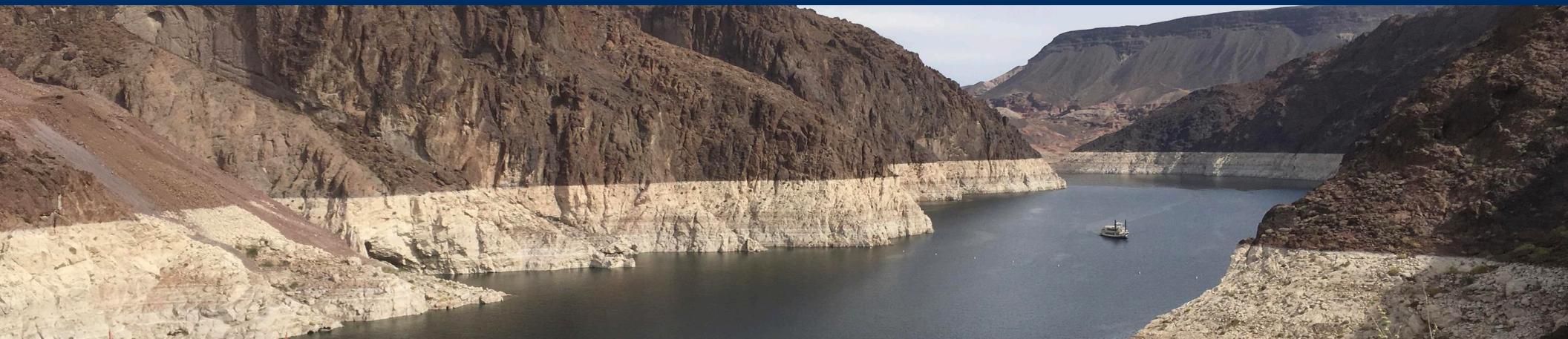


# The Colorado River and the Future

## The “Full Suite” of Assumptions



Jonathan Overpeck  
Samuel A. Graham Dean and William B. Stapp Collegiate Professor  
School for Environment and Sustainability  
University of Michigan



# *The Black Swan*



Outlier, high impact,  
not predictable  
(Taleb, 2007)

(or... what could possibly go wrong?)

See NEW Policy Report from the CO River Research Group:  
*Thinking About Risk on the Colorado River* (May 2019)



**Overview of presentation (i.e., swan watching...)**

**Aridification:** acknowledging political reality and tails

**Megadrought:** a black swan until we're ready for it?

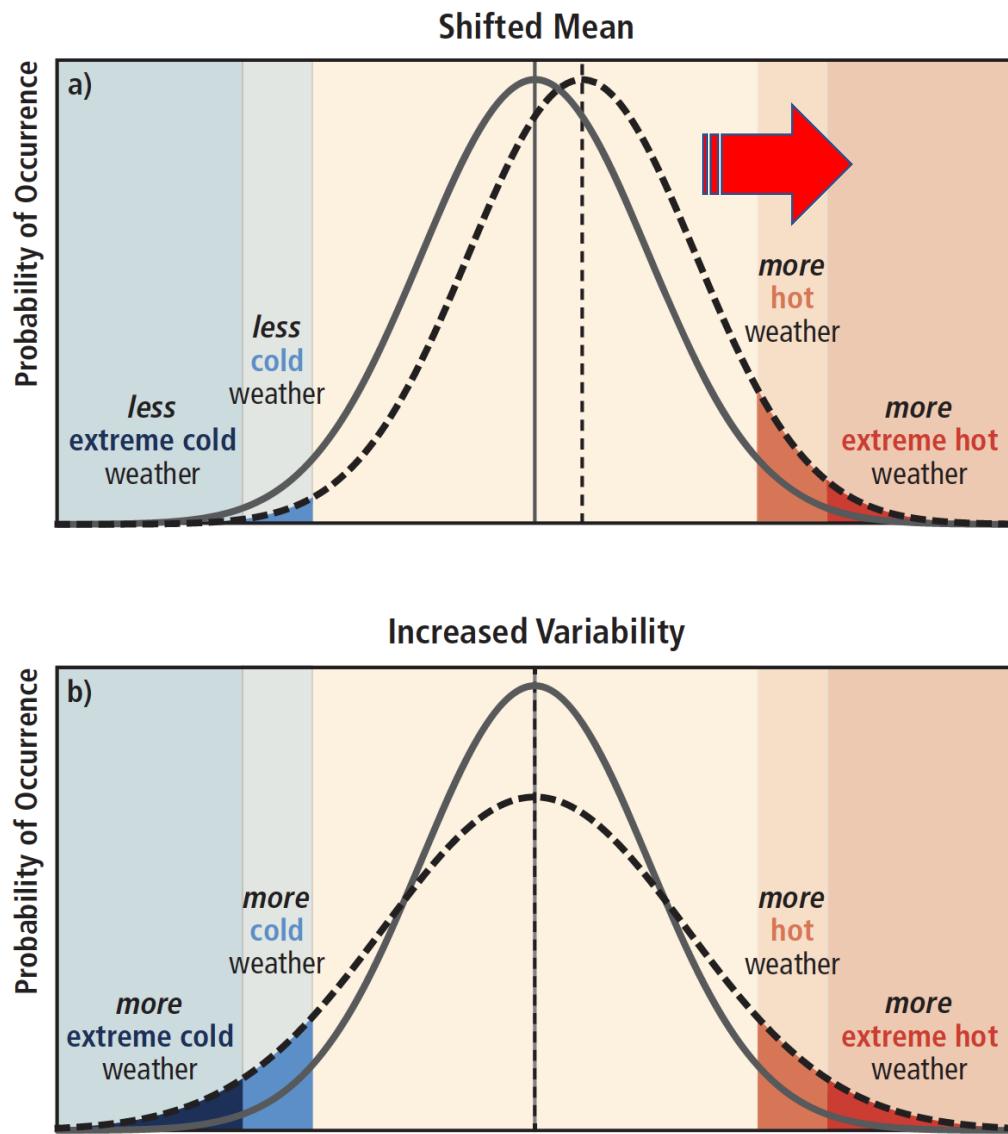
**Mega-flood:** mega-pluvial + warming supercharged extremes

**What else?**

Political reality check  
(we're not even close to on-track for a +2°C world)

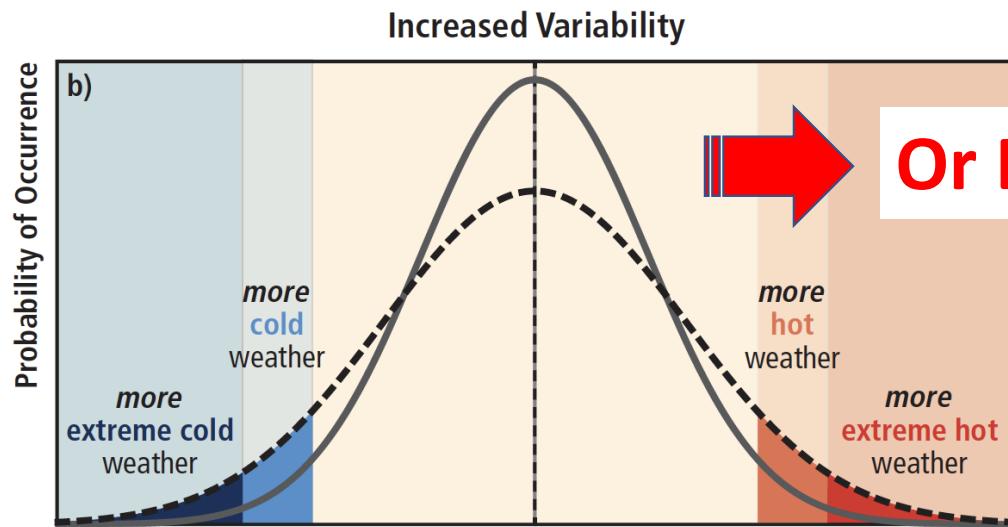
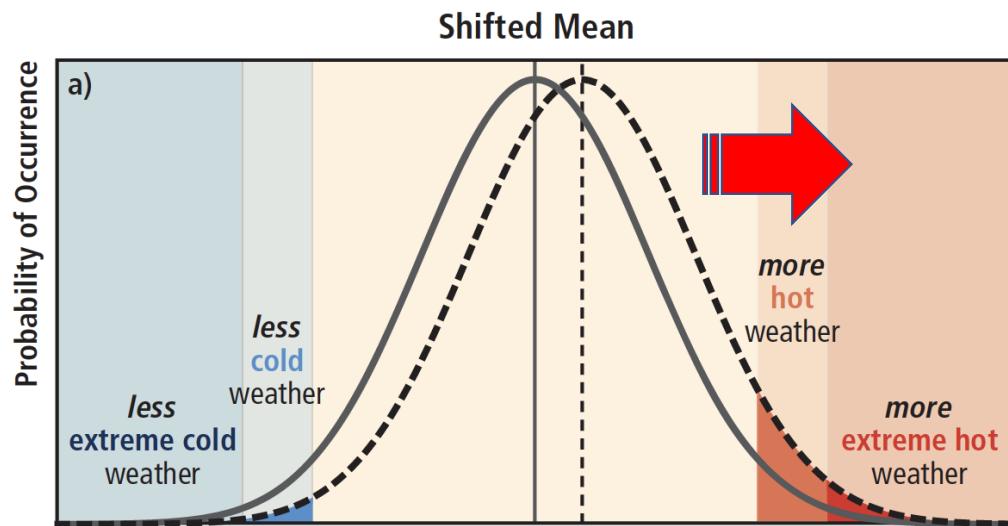
tipping points  
(could preclude a +2-3°C world)

and tails  
(low probability, high impact events)



Works for  
temperature,  
precipitation and  
more

NAS/NRC, 2016, After IPCC, 2012

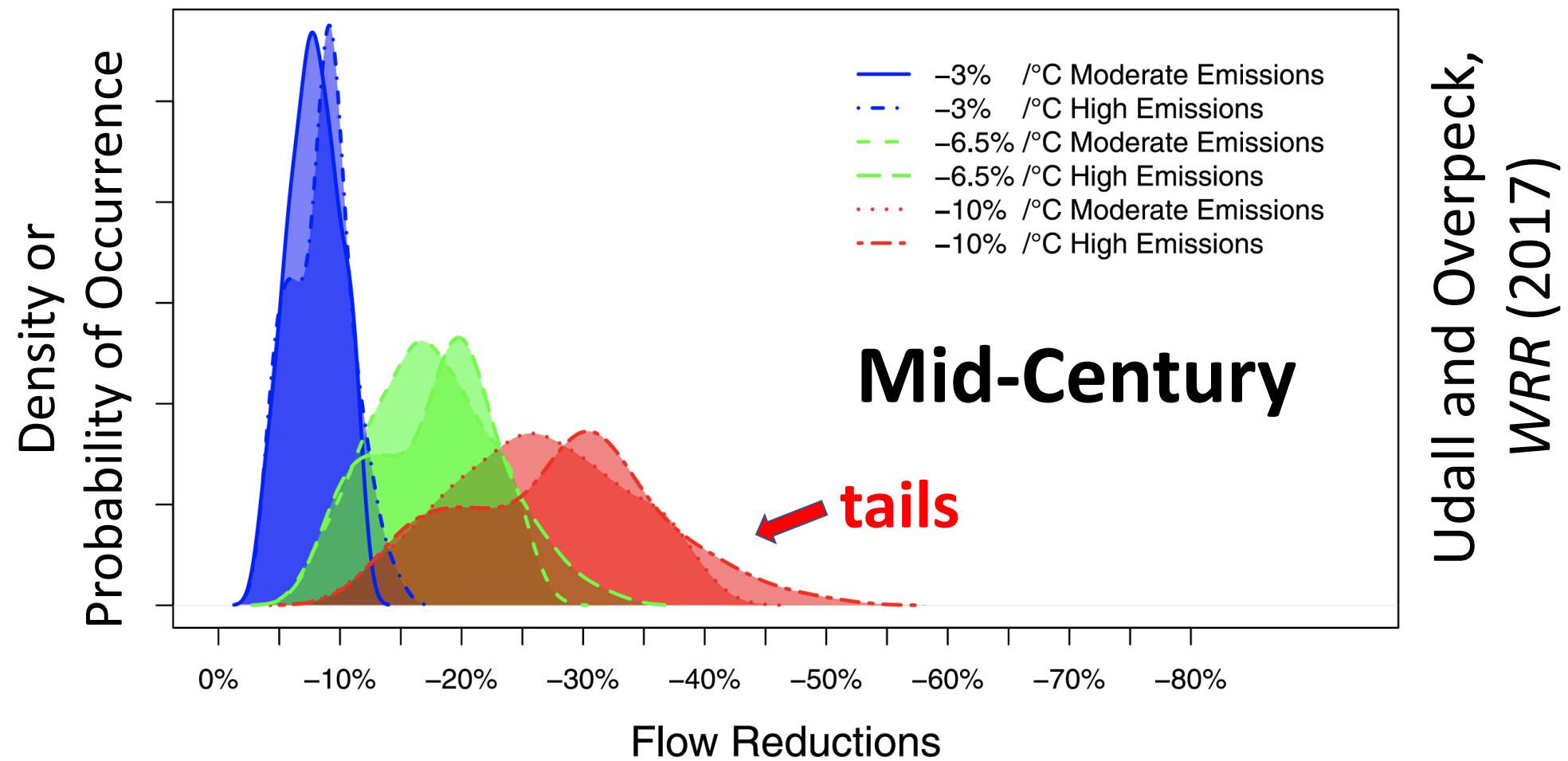


Works for  
temperature,  
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more

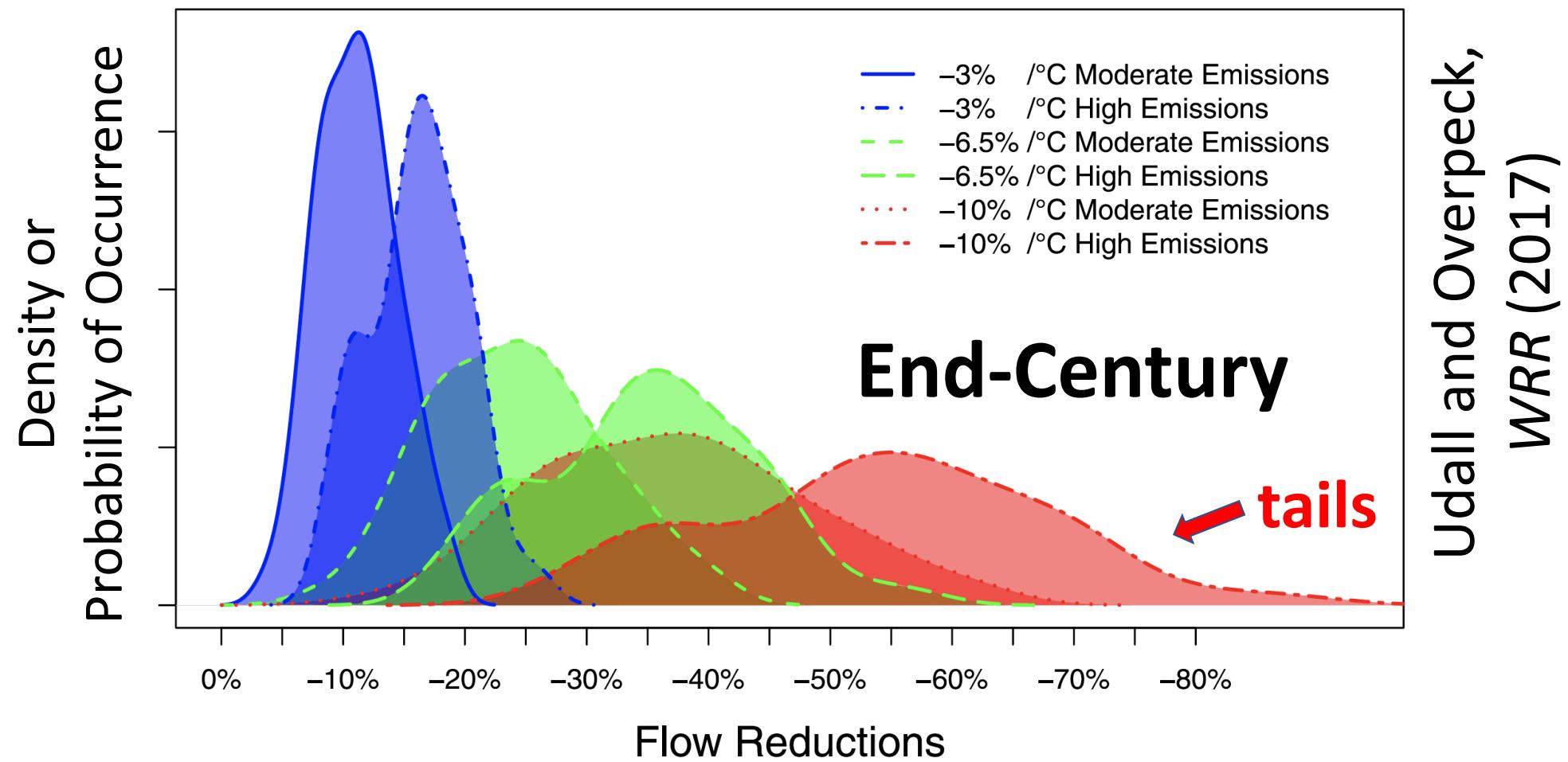
Or Both

NAS/NRC, 2016, After IPCC, 2012

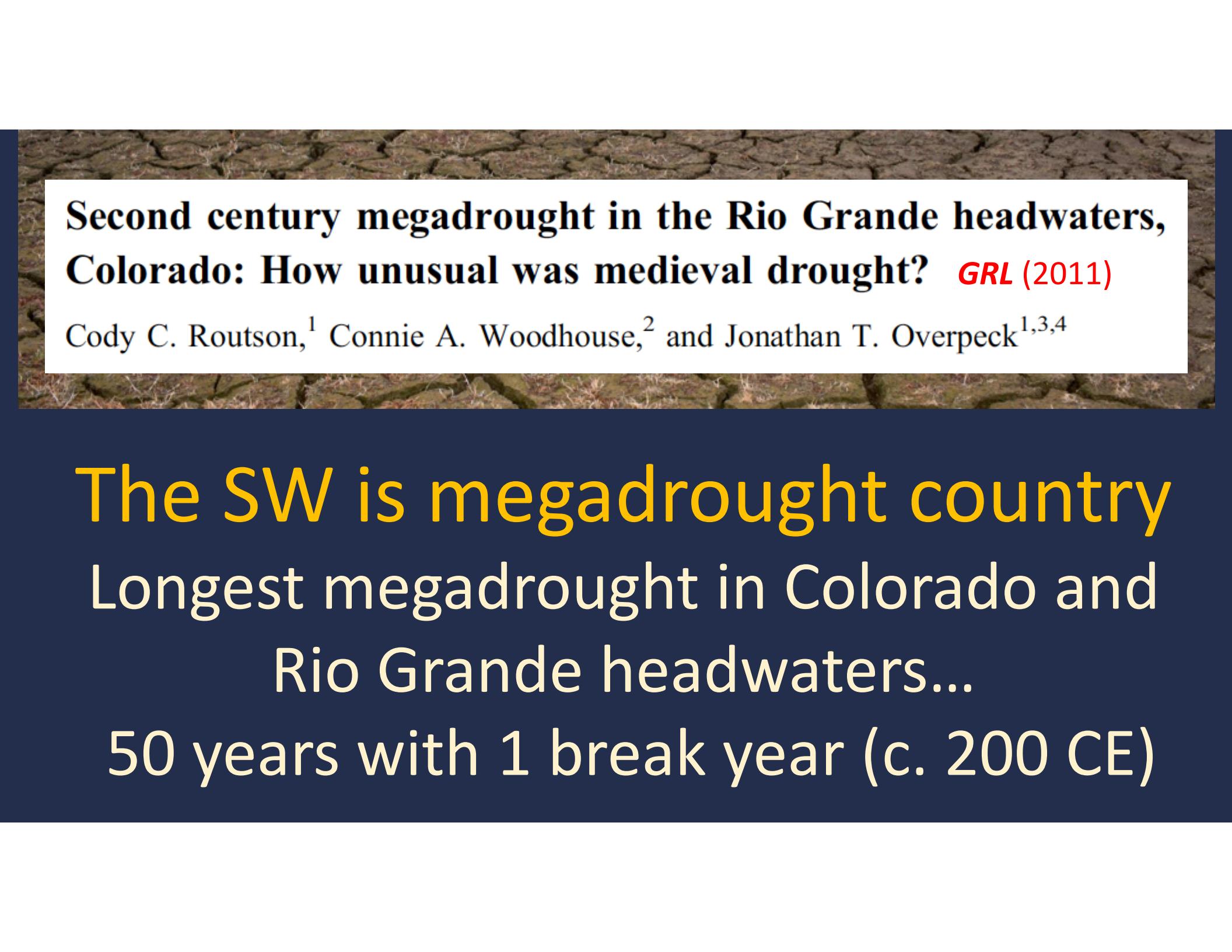
# Projected Temperature-driven Colorado River Flow Reductions



# Projected Temperature-driven Colorado River Flow Reductions



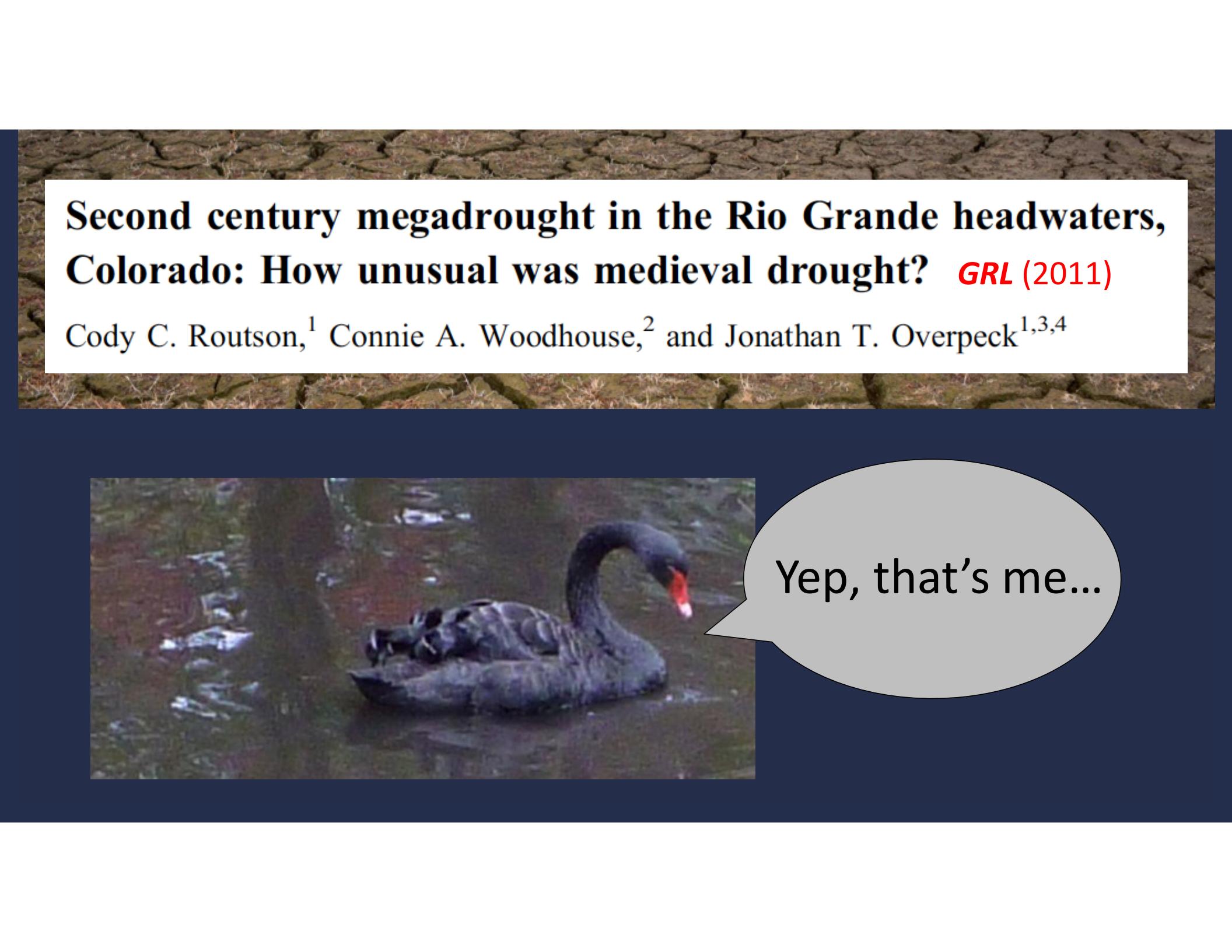
# Megadrought (are we really ready for it?)



## **Second century megadrought in the Rio Grande headwaters, Colorado: How unusual was medieval drought? *GRL* (2011)**

Cody C. Routson,<sup>1</sup> Connie A. Woodhouse,<sup>2</sup> and Jonathan T. Overpeck<sup>1,3,4</sup>

The SW is megadrought country  
Longest megadrought in Colorado and  
Rio Grande headwaters...  
50 years with 1 break year (c. 200 CE)



## **Second century megadrought in the Rio Grande headwaters, Colorado: How unusual was medieval drought? *GRL* (2011)**

Cody C. Routson,<sup>1</sup> Connie A. Woodhouse,<sup>2</sup> and Jonathan T. Overpeck<sup>1,3,4</sup>



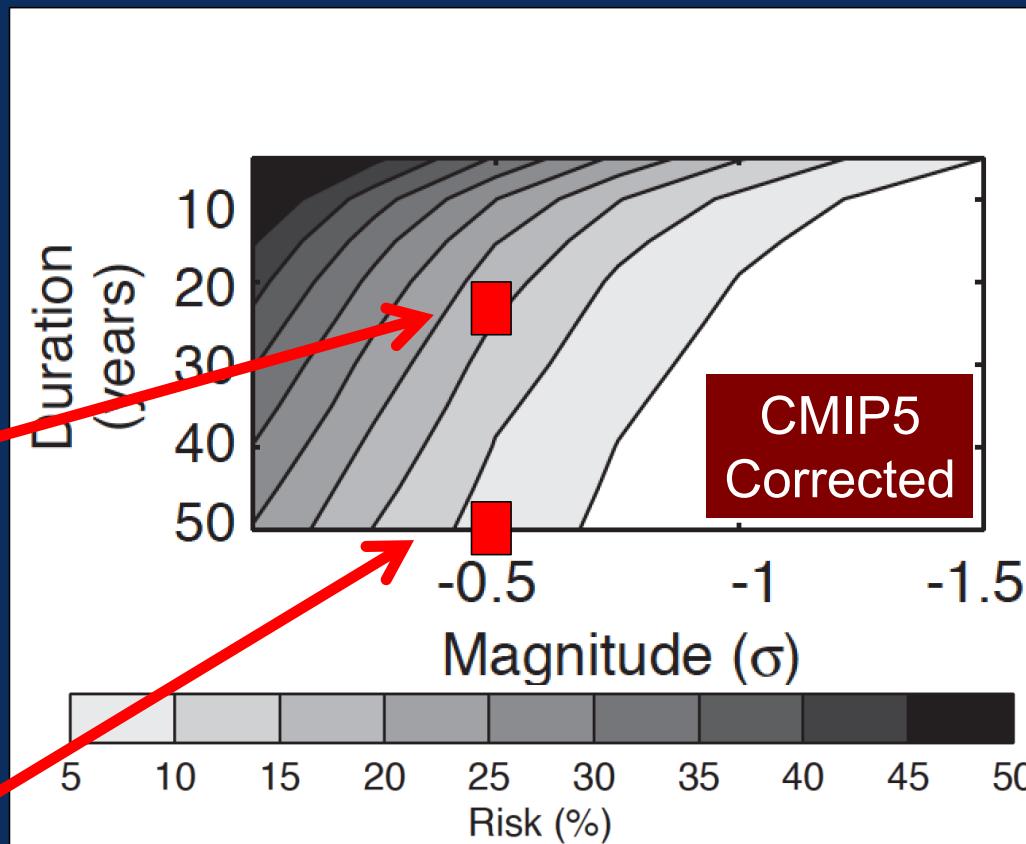
Yep, that's me...

Second half  
21<sup>st</sup> century  
SW U.S.

*Risk of a 25-yr  
megadrought*  
8% → 17%

*Risk of a 50-yr  
megadrought*  
0% → 8%

Bias-corrected megadrought projection



Ault, Cole, Overpeck et al.  
*Journal of Climate* (2014)

So far, climate change isn't increasing mean snowpack in the Upper Basin, and even if it does, it can be negated by drought and megadrought

Thus, warming-driven flow reductions  
**PLUS** megadrought must be a growing  
concern

**>50%** + **>15%**  
**less water in rivers**

Due to temperature driven  
flow reductions alone

(Udall and Overpeck, *Water Resources  
Research* (2017))

**less water in rivers**

Even if average  
precipitation goes up,  
we will still get **droughts**  
and **megadroughts**

**Megaflood:** mega-pluvial +  
warming supercharged extreme

## What if:

We get another multi-year pluvial? (likely)

Do we divert water to more users? Do we refill Powell and Mead?

We **add** snowpack ca. 600-700% or more above normal? (likely)

Paleoclimate data suggest this can happen naturally

+ warming atmosphere can dump more snow if dynamics are right

We **add** an extreme summer rainfall event to get flood >2x size  
of largest ever recorded (i.e., 6250 m<sup>3</sup>/s at Lee's Ferry in  
1921)\* (plausible)

Paleo data indicate event >14,000 m<sup>3</sup>/s (1600-1200 yr BP)

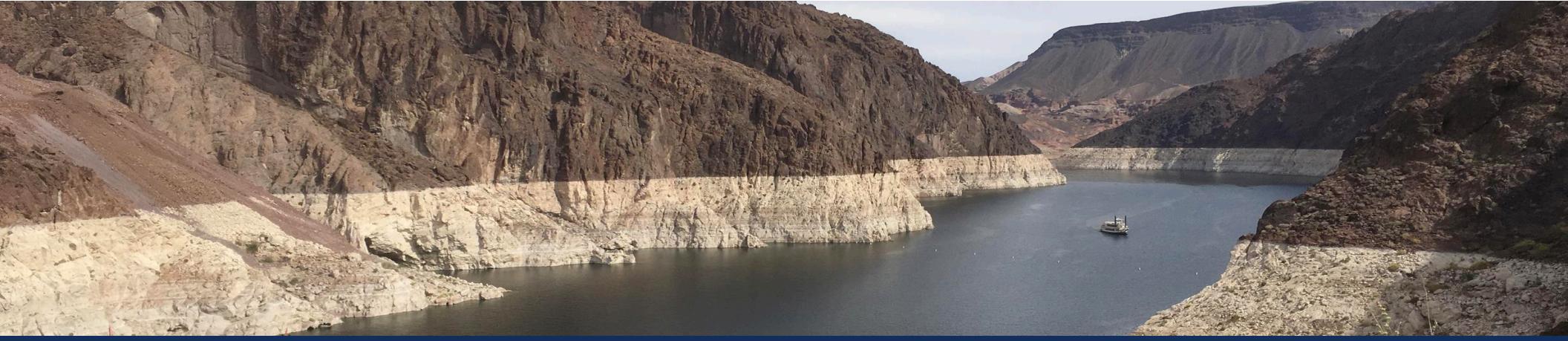
Again, warming atmosphere makes such an event more likely

\*Greenbaum et al., *WRR.* (2014); O'Connor et al. *J. Geology* (1994)

# Megafood



Yep, that's me...



## *The Colorado River and the Future...*

- Don't assume future warming will be multi-model ensemble average
- Don't assume runoff sensitivity to future warming will be modest
- Be ready for multidecadal droughts and pluvials
- Be ready for warming-supercharged snowpack and rainfall events
- **Regularly brainstorm possible Black Swans** (cascading groundwater crises anyone; disruption of CA water distribution by earthquake)?

A photograph of a lighthouse silhouette against a vibrant orange sunset sky. The lighthouse is dark and stands on a small pier or foundation in the water. The ocean in the foreground is a deep blue.

Thanks!



@GreatLakesPeck