

# The Future of the West: Adapting to a Warmer World



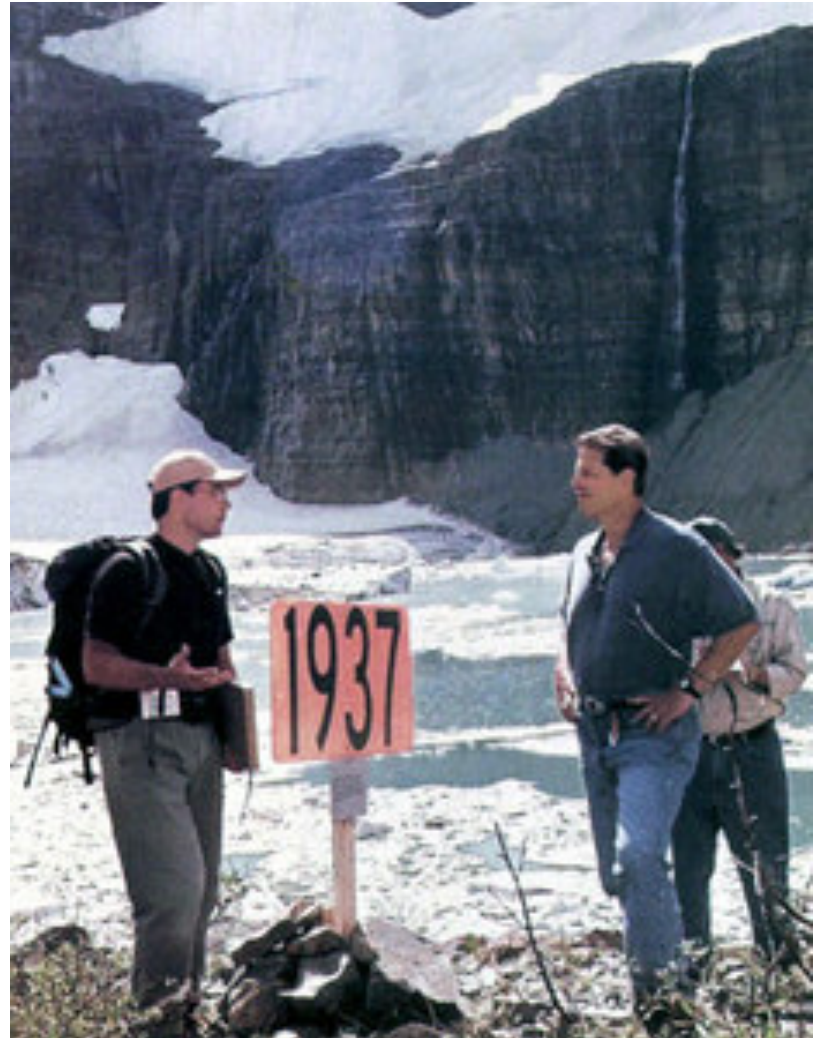
THE UNIVERSITY  
OF ARIZONA®

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School of Natural Resources

# Climate Change or Climate Crisis?

1997: “Climate change and variability”

- Scientists don't agree
- Impacts will be in 2100
- Arctic regions and alpine glaciers are at risk, but not the rest of us



# Climate Change or Climate Crisis?

## 1997: Climate Change

- Scientists don't agree on climate change
- Impacts in 2100
- Arctic and alpine glaciers are at risk

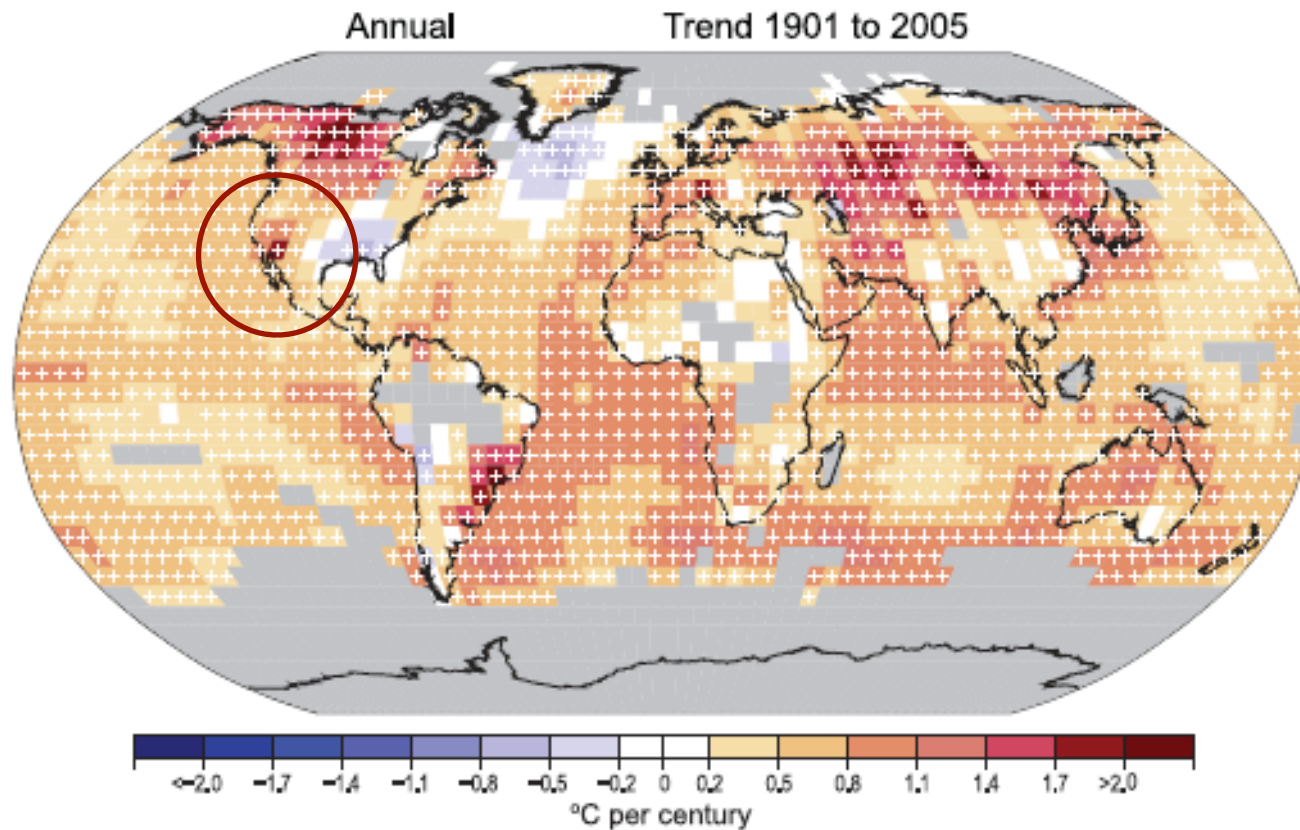
## 2007: Climate Crisis

- Science consensus: global warming is real
- Impacts now
- Vulnerability to climate is widespread, including the West

# Roadmap

- What is the evidence for impacts now?
- Is the Southwest vulnerable?
- Some thoughts on adaptation

# Temperatures are rising in the West



Linear trends in annual temperature,  
1901-2005, IPCC WG I

# Alpine glacier retreat, Glacier NP

ca 1910



*Boulder Glacier, circa 1910  
Morton Elrod photo, courtesy of GNP Archives*

2007

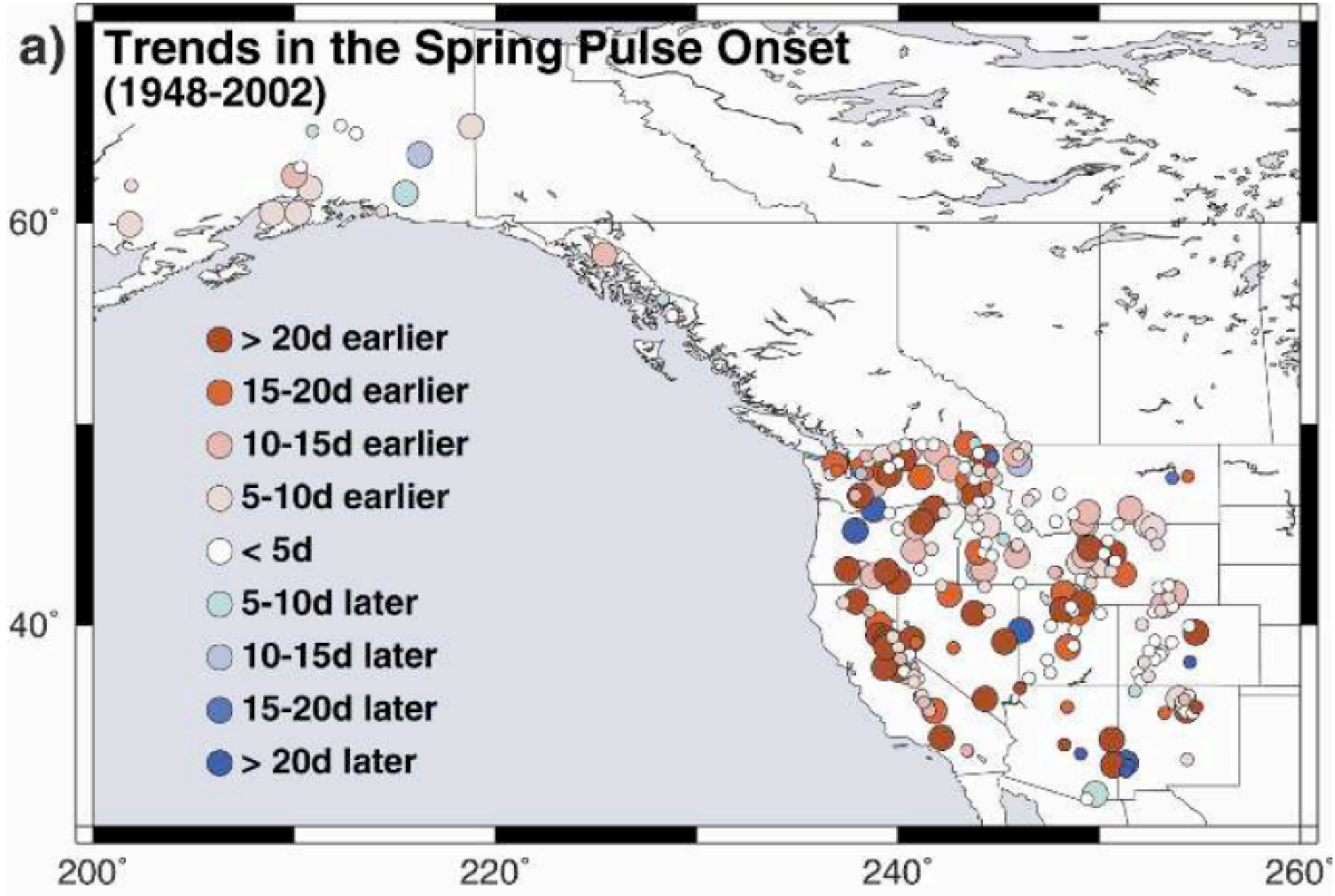


*Boulder Glacier, Aug. 24, 2007  
Fagre / Pederson photo, USGS*

# Warming in the Western US

Abrupt or rapid ecosystem changes, attributable to temperature change, are occurring now:

- snowpack decline
- increased wildfire
- ecological impacts



-- Stewart et al. 2005



# Conventional wisdom: Drought = wildfire

1988: 1.4M acres in Yellowstone



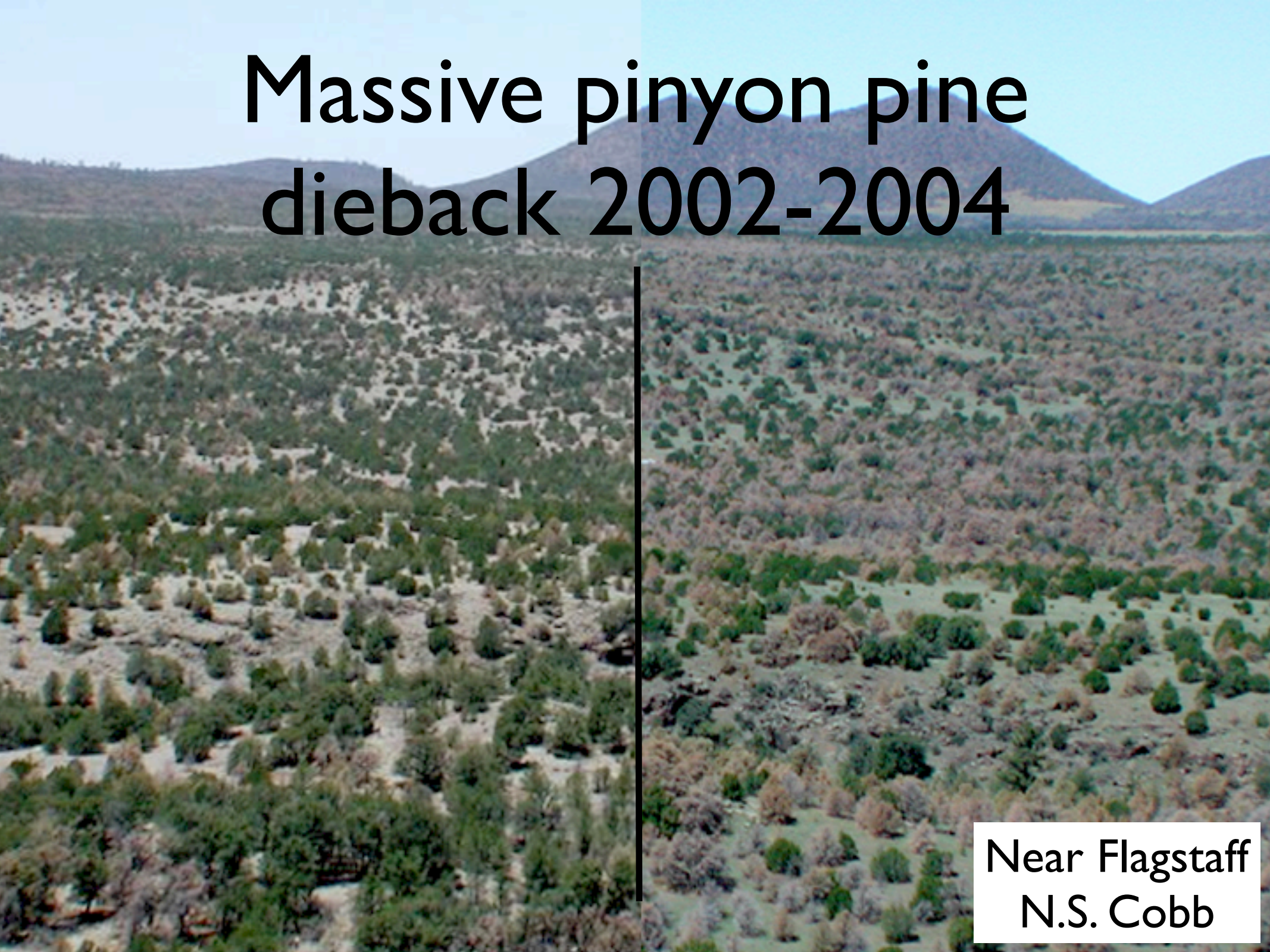
2000: 1.1M acres in Montana

# Warmer temperatures also increase wildfire



- 1116 records of fire in Western US
  - 6x increase in area burned since 1986
  - Higher spring and summer temperatures plus earlier snow melt
- Westerling, Swetnam et al. 2006;  
see also McKenzie et al. 2004

# Massive pinyon pine dieback 2002-2004



Near Flagstaff  
N.S. Cobb

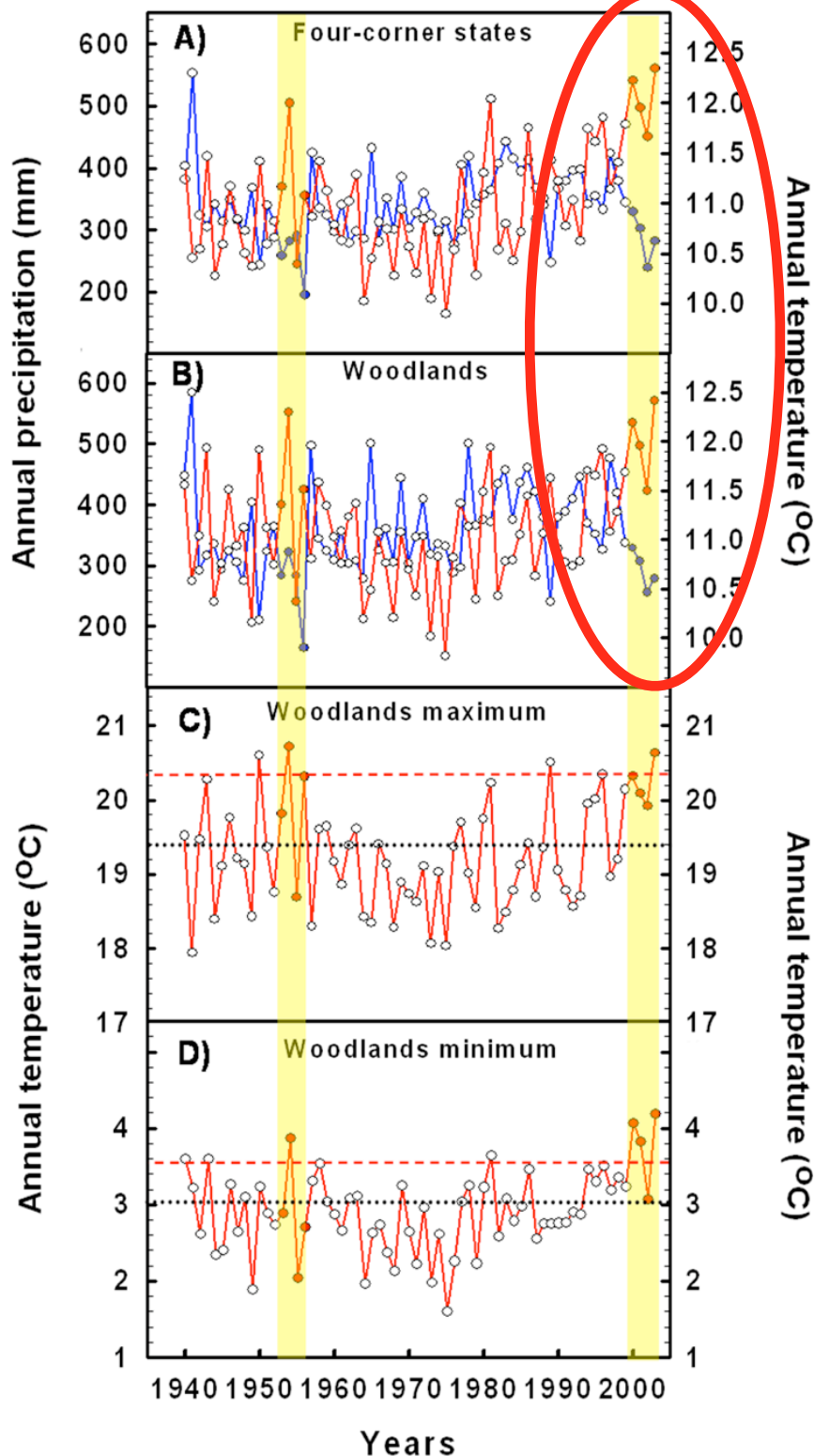
# Pinyon-Juniper die back

summer 2002



Breshears et al. PNAS 2005

# Global change-type drought ?



- 40-80% pinyon pine mortality over 2.5M acres
- prolonged high temperature increased vulnerability to bark beetle

--Breshears et al. 2005

# Ecological Impacts?



# Roadmap

- What is the scientific consensus?
- What is the evidence for impacts now?
- **Is the Southwest vulnerable?**
- Some thoughts on adaptation

# THE ARIZONA REPUBLIC

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azcentral.com

FRIDAY, APRIL 6, 2007

## TODAY'S QUICK READ

### YOUR WORLD



CHRIS BIRCK/GETTY IMAGES

#### San Antonio tops Phoenix

Tim Duncan blocks Steve Nash's shot during the San Antonio Spurs' seventh straight home victory against Phoenix, 92-85. Nash led the Suns with 20 points. Phoenix had its lowest field-goal percentage of the season, 38.6 percent, and its 85 points were only two better than its lowest output of the season. San Antonio came into the game three games behind Phoenix for the No. 2 seed in the West. **Sports. C1**

## Nation & World

**N.C. Senate expresses regret for slavery:** Following the lead of legislators in Virginia, lawmakers unanimously back a resolution acknowledging the state's "profound contribution for the official acts that sanctioned and perpetuated the denial of basic human rights and dignity to fellow humans." **A3**

**Freed Britons return home:** The ordeal with Iran has prompted widespread calls for an official investigation of the incident to confirm where exactly the 15 crew members were captured and whether they had in fact strayed into Iranian waters. **A4**

**Government defends migrant arrests:** More than one-third of 18,000 people arrested in a nearly yearlong federal crackdown on undocumented immigrants were not the people authorities targeted, according to government figures. **A7**

## Valley & State

**Husband arrested in wife's 1981 murder:** Raymond R. Sawyer, 80, "broke down" when a Glendale investigator interviewed him in the hopes of discovering new leads on who strangled the woman, police say. **B1**

**Today's editorial:** The Legislature's reigning hyperpartisan loose cannon, its king of outlandish and self-aggrandizing sensationalism, remains Jack Harper, the Republican senator from Surprise. **B6**

**Today's letter to the editor:** The problems at the Arizona State Veteran Home are not a scandal. No one died. There was no intentional deception to mislead the public. **B6**

## Business

**Bid for auto giant:** Billionaire investor Kirk Kerkorian makes a \$4.5 billion cash offer for DaimlerChrysler AG's Chrysler unit. **D1**

**Spring training saves tourism season:** Cactus League baseball lured enough fans who dropped cash at hotels, ballparks, restaurants, malls and golf courses to make March a winning month. **D1**

**Economic slowdown:** Arizona's economy is slowing from 2006's record pace, but economists differ on what to expect next. **D1**

## Sports

## 4 effects of climate change



MARK HENLE/THE ARIZONA REPUBLIC

### DROUGHT AND HEAT

Higher temperatures change oceanic conditions, leading to more intense droughts. Changes also can worsen the Valley's heat island effect and speed us closer to the first 100-degree overnight low.

# Southwest could become Dust Bowl, study warns

By Shaun McKinnon  
THE ARIZONA REPUBLIC

Rising temperatures will fuel longer and more intense droughts across Arizona and the Southwest, according to a new climate-change report that warns of conditions not seen since the 1930s Dust Bowl.

What sets the report apart from others that have painted an equally bleak future is its assertion that changes already have begun,

### Near-term fire outlook

State predicts an average to above-average 10-week wildfire season. **Valley & State. B1**

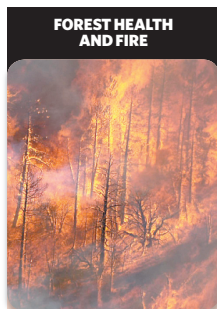
that the state's 12-year-old drought may reflect what scientists call the new climate for the Southwest.

The study, published today in the journal *Science*, arrives along with a broader assessment of global warming by teams of interna-

tional scientists. That report, set for release this morning in Belgium, charts a litany of ecologic and economic threats posed by manmade greenhouse gases and concludes that, in many areas, the threats have now become real.

Both reports attempt to inject urgency into the contentious discussion of climate change, with authors arguing that their dire forecasts will come true unless

See **CLIMATE CHANGE** Page A12



ROB SCHUMACHER/  
THE ARIZONA REPUBLIC

Drought and skewed seasonal runoff undermine forest health, leaving high-country trees open to diseases. Dry conditions increase fire danger.



GLENN PROUDFOOT/  
U.S. FISH & WILDLIFE SERVICE

As drier, hotter conditions develop, wildlife habitat will begin to vanish. As habitat disappears, so will wildlife. Rivers and desert edges will suffer.



MARK HENLE/  
THE ARIZONA REPUBLIC

Rising temperatures mean snow arrives later and melts sooner, upsetting a delicate balance that has allowed the arid West to survive with minimal precipitation.

## TRANSPORTATION

# Big tax hike for roads argued

By Matthew Benson  
THE ARIZONA REPUBLIC

Three years after Maricopa County voters OK'd a 20-year, \$14 billion tax extension for road projects, another even bigger transportation tax hike is in the works.

This time, though, the scope would be statewide and the dollar figures potentially several times larger.

Details are few at this point, with the project list and funding mix yet to be determined. But discussions have begun among key players in the business community, Legislature and Governor's Office. A package could be headed to the state ballot as quickly as next year, with supporters eyeing a spring special election or the November general election.

"We've never had a comprehensive, statewide plan," said Martin Shultz, an Arizona Public Service lobbyist and member of the coalition leading the transportation push. "We've got to do this. We cannot afford not to invest."

The price tag could be \$20 billion to \$40 billion or more over 20 years,

See **HIGHWAYS** Page A14

# Feds to require anti-rollover system on cars

ASSOCIATED PRESS

The federal government said Thursday that it will require all new passenger vehicles to have anti-rollover technology by the 2012 model year, predicting it will save thousands of lives and dramatically reduce rollover crashes.

The Transportation Department said "electronic stability control" could prevent 5,300 to 9,600 deaths annually and up to 238,000 injuries a year once it is fully deployed into the nation's fleet.

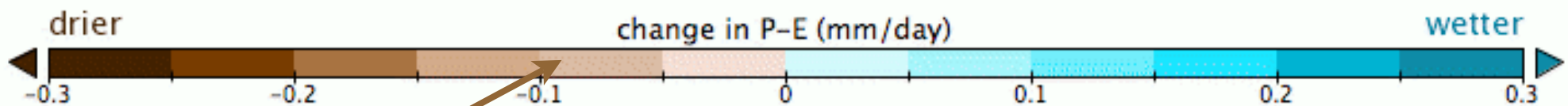
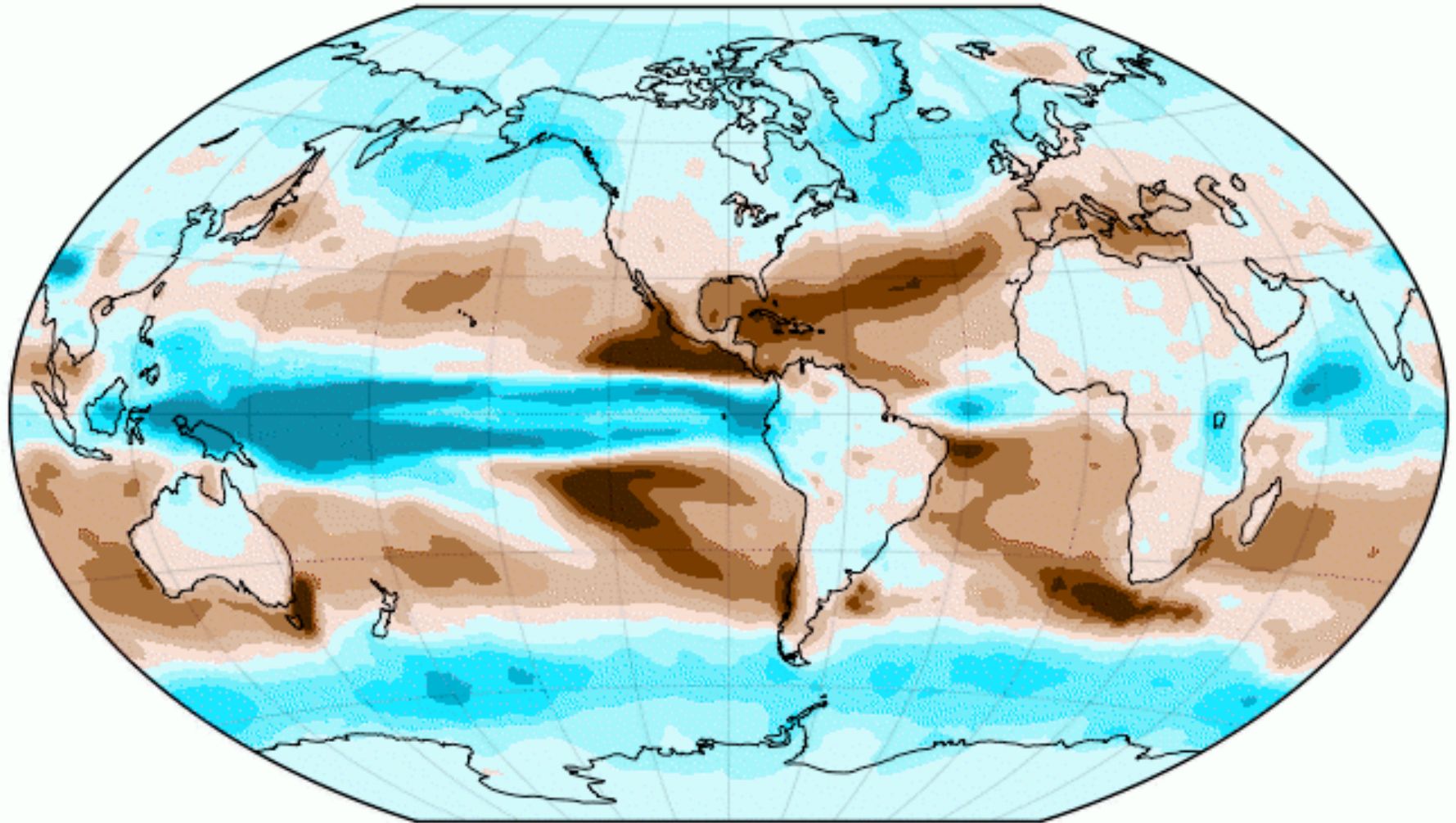
The technology can help motorists avoid skidding across slick roads or maintain control of their vehicle when swerving to avoid an unexpected object in the road.



# Dust Bowl Southwest?

- Seager analyzed 19 global climate model results from recent IPCC assessment
- Scenario: rising CO<sub>2</sub> until 2050 then slow decline to 720 ppm by 2100
- Result: broad consensus among models that SW will dry significantly in 21st century
- ★ Arid transition may already be underway

Change in P-E (2021-2040 minus 1950-2000)



Winkel Tripel projection centered on -90.0°E

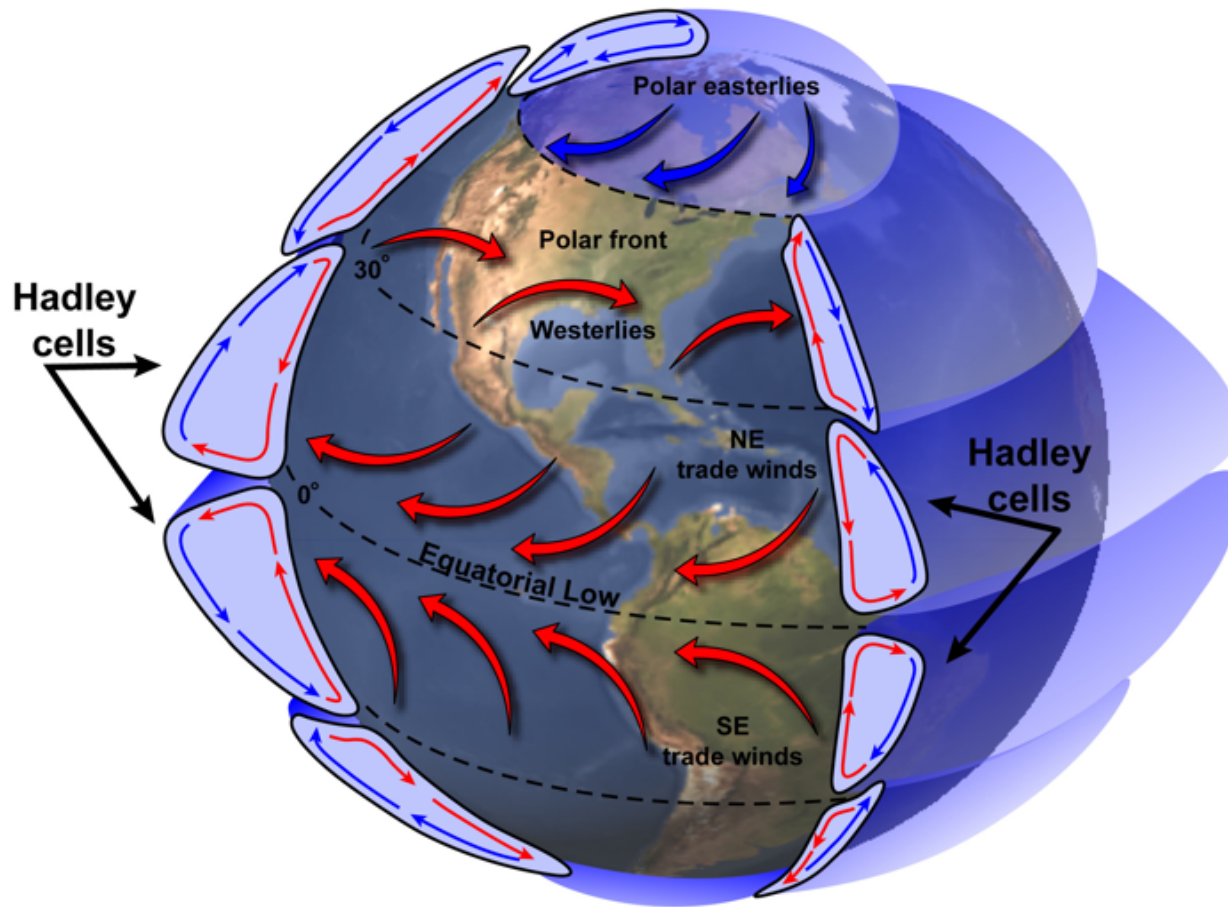
Dust Bowl: 0.09 mm/day

Seager et al 2007

Is current drought a  
super La Nina or...?

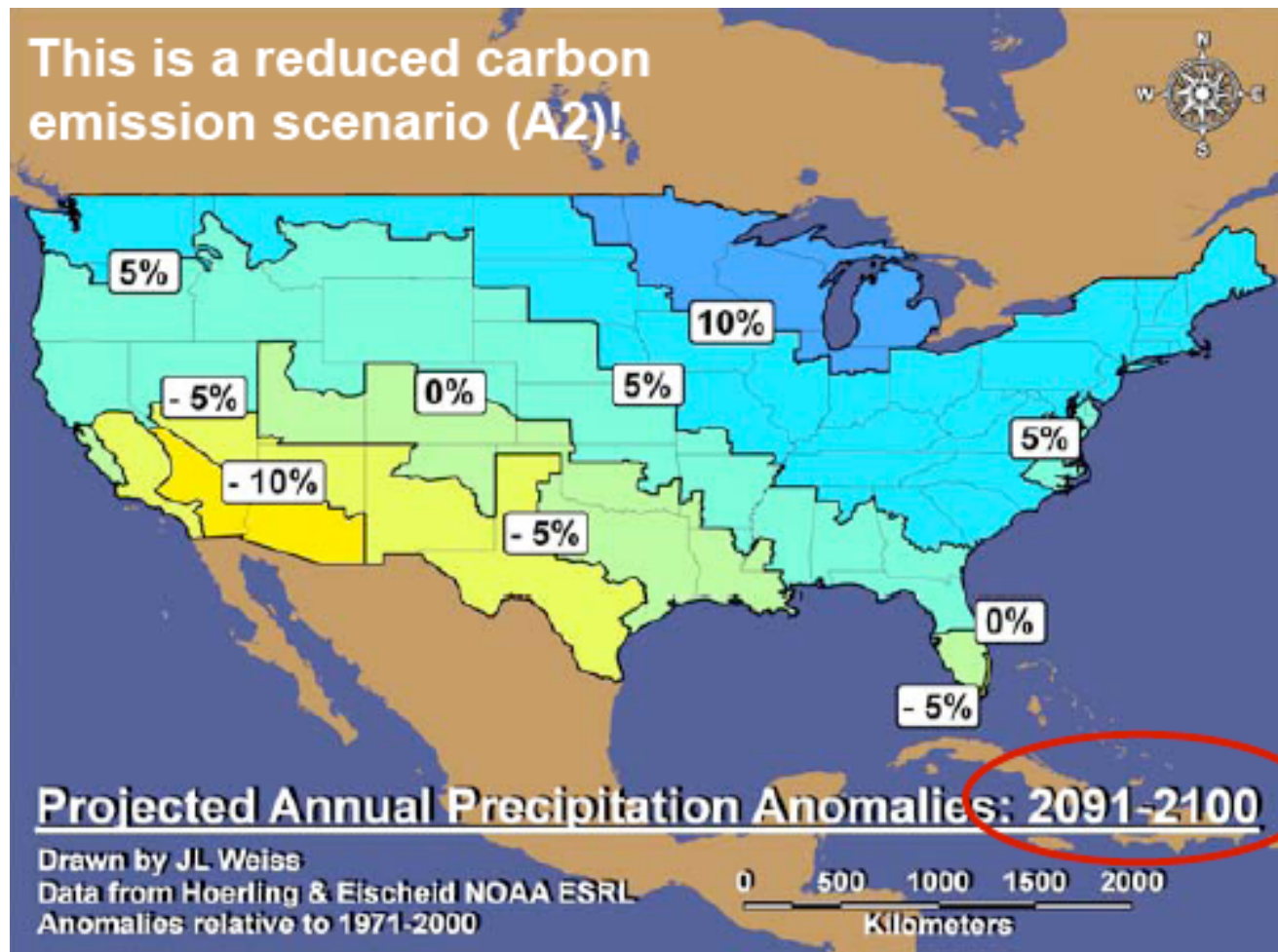


# A new climate state?



- As planet warms, Hadley cell expands Northward
- Rain-bearing Westerlies shift northward

# Increased temperature and reduced precipitation drive Western aridity



# State of science: from canaries to tipping points in a “no analog” world



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*The*  
TIPPING POINT

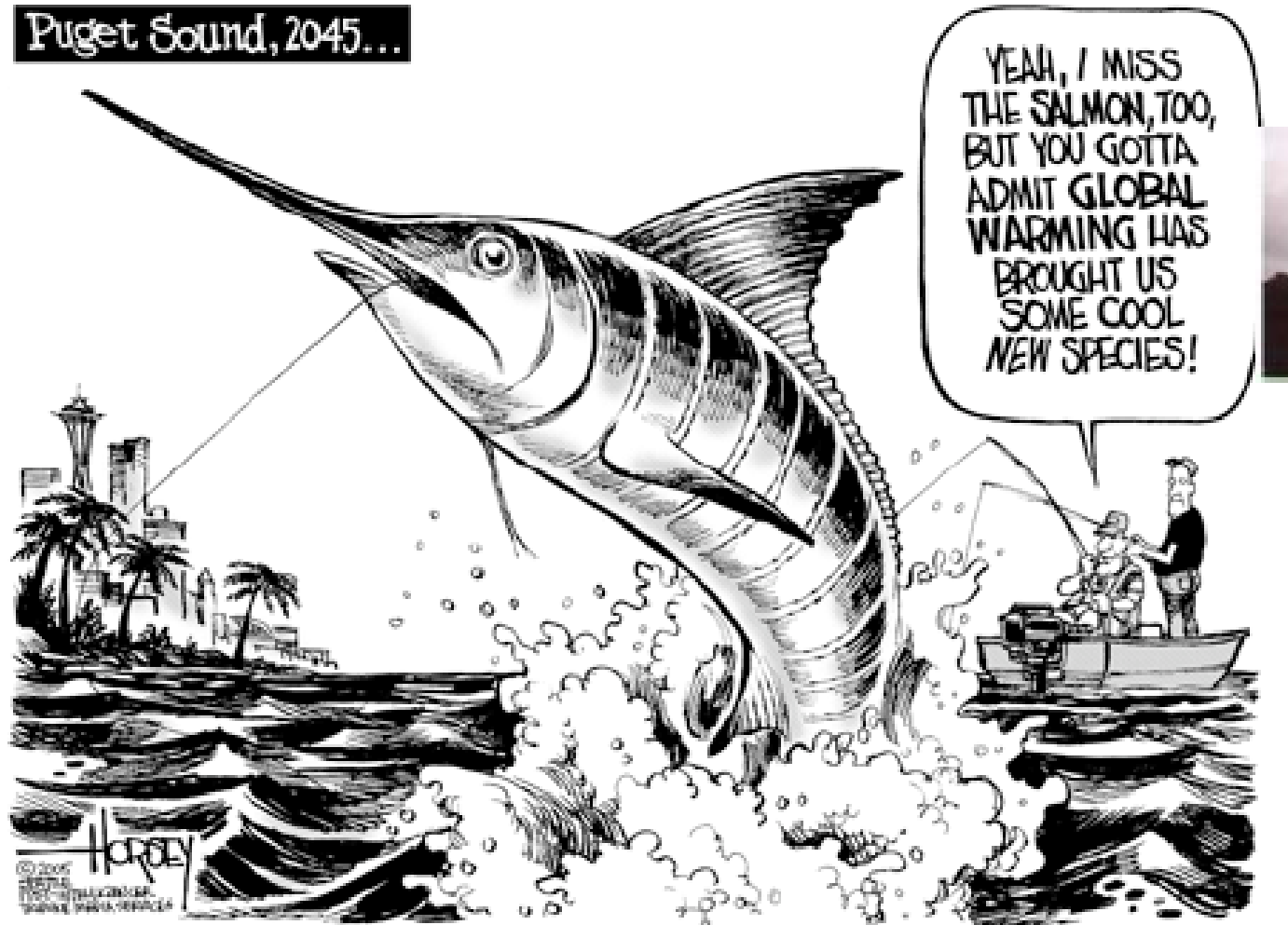
*How Little Things Can  
Make a Big Difference*

MALCOLM  
GLADWELL

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# Adaptation is the challenge

Who chooses winners and losers?



From the Seattle Post-Intelligencer, October 20, 2005

# Questions?



The School of Natural Resources

<http://snr.arizona.edu>