Drought & Climate Change Overview

Jeanine Jones, California Department of Water Resources

First a Word About Defining Drought When Does "Dry" Become "Drought"?

- Meteorological drought
- Hydrological drought
- Regulatory drought
- Drought indices, US Drought Monitor
- Sector-based definitions
- **Drought is a function of impacts (which are typically regional or local)**

When Does "Drought" Become "Drought Emergency"?

- Depends on impacts, and ability to mitigate impacts
- Drought differs from traditional "emergencies" (flood, fire, etc) in its very slow timescale
- California Emergency Services Act
  - Role of local government (counties)
  - Role of state

About Drought

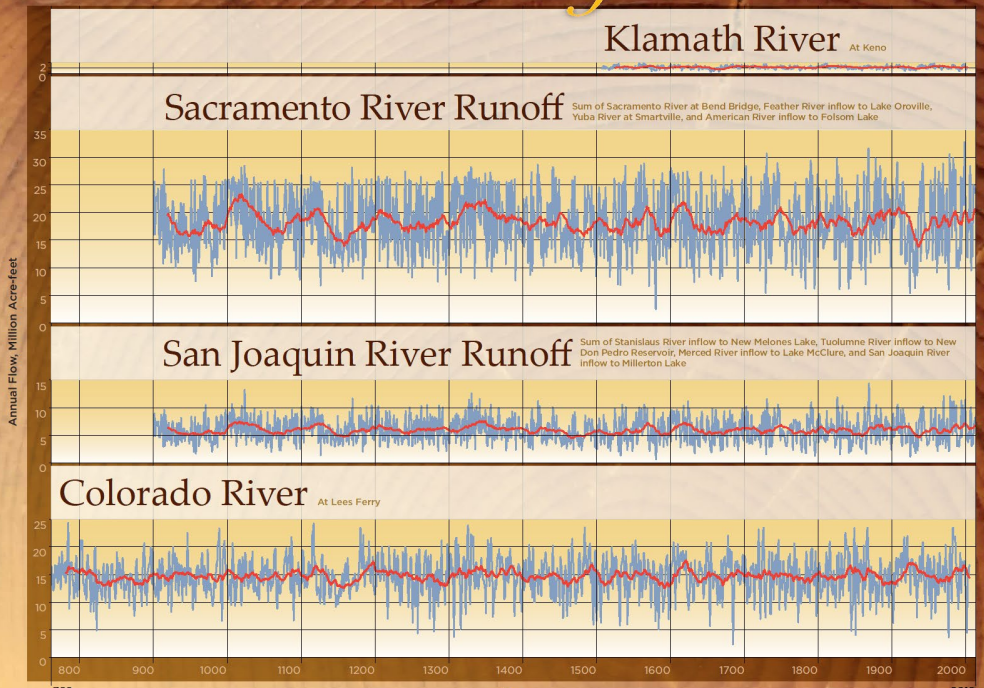
- Drought impacts are site-specific and sector-specific
- The greatest drought impacts are related to unmanaged water uses – e.g., rangeland grazing, wildfire
- The greatest economic impacts of drought in California have been associated with wildfire and forestry damages, not with urban & agricultural water uses
- Small water systems in rural areas are most at risk of public health and safety impacts
- Larger urban water agencies can manage multi-year drought with minimal impacts to customers

Expected Impacts of Multi-Year Drought

- **Unmanaged systems**
  - **Risk of catastrophic wildfire (health & safety, economic)**
  - **Non-irrigated agriculture (livestock grazing)**
  - **Fish & wildlife (e.g., salmonids)**
- **Managed systems**
  - **Small water systems (health & safety)**
  - **Irrigated agriculture**
  - **Green industry (urban water supplies)**
  - **Fish & wildlife (e.g., wildlife refuges, salmonids)**
  - **Other environmental (e.g., land subsidence)**

Droughts in the Holocene

Reconstructed Streamflows & Drought Periods



USING TREE-RINGS TO RECONSTRUCT STREAMFLOW

A tree-ring reconstruction is a set of tree-ring width data that have been calibrated with an instrumental or gaged record of a hydrologic or climatic variable such as annual streamflow or precipitation. The reconstruction, based on a statistical model that describes the relationship between tree growth and the gage record, extends that record back hundreds of years into the past.

Tree growth in dry climates is limited by water availability. Trees that provide the best information about hydroclimatic variability are those particularly sensitive to variations in moisture. These include species such as blue oak, ponderosa pine, Douglas fir, and western juniper, usually growing at lower elevations in sparse stands on dry and rocky sites where soil moisture storage is minimal.

Tree-ring reconstructions of hydroclimatic variables are developed from tree-ring chronologies. A tree-ring chronology is a time-series of annual values derived from the ring-width measurements of 10 or more trees of the same species at a single site. To create a tree-ring chronology, cores from the sampled trees at each site are cross-dated (i.e., patterns of narrow and wide rings are matched from tree to tree) to account for missing or false rings, so that every annual ring is absolutely dated to the correct year. Then all rings are measured to the nearest thousandth of a millimeter using a computer-assisted measuring device. After growth-related trends unrelated to climate are statistically removed, the ring width values from all sampled trees for each year are averaged to create a time series of annual ring width indices. The complete series of ring width indices from a site is called a tree-ring chronology.

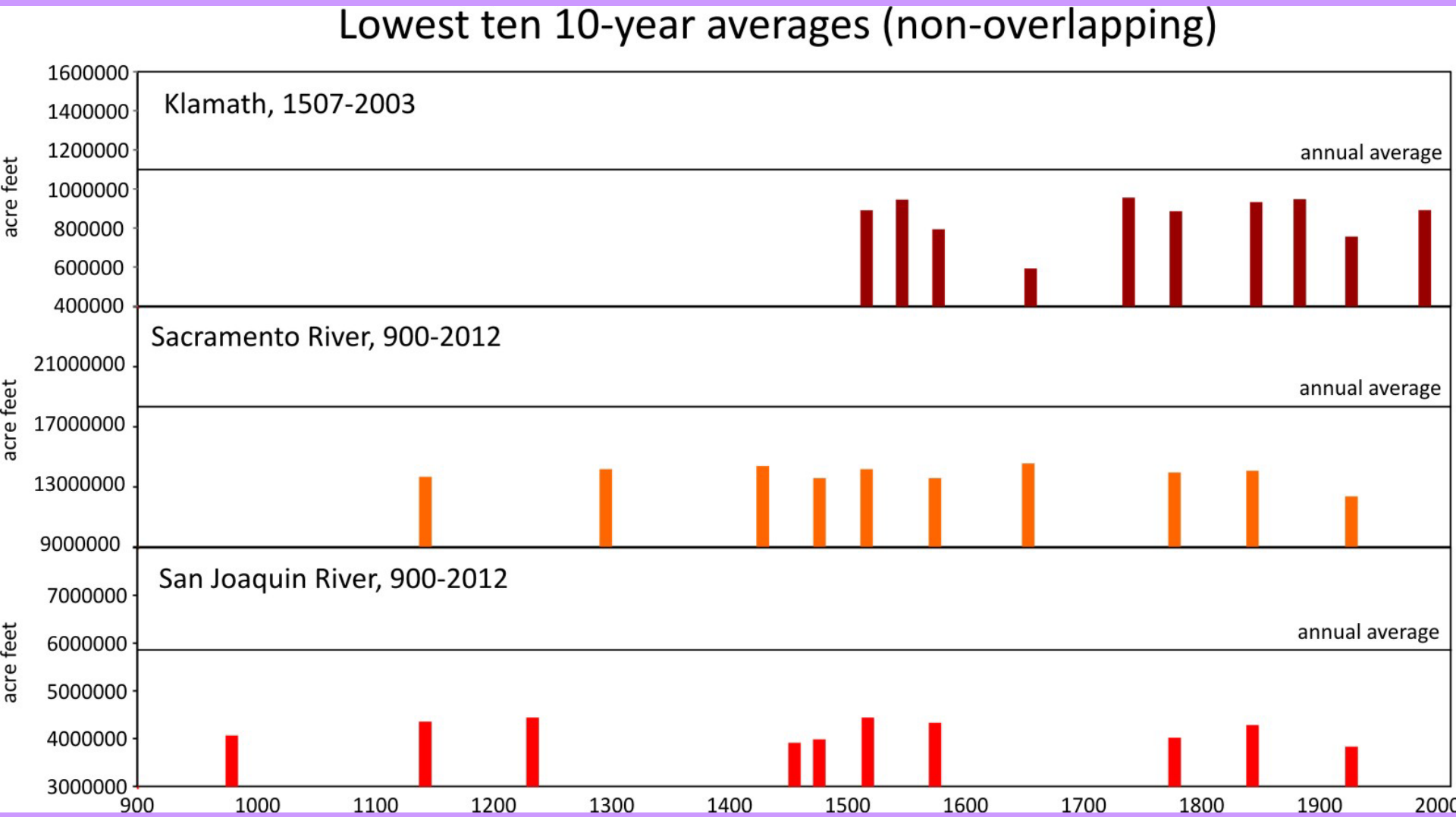
Once a gaged record of interest is selected for reconstruction, a set of tree-ring chronologies from the region near the gage is calibrated with the gage record to form a reconstruction model. A statistical technique called multiple linear regression is commonly used. The reconstruction is evaluated by comparing the observed gage values with the reconstructed values by assessing the amount of variance in the gage record that is explained by the reconstruction.

DROUGHTS PRIOR TO THE HISTORICAL RECORD

The period of reliably measured streamflows for rivers throughout the West seldom reaches beyond 100 years, which represents only a fraction of climatologically modern time. As these streamflow reconstructions show, there have been droughts prior to the historical period that were more severe – particularly in duration – than those in the measured record. The reconstructed record captures a broader range of hydrologic variability than does the historical record, making reconstructions useful for drought preparedness planning. Of particular interest from a scientific perspective is the Medieval Climate Anomaly, a time during which sustained severe drought gripped much of the western United States, as exemplified illustrated in the Sacramento, San Joaquin, and Colorado River reconstructions.

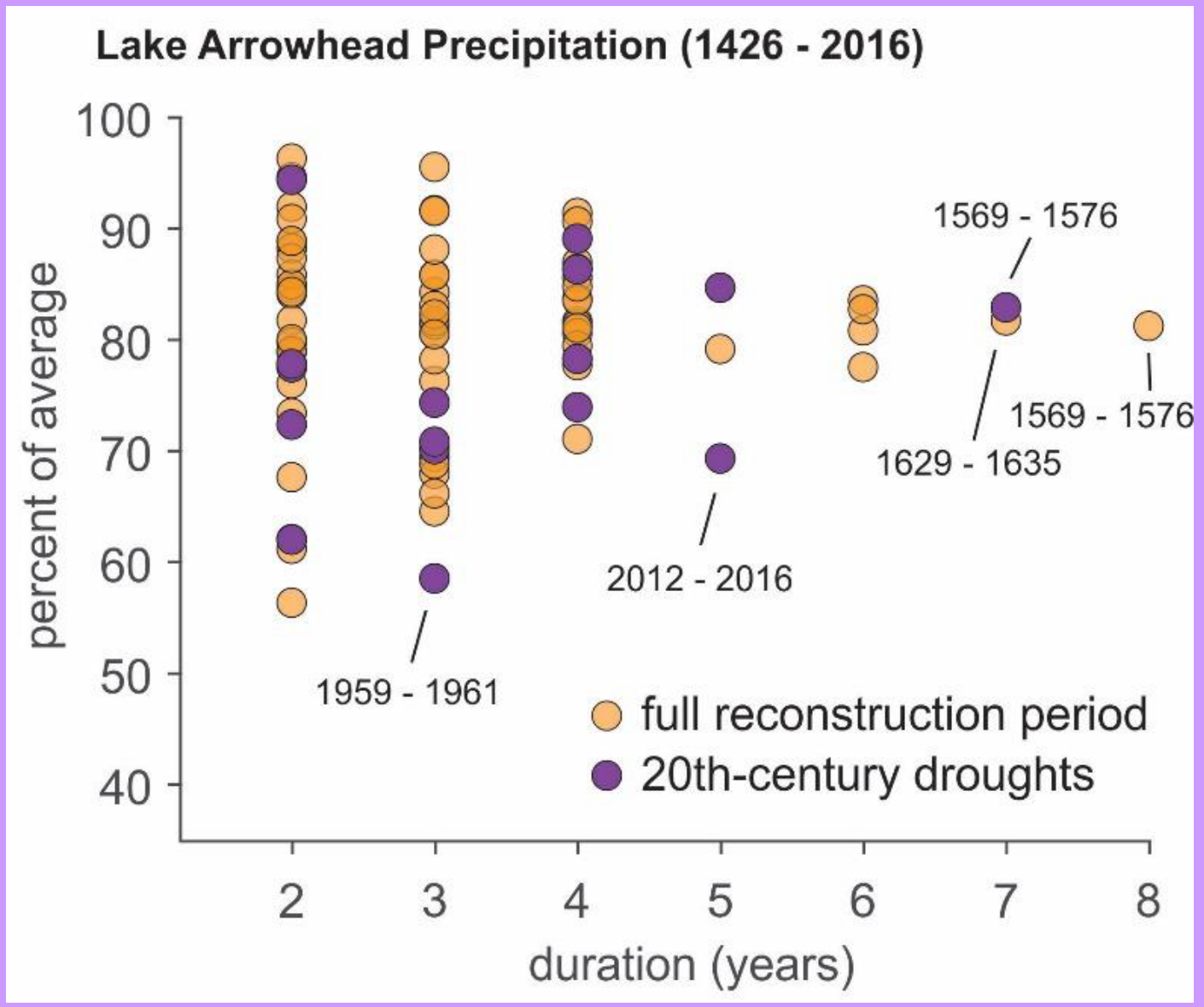
Data source: Work performed by the University of Arizona under contract to the California Department of Water Resources. CDWR Agreements 4600003882 (David Meko, 2006) and 4600008850 (David Meko, Connie Woodhouse, Ramzi Touchan, 2014)

Droughts in Reconstructed Paleo Record



Courtesy of Connie Woodhouse, U of AZ

Understanding Southern California Drought Risk



Courtesy of University of Arizona

California's 20th & 21st Century Statewide Droughts

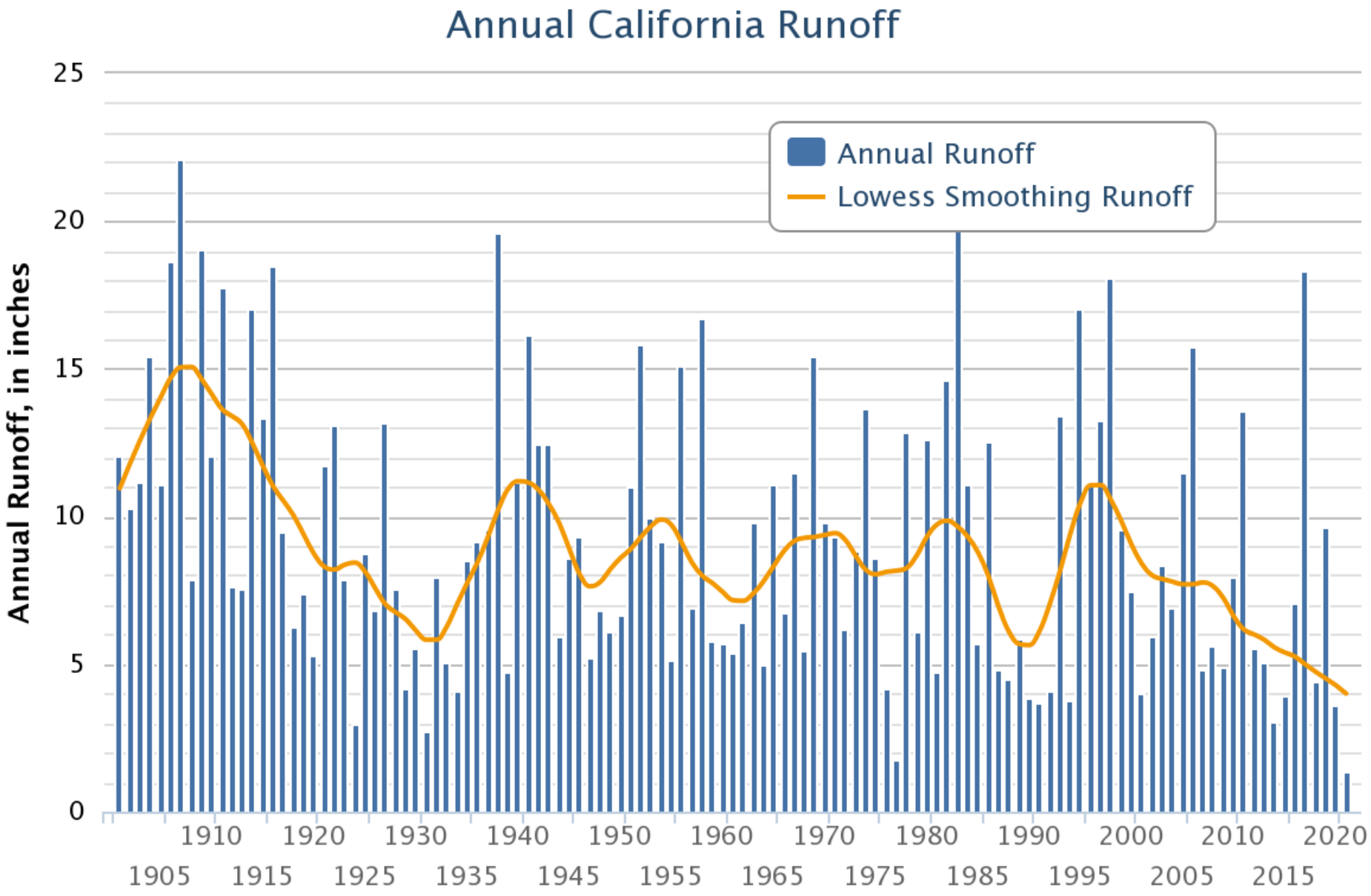
- 1918-20
- 1922-24
- 1929-34
- 1947-50
- 1959-61
- 1976-77
- 1987-92
- 2007-09
- 2012-2016
- 2020- ??

Driest 4 Consecutive Water Years Based on Statewide Precipitation

Year	4-Year Total, inches
2012-2015	62.2
1917-1920	63.1
1923-1926	63.3
1928-1931	64.5
1931-1934	65.1
1921-1924	65.7
1922-1925	65.9
1918-1921	66.8
1929-1932	67.3
1987-1990	67.3
1930-1933	68.0

WRCC data

USGS Calculated Statewide Runoff

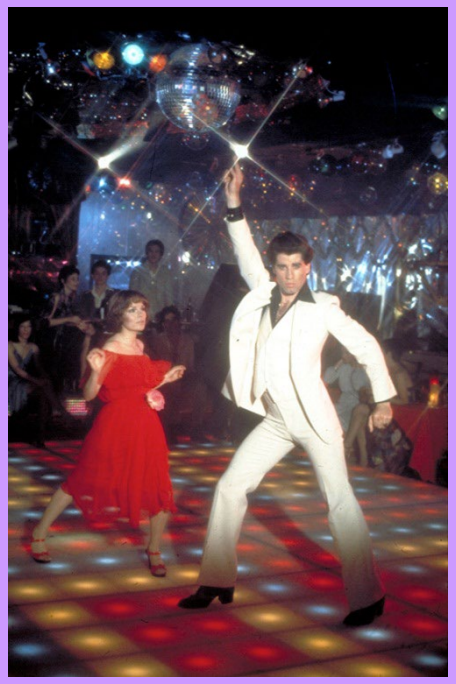


Remember the 1970s?

1976-77

- Delta salinity barriers
- Marin County emergency pipeline
- Statewide reservoir storage at 37% at end of WY 1977
- Bricks in toilet tanks
- Estimated 125,000 acres fallowed

Remember the 1980s?



1987-92

- Longest drought in near-modern times
- State population of 30 million in 1990
- Single driest year – 1991 – was 5th driest on record
- Delta conditions: D-1485, no ESA biological opinions until 1992
- CVP & SWP cutbacks in 1991 & 1992

1987-92

- Santa Barbara emergency pipeline & desalter
- Widespread small water system problems
- About 500,000 acres fallowed
- First state drought water bank
- Water rights legislation regarding conservation & water transfers

How About the 2000s?

2007-09

- Surplus water no longer available from Colorado River
- Delta: D-1641, new Biological Opinion in 2008
- CVPIA provisions in effect
- First-ever statewide proclamation of drought emergency
- Agricultural impacts in San Joaquin Valley: combined effects of drought + recession
- About 500,000 acres fallowed
- Small water system problems

And the 2010s?

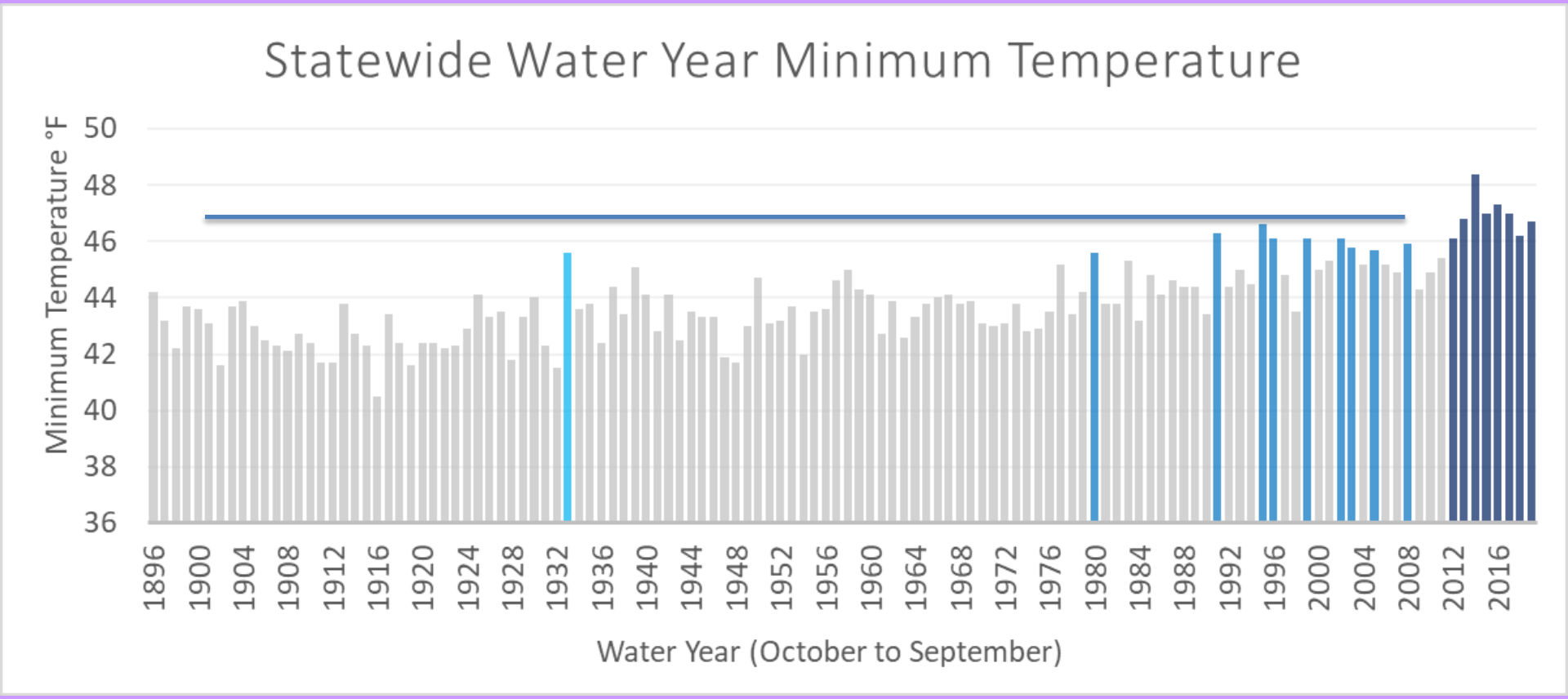
2012-16

- Included warmest years on record, record low statewide snowpack
- State response actions not seen since 1976-77
- First-ever zero CVP ag contractor allocations
- About 500,000 acres fallowed
- First-ever state emergency response for areas of dry private residential wells
- First-ever use of InSAR to monitor statewide land subsidence

2020 - ??

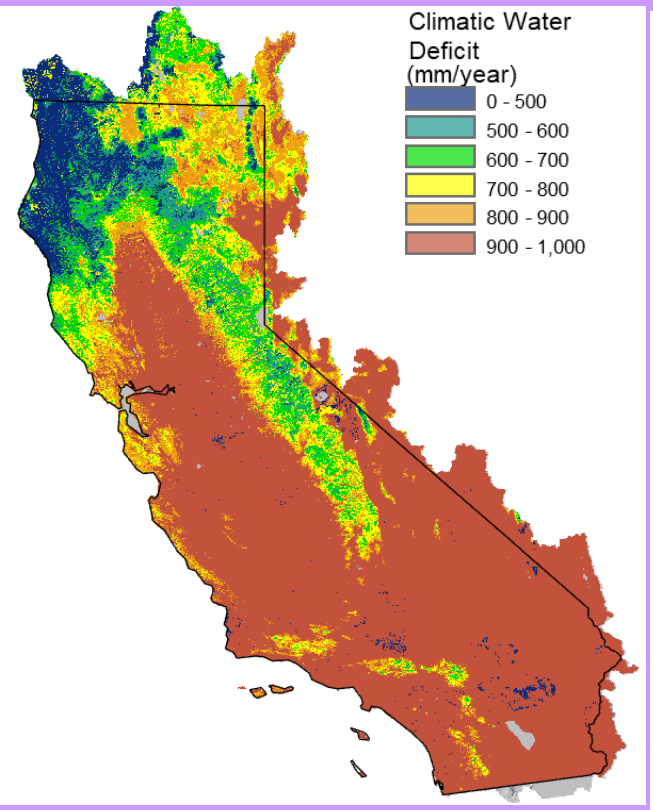
- Zero allocation to most CVP ag contractors in WY 2021, 5% SWP allocation
- Record low Lake Oroville elevation, Hyatt PP unable to generate
- 70% statewide snowpack in WY 2021, yet runoff comparable to 2014-2015
- Groundwater impacts similar to San Joaquin Valley in 2012-16 now seen in parts of Sacramento Valley

Things Are Changing in 21st Century

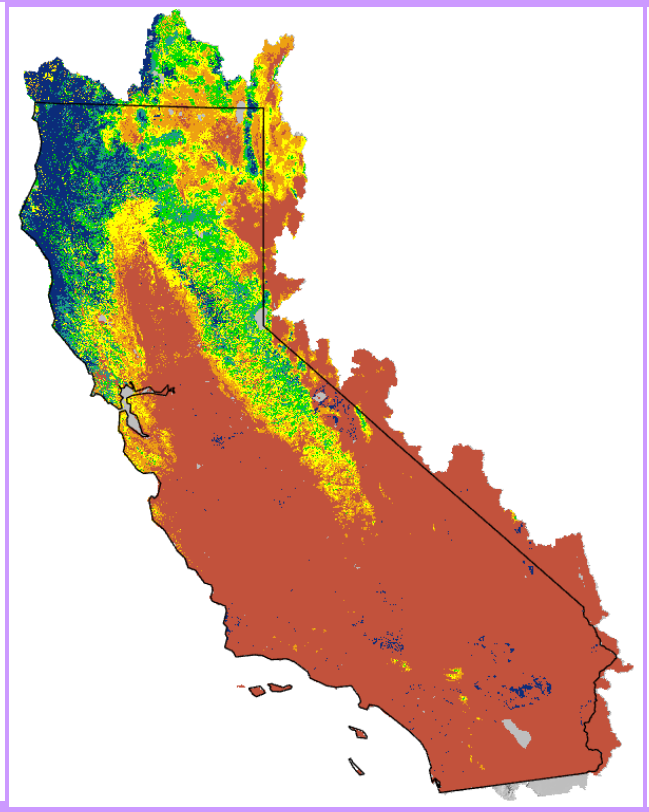


Climatic Water Deficit, USGS Basin Model

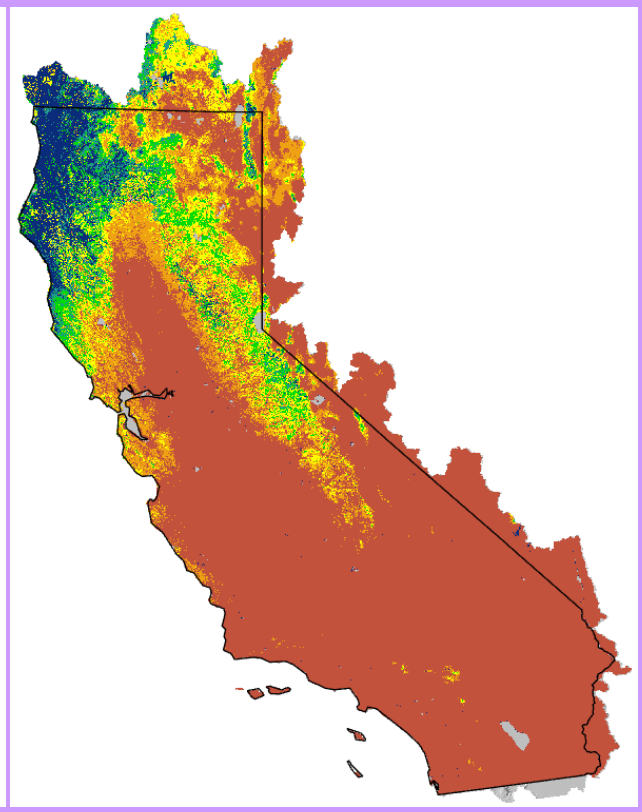
1977
a year with no water



2014
a hot year with no water



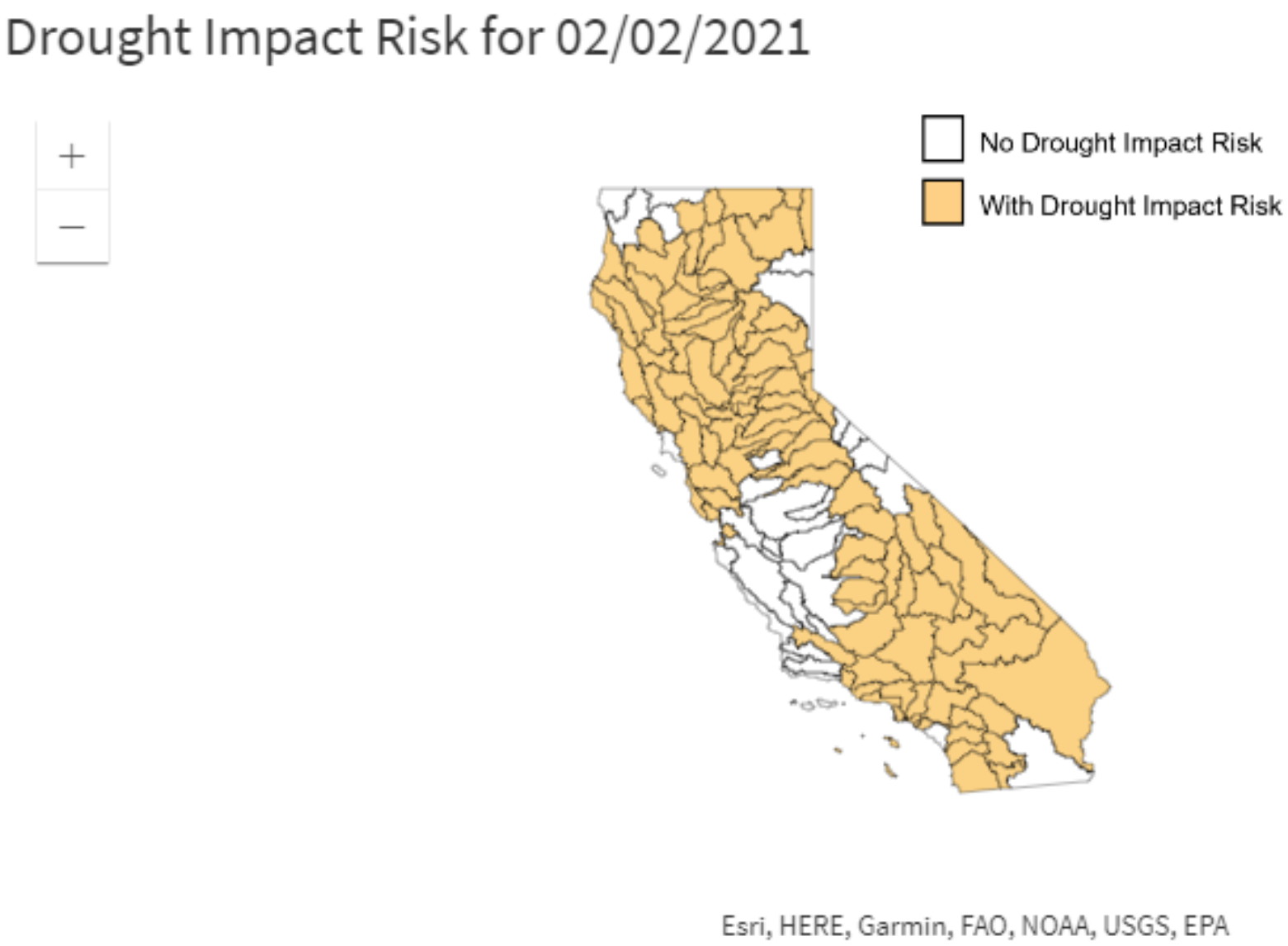
2021
a hotter year with no water



Slide courtesy of Lorrie Flint, USGS

One Year Ago – WY 2021 Was Extreme

Watersheds w/ 70% or less of average precipitation AND 80th percentile temperature



Catastrophic Wildfire Risk

- 1991 Oakland Hills fire (25 lives lost)
- October – November 2003 Southern California wildfires (22 lives lost)
- October 2007 Southern California wildfires (1 million people evacuated)
- 2017 Tubbs Fire, 2018 Camp Fire, 2021 Dixie Fire (urban water distribution system destruction)
- All but 2 of the state's 20 largest & 20 most damaging fires have occurred from 2000 onward

What's Old is New Again

Old

- Multi-year drought in reconstructed & historical records
- Severely reduced CVP & SWP allocations
- Groundwater overdraft & land subsidence

New

- Droughts occur in warming climate
- First-ever Lower Colorado River Basin shortage declared (although CA not cut)
- Early stages of SGMA implementation

Lessons Learned from Recent Droughts

- Act sooner when dry conditions emerge
- Recognize that increased temperatures are creating new or intensified impacts (e.g. wildfire)
- Transition from thinking of drought as an occasional emergency to thinking in terms of creating resiliency in a more arid climate