Discussion

Groundwater, Energy, and Crop Choice

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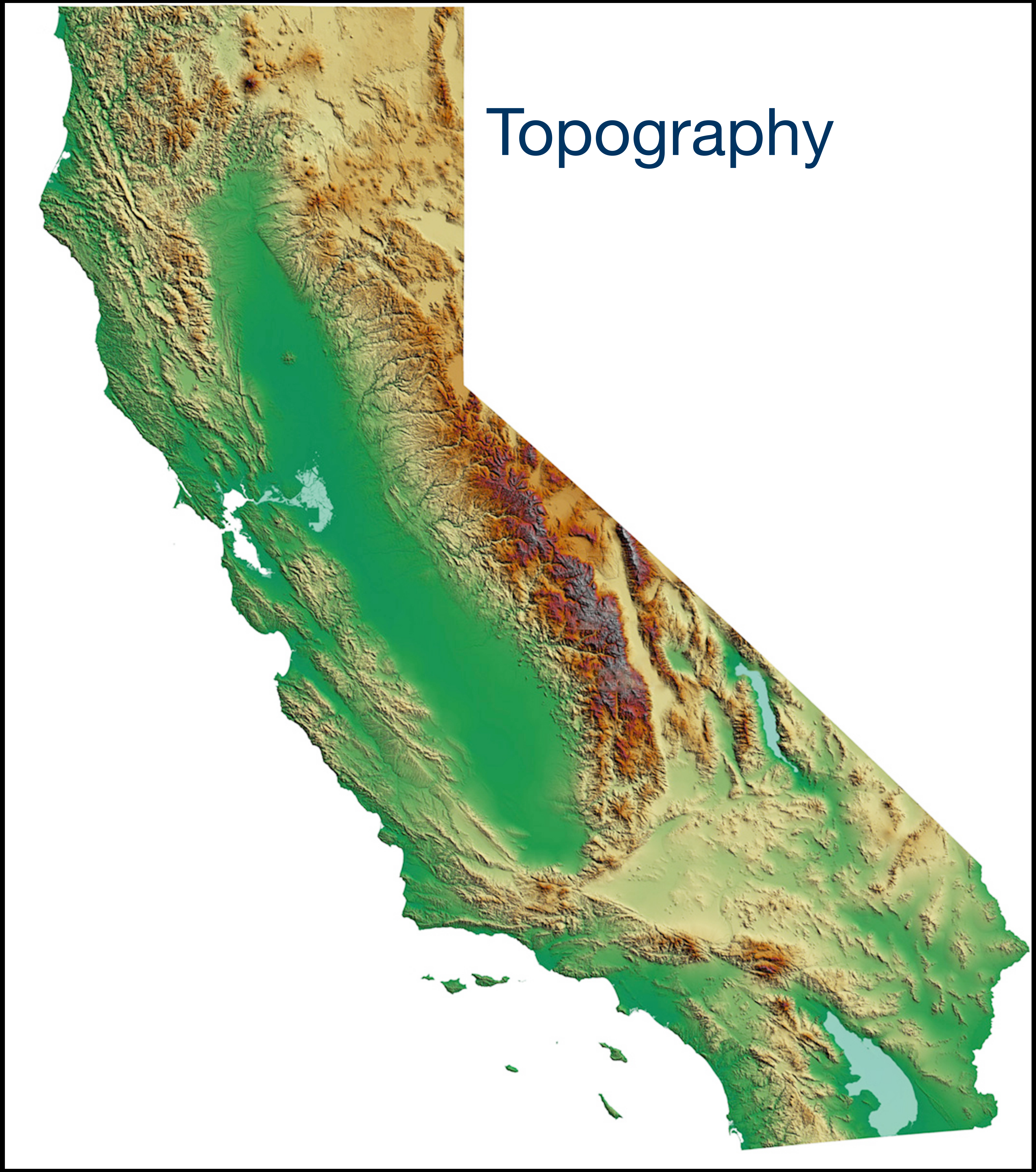
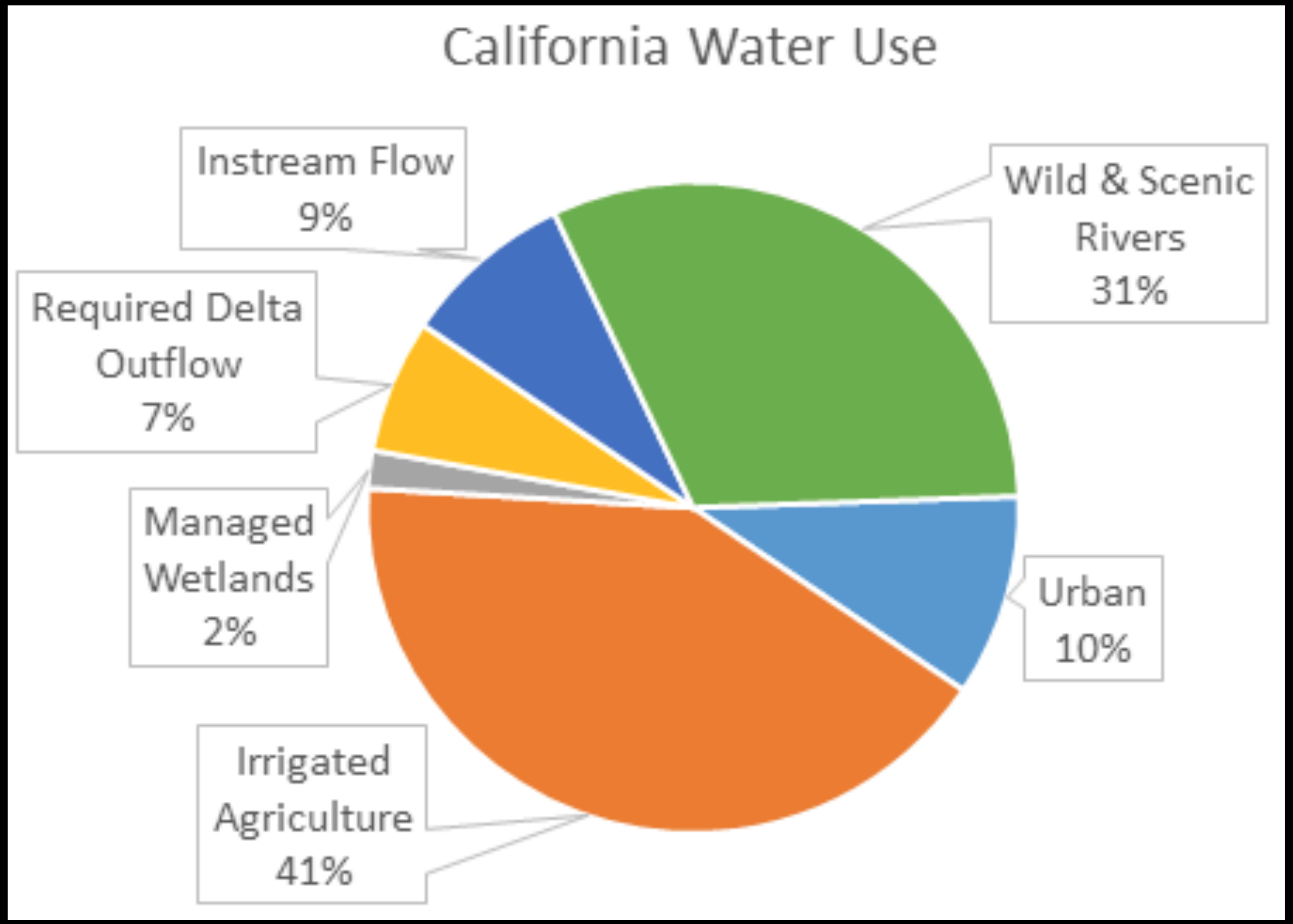
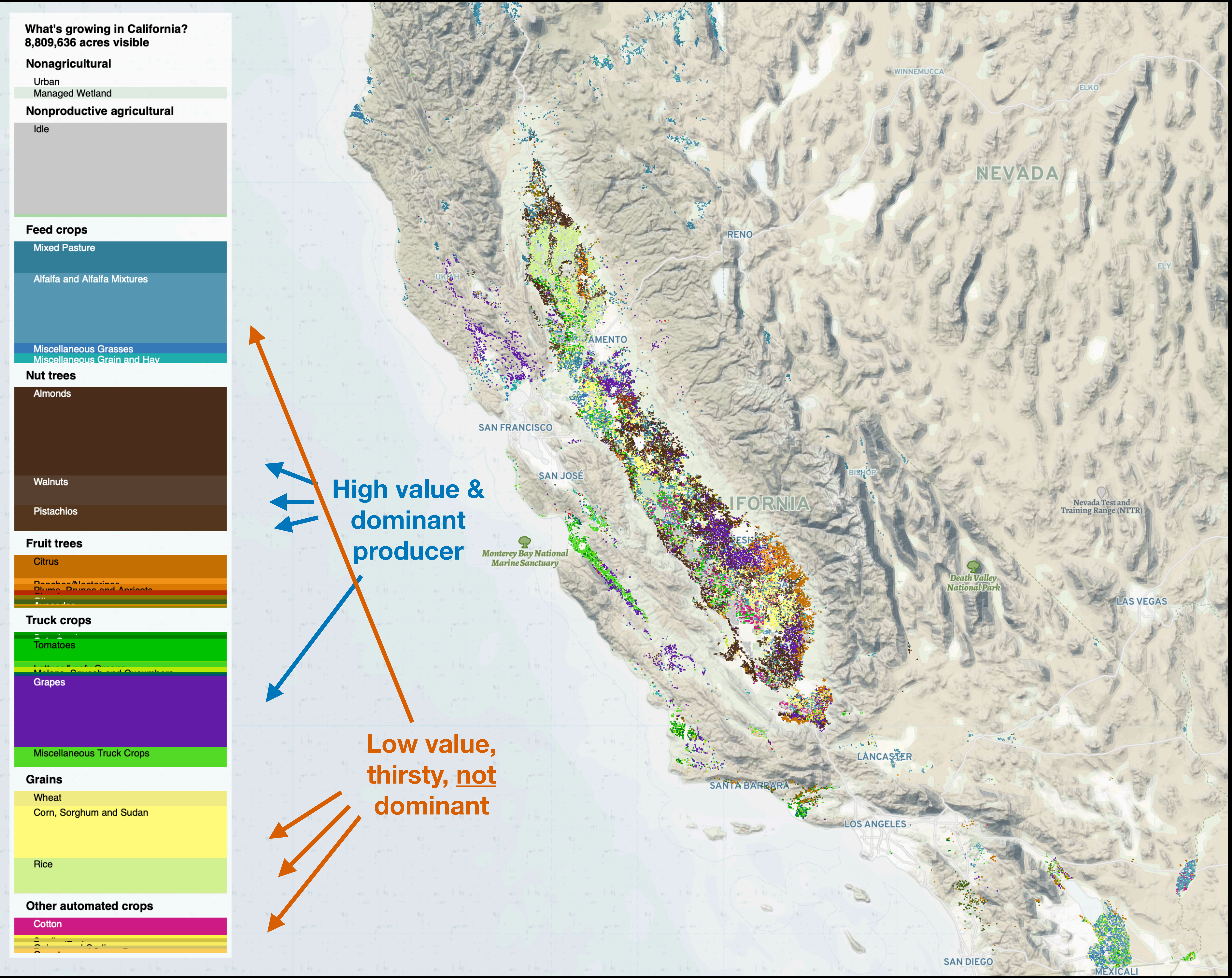
July 20, 2020


Topography

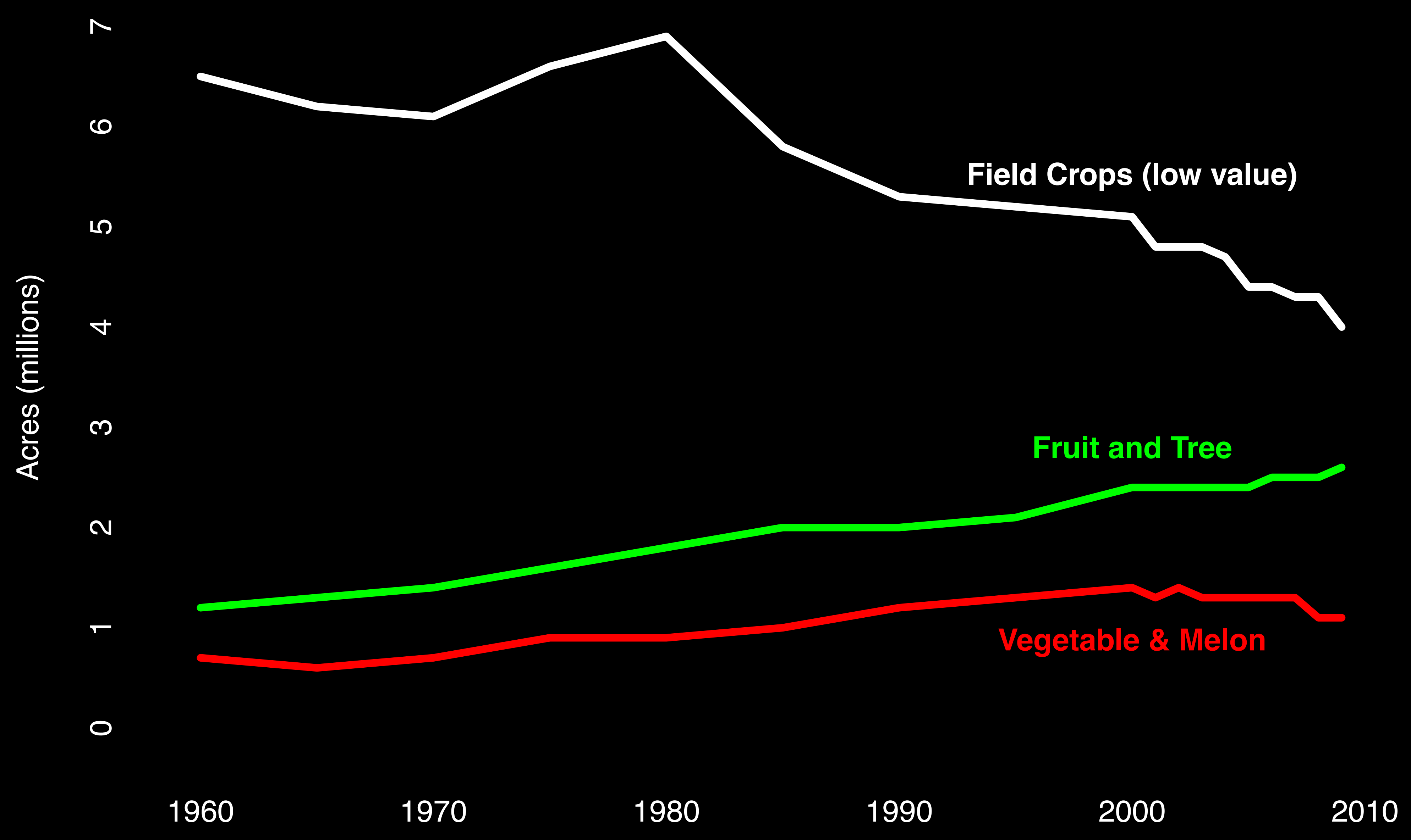

California Water Use
Instream Flow 9%
Wild & Scenic Rivers 31%
Required Delta Outflow 7%
Managed Wetlands 2%
Urban 10%
Irrigated Agriculture 41%


Water Projects
Major Rivers
State Projects
Federal Projects
Local Projects
All Water Projects
Redding
Sacramento
San Francisco
Fresno
Los Angeles

Where Crops Are Grown



Pre-study production trends



Old Problems

- Environmental damages from dams, runoff, growing salinity in soil
- Water rights
  - Surface water: first in use, first in right. Use or lose
  - Common-pool groundwater resources
  - Limited, non-transparent markets

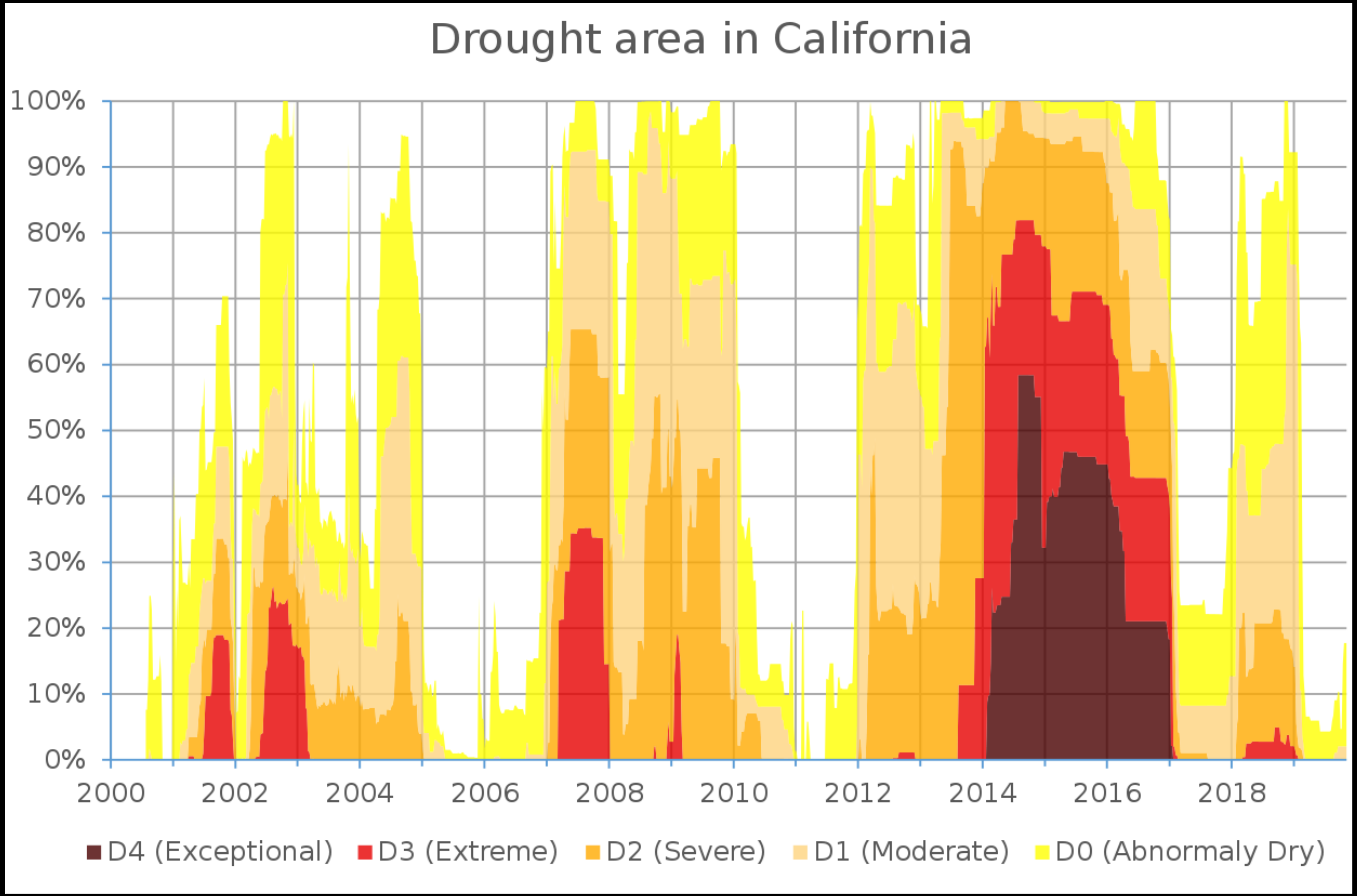
Implication: Inefficient water use — no pricing of externalities, high use on low value crops

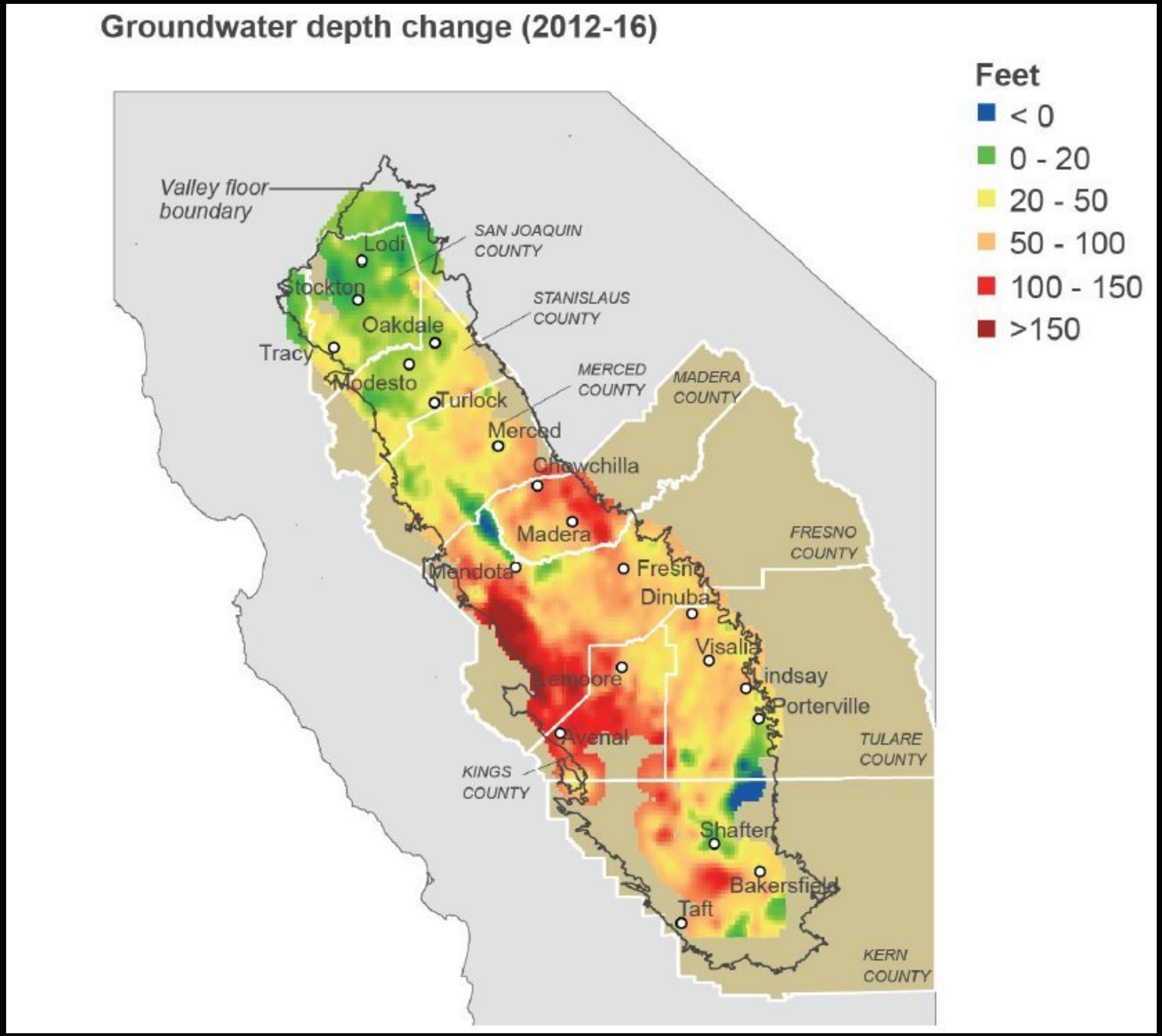
Newer Problems

- Climate Change
  - Earlier Spring melt — lost storage from snow pack
  - More variable precipitation
    - Less usability of existing storage
    - More frequent, more severe drought
- Groundwater depletion
- Better irrigation, but less groundwater recharge

Implication: Irrigation is an very unlikely adaptation strategy for climate change — it actually compounds existing challenges and inefficiencies

Record Drought, 2012 - 2017





Big Questions

What and how much will we be able to produce?

How much can better water pricing help?

<u>This paper's claim</u>: better water pricing can help more than previous studies suggest

Observation #1

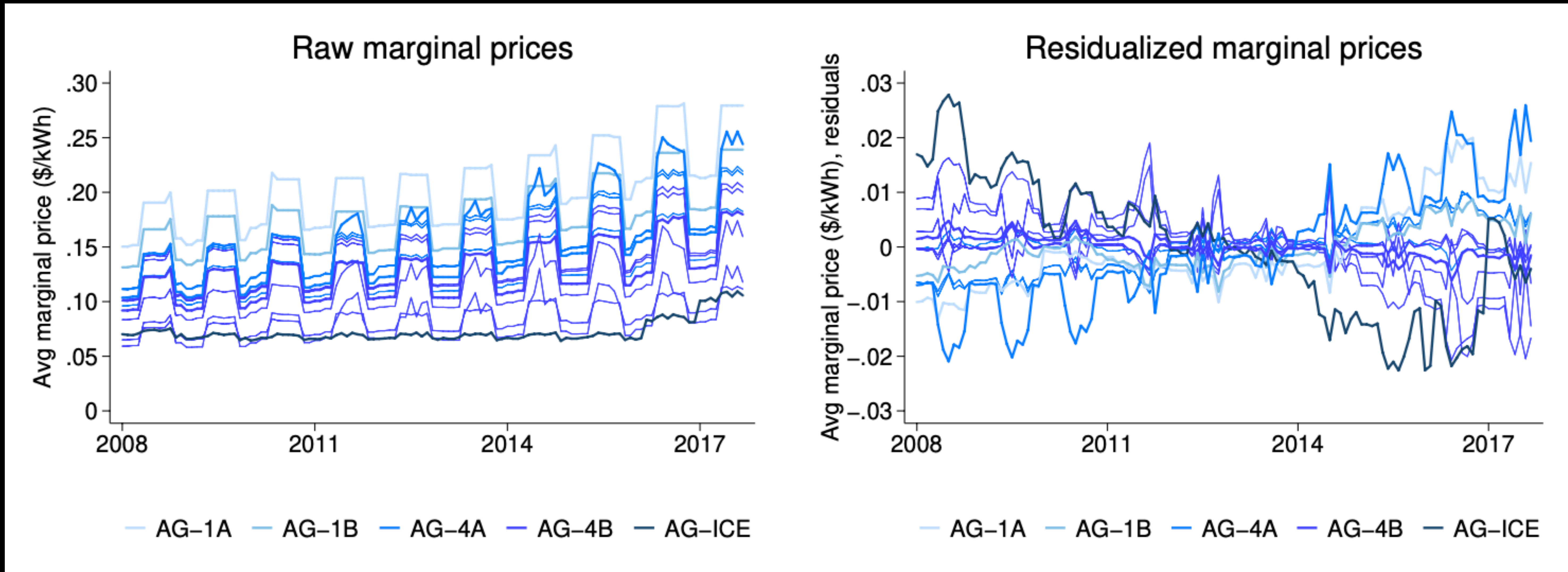
High degree of spatial correlation in:

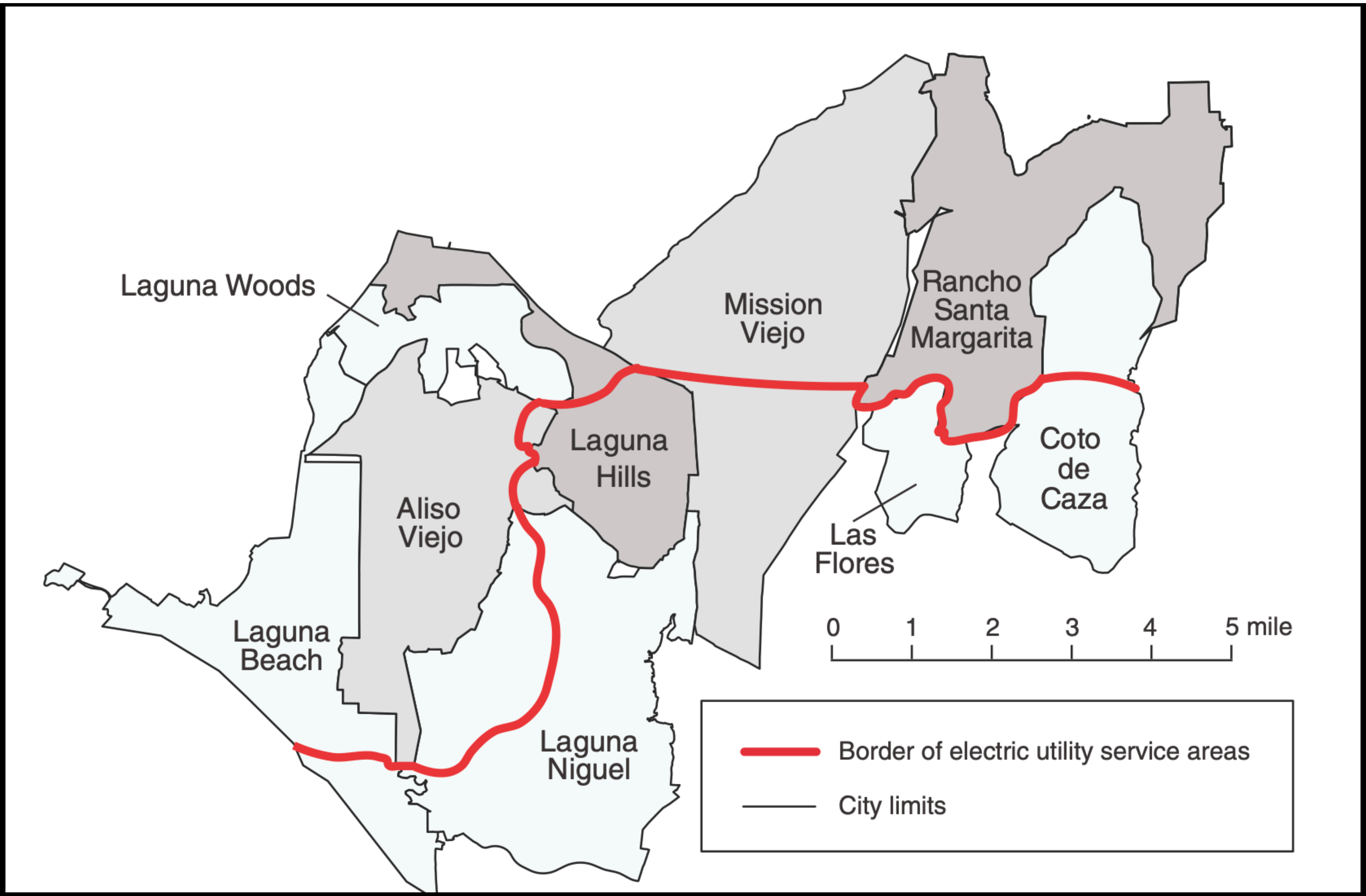
- weather, soils, crop choice
- groundwater depth
- water rights (?)
- electricity prices, trends, & variations (?)

It is hard to unpack the plausible exogeneity of the price anomalies.

Suggestions

1. Show correspondence between tariffs, crops & regions.
2. Make source of price differences more tangible: what rate case decisions and underlying cost factors cause them?
3. Look for narrower comparisons — does utility border run through the middle of a region with similar ex-ante crop mix and groundwater depth?
   - Ito, AER 2014 is great example





Observation #2

Unit of observation — point by month — seems high resolution relative to crop choice

- Tree crops take many years to bear fruit
- Some regions can grow multiple crops
- Some regions have more flexibility in planting

Observation #3

The authors account for spatial/temporal correlations for using two-way clustering: point and month.

- Lags of nearby points likely to be highly correlated too.
- What happens to standard errors if clusters expanded to larger areas (crop districts?) and seasons?

Observation #4

kWh/AF enters both sides of the water demand equation (reciprocally)

$$Q_{it}^{\text{water}} = Q_{it}^{\text{elec}} \div \widehat{\frac{\text{kWh}}{\text{AF}}}_{it} \qquad P_{it}^{\text{water}} = P_{it}^{\text{elec}} \times \widehat{\frac{\text{kWh}}{\text{AF}}}_{it}$$

- Does this influence demand estimates?
- A good price instrument may reconcile.
- But does not "lift" factor into quantity and price variations?
- Critically that pricing anomalies not correlated with lift.

$$\frac{\text{kWh}}{\text{AF}} = \text{kW} \div \frac{\text{AF}}{\text{hour}} = \frac{[\text{Lift (feet)}] \times [\text{Flow (gallon/minute)}]}{[\text{Operating pump efficiency (\%)}] \times [\text{Constant}]} \div \frac{\text{AF}}{\text{hour}}$$

Observation #5

No summary statistics in implied groundwater use by crop and/or region.

- Assume all electricity (less fixed effects) used for water
- How does implied groundwater use plus average surface water allocation square with agronomic predictions?

Observation #6

Growing seasons differ markedly by region and crop.

- Napa, Salinas, Imperial, North SJV, South SJV, West SJV
- Time-period fixed effects won’t capture most temporal shocks critical to a crop/region.
- Many of the aggregated crops, especially annuals, differ considerably in agronomy
- Some crops planted multiple times per year

Question #1

What is the implied "price" of water and how does it vary by crop, by region, and over time?

- The price levels may be as interesting as the slope of demand.
- Easier to defend & compare with other metrics
- "Gut check" on whether approach makes sense and squares with basic agronomy.

Question #2

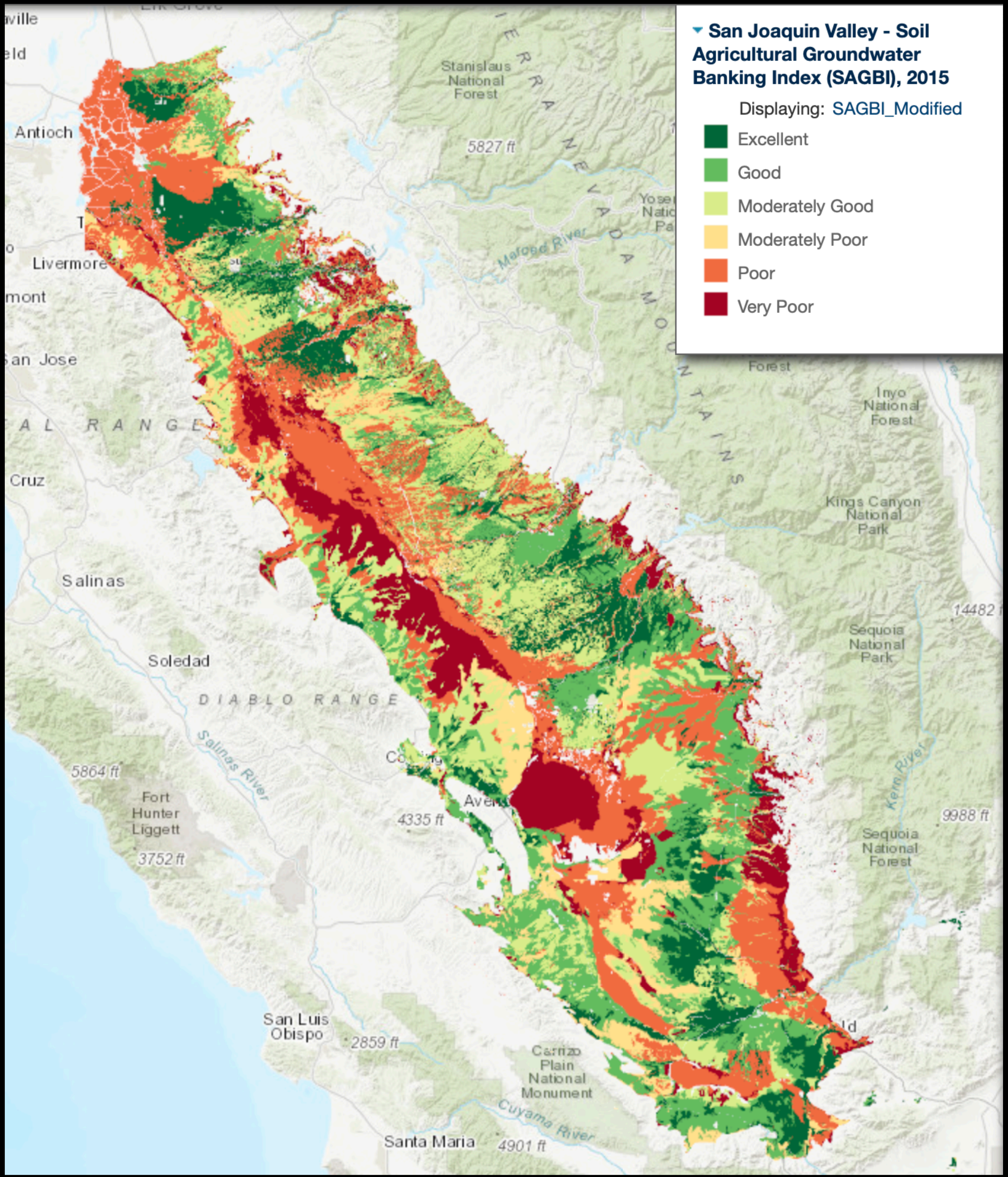
Might observed response be “short-run” instead of “long-run”?

- Plantings have been transitioning from alfalfa and cotton to high-value tree crops for a long time. High electricity prices or drought may simply accelerate transition.
- May save water in short run (when trees are small), with little water reduction in the long run.
- Alternatively, farmers may use groundwater during low-price time of year, surface water allocation in high-price time of year.

Relatedly

“Groundwater banking index”

This may factor into pumping and lift levels — e.g., recharge from prior years with large surface water deliveries.



Question #3

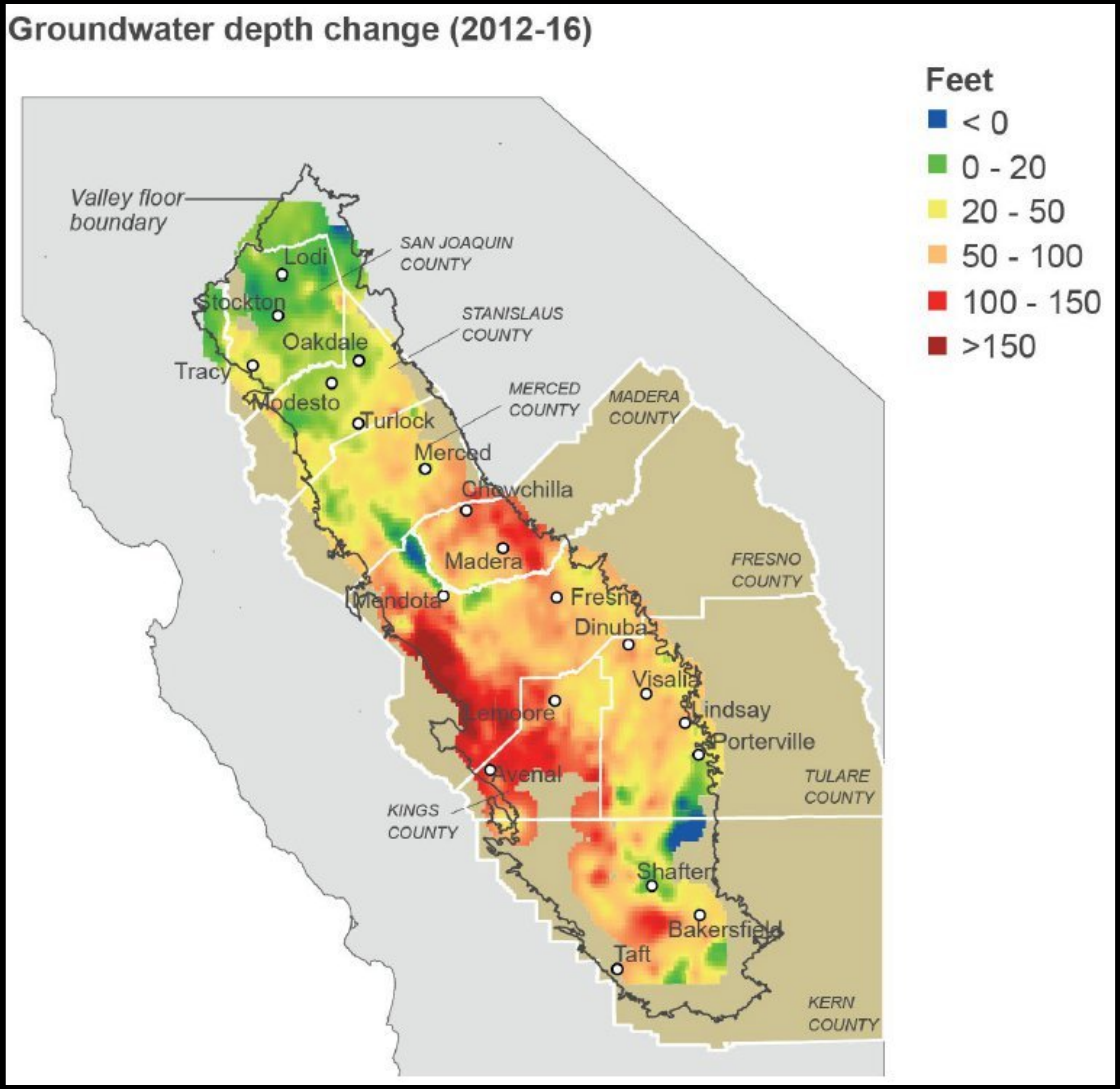
Might on-site solar power factor into demand response?

- High growth in solar over this time frame, very cheap at scale

"Lift" as a source of identification?

<u>Suggestions</u>

1. This source of identification may have challenges, too (endogenous, and non-random). But map suggests high local variability.
2. For both pricing and groundwater anomalies, worry about highly correlated spatial-temporal errors, plus possible confounding.
3. Generally be more circumspect: correlations may not be causal.



Final Observation

Latent variation in surface water rights seems like a huge challenge. But is it?

Strong incentives to wring out big inefficiencies through trade of water or farmland consolidation.

High degree of spatial correlation in land use suggests little latent heterogeneity in costs.

But more aggregated measures may be appropriate to smooth out latent trade of water over time and space.

Summary of Key Comments & Questions

1. Hard to see how “quasi-random” electricity pricing anomalies may be.
2. How much does identification come from drought-driven groundwater depth anomalies?
3. Do water rights vary a lot *within* water districts?
4. *Monthly* time step seems too short for consideration of long-term crop choices.
5. Time fixed effects (or region-by-year fixed effects) cannot account for widely varying crop growing seasons.
6. Do tree crops really use less water over the long run?
7. How do estimates square with computational models and crop budgets?
8. Is solar power a source of response?