Sensitivity of Water Supply in the Colorado River Basin to Warming

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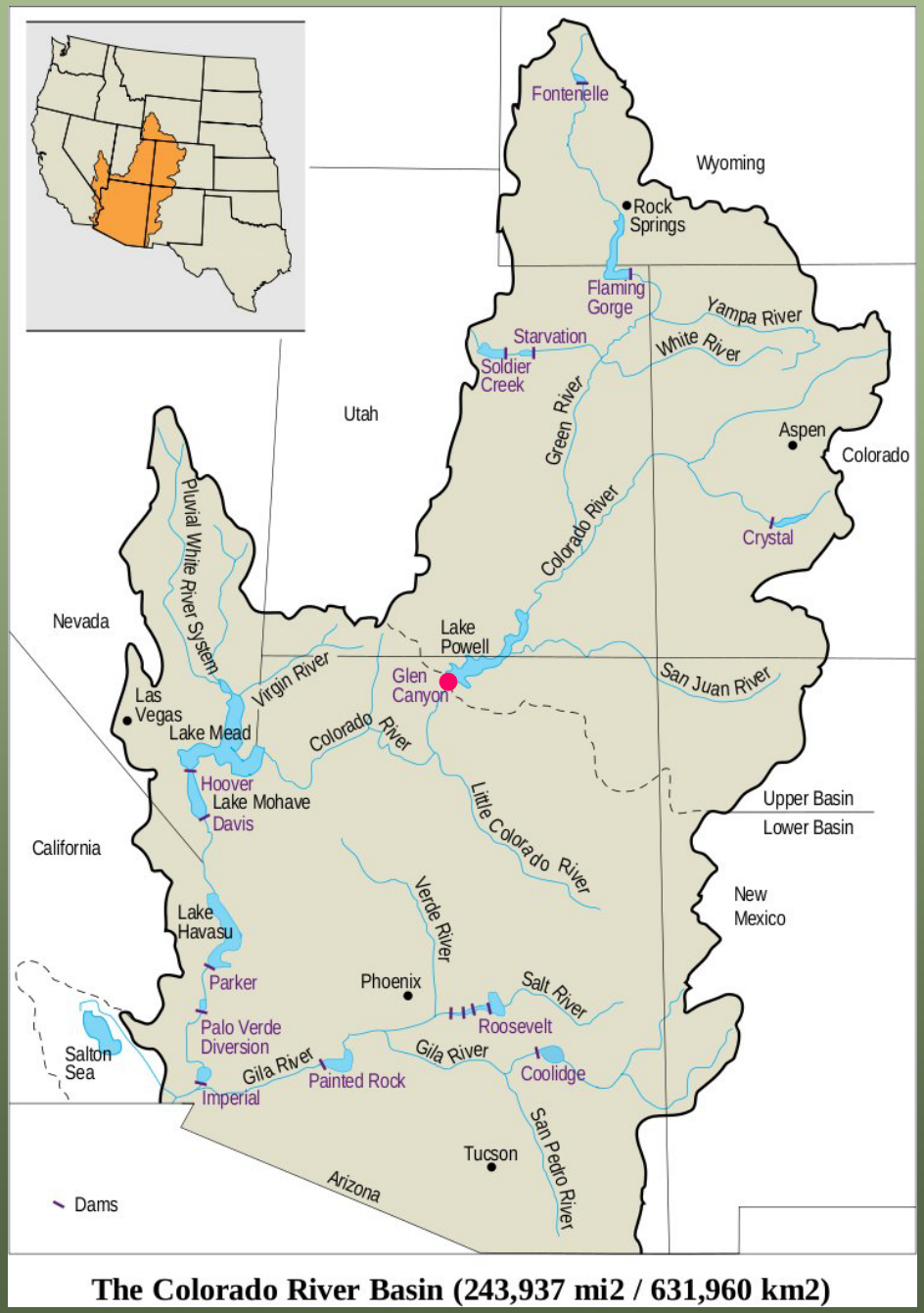
The Colorado River Basin

- Streamgage at Lee's Ferry



Source: D. Alles, 2007

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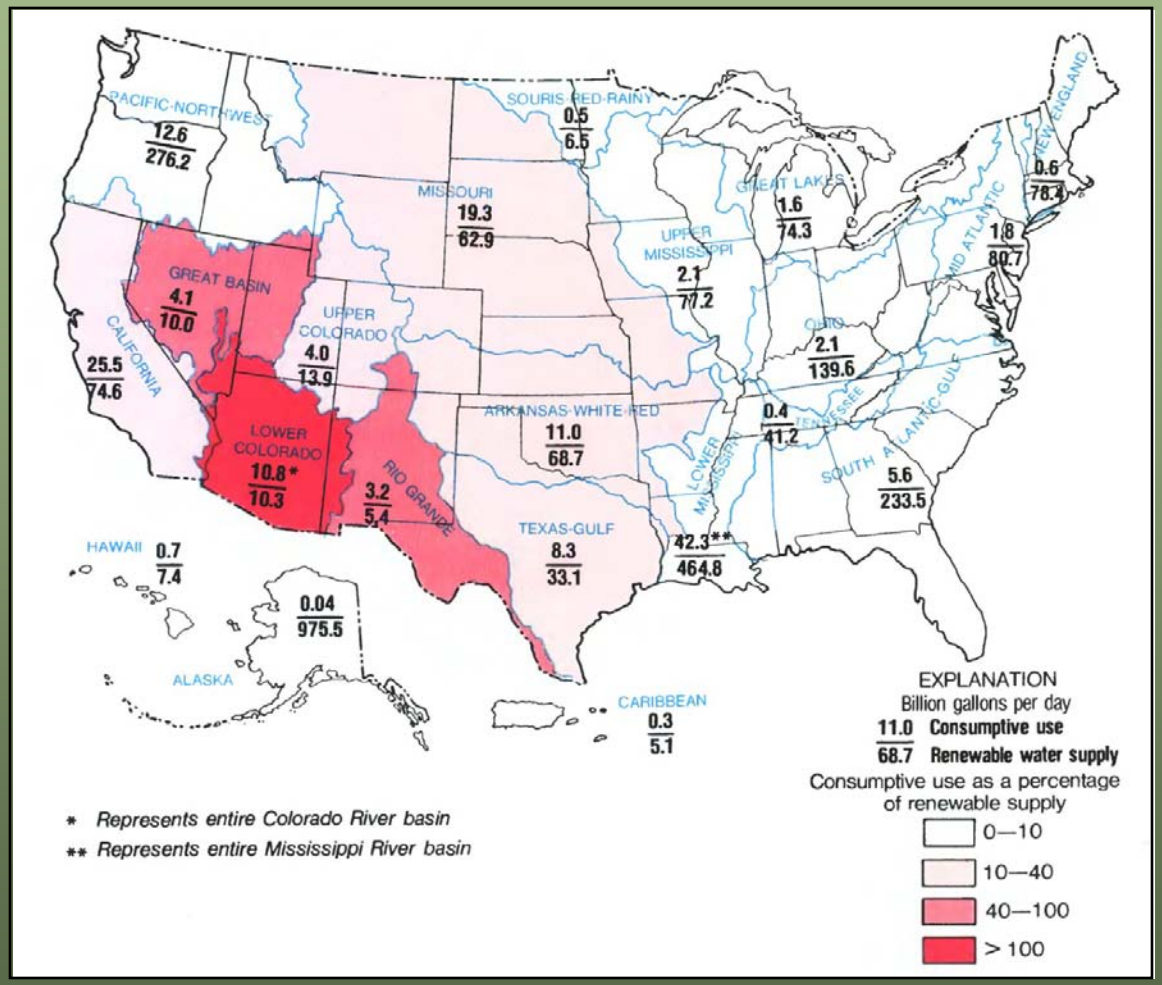
Consumptive use already exceeds renewable water supply in parts of the Colorado River basin.

Average consumptive water use and renewable water supply by water resource region (USGS Water Supply Paper 2250)



based on 1995 estimates of water use

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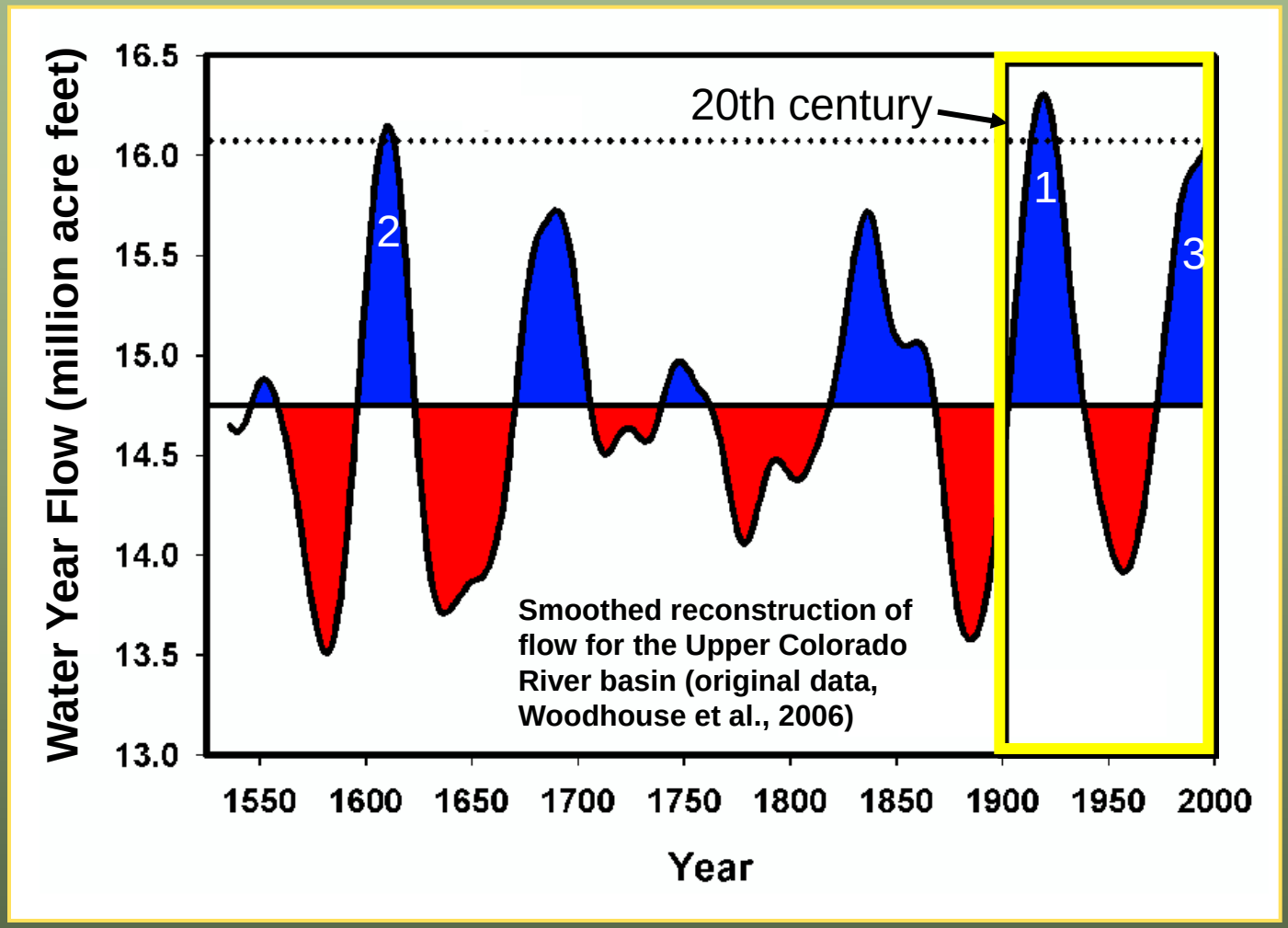
The 20th century included the wettest and 3rd wettest periods in the Upper Colorado River Basin during the past 500 years



Source: Steve Gray, University of Wyoming

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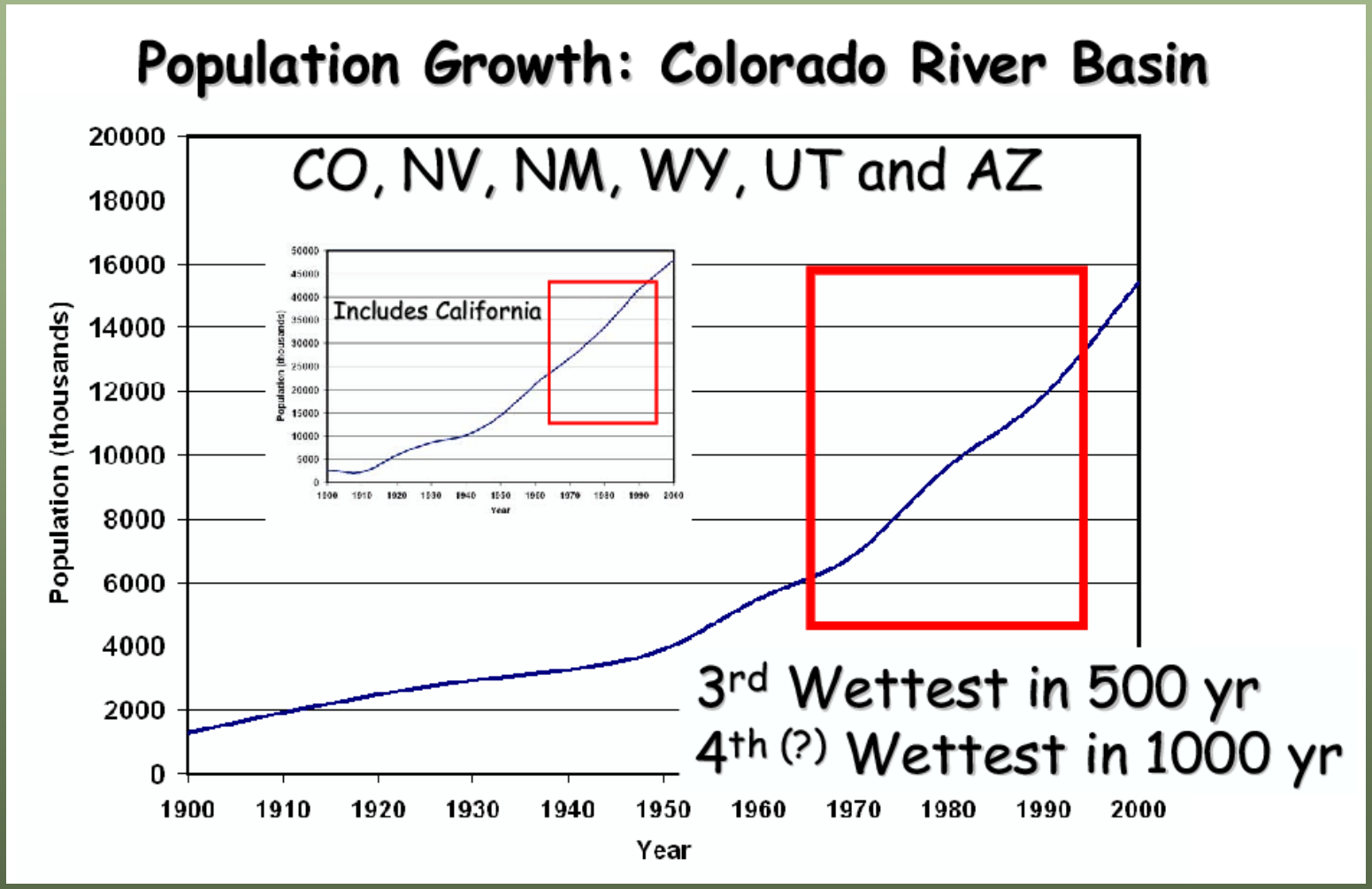
Population growth and water demand have increased dramatically in the Colorado River basin during an anomalously wet period. What will happen when the climate is drier?



Courtesy of Stephen Gray, Univ. of Wyoming

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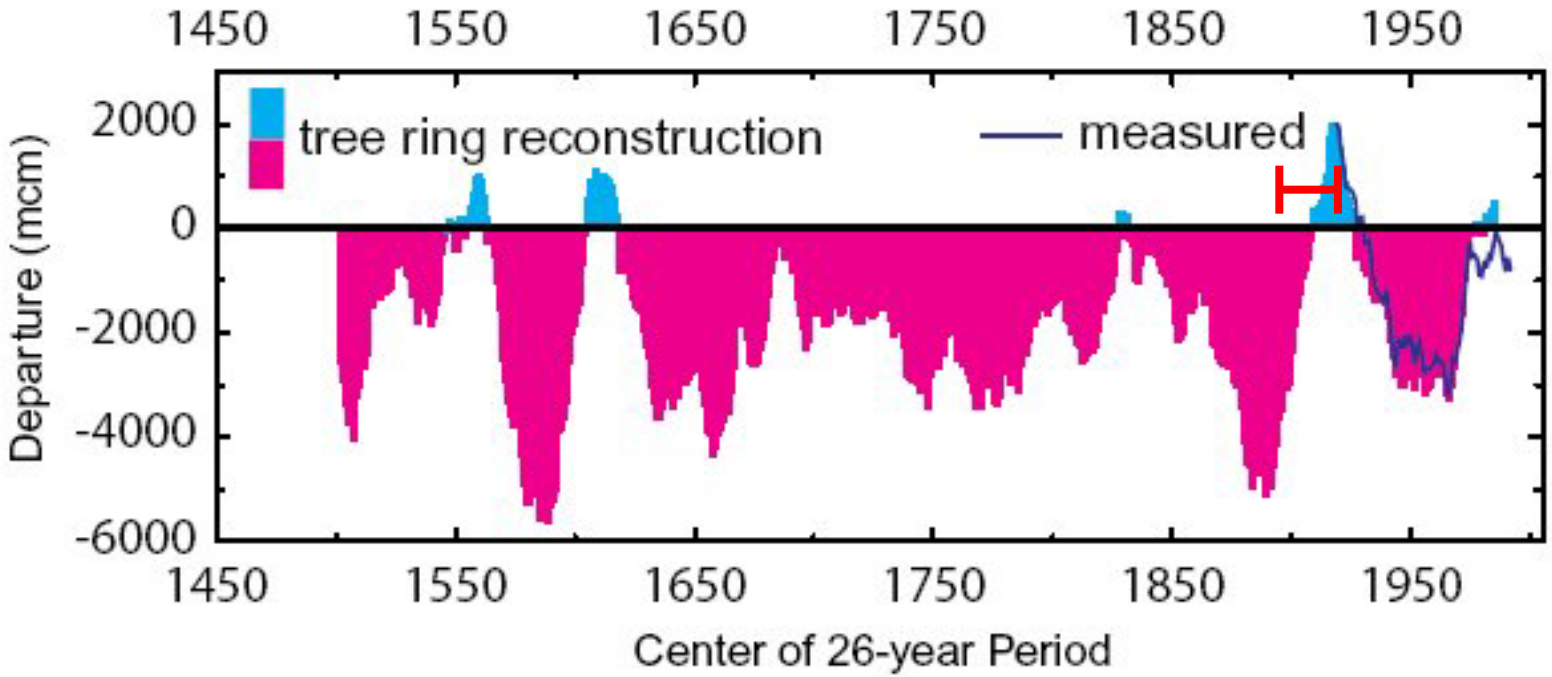
The period used to estimate UCRB flows for the Colorado Compact was wet relative to other periods in the 20th century, as well as to most other periods during the past 500 years.

26-year moving average UCRB flow expressed as departures from the mean flow for the period used for the Colorado Compact



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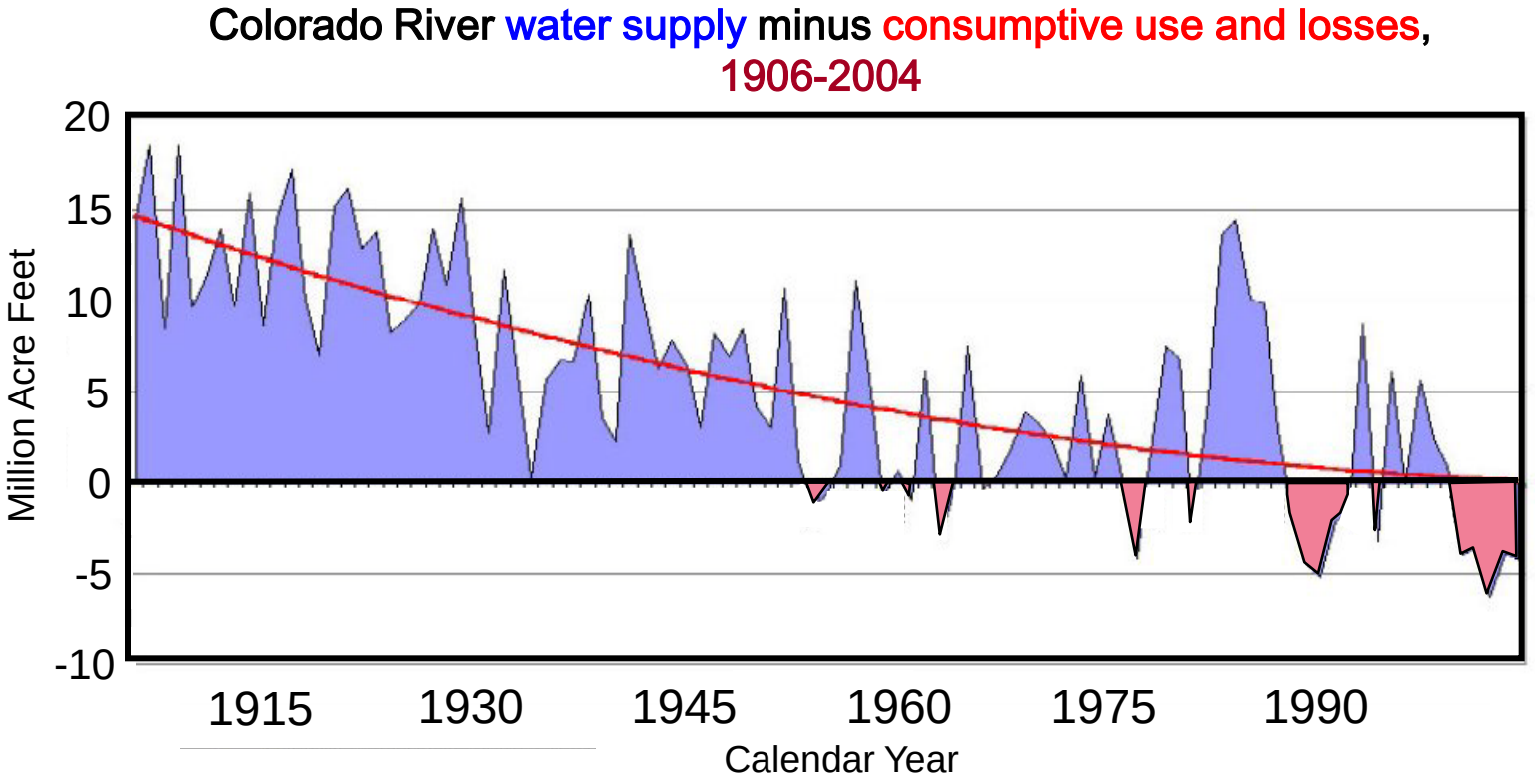
Tree ring reconstruction from Woodhouse et al., WRR, 2006

Increasing water demand is stressing the Colorado River water supply, even during one of the wettest centuries.



Source: Glen Canyon Institute, March 2005

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Are recent dry conditions in the UCRB anomalous, or more reflective of conditions experienced during previous centuries?

photos by John Dohrenwend, Southwest Satellite Imaging

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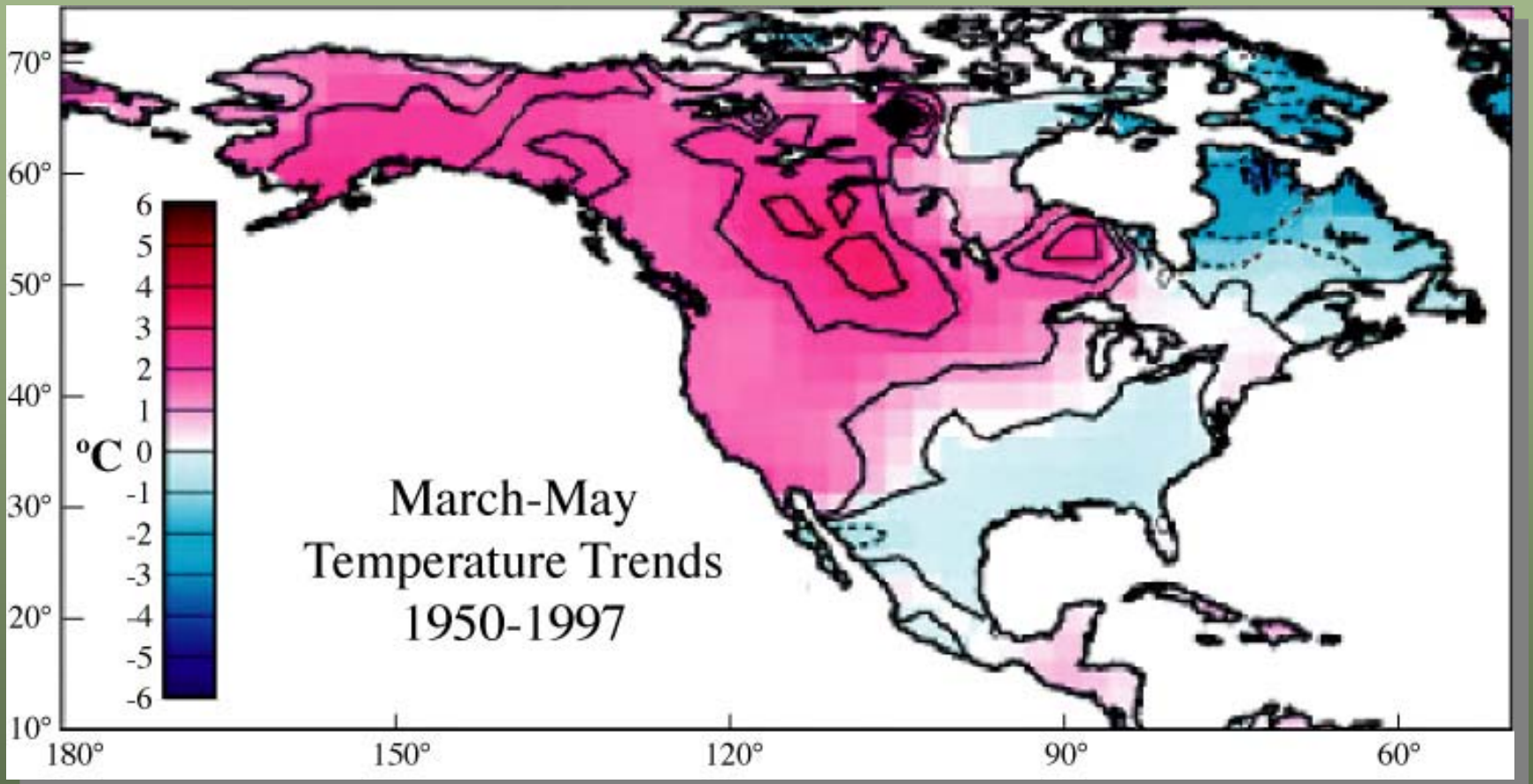
Long-term warming trends are apparent in the western U.S.



Cayan et al., 2001

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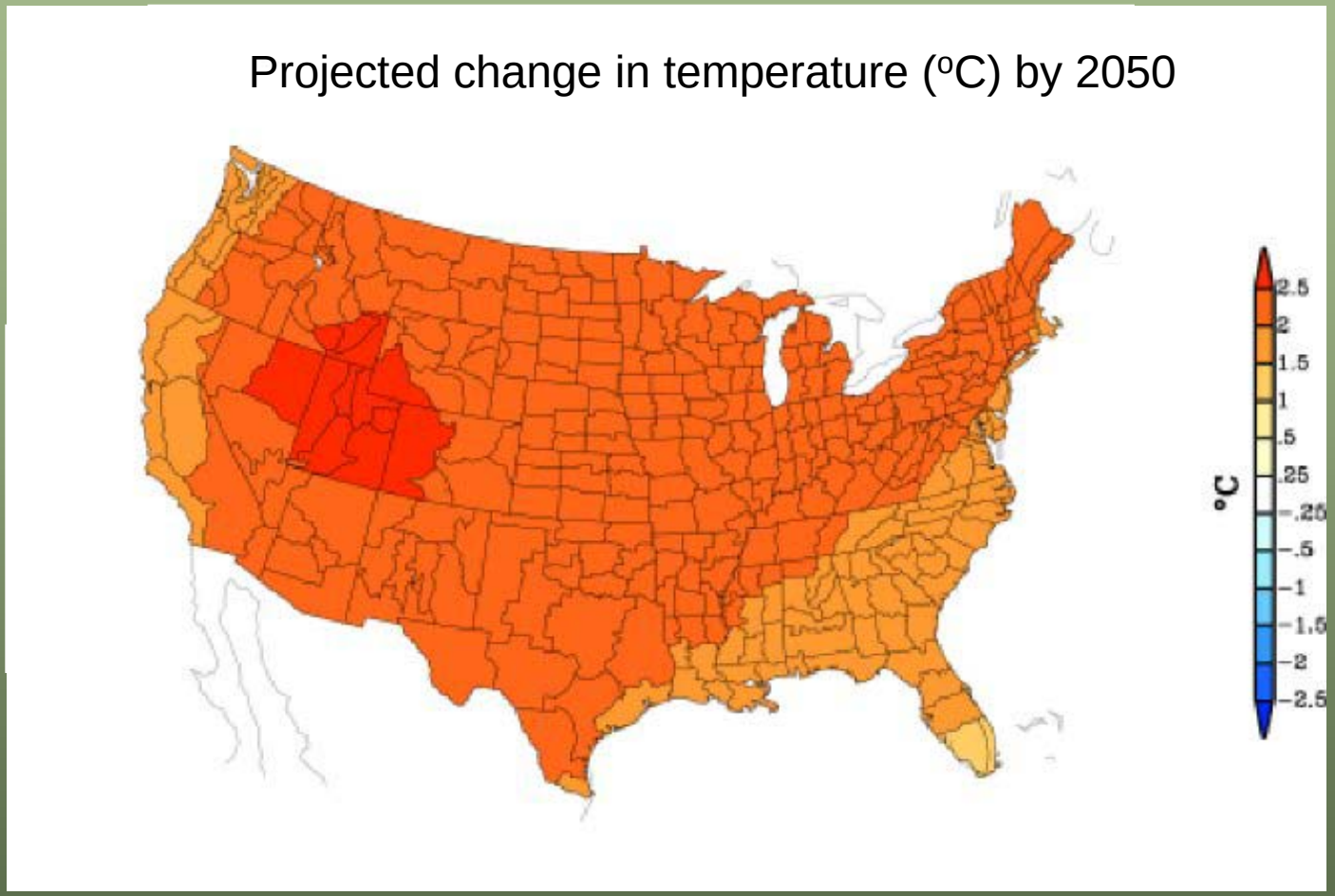
Climate models simulate continued warming for the western U.S.



Projected North American surface temperature to business-as-usual emission scenarios. Data are from the average of 22 IPCC model simulations. The anomalies are computed from a 1972-2000 reference. (Hoerling and Eisheid, 2008)

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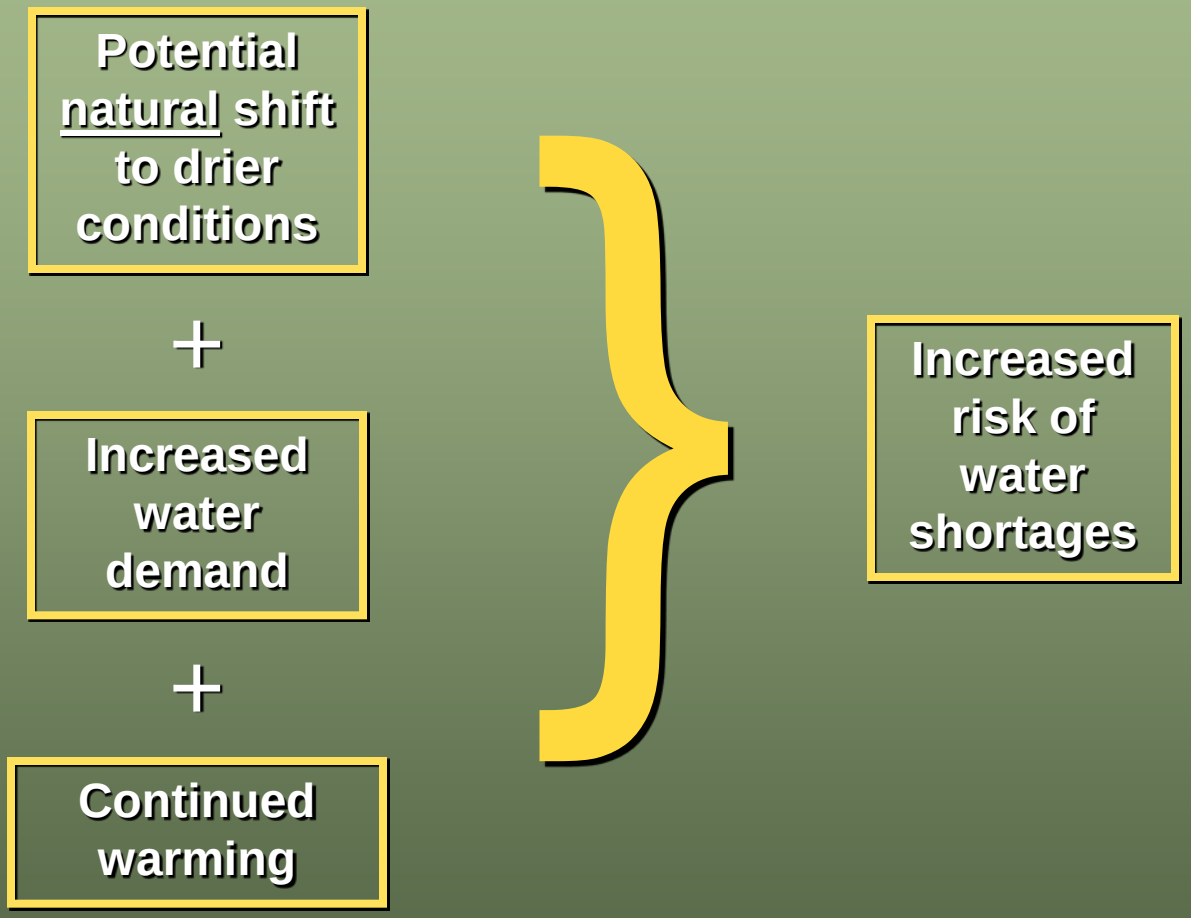
Issues and concerns for the Colorado River Basin



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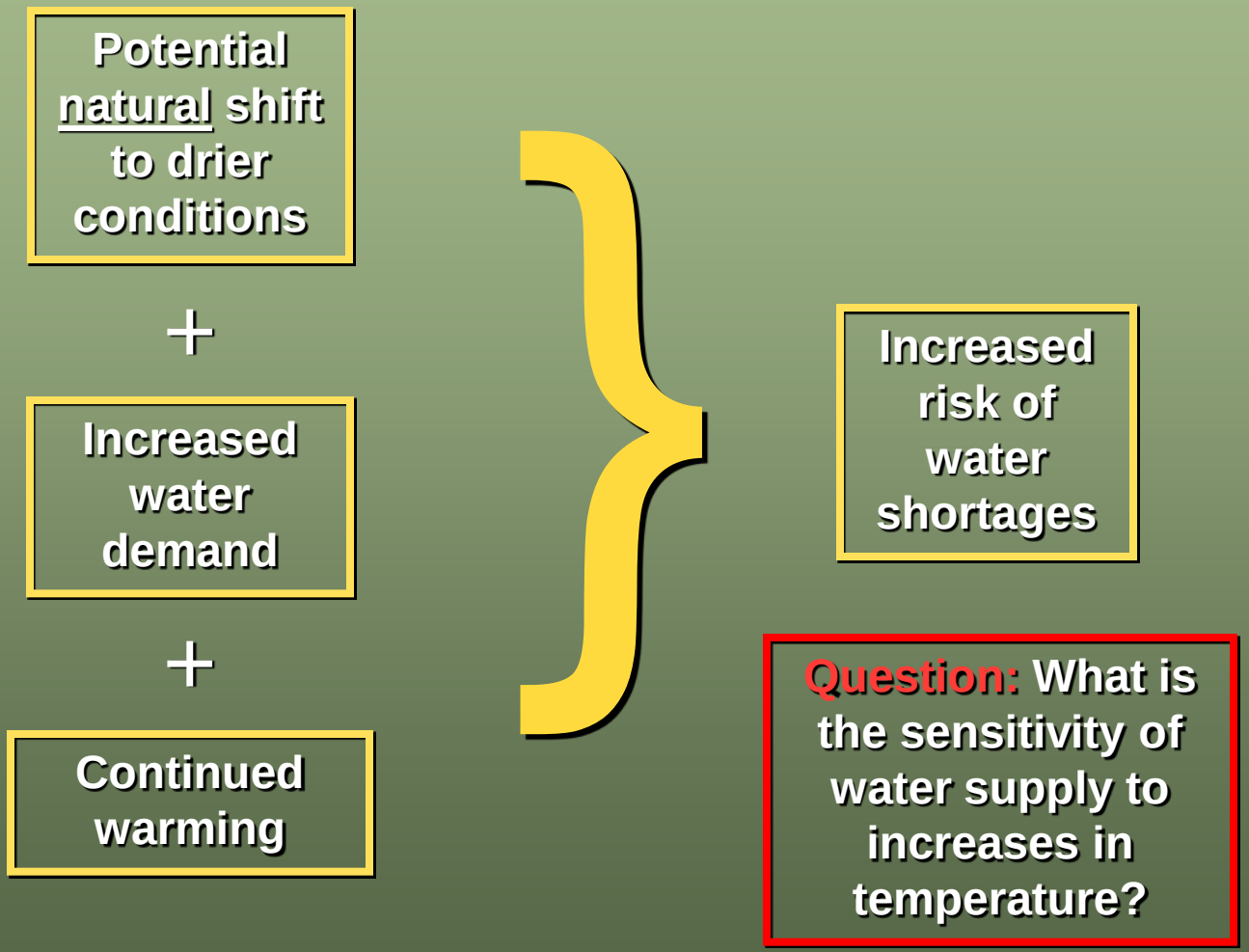

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Data Sets

Flow Data

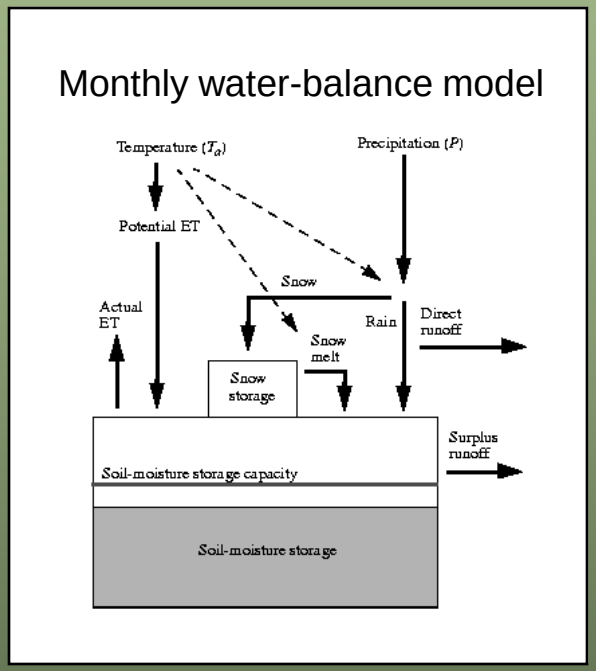
-Upper Colorado River basin water-year (October through September) natural flow values (1906-2004) (U.S. Bureau of Reclamation)

- time series of UCRB water-year flow (1490-1998) reconstructed from tree-rings (Woodhouse et al., 2006)

Climate Data

- monthly temperature and precipitation data for the period (1895-2004) obtained from the Precipitation-elevation Regression on Independent Slopes Model (PRISM) dataset
    - native grid resolution – 4 km
    - aggregated to 62 USGS hydrologic units (HUC8s)

Simple water balance and reservoir storage model for the Upper Colorado River Basin



Water-year Flows

Simple Reservoir Storage Model

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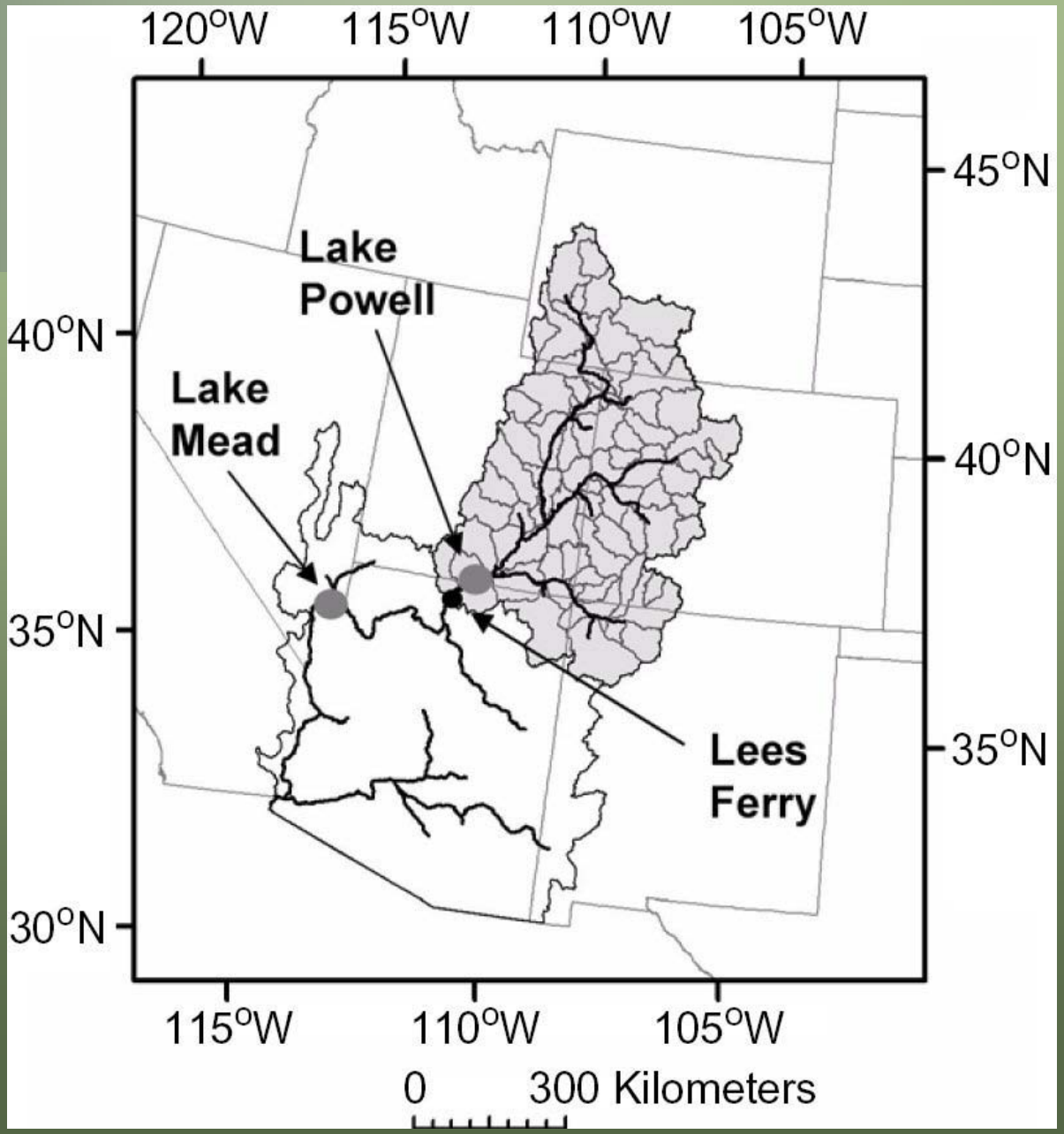
The Colorado River Basin



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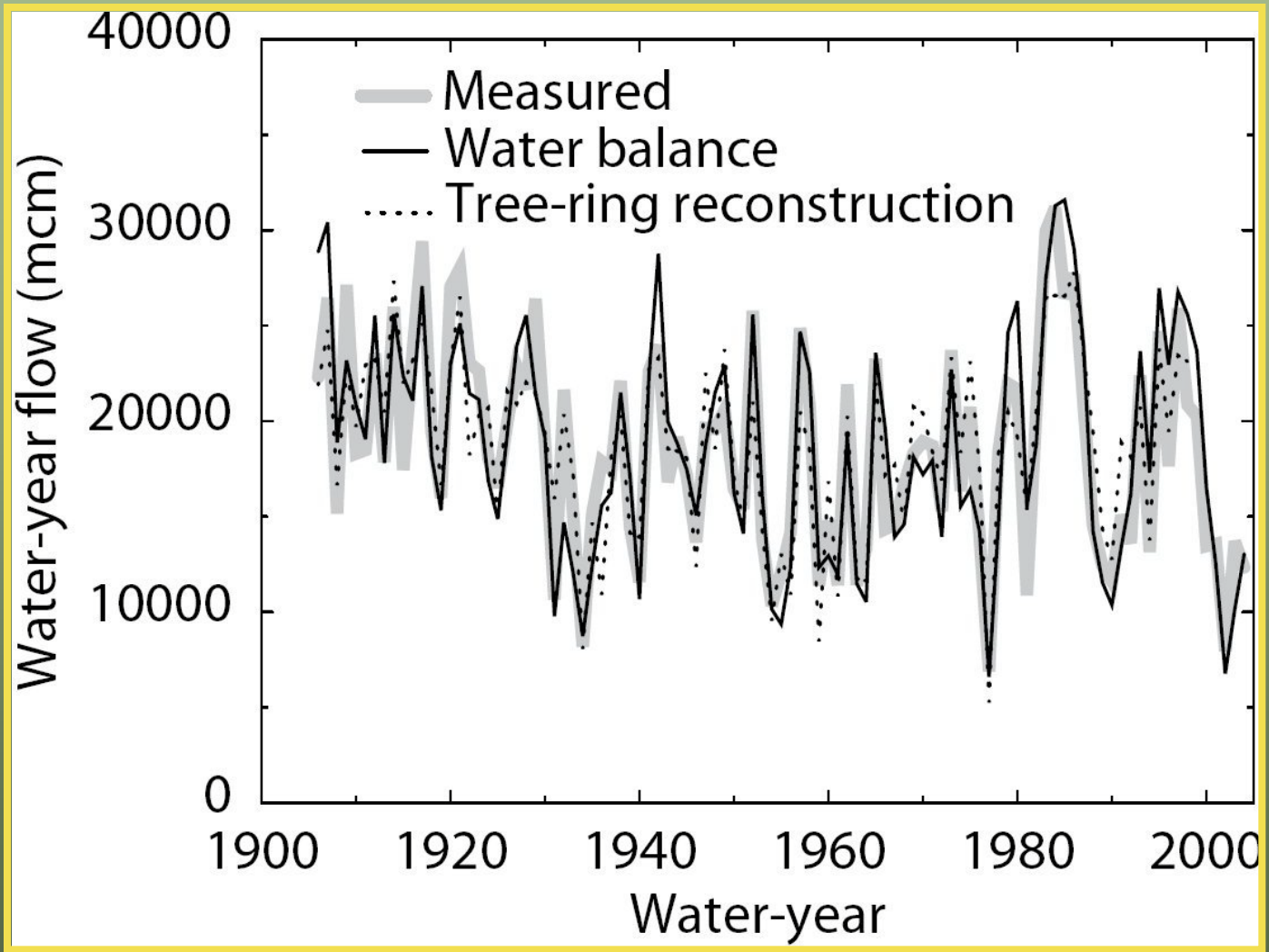
The water-balance model provides reliable estimates of water-year streamflow in the Upper Colorado River Basin.



r = 0.93
bias = 0.7%
rmse = 14.1%

McCabe and Wolock, 2007, GRL

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Effects of warming on Upper Colorado River Basin flow were evaluated in two ways -

Temperature scenarios: 0.86°C and 2°C

1. Applied uniformly to 20th century temperature record and used as input to the water balance model

2. Modified reconstructed flows by percentage changes determined using 20th century data and the water balance model

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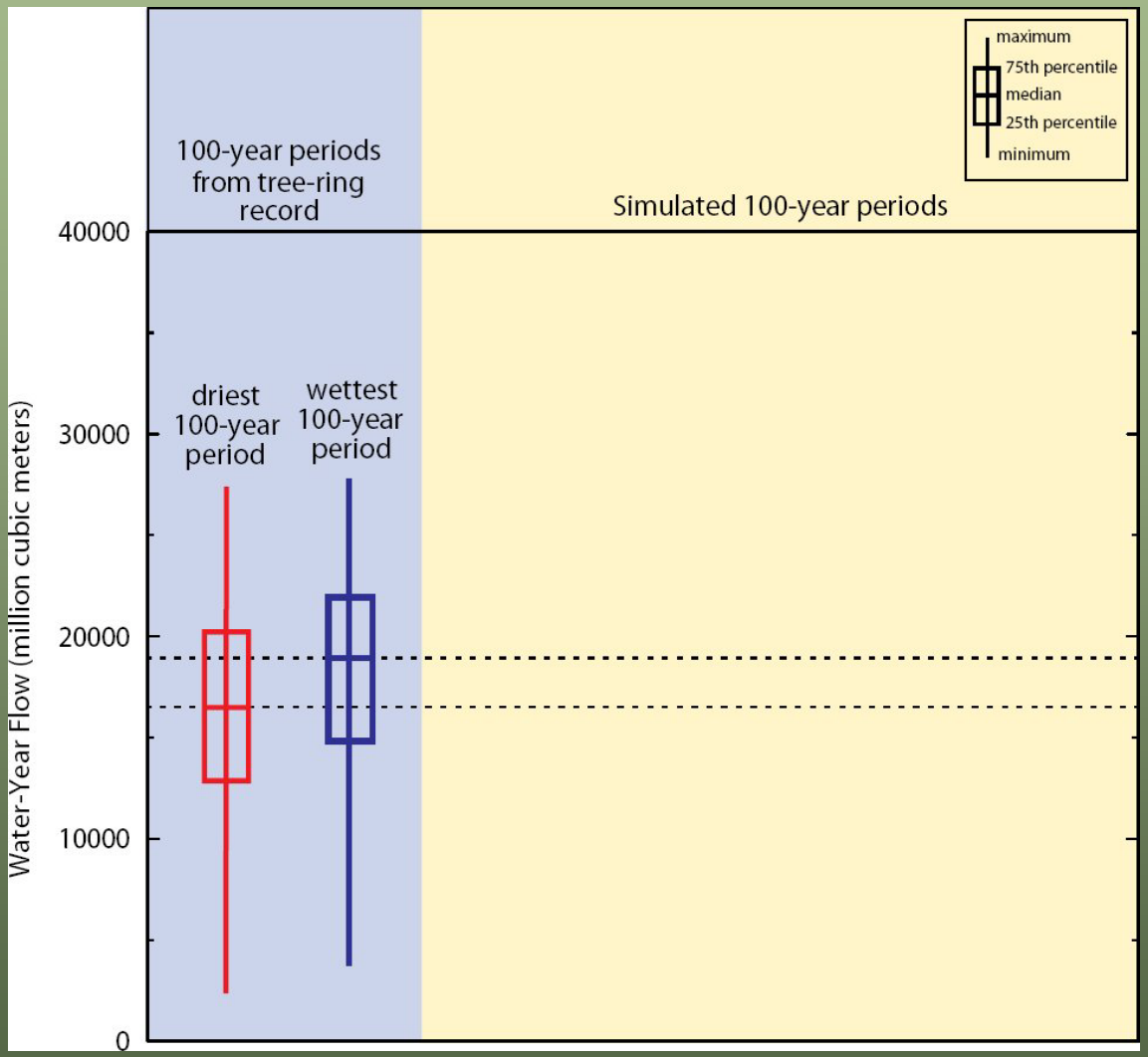
Water-year flow for the Upper Colorado River Basin for 100-year periods



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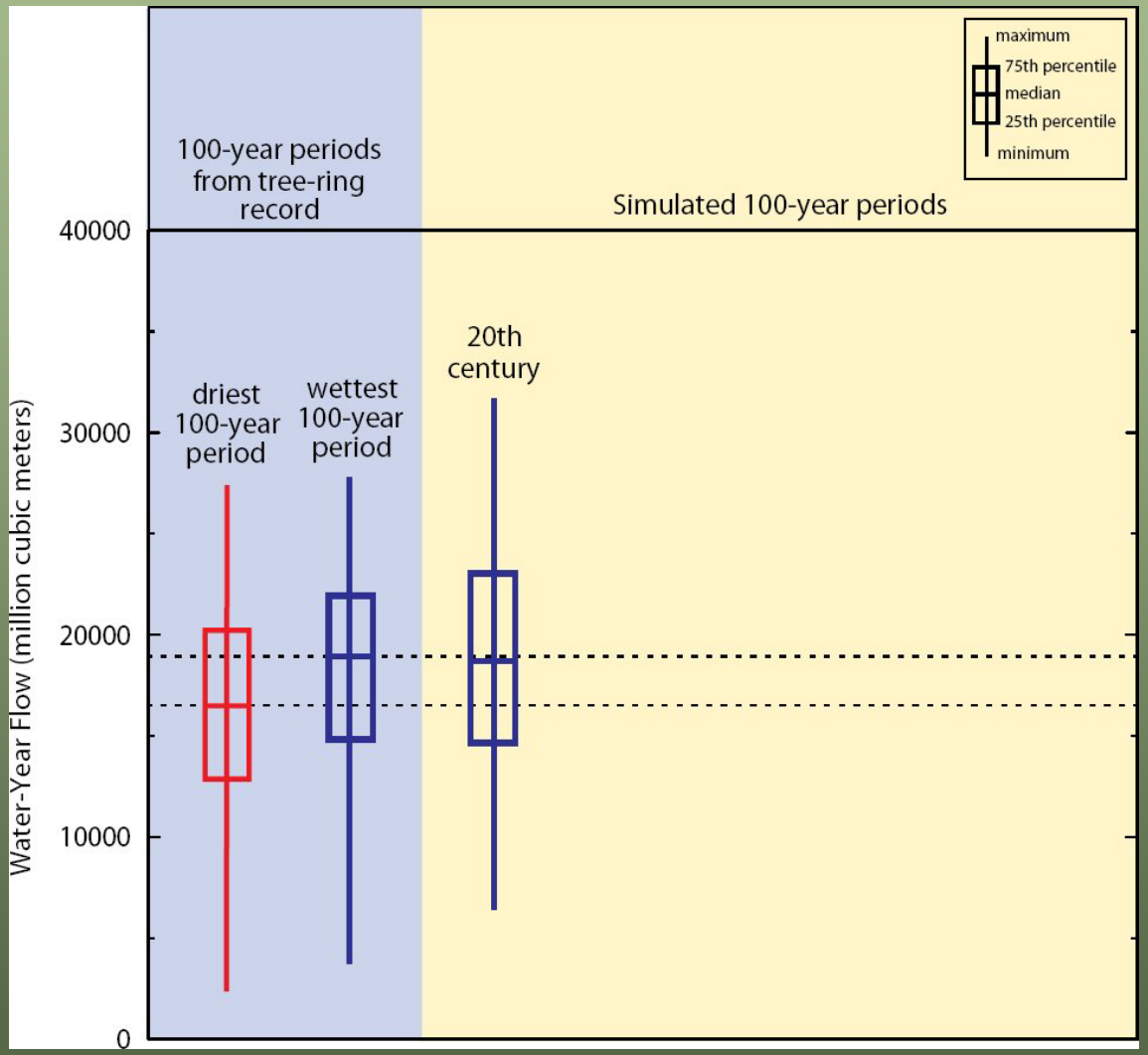

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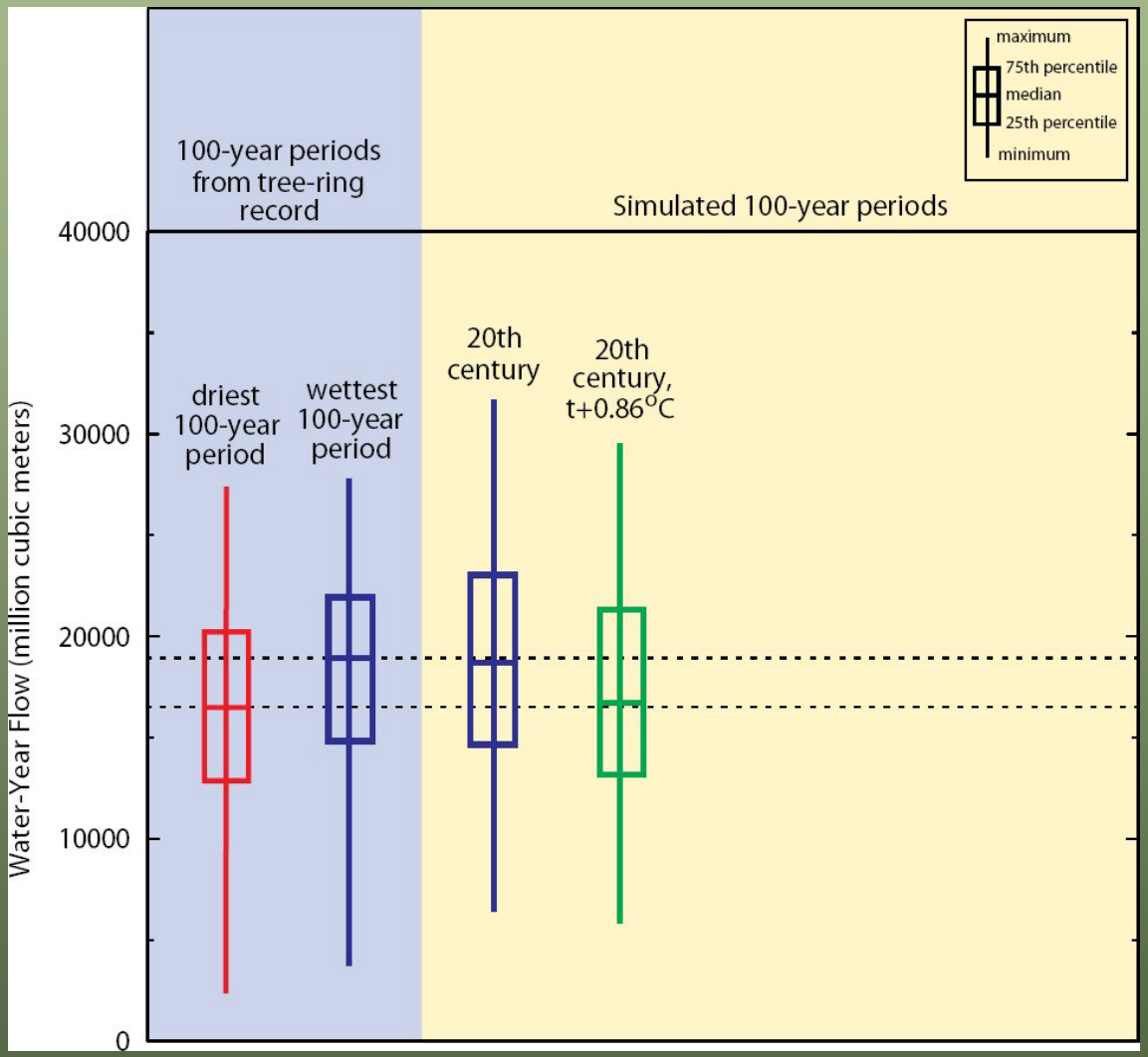

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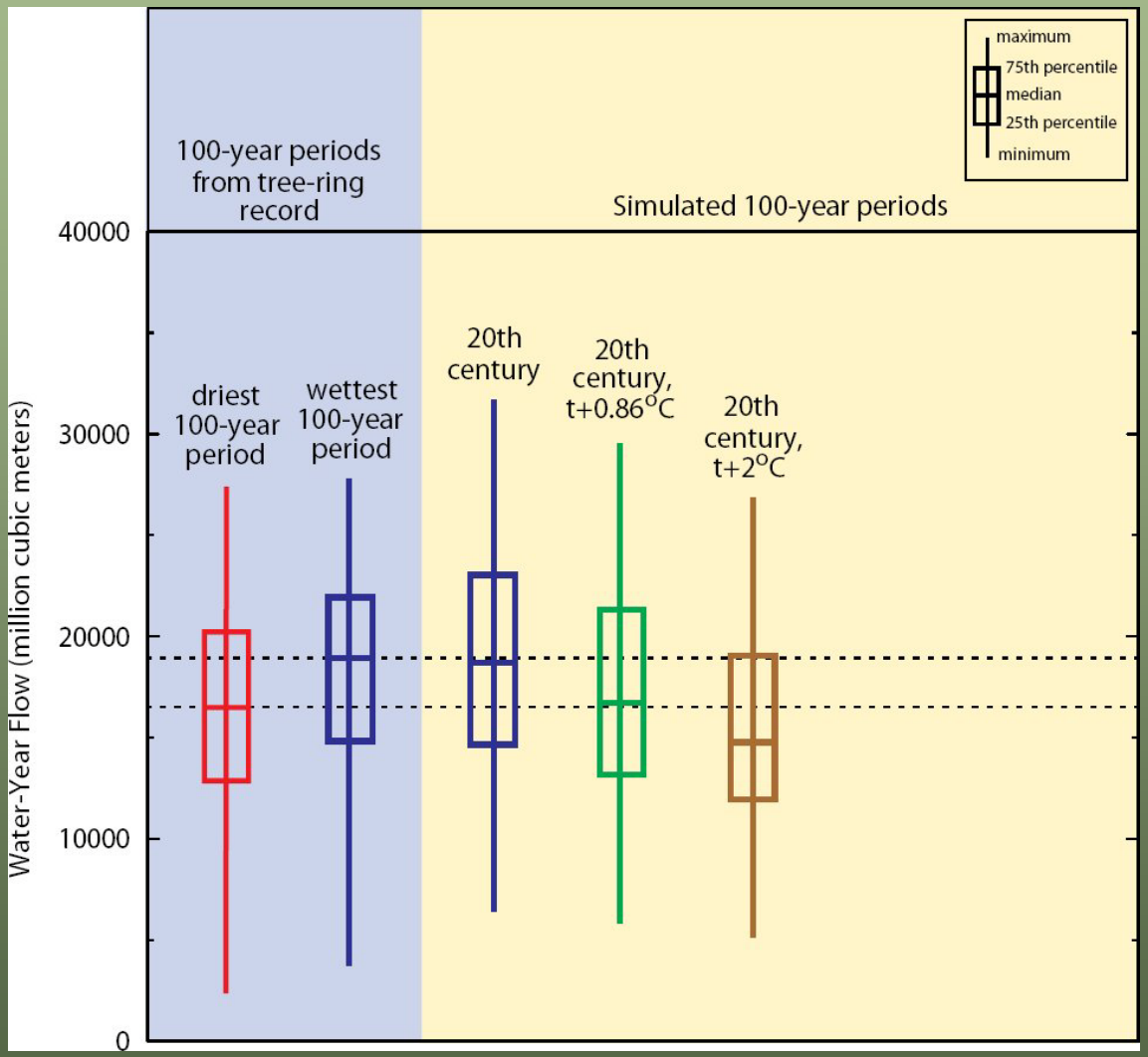

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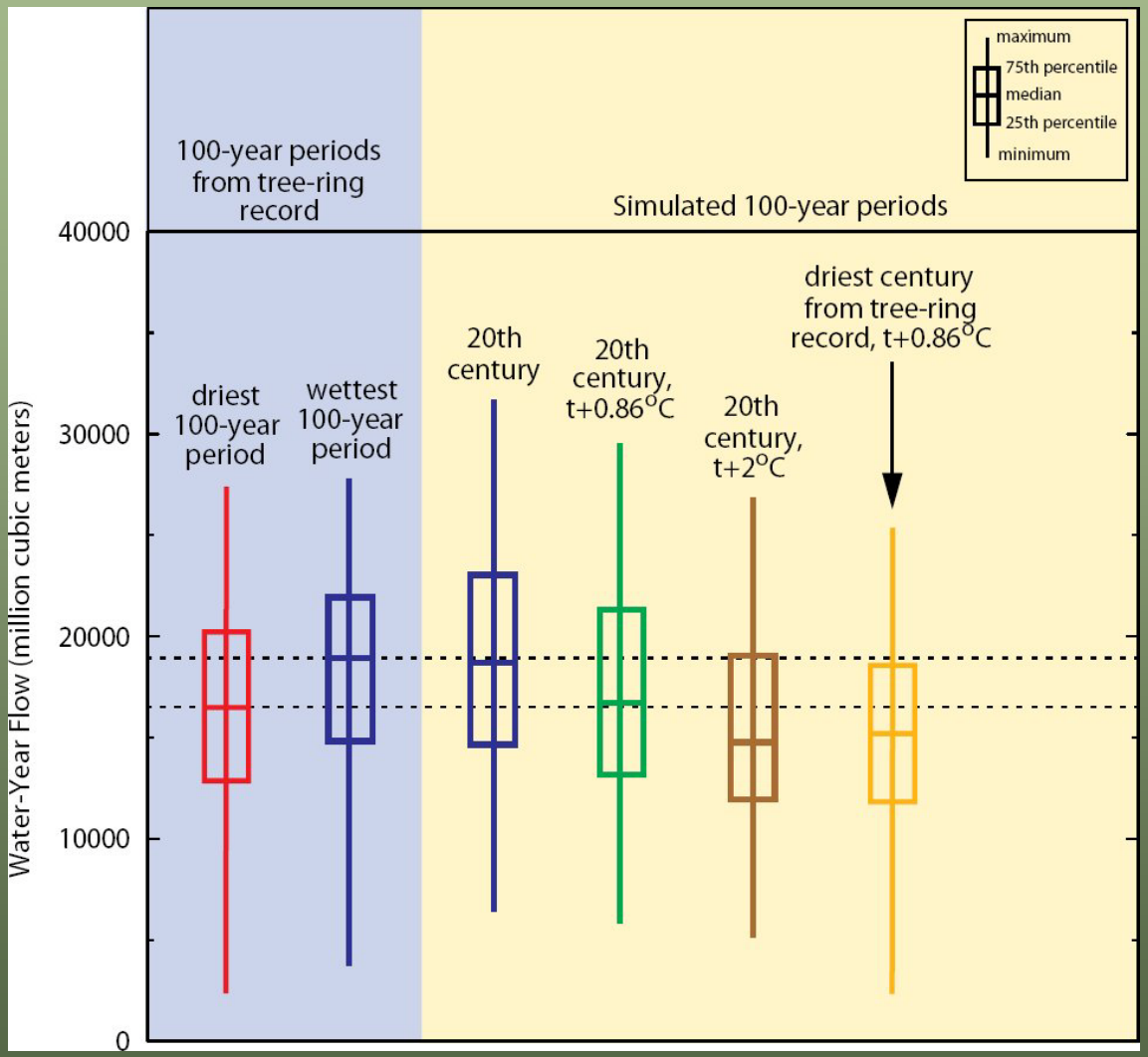

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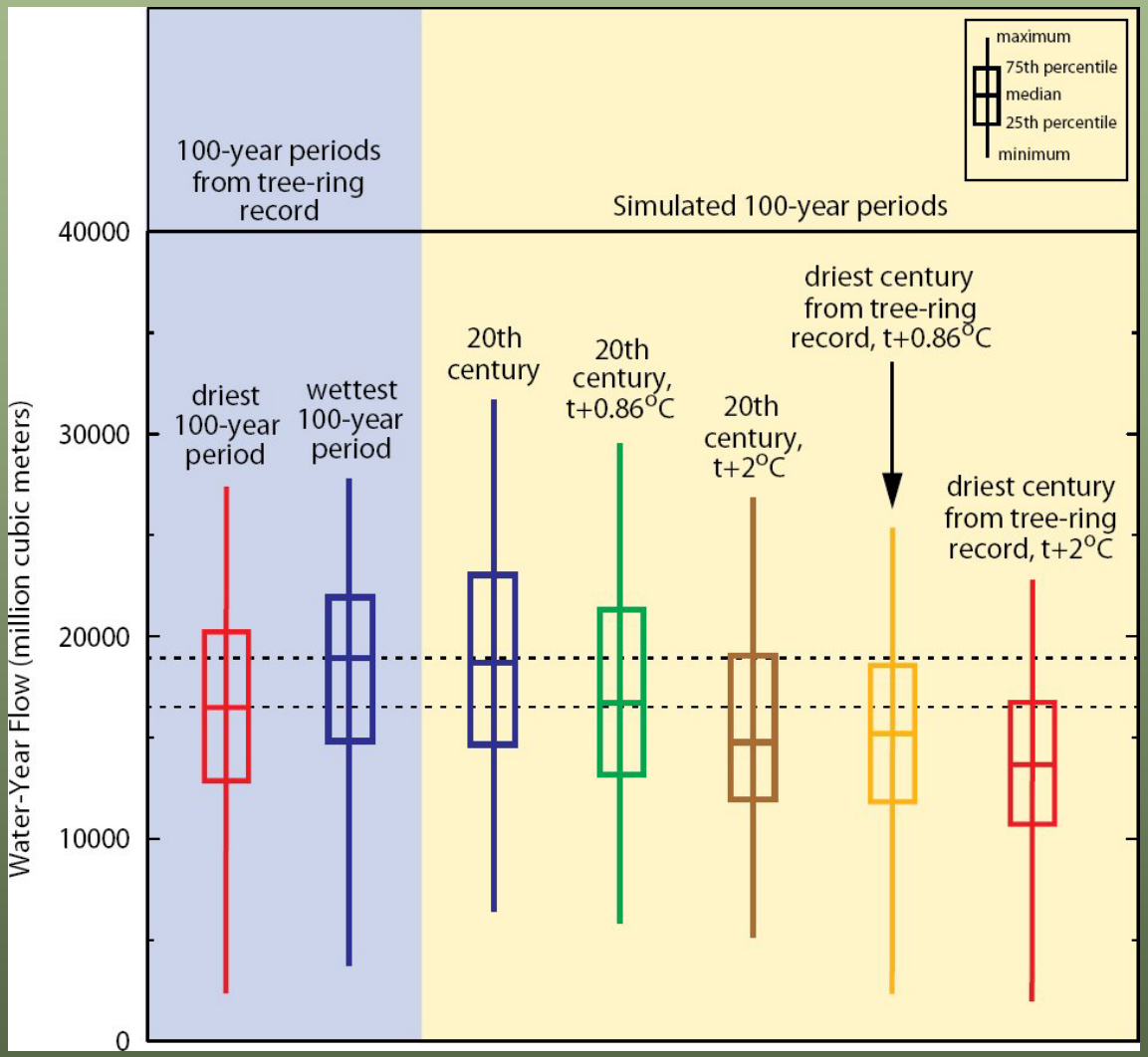

McCabe and Wolock, Geophysical Research Letters, 2007

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Delivery obligations from the Upper Colorado River Basin

Eric Kuhn, General Manager, Colorado River Water Conservation District (simple mass balance computations, 2005)

If mean annual naturalized flow at Lees Ferry is

above 17866 MCM/yr **OK**

after accounting for Upper Basin depletions

- leaves enough water to meet Compact obligations to CA, NV, AZ, & Mexico

If mean annual naturalized flow is

below 17866 MCM could mean **TROUBLE**

- not enough water for apportionments to CA, NV & AZ
- Upper Basin's Mexican Treaty obligation critical
- Interstate litigation likely
- Lakes Powell & Mead would operate at low levels

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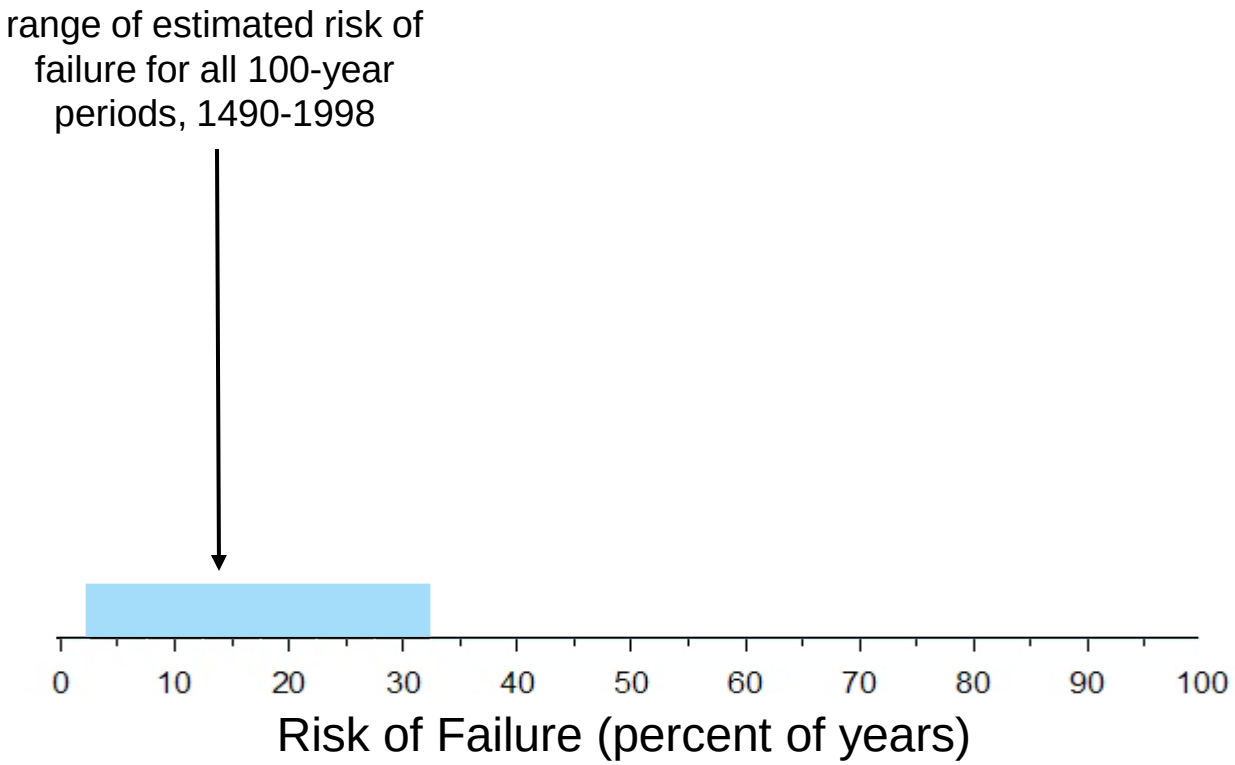
Risk of failing to meet the delivery obligations of the Colorado Compact during a 100-year period



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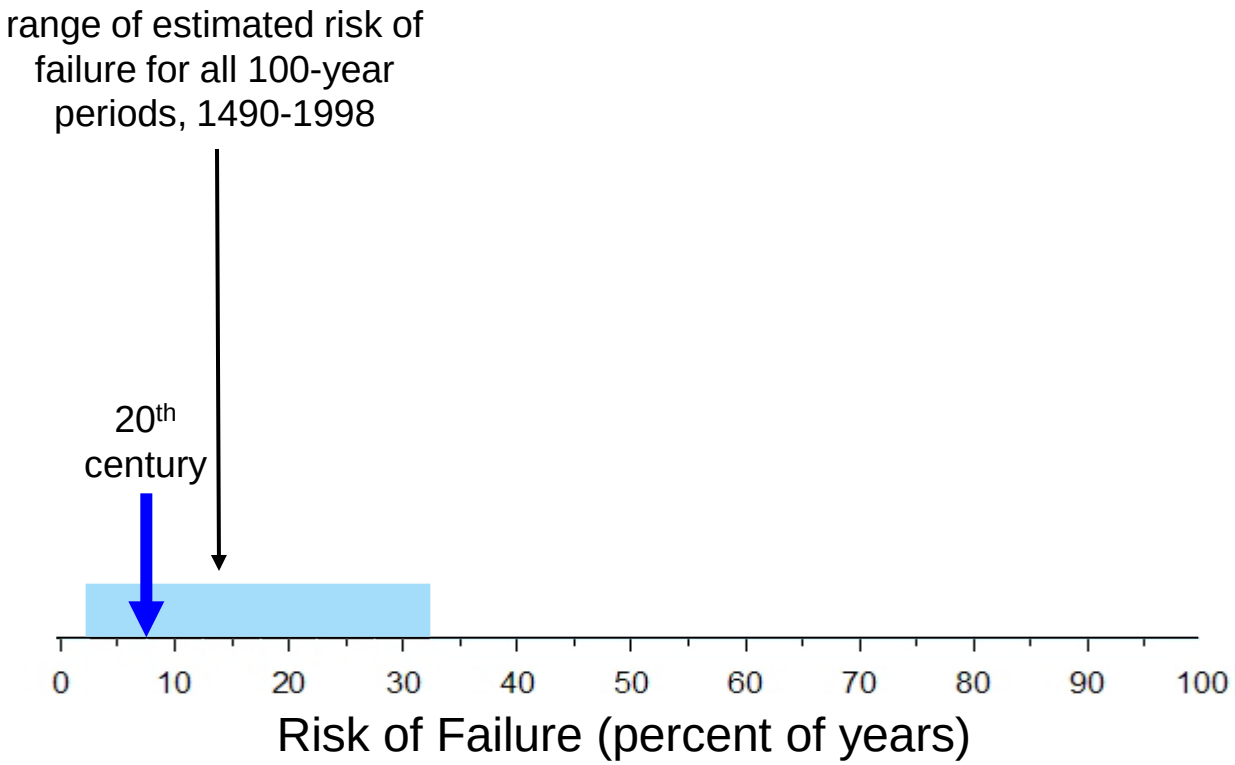

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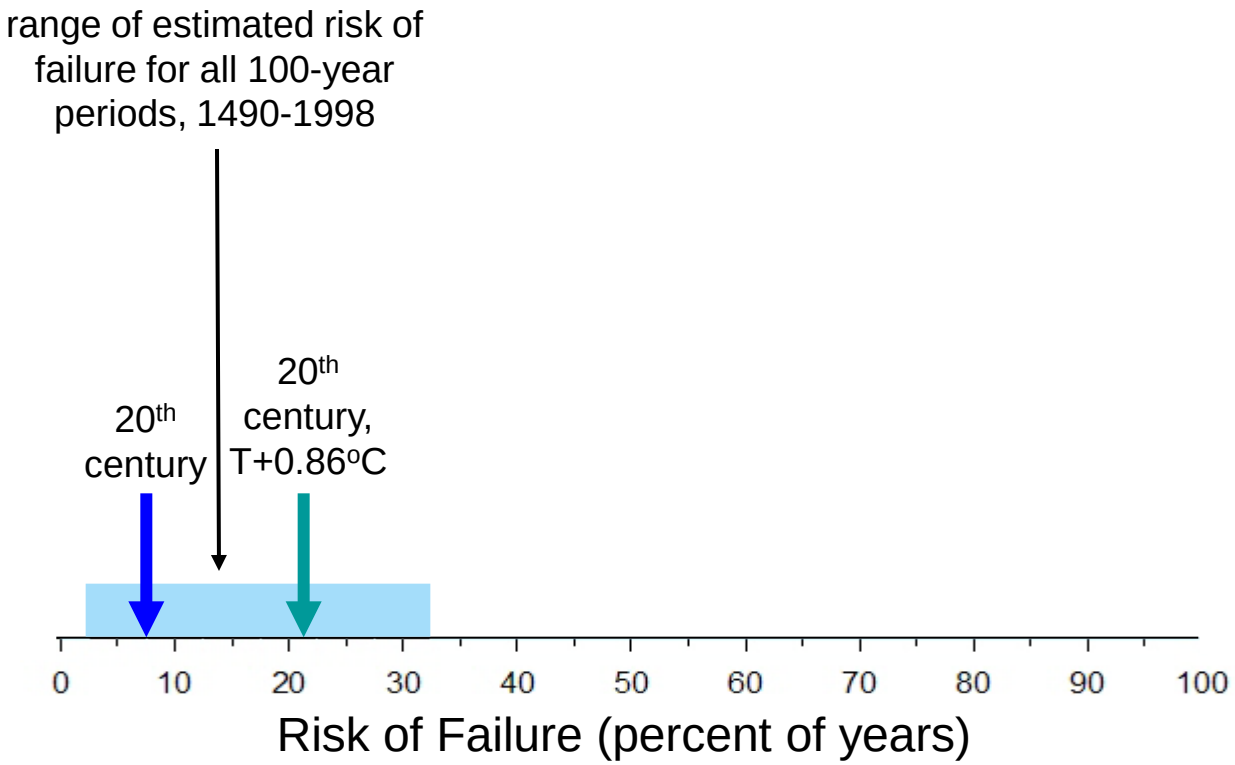

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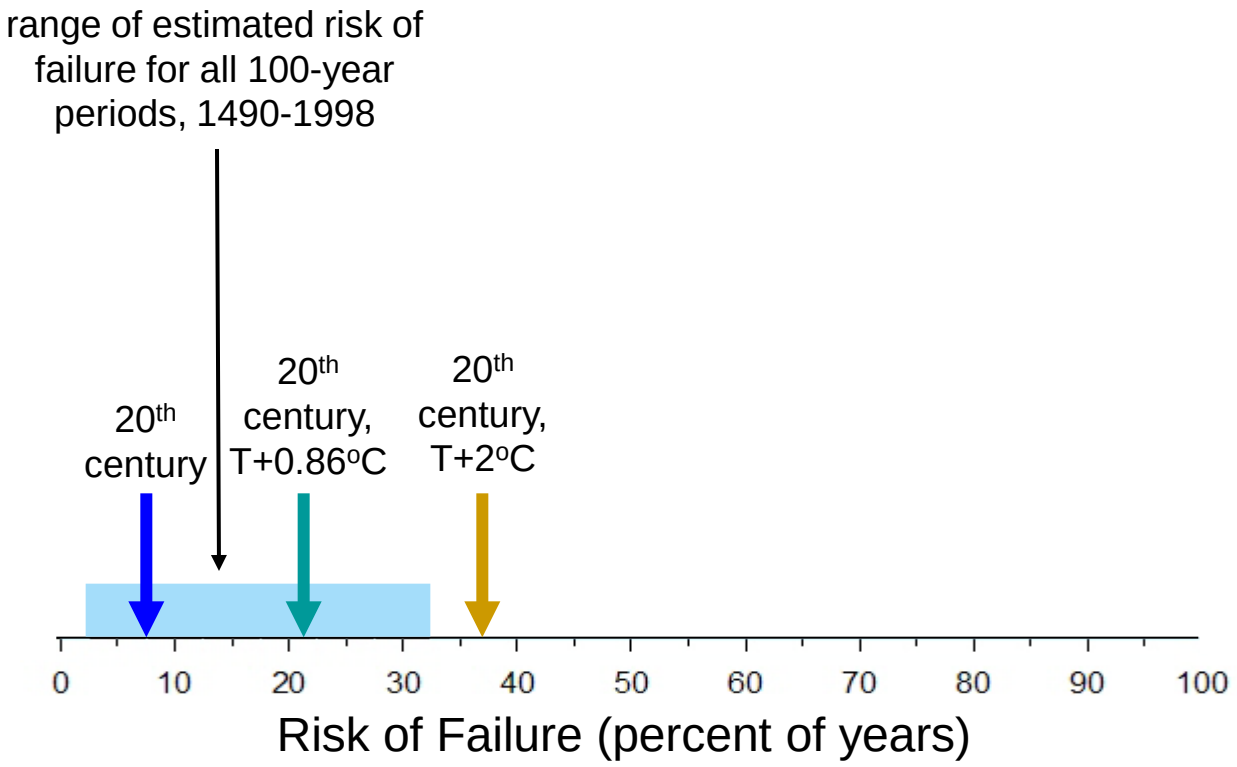

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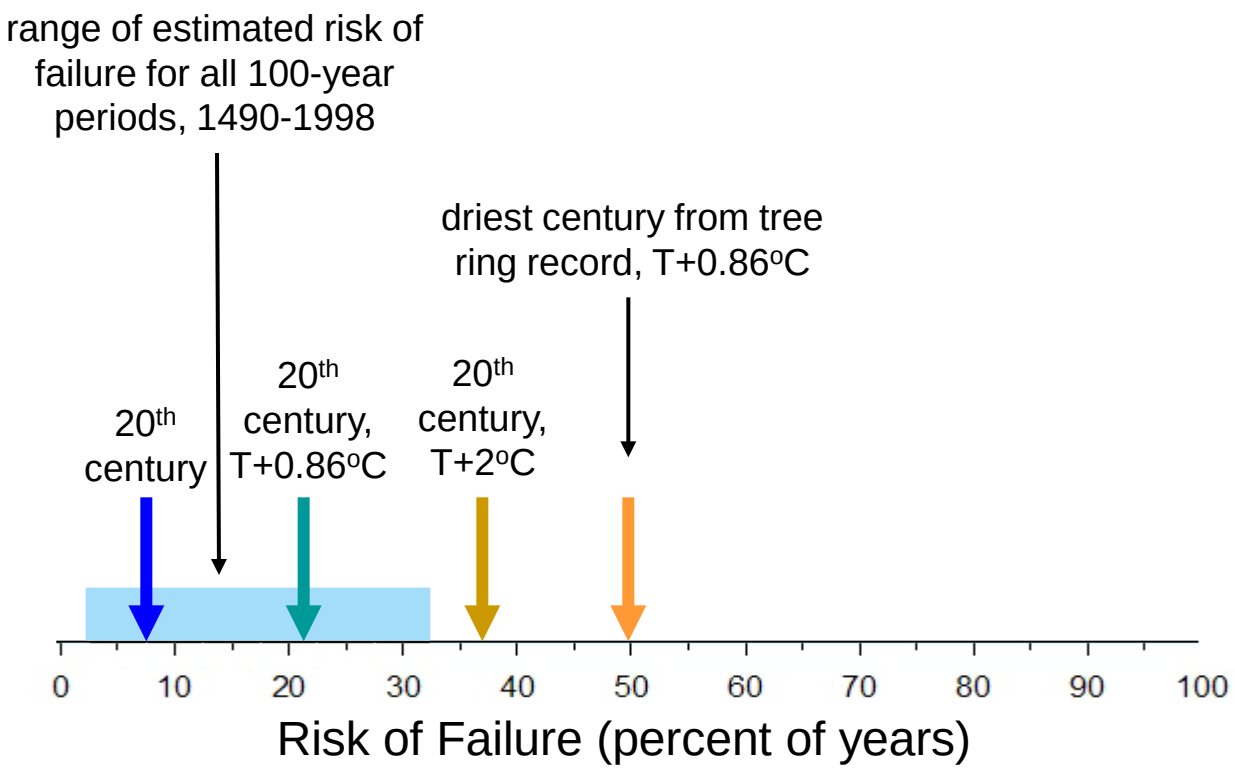

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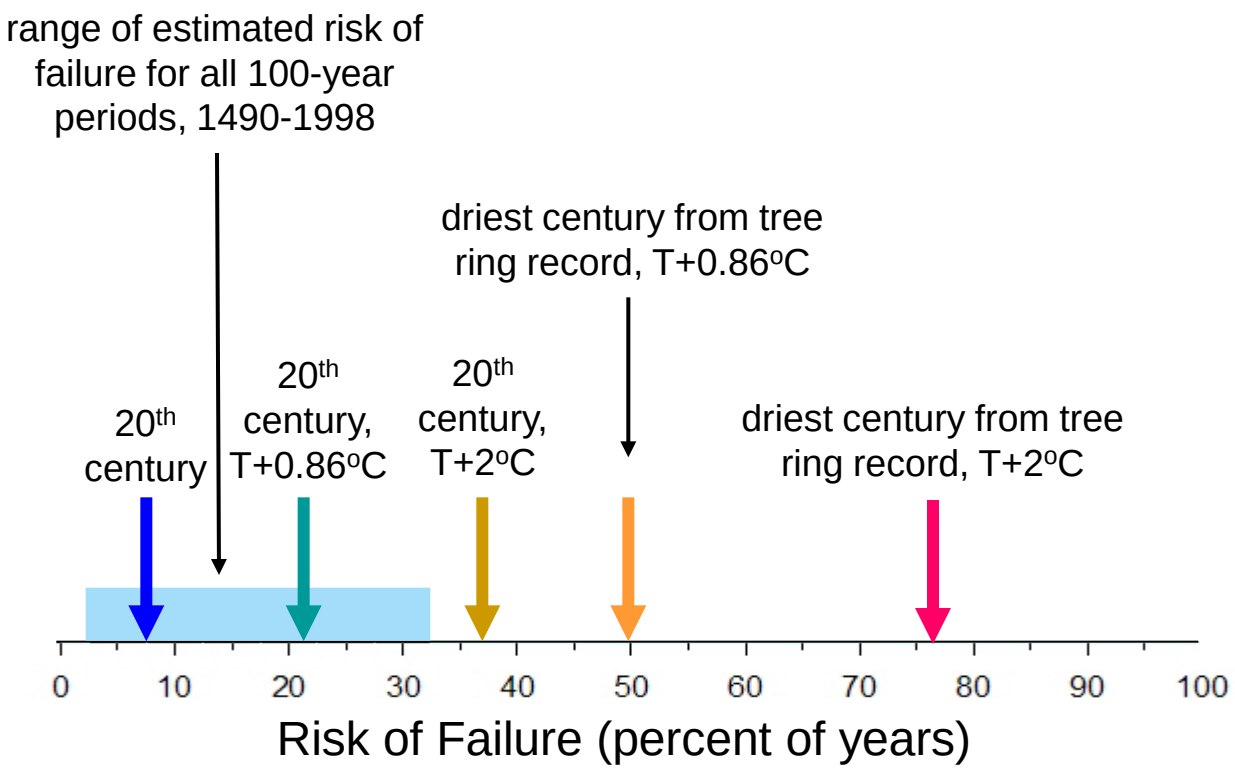

McCabe and Wolock, Geophysical Research Letters, 2007

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For some scenarios even increasing reservoir storage capacity will not mitigate the effects of increased temperatures.

Fraction of time the water-year flow of the UCRB fails to meet the delivery obligations of the Colorado Compact

Scenario	Current reservoir storage	Unlimited reservoir storage
20th century	0.07	0.00
20th century, T+0.86ºC	0.22	0.15
20th century, T+2ºC	0.37	0.37
Driest century	0.30	0.12
Driest century, T+0.86ºC	0.50	0.49
Driest century, T+2ºC	0.77	0.77

McCabe and Wolock, 2007, GRL

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Summary

The consumptive use of water in the Colorado River basin may have already exceeded natural supply.

Given current consumptive water use, small additional increases in temperature likely will result in water shortages in the Colorado River basin.

Unless temperature increases are less than 1°C, increasing reservoir storage capacity in the UCRB likely will not mitigate the effects of increased temperatures on water supply.

Reductions in water use may be the most effective way to mitigate the effects of increasing temperatures on water supply in the Colorado River Basin.

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Future of Colorado water supply

Coutesy of T. Barnett, Scripps Inst. of Oceanography

Current water use in the Colorado River Basin likely <u>is not sustainable</u> under a warmer climate.

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Is a drier Colorado River basin on the horizon?

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