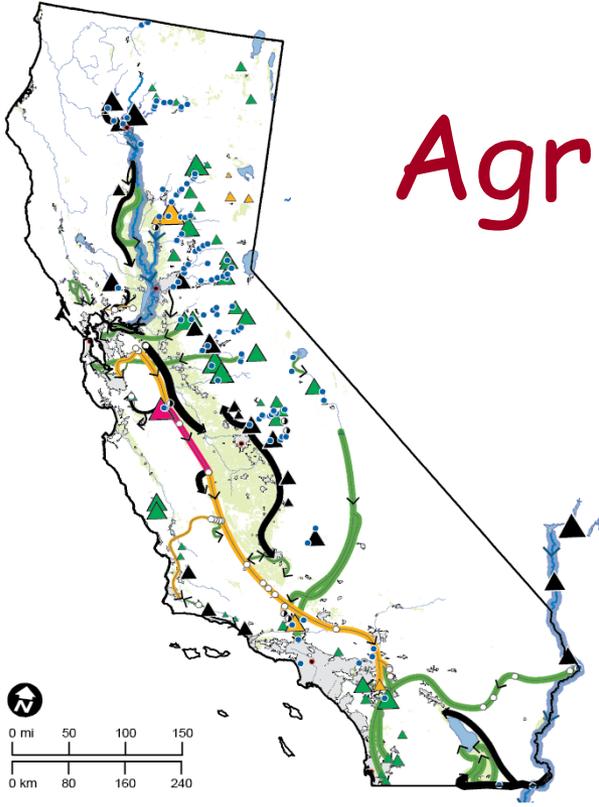


Agriculture and Water in California



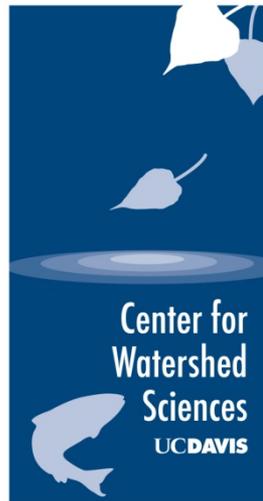
Jay R. Lund

Center for Watershed Sciences

University of California, Davis

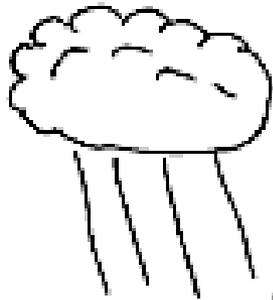
CaliforniaWaterBlog.com

NOBODY LIKES US
"BIG PICTURE"
PEOPLE



Where to begin?

HOW WE GET WATER IN OUR HOMES



1 acre-ft = 1,233 m³
1 maf = 1.233 km³
1 acre = 0.42 hectares



I DON'T
HAVE ANY
INFORMATION
ON THIS BIT

California's Mediterranean Climate

1. Wet winters, no rain in summer
2. Special agriculture
3. Nice for tourists
4. Attracts people & industries globally
5. Migration fuels growth in all industries



California is a popular and dry place

California's Global Setting

1. Access to Asian and North American markets
2. Global economic orientation
 - a. Hides – early 1800s, Gold – late 1800s
 - b. Agriculture – 1890s to present
 - c. Hollywood – since early 1900s
 - d. Education and services – since 1900s
 - e. Electronics, aircraft, and software – post WWII
 - f. Almonds, nuts, wine, rice
3. California is a global economy and society
4. Economics drives most water management

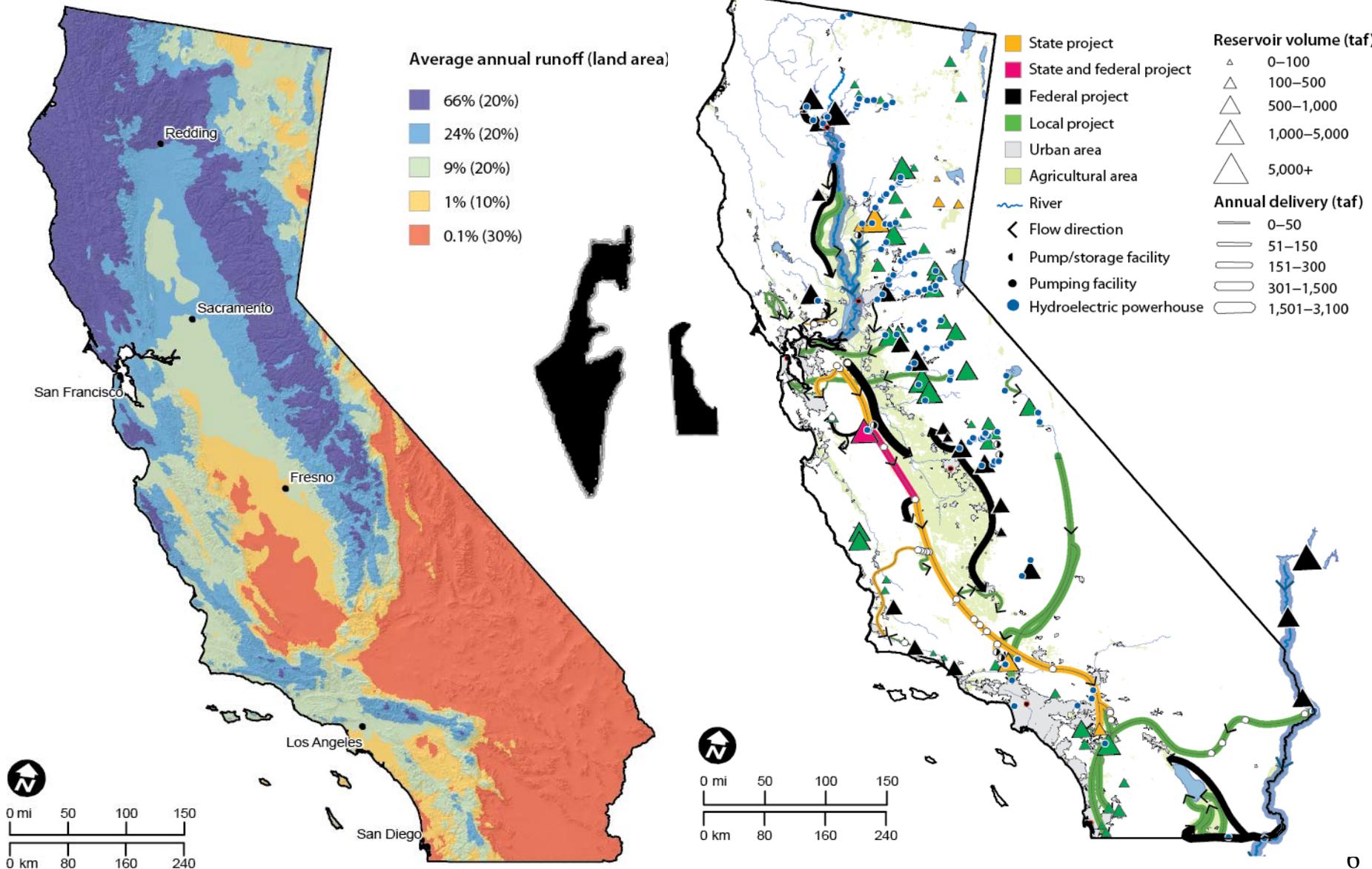


California's Agriculture 2015

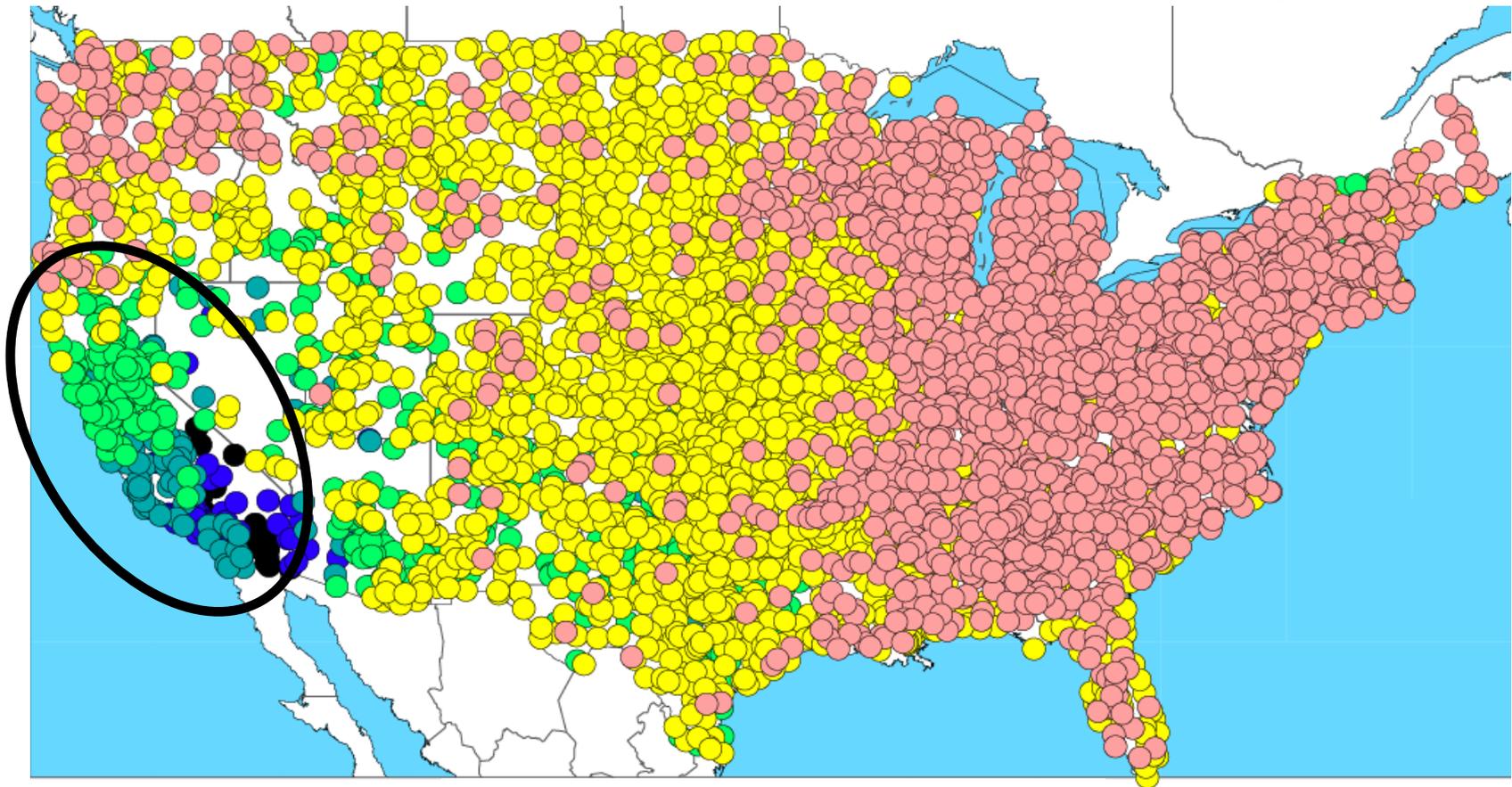
400 commodities, \$47 billion output/year:

- Dairy— \$6.29 billion
- Almonds — \$5.33 billion
- Grapes — \$4.95 billion
- Cattle & Calves — \$3.40 billion
- Lettuce — \$2.26 billion
- Strawberries — \$1.86 billion
- Tomatoes — \$1.71 billion
- Flowers & Foliage — \$1.08 billion
- Walnuts — \$977 million
- Hay — \$945 million

Water and People in California



Most annual rainfall variability in US



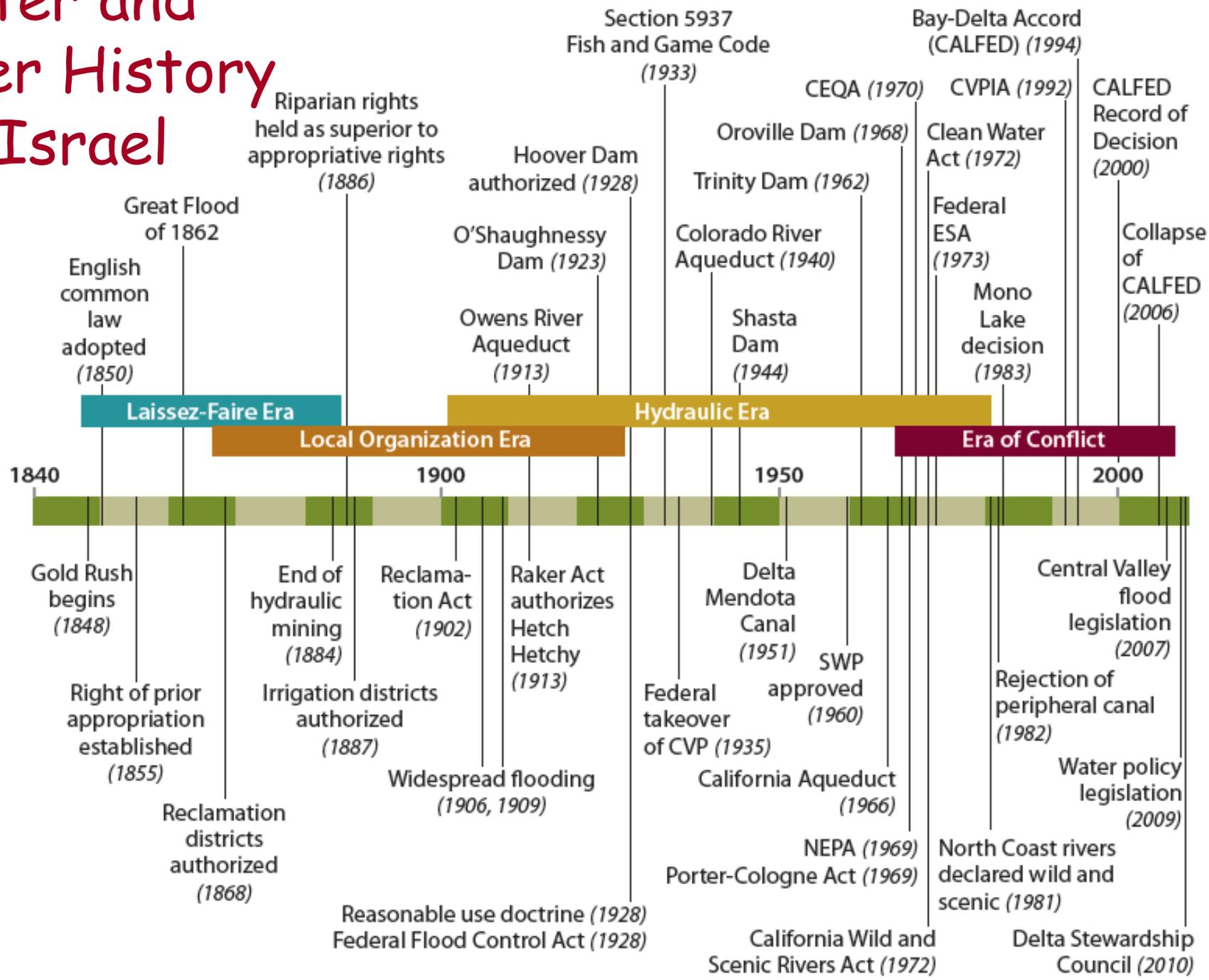
Annual coefficient of variation



SOURCE: Dettinger, et al. 2011. "Atmospheric Rivers, Floods and the Water Resources of California." *Water* 3(2), 445-478. .

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.

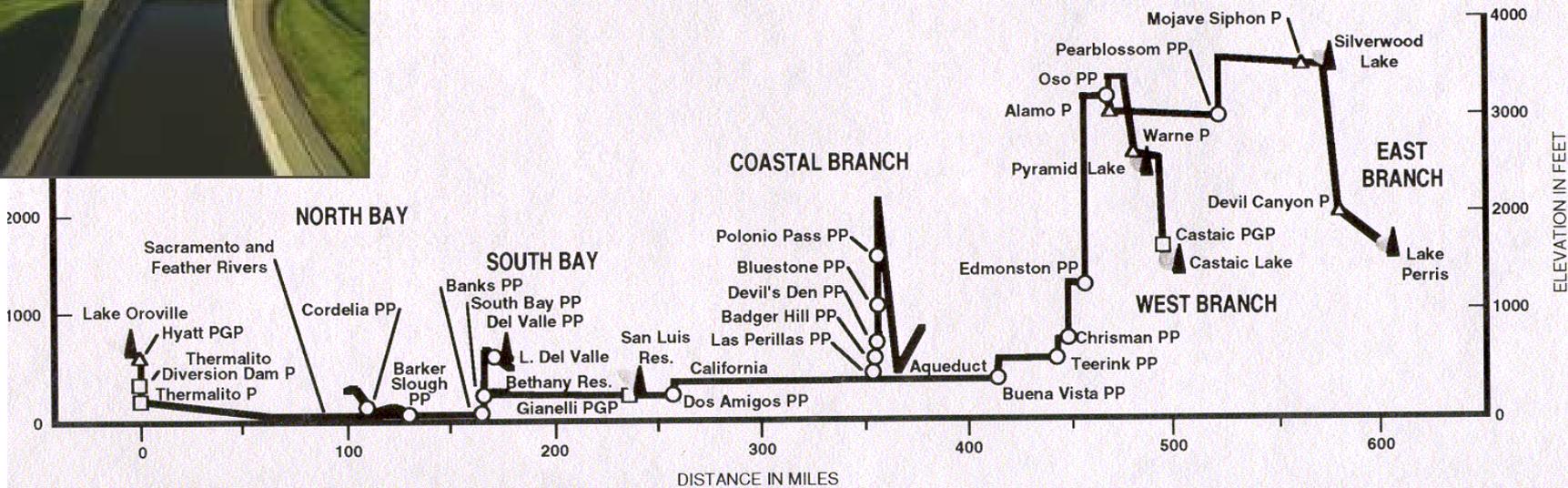
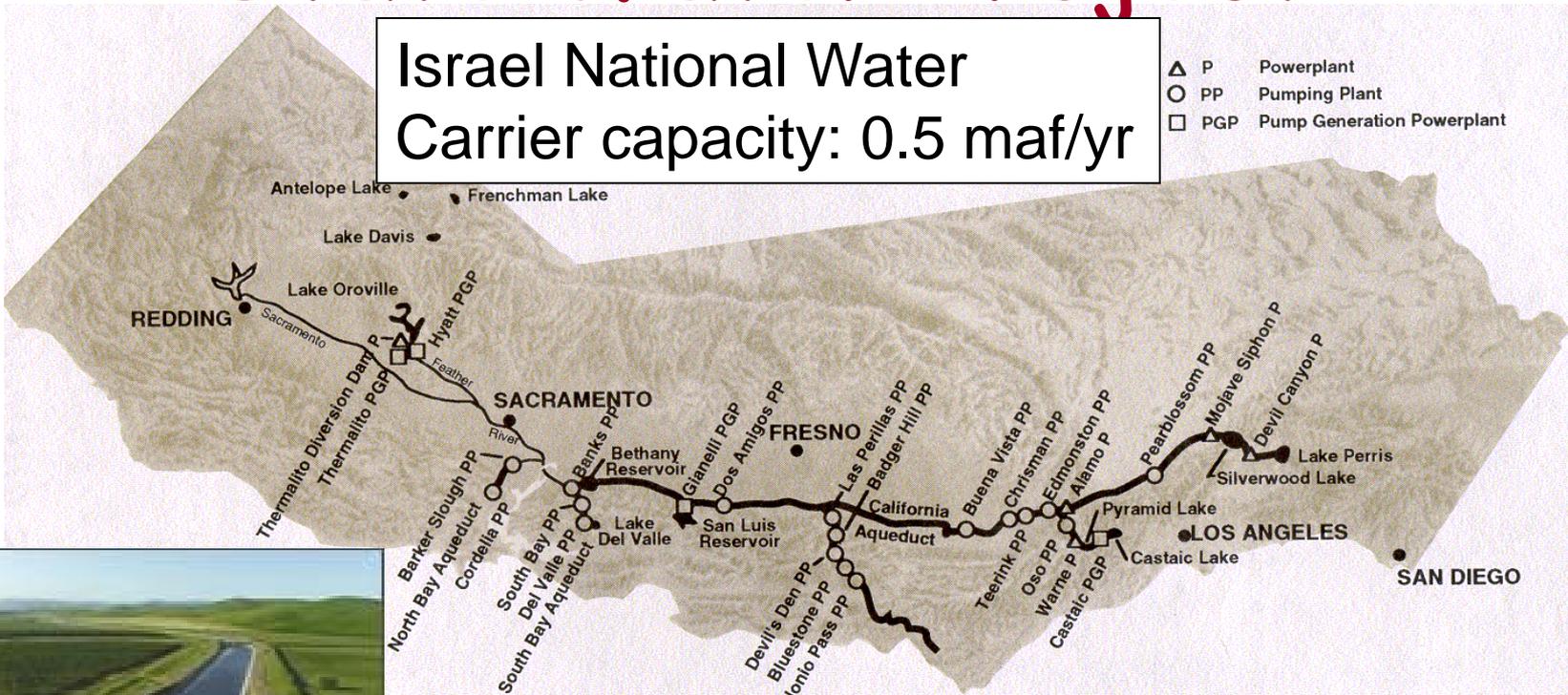
Shorter and Longer History than Israel



State Water Project

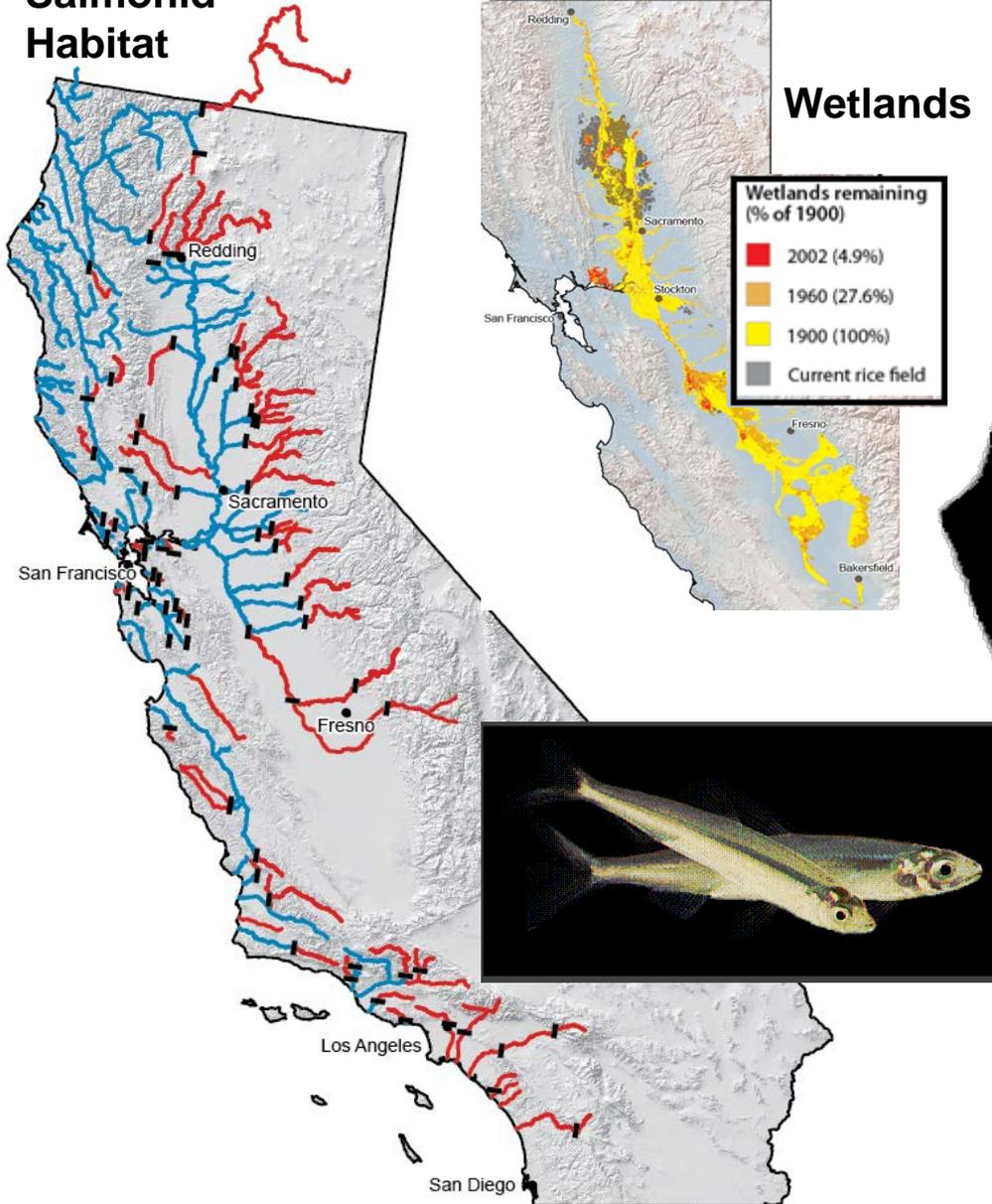
Israel National Water
Carrier capacity: 0.5 maf/yr

- △ P Powerplant
- PP Pumping Plant
- PGP Pump Generation Powerplant

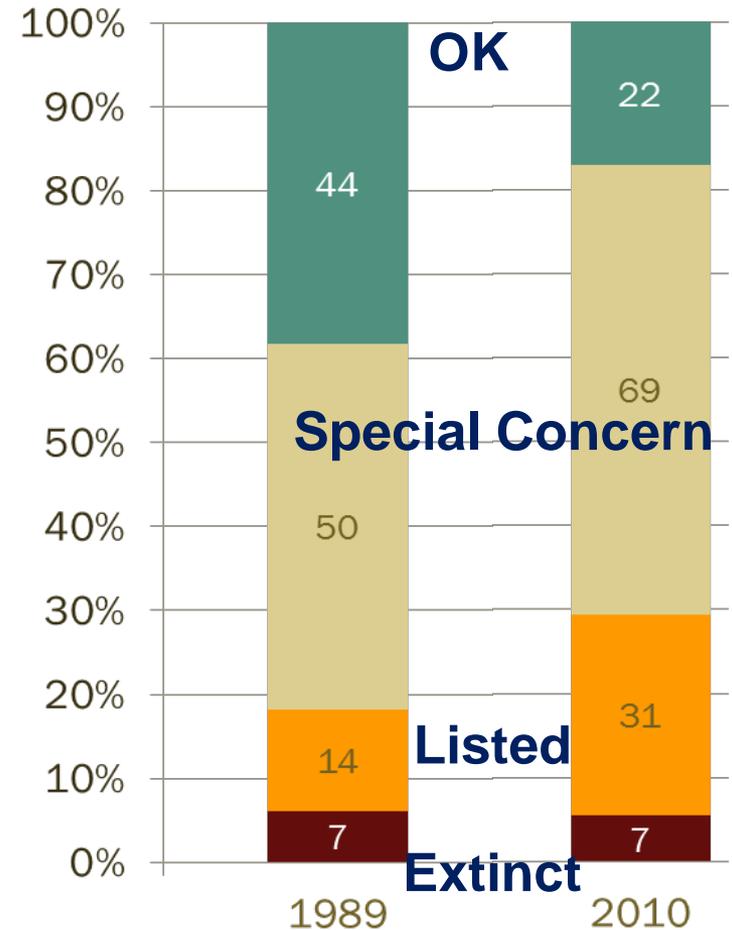


Native Habitat and Fishes

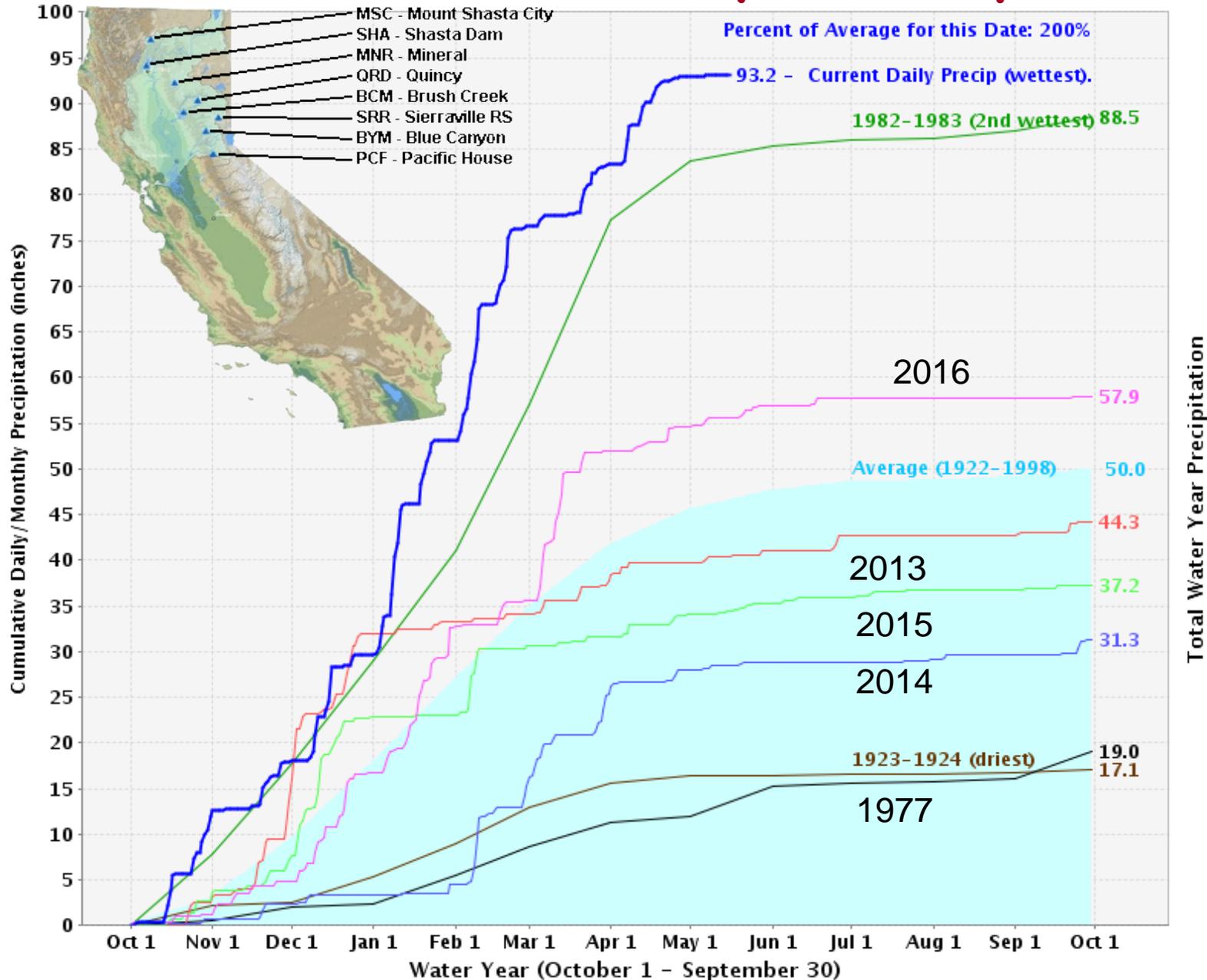
Salmonid Habitat



California's freshwater fishes are losing



Sacramento Valley Precipitation



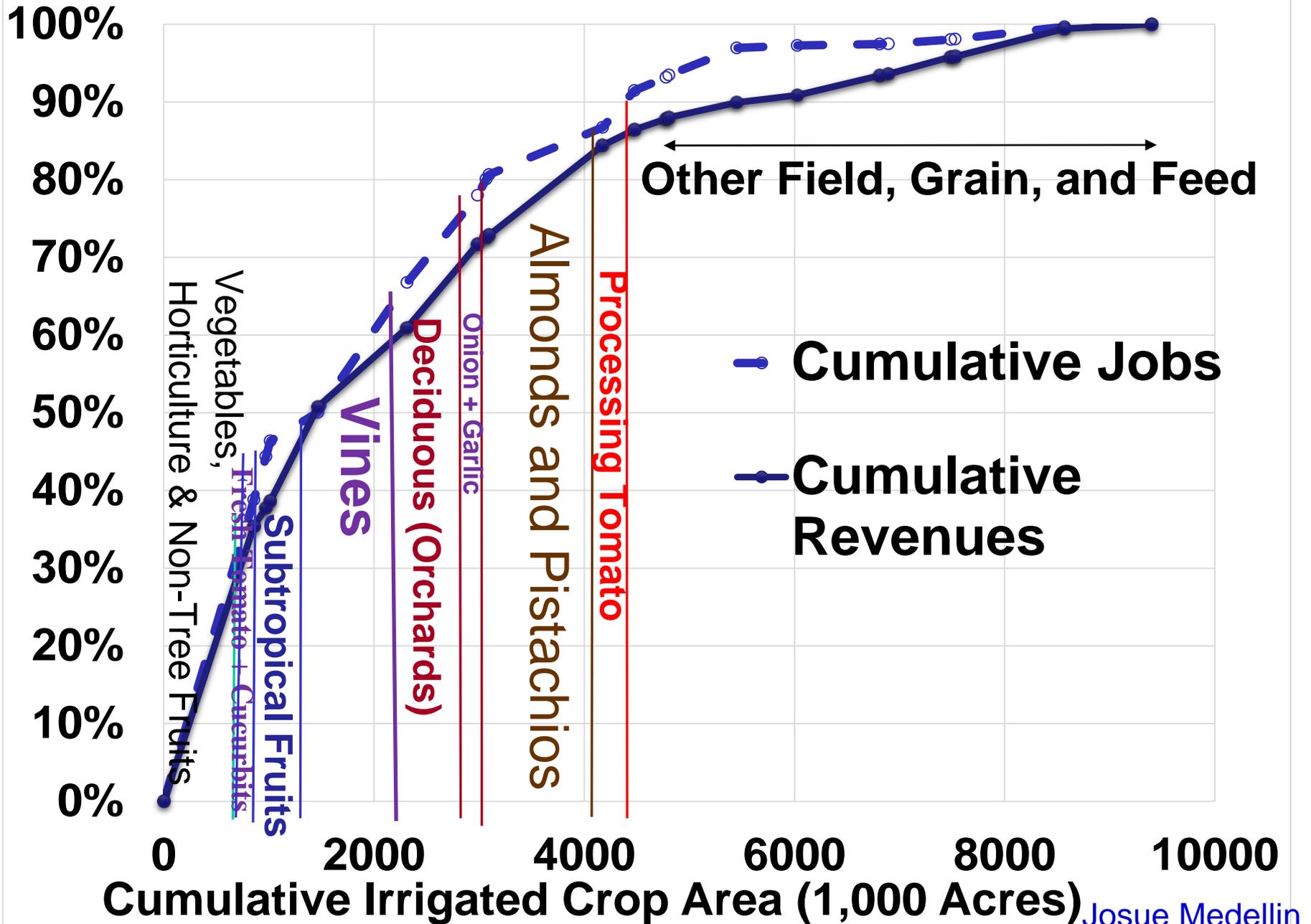
2015 Estimated Agricultural Drought Impacts

Description	Impact	Base year	Percent
Drought water shortage (million acre-ft)	8.7	26.4	33%
Groundwater replacement (million acre-ft)	6.0	8.4	72%
Net water shortage (million acre-ft)	2.7	26.4	10%
Drought-related idle land (acres)	540,000	9 million*	6%
Crop revenue losses (\$)	\$900 million	\$35 billion	2.6%
Dairy and livestock revenue losses (\$)	\$350 million	\$12.4 billion	2.8%
Costs of additional pumping (\$)	\$590 million	\$780 million	75.5%
Net revenue losses (\$)	\$1.8 billion	45 billion rev.	4%
Total economic impact (\$)	\$2.7 billion	NA	NA
Direct job losses (farm seasonal)	10,100	200,000 [#]	5.1%
Total job losses	21,000	NA	NA

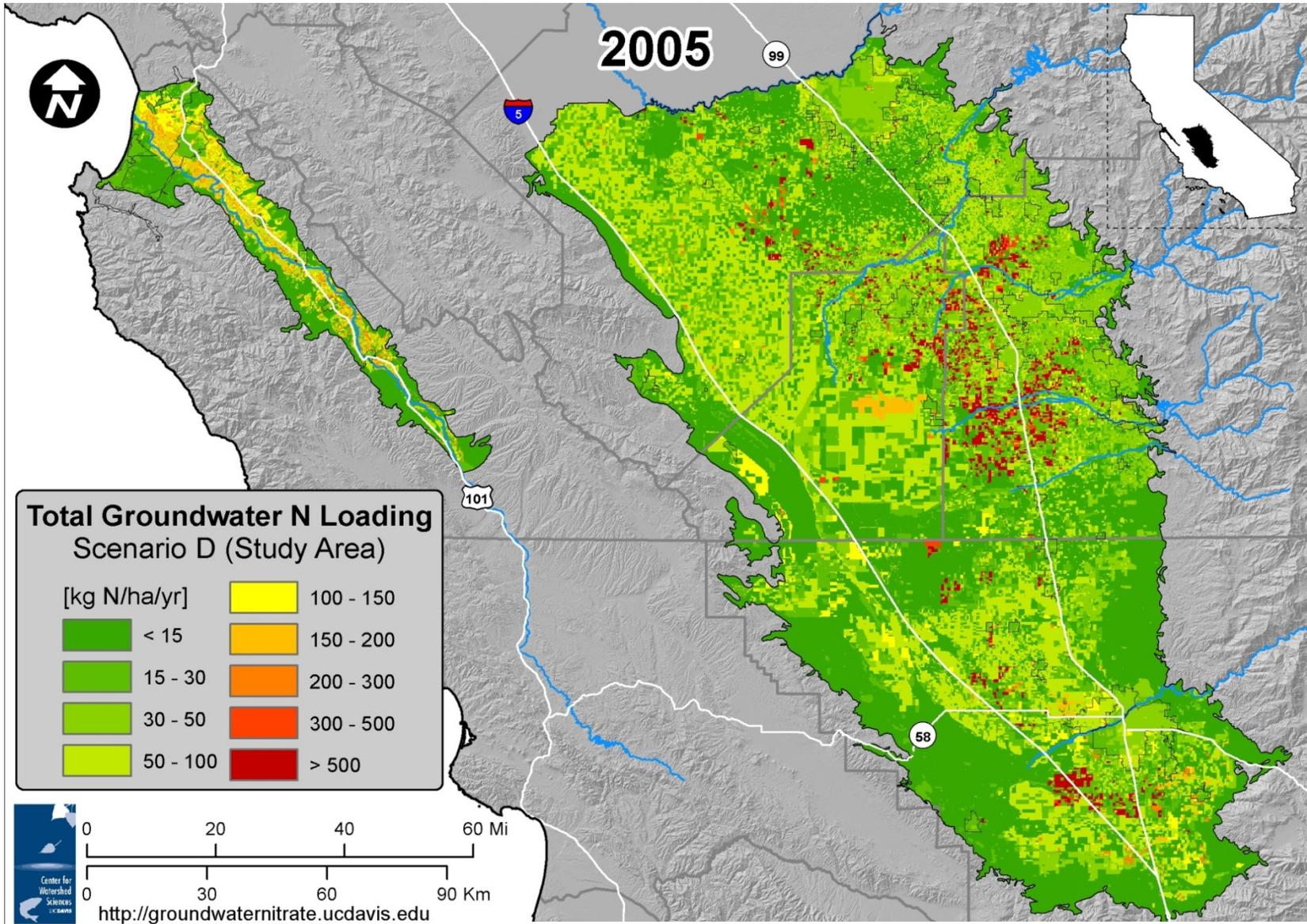
* NASA-ARC estimate of normal Central Valley idle land is 1.2 million acres.

[#] Total agriculture employment is about 412,000, of which 200,000 is farm production.

Cumulative Jobs and Revenues



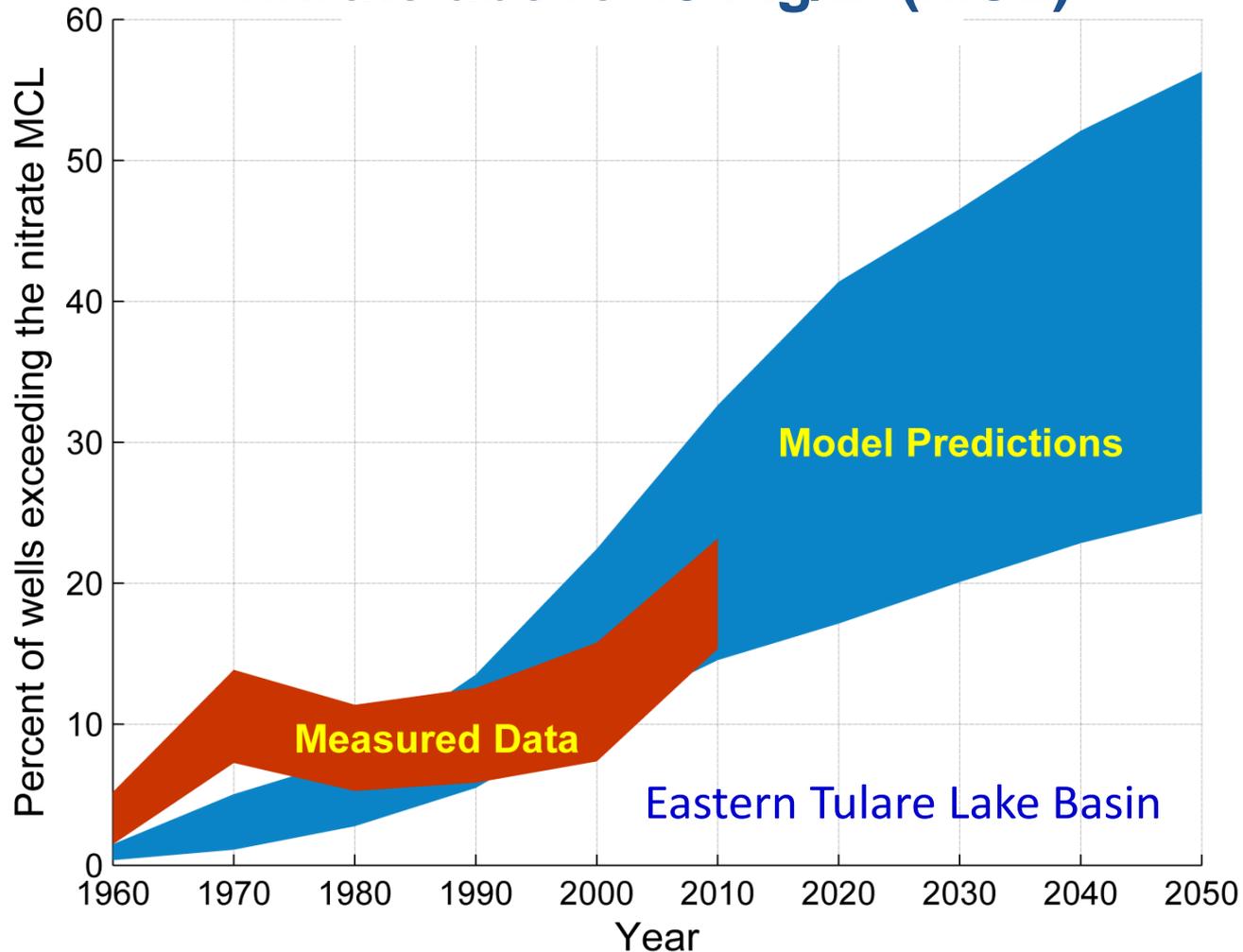
Groundwater Nitrate



Assumes Manure Remains On-Dairy

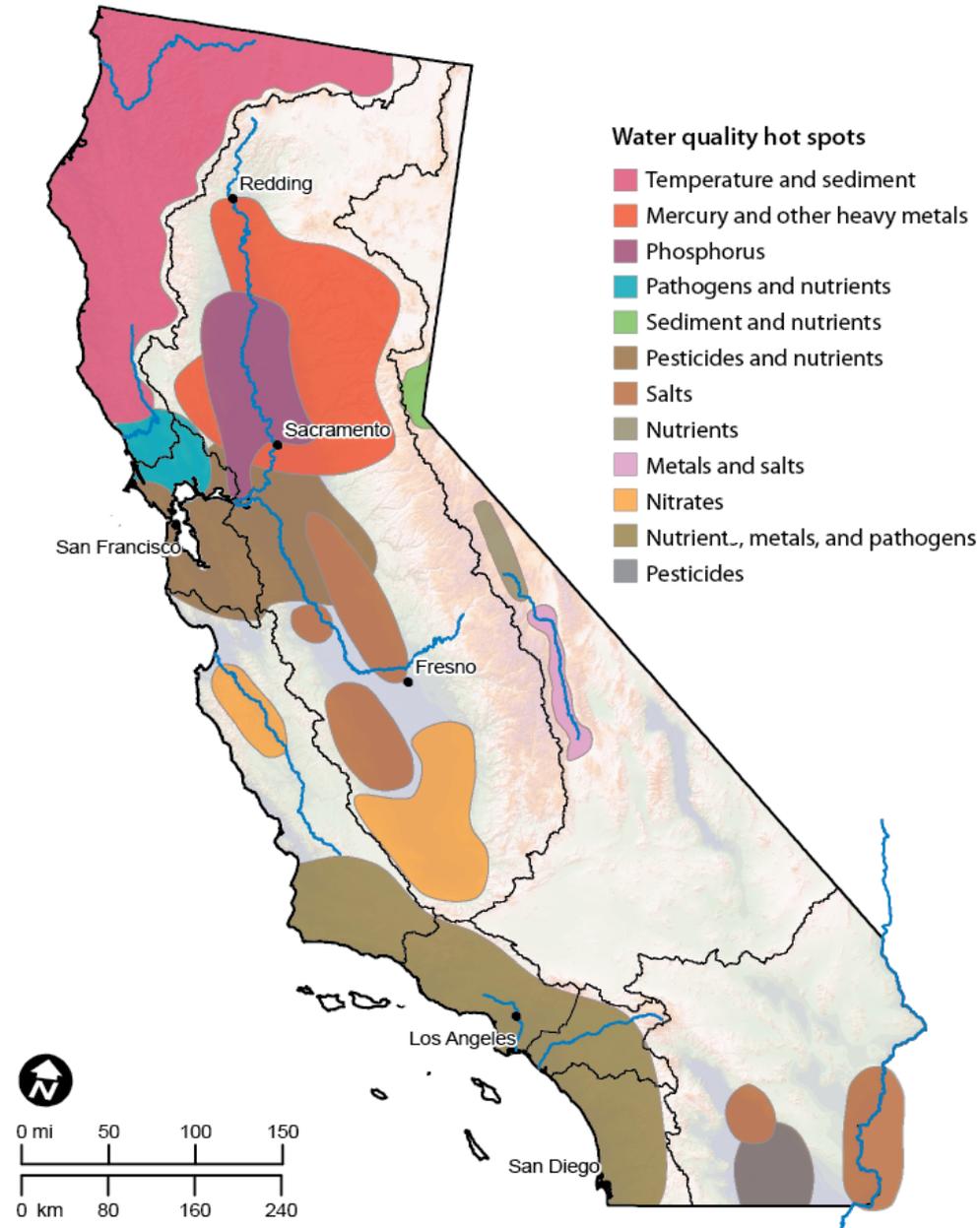
Predictions Using Groundwater Nitrate Loading

**Exceedance Probability,
Nitrate above 45 mg/L (MCL)**



Dry with Regional Water Problems

- 1) Klamath River system
- 2) Sacramento Valley
- 3) Mountain communities
- 4) The Delta
- 5) Bay Area
- 6) San Joaquin River
- 7) Tulare Basin
- 8) Southern California
- 9) Salton Sea
- 10) Colorado River
- 11) Salinas Valley
- 12) Groundwater



Grading California on a Curve?

Country/ State	Population (millions)	Wealth (GDP PPP/person)	Food Production (\$ billion)	Native Freshwater Aquatic Ecosystem Condition
California	39	\$62,000	\$45	Struggling, much diminished
Algeria	39	\$13,000	\$8	Largely eliminated
Australia	24	\$68,000	\$25	Substantially eliminated
Chile	18	\$22,500	\$8	Substantially eliminated
Greece	11	\$26,000	\$6	Largely eliminated
Israel	8	\$36,000	\$3	Largely eliminated
Italy	61	\$35,600	\$29	Largely eliminated
Morocco	33	\$7,000	\$9	Largely eliminated
S. Africa	54	\$12,500	\$13	Struggling, much diminished
Spain	46	\$43,000	\$32	Largely eliminated

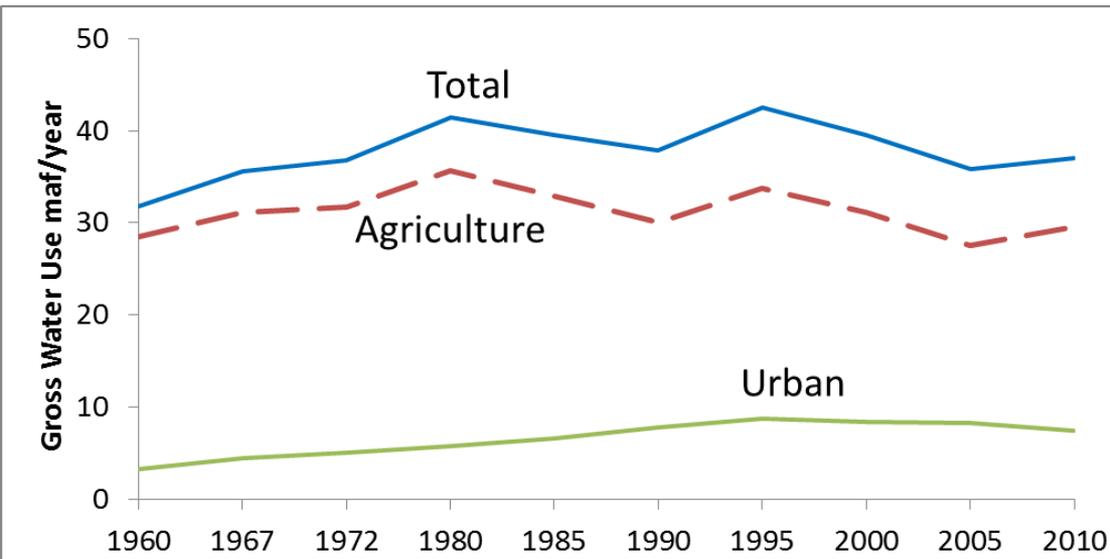
Mediterranean climates always have severe water problems – and much they can learn from each other.

Today's Challenges

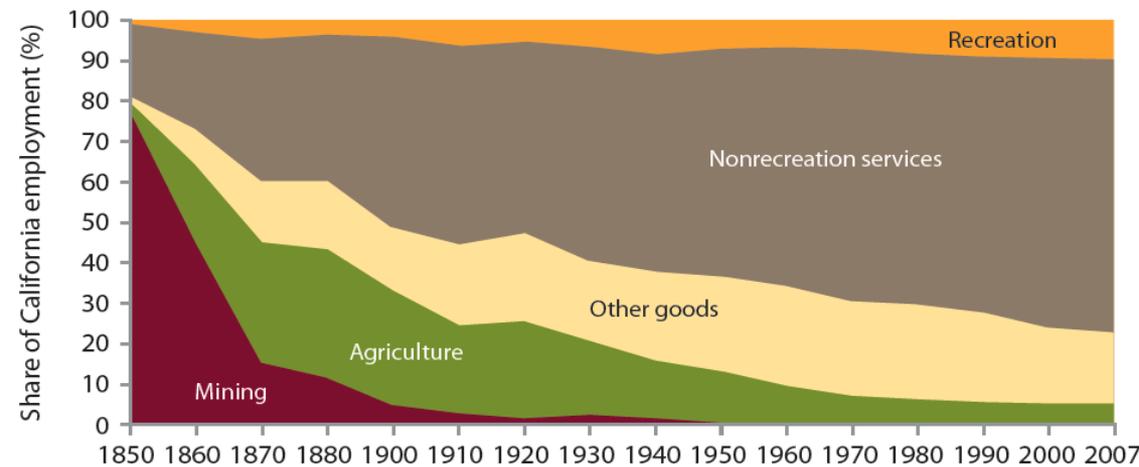
- 1) Groundwater sustainability and management
- 2) Delta water supplies & transfers
- 3) Ecosystem management
- 4) Rural communities
- 5) Modernizing statewide system
 - Infrastructure
 - Water rights
 - Environmental regulation



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



Portfolio-based Management

Supply

- Reoperation
 - Reservoirs
 - Conveyance
- Conjunctive use
- Expand conveyance & storage
- Urban reuse
- New water treatment
 - Wastewater reuse
 - Ocean Desalination
 - Contaminated aquifers
- Stormwater capture
- Source protection

Demand and Allocation

- Agricultural water use efficiencies and reductions
- Urban water use efficiencies and reductions
- Ecosystem demand management
- Recreation water use efficiencies

Incentive policies

- Pricing
- Markets
- Subsidies, taxes
- Education

Drivers of Change

- Climate
 - Sea level rise
 - Warming
 - Precipitation change
- Deterioration
 - Aging infrastructure
 - Contaminants – salts, nitrates, etc.
 - Mining legacy
 - Groundwater overdraft
 - Earthquakes
 - Sacramento-San Joaquin Delta
- Economy and Demography
 - State and federal finances
 - Global markets, connections
 - Population growth and urbanization
- Ecosystems
 - New invasive species
 - Continued degradation
- Science and technology
 - New chemicals
 - New Technologies



California Agriculture lessons

- 1) Droughts need not be an agricultural disaster
- 2) Groundwater, groundwater, groundwater
- 3) Agriculture must reduce water use in some areas
- 4) Water markets provide flexibility
- 5) Farmers and local districts are most accountable decision-makers
- 6) Permanent and high-valued crops support prosperity and jobs
- 7) No need to panic if water is well managed

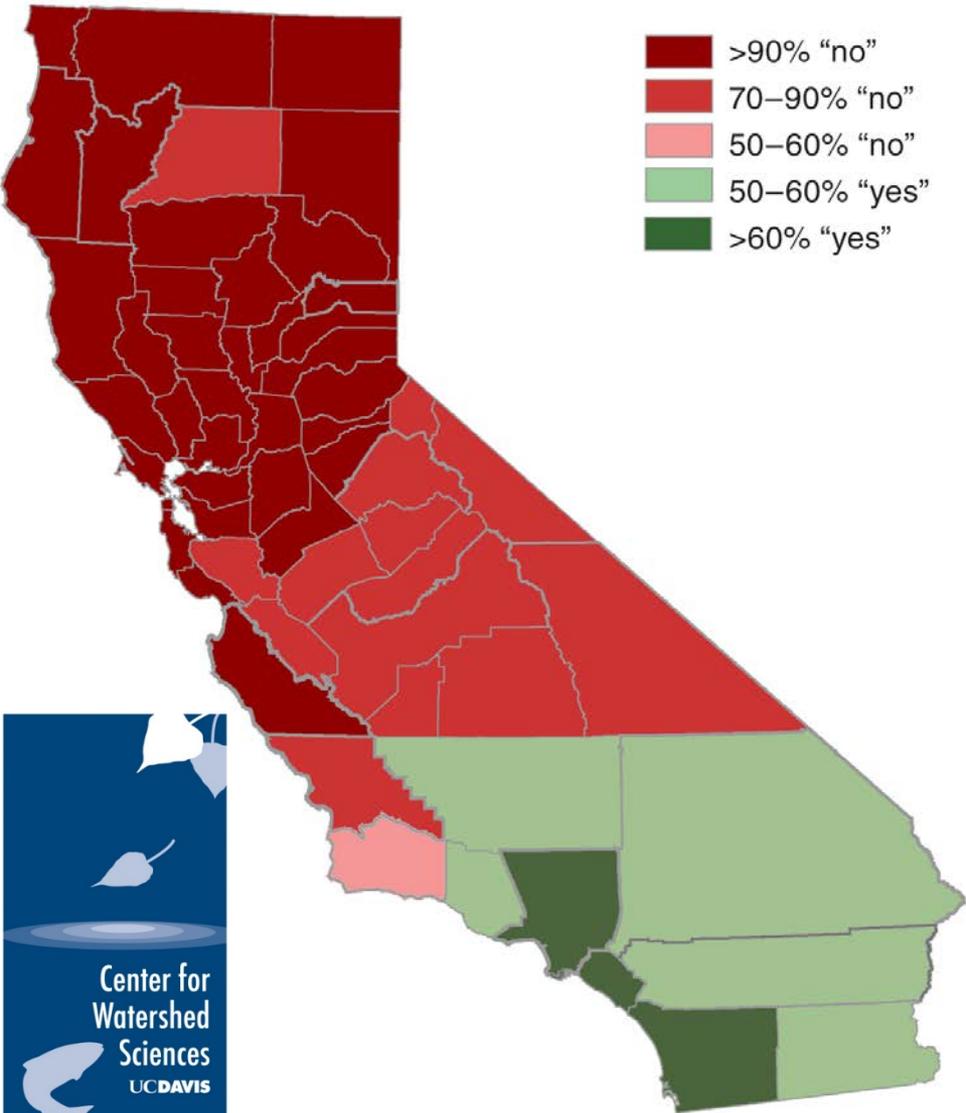
Resistance is Futile



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

We cannot climate-proof, but we can manage better.

Suggested Readings



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

Hanak et al. (2010) *Myths of California Water*, PPIC.org

Hundley (1992), *The Great Thirst*, UC Press.

Kelley (1989), *Battling the Inland Sea*, UC Press.

Lund et al. (2010) *Comparing Futures for the Sacramento San Joaquin Delta*, UC Press

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

Aquaforia.com

CaliforniaWaterBlog.com