

# Future Southwest Climate: A Betting Guide

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## Outline of the talk:

- (1) Focus on the *threats*, natural and otherwise
- (2) Highlight that changes are *already underway*
- (3) A (very) little on what can be done about the threats



Source: Phil Pasteris, Global Water Resources. April 16, 2009

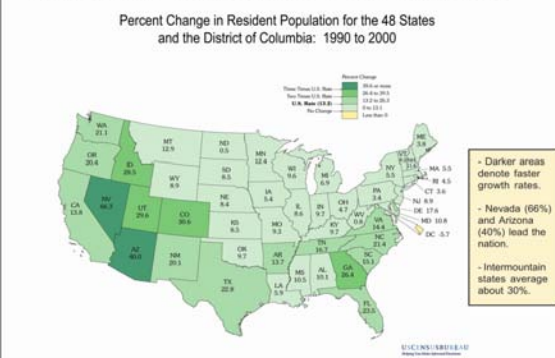
## The Southwest and the Perfect Storm Ahead...

### The big threats...

- 1) SW includes the fastest growing states of the U.S.
- 2) Water is over-allocated in many watersheds
- 3) Major climate change is already underway
- 4) Droughts unprecedented in last 100 years are likely
- 5) Major landscape transformations have started (optional topic)

## The population of some SW states slated to double by 2030...

Demographic Changes: Population Has Grown Fastest in the West, Particularly in the "Public Land States"

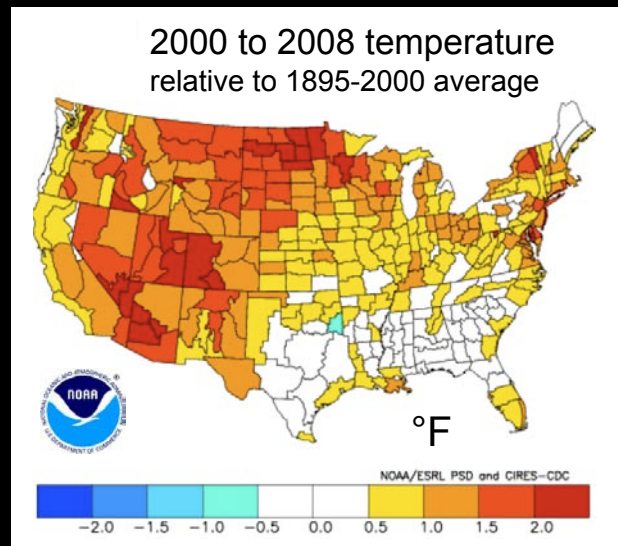


Source: U.S. Census Bureau

## A key observation – the West is warming

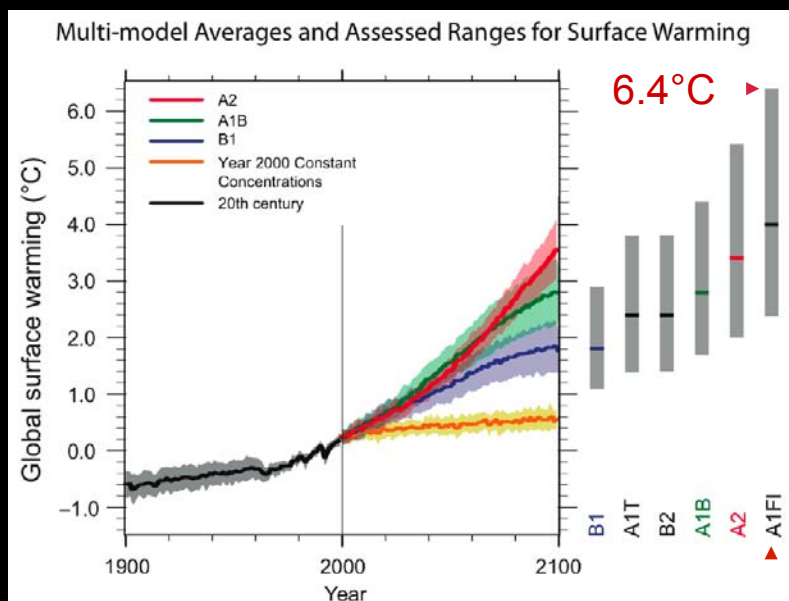
Parts of the West have **already** warmed more than 2°F relative to average 20th century temperatures...

The Southwest is among the most rapidly warming regions of the world



IPCC, 2007

... and it's going to get worse...



Likely warming depends on emissions scenario

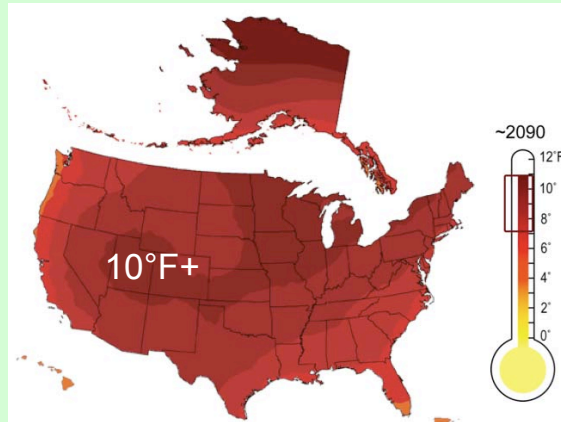
Presently increasing faster than the A2 or A1FI scenario

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*The warming will continue to the extent we allow it to...*



Forced by SRES A1FI - Karl et al., (2009)

## What's ahead in the West? (besides more people)

**Depends on... emissions, and understanding uncertainty, but...**

**Warmer** – sure bet (*already happening*)

... and warming is a primary driver of other things near and dear to the Colorado River Basin

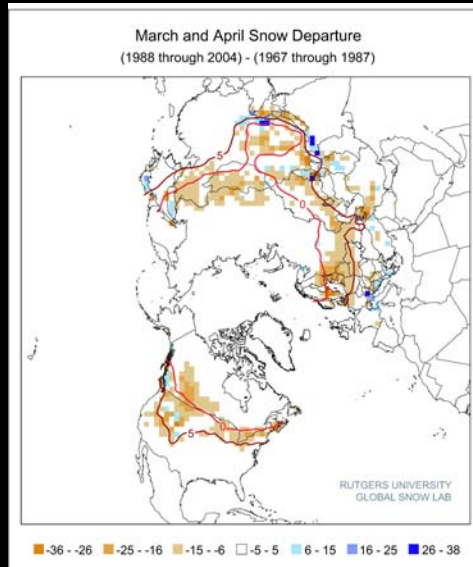


# What's ahead in the West? (besides more people)

Depends on... emissions, and understanding uncertainty, but...

Warmer – sure bet  
*(already happening)*

**Less snow** – good odds,  
especially in spring  
*(already happening)*



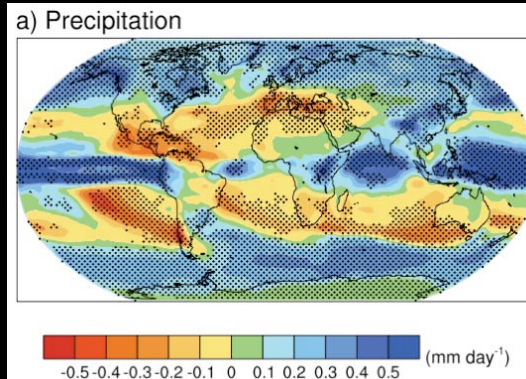
# What's ahead in the West? (besides more people)

Depends on... emissions, and understanding uncertainty, but...

Warmer – sure bet

Less snow – good odds

**Less late winter precip** –  
likely, decent odds too  
*again, all already  
happening...*



## What's ahead in the West? (besides more people)

Depends on... emissions, and understanding uncertainty, but...

Warmer – sure bet

Less snow – good odds

Less late winter precip – likely, decent odds too

**Less streamflow** – likely, decent odds too

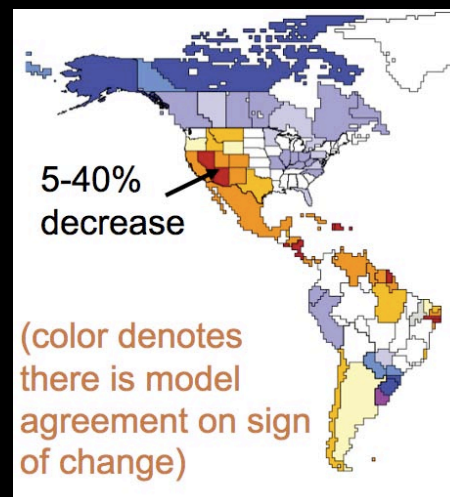
*again, all already happening...*

...even **by mid-century**, and with modest reductions in carbon dioxide emissions, the **Colorado River flow will likely decrease**

### State-of-the-art...

Latest research indicates that the best estimate is a **20% reduction**, and also...

...that there is a **30% chance the Colorado River reservoirs could go to empty by 2050** (all 60 MAF)



Milly et al., 2008; updated by Rajagoplan et al., 2009

## What's ahead in the West? (besides more people)

Depends on... emissions, and understanding uncertainty, but...

Warmer – sure bet

Less snow – good odds

Less soil moisture – good odds in SW especially

Less late winter precip – decent odds

Less streamflow – depends on basin, more likely in many, especially in SW

**More intense precip, more flooding and more drought** – all good odds

## *The Southwest and the Perfect Storm Ahead...*

### **The big threats...**

- 1) SW includes the fastest growing states of the U.S.
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*Decades-long droughts are likely even in absence of climate change*

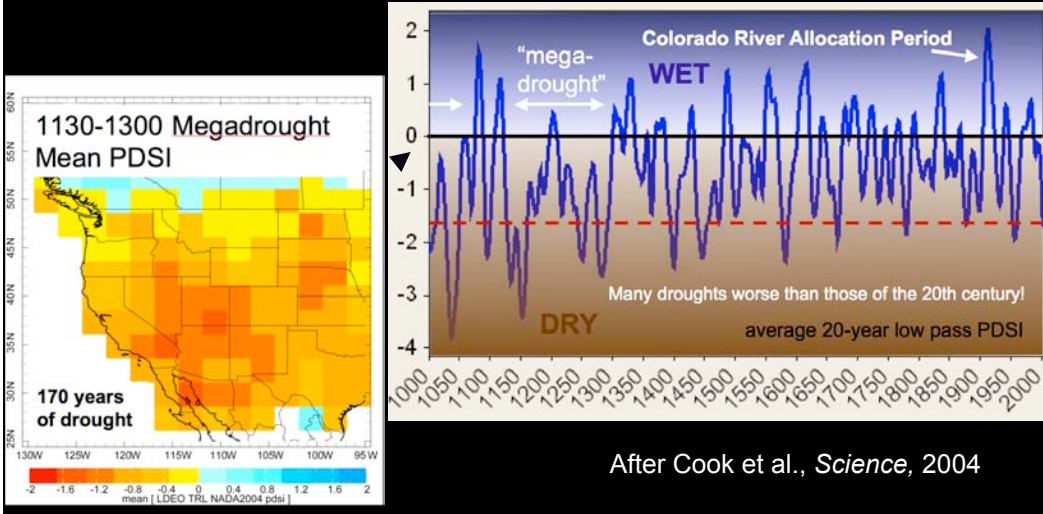


Photo: J. Overpeck



## Another Challenge: **the megadrought threat**

Even in the absence of climate change,  
**decades-long droughts** did, and will continue  
to occur



## What's ahead in the West? (besides more people)

Depends on... emissions, and understanding  
uncertainty, but...

Warmer – sure bet

Less snow – good odds

Less soil moisture – very good odds

Less late winter precip – good odds

Less streamflow – good odds

More intense precip, more flooding and **more  
drought** – good odds

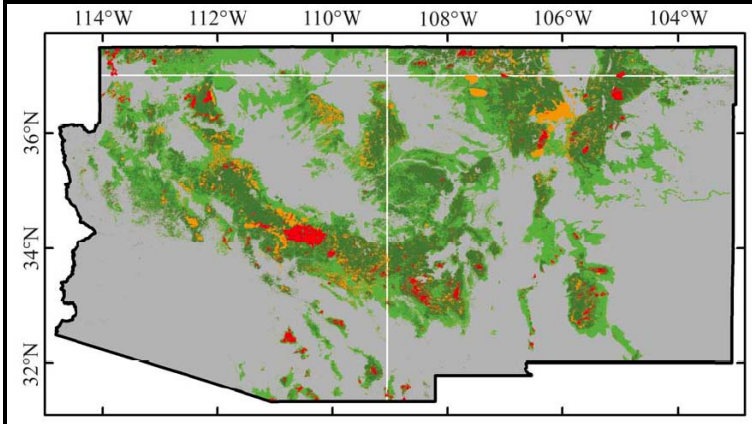
**Major landscape veg transformations** – like betting  
on whether the summer will be warm...

**Title:** Forest responses to increasing aridity and warmth in the southwestern United States adapting to change

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PNAS (in review)



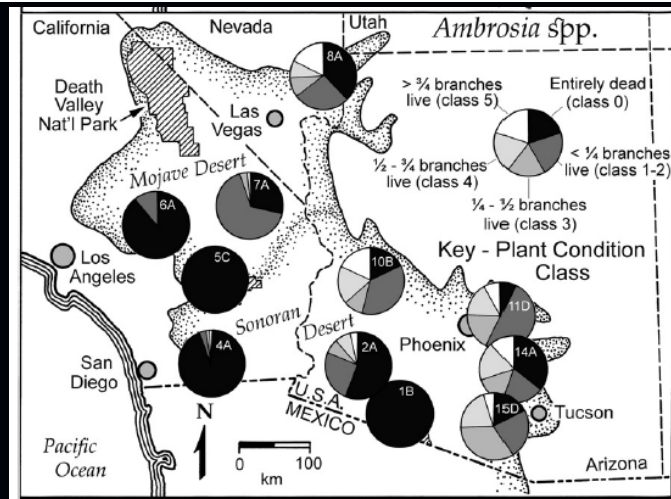
10% forest and woodland death since 1984 in the SW due to:  
 bark beetles (7%)  
 Wildfire (3%)

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Perennial plant mortality in the Sonoran and Mojave deserts in response to severe, multi-year drought

J.R. McAuliffe <sup>a,\*</sup>, E.P. Hamerlynck <sup>b</sup>

Over 20 species of drought-deciduous shrubs sustained high mortality





## *Pulling it together...*

- Global warming (etc.) is very real – and already affecting the Colorado River Basin!
- Humans are causing much of the change - little doubt
- More climate change **and drought** is a sure bet - ***we must develop adaptation capability***

And, of course, we can dial down the climate change via reductions in greenhouse gas emissions



Photo: J. Overpeck



Photo: J. Overpeck