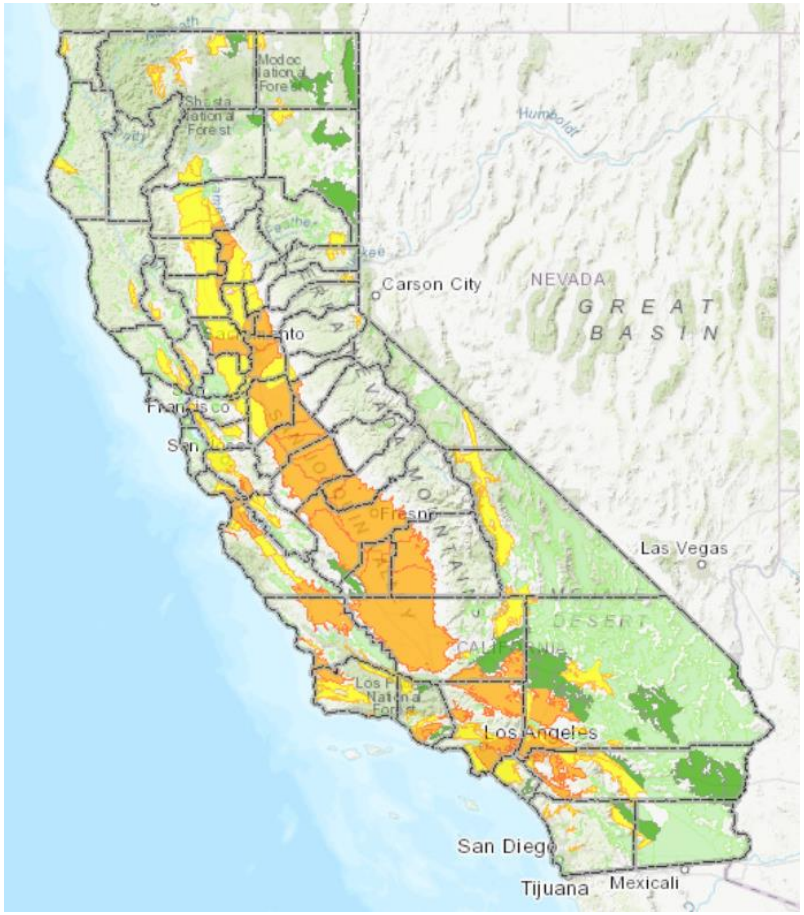


Sustainable Groundwater Management Act

- In 2014, Governor Jerry Brown signed into law a three-bill legislative package, known as the Sustainable Groundwater Management Act (SGMA)

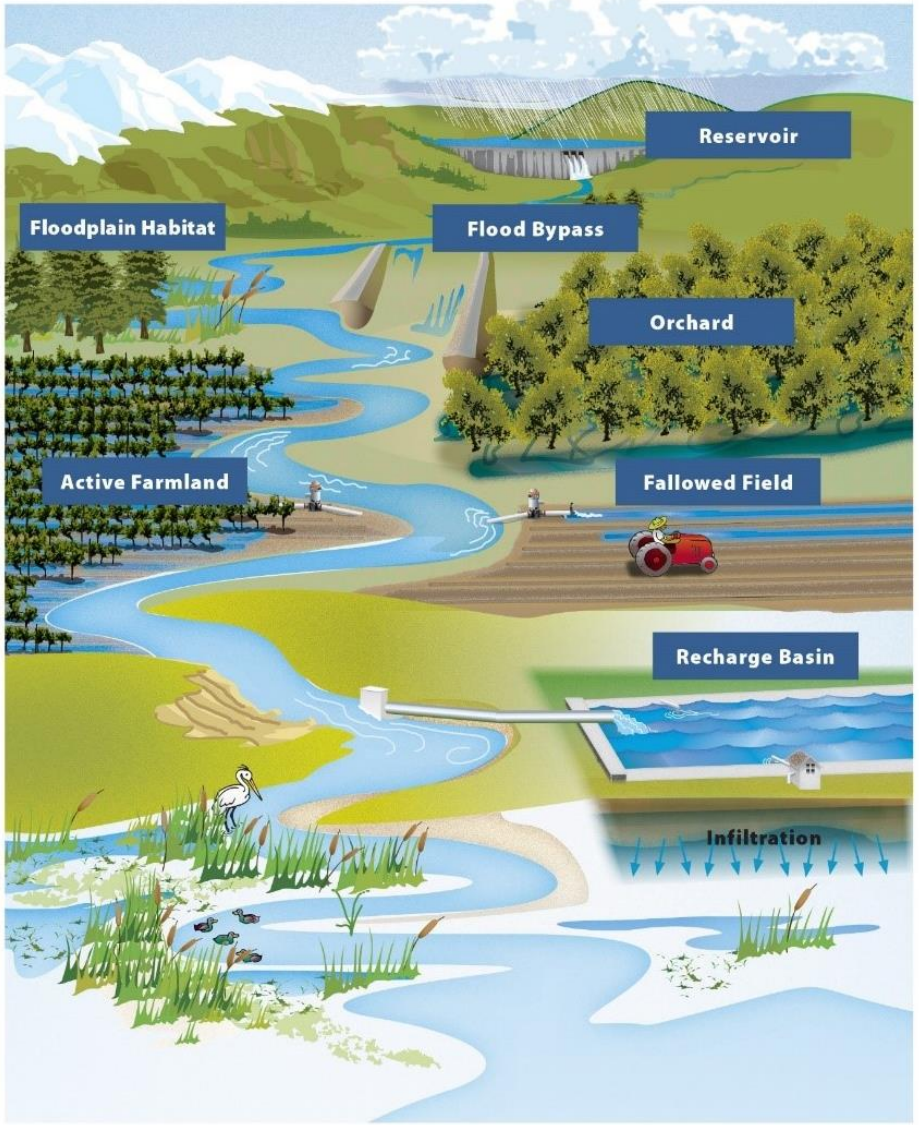
- For the first time in its history, California has a framework for sustainable, groundwater management
  - "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results."

CASGEM Basin Prioritization (July 2018)

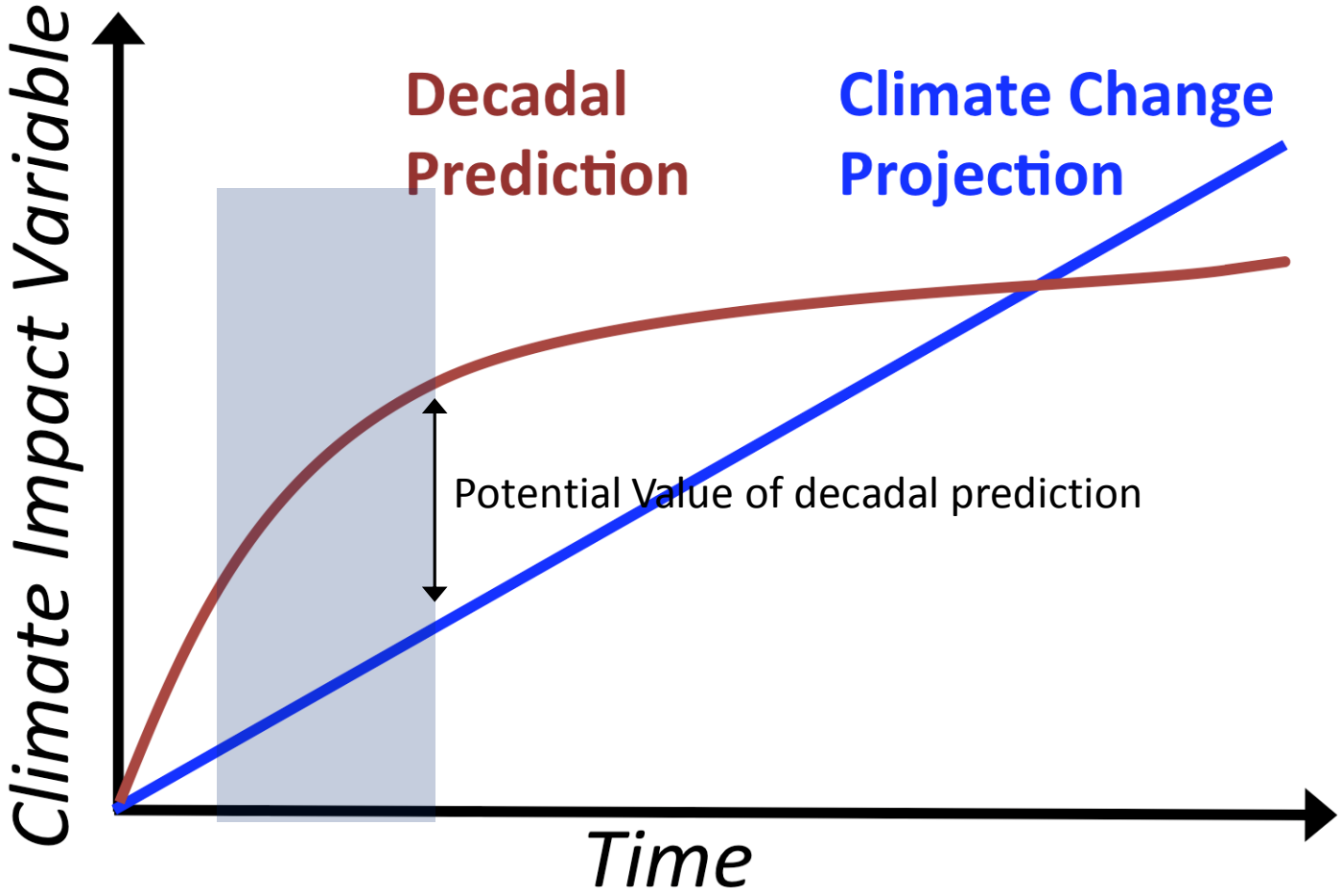


Managed Aquifer Recharge

- **Overall objective is to slow the flow to allow for groundwater recharge**

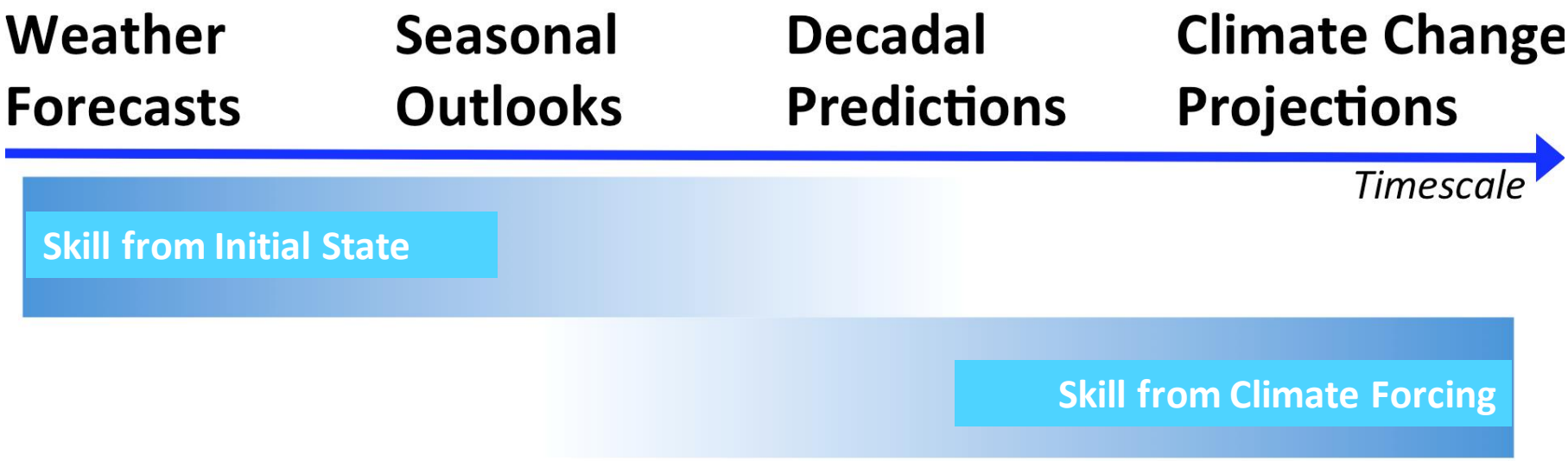


Understanding Decision-Climate Interactions on Decadal Scales



NCAR is Sponsored by NSF

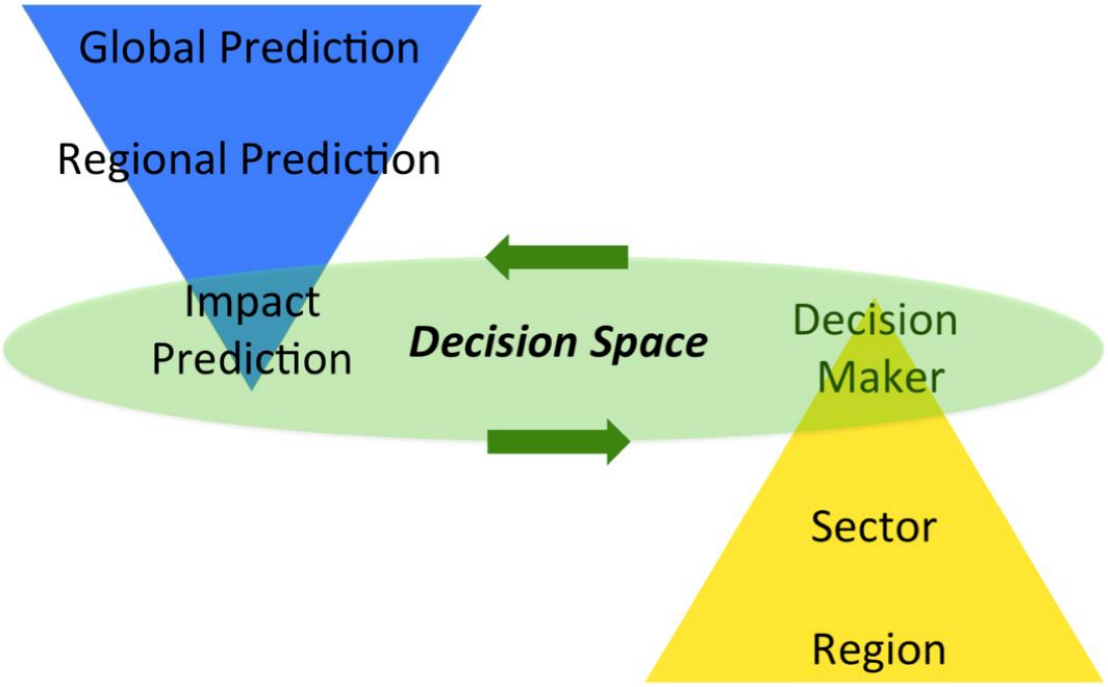
Decadal Prediction



- *Adapted from Meehl et al (2009)*

Understanding the Decision Space

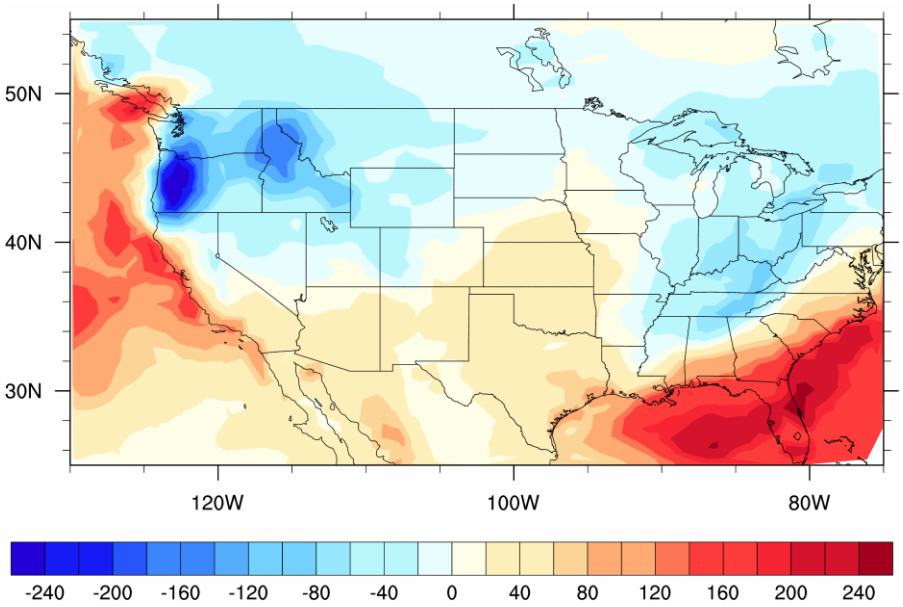
- **Part 1: Understand current information needs and use.**
- **Part 2: Build predictive capacity for the needed information.**



Advancing Understanding of Decadal Variability of Atmospheric Rivers and Winter Precipitation Change

Simulations of the 2016/2017 season under opposite phases of the Interdecadal Pacific Oscillation (IPO) using the Model for Prediction Across Scales

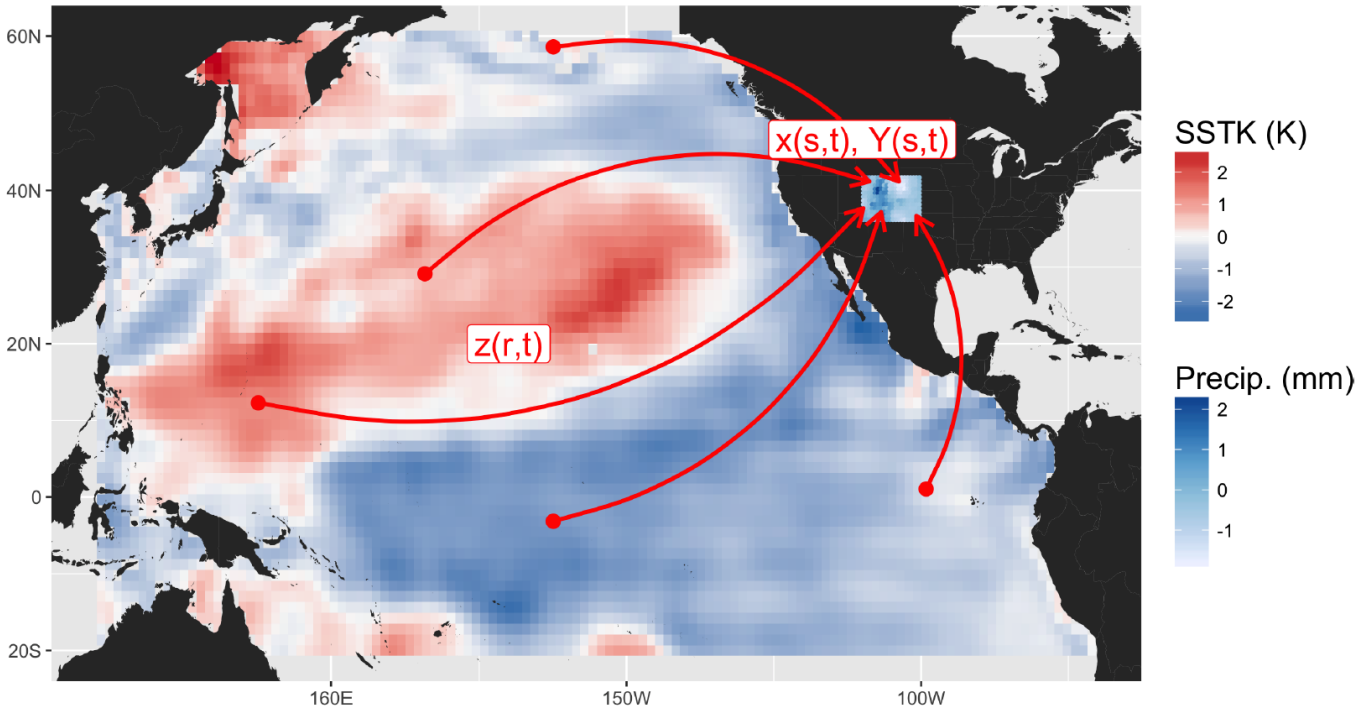
+IPO increases California precipitation, and brings twice the number of strong ARs



(mm)

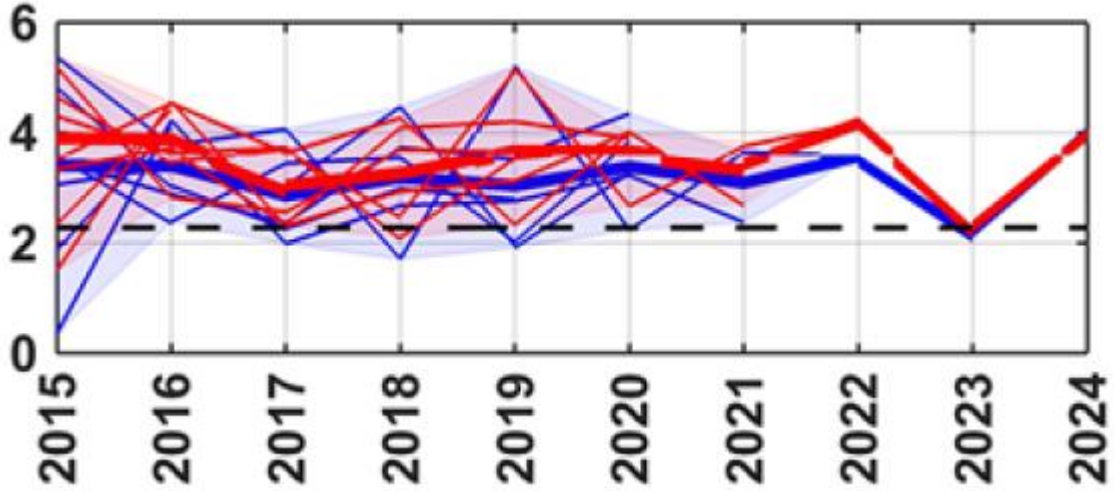
A Teleconnection Model of US Precip

- Model US precipitation on Pacific Ocean temperature patterns
- These temperature patterns have some predictive skill on decadal timescales
- May outperform raw precipitation predictions from global models



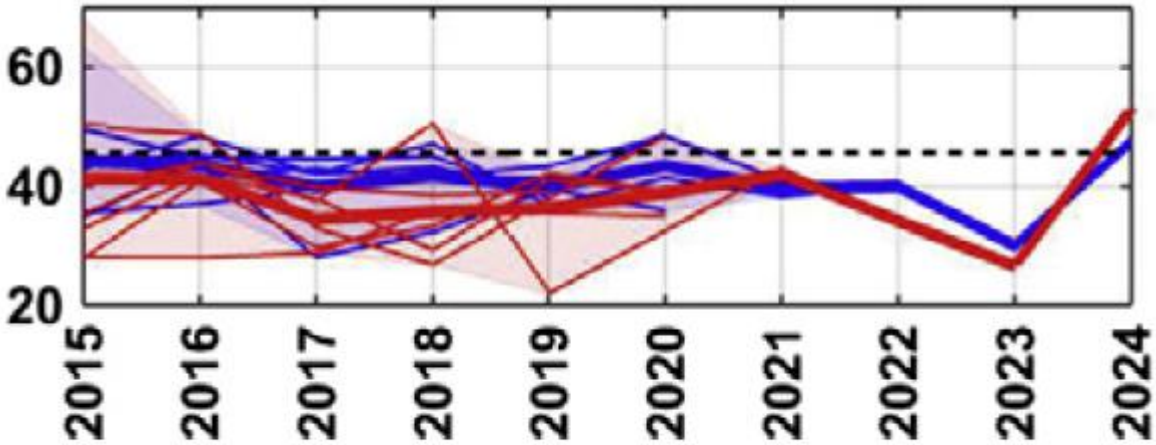
Predictions of Warmer and Drier Winters for the US Southwest Region

Temperature



Normal

Precip

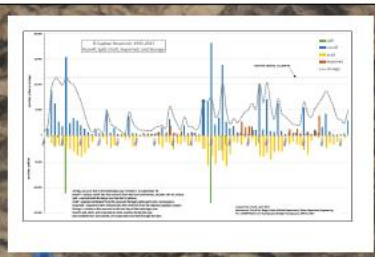


Normal

Salvi et al. (2017)

Potential Role of FIRO

- Improve forecast of risk of reservoir flood releases
- Provide early indication of seasonal “wetness” for triggering proactive releases to groundwater
- Predictions of early onset of multi-year dry conditions to trigger more active groundwater management
- Assist in optimizing integrated storage systems
- Assist in determining conveyance facility needs



In Closing

- Integrated systems-based approaches needed to expand benefits of storage, and adapt to climate change
- Conjunctive management requires regulating capacity of surface storage
- State policy efforts provide the backing for improved conjunctive management
- Improved prediction at multiple time-scales can improve optimization of storage systems
- FIRO could play an important role in many integrated systems


Q&A