Reconstructions of Past Streamflow from Tree Rings: Placing the Gage Record in a Long-Term Context

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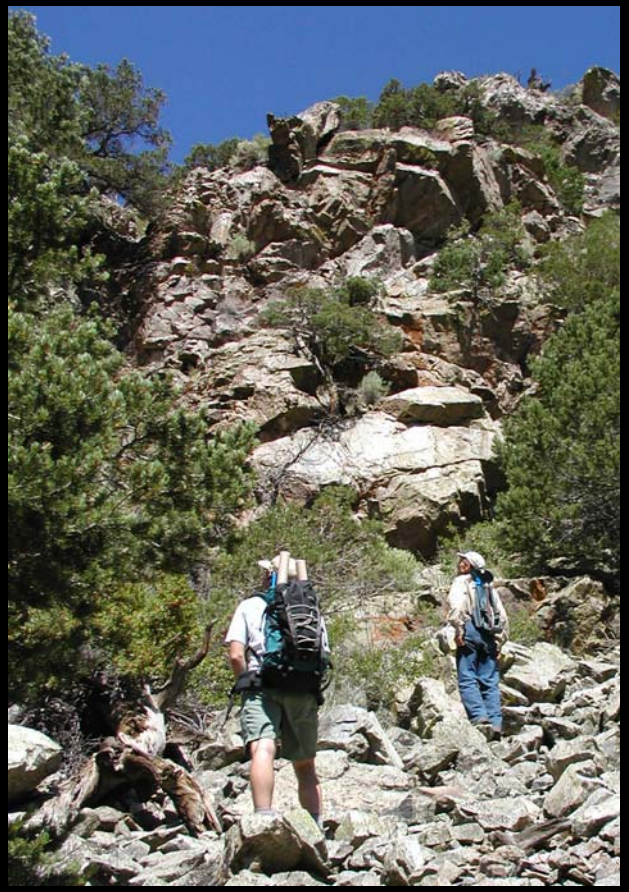
Photo: B. O'Dowd, from http://www.fs.fed.us/r2/sanjuan/

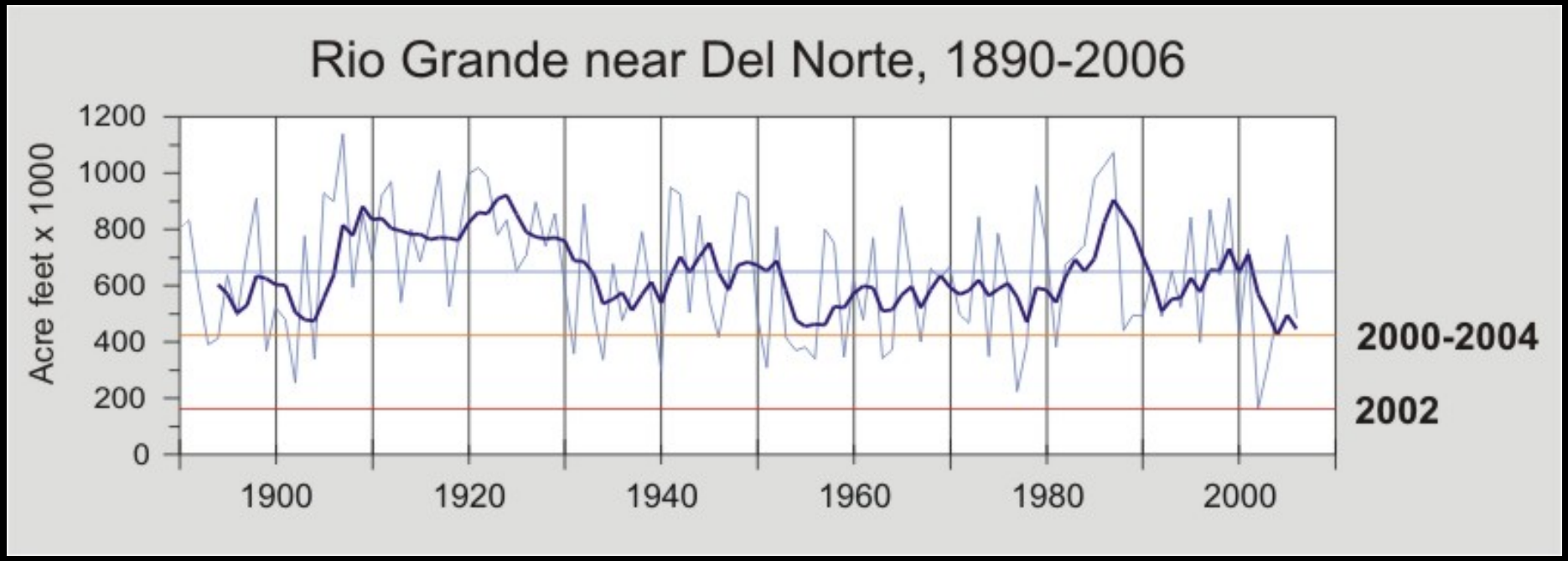
Photo: Big Bend NP

Overview

- Why consider climate and hydrology of the past?
- How tree rings provide information on past streamflow
- What tree rings say about hydrologic variability over past centuries
- Is the past relevant to the future?



Rio Grande Streamflow, Gage Record in Water Years



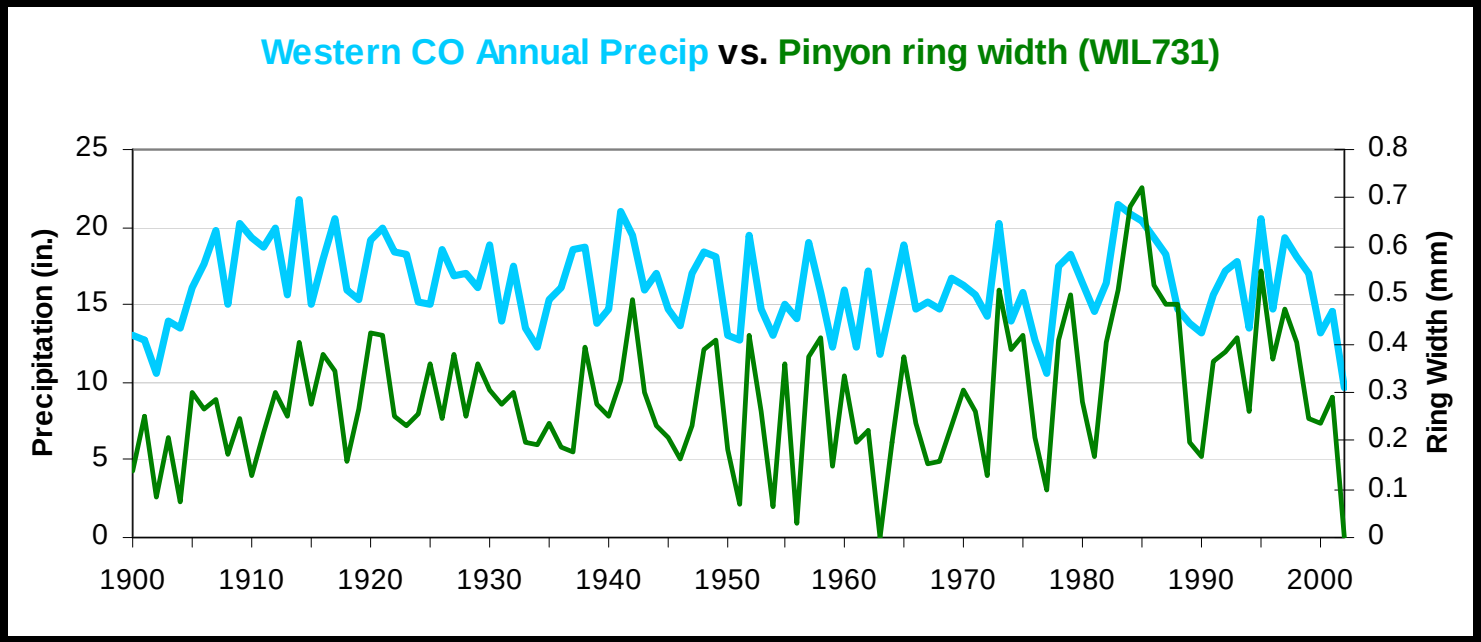
Lowest flow year, 2002

Lowest 5-year average, 2000-2004

Lowest 7-year average, 1950-1956 (2000-2006, 2nd lowest)

- **How often do periods of drought such as 2000-2004 occur?**
- **Have there been more severe droughts prior to the gage record?**

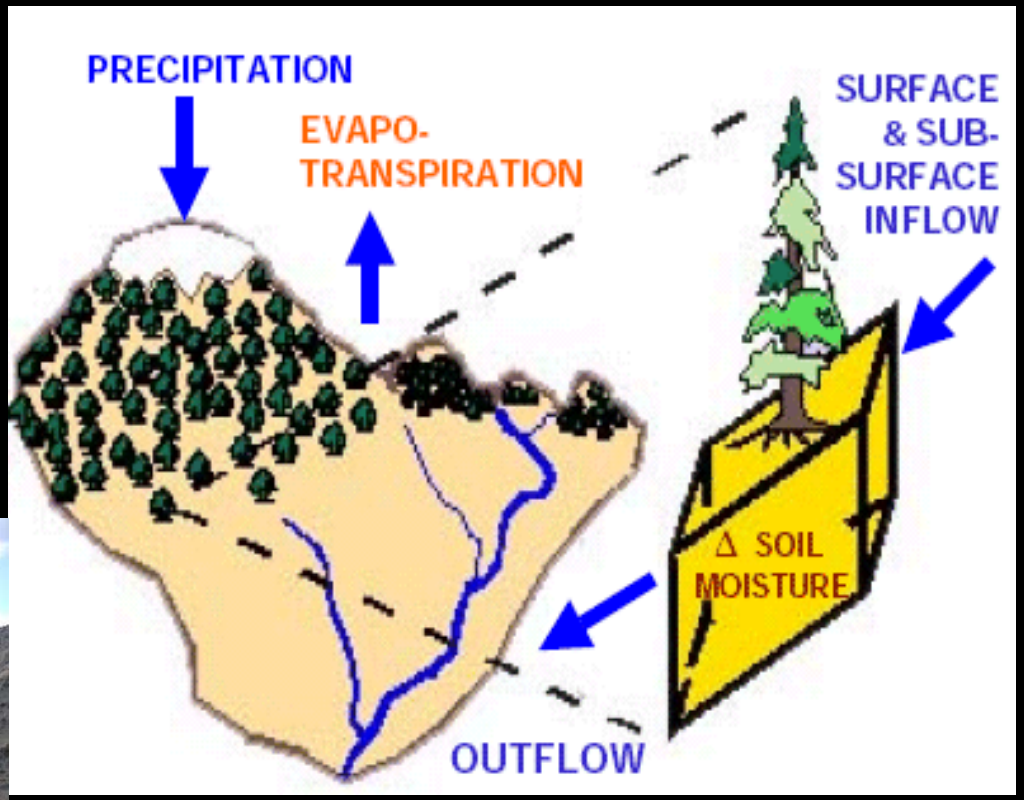
In the Southwestern U.S., moisture-stressed trees closely track variations in precipitation



Ring widths from a single tree near Grand Junction are plotted with annual precipitation in the Colorado River basin. (r = 0.69).

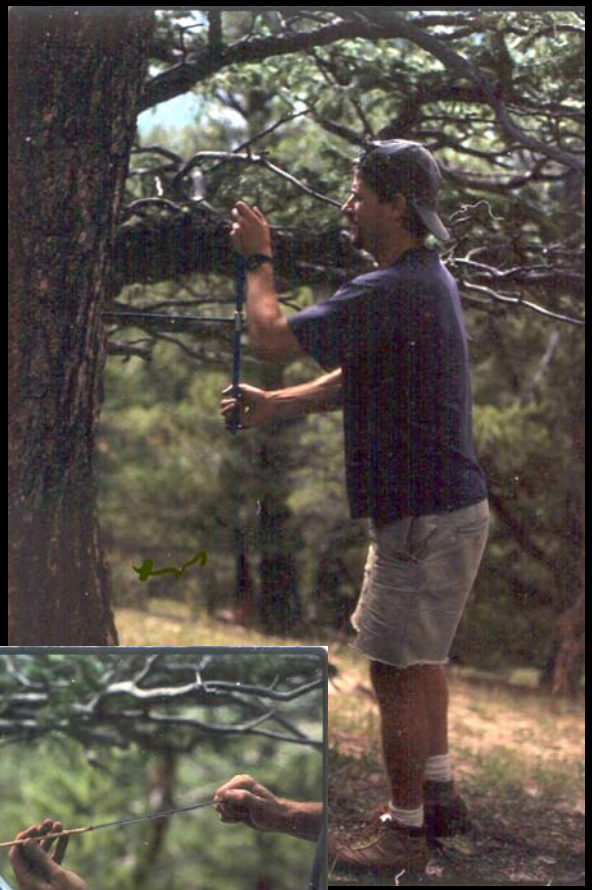
How is tree growth related to streamflow?

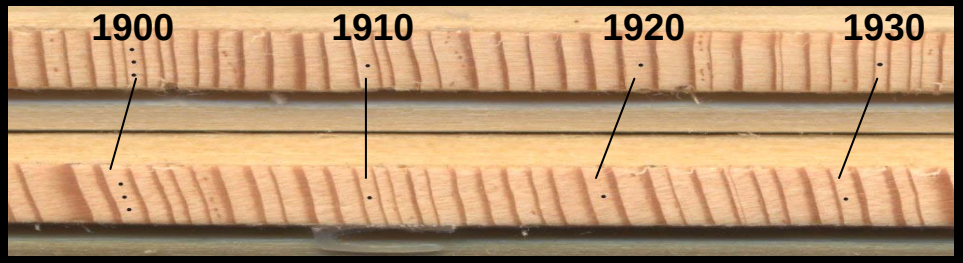
Ring widths and streamflow both integrate the effects of precipitation and evapotranspiration, as mediated by the soil, over the course of the water year.



How do we sample trees to get climate information?

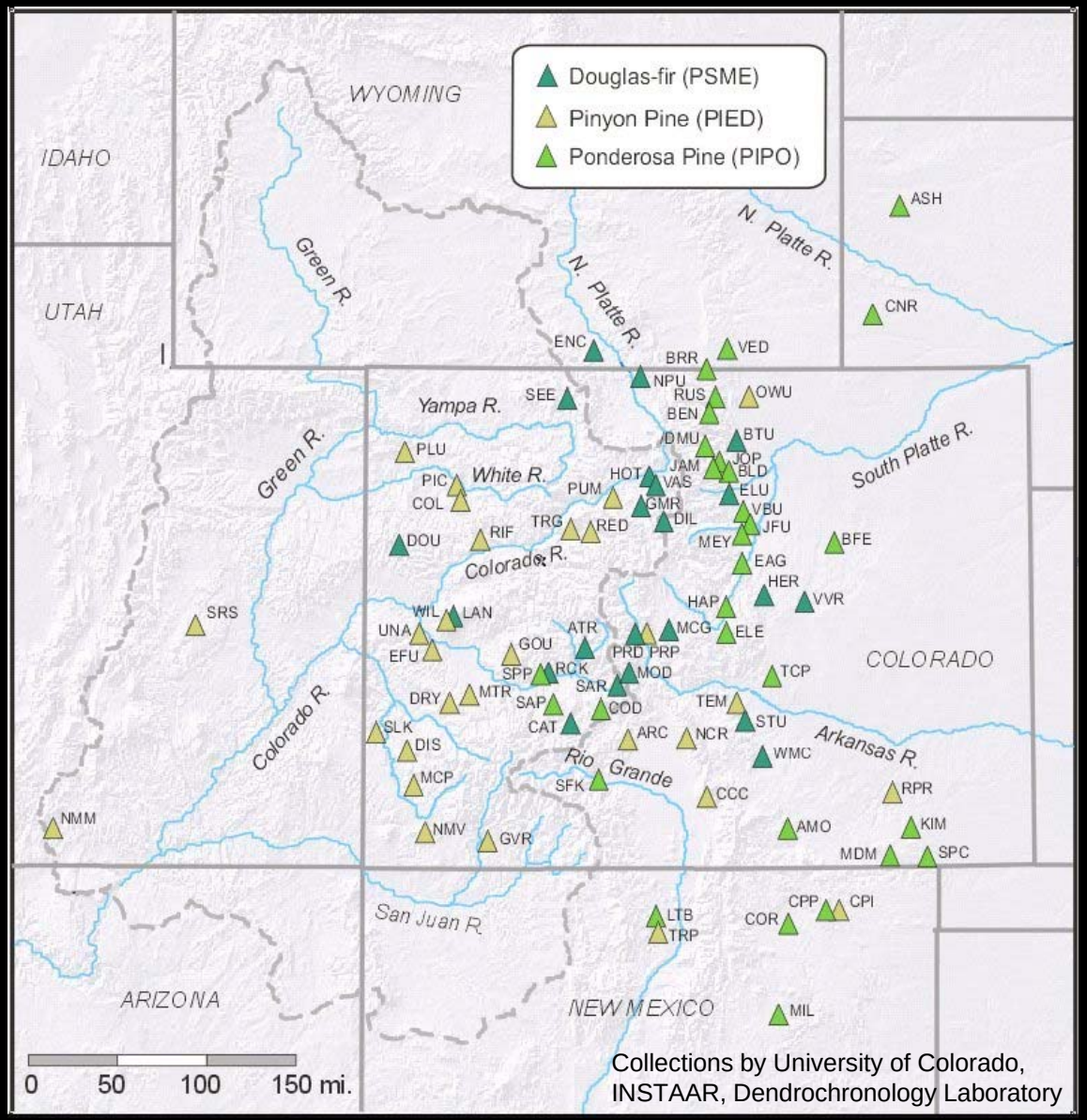
An increment borer is used to sample cores from about 20 trees at a site



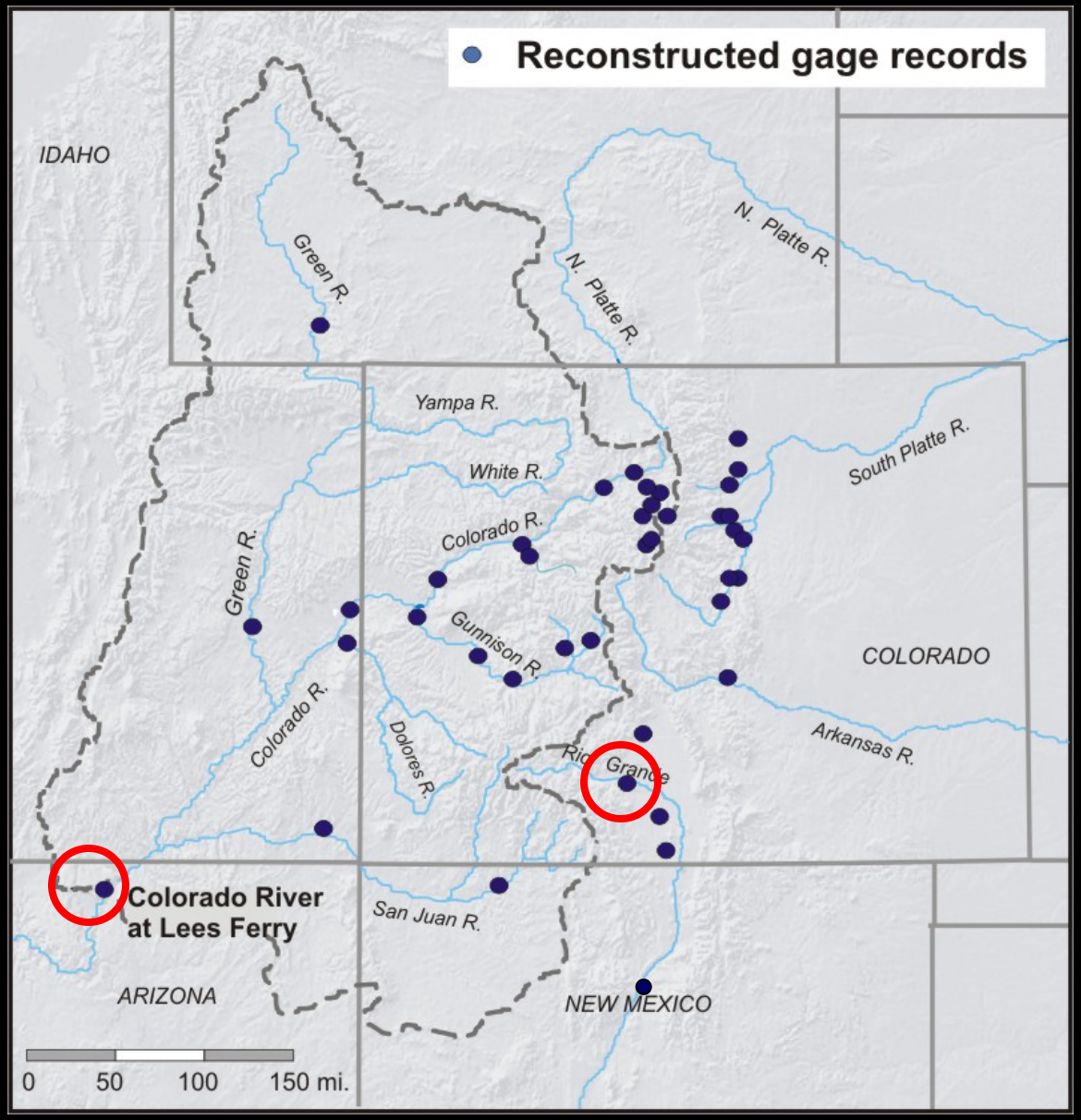


Cores mounted and sanded, then dated, measured, and averaged into site tree-ring chronologies

Locations of tree-ring chronologies in Colorado and vicinity, collected over the past decade

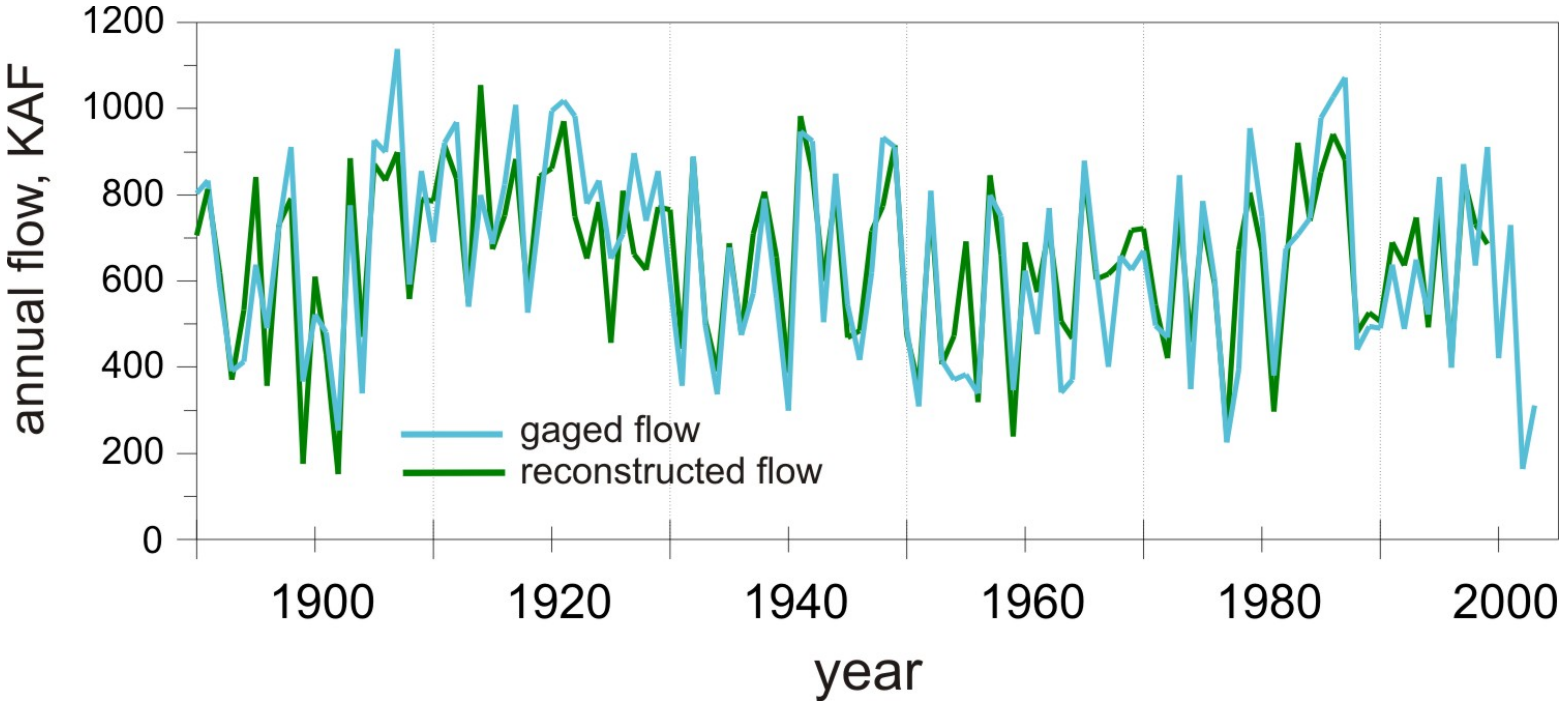


Collections by University of Colorado, INSTAAR, Dendrochronology Laboratory



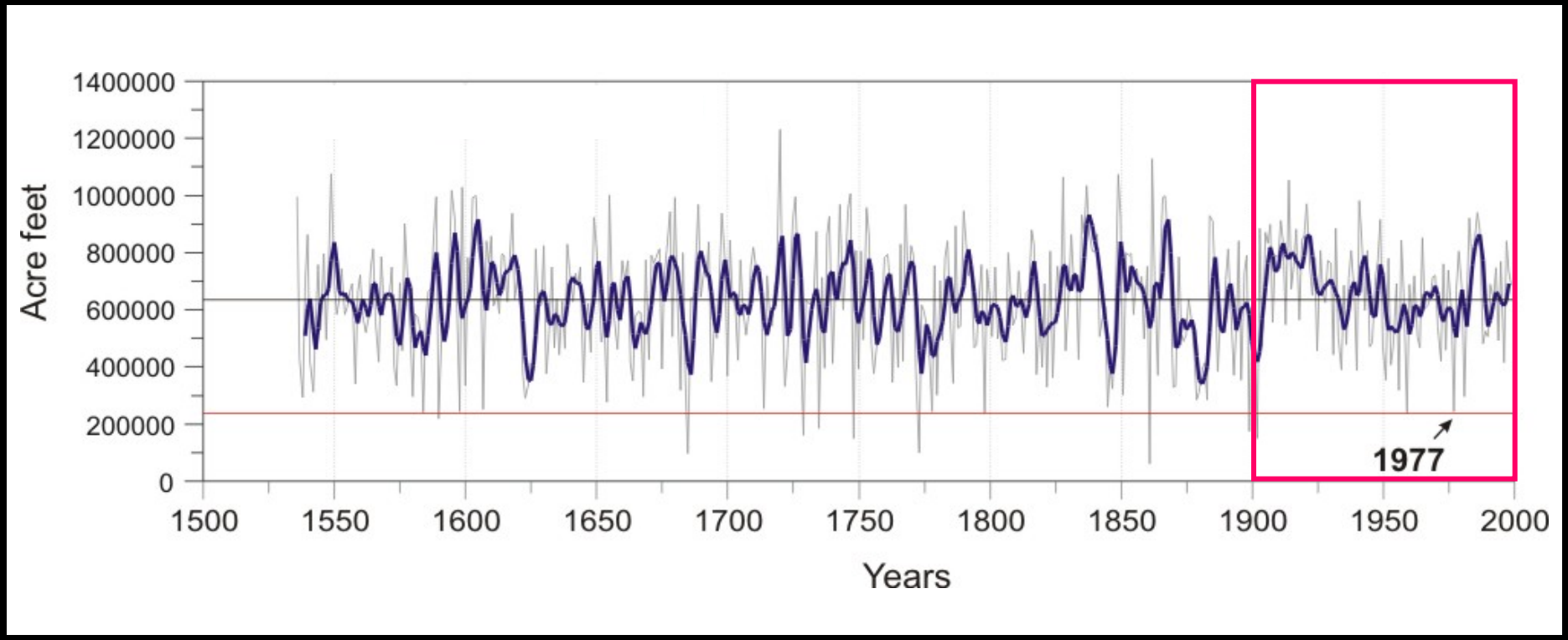
The network of tree-ring chronologies has been used to reconstruction a number of gages in watersheds that include the Colorado River and its tributaries, and the Rio Grande.

Rio Grande near Del Norte
Gaged vs Reconstructed Flows, 1890-1997



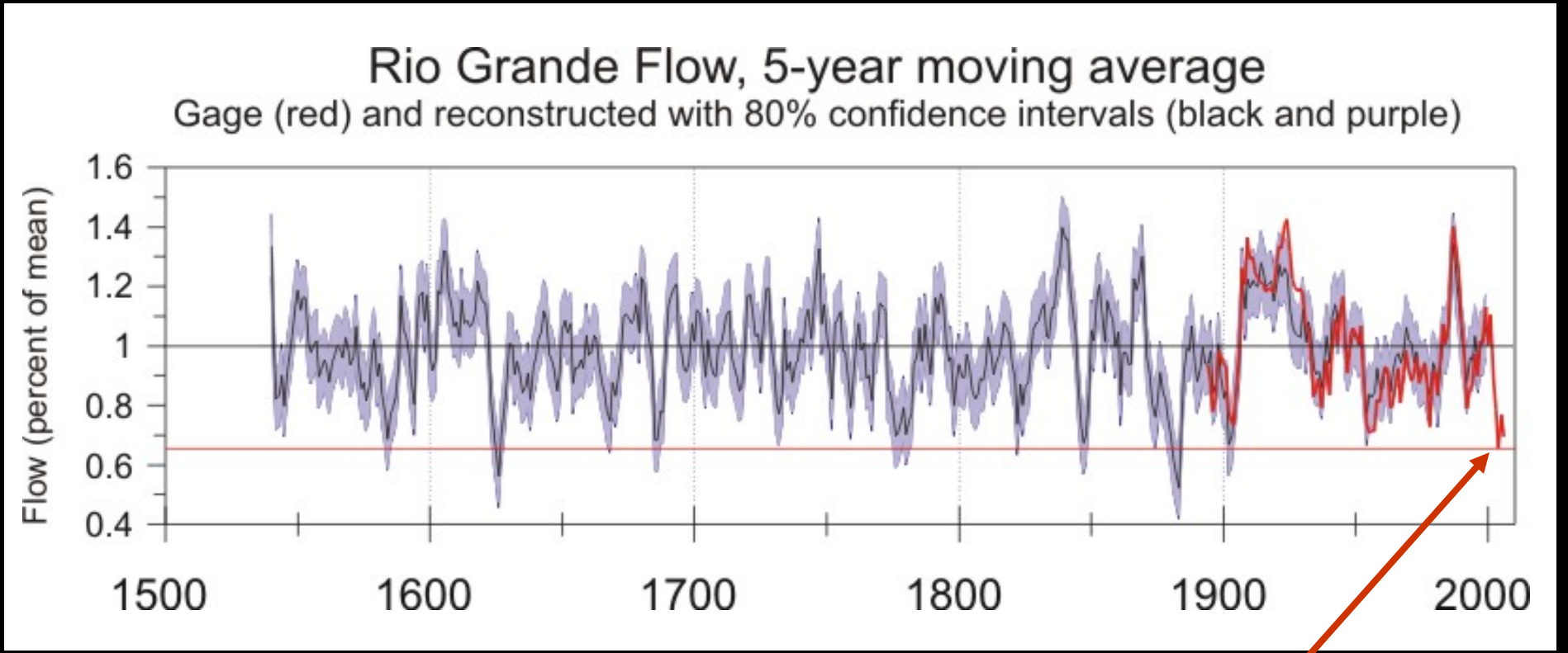
75.5% of the variance in the Rio Grande gage record is explained by the reconstruction. About 25% of the variance is unexplained, representing the uncertainty in the reconstruction model.

Rio Grande Annual Streamflow Reconstruction 1536-1999

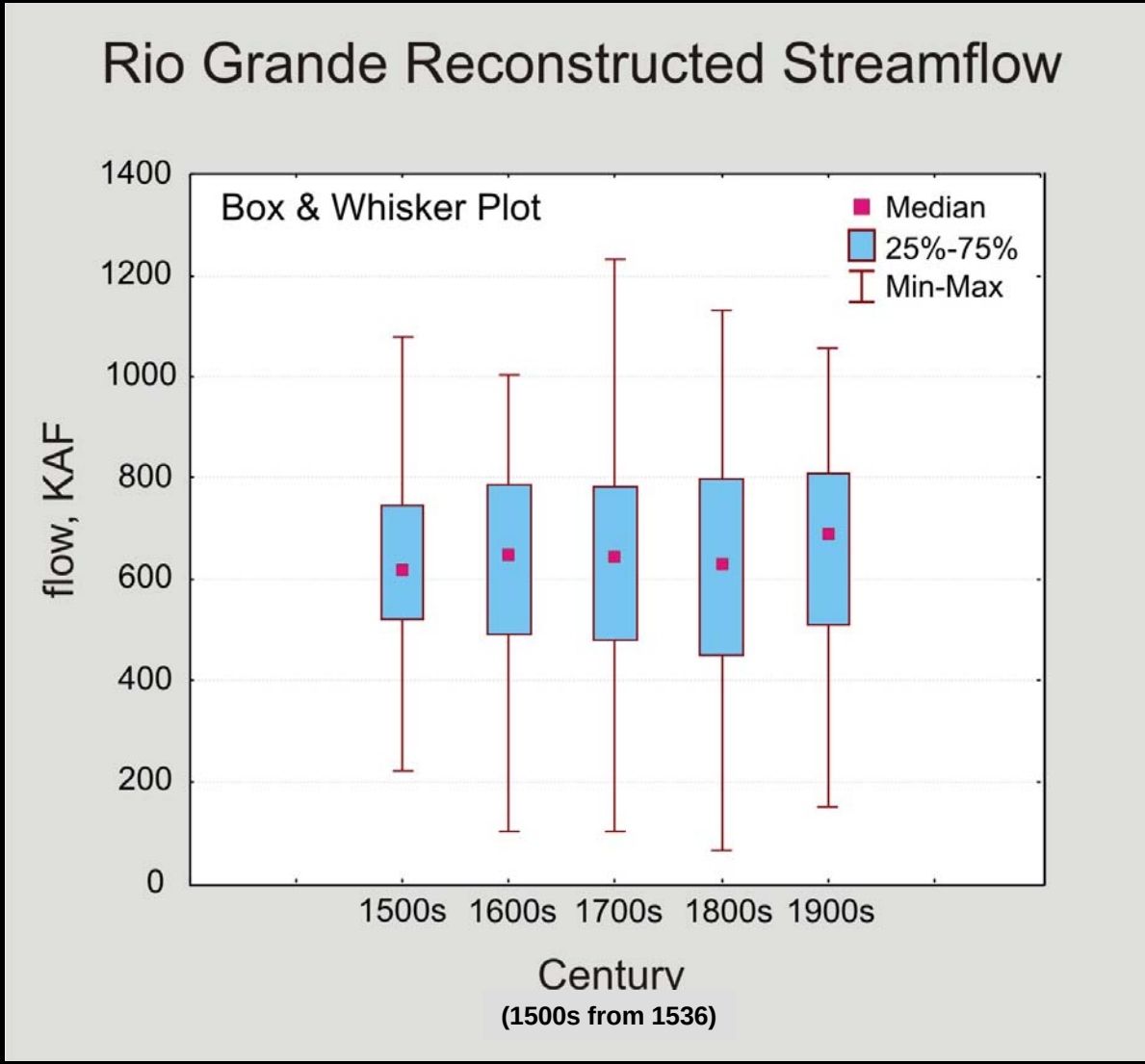


- How representative is the 20th century in the context of the past centuries?
- Have there been more severe droughts prior to the gage record?

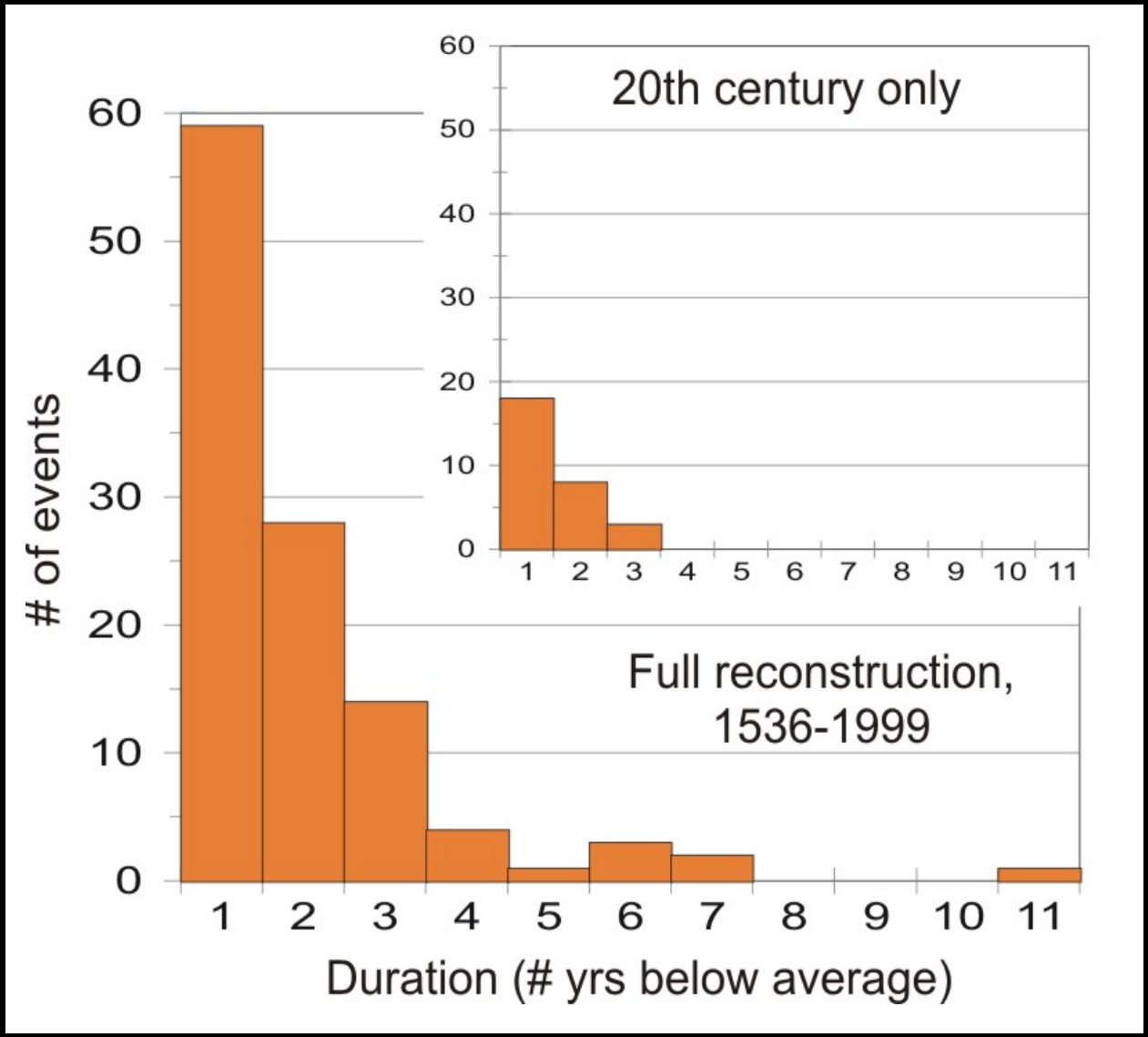
The 2000-2004 Drought in a Long-Term Context



Comparison of 20th century and full reconstruction

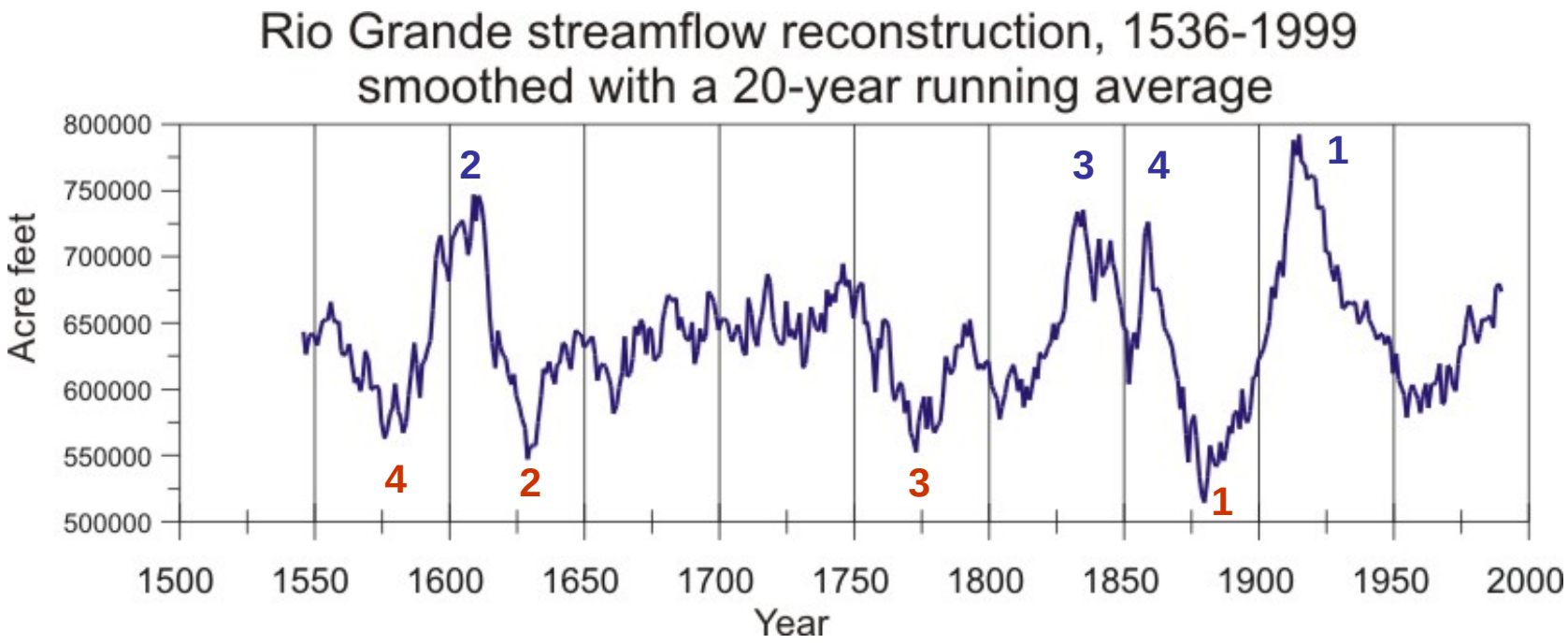


Reconstructed Rio Grande Streamflow, 1536-1999
Drought Frequency



Here, drought is defined as one or more consecutive years below long-term average.

20-year periods of wet and dry conditions



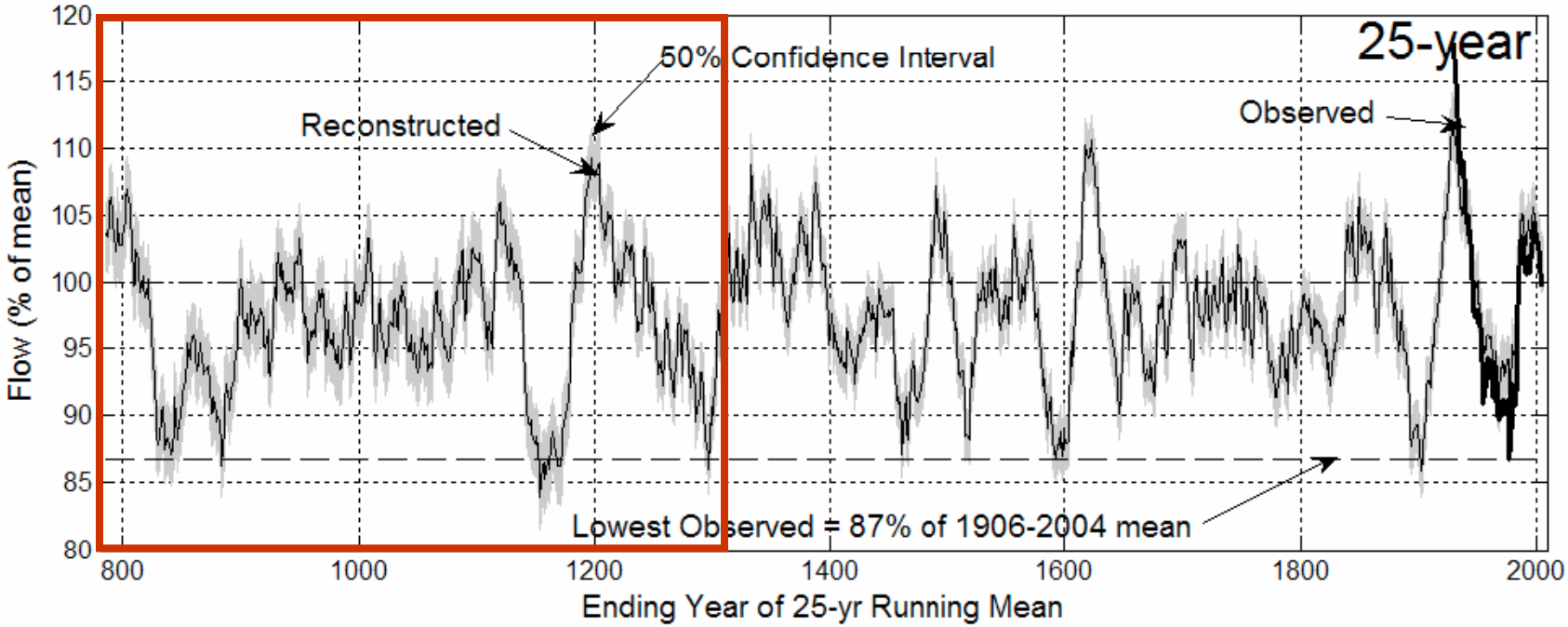
Wettest and driest non-overlapping 20-year averages

DRIEST	WETTEST
1870-1889	1905-1924
1619-1638	1599-1618
1763-1782	1825-1844
1566-1585	1849-1868

What about streamflow going further back in time?

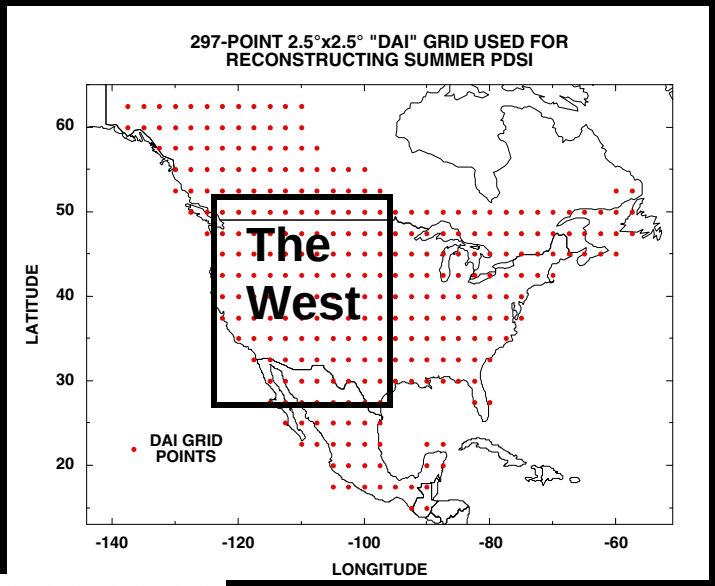
Stumps, logs, and remnants of wood can be used to extend living chronologies back in time.

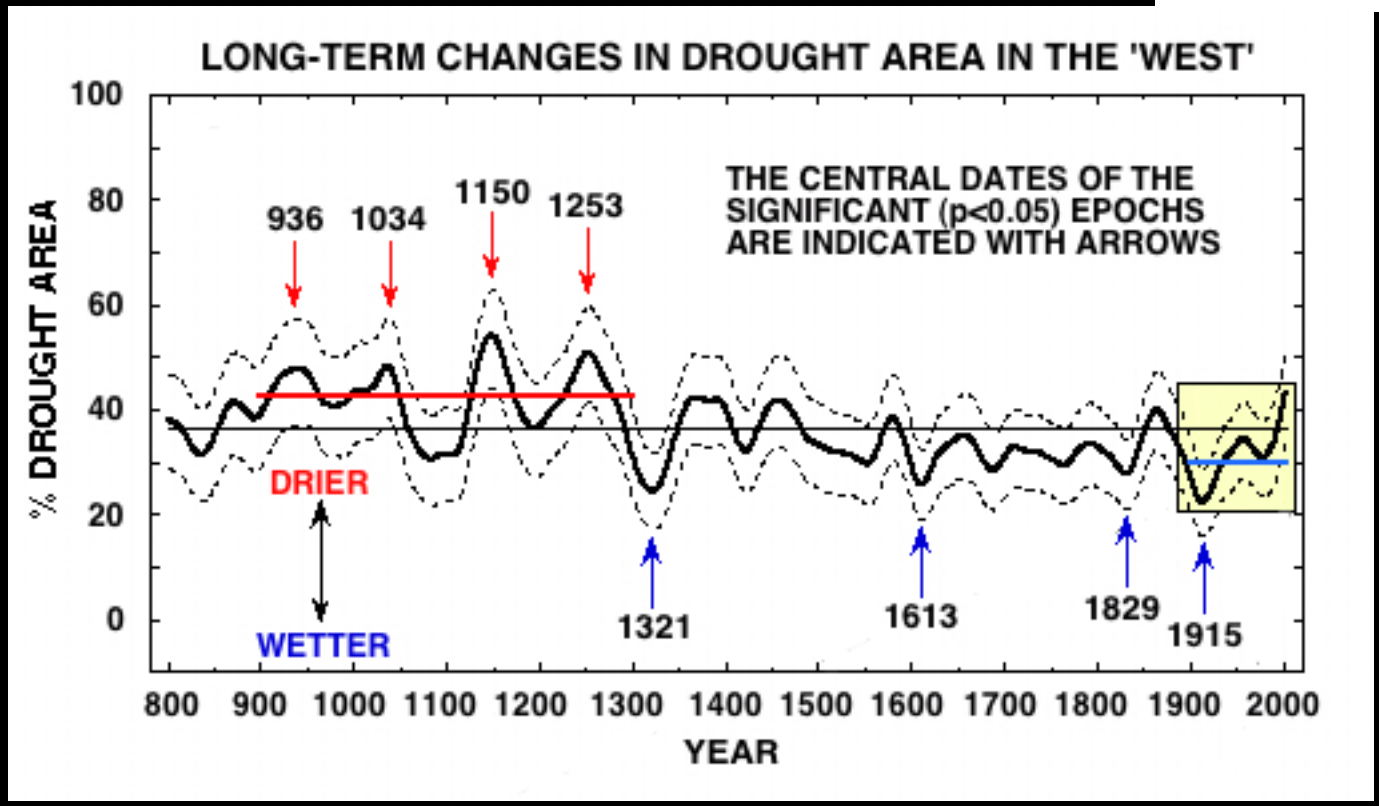
Reconstruction of Colorado River at Lees Ferry, AD 762 - 2002



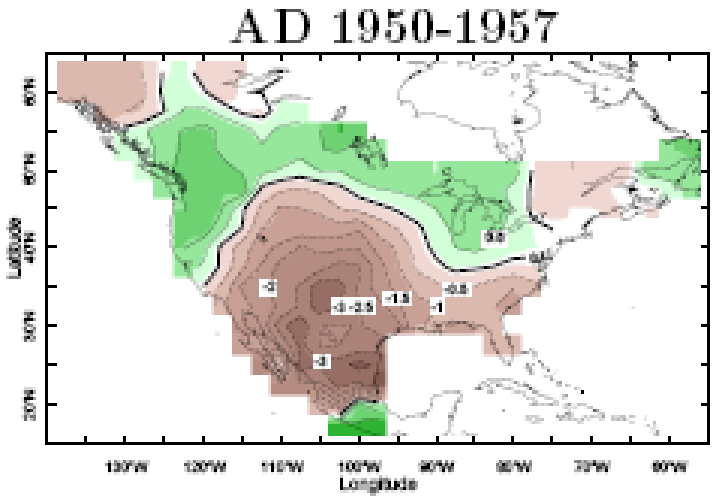
25-yr running means of reconstructed and observed annual flow of the Colorado River at Lees Ferry, expressed as percentage of the 1906-2004 observed mean (Meko et al. 2007).

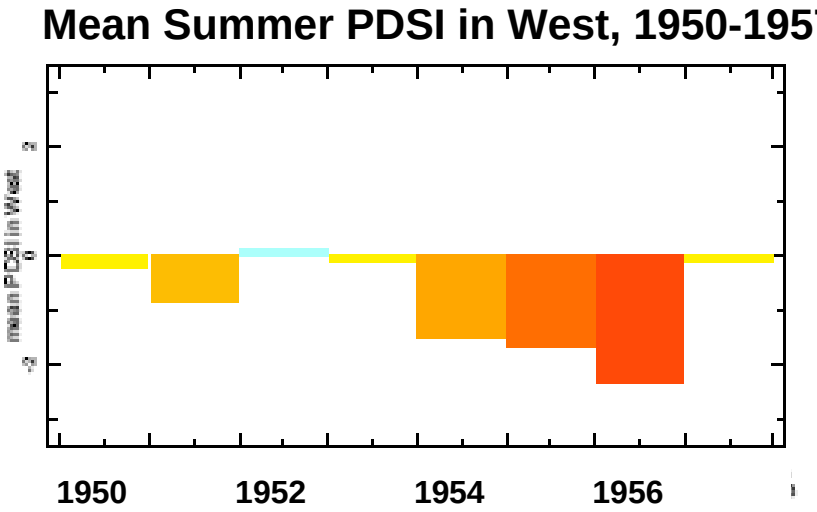
Periods of persistent low flow correspond to an expanded area experiencing in the western US, ~850-1300

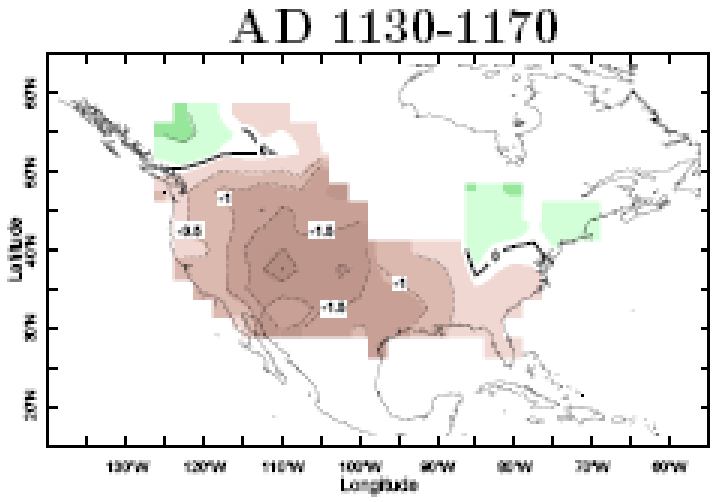


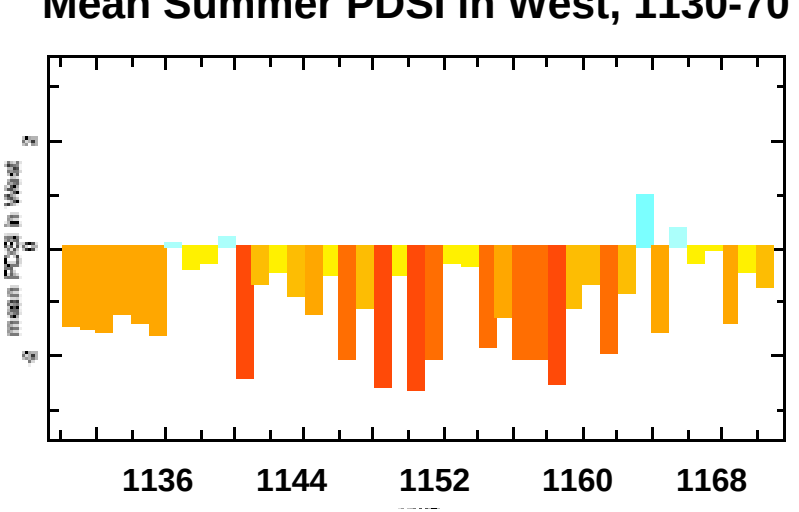


The 1950s Drought compared to the 12th Century Drought (1130-1170)







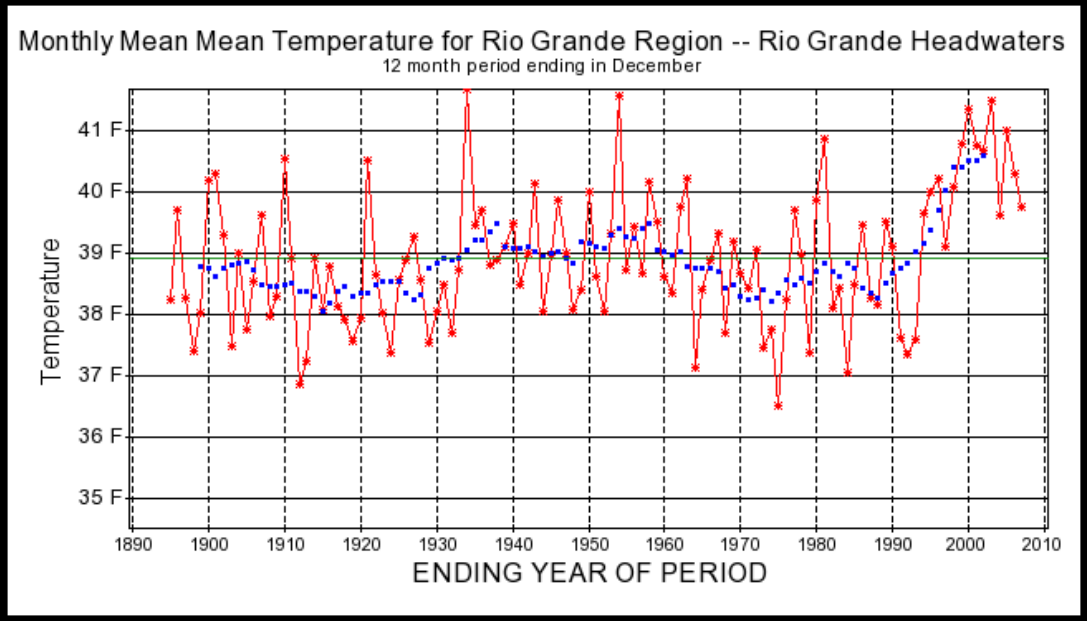


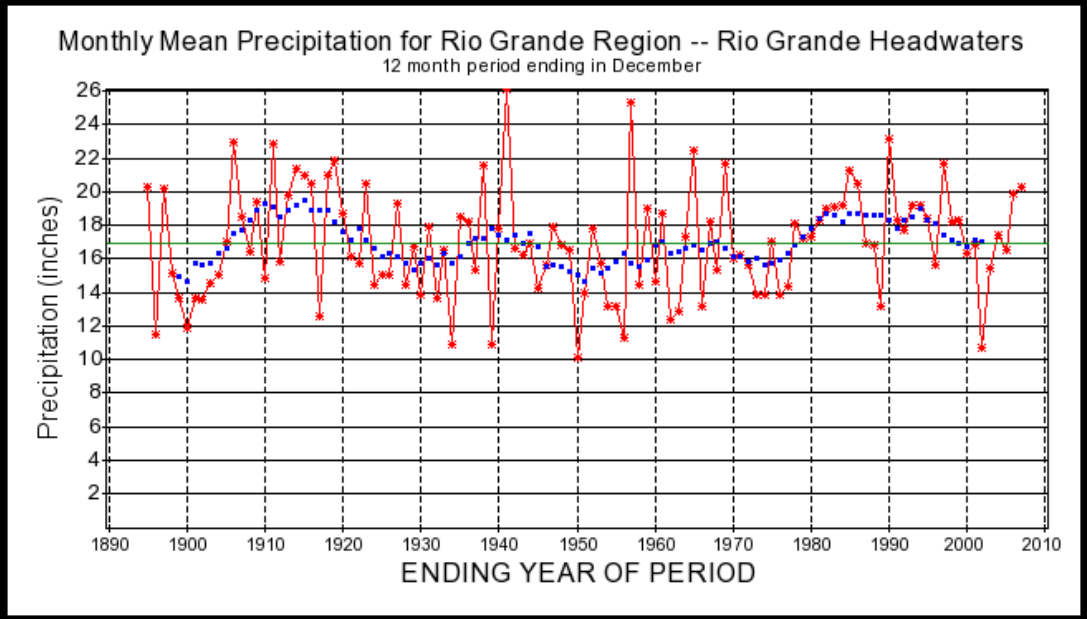
Herweijer et al., in press, *Journal of Climate*

Will the climate of the future look anything like the past?

Increased temperatures are already evident in many areas, and are projected to continue.

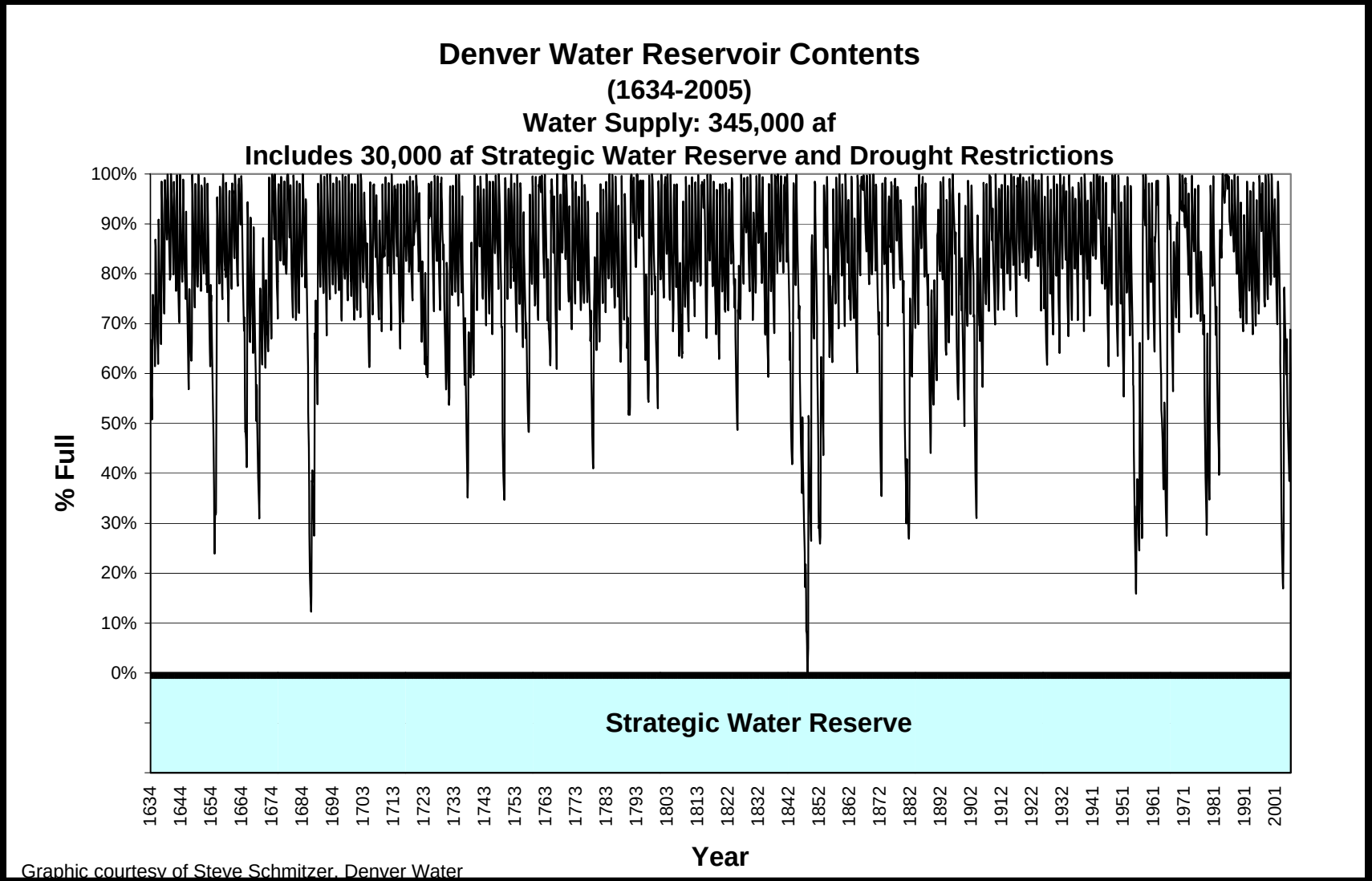
Precipitation trends are less clear in many regions.





http://www.cefa.dri.edu/Westmap/westmappass.php

There is no reason to believe that long-term natural hydrologic variability will not continue in the future. The broader range of variability in streamflow reconstructions is now being used by a number of water providers as a basis for planning.



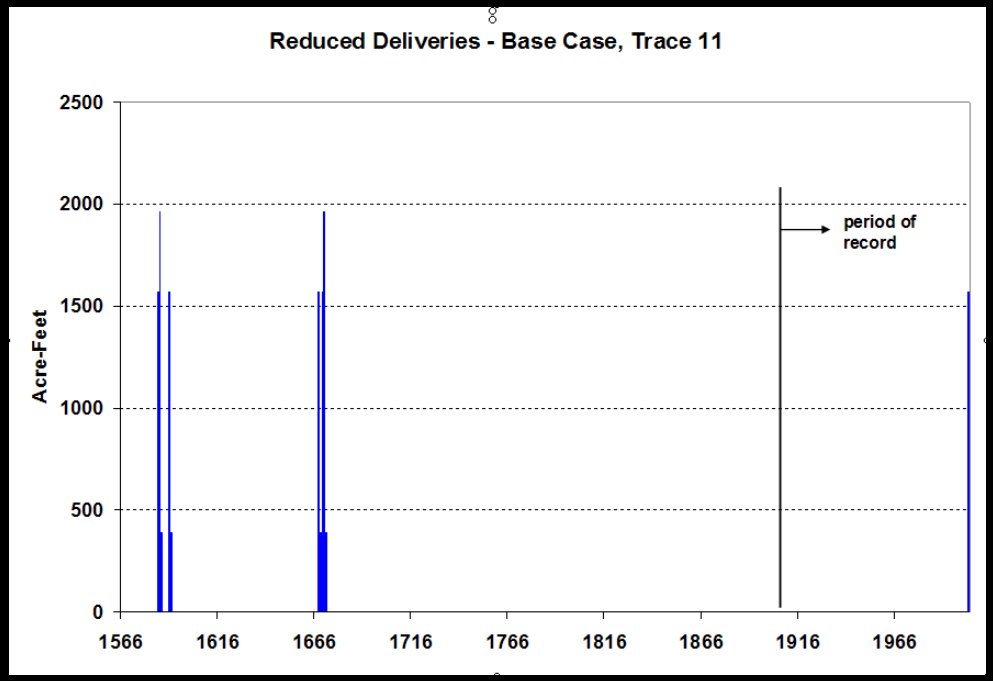
Graphic courtesy of Steve Schmitzer, Denver Water

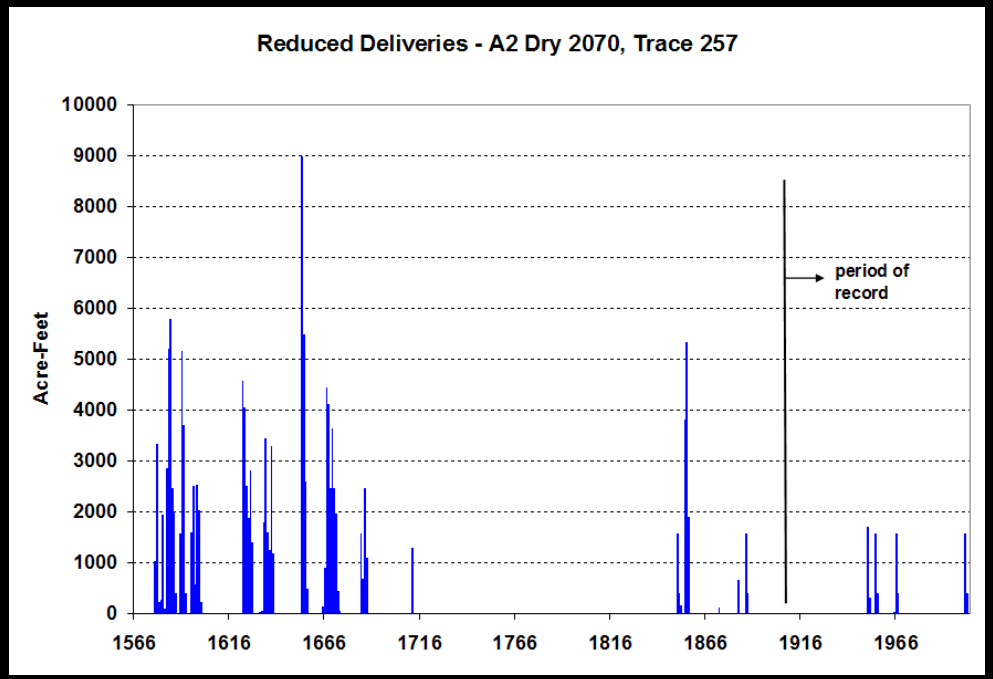
How are tree-ring data relevant to the future?

- Tree-ring reconstructions of hydrology can provide a long-term context from which to evaluate shorter instrumental records
- The past will not be an analogue for the future, but the extended records of past hydrology provide a baseline for planning which also must consider a warmer future.

An example from the City of Boulder: Blending the long-term natural hydrologic variability from tree-ring reconstructed streamflow with projections for future climate

From Lee Rozaklis, AMEC Earth and Environmental





Tree-Ring Research in the Rio Grande Basin

- Preliminary reconstruction of the Rio Grande at Otowi is available.
- Reconstruction of Rio Conchos watershed cool season precipitation in progress
- Proposal for monsoon precipitation reconstruction is being considered by National Science Foundation for funding