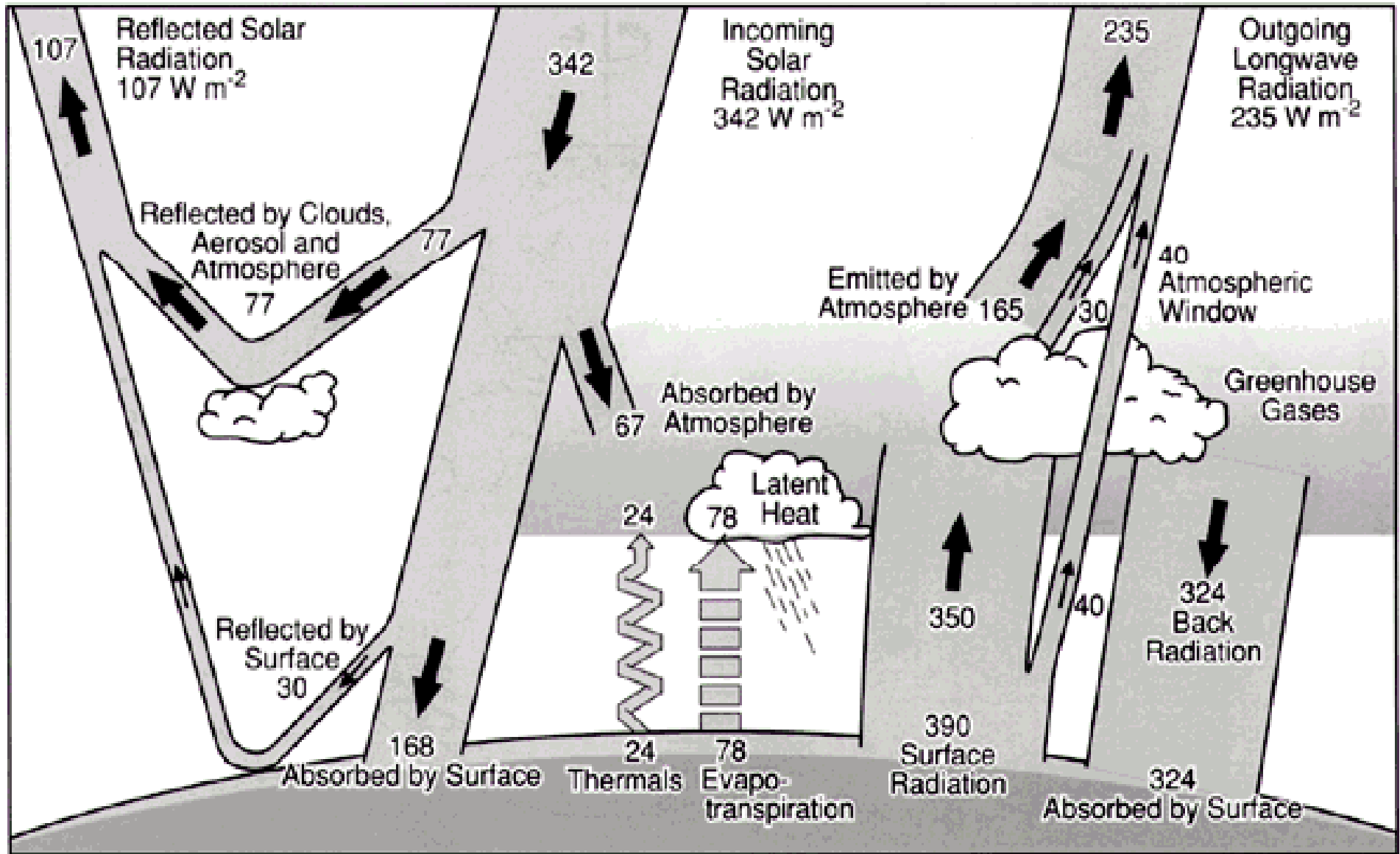


# **Climate Change Science and Mitigation/Adaptation Tools**

Bob Heinith  
Hydro Program Coordinator  
Columbia River Inter-Tribal Fish  
Commission

- **What are the leading causes of climate change or destabilization?**
- **How will climate change affect the Western U.S., Columbia Basin and Puget Sound?**
- **What mitigation/adaptation tools are available to counteract climate change?**
- **What opportunities do tribes have to engage and manage climate change science?**

# Earth's Annual Energy Budget (ISAB 2007)



# The Big Picture

- Target Atmospheric CO<sub>2</sub>:  
Where Should Humanity Aim?

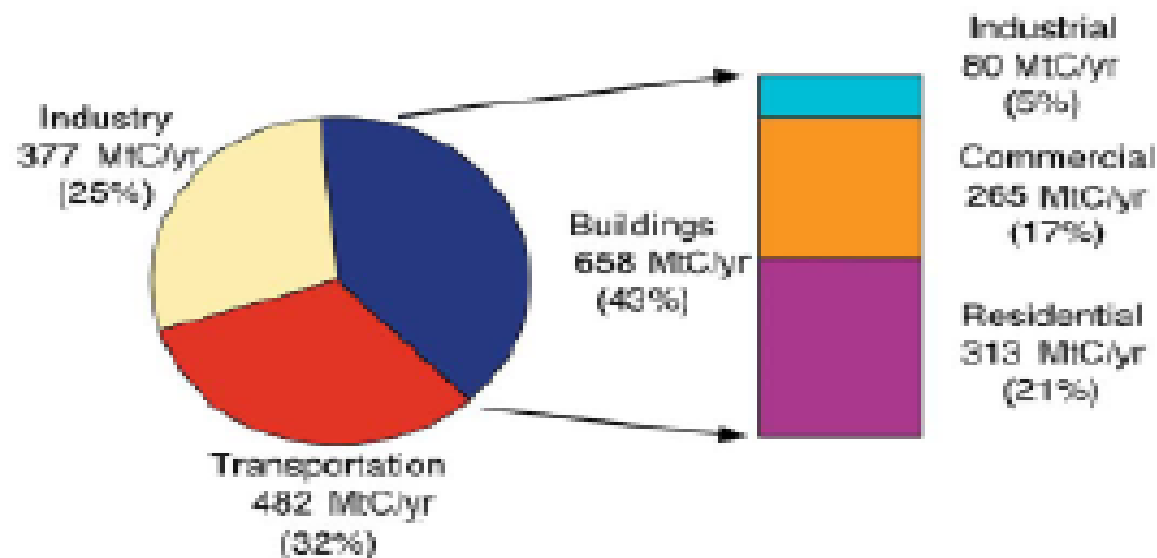
James Hansen, et al (2008)

- 350 ppm should be the target
- Current concentration is 385 ppm
- IPPC has set target at 450 ppm

[www.columbia.edu/~jeh1/2008/TargetCO2\\_20080317.pdf](http://www.columbia.edu/~jeh1/2008/TargetCO2_20080317.pdf)

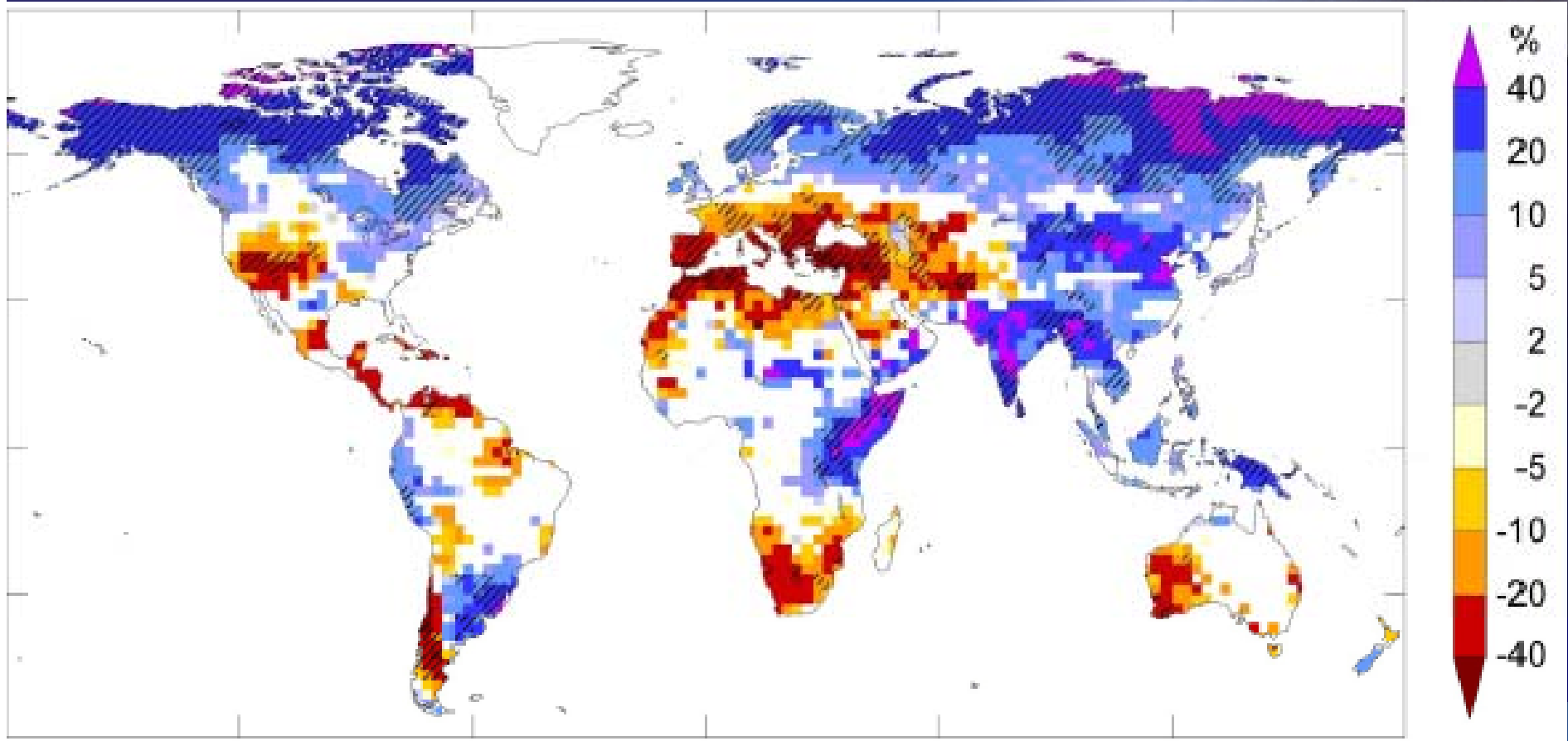
# Reducing CO<sub>2</sub> Emissions through Renewable Energy and Efficiency

## The Big Picture of CO<sub>2</sub> Emissions



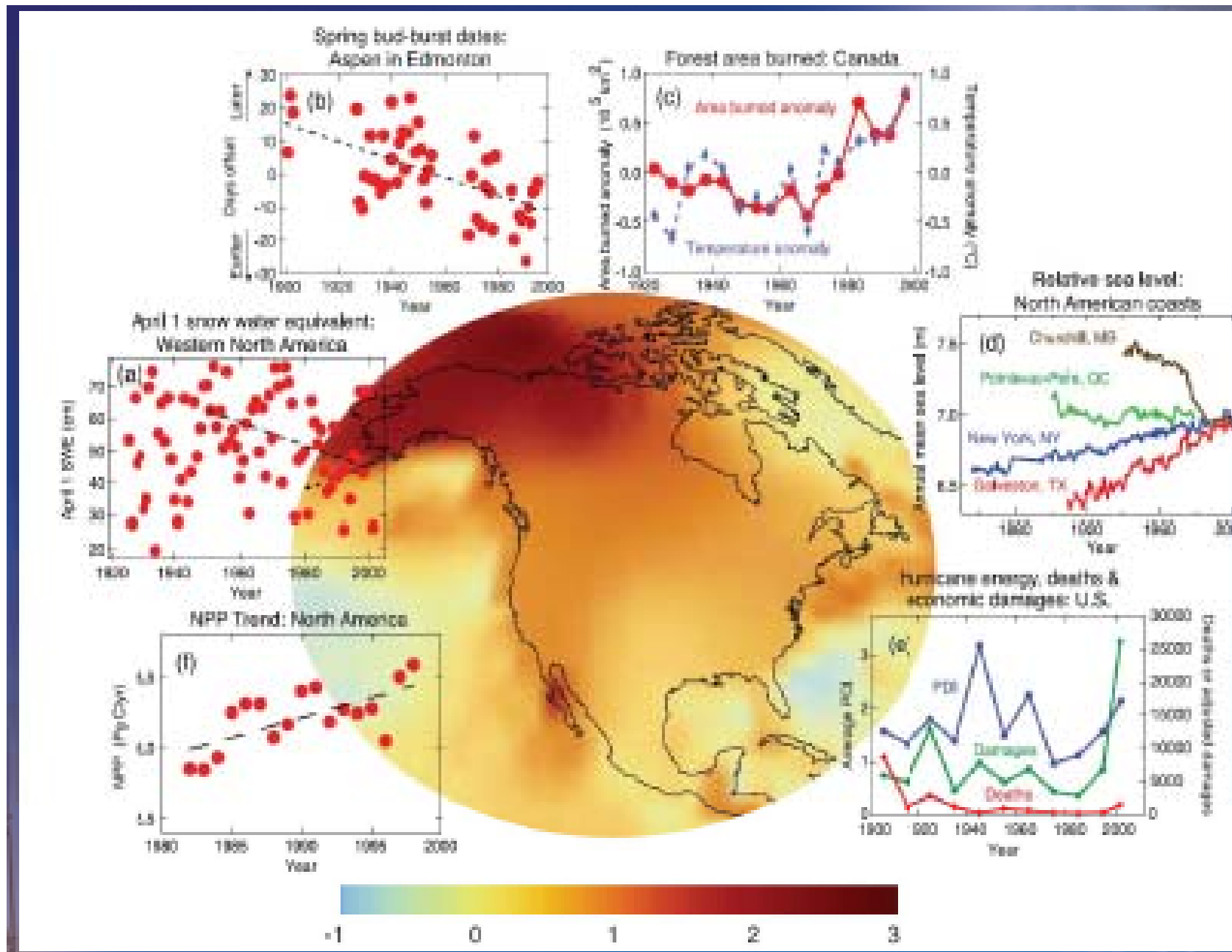
**Source: ASES, Tackling Climate Change in the U.S.**

**Changes in run-off, 21st century. White areas are where less than two-thirds of models agree, hatched are where 90% of models agree**

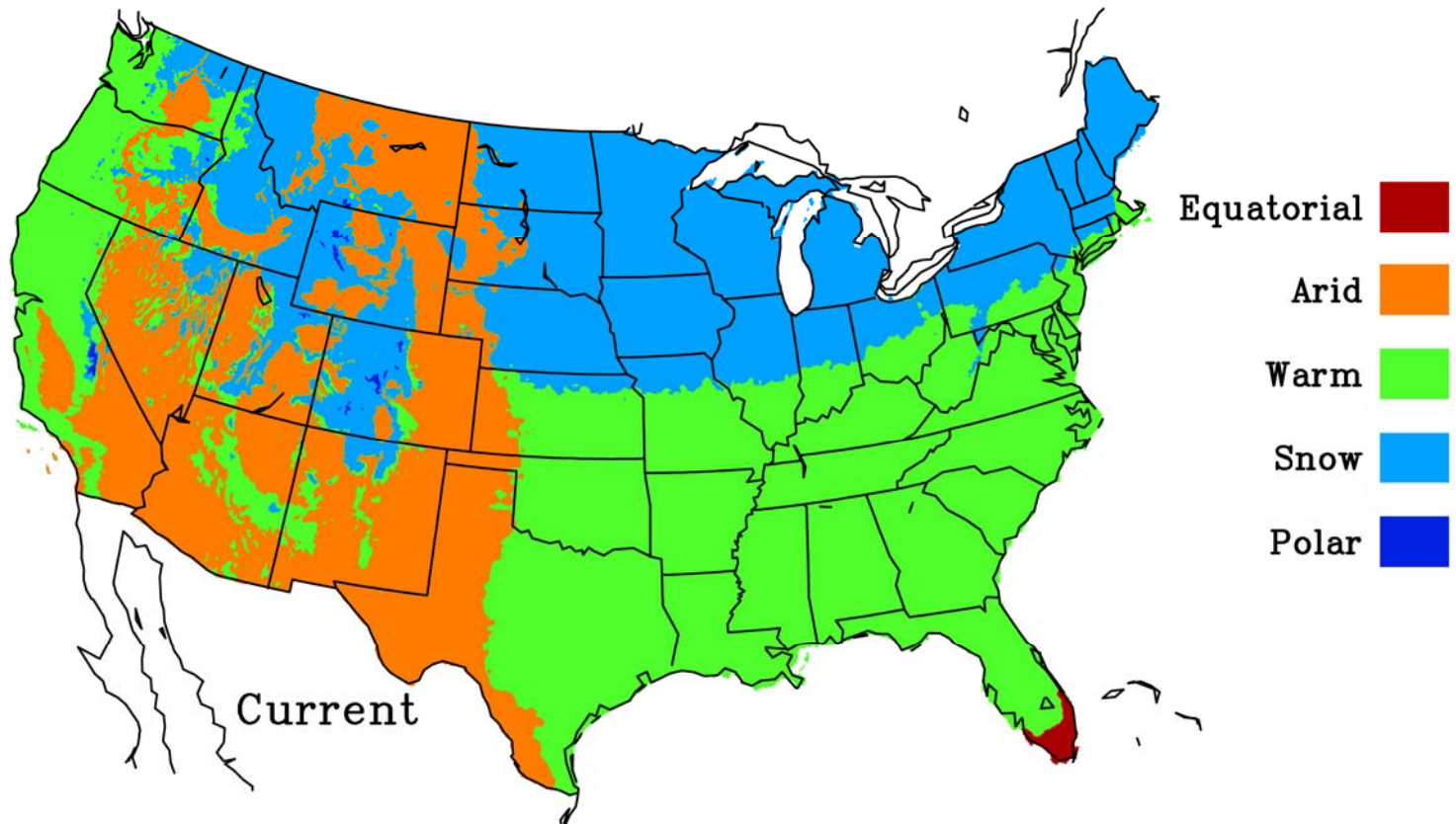


**IPCC Technical Paper on Climate Change and Water**  
Released April 2008

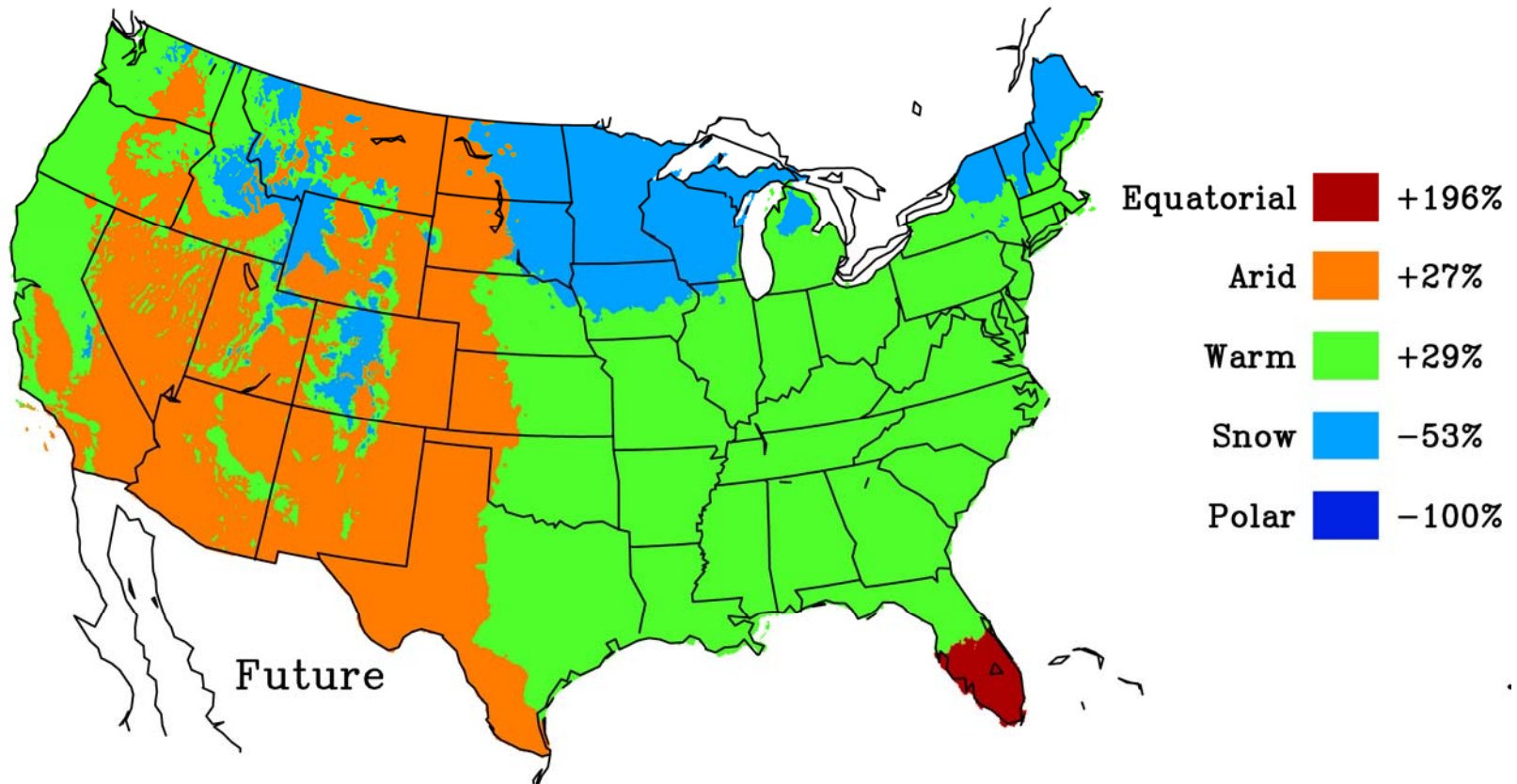
# Observed Trends in Western North America

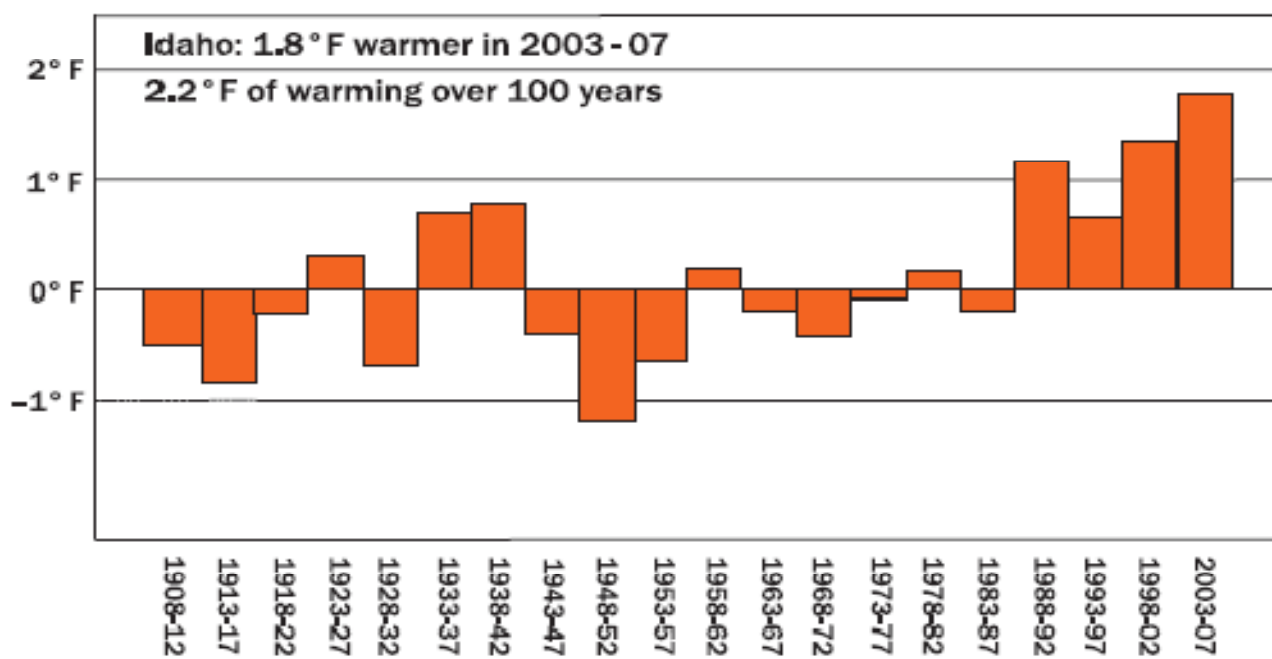
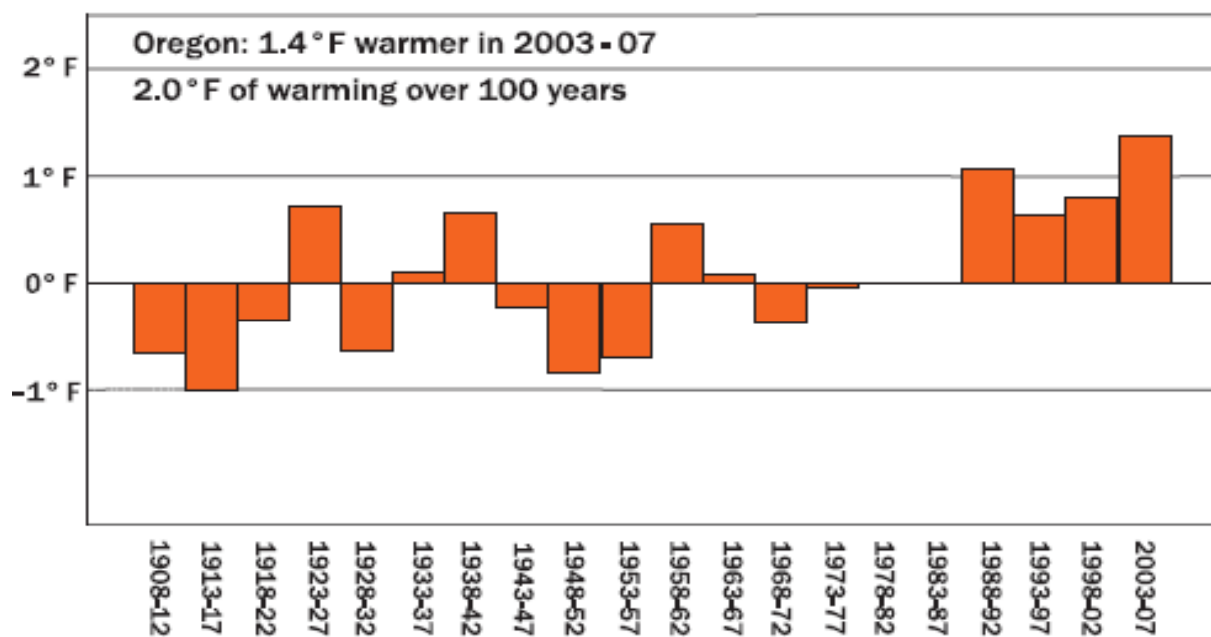


# Koppen-Geiger Climate Classification



# Koppen-Geiger Climate Classification





## Realities of Global Warming in the 11 Western States

**Deadly Heat Waves:** In **California**, a heat wave in July 2006 led to an initial official count of at least 143 deaths—a total being reviewed by the state government following a press analysis that the real death toll may have been 466.

**Diminishing Reserves:** The volume of water in Lake Powell—a man-made Colorado River reservoir in **Arizona**—dropped by two-thirds between 2000 and 2005. This draining of the reservoir was more rapid and severe than thought possible. It is currently less than half full.

**No Snow:** On the date the snowpack at Snoqualmie Pass in **Washington** normally reaches its peak of 92 inches, in 2005 there was no measurable snow at all.

**Charred Habitat:** Destructive wildfires in northern **Nevada** in 2006 charred pronghorn antelope habitat and forced the relocation of half the regional herd.

**Grizzly Bears at Risk:** Warmer temperatures in **Wyoming** have allowed mountain pine beetles to invade high-elevations in the Yellowstone area, where they may eliminate whitebark pines, whose nuts are the most important food source for the area's grizzlies.

**Ruinous Wildfire:** **Colorado** suffered the largest wildfire in its history in 2002. Nine firefighters died, nearly 1,000 structures were destroyed, 915,000 acres burned, and \$1.7 billion were lost in tourism revenue.

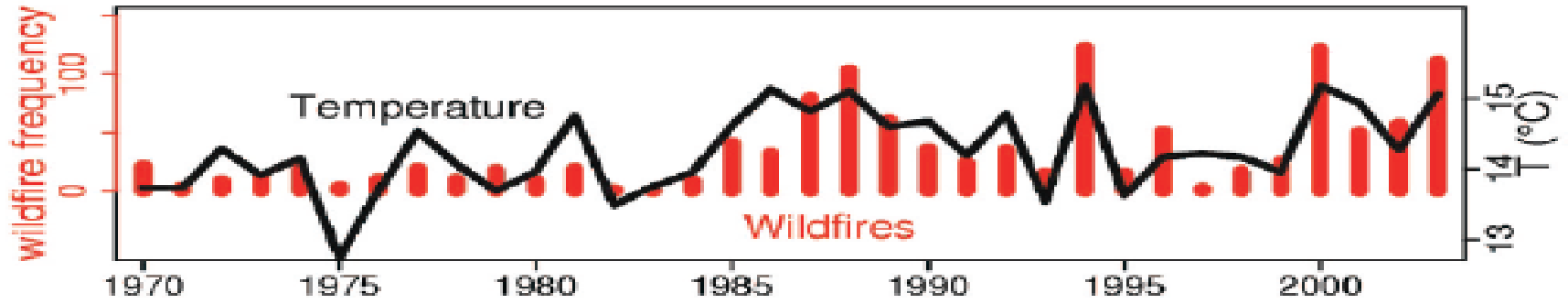
**Disastrous Drought:** Drought hit **Utah** so hard in 2002 that every county in the state qualified for disaster relief. 2,600 Utahans lost their agricultural jobs and the dryland harvest shrank 30 percent.

**Livestock Loss:** **New Mexico** lost \$279 million in income from livestock production due to the 2002 drought. In **Montana**, drought forced ranchers to cull 150,000 cattle from their herds in three years, bringing the state's cattle population to a 40-year low in 2004.

**Lost Revenue:** **Idaho** was forced to cancel sage grouse hunting season after wildfires destroyed much of the bird's habitat in 2007.

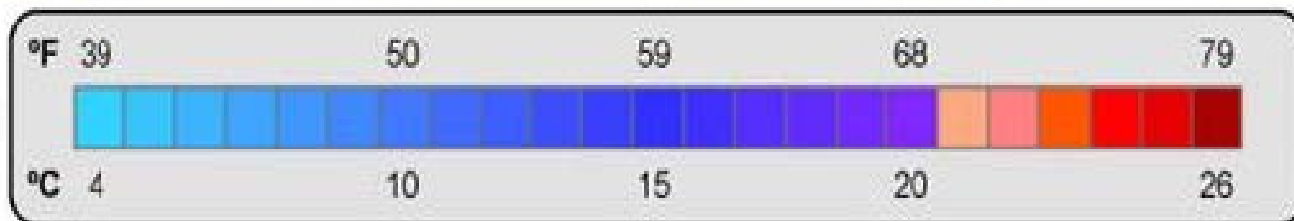
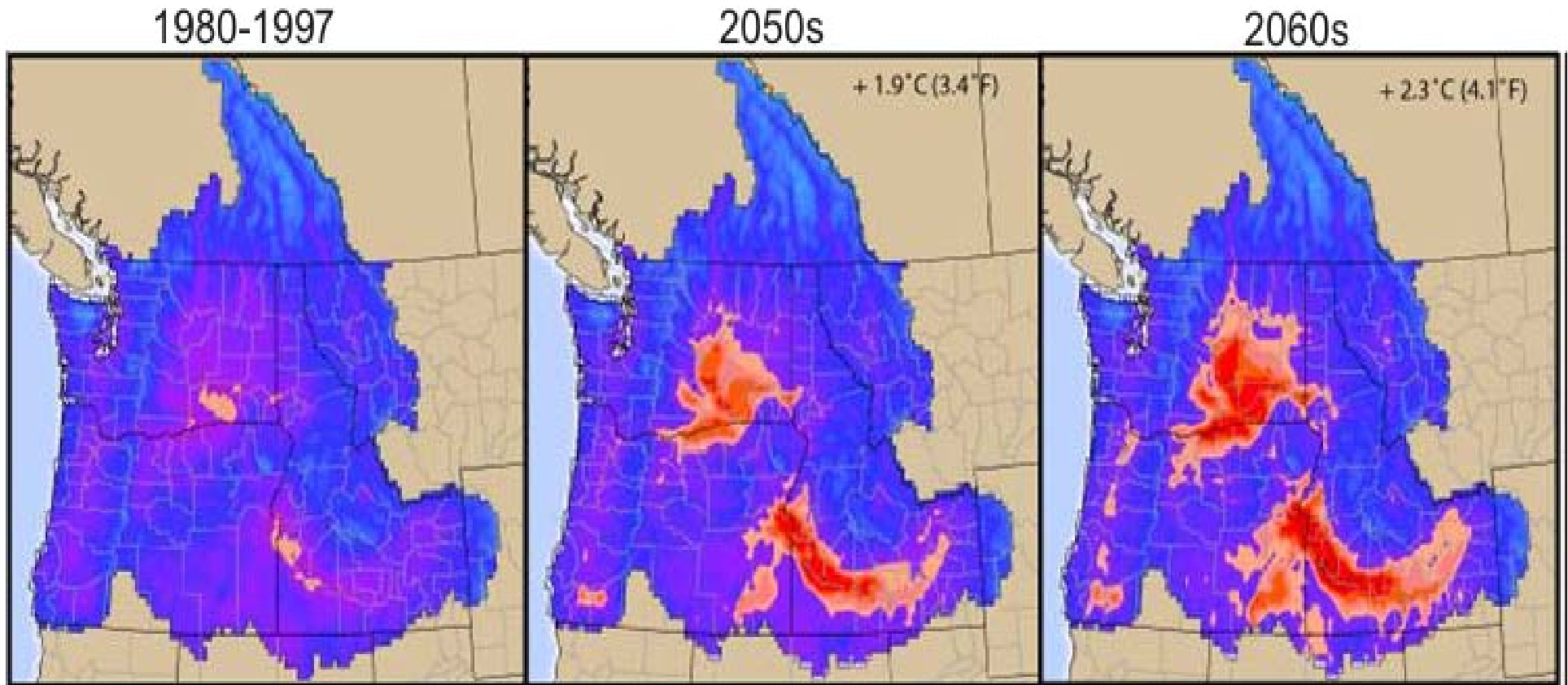
**Dead Zone:** An area of ocean waters with too little oxygen to support sea life off the **Oregon** coast, caused by changed weather patterns, has grown in four years to cover an area the size of Rhode Island.

# Western US Forest Wildfires and Spring–Summer Temperature



A forest fire smolders in Montana in 2007, part of an unusually severe fire season in the state.

# Temperature Changes and Predictions for the CRB (ISAB 2007)



OBSERVED AND PROJECTED CHANGES IN WESTERN US AND IMPACTS TO WILDLIFE				
	20th century changes (+1°C)	Future Projections (2020-2029, +1-1.5°C)	Implications for Wildlife	Refs.
Warmer stream temperature		+0.6-1.2°C	Reduced survival and reproduction of salmonids; impacts on cold water fisheries	1,2,3,4,5,6,7,8,9,10
Warmer winters and spring	+0.1°C/decade through 20th century; greatest warming in spring and winter	+1-1.5°C; greater magnitude of warming in winter and spring	Shifting geographic range; increased pest/pathogen outbreaks; temperature-dependent sex determination; accelerated parasite life cycles and improved pathogen survival	2,10
Earlier spring arrival	Advancement of spring by 5 days/decade; longer growing season (2 days/decade)	Continued earlier spring arrival	Earlier migrations, nesting, breeding, budburst, flowering; changes in synchrony and inter-species interactions;	10,12
Streamflow	Peak streamflow 3 weeks earlier than average in existing historical record	Earlier peak streamflow; higher winter/early spring flows; lower summer flows	Higher flood frequency; earlier peak flow; reduced natural summer and autumn flows; reduced frequency of reservoir refill; increase in the duration of summer dry period; floodplain habitat increasingly isolated from the active river environment; reduced habitat and survival for terrestrial and aquatic species	2,10
Snowpack	April 1 snow water equivalent declining 15-30%; earlier snowmelt timing	Generally decreasing snowpack; decreased length of snow season	Reduced habitat for bighorn sheep, wolverine and other snow-dependent species; reduced water availability; shrinking alpine habitat;	10
Glaciers	Declines in glacier volume and area across the west	Glaciers in Glacier National Park disappearing by approx. 2030	Impacts on glacier-fed streams and lakes	2,10
Fire	Longer fire season, increased fire frequency and intensity; due to spring/summer warming and earlier spring snowmelt	Even longer fire season, increased fire frequency and severity.	6x more acres burned over last 15 yrs vs. previous 15 yrs; changes in forest species composition; changes in physical forest structure; increases in invasive species	2,10,11
Sea level rise	0.7mm/year increase globally over last 40 years.	0.18-0.59 m increase globally [by 2090-2099, not 2020-2030]	Loss of coastal wetlands, salt marshes and other coastal habitats; increased salinization of freshwater; changes in the freshwater-saltwater interface in estuaries; increased storm surges and coastal erosion;	2,10,13
Sea ice	Some fracture of shelf ice	Arctic mostly ice-free in summer	Loss of critical habitat for polar bear; other arctic ice dependent species	2
ENSO + PDO cycles	Increasing frequency of ENSO and positive PDO events		Changes in off-shore productivity; marine species distributions;	2,14
Ocean Chemistry		Increase in CO <sub>2</sub> ; increasing acidity	Reduces carbonate for shell organisms important as salmon prey	2
Invasive Species	Spreading worldwide; out competing native wildlife	Spreading throughout west	Habitat under climate change more amenable to invasive than native species	2
Estuary		Decrease in flows + sediment transport; increase in water temp.; change to salinity regimes	Reduction in fish and wildlife habitat and populations	2,15

# Climate Change Impacts on Water Quality

- Increased productivity leads to increased nutrient cycling and accelerated eutrophication in lakes with sufficient nutrients and oxygen; otherwise oxygen depletion may limit overall productivity
- Possible lake stratification weakening in cold regions of country, anoxic zones could disappear
- Increased temperatures enhances toxicity of metals and increases accumulation of toxics in organisms
- Higher temps may lead to faster transfer of toxics from water column to sediments
- Not just climate, but other human actions affect WQ

# Reliability of meeting CRB water needs- present compared to future (ISAB 2007)

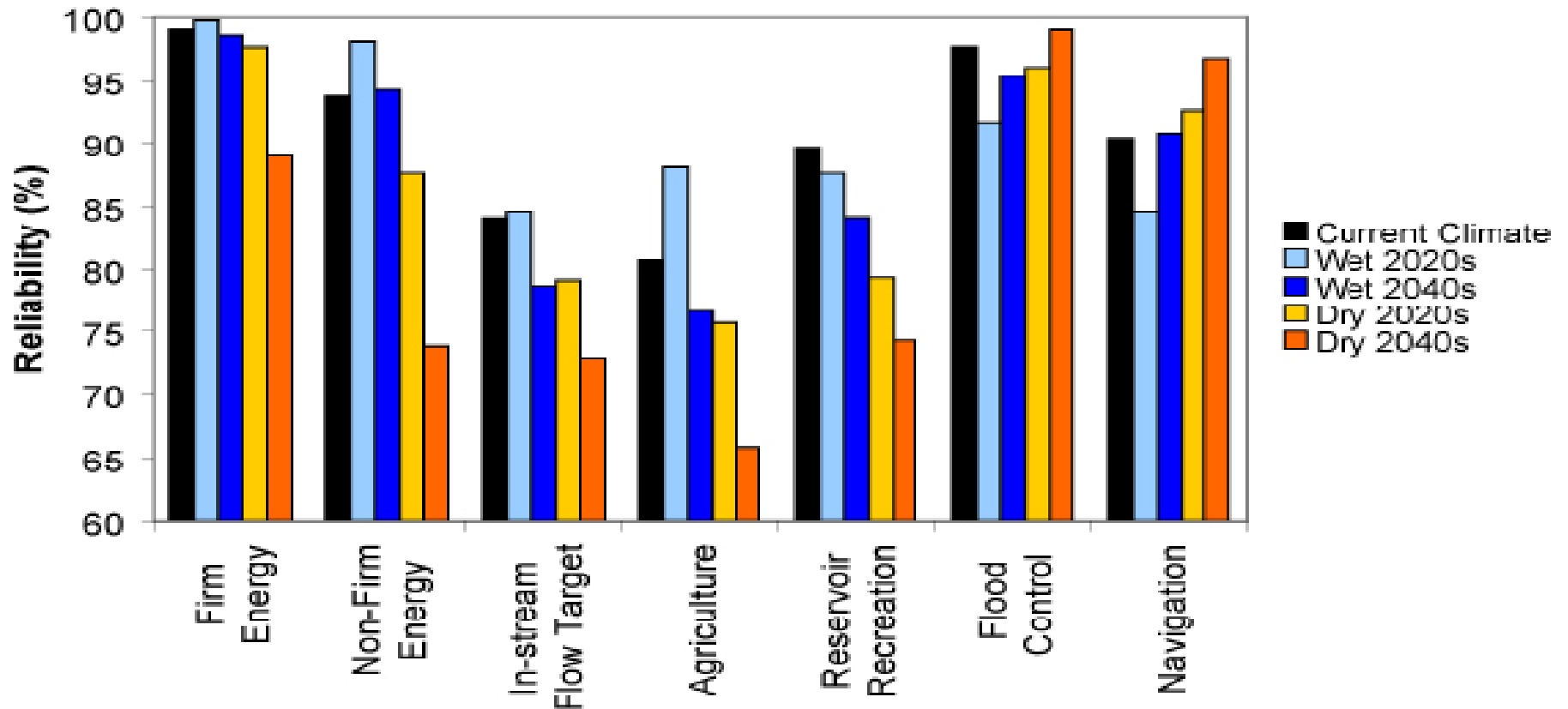
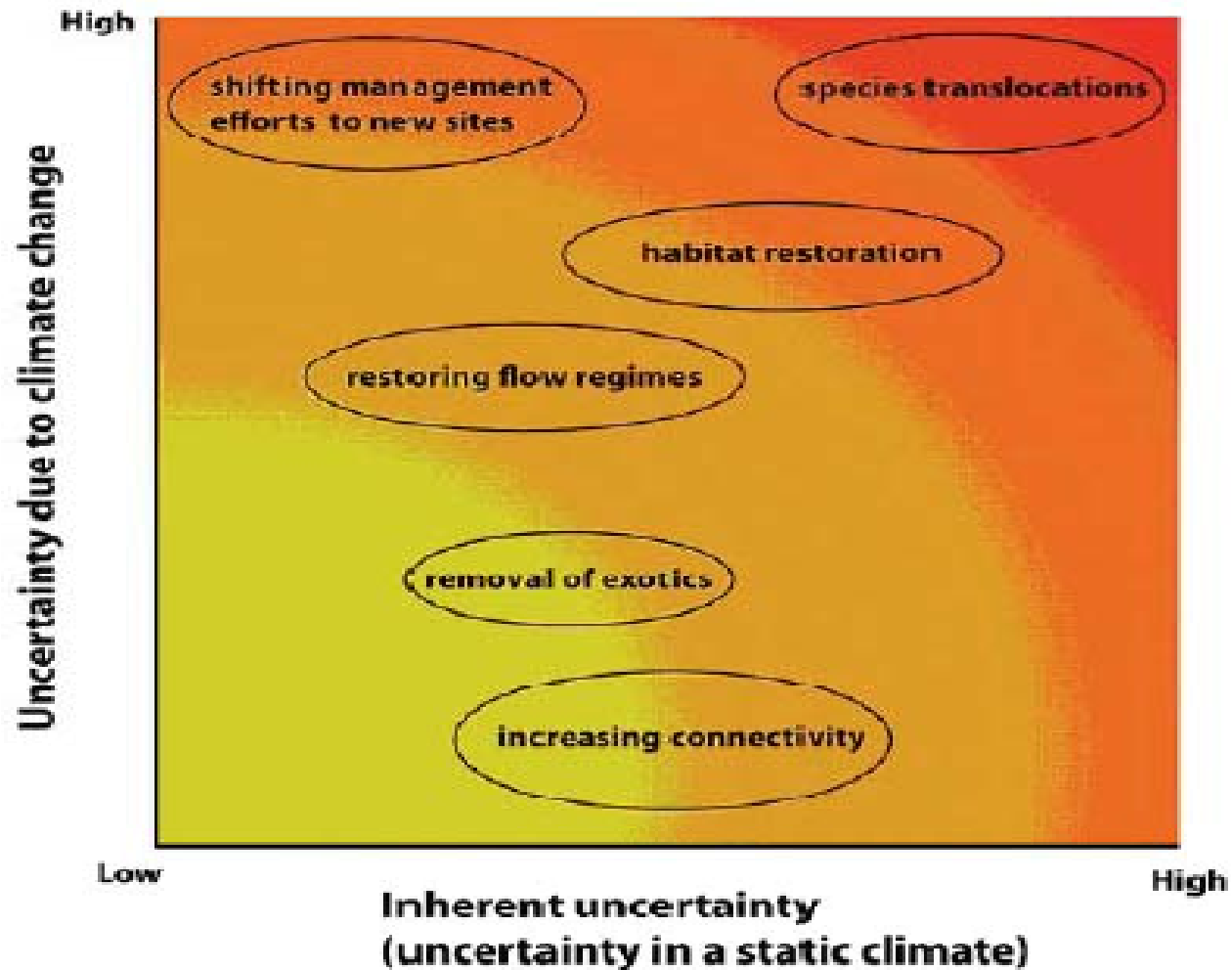


Figure based on data from Miles et al. (2000)  
Figure source: Climate Impacts Group, University of Washington

# Climate Change Challenges

- Complex
- Uncertain
- Scale

## Risk Associated with Management Activities



From Lawler, JJ, TH Tear, C. Pyke, B. Shaw, P. Gonzalez, E. Kareiva, L. Hansen, L. Hannah, K. Klausmeyer, A. Aldous, C. Bienz, and S. Pearsall. In press. Resource management in a changing and uncertain environment. *Frontiers in Ecology and the Environment*.

# **Potential Mitigation Tools (ISAB 2007)**

**Change hydrosystem operations. Modify flood control. Reduce frequency and magnitude of winter flows, extend spring runoff later in the year.**

**Reduce water temperatures in fishladders with water drawn from lower, cooler strata in the forebay water column**

**Increase flow augmentation from cool/cold water storage reservoirs (i.e Grand Coulee and Hells Canyon)**

**Open backwater, slough, and other off-channel habitats along mainstem reservoirs and estuary to help reduce water temperature.**

# Possible Adaptation Tools

- Recycle Water
- Increase energy efficiency
- Increase water storage capacity
- Water Markets
- Water pricing- metering
- Endangered Species Act
- Inter-basin water transfers
- Land use/population planning/eco services

# Tribal Engagement in Climate Change Science

- Collaborate with international (IPPC), state (WGA Western Wildlife Habitat Council), federal (NOAA Drought Information Center) and other scientific groups (UW Climate Impacts Group)
- Establish collaborative monitoring networks to gather new data in tribal areas
- Share existing/new data- become involved with regional process models (hydrology, ecology, fire models, focus species, ect.)

# **Tribal Engagement in Climate Change Science (Part 2)**

- Work across jurisdictional lines to conserve and secure functioning habitats and populations that remain
- Use old tools (flow/temperature management), develop new tools, utilize Traditional Ecological Knowledge



B. Reardon photo USGS 2005