Conjunctive Use of Water in the Central Valley: Past, Present, and Future

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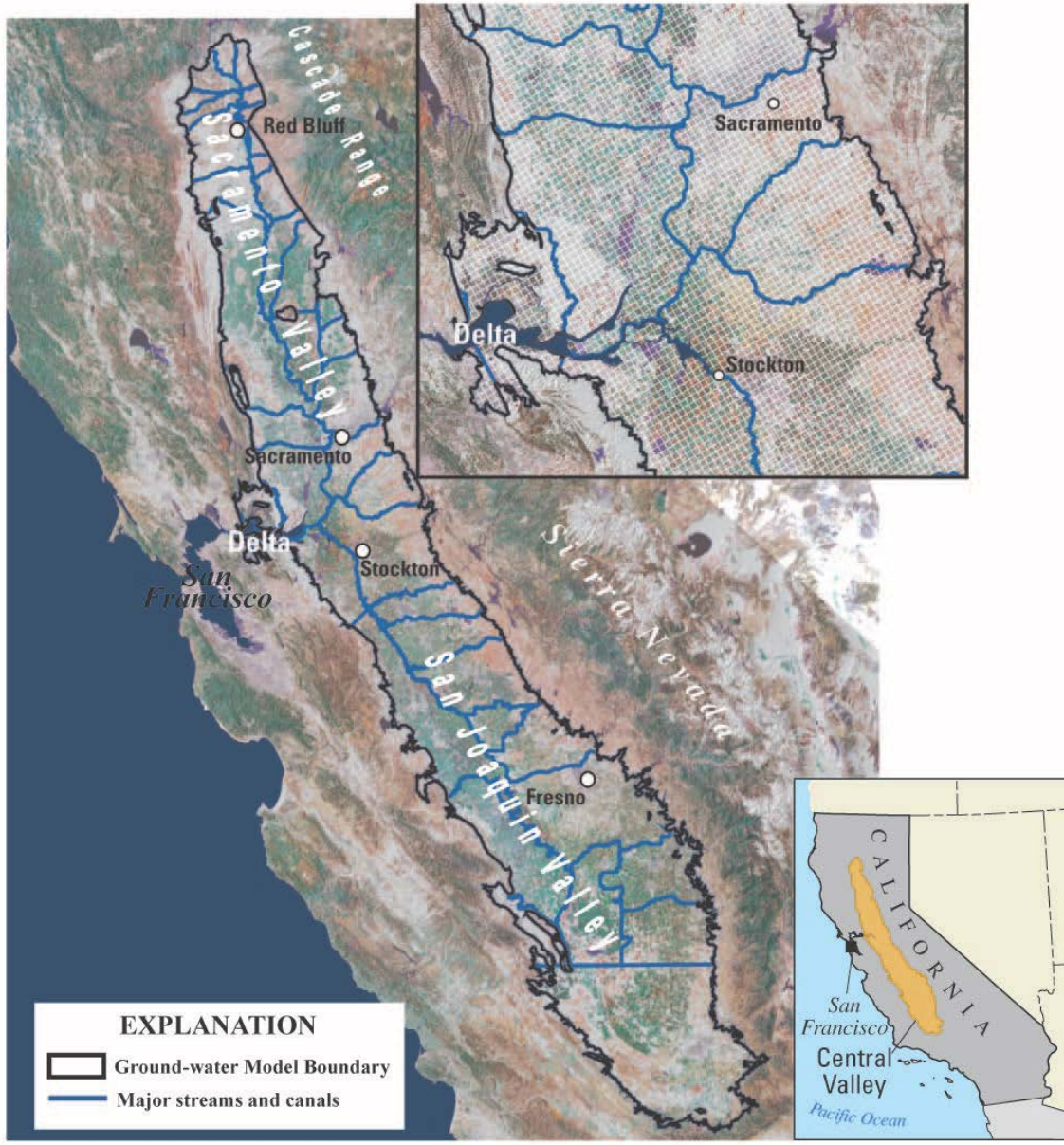
April 19, 2016

USGS

http://ca.water.usgs.gov/projects/central-valley/

Central Valley Facts:

- **52,000 square kilometers**
- **Using about 1% of U.S. farmland, California's Central Valley**
  - **-Produces more than 250 different crops**
  - **-Supplies 7% of the U.S. agricultural output (by value) — 1/4 of the Nation's food, including about half of the Nation's fruits, nuts, and vegetables**
- **Approximately 20% of the Nation's groundwater is pumped from the Central Valley aquifer system – currently about 15%**



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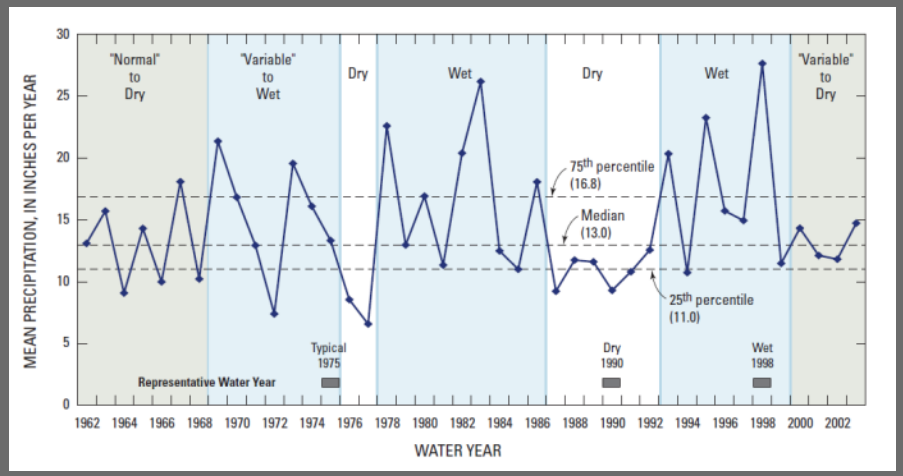
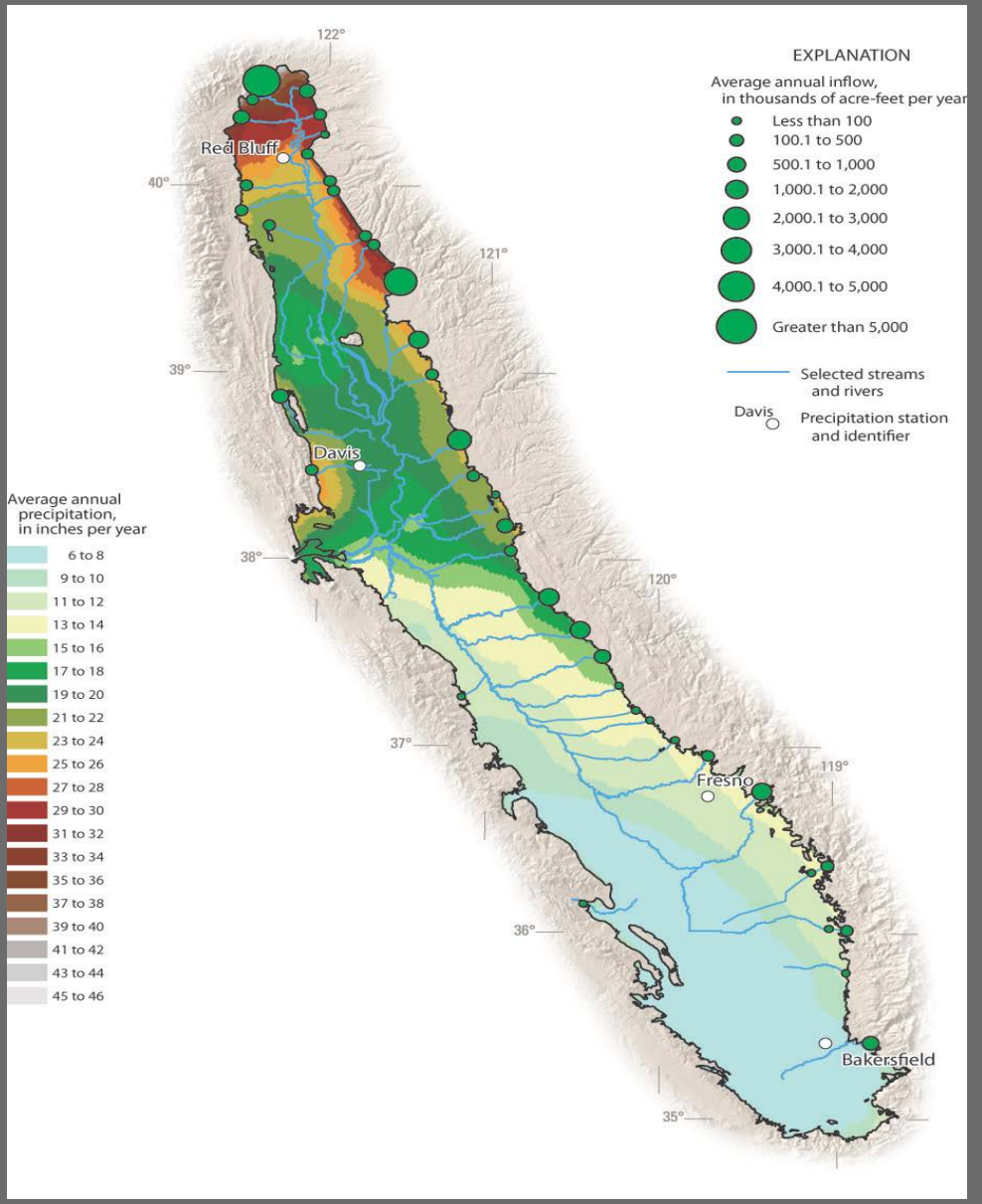
Climate and Water Resources

- Vary Geographically
- Vary with Time
  - Annually
  - Seasonally





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Drought

Many ways to look at

Amount of water stored California Reservoirs
Snow Water Equivalent and Temperatures

(from CNAP)

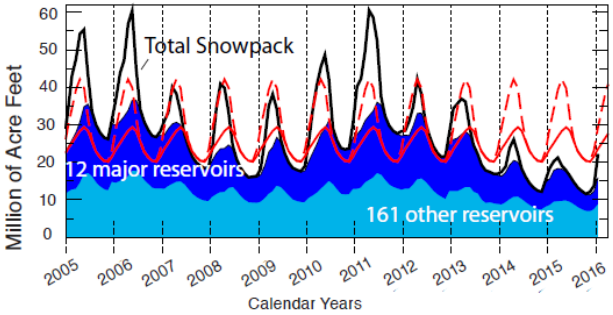


Figure 1: The total water stored in the 12 major reservoirs defined by CA Department of Water Resources, and the other 161 reservoirs, and in the monthly snowpack. The solid red line is the average reservoir storage from 2000-2015 and the dashed red line is the average snowpack plus reservoir storage. Updated from Dettinger and Anderson, 2015.

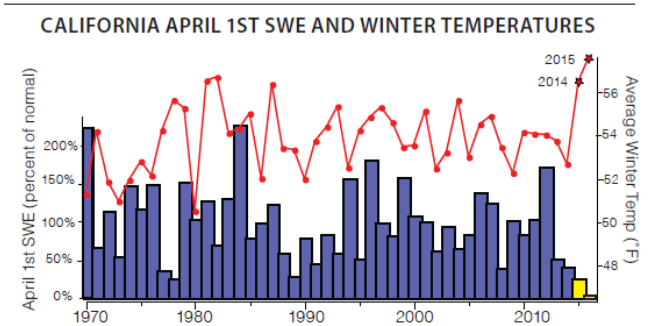
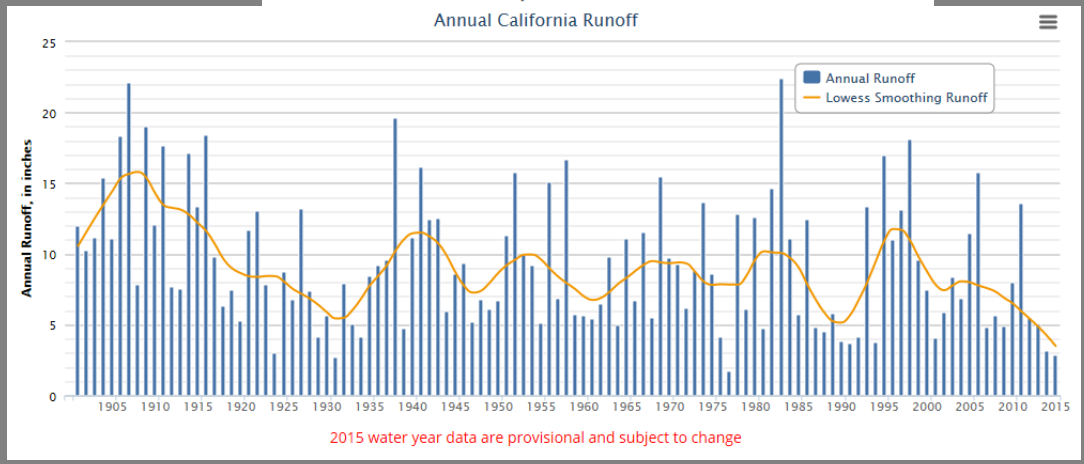


Figure 2: April 1st percent of normal SWE (blue bars and 2014 -2015 yellow bars) and winter (DJF) temperatures (red line) for California. Data courtesy of the CA DWR and WRCC.

The [Annual California Runoff graph] from Water Watch shows that the last four water years (2012-2015) have been the lowest on record statewide - Varies north to south

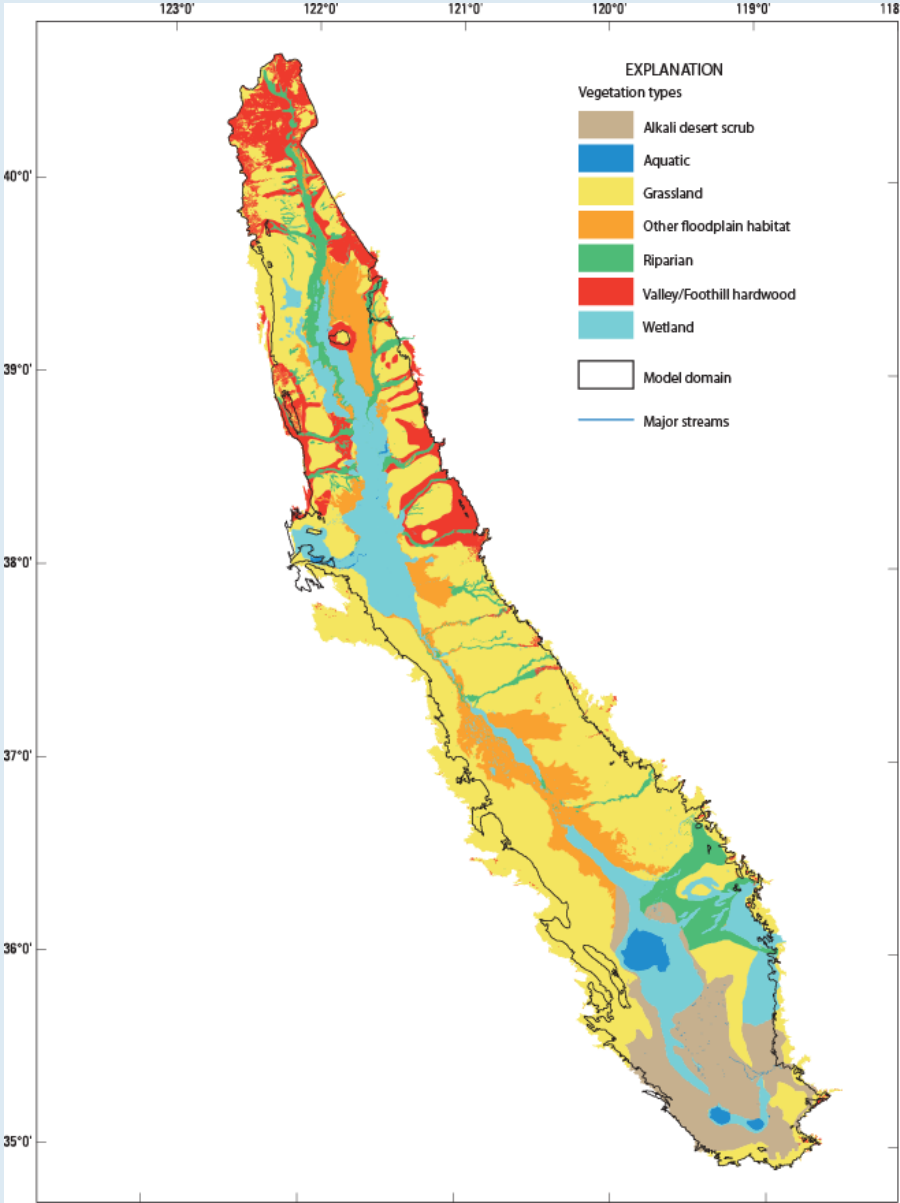


Central Valley Water Use Pre-development

- Natural system
  - Extensive wetlands
- Development began in 1800s
- 1914 water act addressed surface water
- Until this year, groundwater not regulated (local responsibility):

"legally landowner can pump ground water as long as it is put to a reasonable and beneficial use"

(except adjudicated basins)

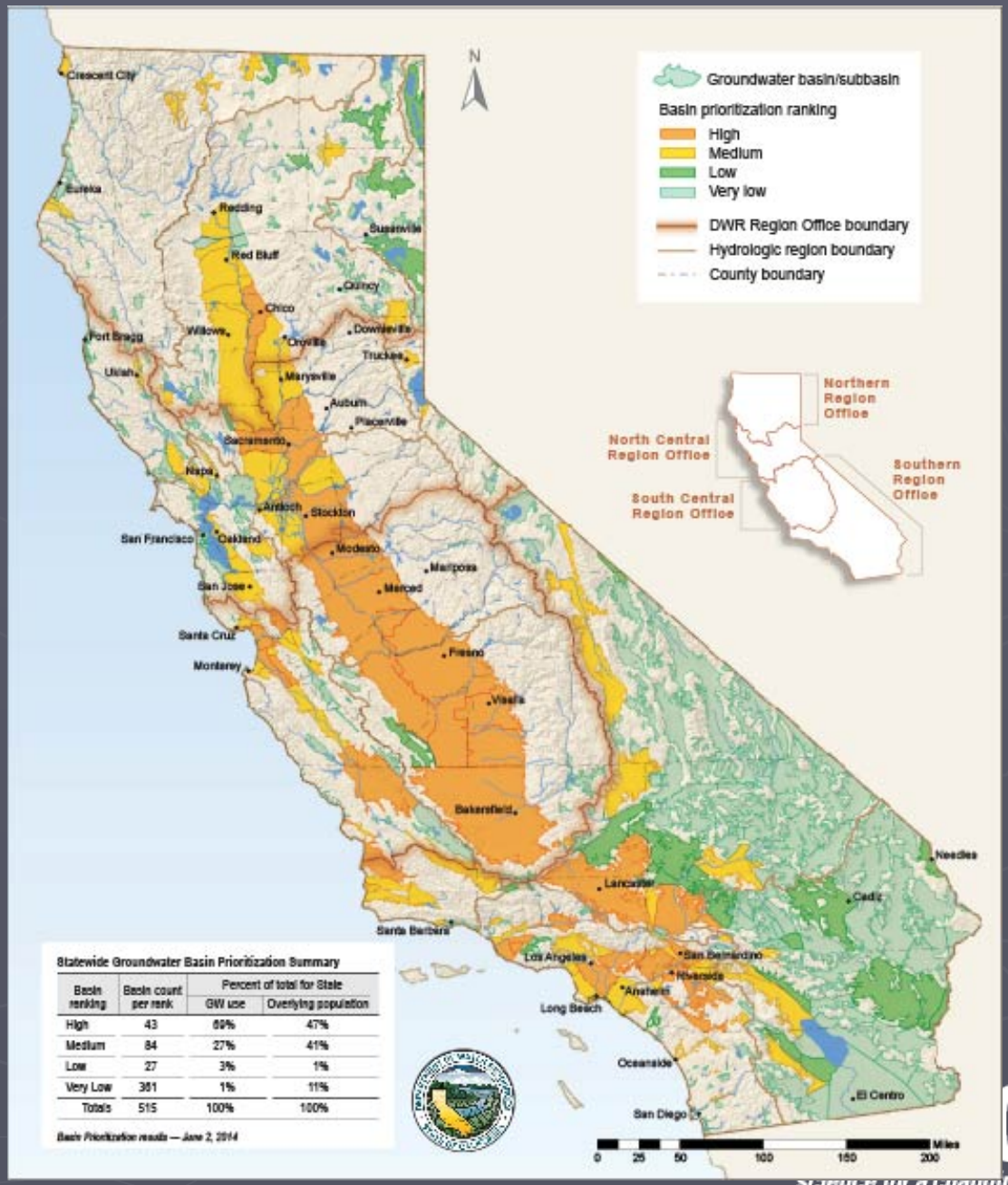


Sustainable Groundwater Management in CA

DWR Basin Prioritization →

Sustainability criteria:

- Lowering of Groundwater Levels
- Reduction of Groundwater Storage
- Seawater Intrusion
- Water Quality Degradation
- Land Subsidence
- Depletions of Surface Water



Statewide Groundwater Basin Prioritization Summary

Basin ranking	Basin count per rank	Percent of total for State	
		GW use	Overlying population
High	43	69%	47%
Medium	84	27%	41%
Low	27	3%	1%
Very Low	361	1%	11%
Totals	515	100%	100%

Basin Prioritization results — June 2, 2014

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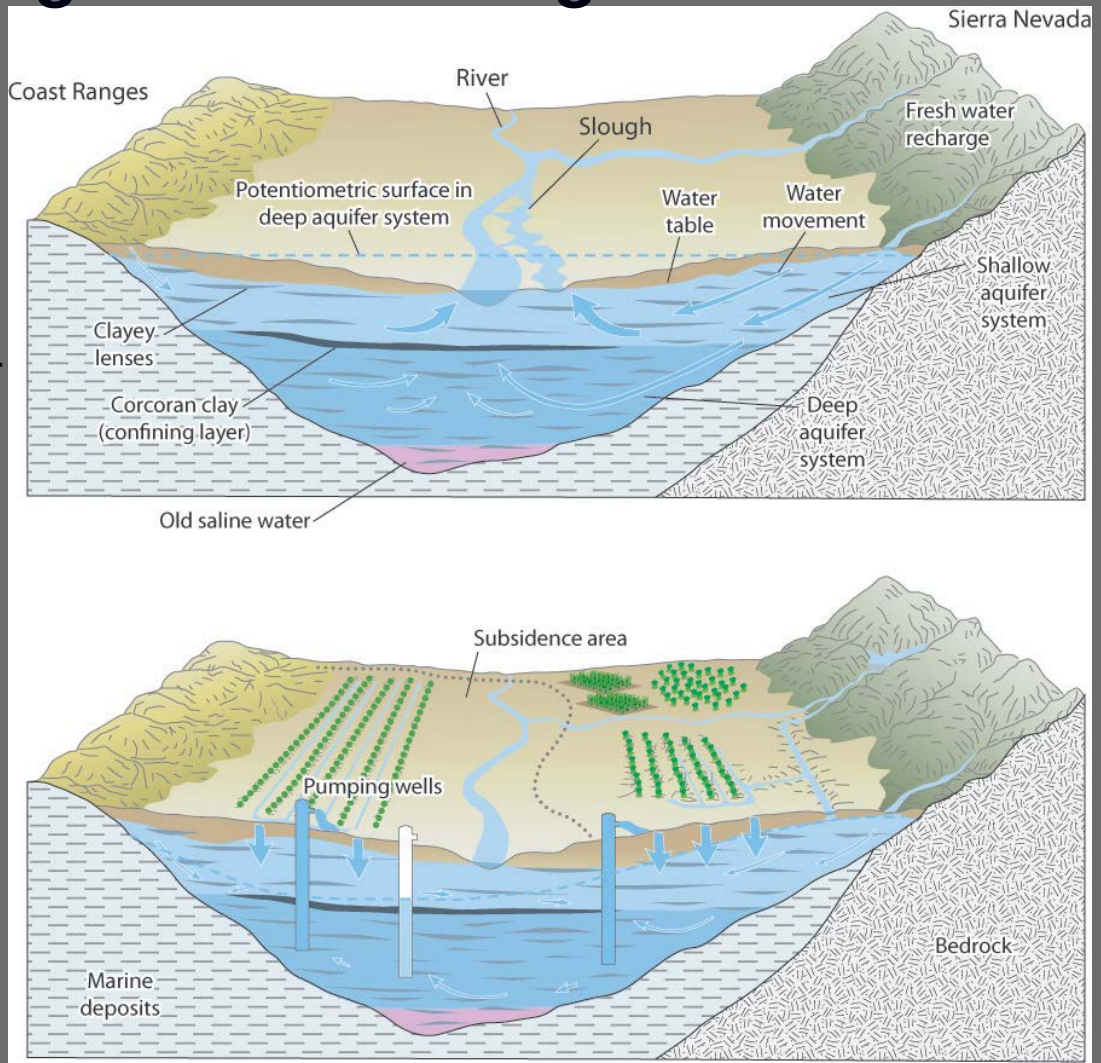
System Conceptualization:

- **DEVELOPMENT AND IRRIGATED AGRICUTURE**
  - Major effects on **volume** and **distribution** of groundwater **recharge** and **discharge**
    - PRE-DEVELOPMENT
      - Natural system
    - DEVELOPMENT
      - Began in about 1850
      - Most hydrologic data after major hydrologic changes
    - POST-DEVELOPMENT
      - Engineered system –
        - Canal network
        - Reservoirs

control inflows



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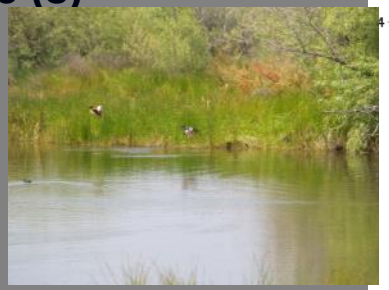
Land Use

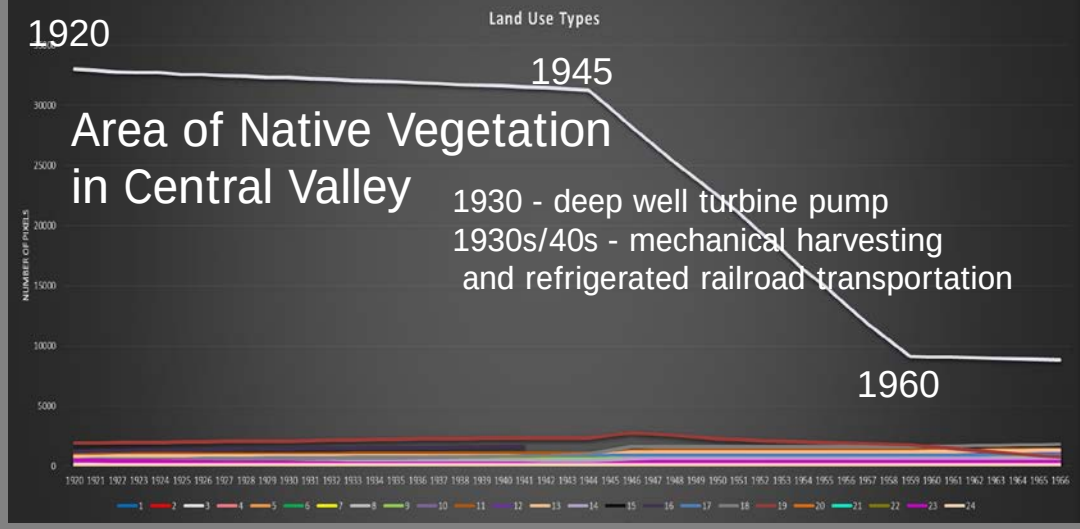
- Native
- Municipal/Industrial (Urban)
- Agricultural
  - Measure of the amount of water used to irrigate crops
  - Depends on:
    - Crop type
    - Climate
    - Soils
    - Efficiency
  - Central Valley 7 million acres of irrigated crops
    - Sacramento Valley (2)
    - San Joaquin Basin (2)
    - Tulare Basin have (3)

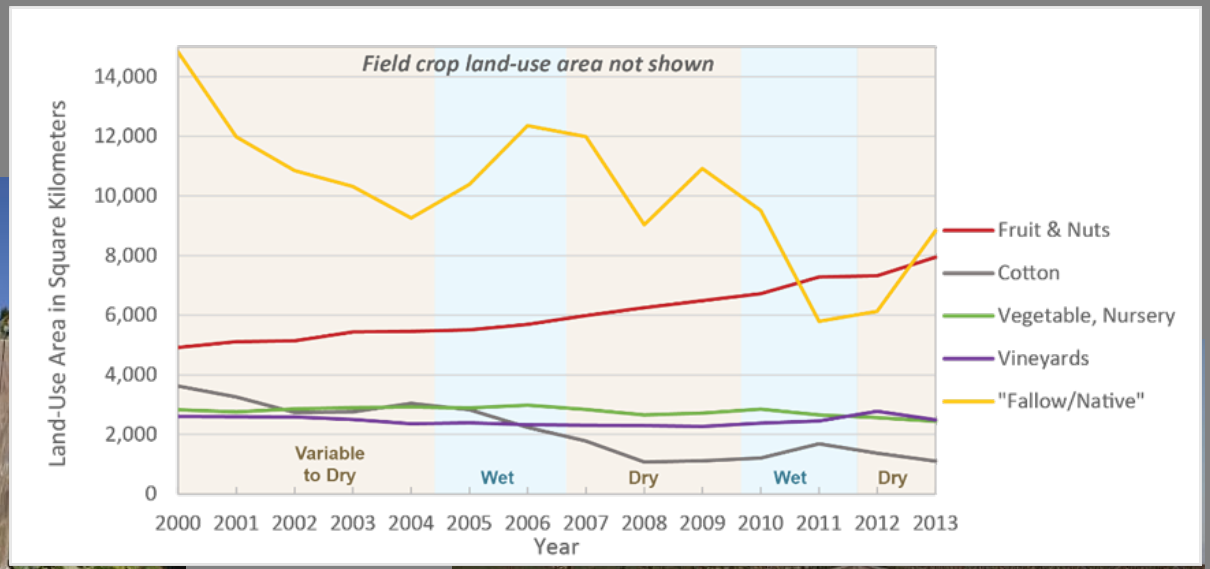
Also Environmental

- Delta flows
- San Joaquin River

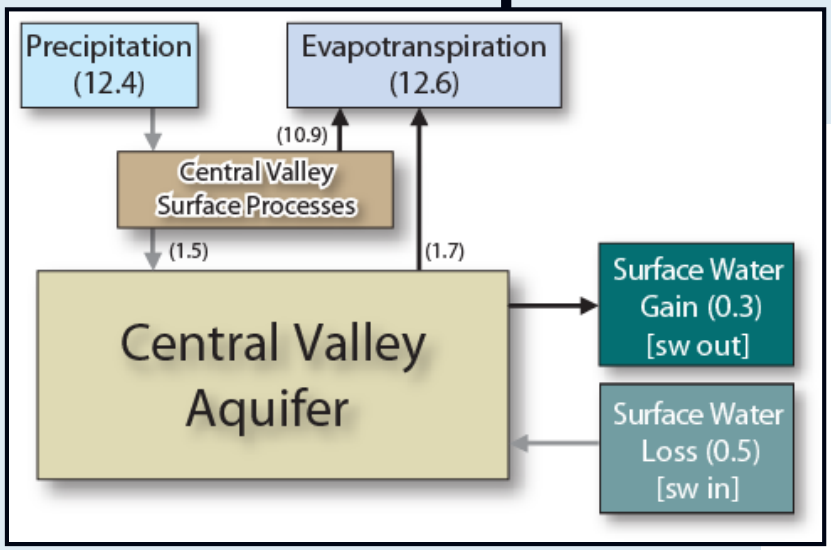


Landuse changes





Pre-development

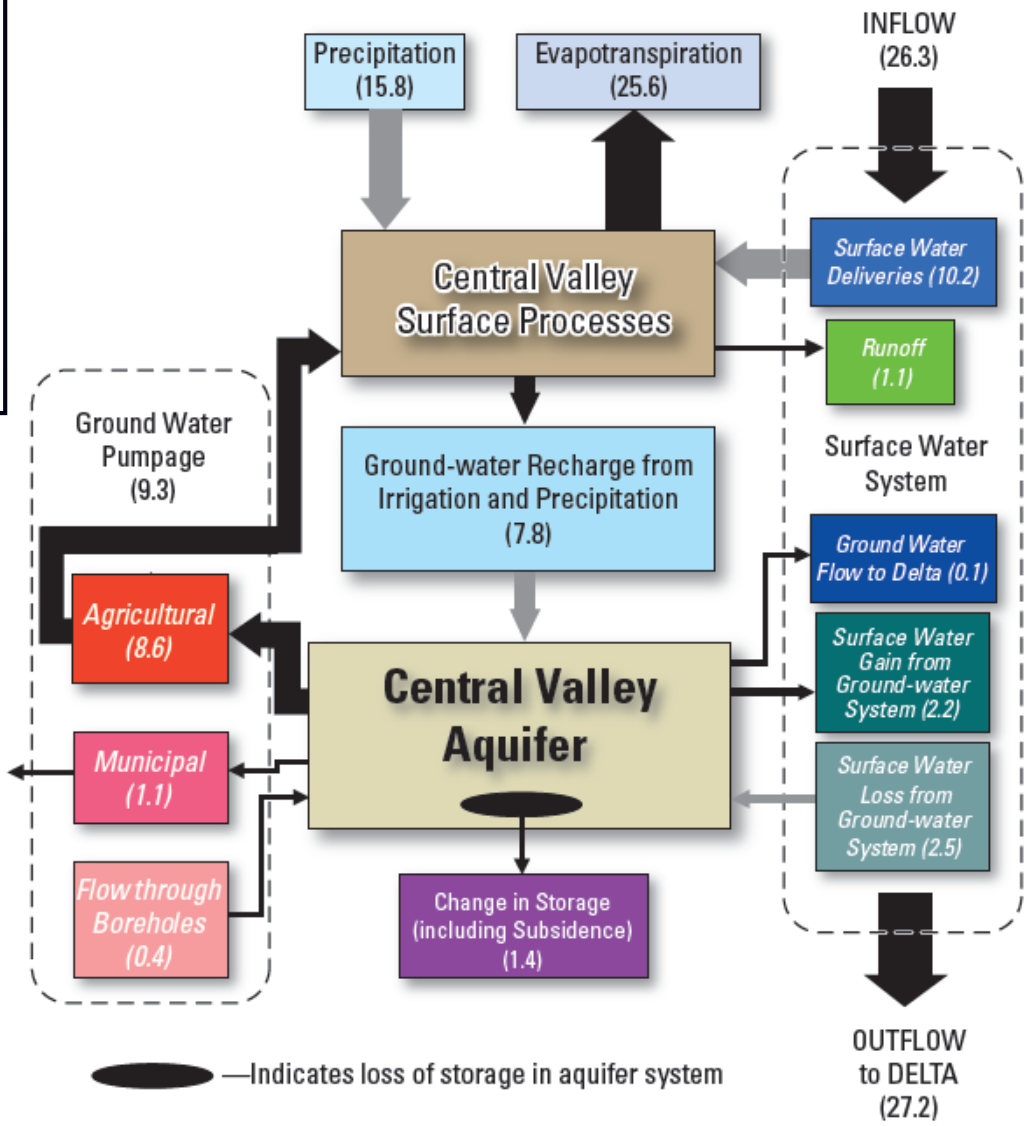


Natural ➡ **Engineered**

Simple ➡ **Complex**

2 million acre-feet/year recharge /discharge ➡ **12 million** acre-feet/year recharge /discharge

1962-2003/Engineered



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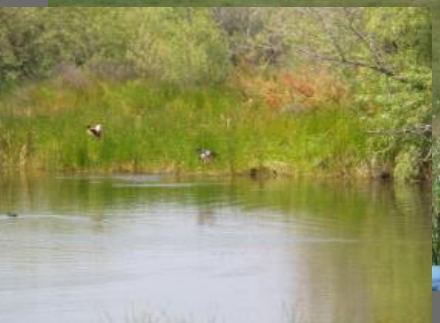
Water Supply

Conjunctive Use

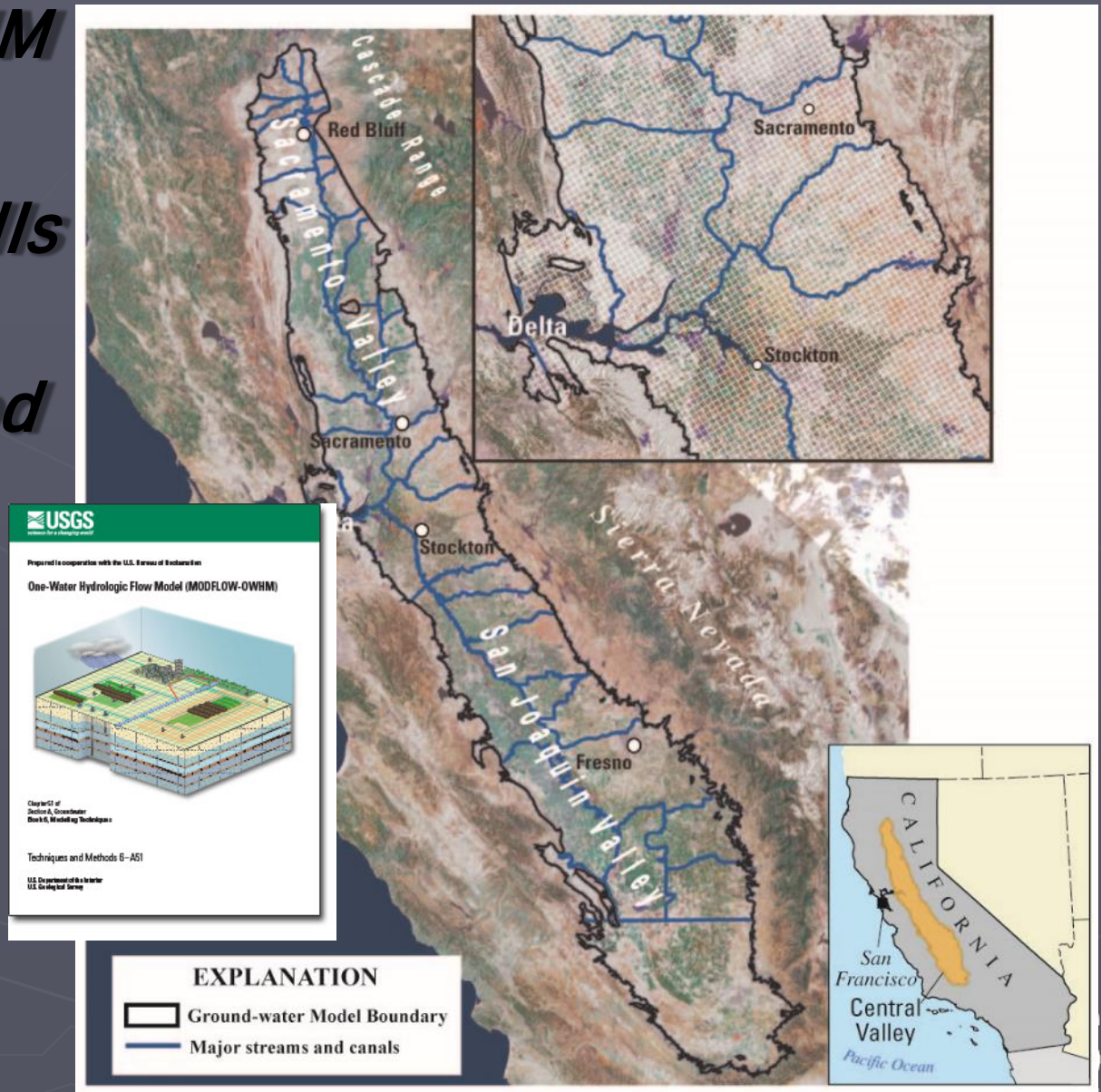
– Surface Water

– Groundwater



Central Valley Hydrologic Model

- *MODFLOW-OWHM*
- *13 layers*
- *1 square mile cells*
- *Calibration for 1961-2013 period*
- *Monthly stress periods*
- *Simulates 1921-2013*



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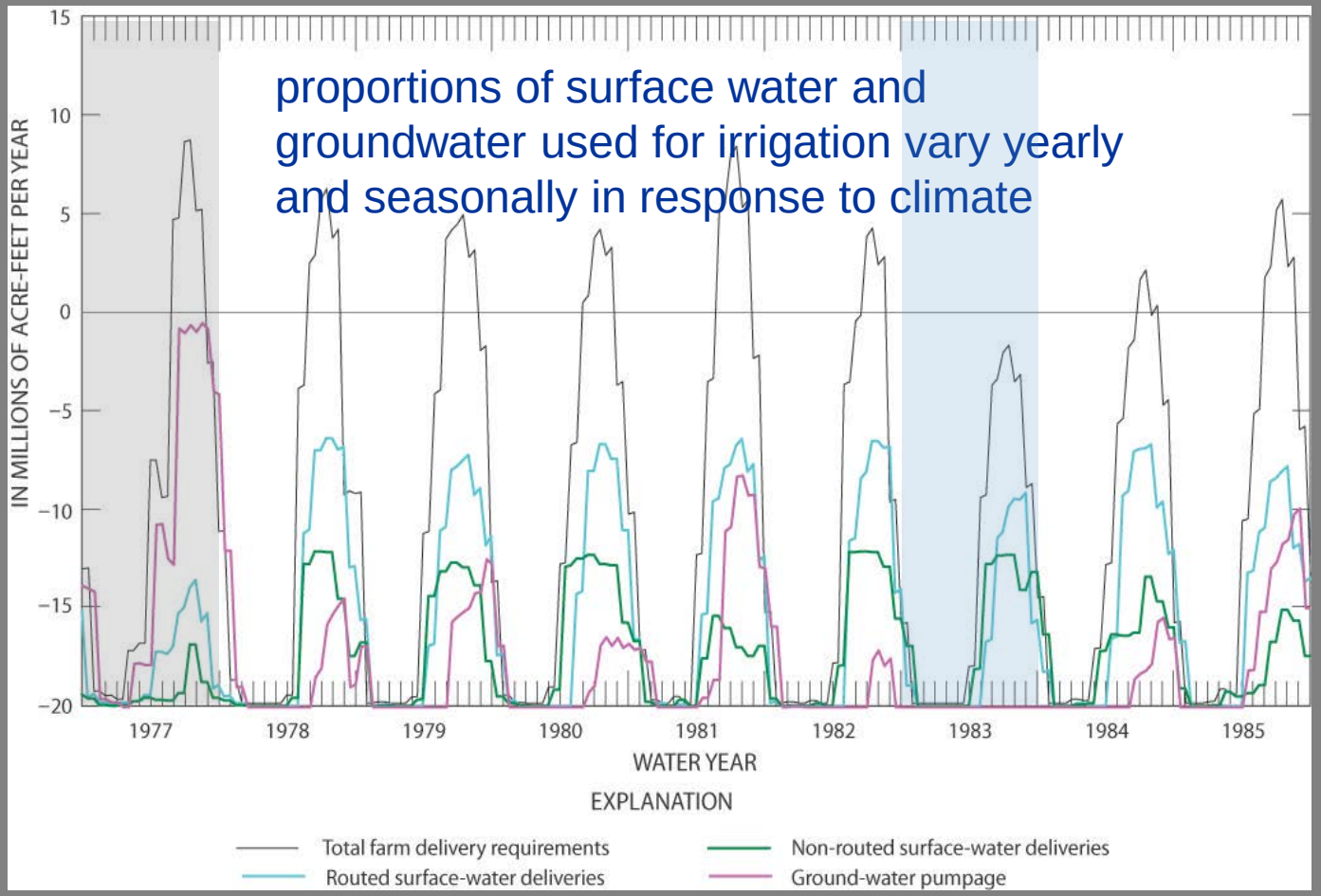
Climate Change/Variability

- ***Early in growing season, dominantly surface water deliveries***
- ***Later in growing season, surface-water shortfall made up by groundwater pumpage***
- ***Drought '77 (high pumping all growing season)***
- ***Wet Period '83 (lower delivery, mostly surface water)***



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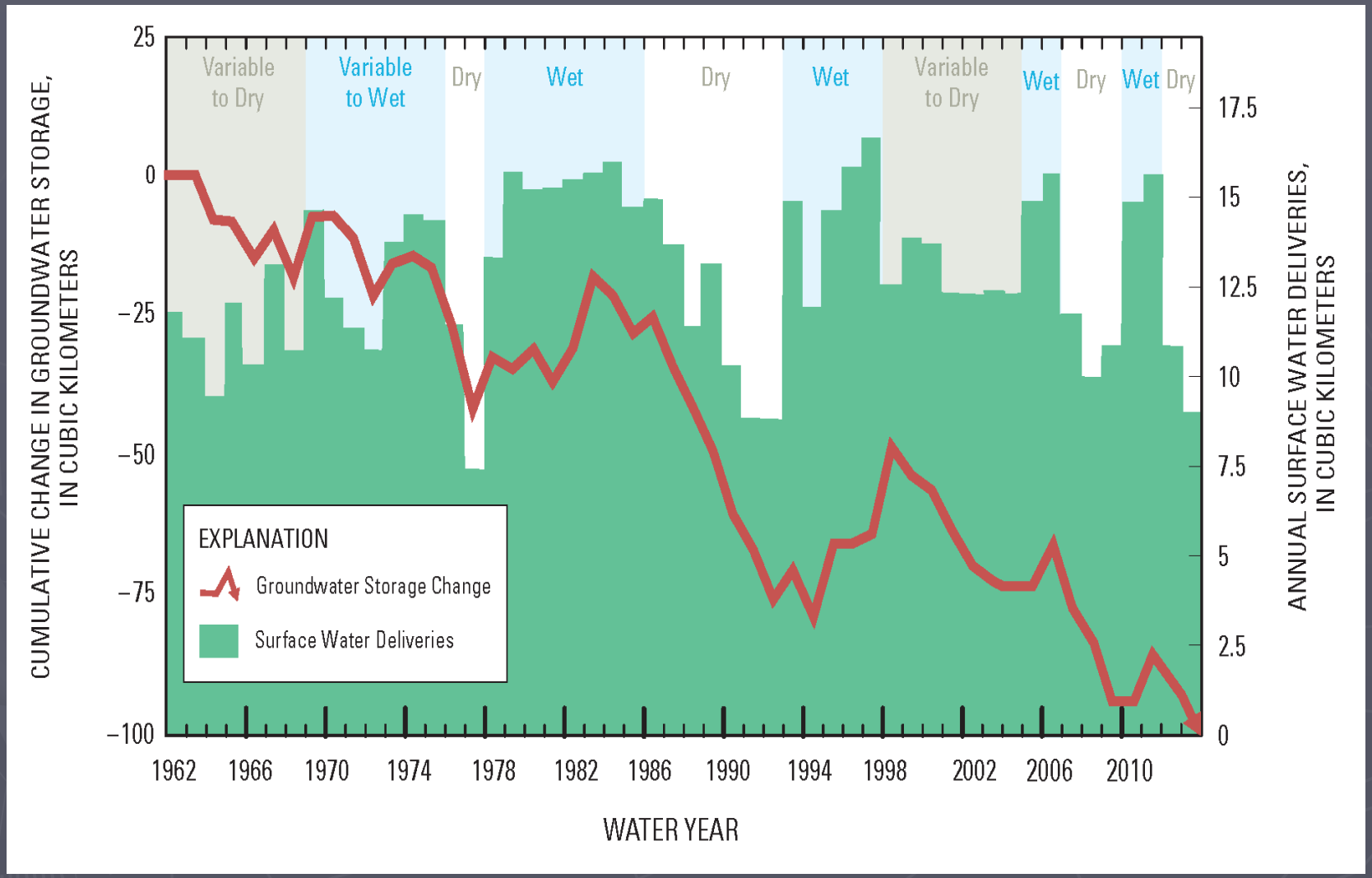
Results - Storage Change



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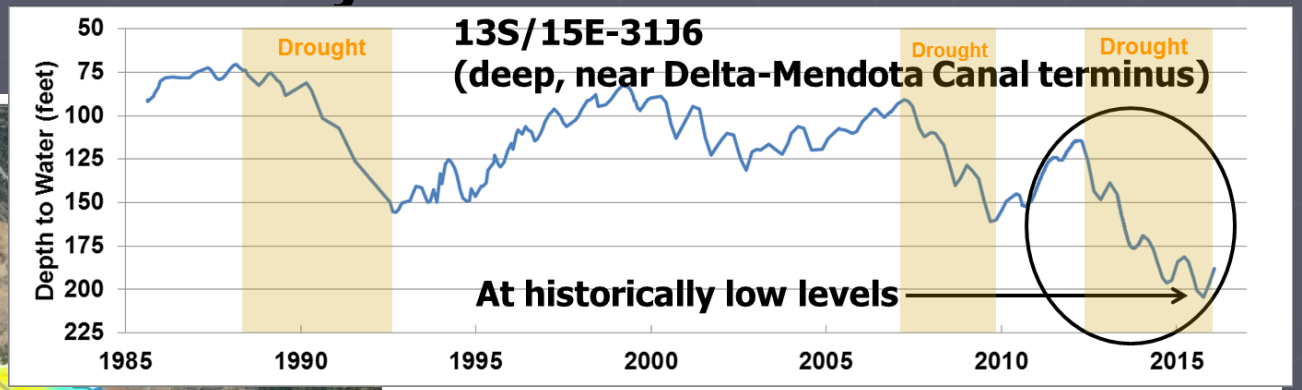
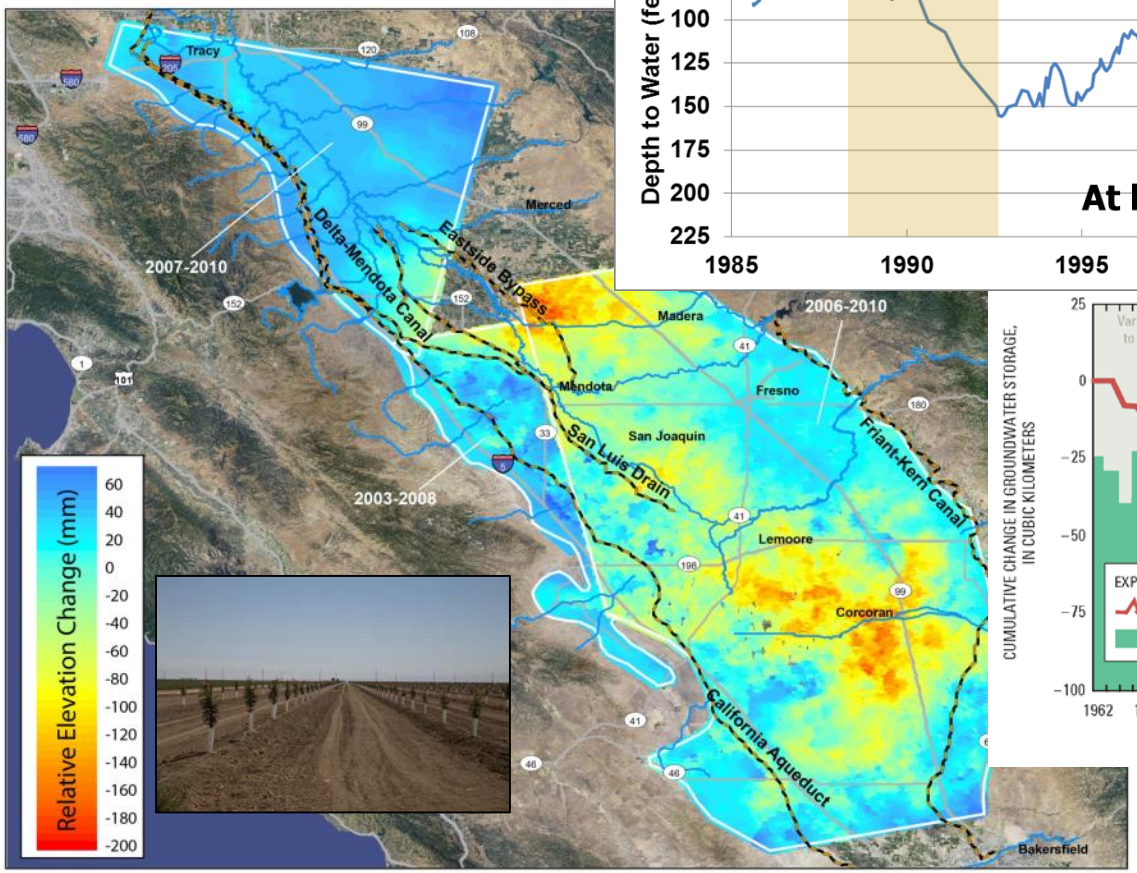
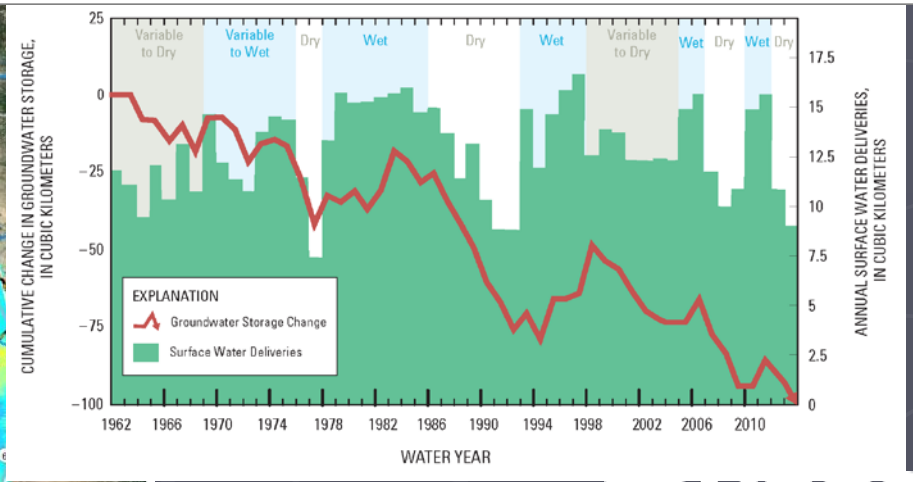
Effects on Central Valley:

The recent drought, land-use changes, and restrictions on surface-water flows have resulted in extensive pumping, large groundwater-level declines, widespread land subsidence, and salinity issues







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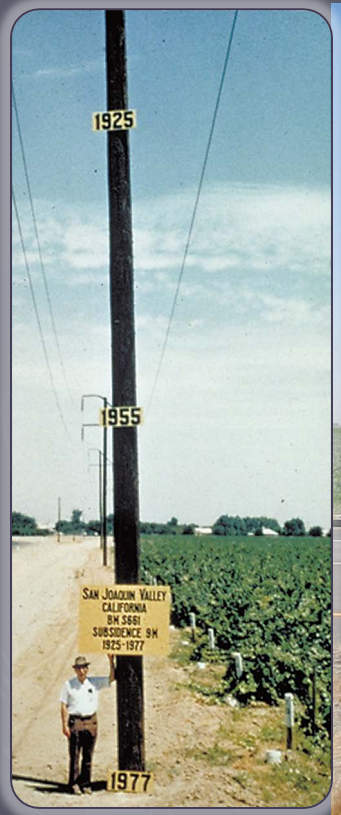
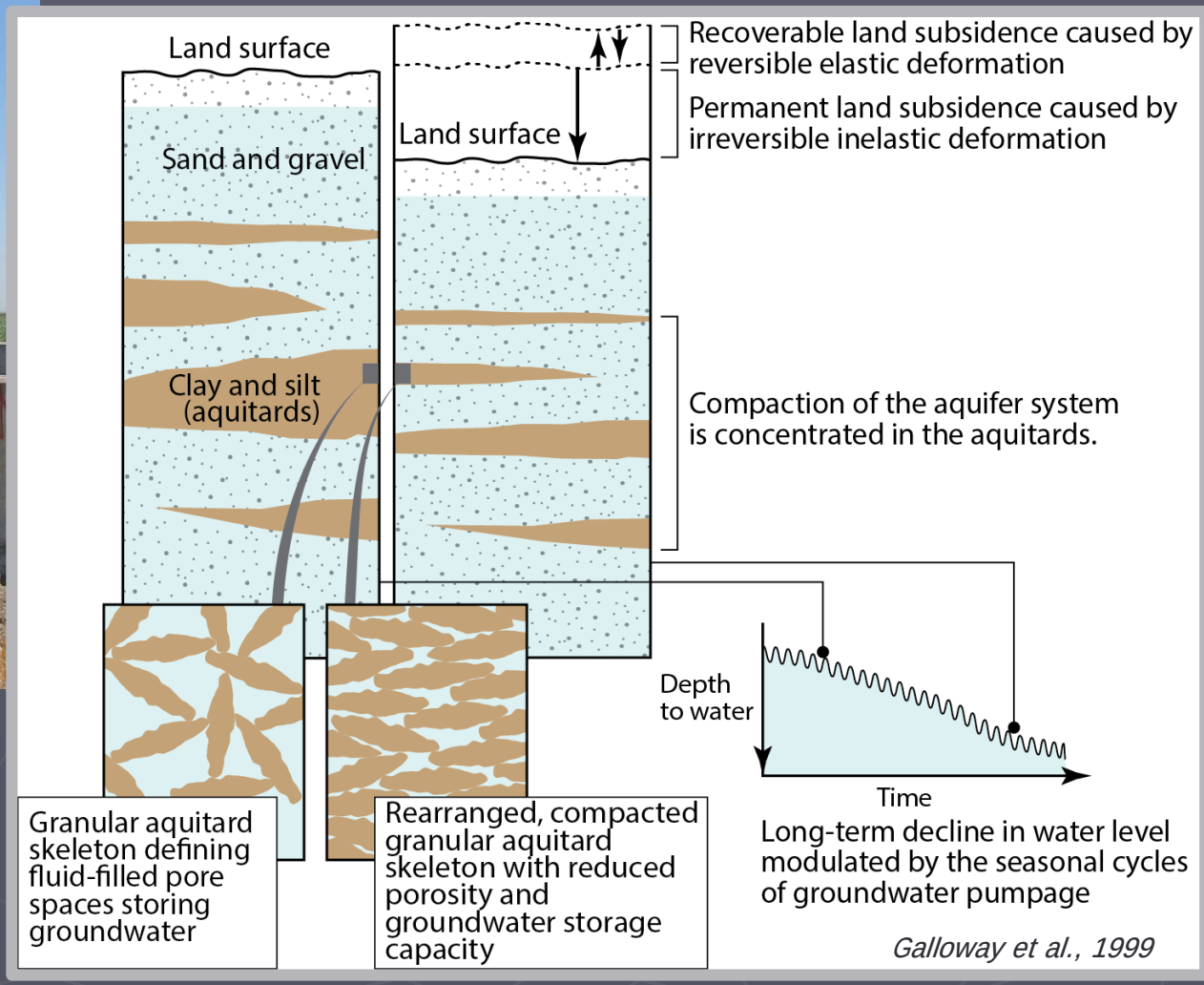
What is Subsidence?





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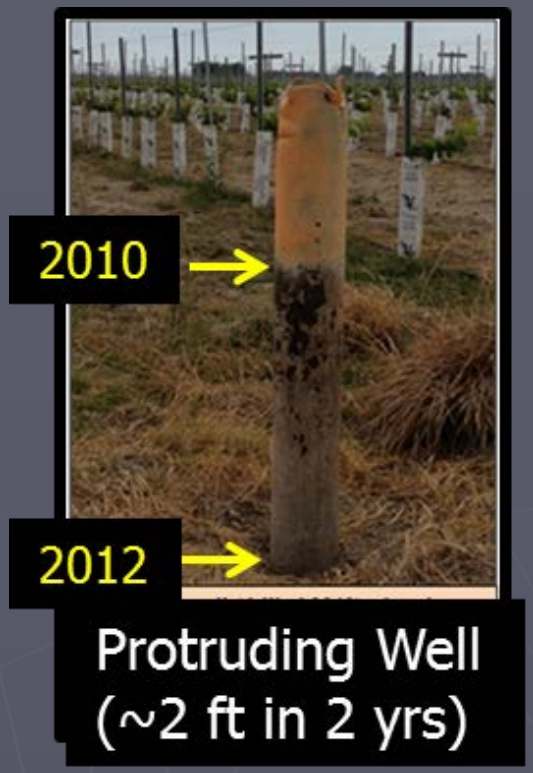
Subsidence effects



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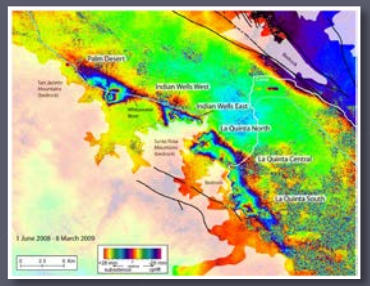
How is subsidence measured?

Bench Mark Surveys

InSAR/PSInSAR



Spirit Leveling

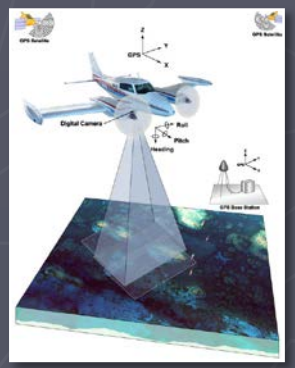
Extensometer

Tripod LiDAR

Campaign GPS

Continuous GPS

Airborne LiDAR



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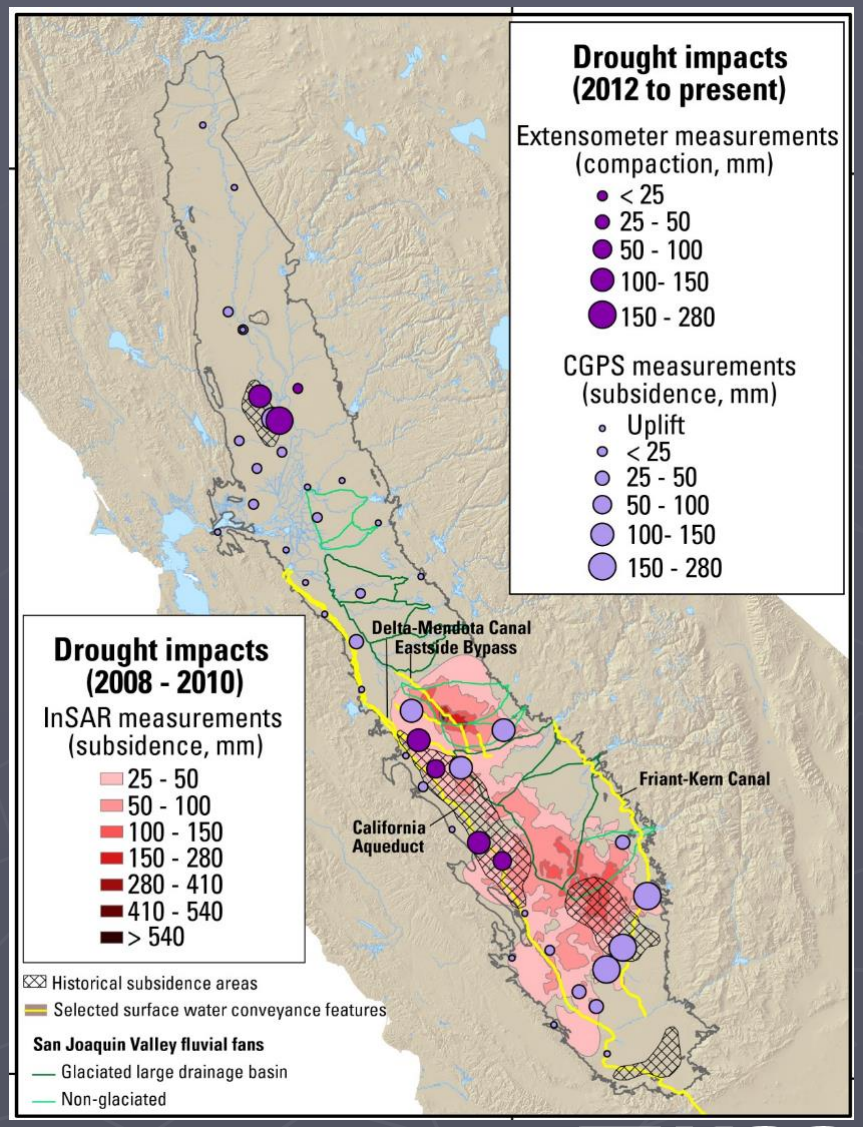
Recent Subsidence

- GPS Surveys
- Continuous GPS
  - 27 sites on valley floor
- InSAR



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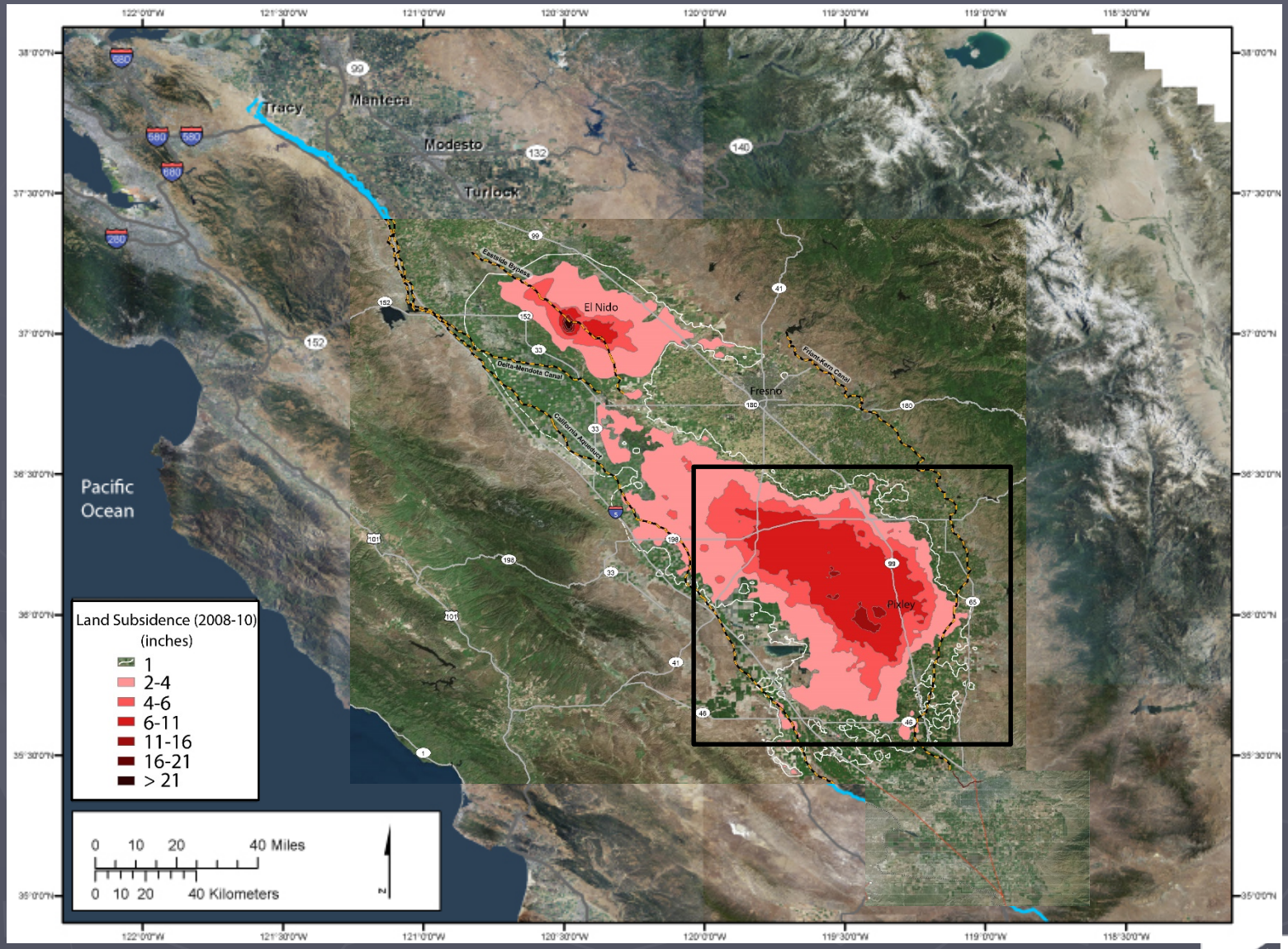
Historical Subsidence



Preliminary and subject to revision

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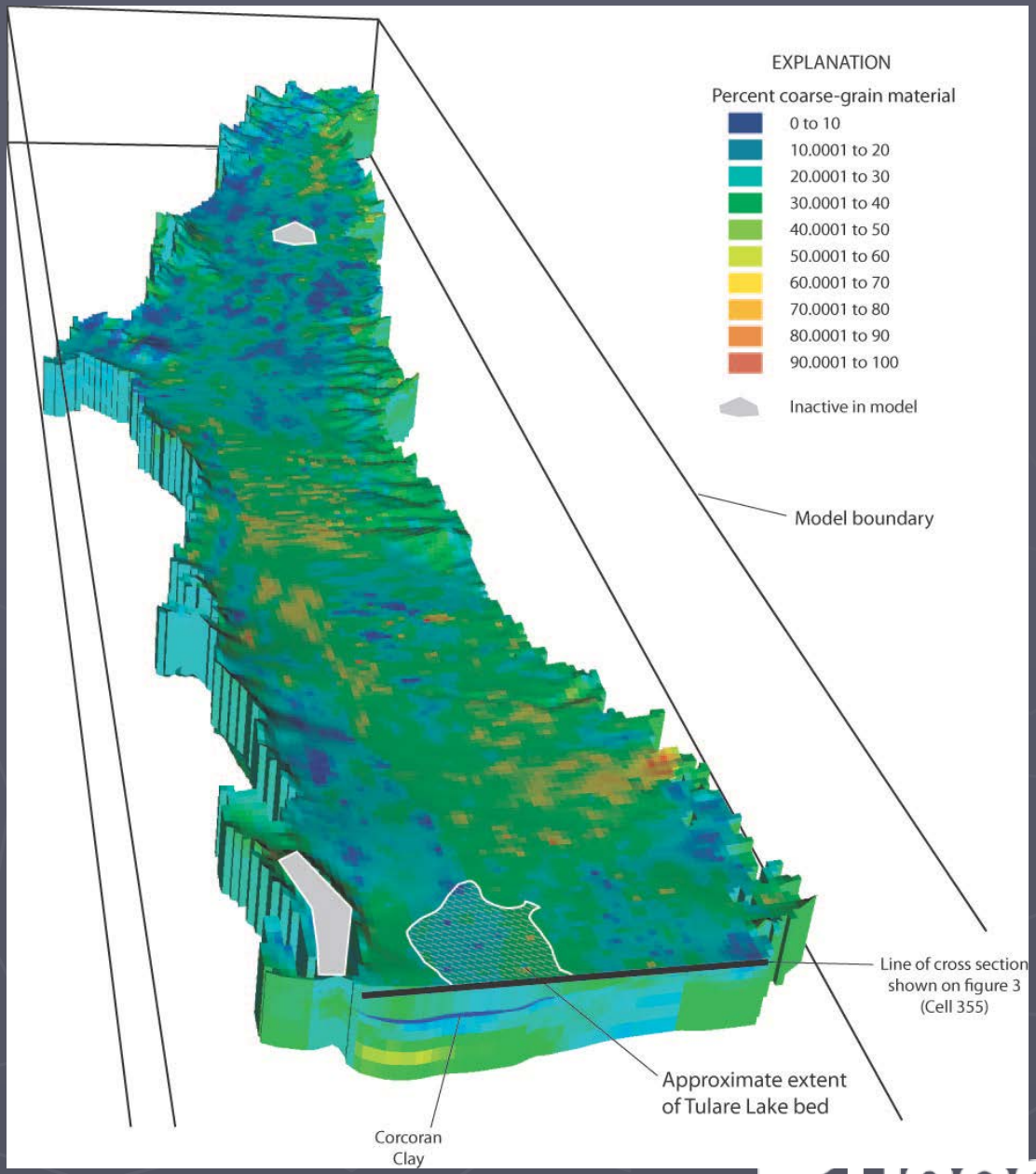
Texture Analysis:

3D model

- Based on 10,079 drillers logs
- Interpolated to one-mile spatial grid at 50 foot depth intervals
- Defines sediment characteristics of the aquifer



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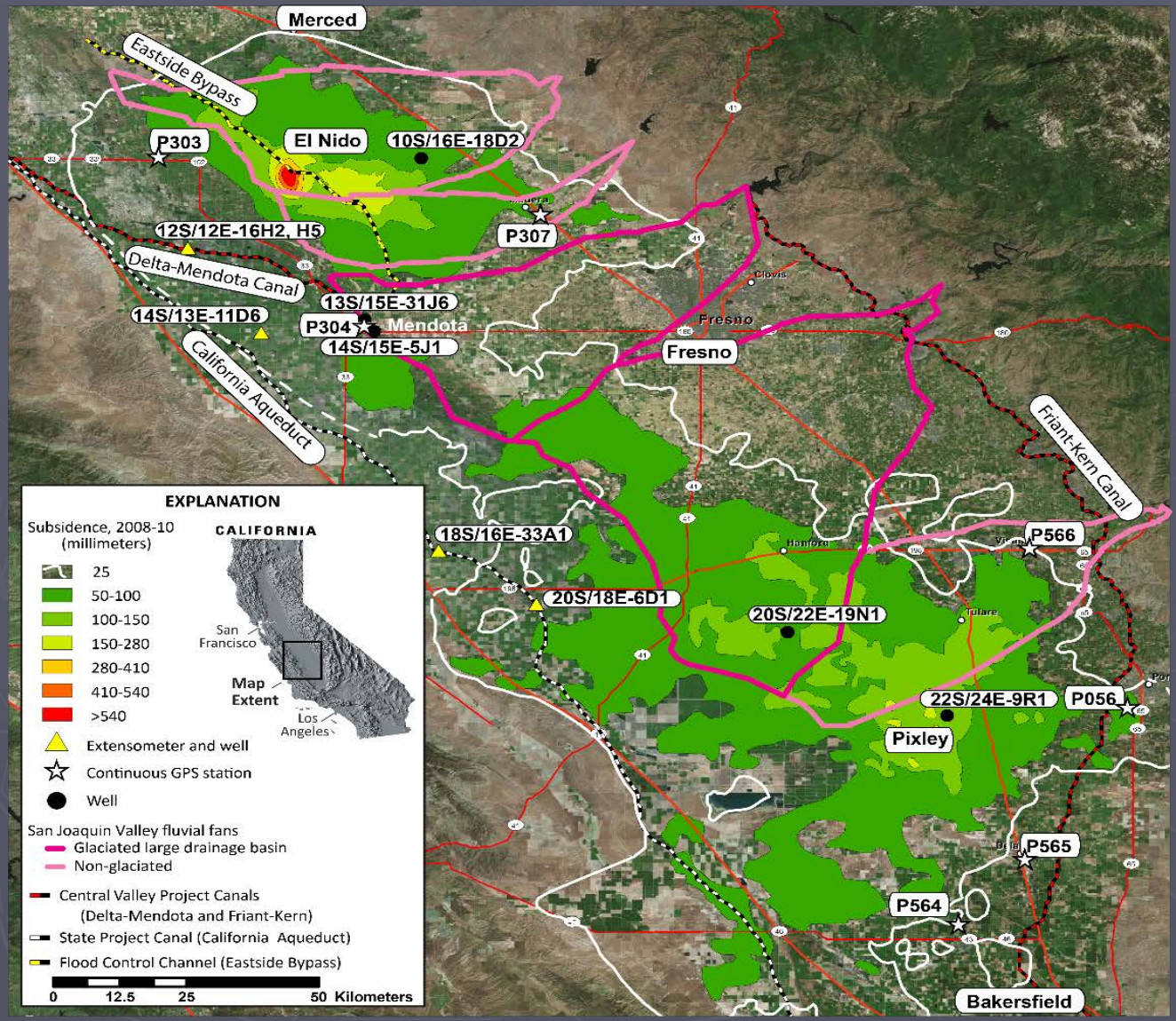
Subsidence and Geology



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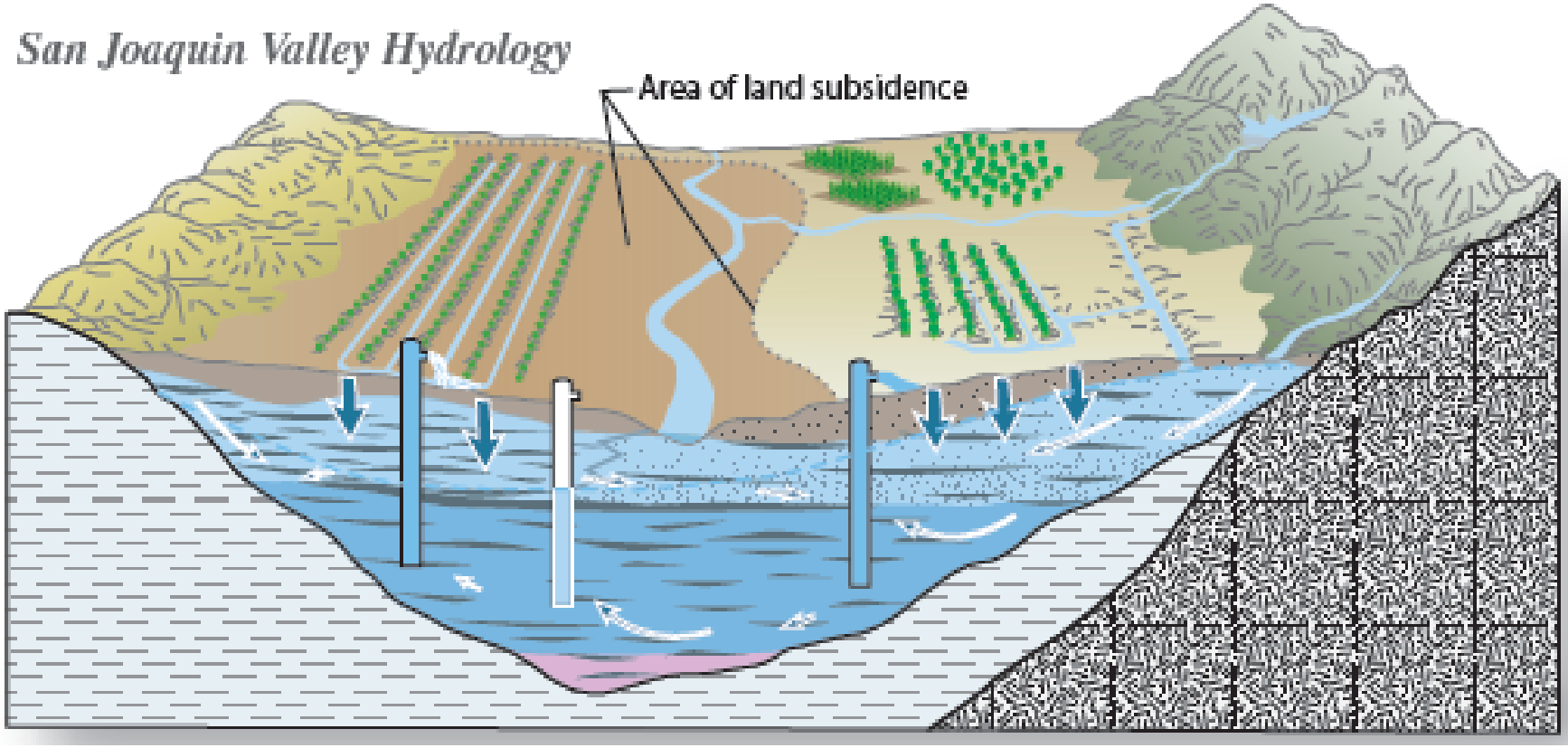
Most Compaction Occurred Below the Corcoran Clay



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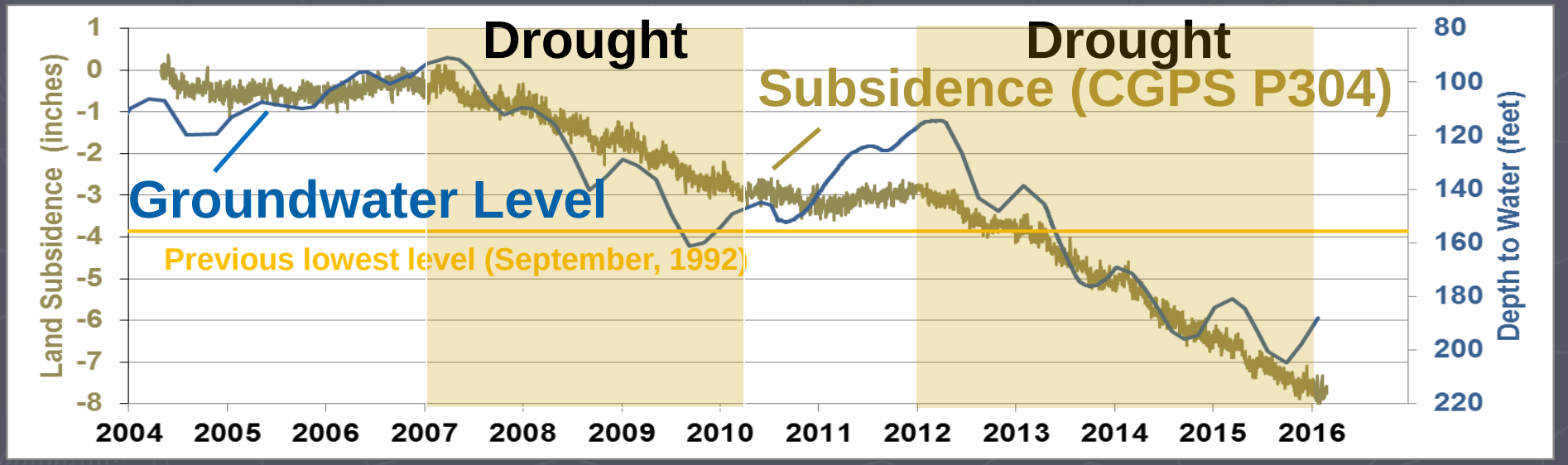
Subsidence, Land use, and Water Availability

- Renewed subsidence concern during 2007-09 drought, and the recent drought
  - Reduced surface water importation
  - More reliance on the groundwater resources



CGPS data from UNAVCO; water level data from DWR, USGS, and Luhdorff and Scalmanini Consulting Engineers

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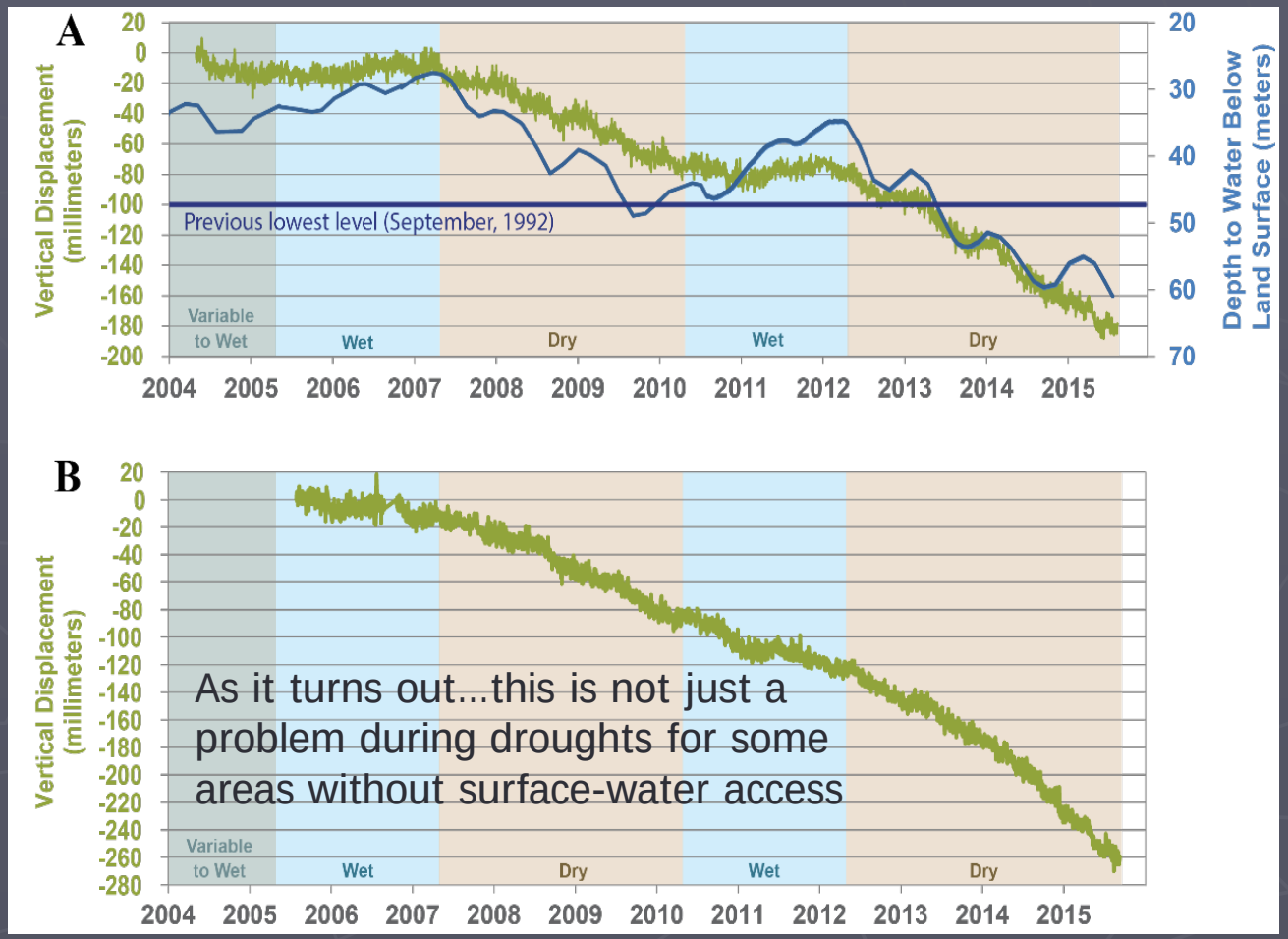
Subsidence, Land use, and Water Availability



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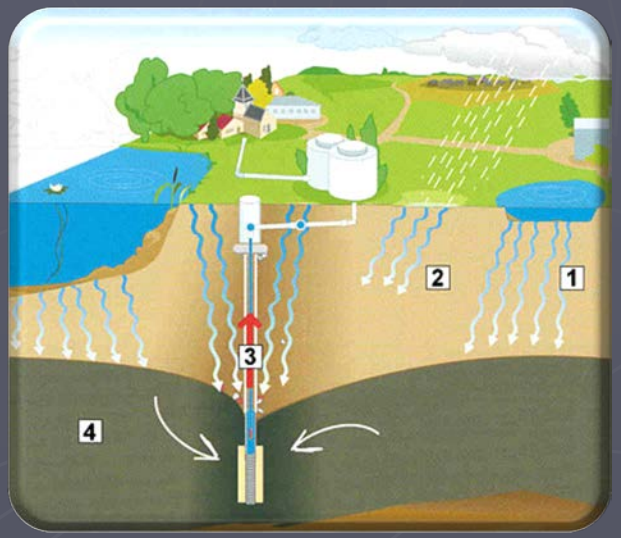
What Can Be Done About It?

- Develop tools and analyses such as these to point out challenges
  - Integrated Hydrologic models (CVHM)
- Focus on maintaining groundwater levels above the critical threshold
  - Reduction of groundwater withdrawal
    - Decreasing groundwater demand
    - Limiting/redistributing groundwater use
    - Increasing supplemental water supply
  - Enhanced groundwater recharge
    - Artificial recharge: direct well injection or surface infiltration
    - Natural recharge: source protection



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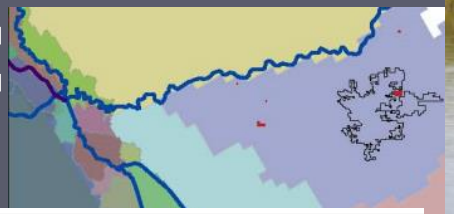
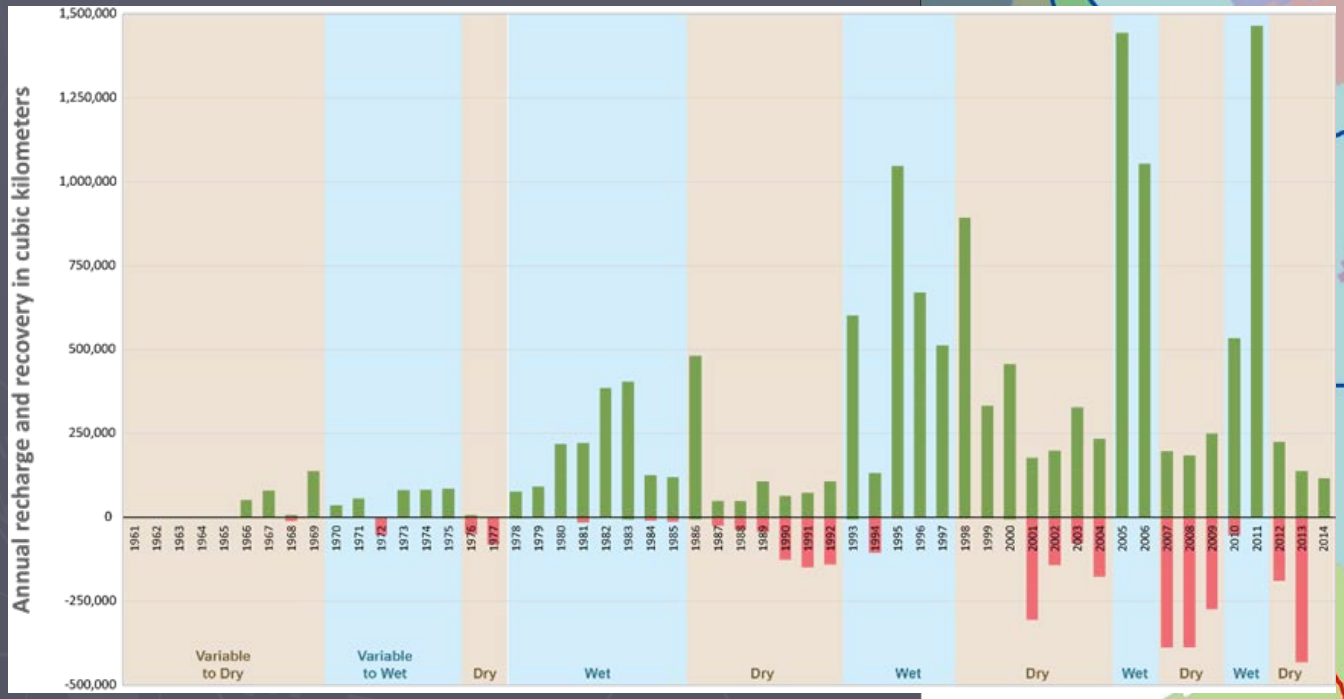
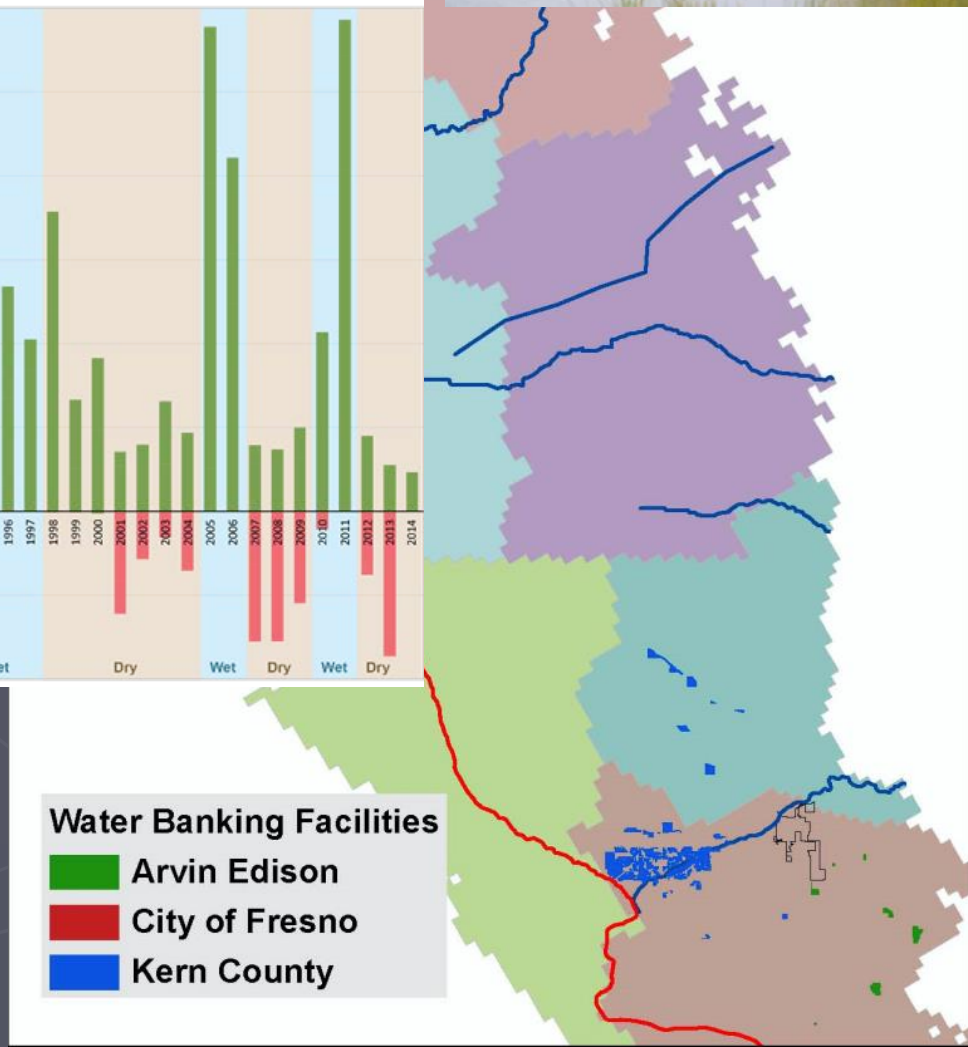
Managed Aquifer Recharge







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PAST/PRESENT/FUTURE:

Conjunctive Use: Joint use and management of surface-water and groundwater resources to maximize reliable supply and minimize damage to the quantity or quality of the resource.

Sustainability: Development and use of water in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social consequences.

Adaptation: Depends on changes in supply and/or demand, alignment with climate variability/change, and changes in water governance/policies

Summary and Conclusions

- Using about 1% of U.S. farmland, the Central Valley
  - -Produces more than 250 different crops
    - -Supplies 7% of the U.S. agricultural output (by value)
      - ¼ of the Nation's table food and ½ fruits, nuts, and vegetables
- Depending on the year, 10-20% of the Nation's groundwater is pumped from the Central Valley
- The recent drought, land-use changes, and restrictions on surface-water flows have resulted in extensive pumping, large groundwater-level declines, and widespread land subsidence
- How will recent legislation impact this?
  - Numerical models are a useful tool to forecast information based on alternative scenarios
  - GRACE is useful tool at regional scales to analyze recent trends

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Thanks!
http://ca.water.usgs.gov/projects/central-valley/
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