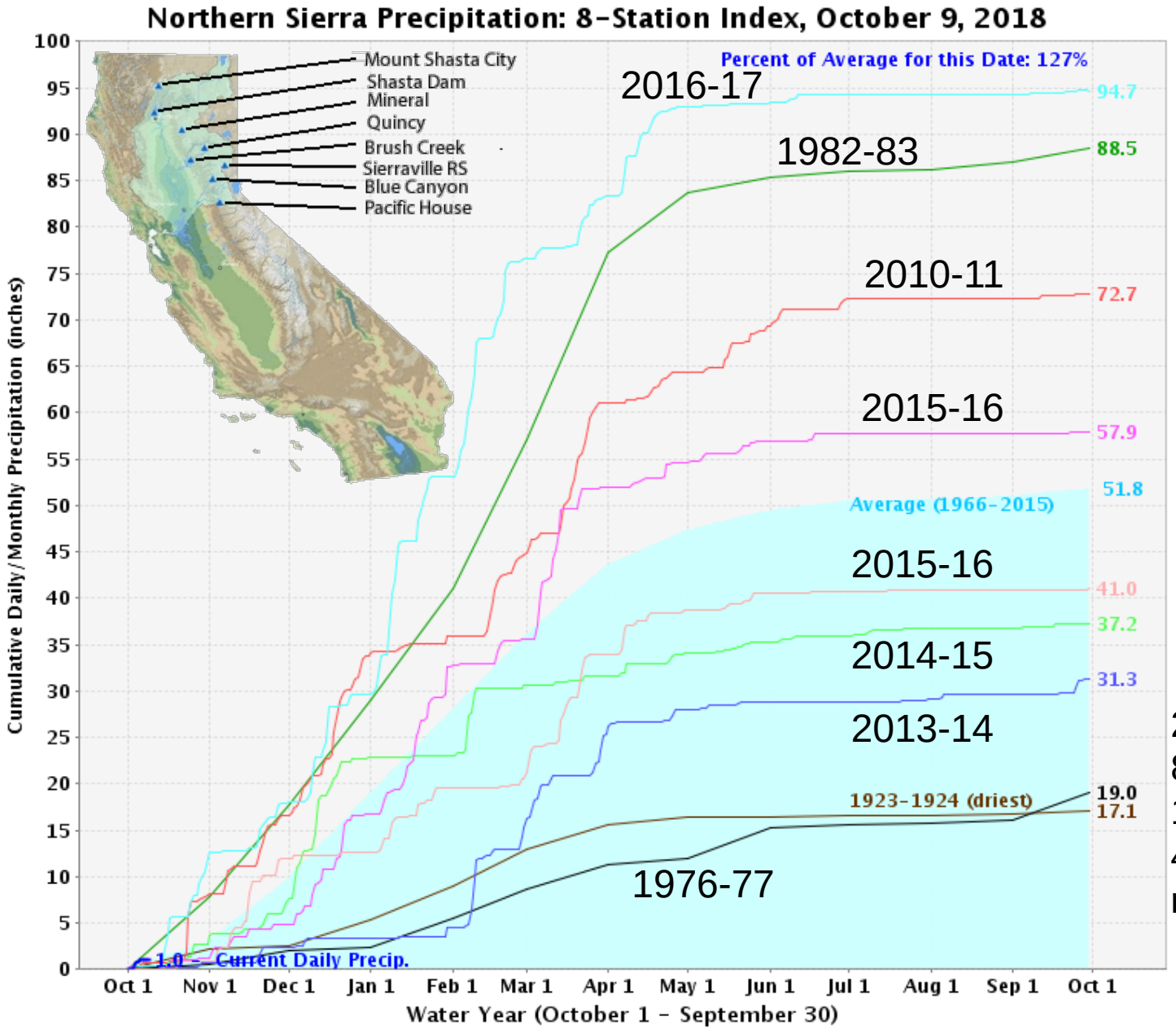
# Tantalus

In Hades, thirsty Tantalus was burdened to have water rise to his neck threatening to drown him, but receded when he stooped to drink. Above him was a boulder, threatening to crush him at some uncertain future time.

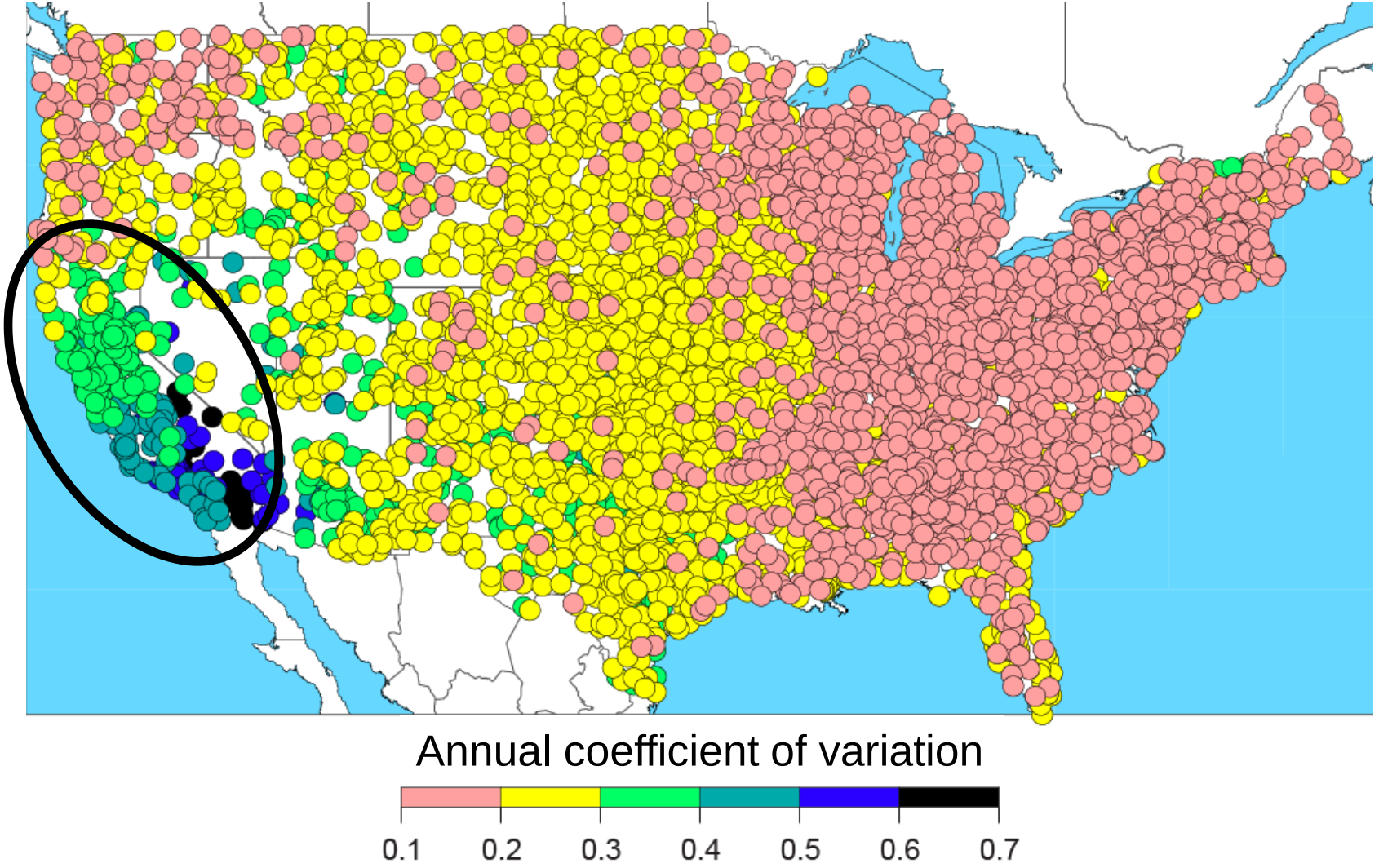
Like California water management!

# Sacramento Valley Precipitation




2014:
8th driest in 106 years,
4th driest in runoff

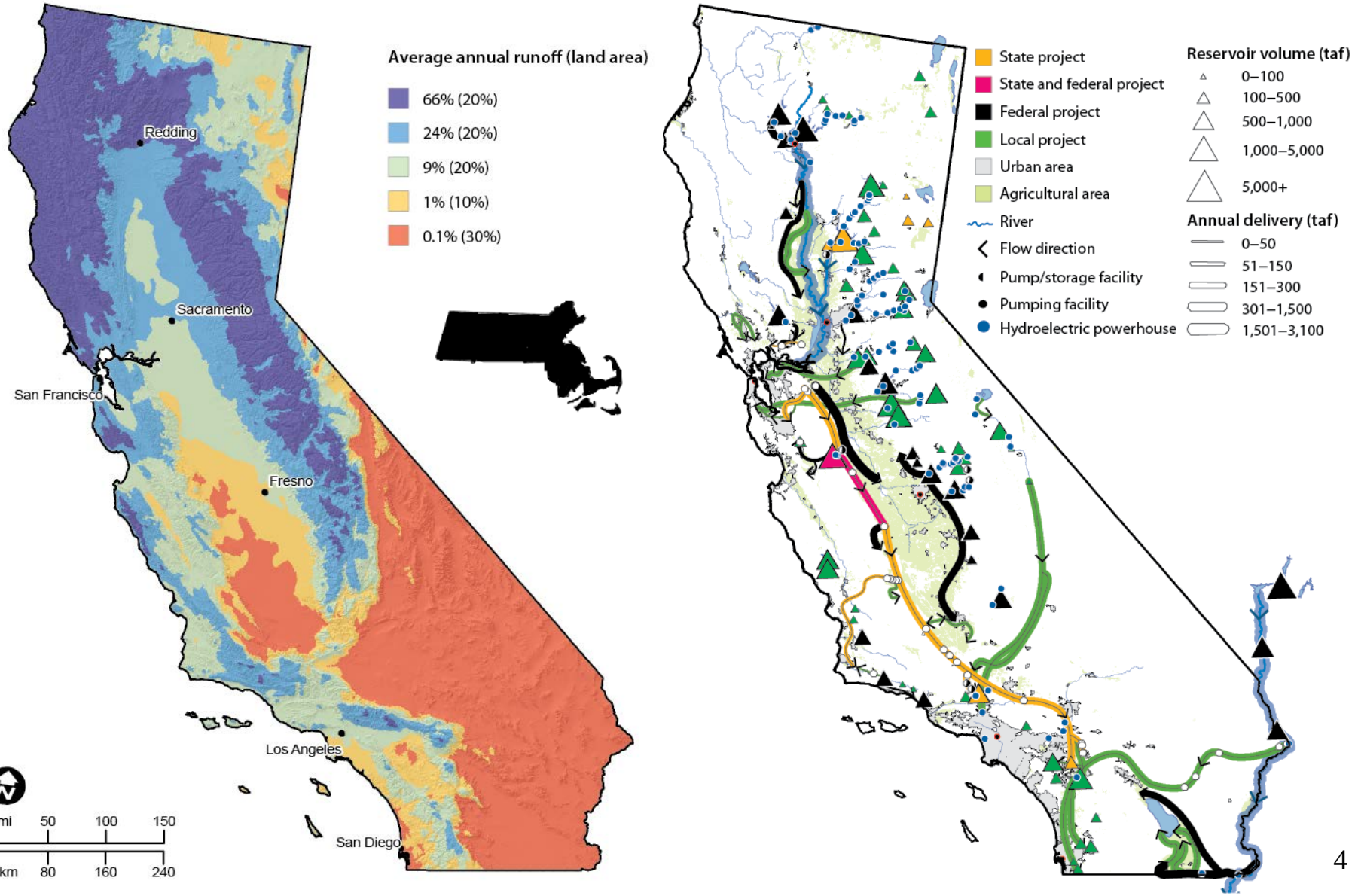
# Most annual rainfall variability in US




SOURCE: Michael Dettinger, 2011. “Climate Change, Atmospheric Rivers, and Floods in California—A Multimodel Analysis of Storm Frequency and Magnitude Changes.” Journal of the American Water Resources Association 47(3):514-523.

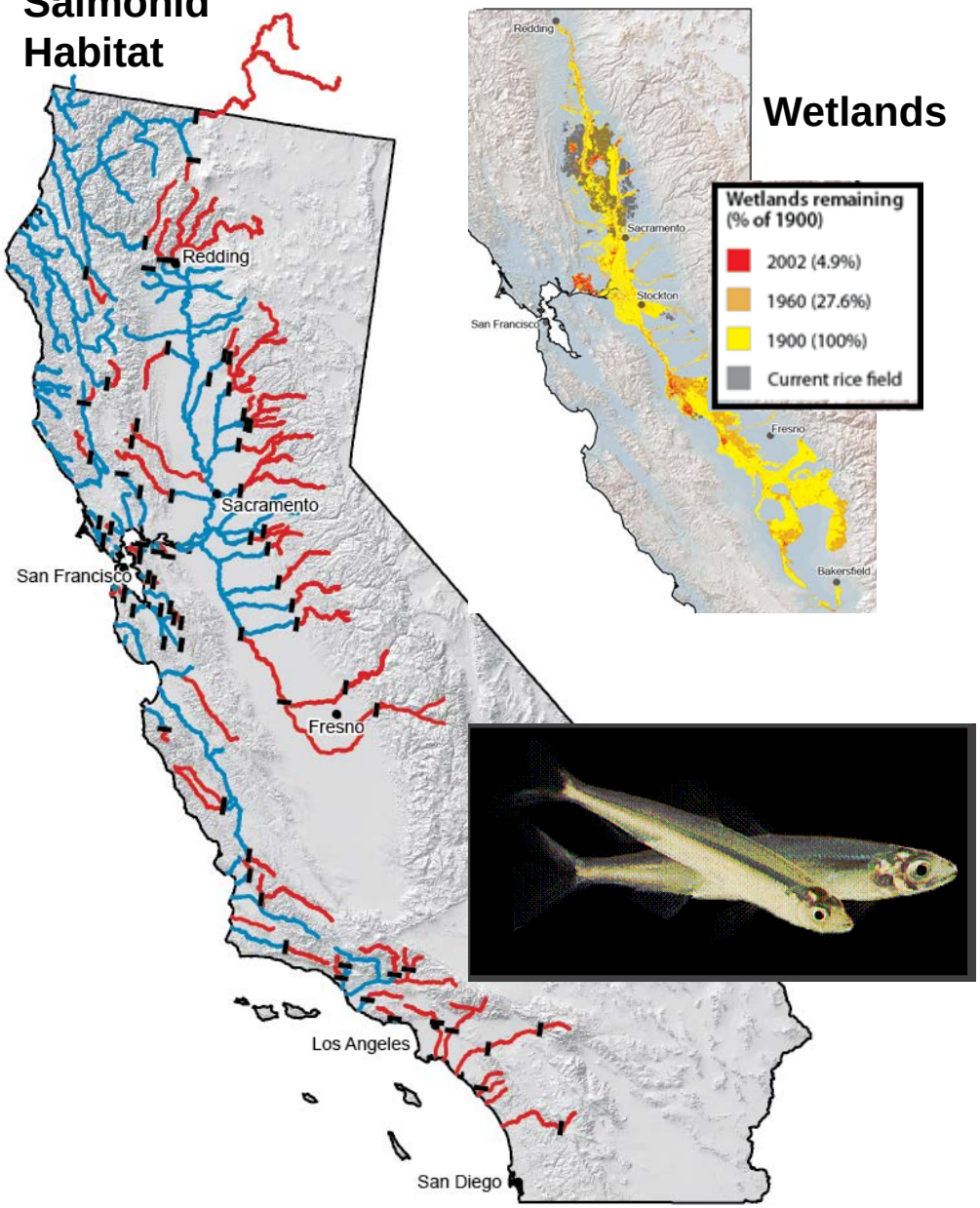
NOTES: Dots represent the coefficient of variation of total annual precipitation at weather stations for 1951-2008, Larger values have greater year-to-year variability.

# Complexity of Water in California



# Native Habitat and Fishes

**Salmonid Habitat**

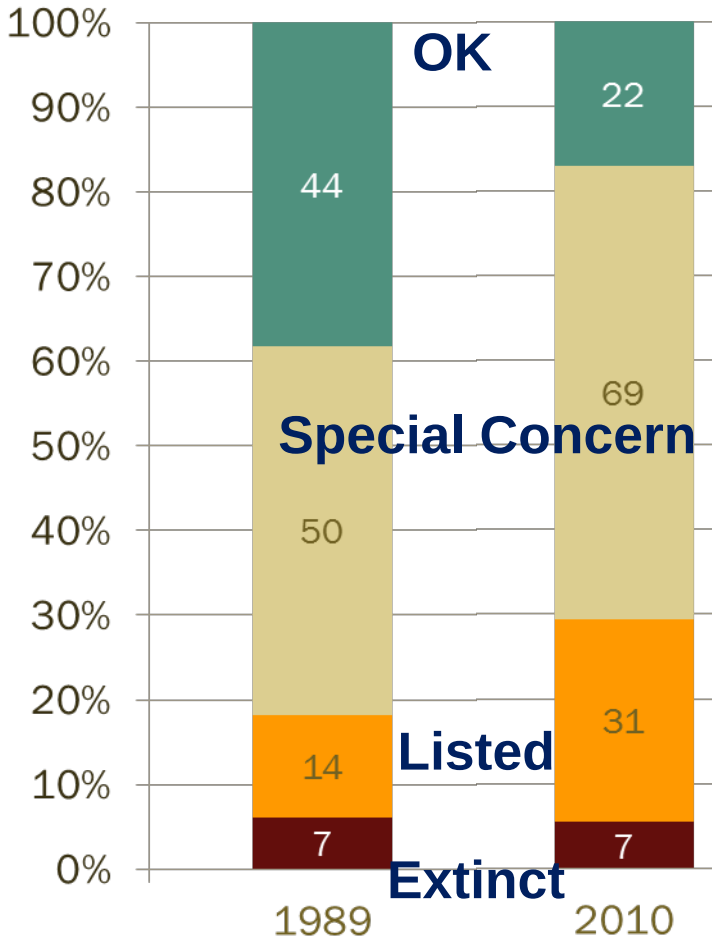



**Wetlands**



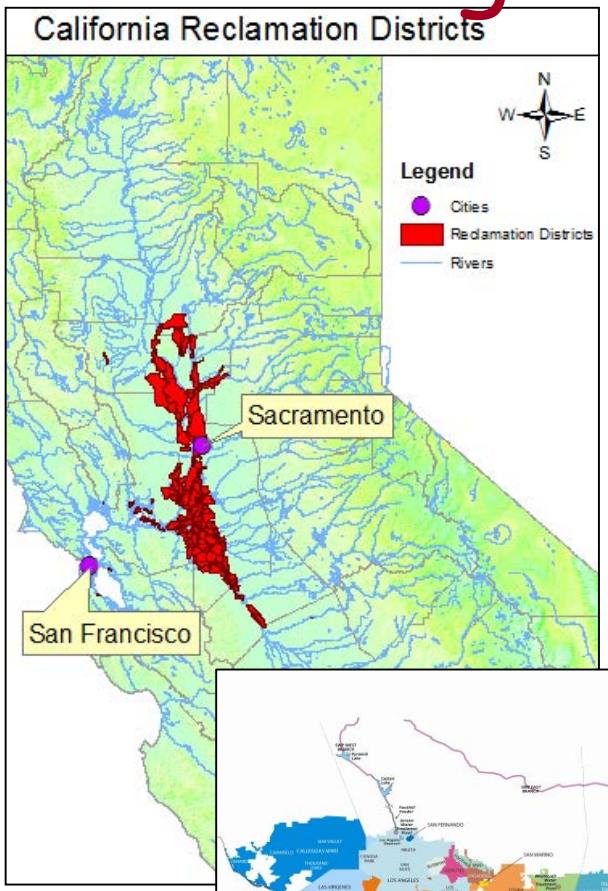


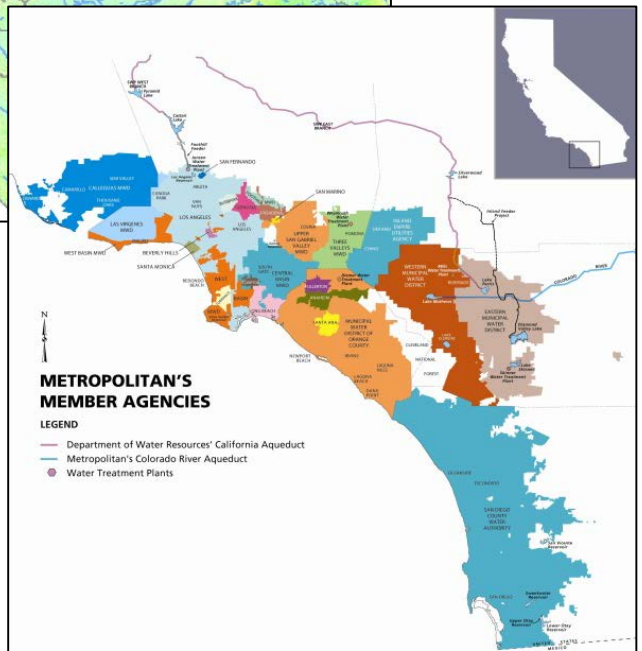

**California's freshwater fishes are losing**



# Many Local, State, Federal Agencies

- Separate Federal and State agencies & laws – wholesalers & regulators
- 1,000s of locally-elected water agencies
- Most infrastructure funded & governed by local and regional water districts
- Many coordinating water contracts



# Future Climate Changes

1) Sea level rise
2) Warmer temperatures
3) More variability
4) Precipitation changes?

And many non-climate changes…

# Many Drivers of Change

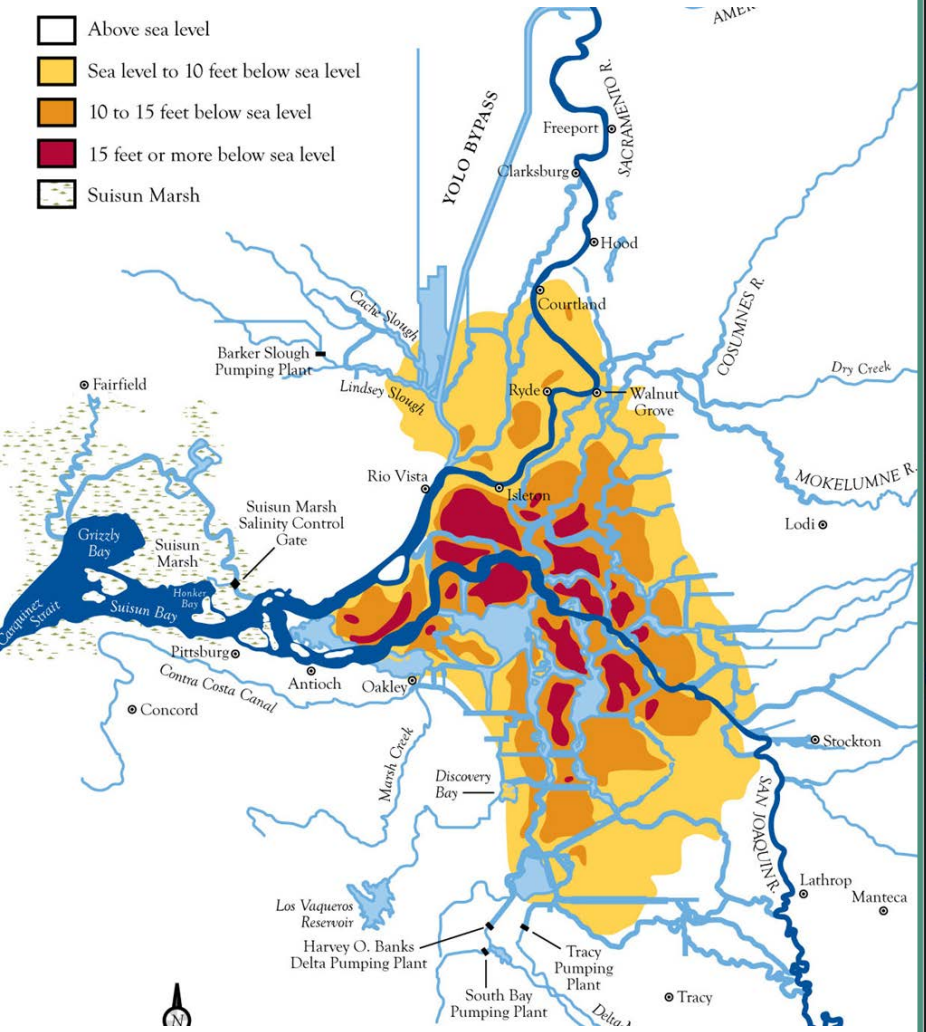
- Climate
  - Sea level rise
  - Warming
  - Precipitation change
  - Whiplash across extremes
- Ecosystems
  - New invasive species
  - Continued degradation
- Deterioration
  - Groundwater overdraft-SGMA
  - Salt, nitrate contaminants
  - Aging infrastructure
  - Sacramento-San Joaquin Delta
  - Mining legacies
  - Earthquakes

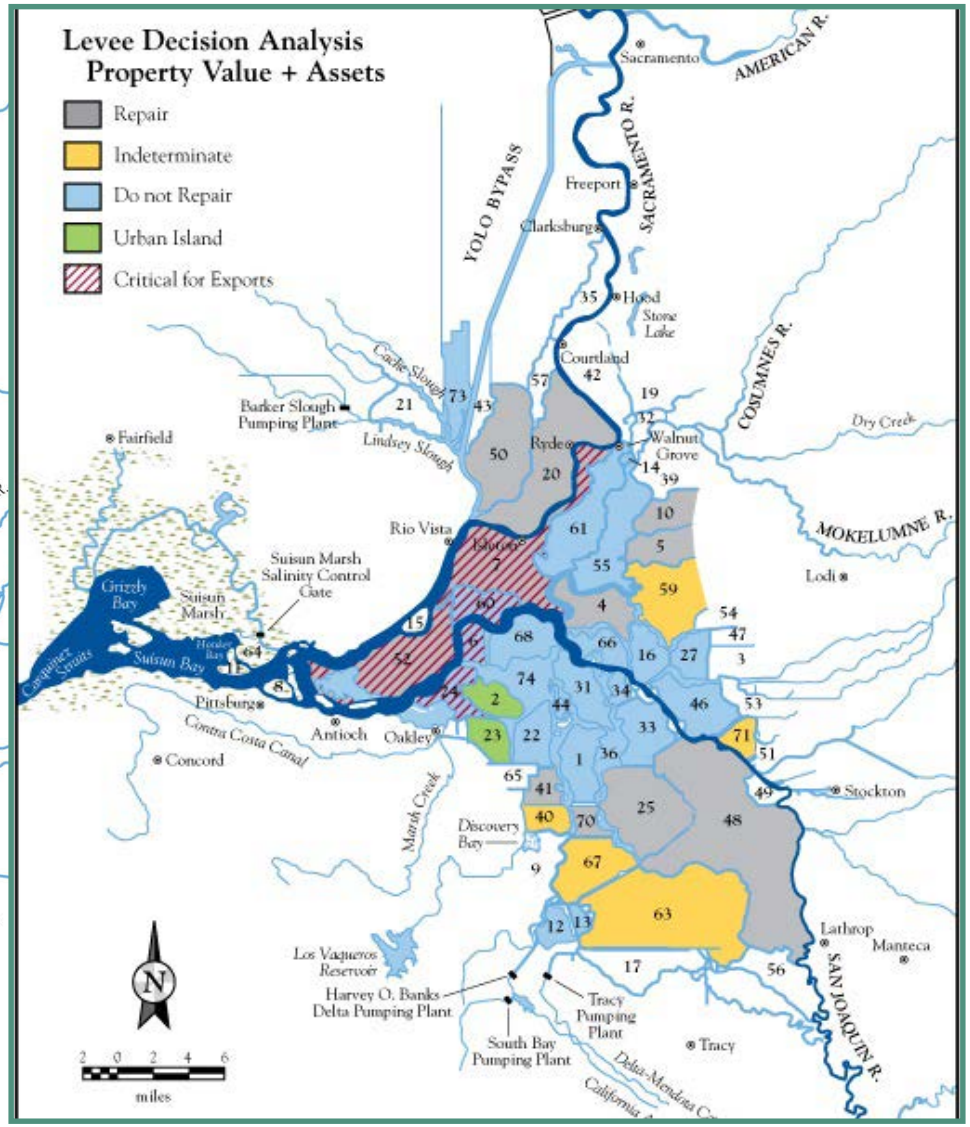

- Economy and Demography
  - State and federal finances
  - Globalization
  - Population growth and urbanization
- Regulatory changes
  - Energy
  - Environment
  - Social/economic
- Science and technology
  - More data!
  - New chemicals
  - New technologies

# Sea Level Rise and Infrastructure

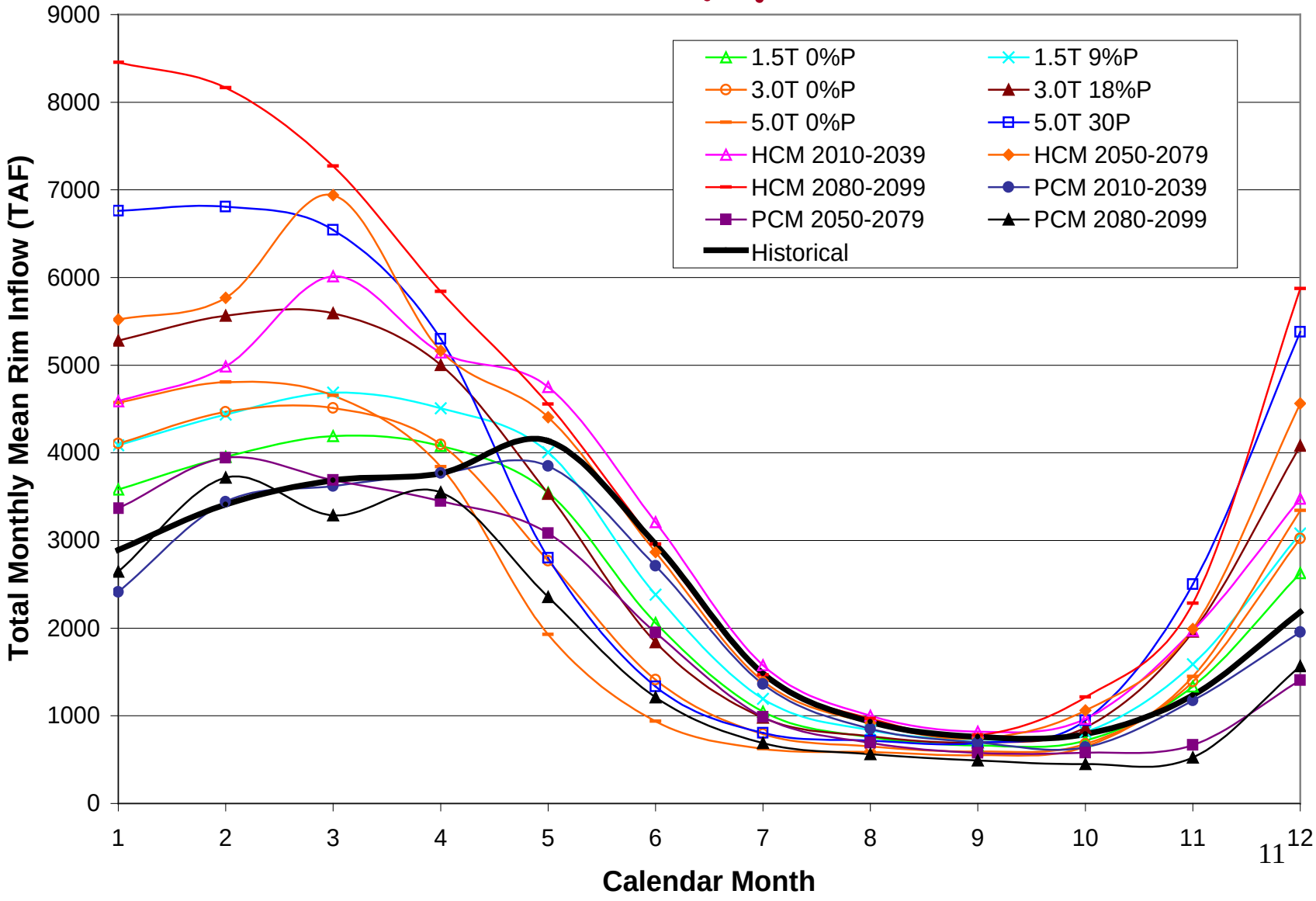
1) Roads
2) Land use
3) Parks
4) Wastewater plants
5) Sewers
6) Ecosystems

# Delta and Sea Level Rise



# Warming and Central Valley Streamflow

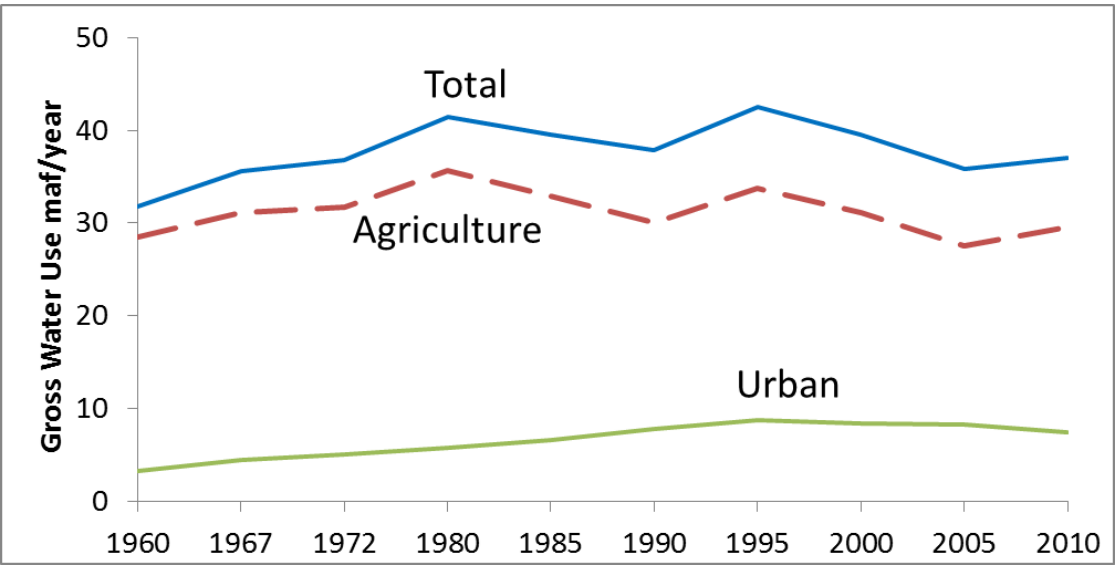


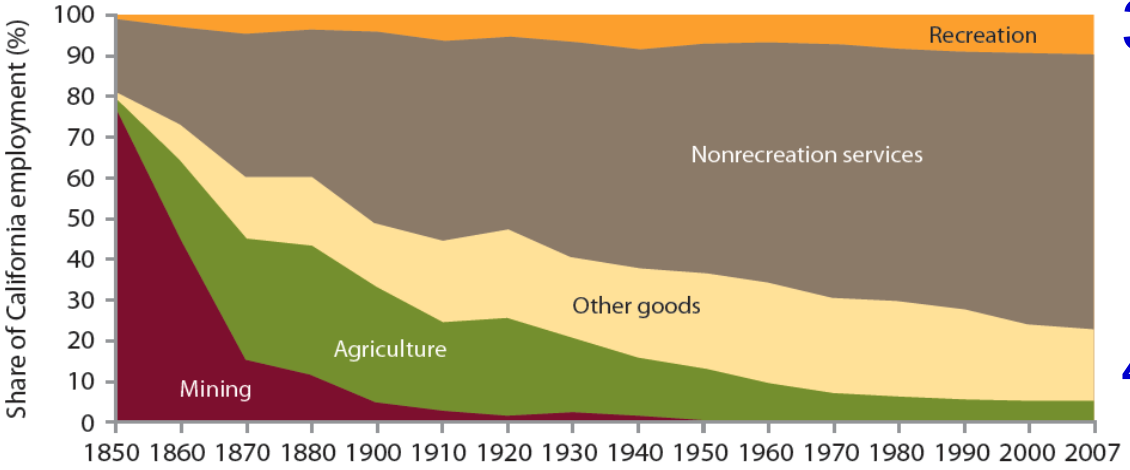
# Resistance is Futile

1) Coastal erosion and flooding
2) Flooding in parts of the Delta
3) Reduced Delta diversions
4) Less irrigated land in the southern Central Valley
5) Less urban water use, more reuse & storm capture
6) Some native species unsustainable in the wild
7) Funding solutions mostly local and regional
8) State's leverage is mostly regulatory, not funding
9) Nitrate groundwater contamination is inevitable
10) Groundwater will be managed more tightly
11) The Salton Sink will be largely restored

California will always have water problems, but we can manage better.

# Reasons for Hope

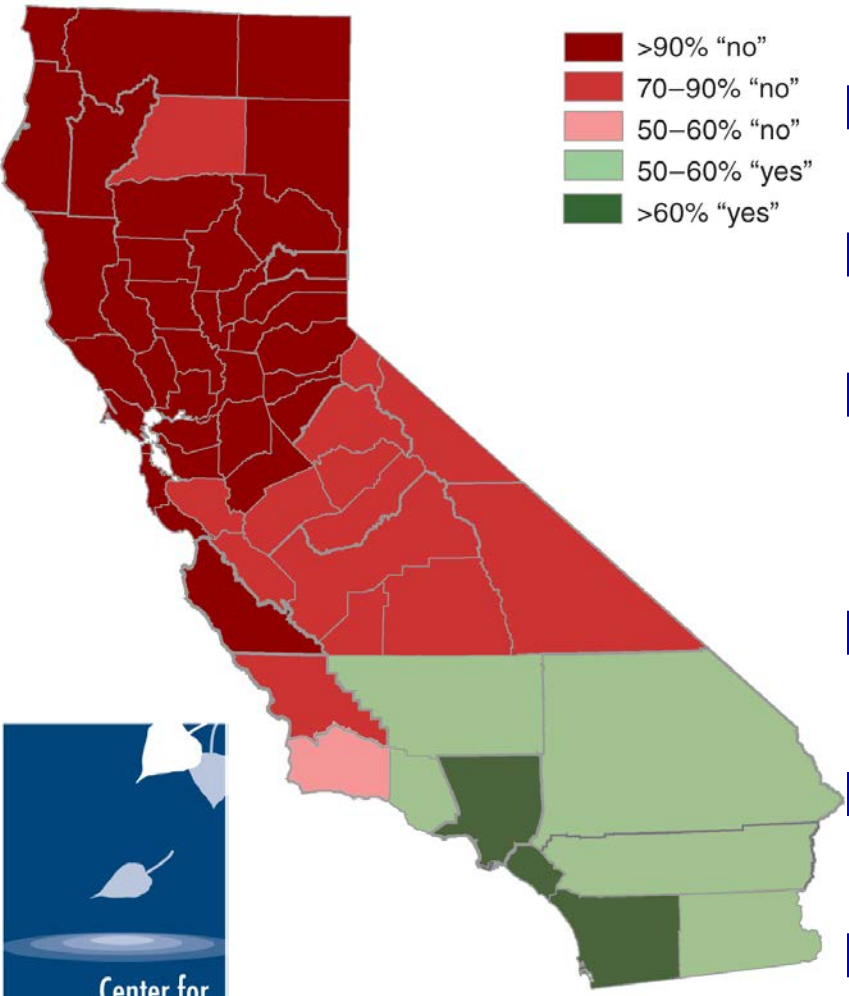



1) Human water use peaked?
2) Economy depends less on water abundance
3) Water markets can shift use and civilize change
4) We agree we have a problem

Source: Hanak et al. 2011

# Suggested Readings





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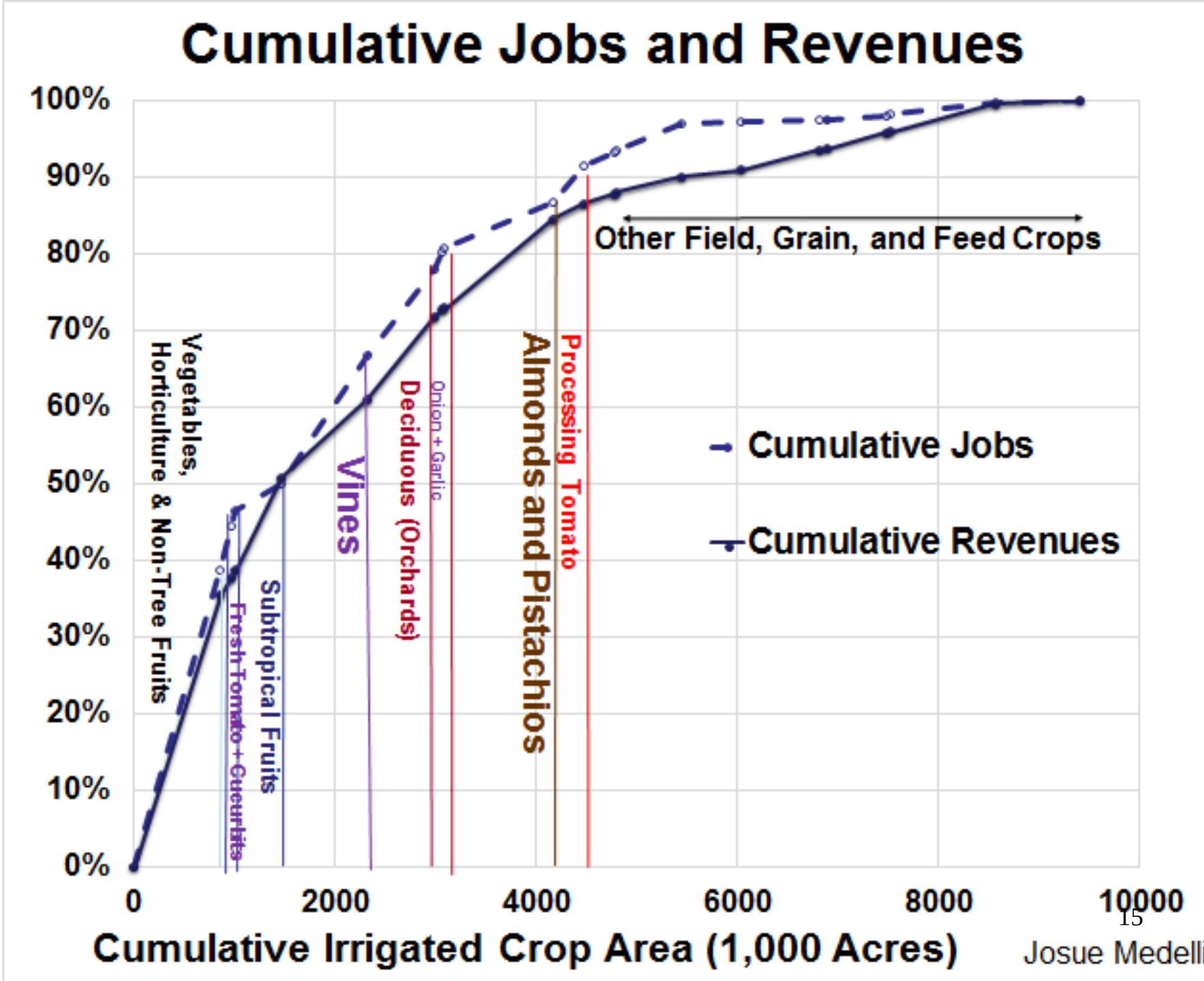
Lund et al. (2018) "Lessons from California's 2012–2016 Drought"

Pisani (1983), *From Family Farms to Agribusiness*, UC Press

MavensNotebook.com

CaliforniaWaterBlog.com


Center for Watershed Sciences UCDAVIS



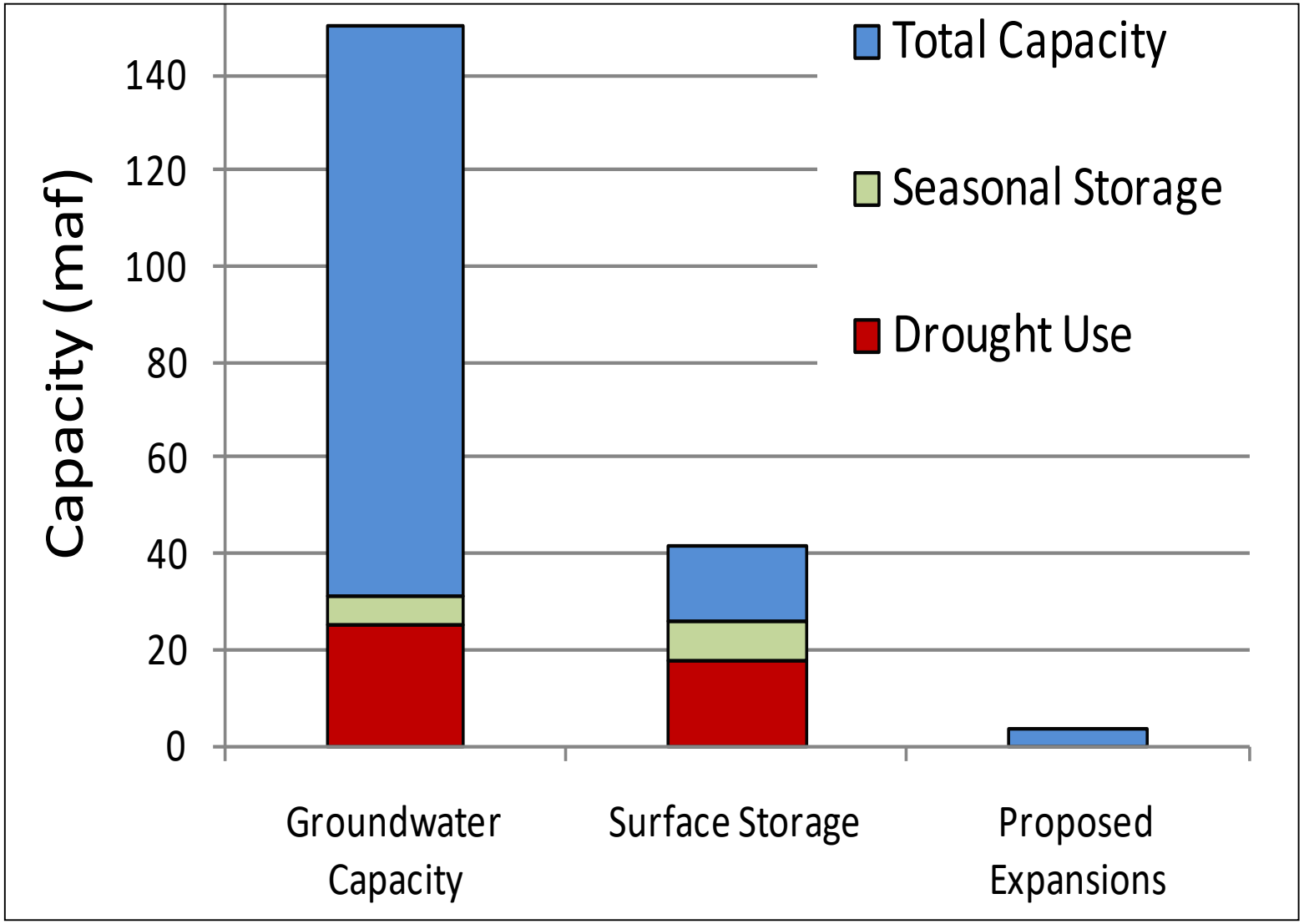



Josue Medellin

# Some details

1) Future water demands matter too! Similar magnitude to climate warming effects
2) California's system can adapt, at some cost
3) Groundwater use expands to dampen inter-annual variability
4) Groundwater takes more over-year storage, freeing surface reservoirs for floods
5) Delta operations can mediate or hurt

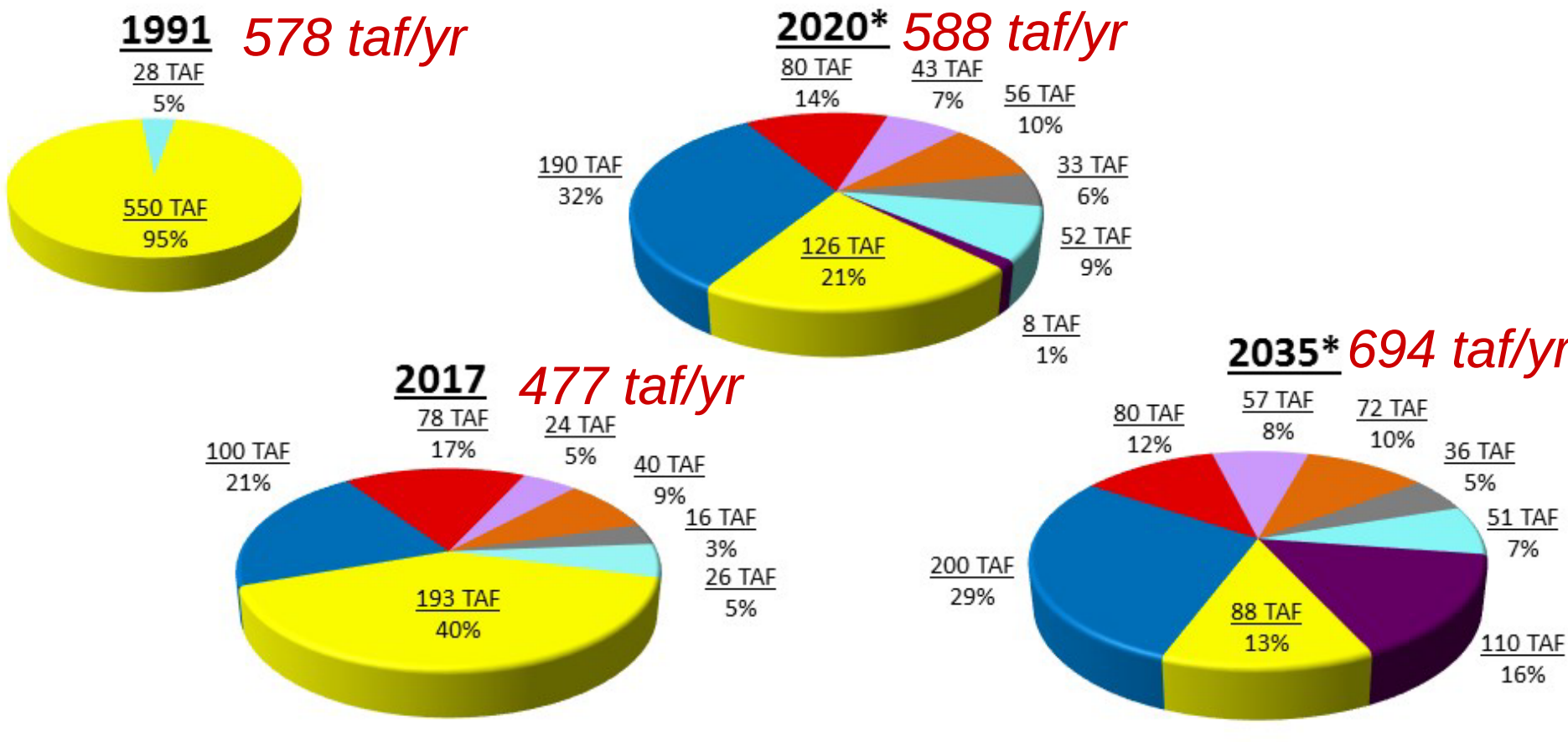
# Water Storage Capacity and Uses in California



# Water supply system portfolio actions

| Water supply | |
|---|---|
| **Water Source availability** | **Treatment** |
| Capture of fog, precipitation, streams, groundwater, wastewater | Existing water and wastewater treatment |
| Protection of source water quality | New water and wastewater treatment |
| **Conveyance capacities** | Wastewater reuse |
| Canals, pipelines, aquifers, tankers (sea or land), bottles, etc. | Ocean Desalination |
| | Contaminated aquifers |
| **Storage capacities** | **Operations** |
| Surface reservoirs, aquifers and recharge, tanks, snowpack, etc. | Reoperation of storage and conveyance |
| | Conjunctive use |
| **Water demands and allocation** | |
| Agricultural use efficiencies and reductions | Ecosystem demand management |
| Urban water use efficiencies and reductions | Recreation water use efficiencies |
| **Incentives to work well together** | |
| Pricing | Subsidies, taxes |
| Markets | Education |
| "Norming", shaming | |

# San Diego water supply portfolio



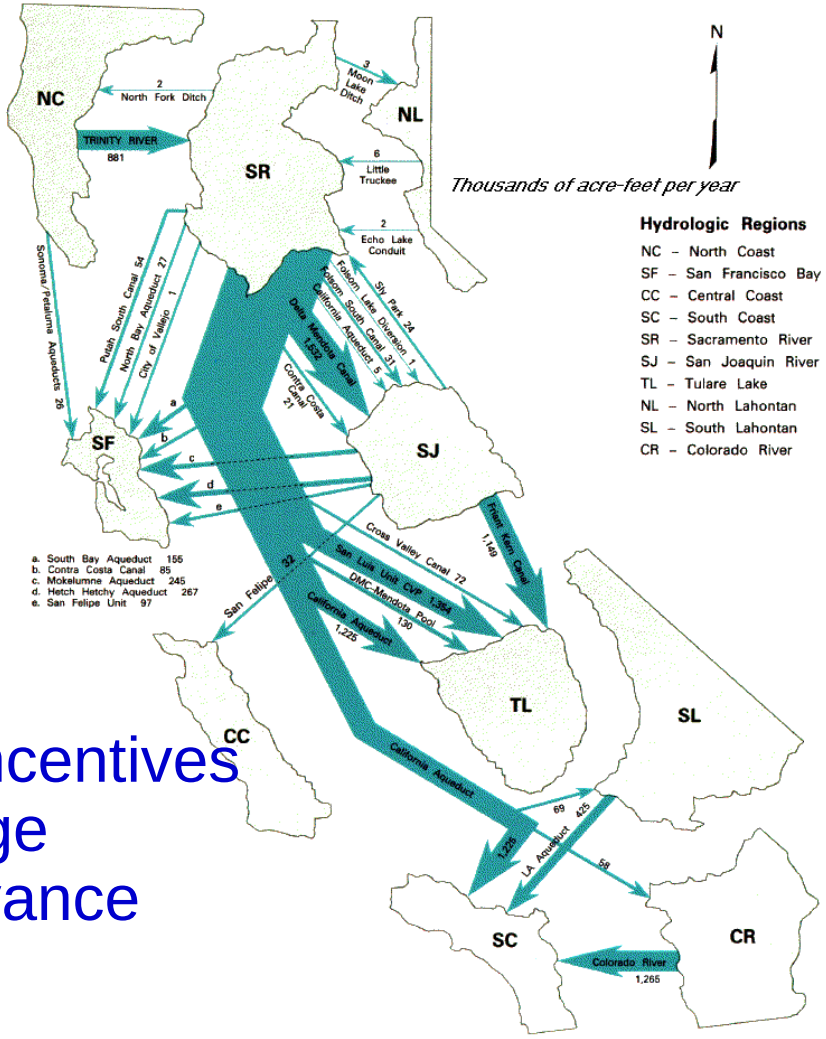

* Includes verifiable and additional planned local supply projects from 2015 UWMP

(TAF=Thousand Acre-Feet)

# Local and Statewide Portfolio

Local Activities:
- Conservation and use efficiency
- Wastewater reuse
- Desalination (brackish & ocean)
- Groundwater use and recharge
- Surface reservoir operations
- Water markets and exchanges

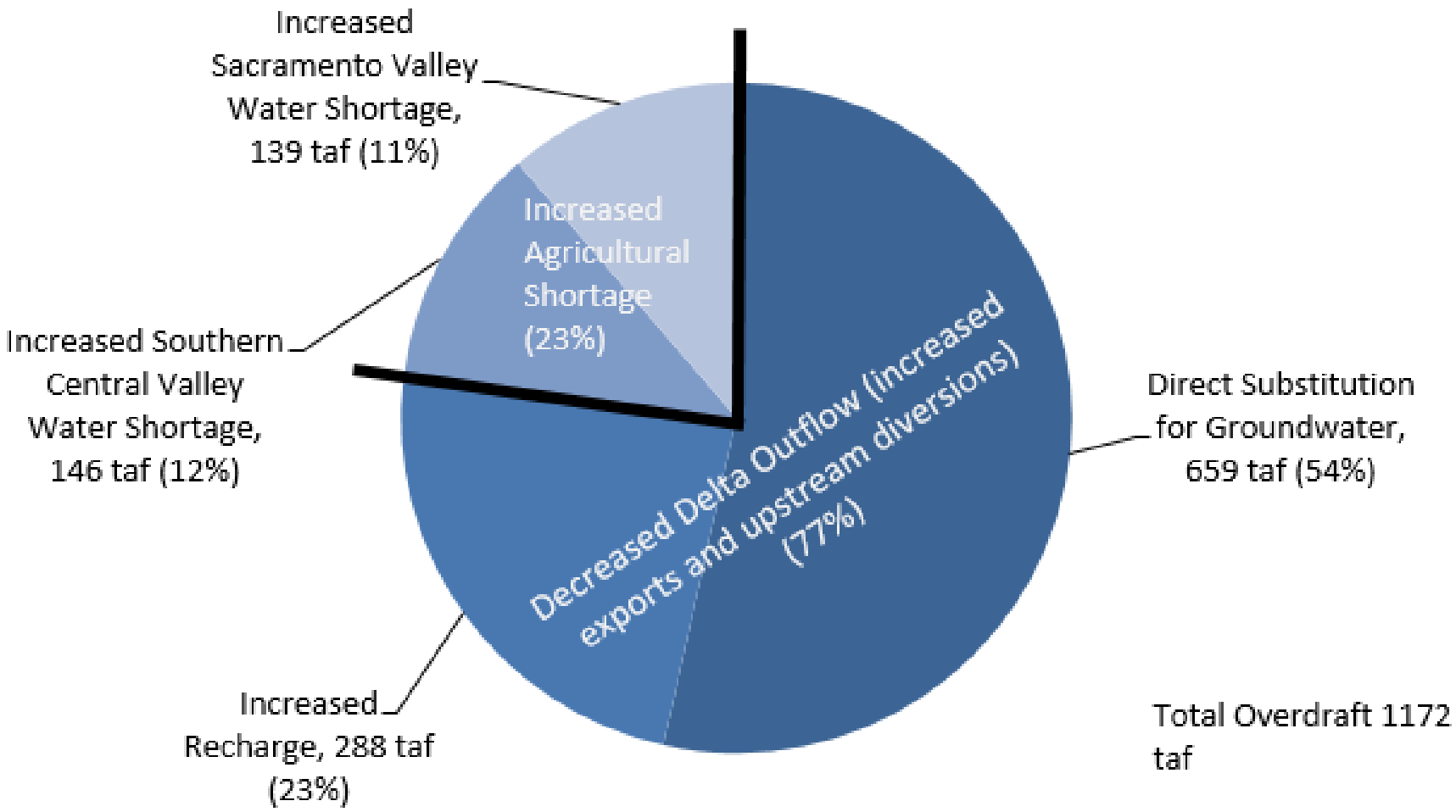
Statewide Activities:
- Inter-regional water conveyance
- Surface reservoir operations
- Plumbing codes & conservation incentives
- Groundwater banking and recharge
- Water market support and conveyance
- Wastewater reuse subsidies



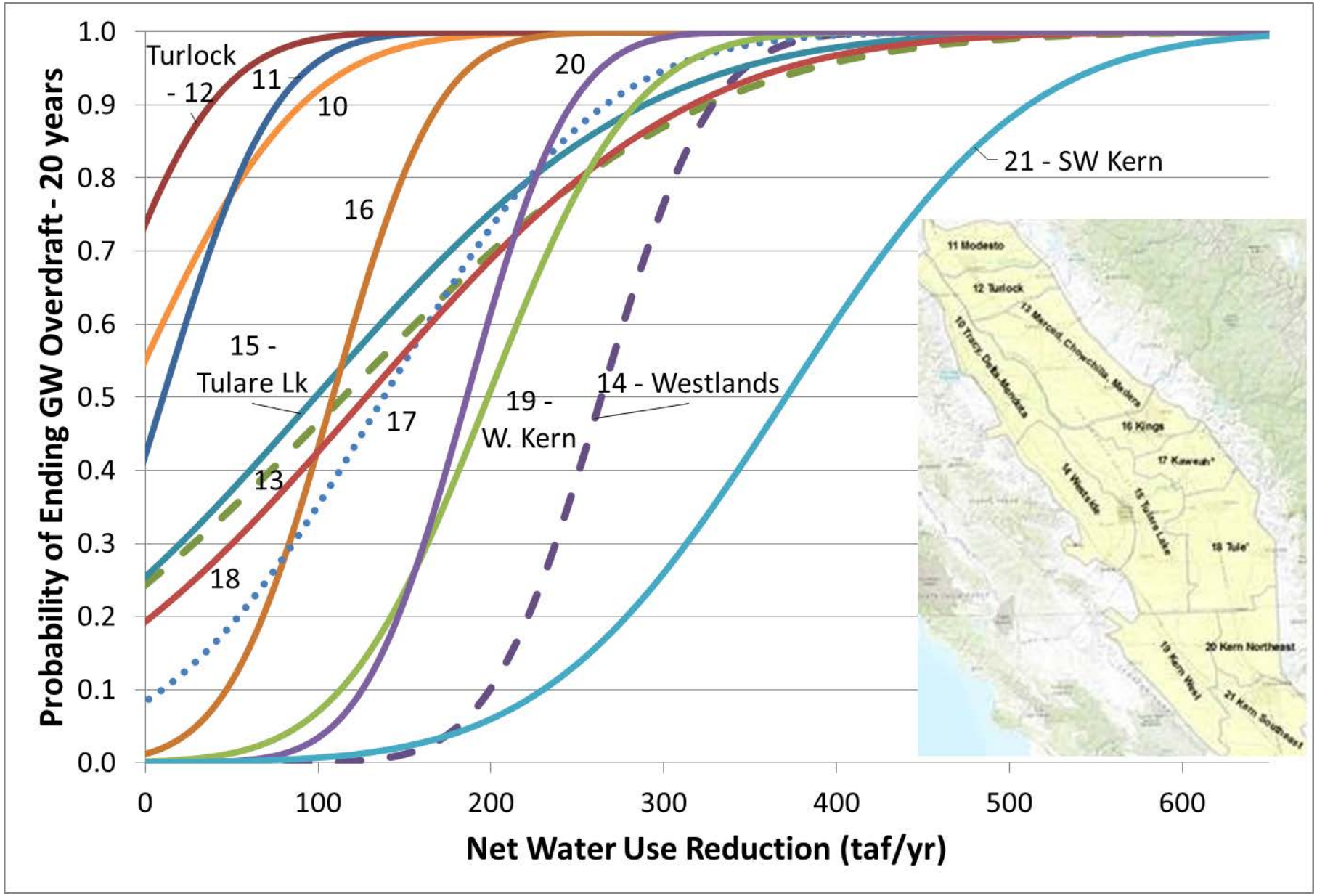

Integrating mix of actions – portfolio planning.

# SGMA connects to the Delta

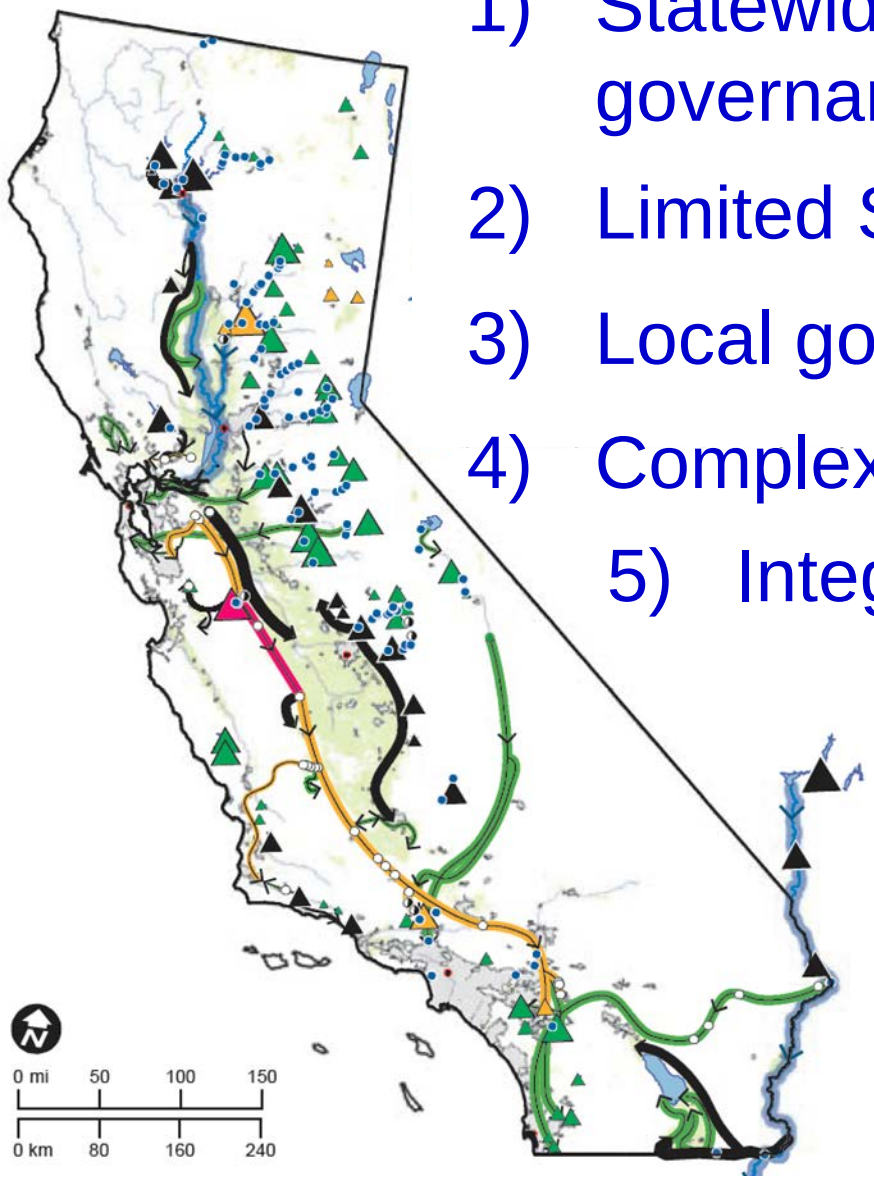
- Ending overdraft increases pressure on Delta operations. CALVIN results (Nelson et al., 2016)



# Groundwater sustainability



# Conclusions




1) Statewide water system, with local governance and fragmented regulation
2) Limited State and Federal abilities
3) Local government is most important
4) Complexity enriches possibilities
5) Integrated portfolios are the future
6) Nature and economics eventually prevail over indecision and existing law
7) Universities can help