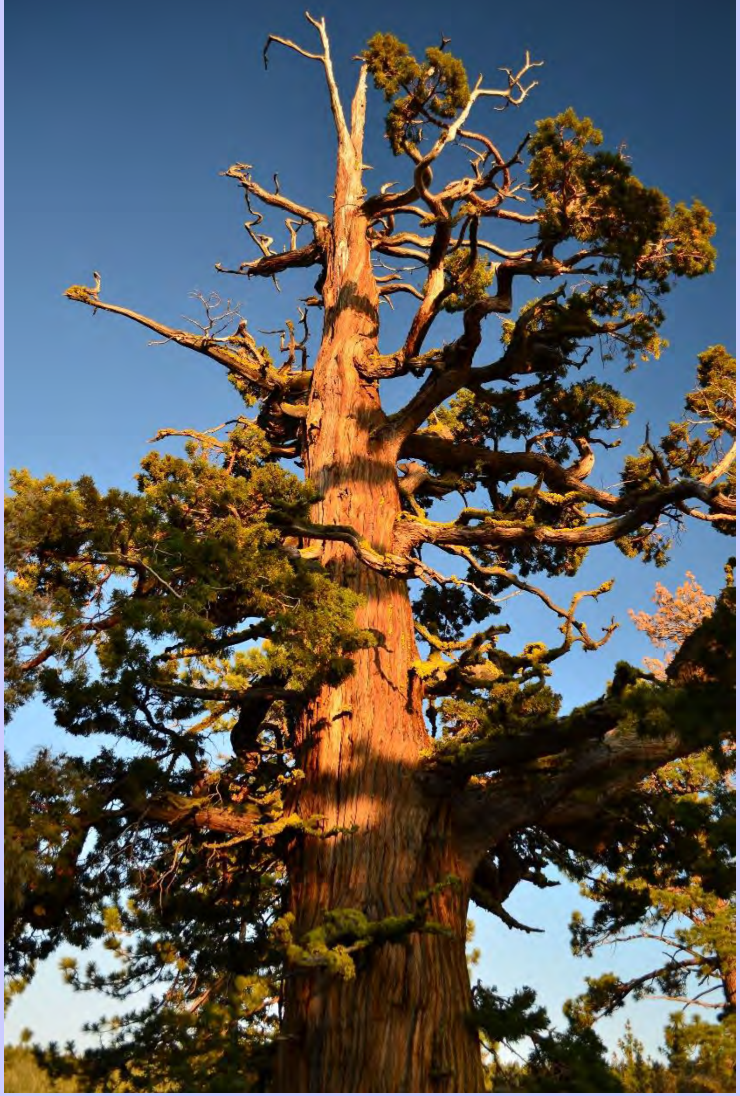
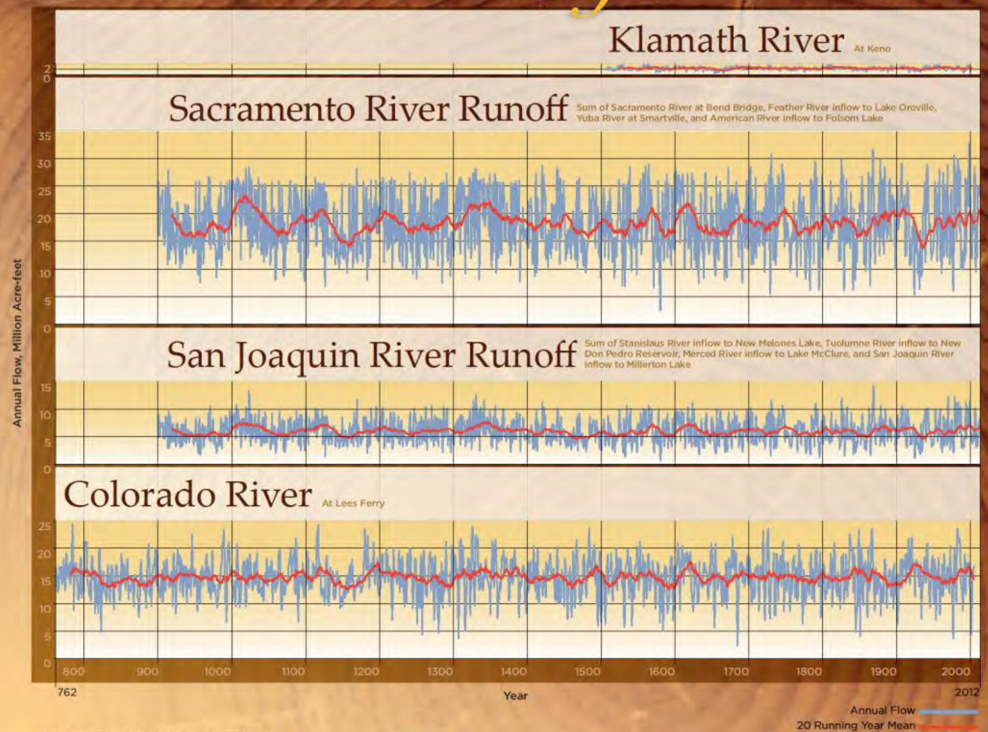


Assessing Drought Risk in California

(Can Trees Help?)

Jeanine Jones, Department of Water Resources

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

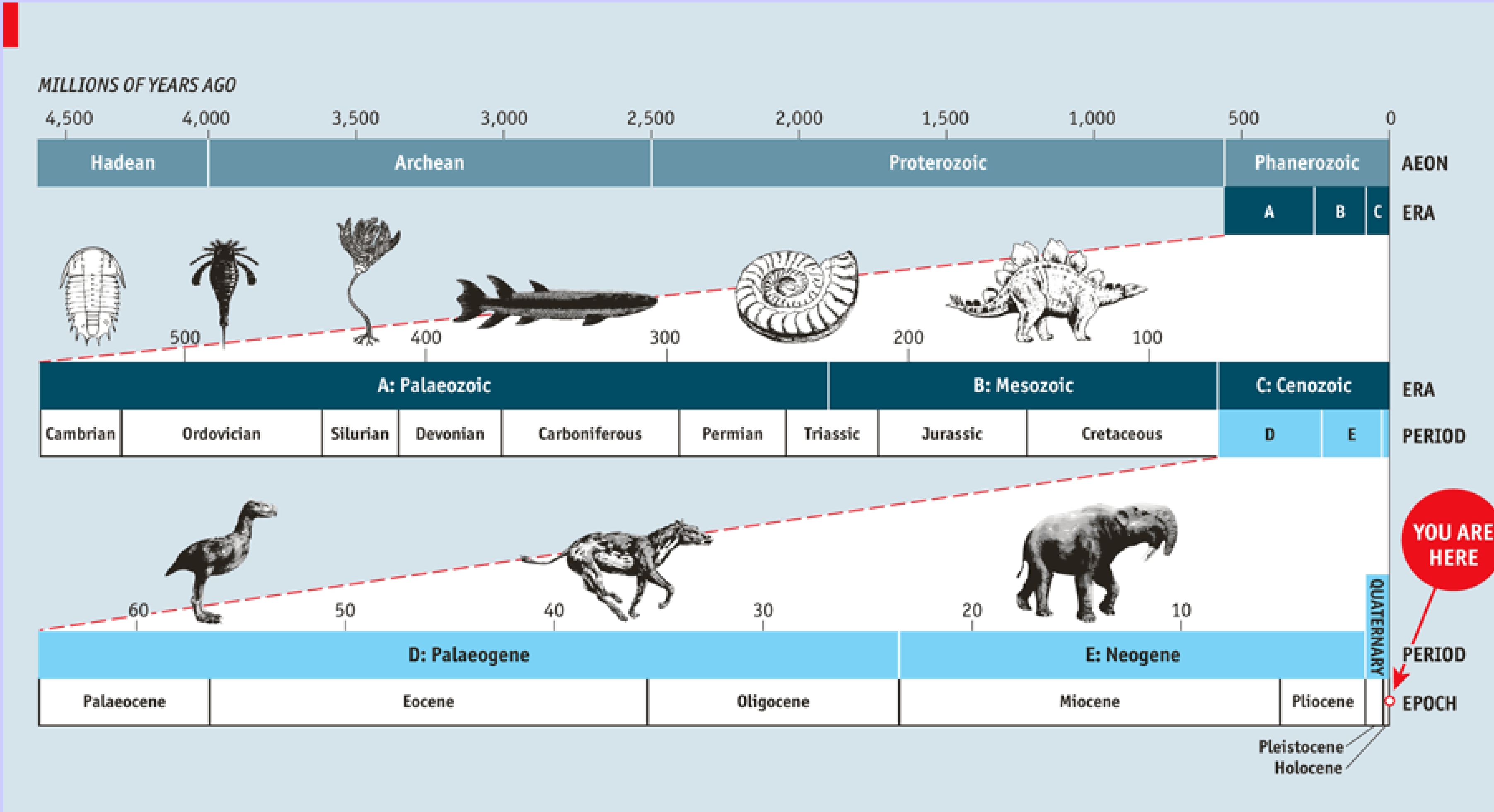
The period of reliably measured streamflows for rivers throughout the West seldom reaches beyond 100 years, which represents only a fraction of climatologically modern time. As these streamflow reconstructions show, there have been droughts prior to the historical period that were more severe – particularly 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)

S.T. Harding & the 1930s Drought

- Early recognition of California paleodroughts much greater than droughts in historical record, based on submerged tree stumps in Lake Tahoe

National Geographic Photo



Source: The Economist

How long a drought should we plan for?

(We are sampling an infinitesimal part of a very small part of a much longer climate record!)

How much risk are you willing to take?

How vulnerable is your system?

How much reliability can you afford?

Points to Keep in Mind About Drought

- Droughts/dry years are a normal part of the hydrologic cycle
- Drought conditions develop slowly; drought by itself is not an emergency – drought impacts drive action
- Drought impacts are site-specific and sector-specific
- Impacts increase with drought duration
- Drought vulnerability can change over time
- The greatest economic impacts of drought in California have been associated with wildfire and forestry damages, not with urban & agricultural water uses

CA UWMP Statutory Requirements

- Urban Water Management Plans (UWMPs), agencies serving > 3,000 AF annually, or 3,000 customers, prepare & update every 5 years
- Apply to 400+ systems
- Water shortage contingency analysis of:
  - Staged response actions to be taken by water supplier for shortages up to 50% reduction in supply
  - Specific water supply conditions associated with each stage
- Actions to prepare for/respond to a catastrophic interruption of water supplies
- Historically, 3-year drought planning requirement, changed in 2018 to 5-year drought

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

*Defined as consecutive dry years at statewide spatial scale

Driest 4 Consecutive Water Years Based on Statewide Precipitation

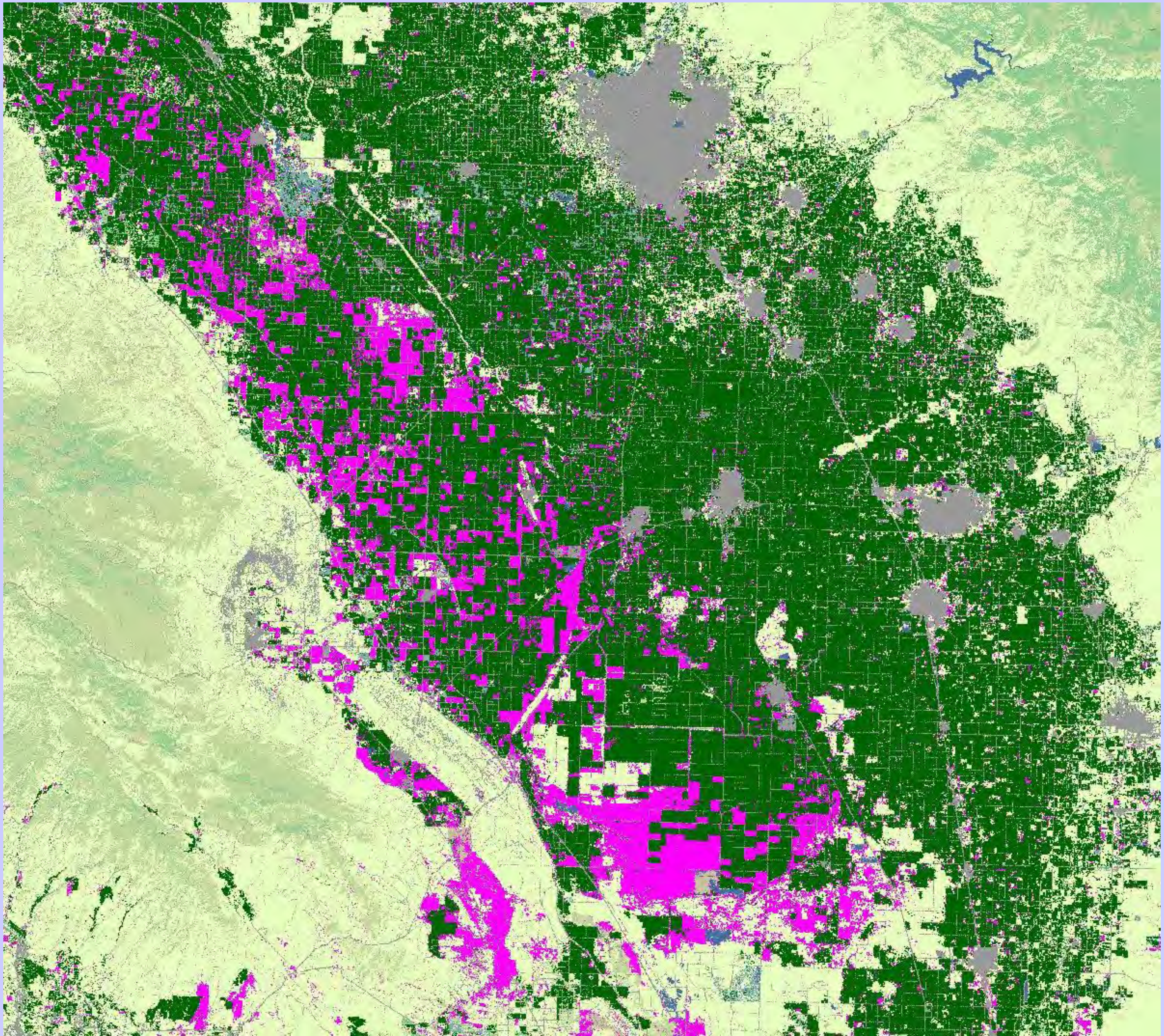
Year	4-Year Total, inches
2012-2015	62.2
1917-1920	63.1
1923-1926	63.3
1928-1931	64.5
1931-1934	65.1
1921-1924	65.7
1922-1925	65.9
1918-1921	66.8
1929-1932	67.3
1987-1990	67.3
1930-1933	68.0

WRCC data

Expected Impacts of Multi-Year Drought – Lessons Learned

- **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)

USDA NASS Cropland Data Layer – San Joaquin Valley Idled Acreage, 2009 Drought



Vulnerability Factors for Public Water Systems

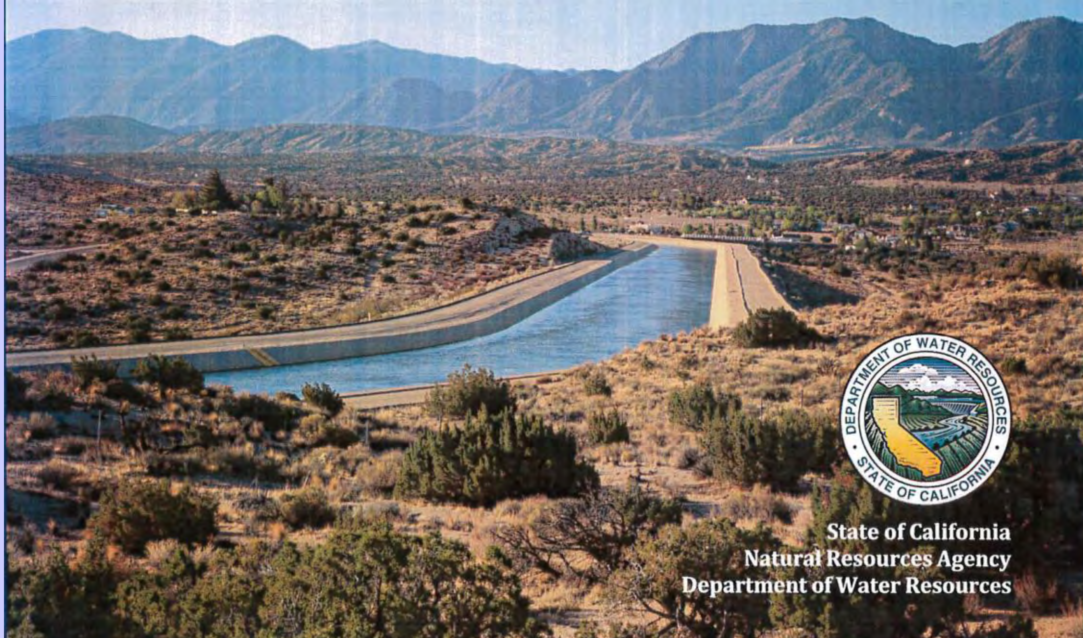
- Fractured rock groundwater
- Fewer connections (small systems)
- Single source (e.g., groundwater)
- Limited storage capacity
- No interconnections
- Rural location
- Wildfire risk area

Drought Preparedness Basics

- Vulnerability assessment
- Monitoring
- Planning
  - Safe Drinking Water Act emergency plan (public water systems)
  - Urban Water Management Plans
  - Long-term planning (capital improvement plans)
- Response

The State Water Project
Draft Delivery Capability Report 2017

December 2017



State of California
Natural Resources Agency
Department of Water Resources

RECLAMATION

Managing Water in the West

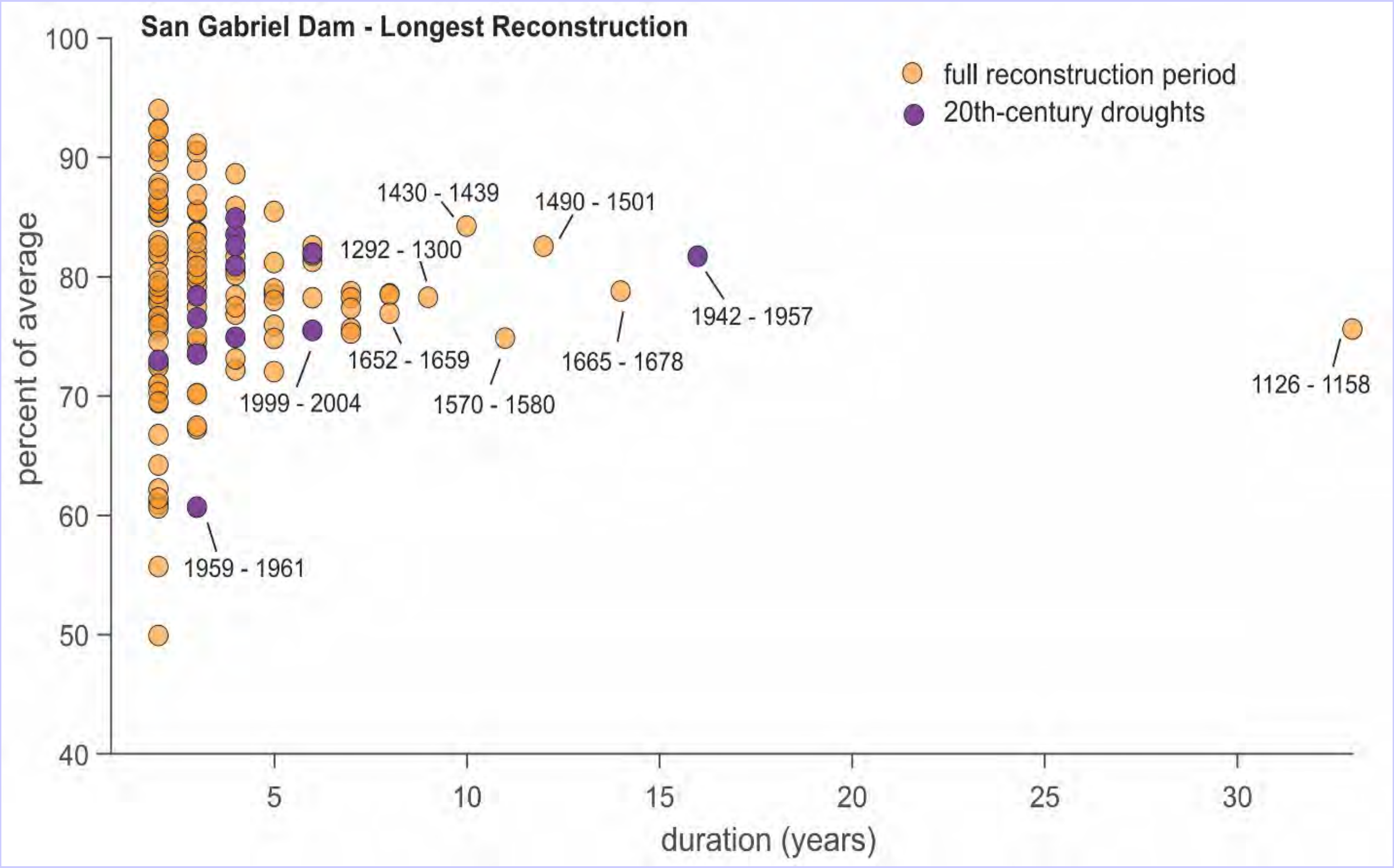
Colorado River Basin Water Supply and Demand Study

Executive Summary

U.S. Department of the Interior
Bureau of Reclamation

December 2012

Drought Risk for Local Supplies



Courtesy of University of Arizona

Planning for Drought Duration – It's the Low-Hanging Fruit!