# Another California Drought: 2020 - ???

"You can never step in the same river twice"
Heraclitus

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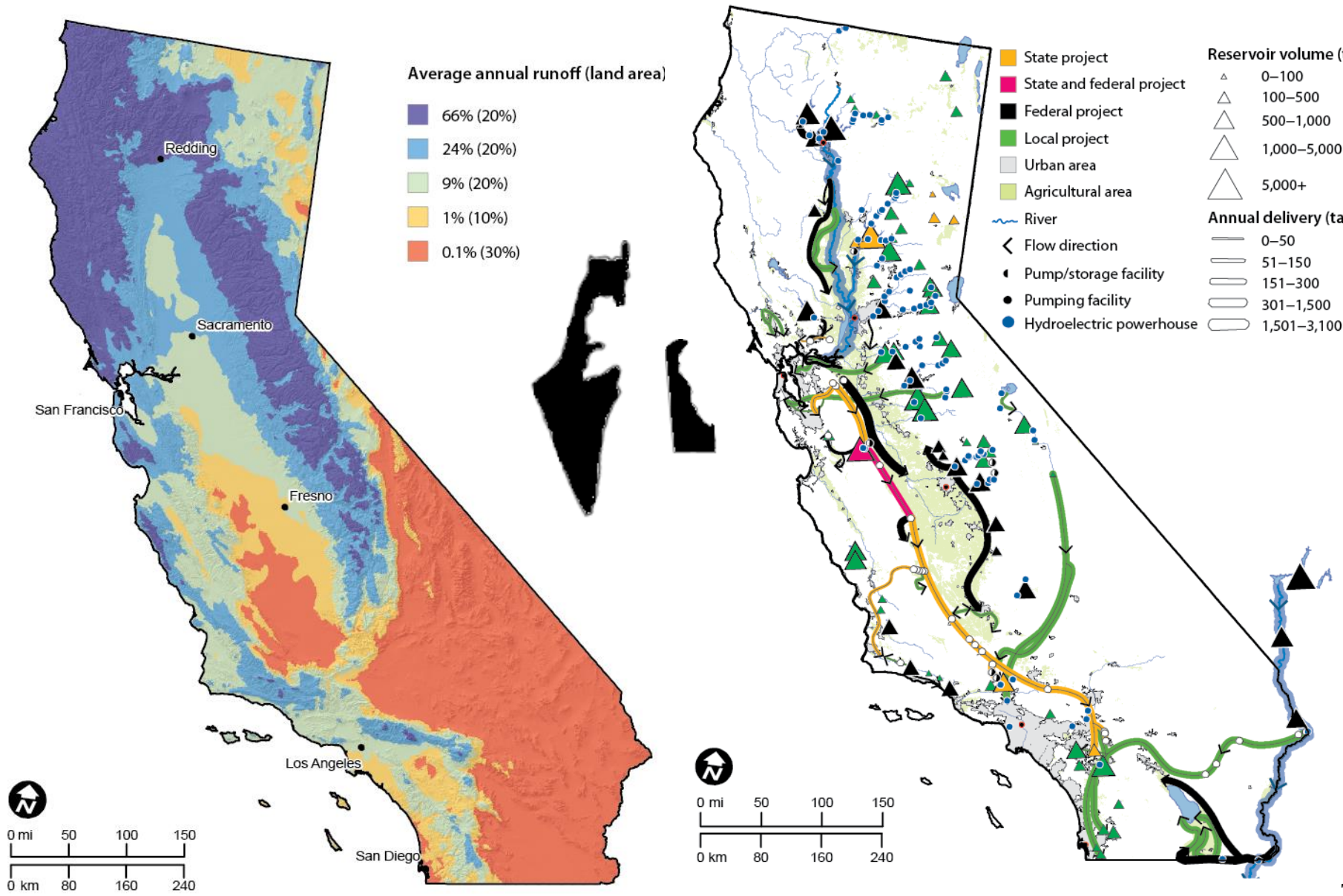
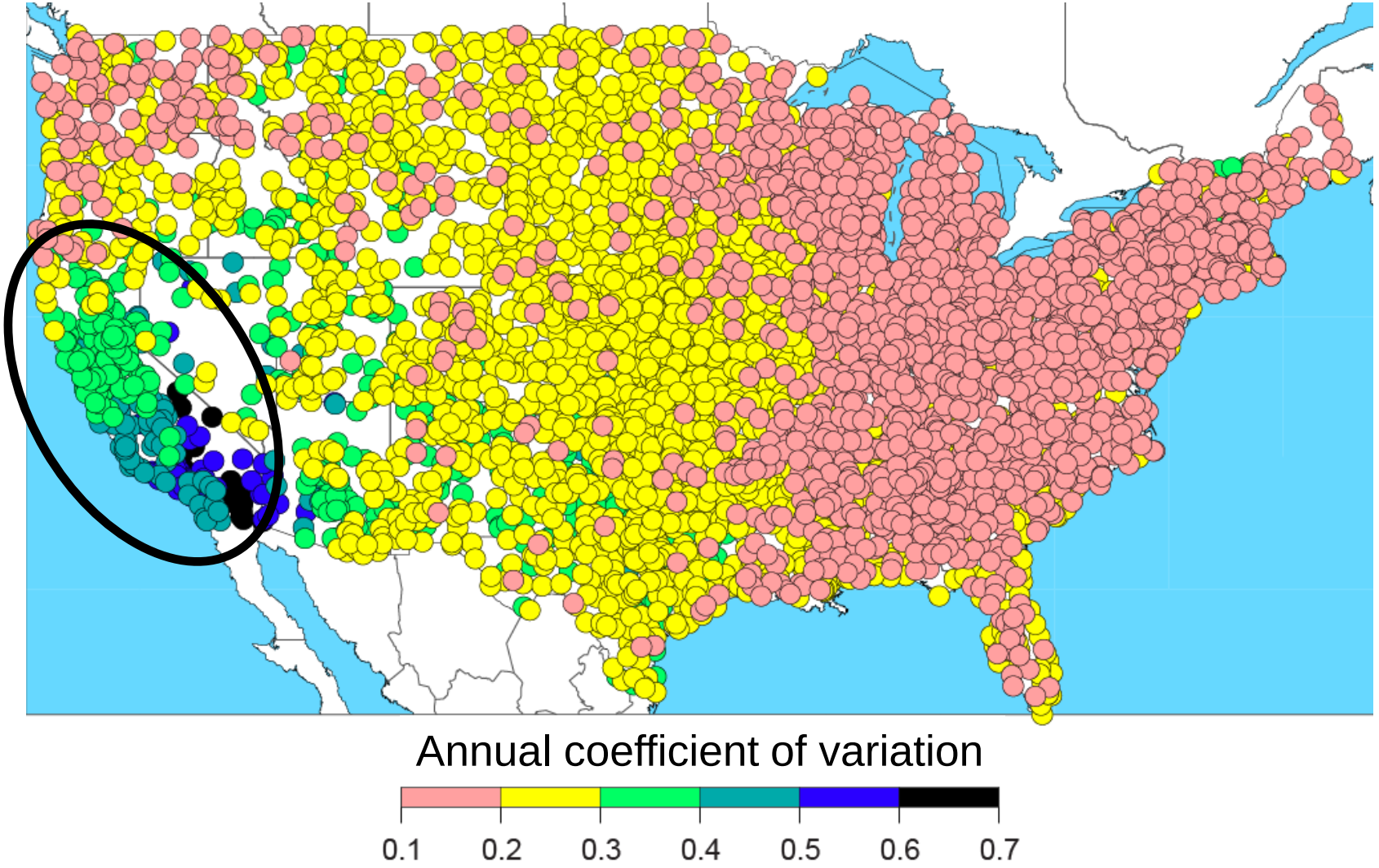
# Water and People in California



# Droughts in California

1. California has lots of droughts
2. California has a dynamic society, economy, & climate
3. Globalization eternally important for California water
4. Economic structure drives most management change
5. Droughts/pivotal events help water management adjust to changing objectives and conditions
6. Adjustments are technological and institutional
7. Adjustments build on existing institutions and infrastructure
8. Adjustments also rebalance portfolio of local, regional, state, and federal roles and innovations

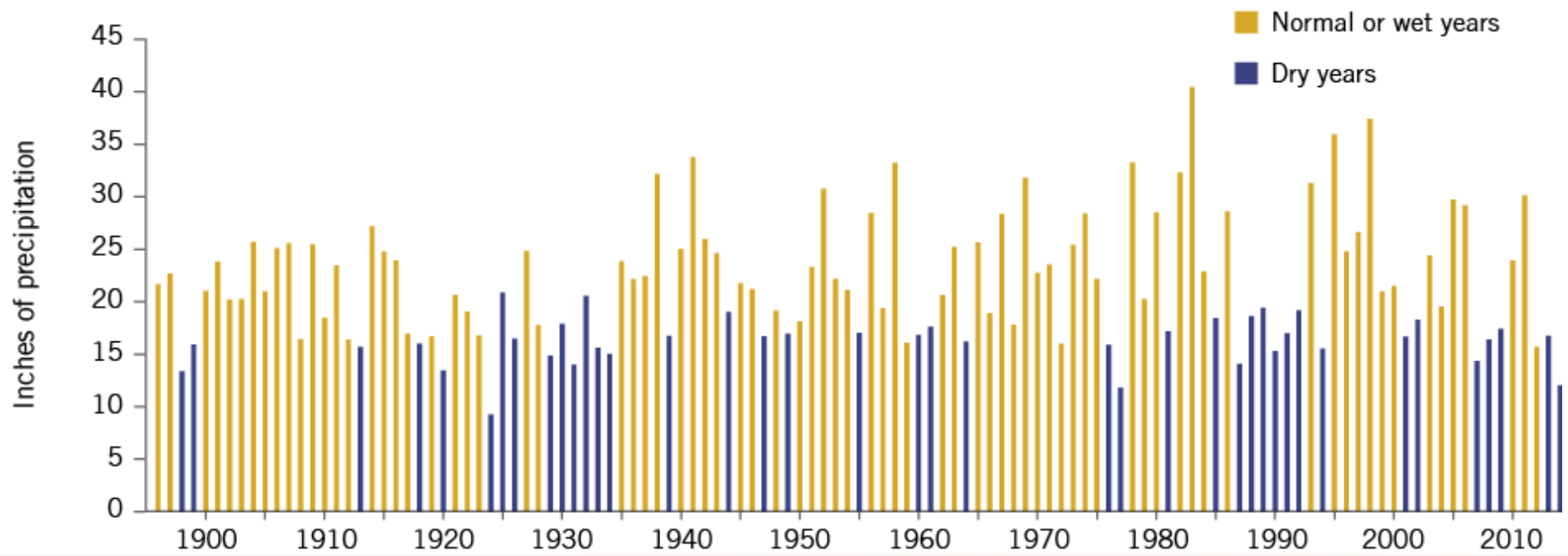
# Most annual rainfall variability in US




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

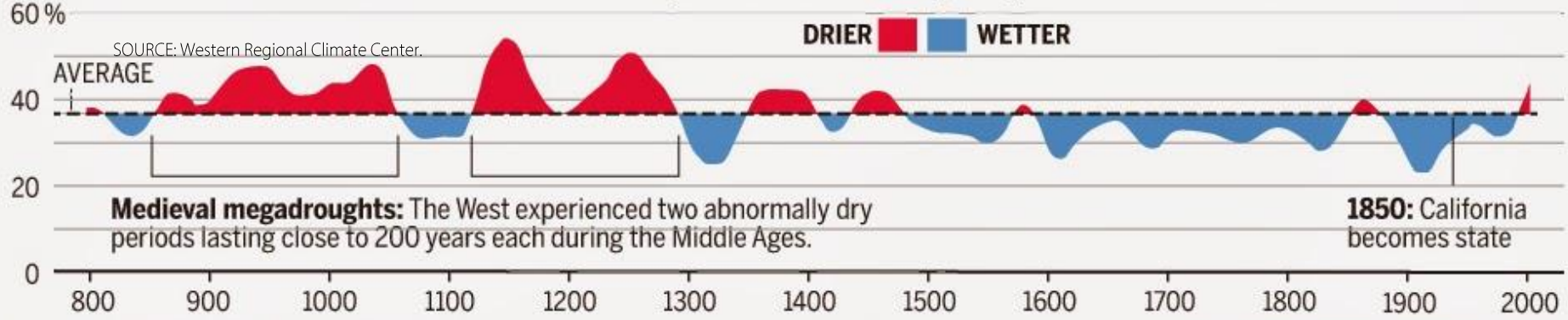
NOTES: Dots represent the coefficient of variation of total annual precipitation at weather stations for 1951-2008. Larger values have greater year-to-year variability.

# California has lots of droughts




## A 200-year drought?

Evidence from tree rings shows that drought was historically much more widespread in the American West than now, while the 20th century was wetter than normal.
Percentage of the West affected by drought from 800 A.D. to 2000:



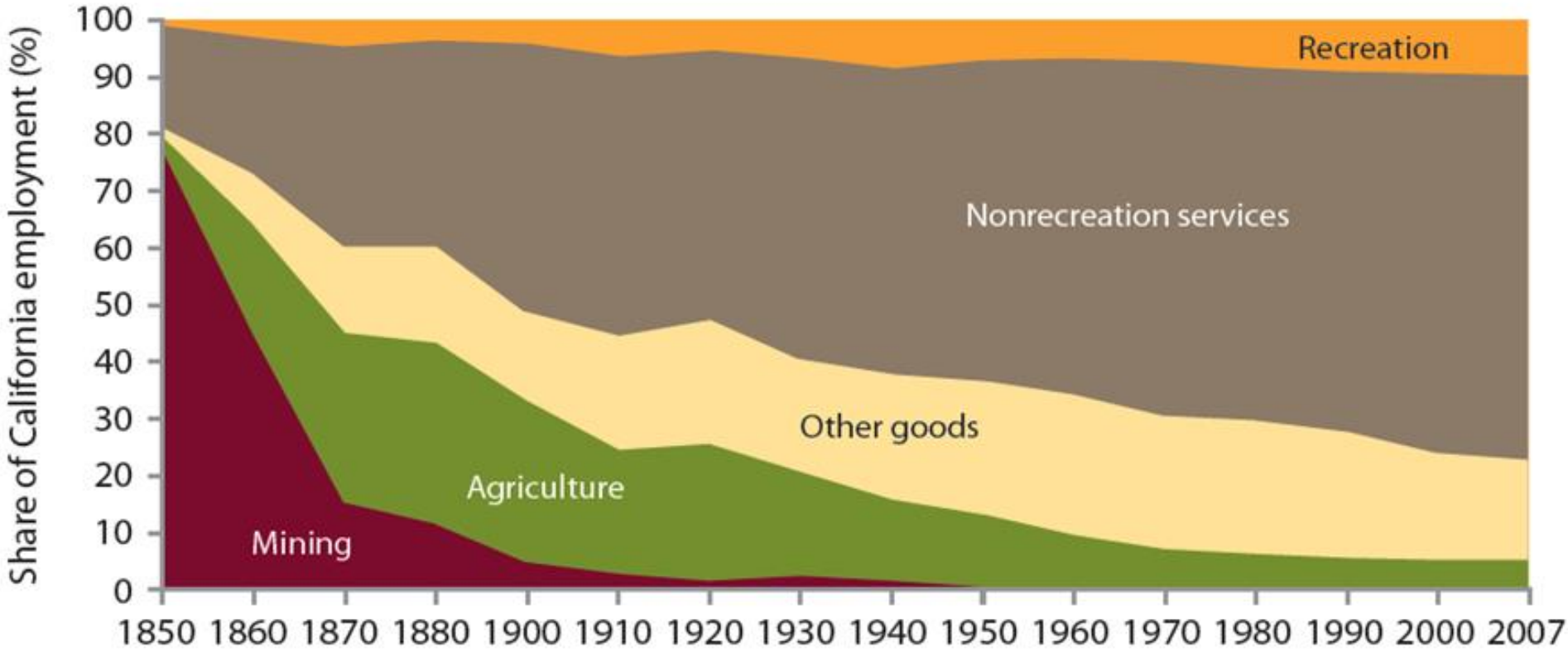

Source: E.R. Cook et al., Earth-Science Reviews

KARL KAHLER/BAY AREA NEWS GROUP

# Each drought hits a different economy

| Droughts | Economy |
| --- | --- |
| • Paleo-droughts | • Pre-European |
| • 1800s | • Range cattle |
| • 1924 | • Early farming |
| • 1928-32 | • More farming |
| • 1976-77 | • Farms + cities |
| • 1988-92 | • Farms, cities, environment |
| • 2007-09 | |
| • 2012-16 | |
| • 2020 - ??? | |

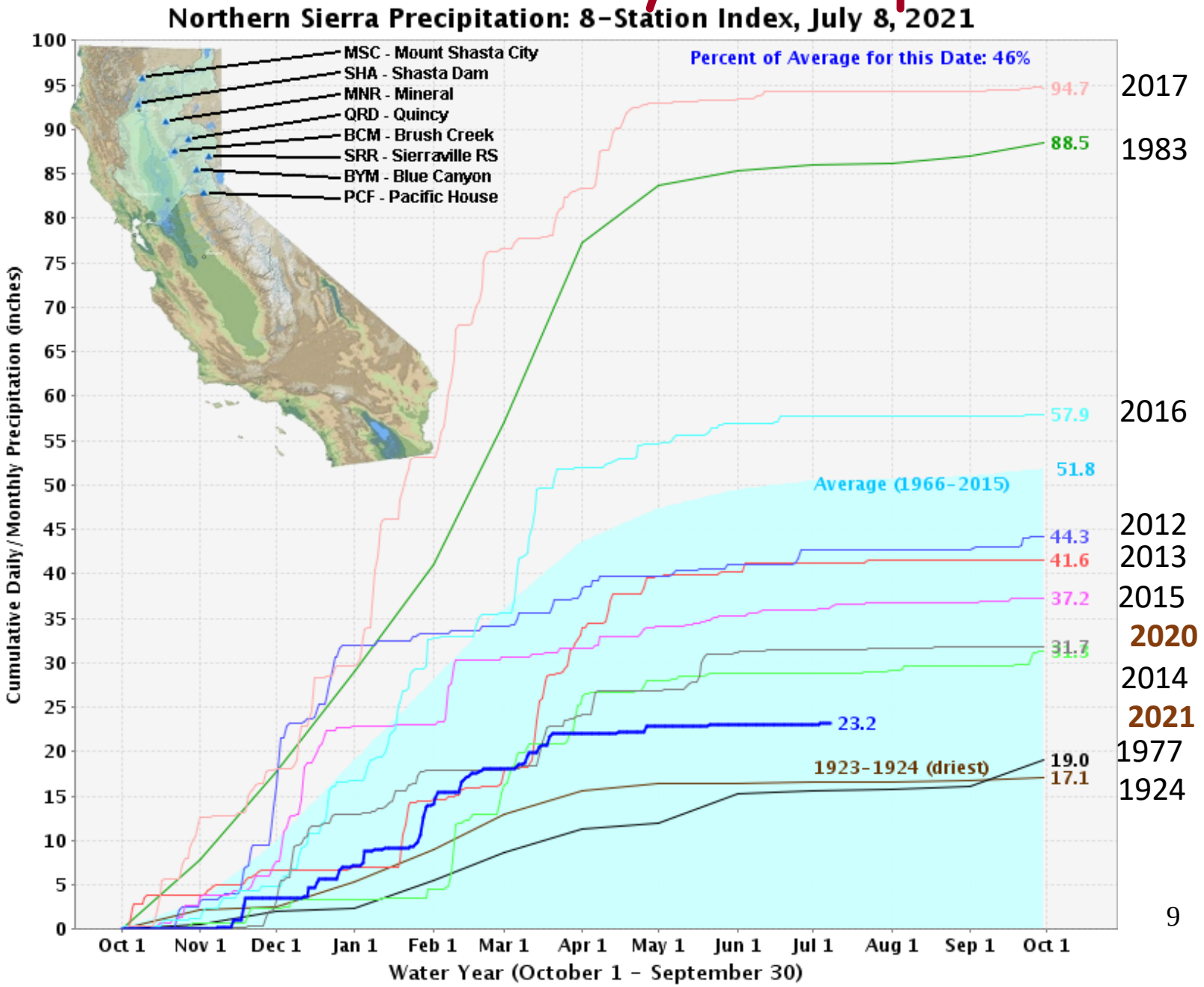
# California's economy less agricultural – more robust to drought



# Swinging Portfolio Development: Institutions and Technology

| Droughts | Actions |
| --- | --- |
| • 1800s | Local, private irrigation |
| • 1924 | Local, public + private diversions |
| • 1928-32 | Regional, statewide- dams, canals |
| • 1976-77 | Local urban conservation, trades |
| • 1988-92 | Interties, conj. use, water markets, new storage – regional, local |
| • 2007-09 | More data, Delta institutions |
| • 2012-16 | Groundwater – local region w/ state; urban cons. Mandates; fires? |

# Sacramento Valley Precipitation



# Reservoir Storage in 2 Droughts

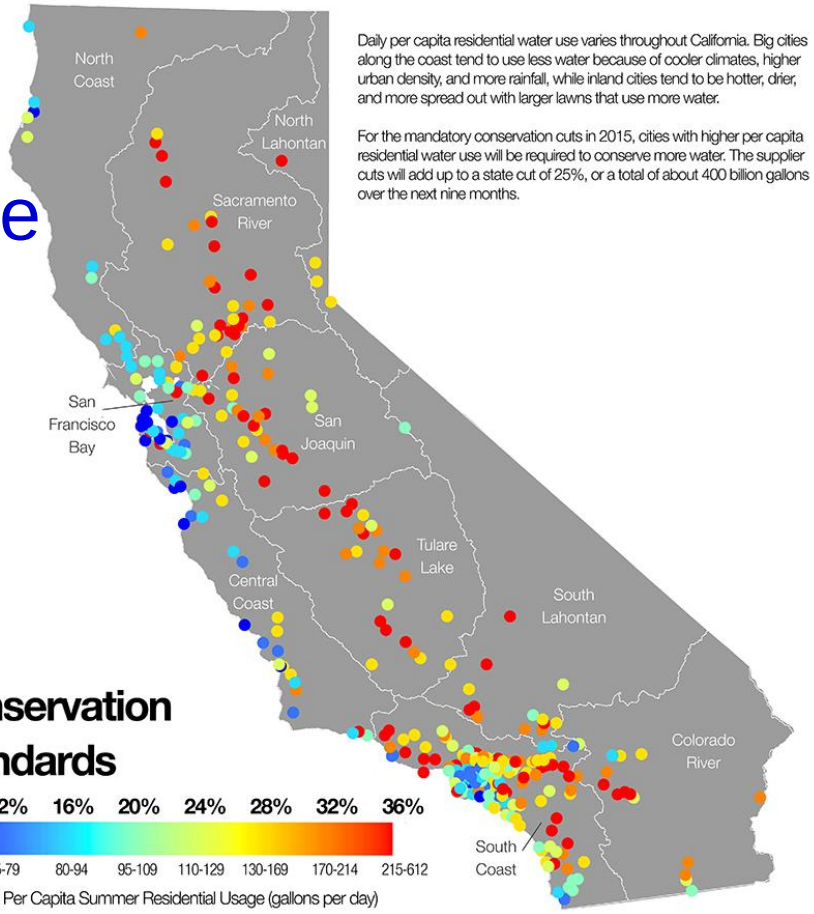
| STORAGE AS OF May 31, 2021 by Drainage Area | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Area | Reservoirs | Total Capacity 1000 AF | Hist Ave 1000 AF | 2014 1000 | 2015 1000 | 2020 1000 AF | 2021 1000 AF | % Ave 2021 | % Cap 2021 | |
| **California** | | | | | | | | | | |
| North Coast | 6 | 3,096 | 2,494 | 1,355 | 1,239 | 2,217 | 1,489 | 60 | 48 | |
| San Francisco Bay | 17 | 715 | 515 | 453 | 455 | 481 | 395 | 77 | 55 | |
| Central Coast | 6 | 982 | 676 | 186 | 180 | 512 | 315 | 47 | 32 | |
| South Coast | 29 | 2,123 | 1,494 | 955 | 932 | 1,460 | 1,206 | 81 | 57 | |
| Sacramento | 43 | 16,151 | 13,332 | 8,274 | 8,269 | 12,476 | 7,961 | 60 | 49 | * |
| San Joaquin | 34 | 11,478 | 8,167 | 4,949 | 4,084 | 8,911 | 6,537 | 80 | 57 | # |
| Tulare Lake | 6 | 2,088 | 1,349 | 623 | 462 | 1,406 | 709 | 53 | 34 | |
| North Lahontan | 5 | 1,073 | 645 | 227 | 55 | 839 | 393 | 61 | 37 | |
| South Lahontan | 8 | 412 | 269 | 251 | 236 | 311 | 262 | 97 | 64 | |
| SUBTOTAL | 154 | 38,116 | 28,940 | 17,273 | 15,912 | 28,614 | 19,267 | 67 | 51 | |
| **Interstate reservoirs** | | | | | | | | | | |
| North Coast | 3 | 1,137 | 778 | 327 | 395 | 657 | 417 | 54 | 37 | |
| Colorado River (1) | 4 | 52,939 | 38,833 | 25,154 | 25,015 | 25,484 | 20,116 | 52 | 38 | * |
| SUBTOTAL | 7 | 54,076 | 39,611 | 25,482 | 25,410 | 26,141 | 20,532 | 52 | 38 | |
| **TOTAL** | **161** | **92,193** | **68,551** | **42,755** | **41,322** | **54,755** | **39,800** | **58** | **43** | * |
| 1 - includes lakes Powell and Mead | | | | | | | | | | |

# Droughts with a Warmer Climate

- Less streamflow and soil moisture for the same precipitation.
  - Less runoff overall
  - Shift of runoff from spring to winter
  - Need more cold water for salmon habitat
  - More forest and wildfire impacts
- Permanent changes in forest and aquatic ecosystems.
- Increased problems with flood operations.

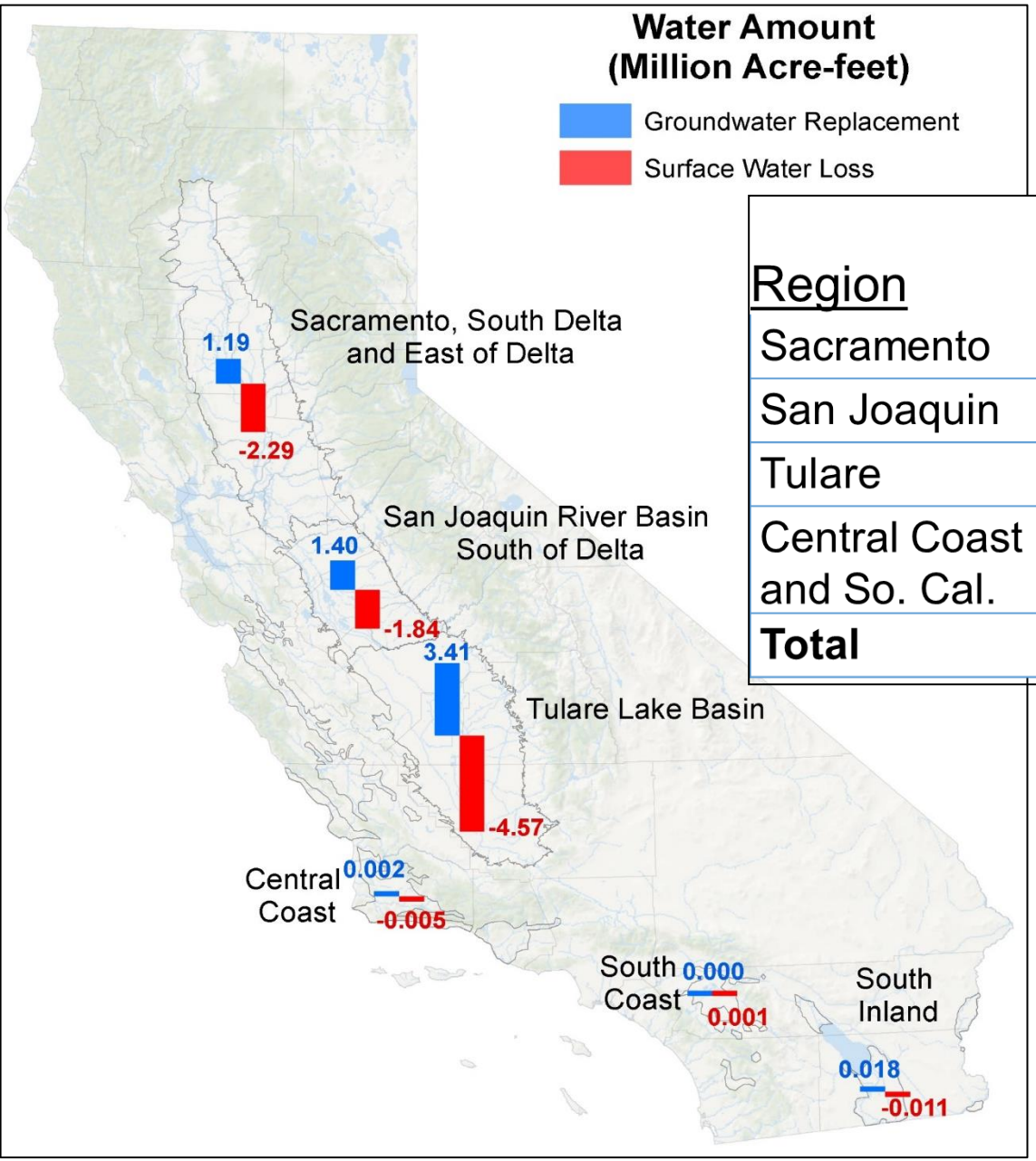
# Urban and Suburban Impacts

1) Mostly well prepared, following 1988-1992 drought
2) Santa Clara Valley, Healdsberg, Fort Bragg
3) Little economic disruption
4) Disrupts urban water finance and plans
5) Problem for state policy – local vs. state responsibility

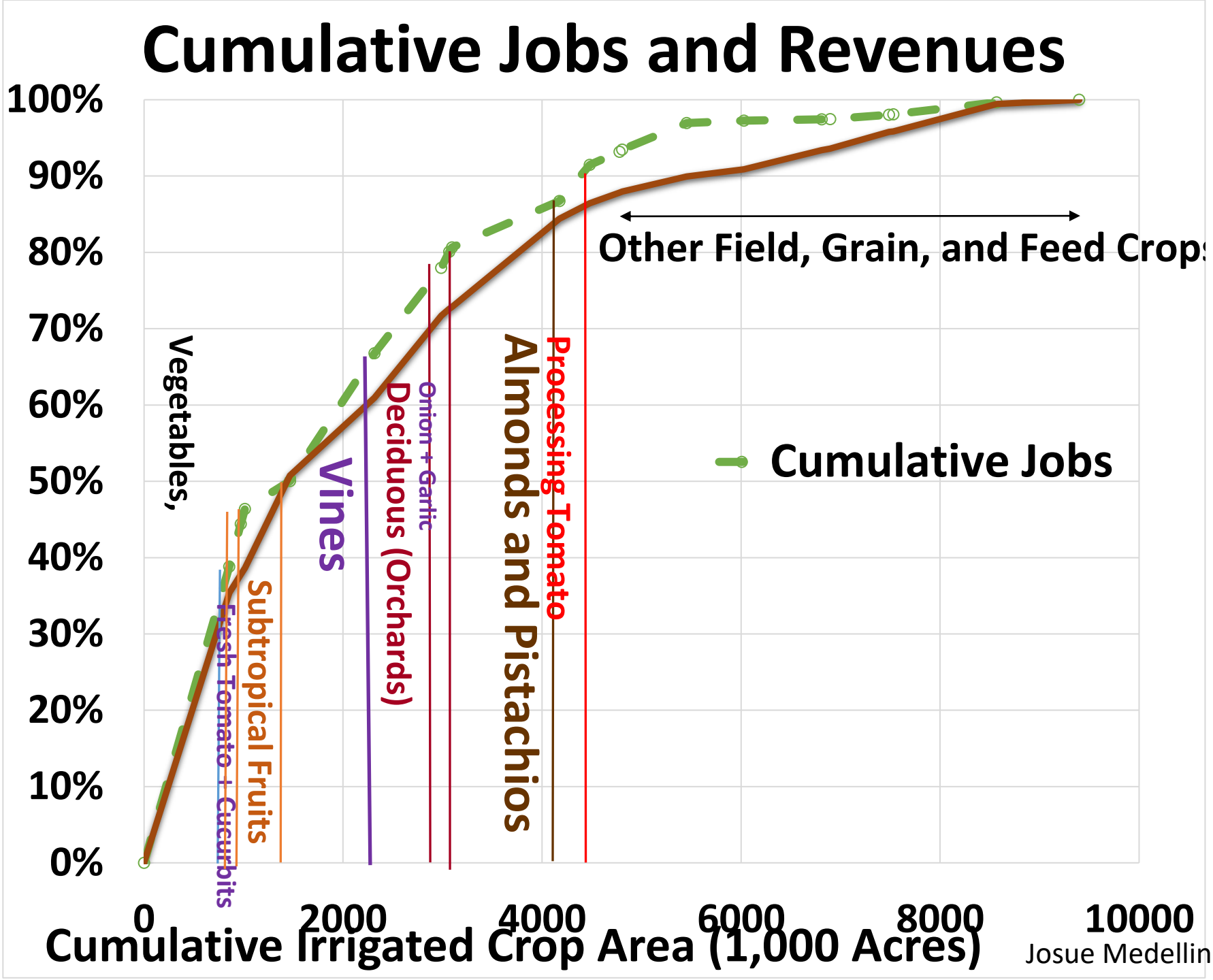



Circle of Blue

# 2015 Agricultural Water Use Changes (maf)




| Region | Surface Water | Ground-water | Net Shortage |
|---|---|---|---|
| Sacramento | -2.29 | 1.19 | -1.1 |
| San Joaquin | -1.84 | 1.40 | -0.44 |
| Tulare | -4.57 | 3.41 | -1.16 |
| Central Coast and So. Cal. | -0.02 | 0.02 | 0.01 |
| **Total** | **-8.72** | **6.02** | **-2.7** |


Cumulative Jobs and Revenues
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
2000
4000
6000
8000
10000
Cumulative Irrigated Crop Area (1,000 Acres)
Other Field, Grain, and Feed Crops
Cumulative Jobs
Vegetables,
Fresh Tomato + Cucurbits
Subtropical Fruits
Vines
Deciduous (Orchards)
Onion + Garlic
Almonds and Pistachios
Processing Tomato
Josue Medellin

# 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 | $40 billion | 2.3% |
| Dairy and livestock revenue losses ($) | $350 million | $13 billion | 2.7% |
| Costs of additional pumping ($) | $590 million | $780 million | 75.5% |
| Net revenue losses ($) | $1.8 billion | 54 billion rev. | 3.3% |
| **Total economic impact ($)** | **$2.7 billion** | NA | NA |
| Direct job losses (farm seasonal) | 10,100 | 200,000# | 5.1% |
| **Total job losses** | **21,000** | NA | NA |

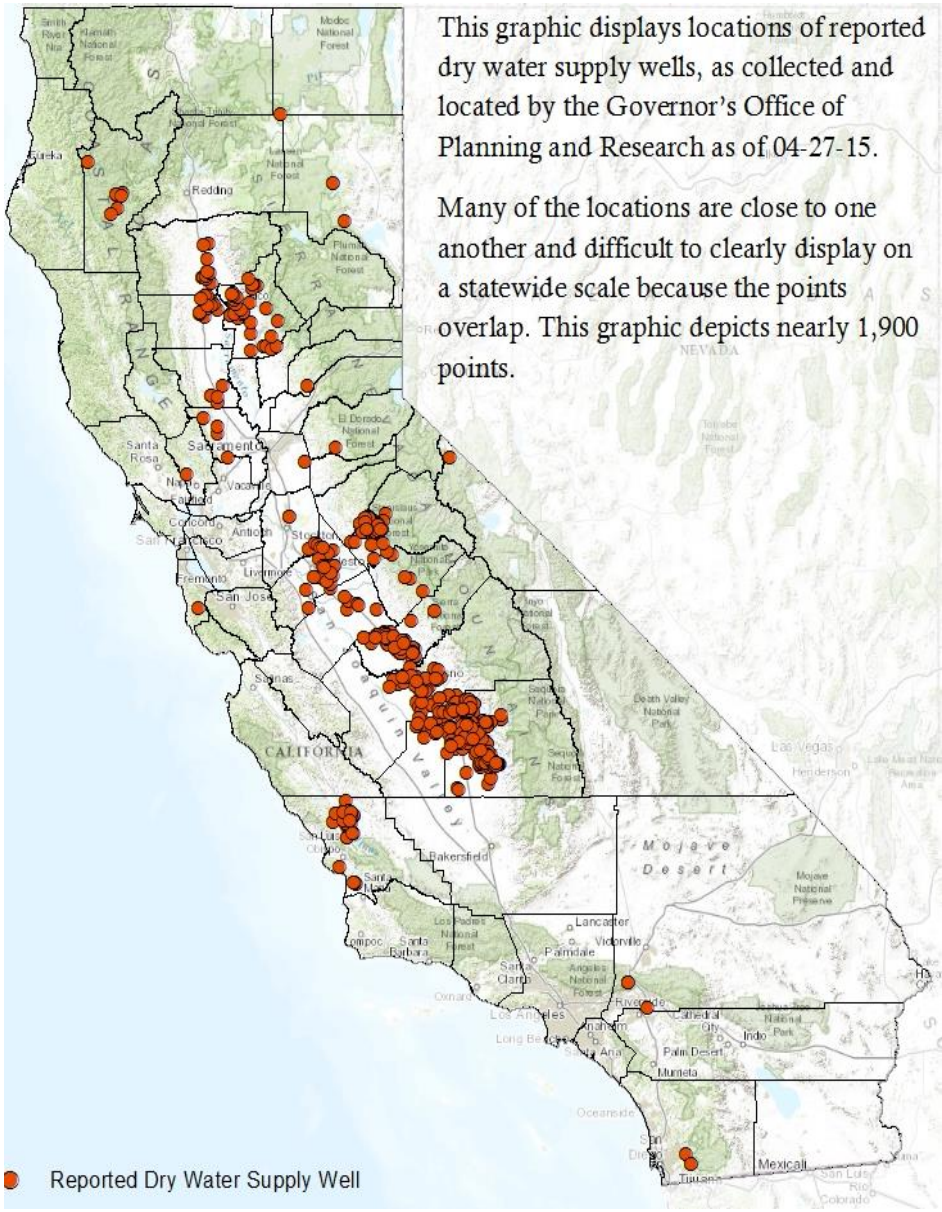
* NASA-ARC estimate of normal Central Valley idle land is 1.2 million acres.

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

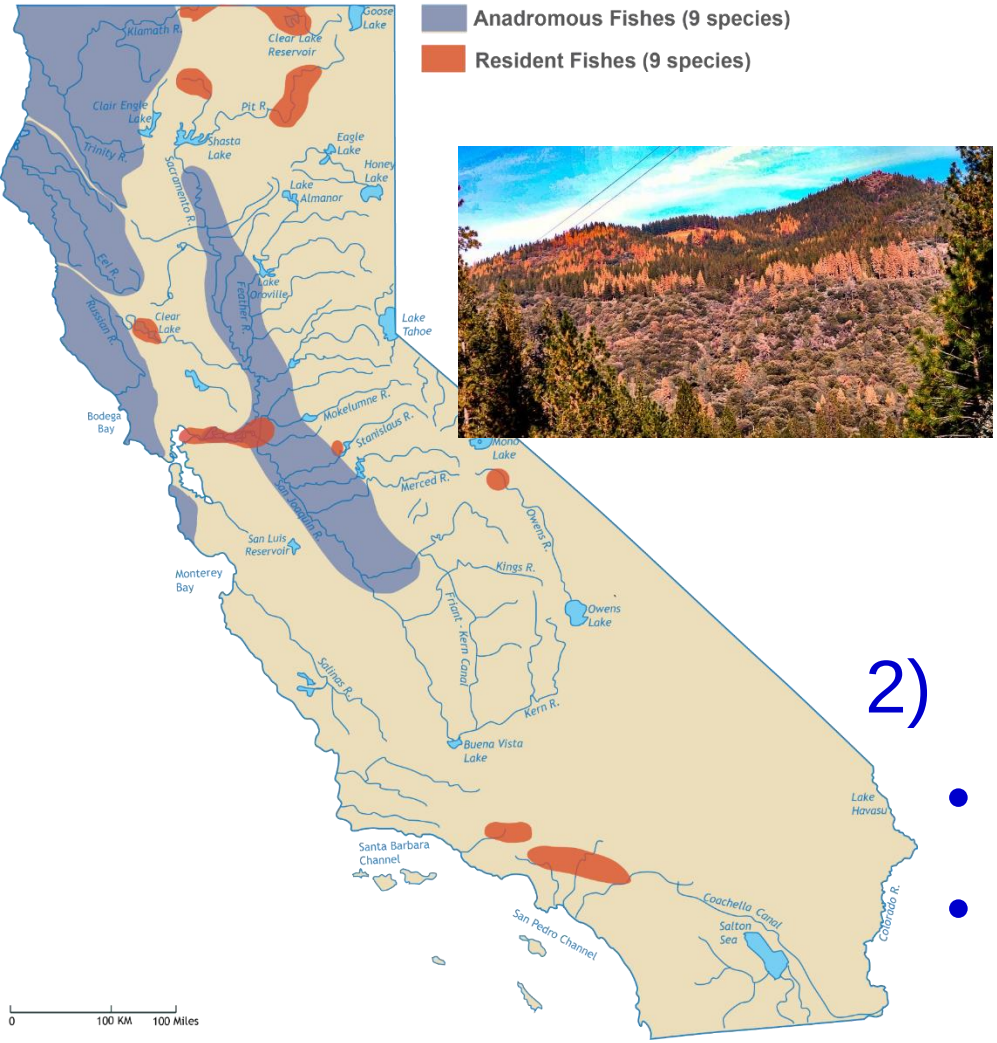
# Rural communities

- In 2015, 2,000+ dry domestic wells, 100+ small systems in trouble
- Strong emergency response
- But time lags still too long
- Local economic hardship

Reminds us of problems of small rural water systems



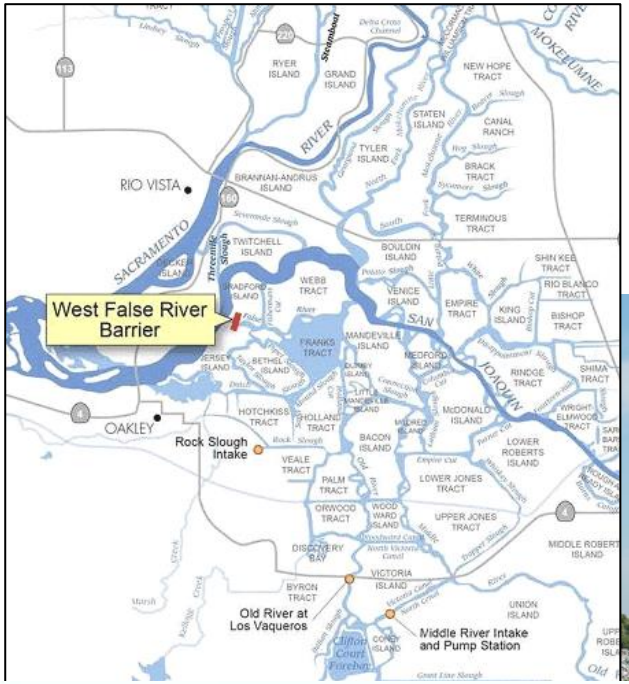
# Ecosystems and drought management



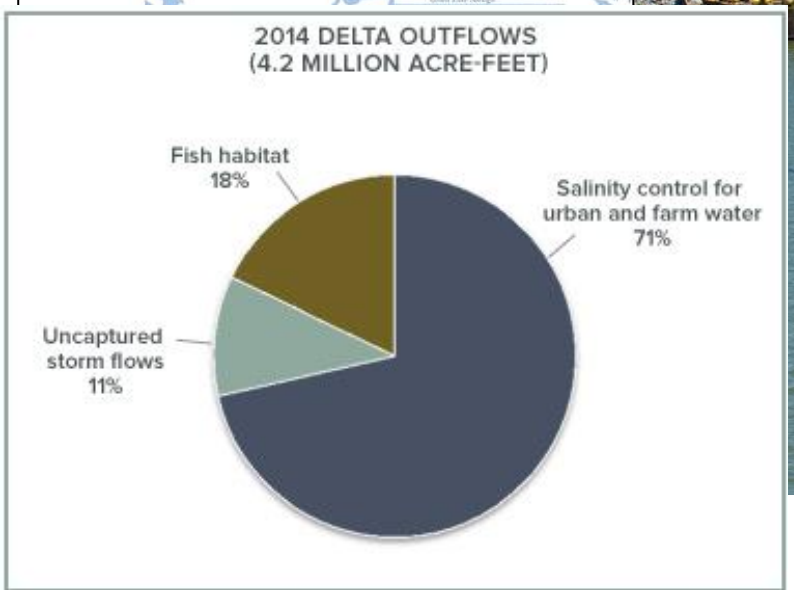



1) 2012-2016 problems:
   - Forests - 140 million dead trees; fires
   - Fish: cold water, hatcheries, salinity
   - Waterfowl
   - Wildfires
2) Poor drought preparation
   - Among regulatory agencies
   - Between ecosystem and project agencies

# Delta Flows & Drought Barrier




DWR




PPIC

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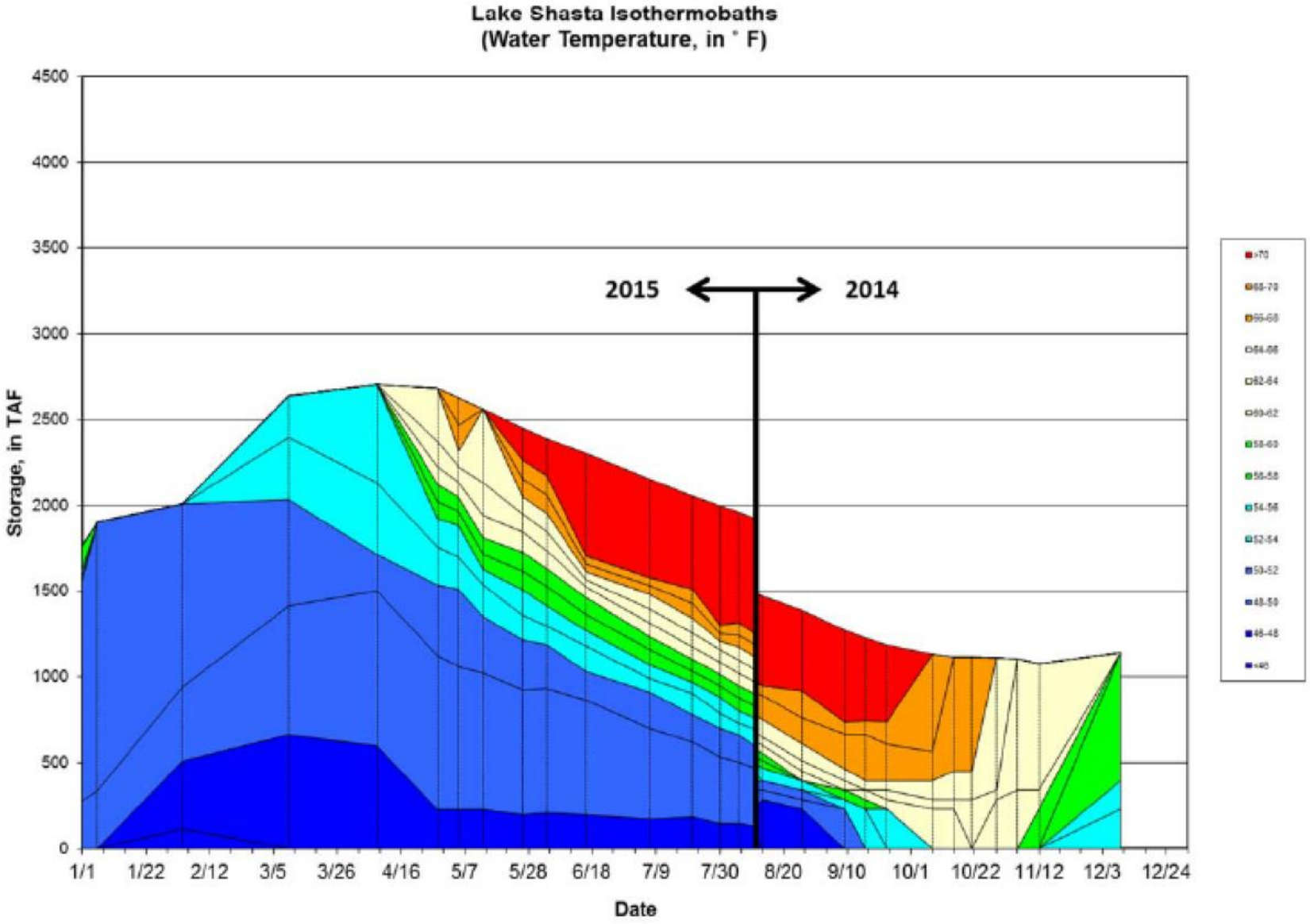
# Cold Water at Shasta Dam

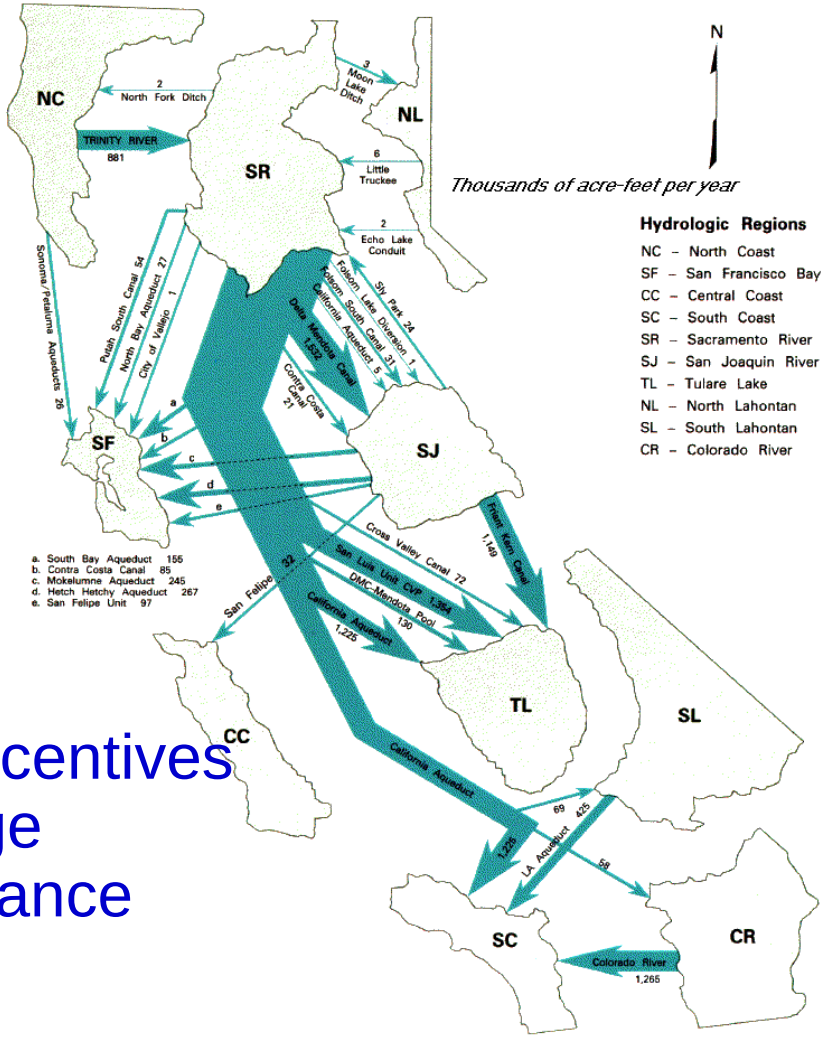



NMFS August 2015

# Local and Statewide Portfolios

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.

# Droughts test water systems!

1. Water systems and the societies they serve are always changing
2. Droughts bring attention to needs for change
3. The drought helped California improve water management – groundwater
4. Failing in ecosystem management and accounting – but addressing groundwater
5. Every generation needs at least a threatening drought, and a threatening flood
6. Learn from test!  No panic or complacency.

# Drought Test Grades?

| Group | Grade so far | Comments to parents |
|---|---|---|
| Urban | A- | Excellent preparation; sometimes shows lack of regard for others in class; learned much from previous tests. |
| Agriculture | B+ | Good preparation, mostly. Quick learners. Groundwater still a weakness. |
| Rural water supply | C | Test highlighted general poor preparation. Groundwater and organizational weaknesses. |
| Environment | D | Unprepared for test, or studied for a different test. Must prepare for next test. |
| Government agencies | B/C | Students must prepare more closely together for the next test. |

# 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 |

Climate change likely to affect California less than others.

# Drought lessons for California

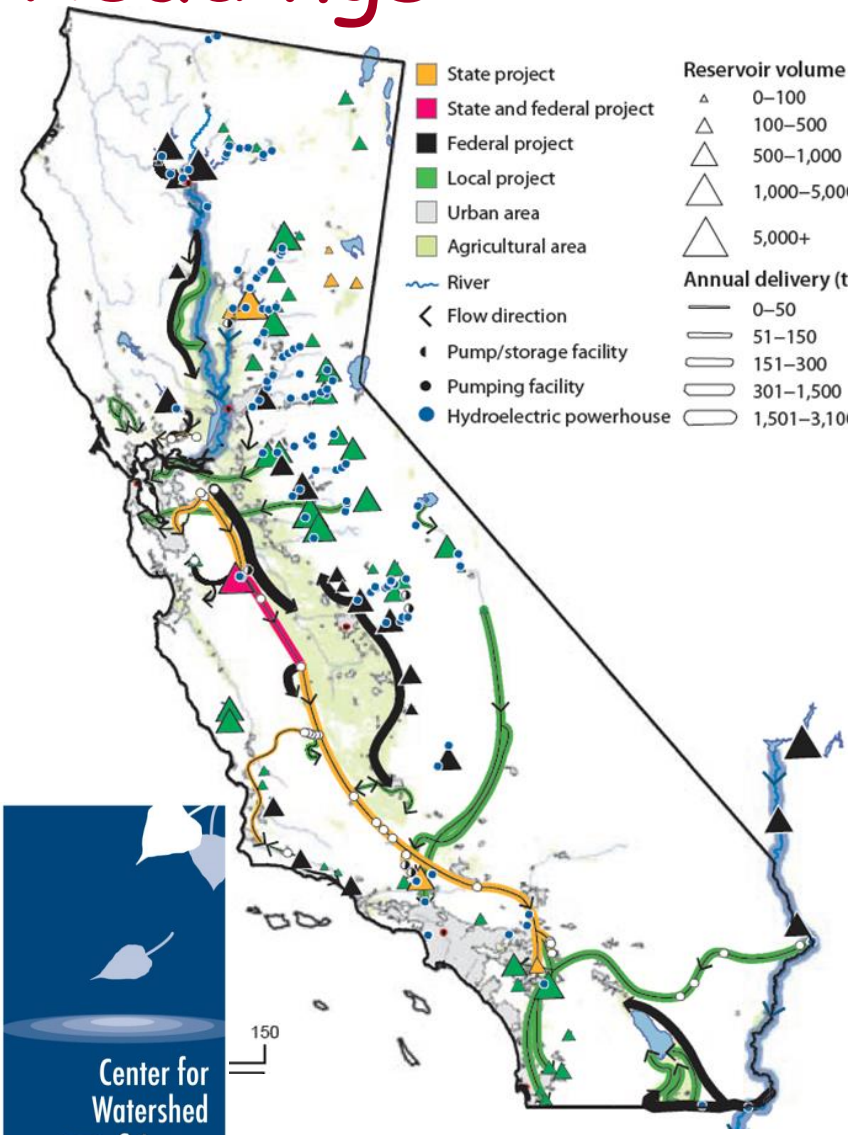
1. California's human uses adapted to drought well, with some exceptions – portfolio approaches
2. Groundwater is a major drought buffer, needs management (SGMA)
3. Globalization also buffers against drought
4. Ecosystems (forests, aquatic) need attention
5. Droughts/pivotal events help water management adjust to changing objectives and conditions
6. Technological and institutional adjustments also rebalance portfolio of local, regional, state, and federal actions and roles

# Resistance is Futile

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

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

# Further Readings

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