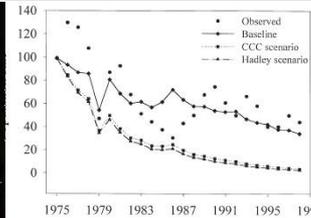




# Scarce western water is about to get scarcer

## What are the implications for freshwater ecosystems?

Jill Baron, US Geological Survey  
Colorado State University  
Fort Collins CO

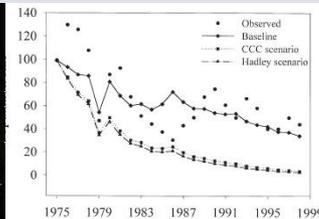




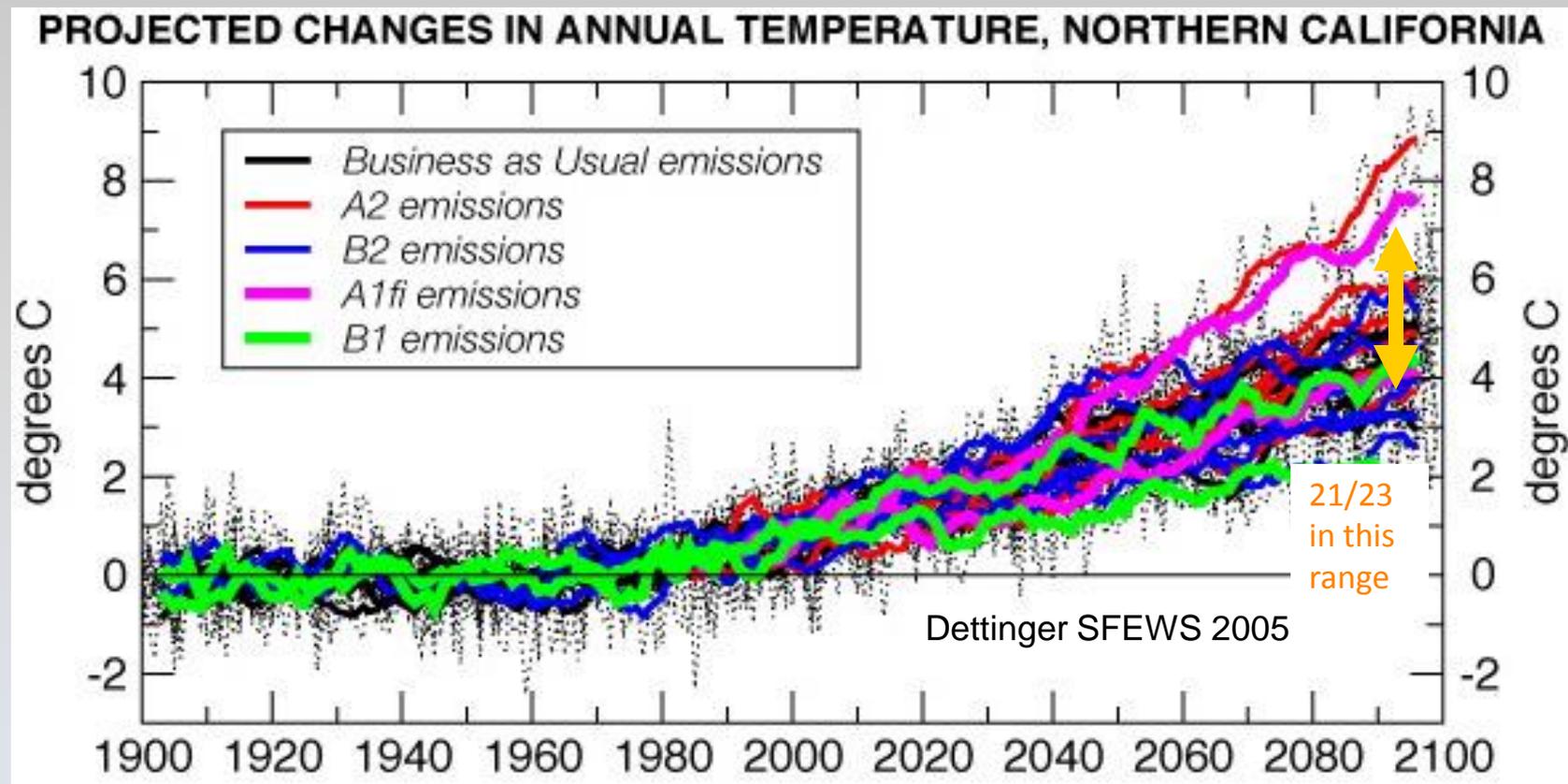
# Punchline

There will not be enough water in the West to satisfy all human and environmental needs

Proactive management can help protect freshwaters and the services they provide



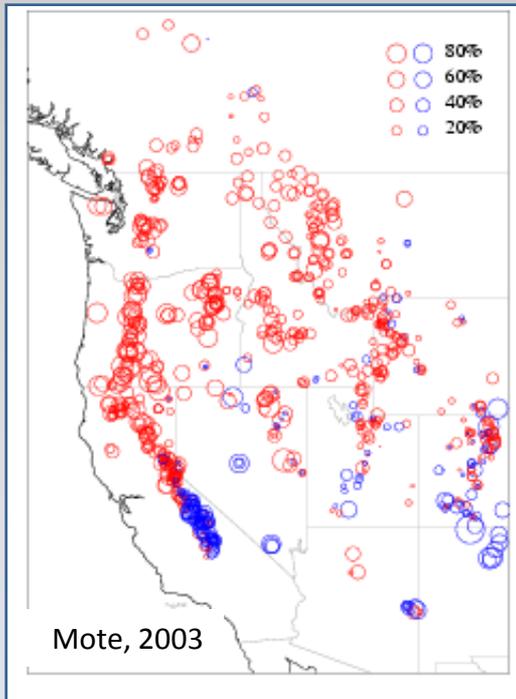
In response to historical and projected greenhouse-gas emissions, current climate models consistently **project warming for the West.**



*They also suggest that changes should already be underway and that TRULY major changes may be only about 20 years away...*

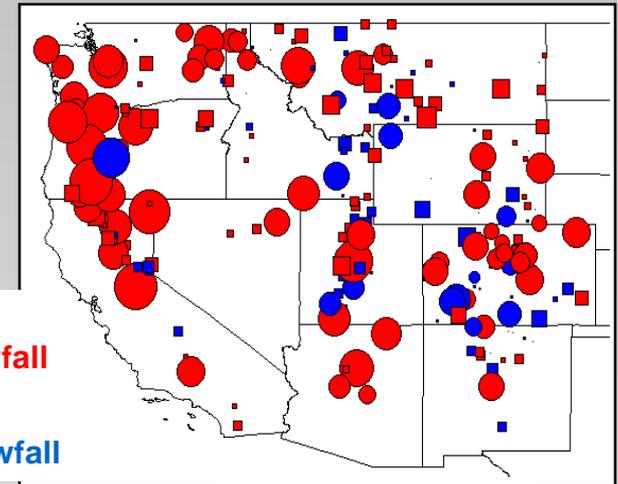
# Significant hydroclimatic changes already

Less snow/more rain



-2.2 std devs  
LESS as snowfall

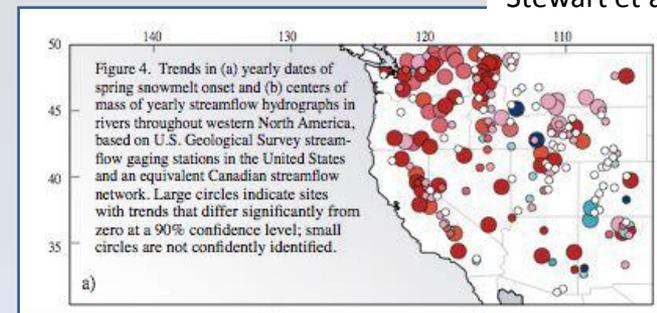
+1 std dev  
MORE as snowfall



Knowles et al., 2006

Less spring snowpack  
Trends (1950-1997) in  
Apr 1 snow-water

Stewart et al., 2005

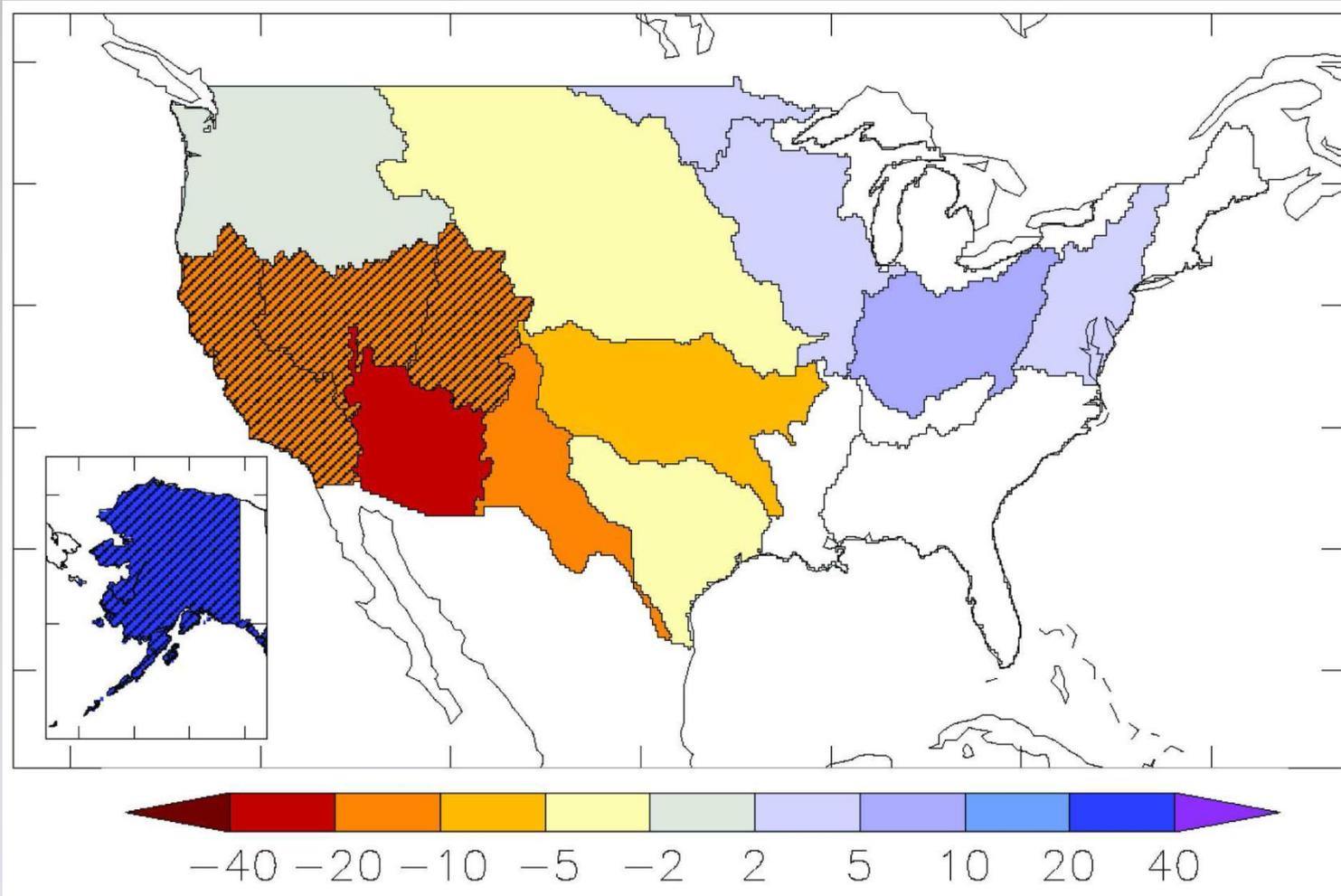


# What are expected climate and climate-derived changes in the West?

↑	Temperatures
↑	Earlier Snowmelt
↓	Snowpack
↑	Evapotranspiration
↑	Drought severity and length
↑	Extreme precipitation events

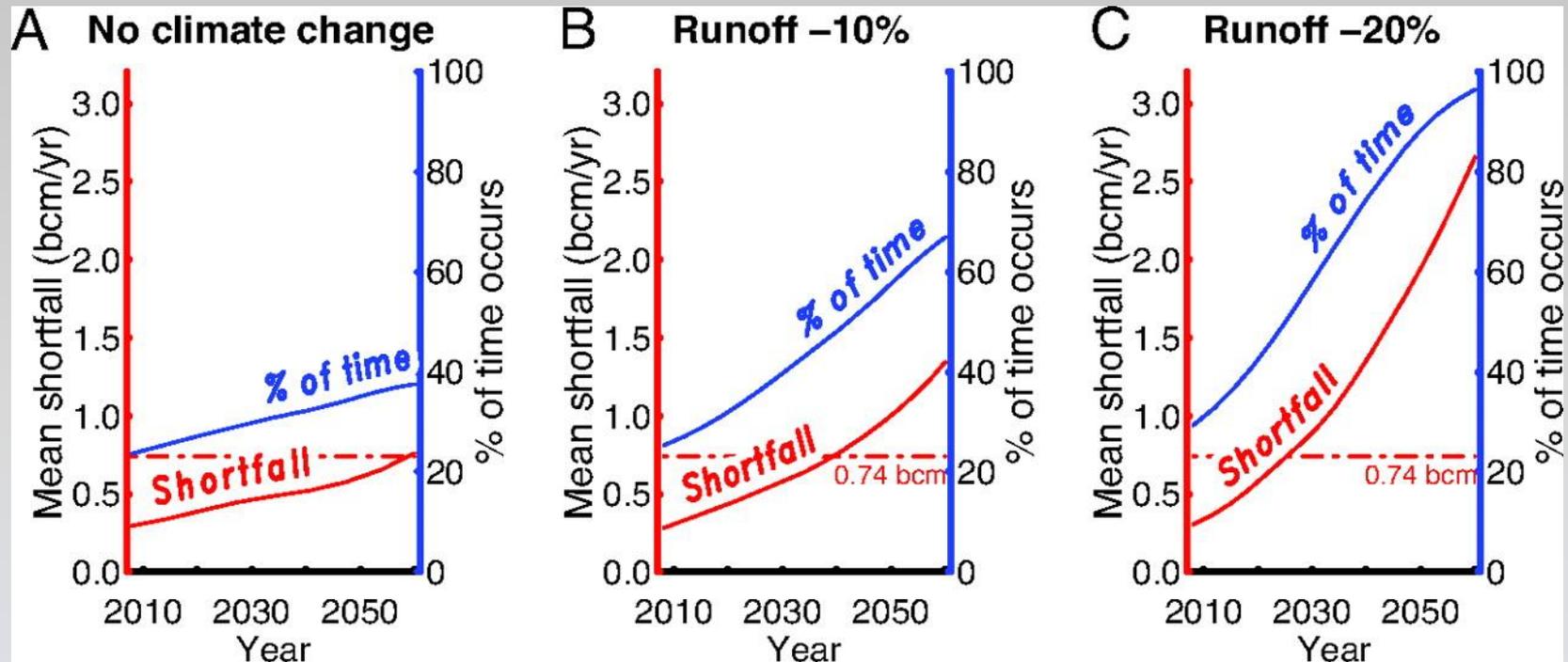


# Projected Changes in Annual Runoff, 2041-2060



Percentage change relative to 1900-1970 baseline. Any color indicates >66% of models agree on sign of change; diagonal hatching indicates >90% agreement.

# Colorado River projected to be severely short of deliverable water with ANY decline in runoff

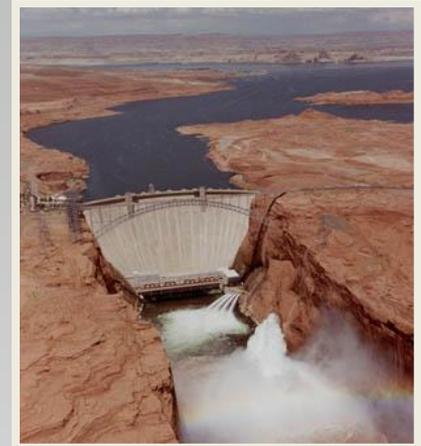


Probability of experiencing delivery shortages (blue, %), and the mean delivery shortage (red, bcm/yr), for the cases with no climate change (A) and a reduction in Colorado River runoff of 10% (B) and 20% (C)



# What are the implications for freshwater ecosystems?





Freshwaters already affected by human actions including development, dams, extractive uses, species manipulations and pollution



# Combined effects of human influence and climate change

- Reduce water quality
- Shrink bird and fish migration corridors
- Trout and salmon fisheries likely to contract by 40-60%



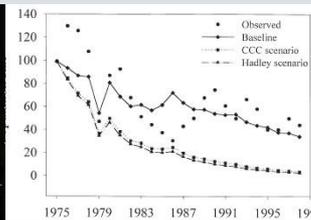
Map from maps.com





# How do we protect freshwater ecosystems?

Freshwater ecosystems and their services should be explicitly considered in decisions affecting future western waters



# Adapting to Climate Change: Incorporating Sound Science

- Identify resources and processes at risk from climate change
- Identify climate-related thresholds
- Define reference conditions for protection or restoration
- Monitor and assess the resources and processes



# Adapting to Climate Change: Attend to the Institutions

- Manage *proactively*
  - Alleviate current stresses
  - Manage at the watershed scale, but also have local strategies
    - Protect and restore river corridors
    - Practice conjunctive ground/surface water management
    - Secure beneficial flows for freshwaters
    - Protect and replicate habitats

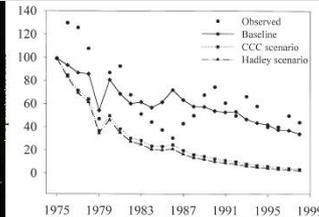




# Punchline

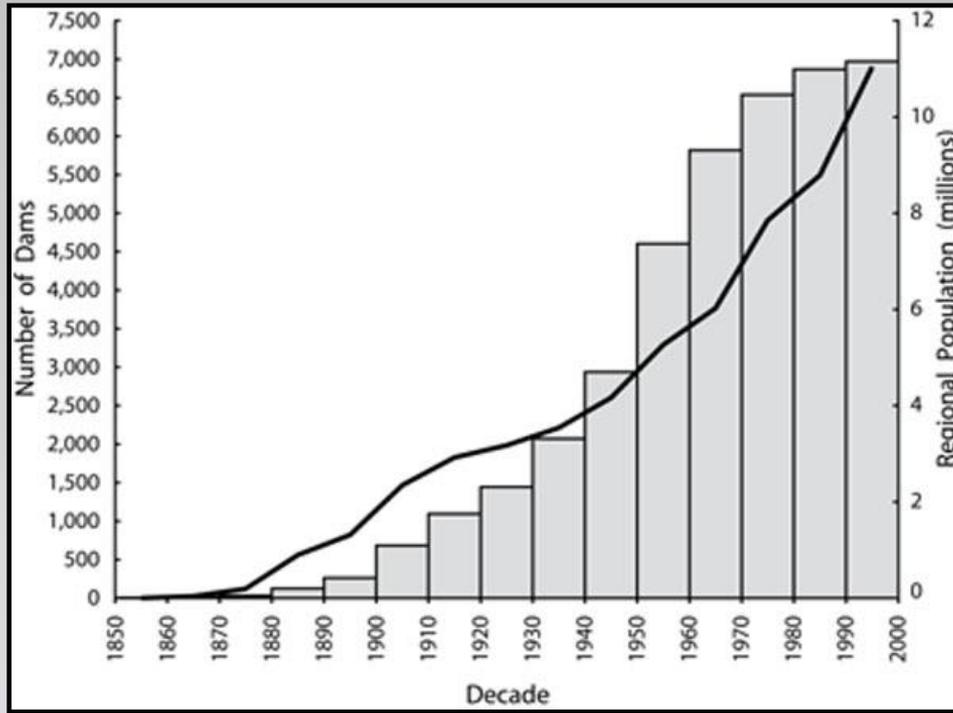
There will not be enough water  
in the West to satisfy all human and  
environmental needs

Proactive management can help  
protect freshwaters  
and the services they provide





# Western water is appropriated for societal use



“...in a very few decades all the waters of the arid region of the United States would be used for irrigation purposes.”

John Wesley Powell 1867  
(as reported in deBuys 2001)

In Colorado, 67,747 separate points of water diversion.

Decreed water allotments total >2.2 trillion m<sup>3</sup>/yr (1.8 billion acre-ft.)

The allotment is more than 150 times the historical mean annual runoff for the entire state.