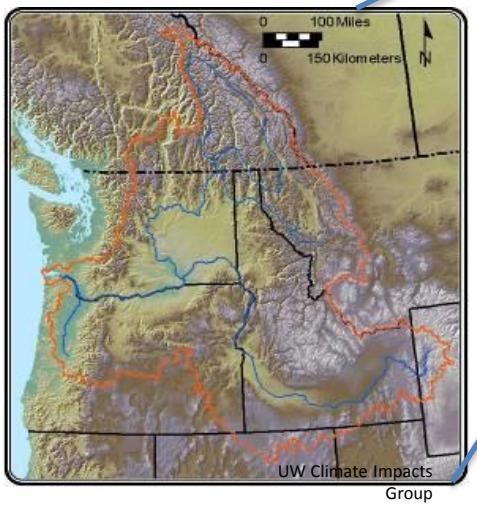
Climate Change in the Yakima Basin: Implications for Aquatic Habitat and Water Management

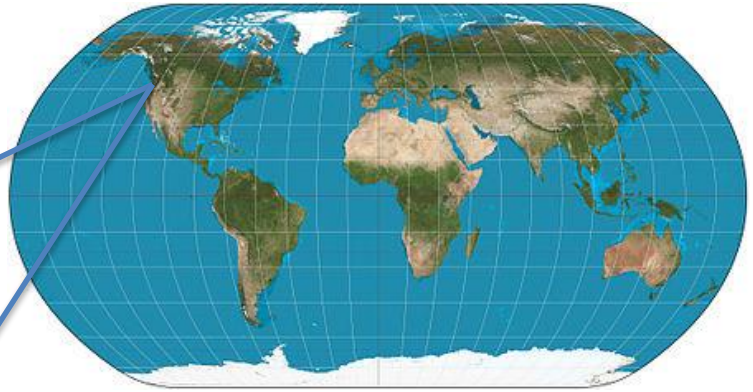
Yakima Basin Science & Management Conference 2015

Ingrid M. Tohver – Climate Impacts Group, University of Washington

The Climate Impacts Group

An interdisciplinary team based at UW studying climate impacts in the Pacific Northwest since 1995





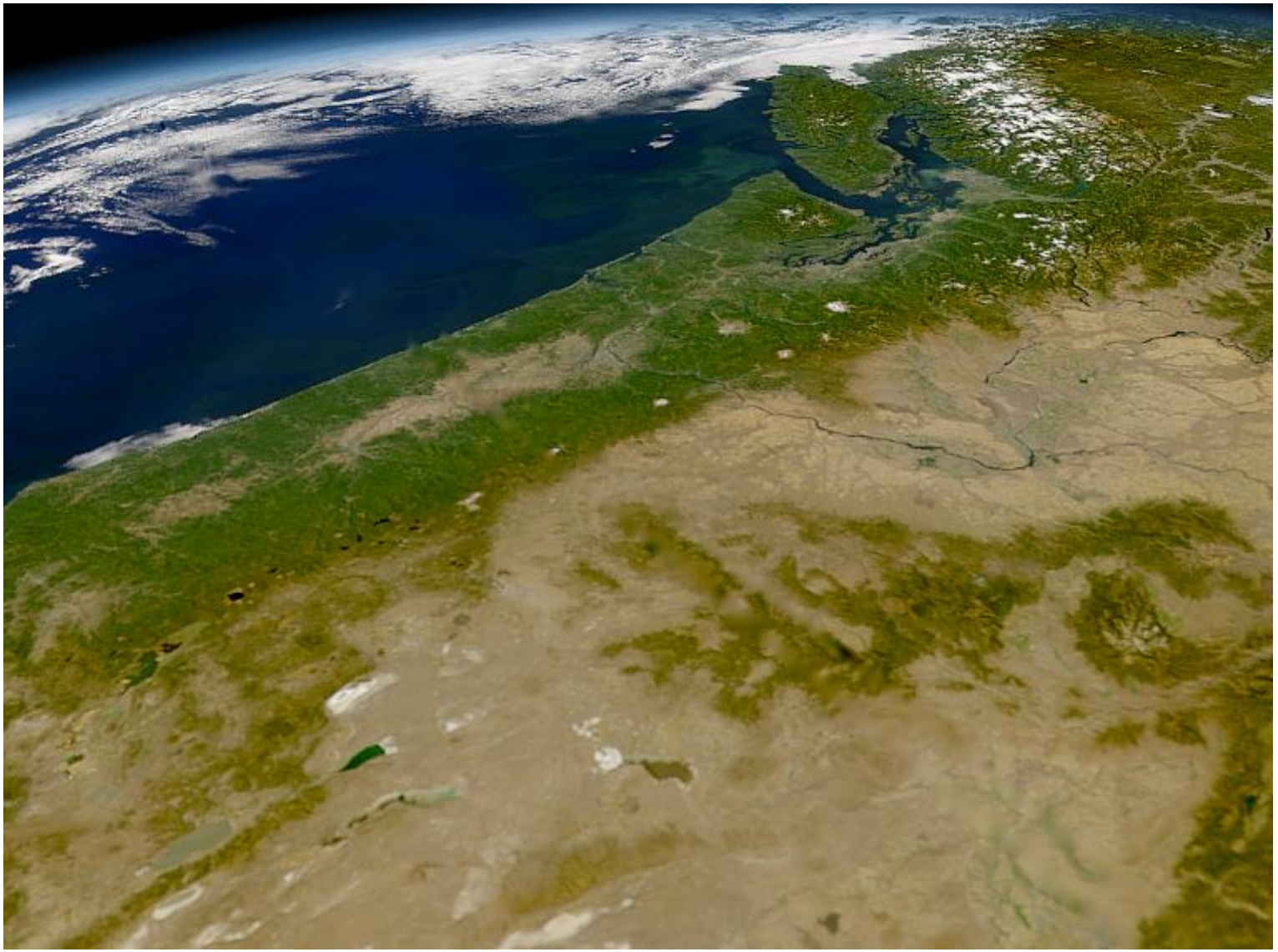
Areas of study:

- **Water resources**
- ***Salmon***
- **Forests**
- **Coasts**
- ***Agriculture***

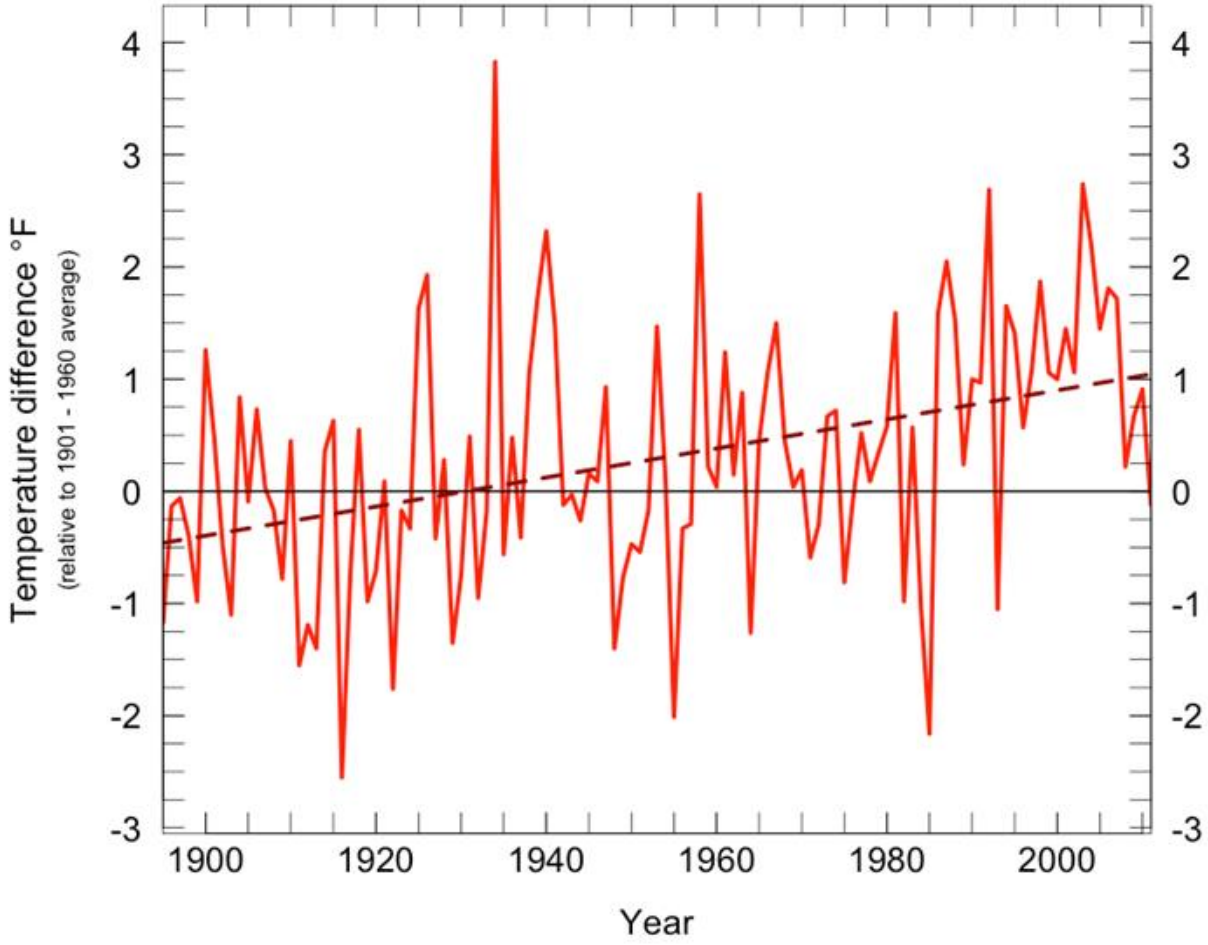
Objectives

- **Increase regional resilience to climate variability and change**
- **Produce science accessible to (*and useful for!*) the decision making community**

Observed Changes in PNW Climate



Average annual PNW temperature has increased +1.3°F (1885-2011)



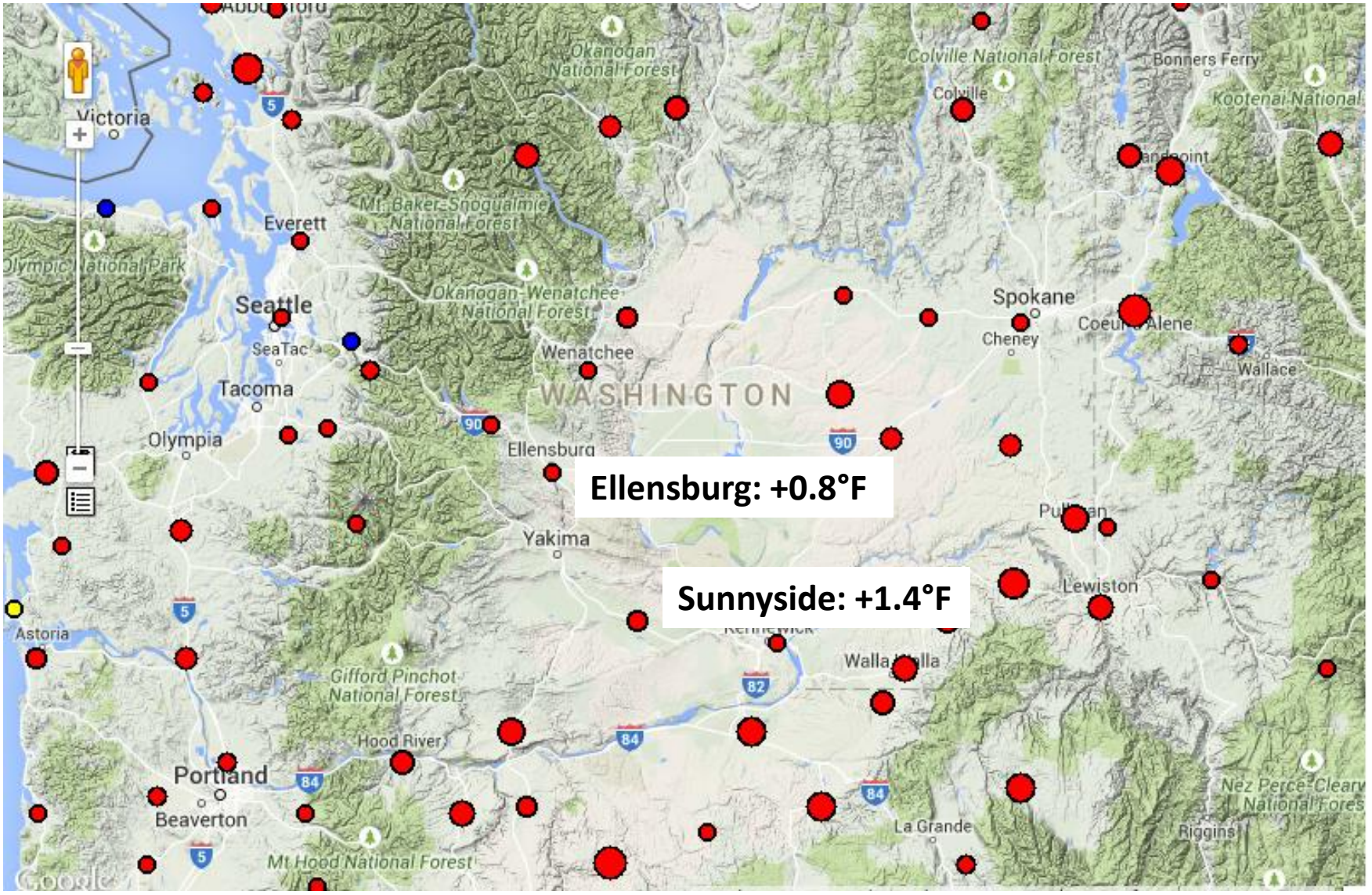
Warming observed in all seasons except spring (1980-2011)

Rate of warming has increased since 1970

Short-term periods of cooling (seasonal or annual) are normal

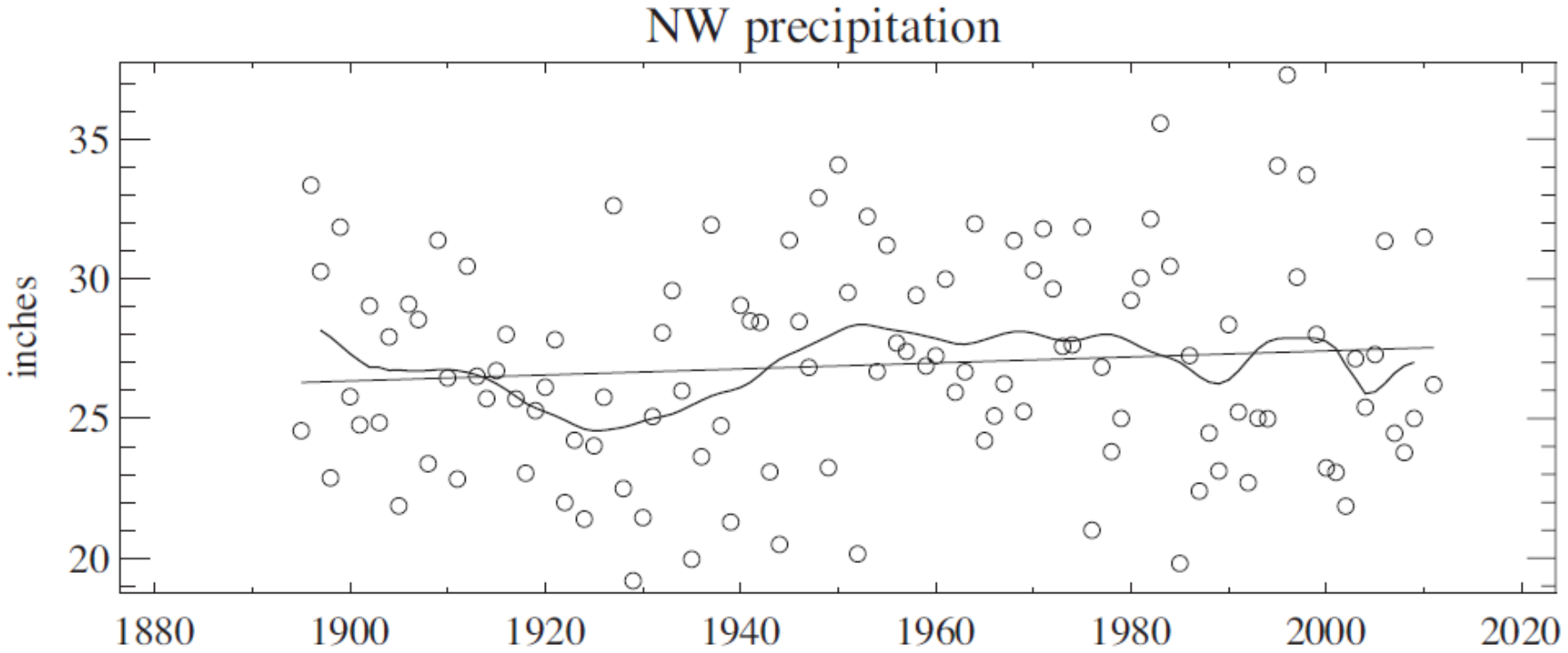
(Figure source: Climate Impacts Group; see also Kunkel et al. 2013, Mote et al. 2013; Abatzaglou 2014)

Mean Temperature Trend Analysis 1895-2014



http://www.climate.washington.edu/trendanalysis/

No clear trend in observed average annual precipitation

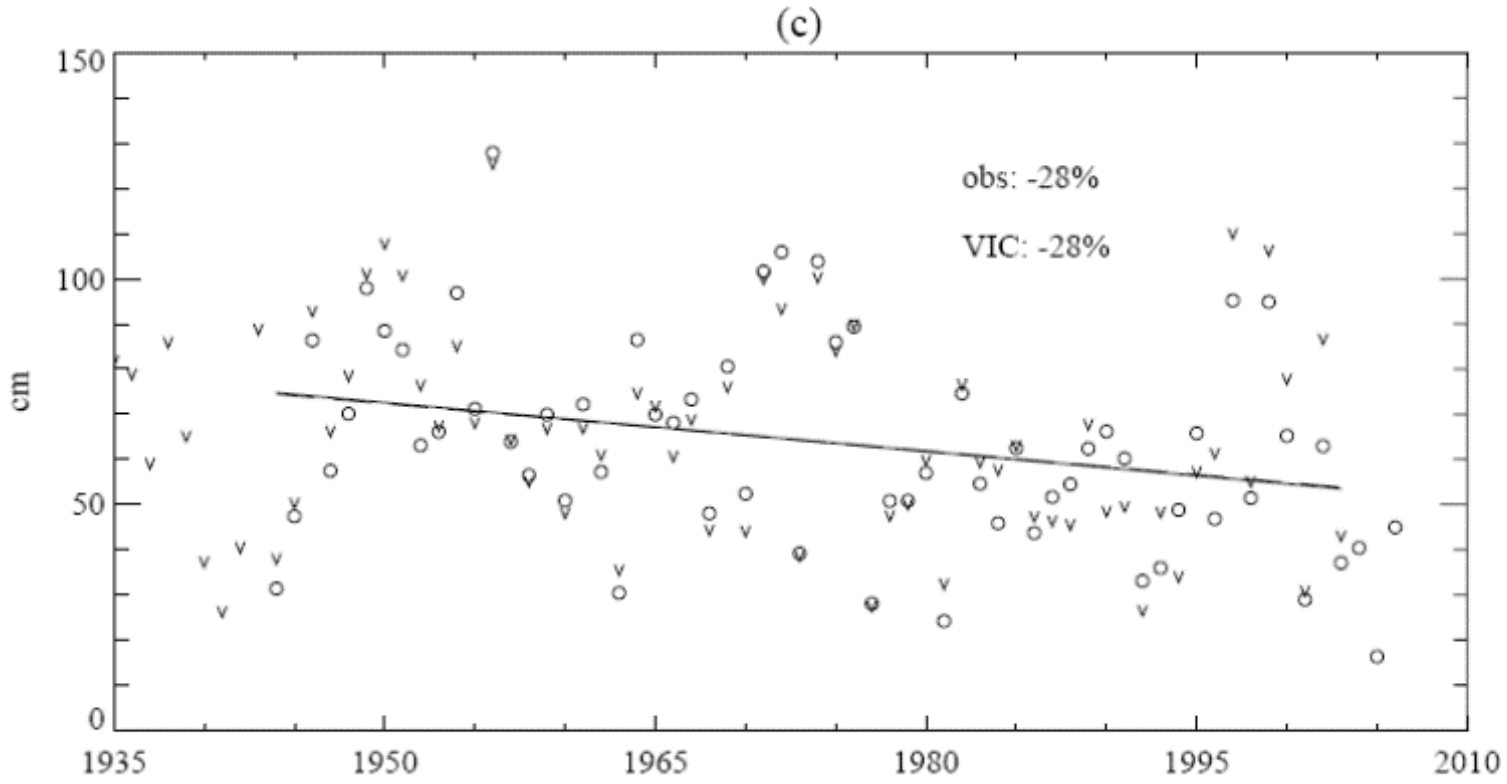


- Slightly higher variability (+16%) since 1970
- No statistically significant trends

Figure 2.4 in Dalton et al. 2013

Decline in Long-term Spring Snowpack

Spring snowpack varies year-to-year, but declined ~25% from mid-20th century through 2006

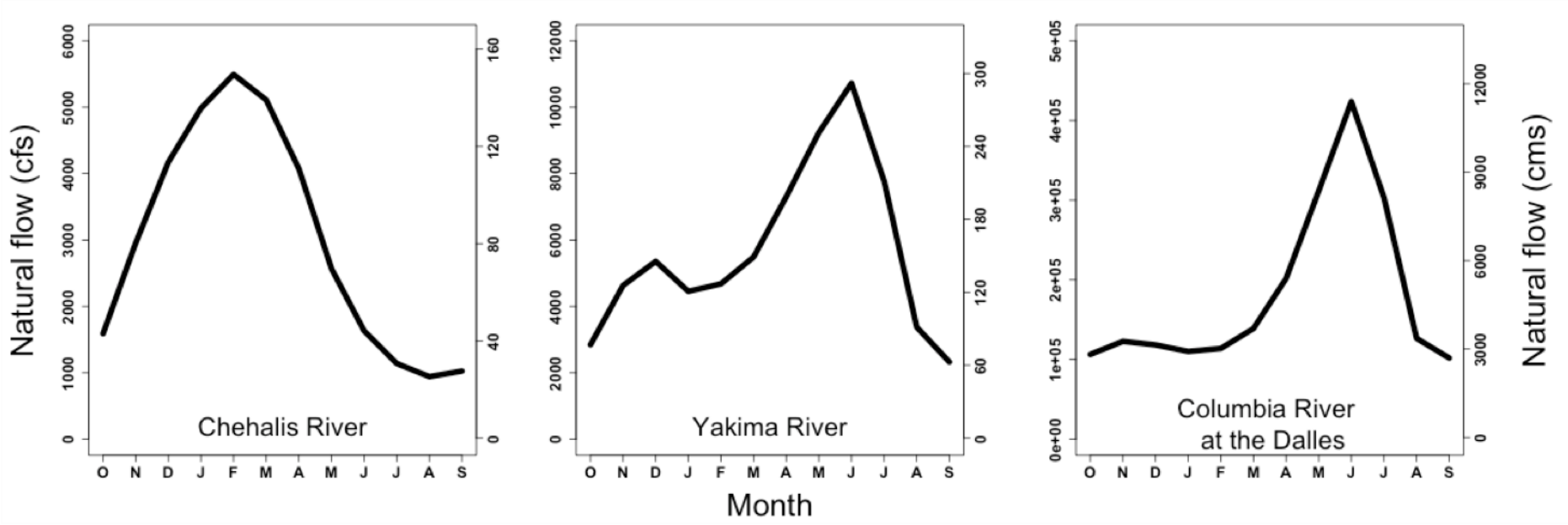


Changes in regionally averaged April 1 SWE for the WA and OR Cascades, 1944-2006

Mote et al. 2008

Snow-Influenced Hydrology

rain-dominant | **"transient"** – double peaked | **snowmelt-dominant**

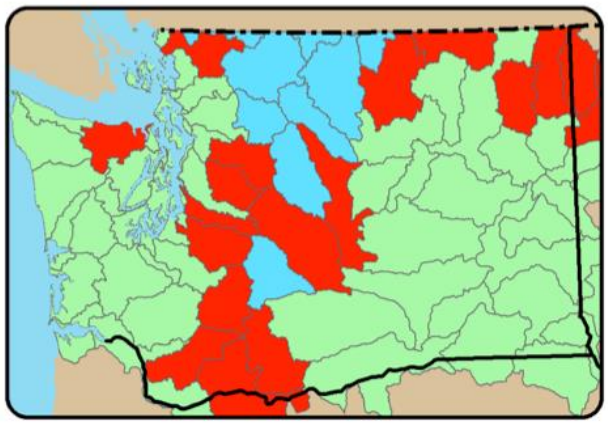


Watershed Classification

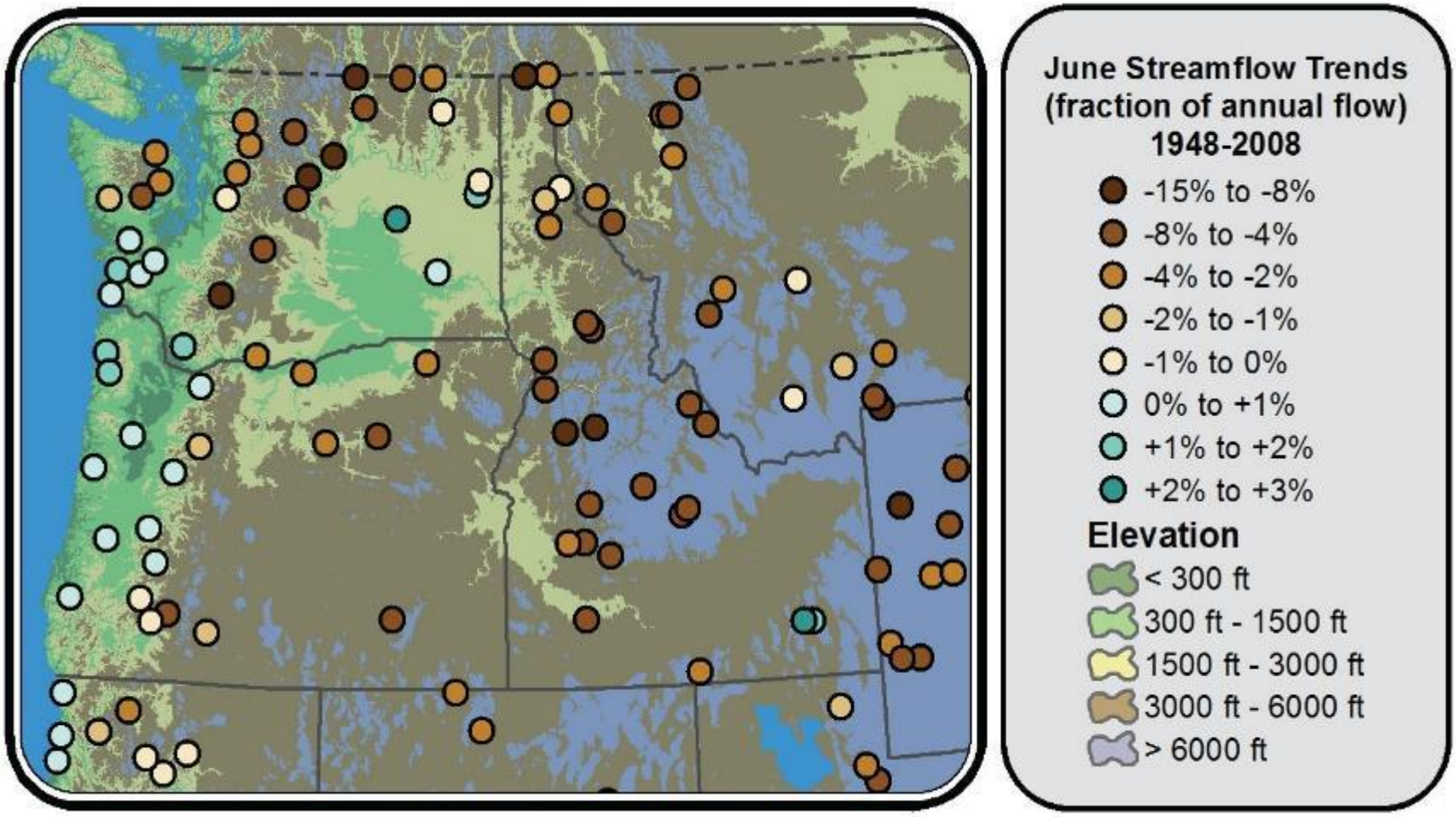
Ratio of April 1 SWE to October - March Precipitation

- < 0.1 Rain dominant
- 0.1 - 0.4 Transition
- > 0.4 Snow dominant

Historical



Earlier Peak Streamflow in Snowmelt-Influenced Basins

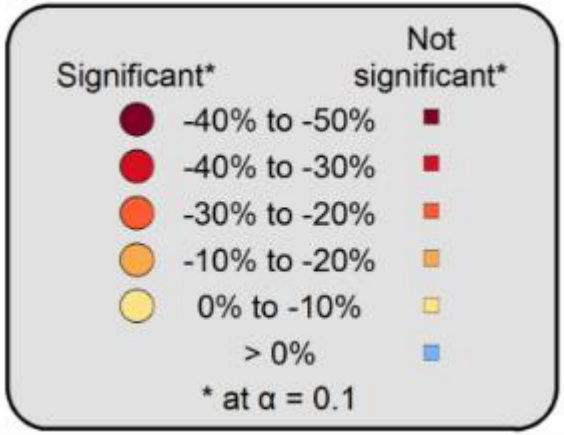


National Climate Assessment 2014, Figure 21.1

National Climate Assessment

Decrease in Summer Low Flows

1948-2006



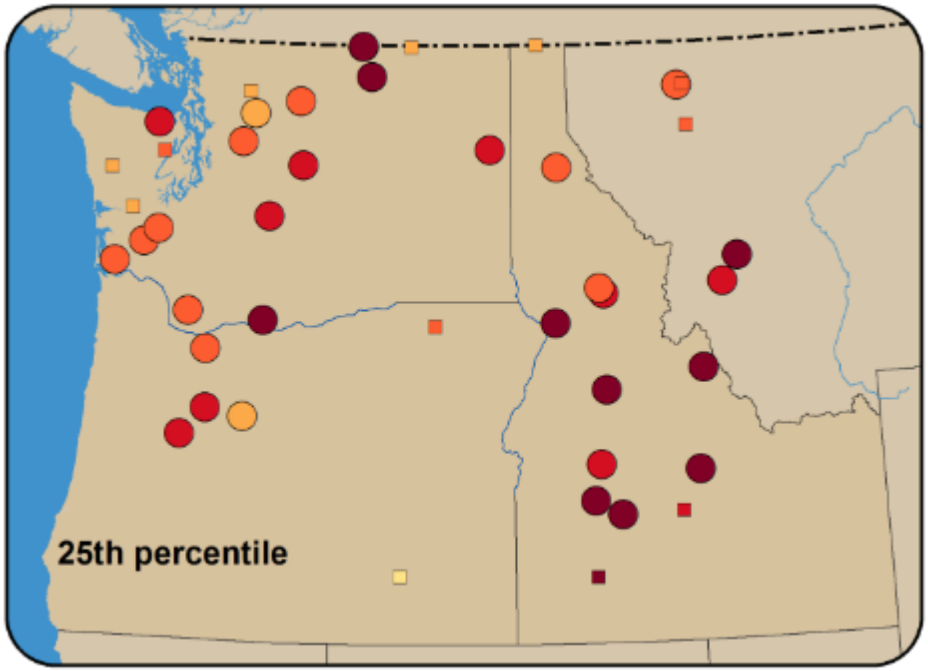
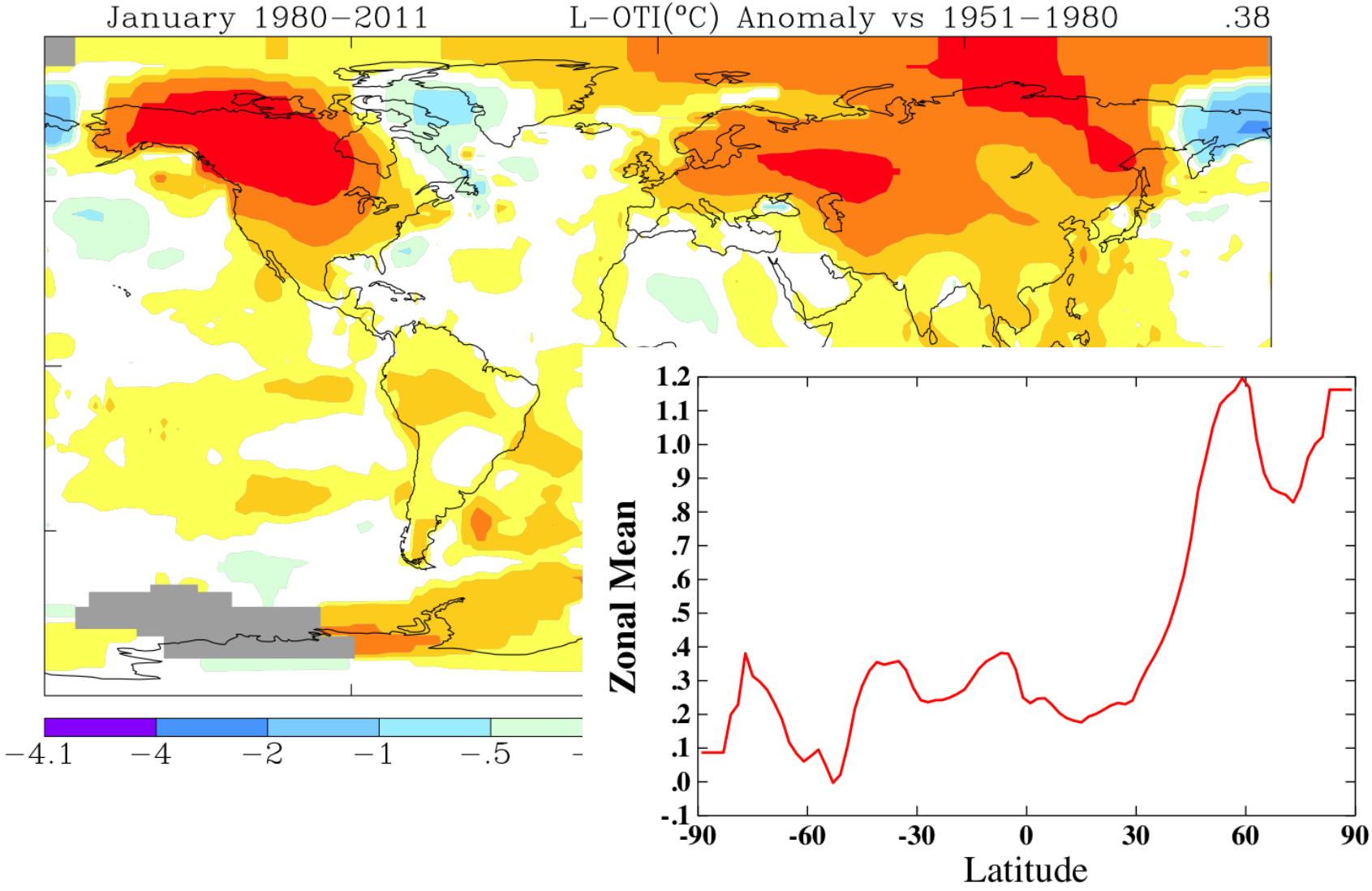


Figure from Raymondi et al. 2014; adapted from Luce and Holdren 2009

Observed Global Temperatures



Data source: NASA Goddard Institute for Space Studies

Observed Global Temperatures Anomalies

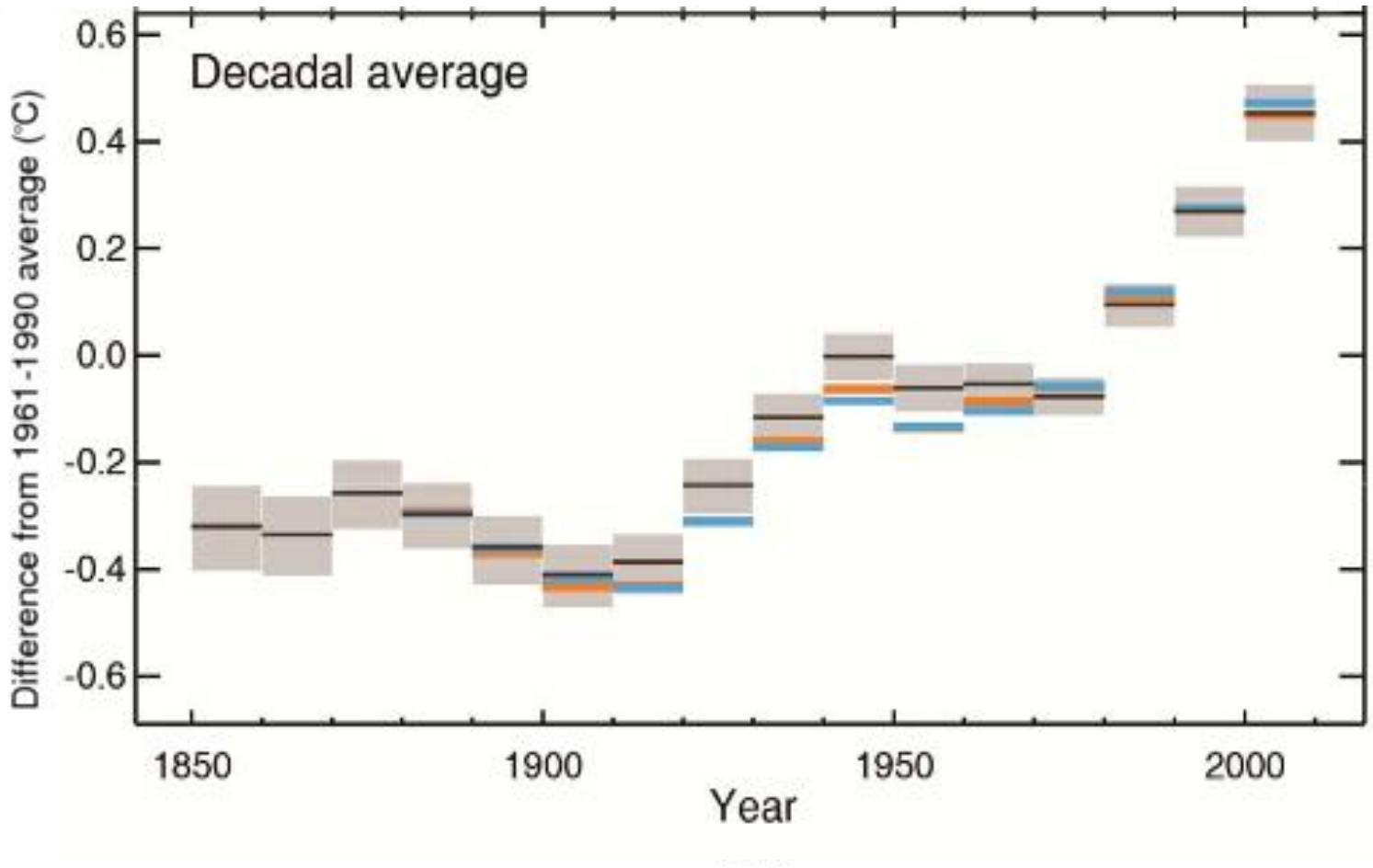
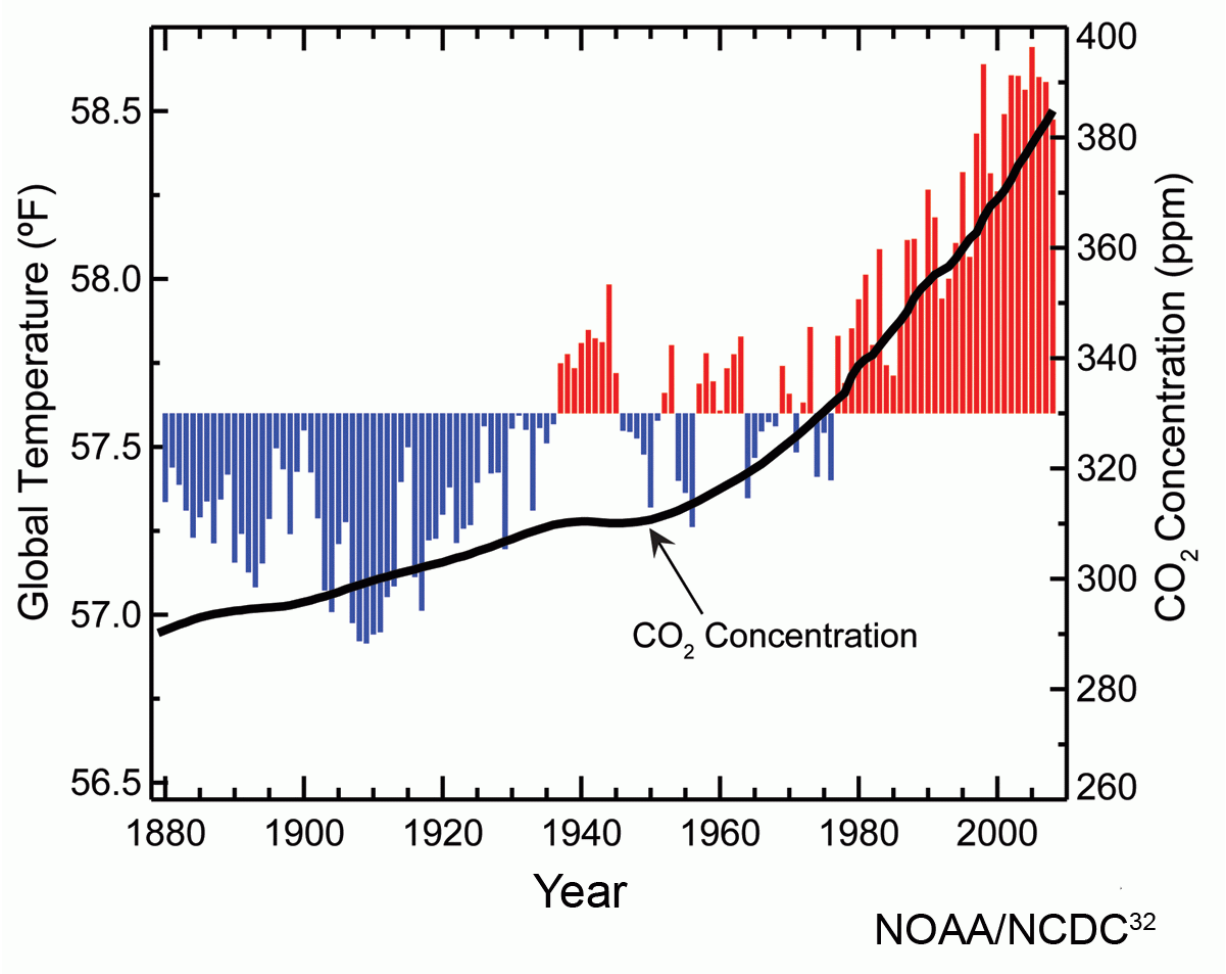


Figure sources: Met Office and IPCC 2013

Global Climate System and Models

Major determinants of climate:

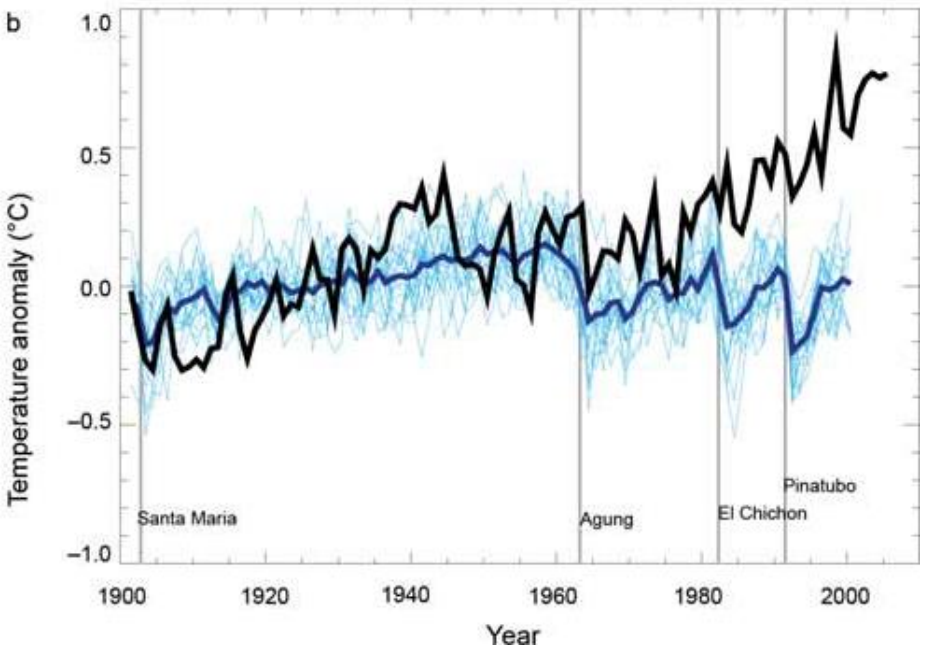
- **Solar radiation***
- **Atmospheric GHGs***
- **Natural climate variations**
- **Volcanoes**



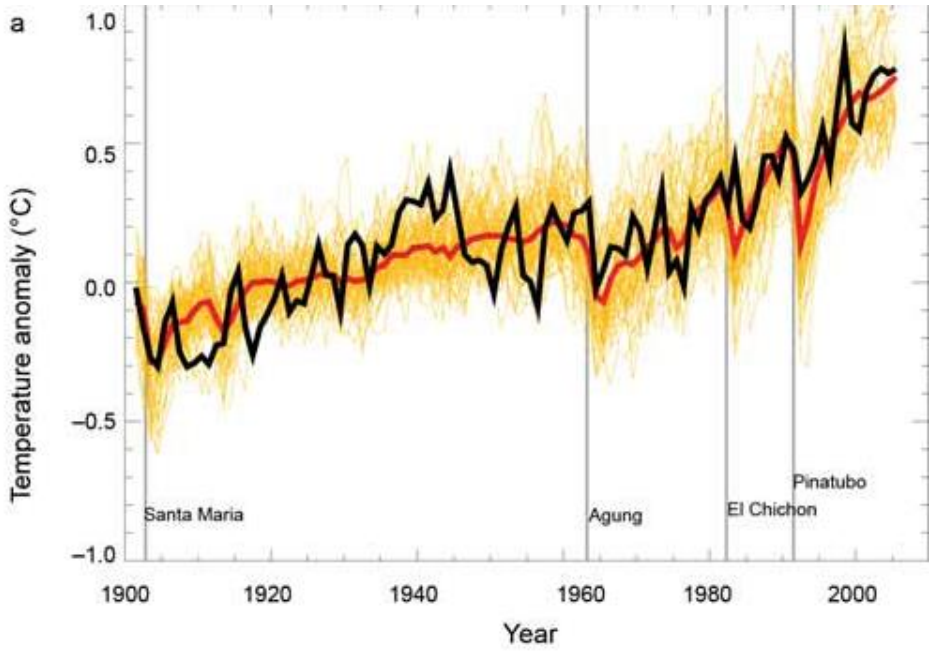
Climate models represent the interactions of the atmosphere and oceans as numbers

Climate Model Responses to Inputs

Only natural forcings



Anthropogenic and natural forcings



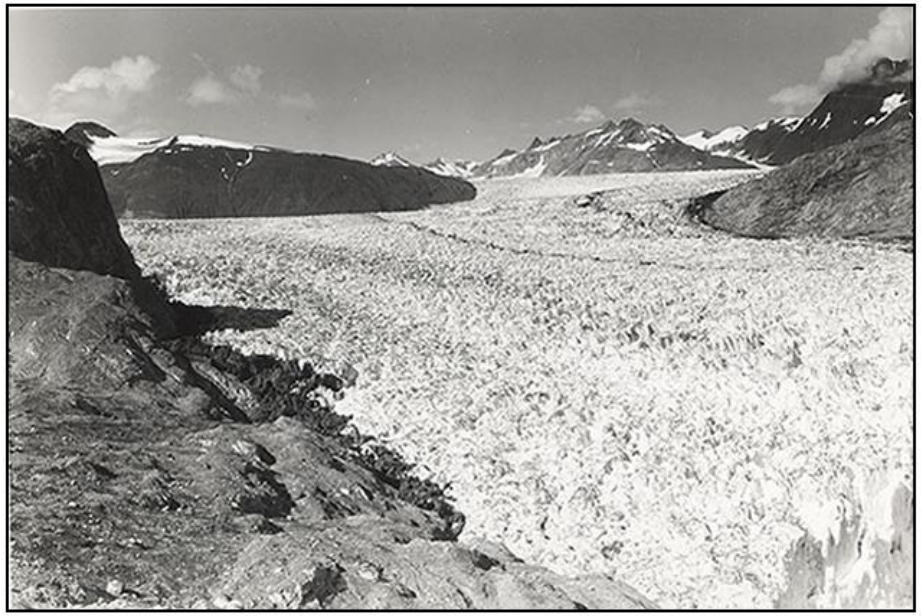
Models cannot track observed temperature changes without the input of human-generated greenhouse gases

Source: Hegerl et al. 2007

The Future Ain't What it Used to Be

- Yogi Berra

Muir Glacier in Alaska



Aug 13, 1941

Aug 31, 2004

Image Credit: *National Snow and Ice Data Center*

Projected 21st Century Global Warming

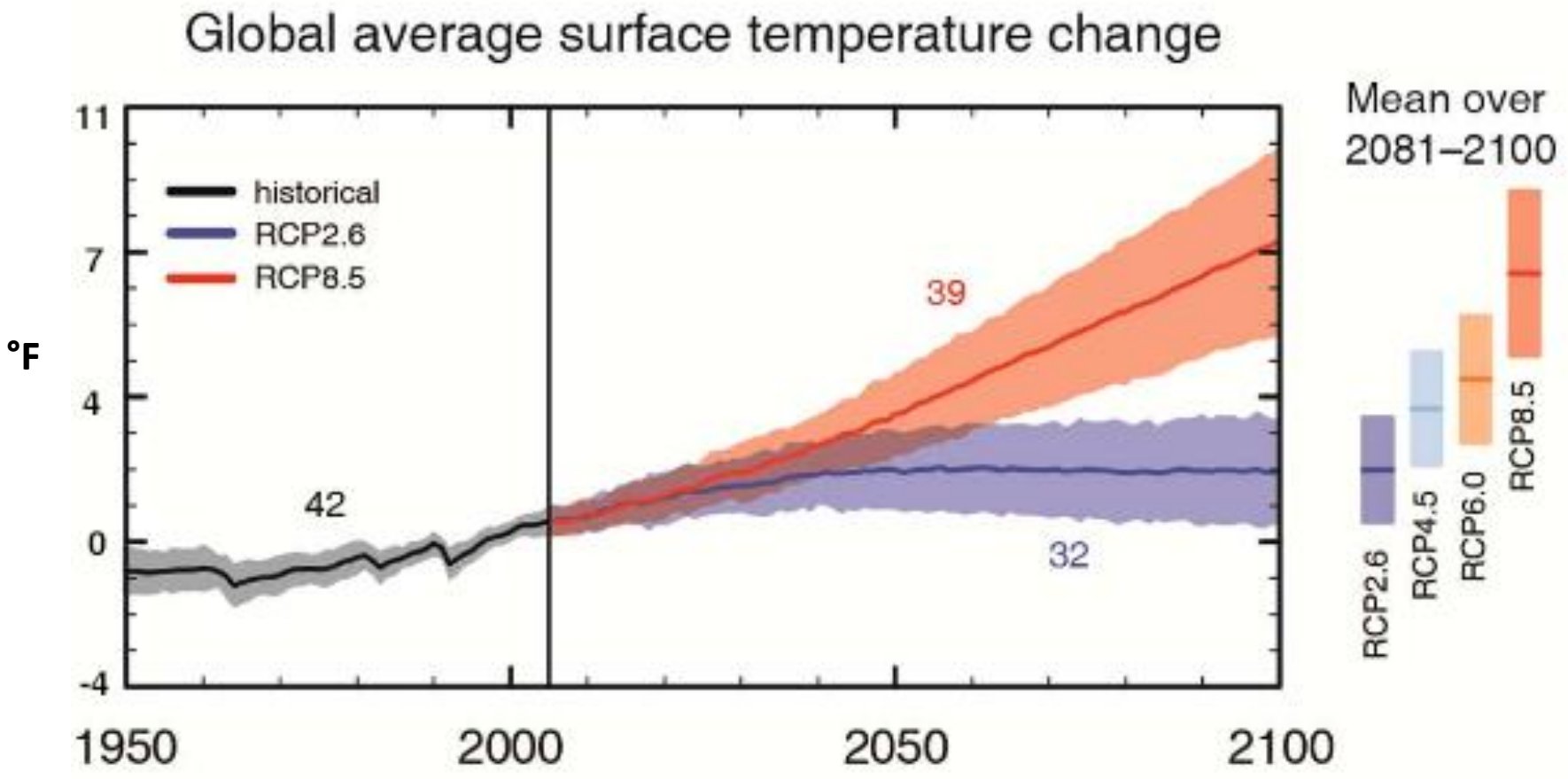
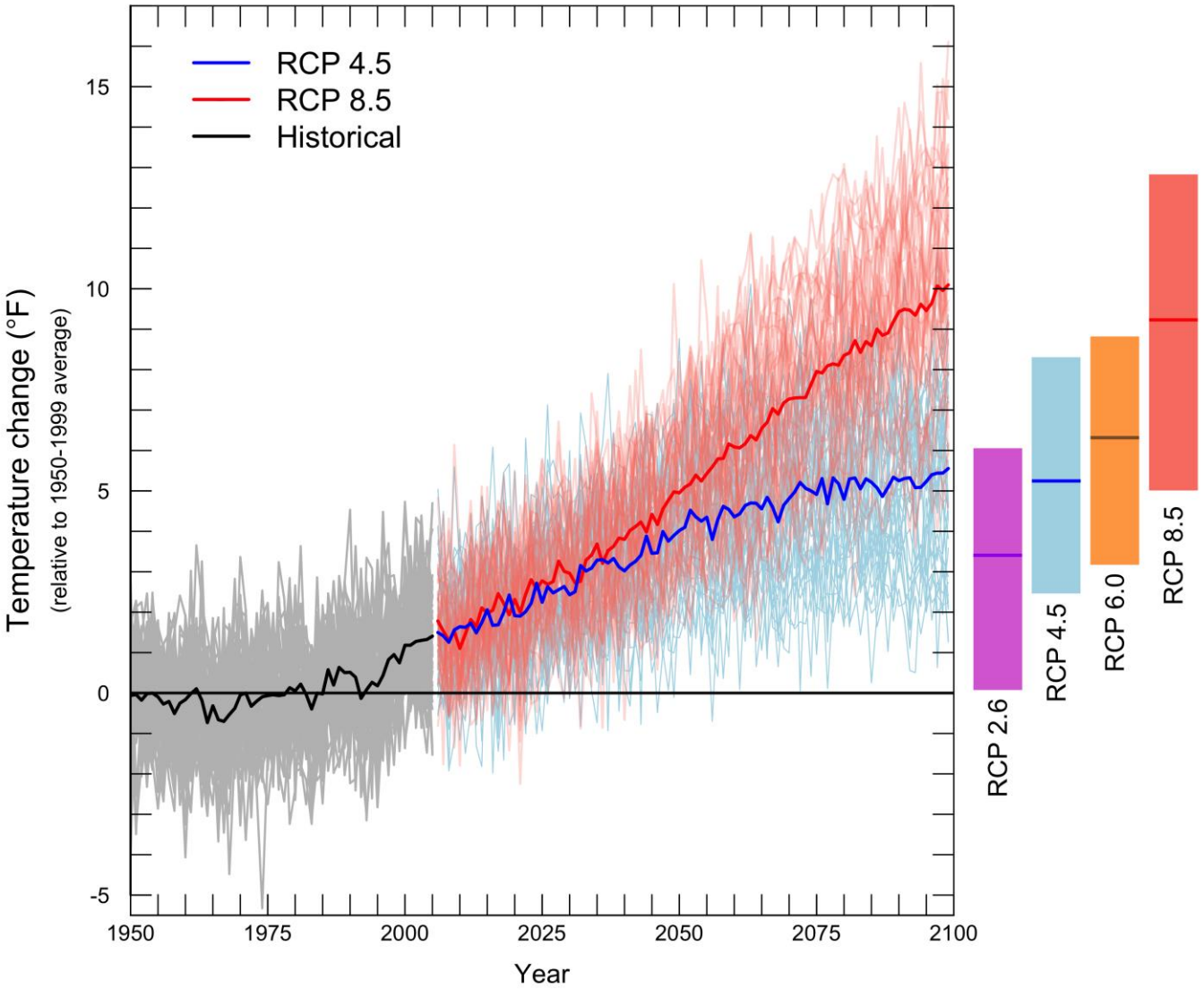


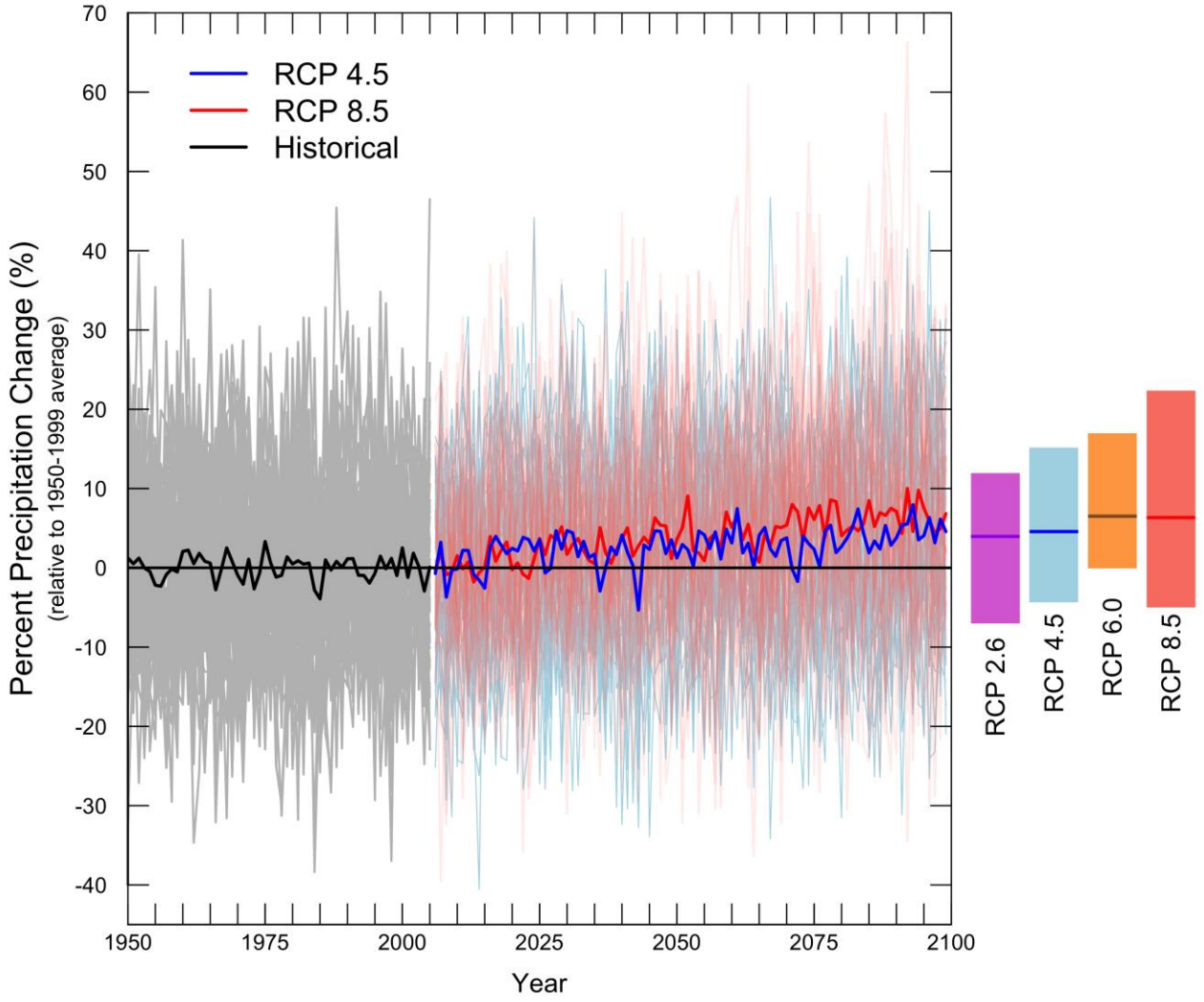
Image source: IPCC 2103

Projected Increases in PNW Temperature



Data source: Abatzoglou (2014)

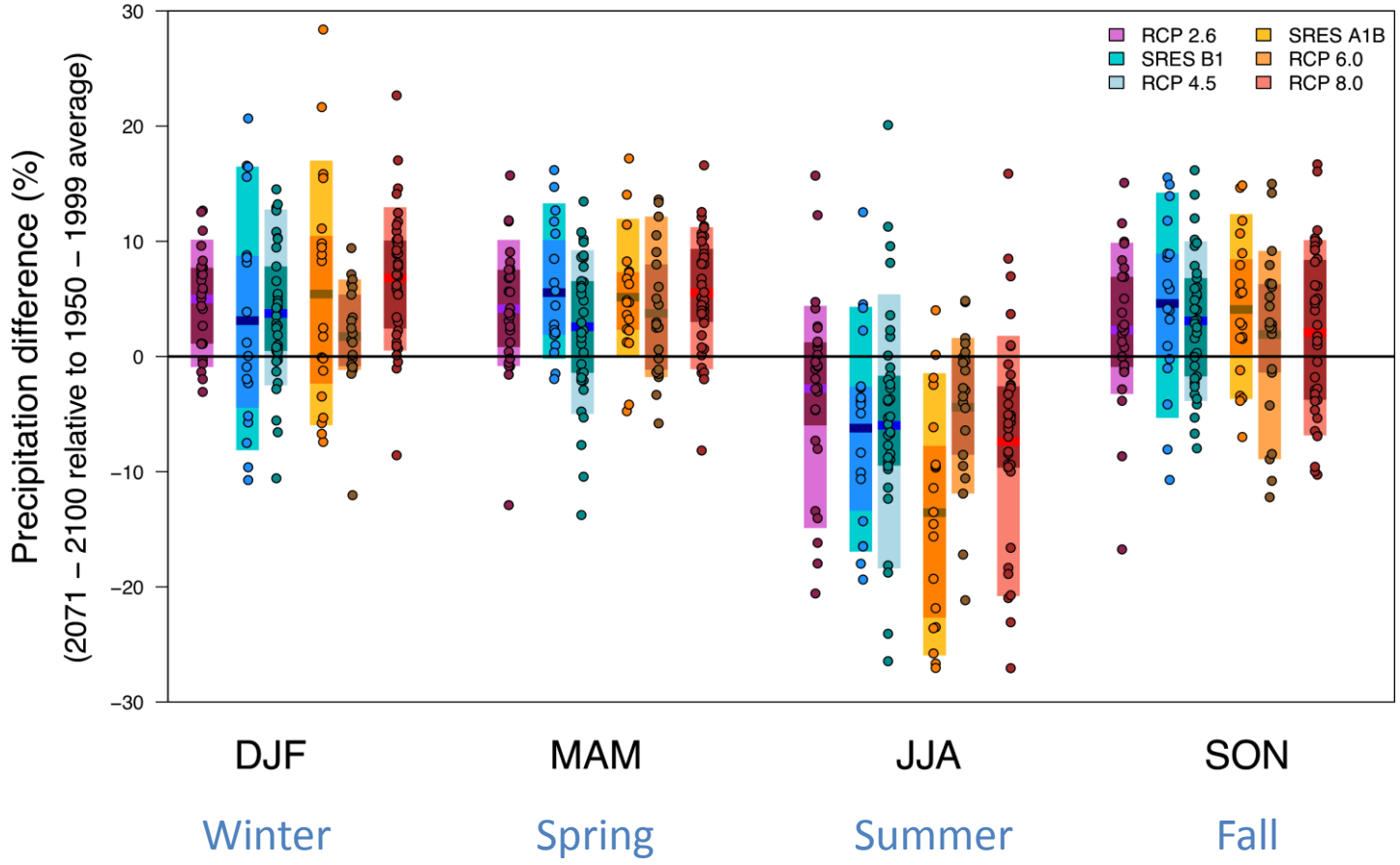
Projected Changes in PNW Annual Precipitation



Small changes in annual precipitation (-5% to +10 %)

Data source: Abatzoglou (2014)

Projected Changes in Seasonal Precipitation



Some models show large seasonal changes

Data source: Abatzoglou (2014)

Projections for the Yakima Basin

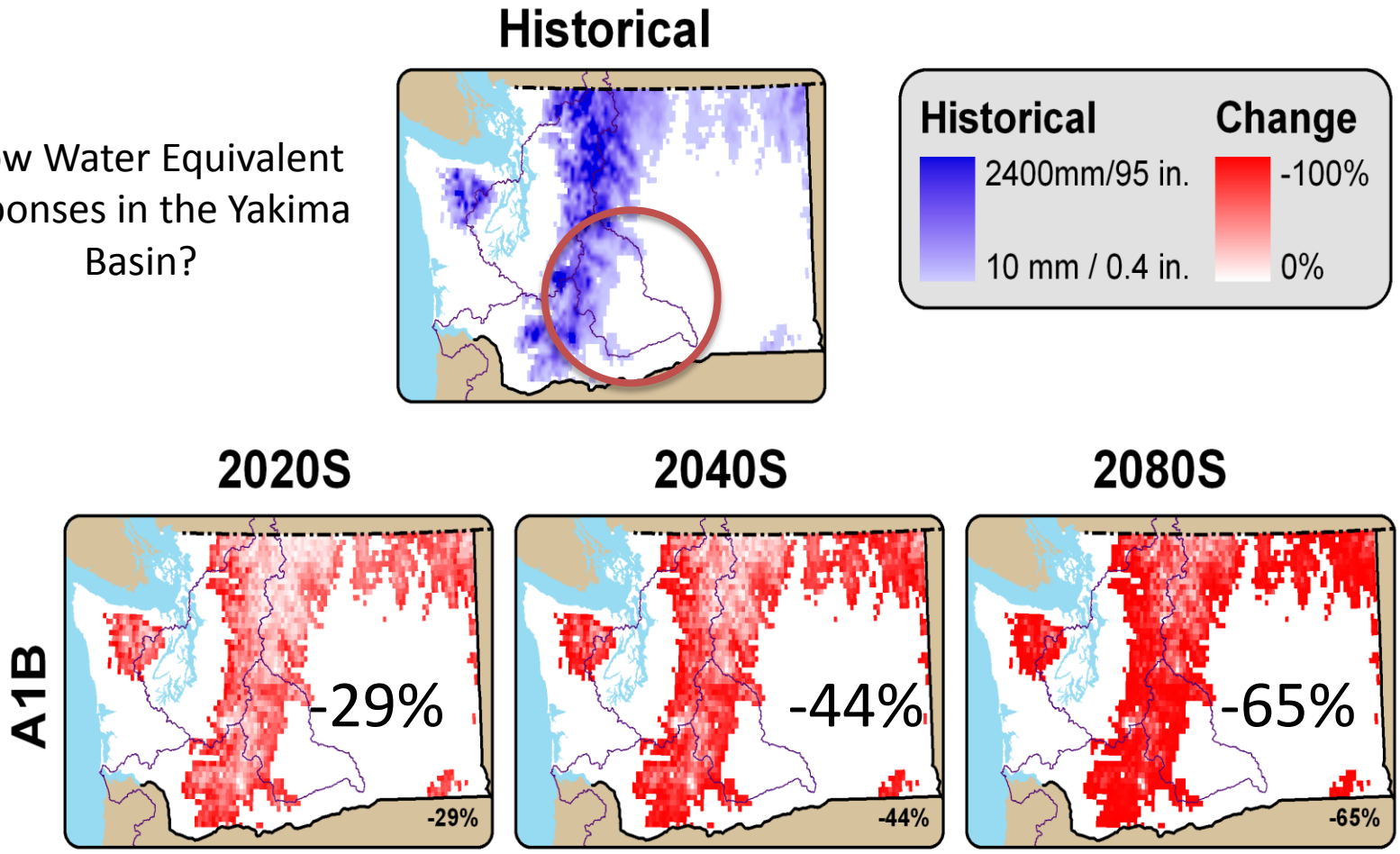
Precipitation* (% change)	2020s (2010 – 2039)	2040s (2030 – 2059)	2080s (2070 – 2099)
Annual	+ 0.22%	+ 2.1%	+ 4.9%
Cool season (Oct – Mar)	+ 2.3%	+ 5.4%	+ 9.6%
Warm season (Apr – Sep)	- 4.2%	- 5.0%	- 4.7%
Temperature* (°F change)	**2020s (2010 – 2039)**	**2040s (2030 – 2059)**	**2080s (2070 – 2099)**
Annual	+ 2.1	+ 3.7	+ 6.3
Cool season (Oct – Mar)	+ 1.9	+ 3.3	+ 5.8
Warm season (Apr – Sep)	+ 2.4	+ 4.1	+ 6.8

***Compared to 1970 – 1999 averages**

Vano et al. 2010

Primary Driver: Loss of Snow Cover

Snow Water Equivalent responses in the Yakima Basin?

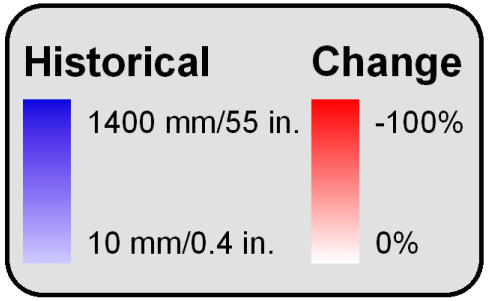


As temperatures warm, more winter precipitation projected to fall as rain rather than stored as snow.

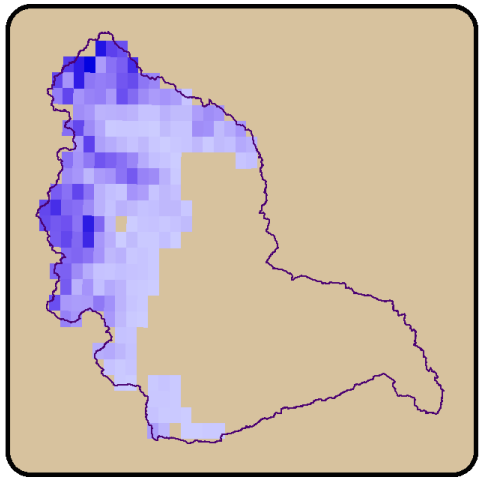
Spring snowpack is projected to decline, *especially in warmer mid-elevation basins.*

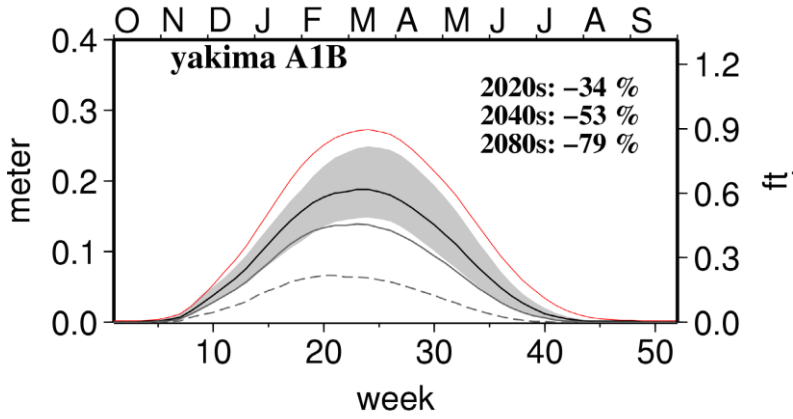
Snowpack projected to melt earlier with warmer spring temperatures.

April 1 Snow-Water Equivalent

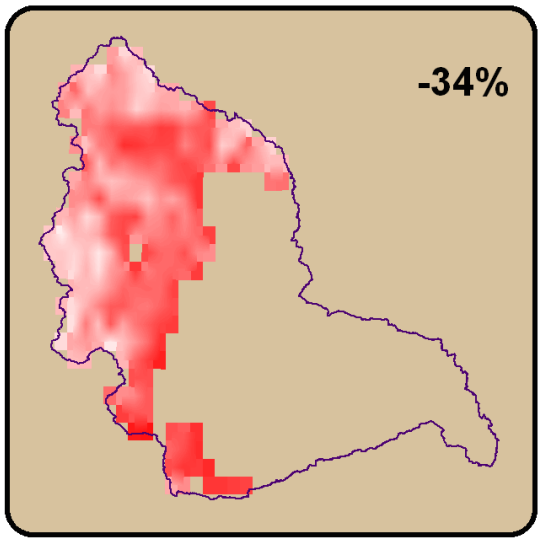


Historical

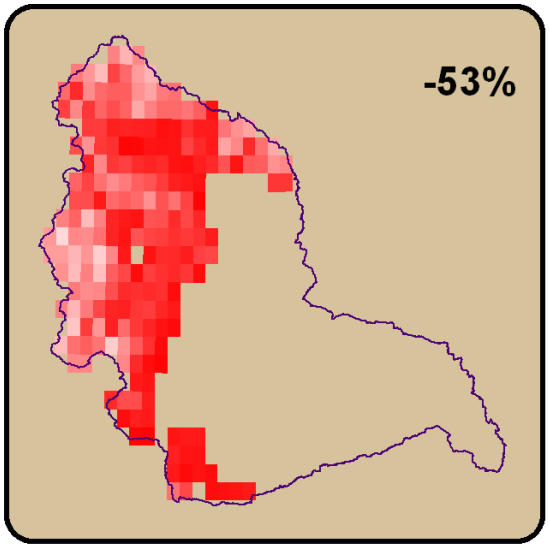




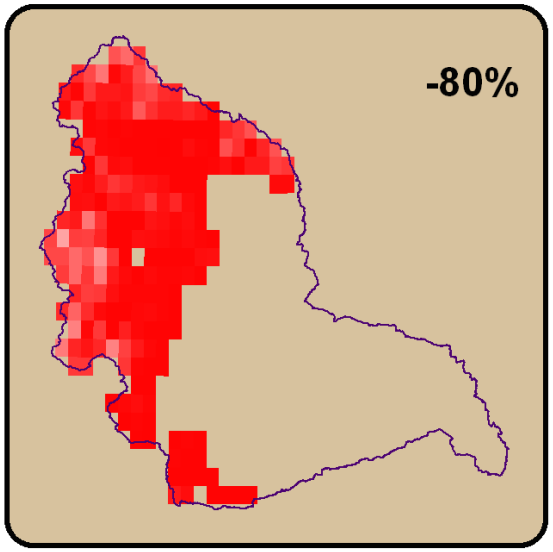
2020s



2040s

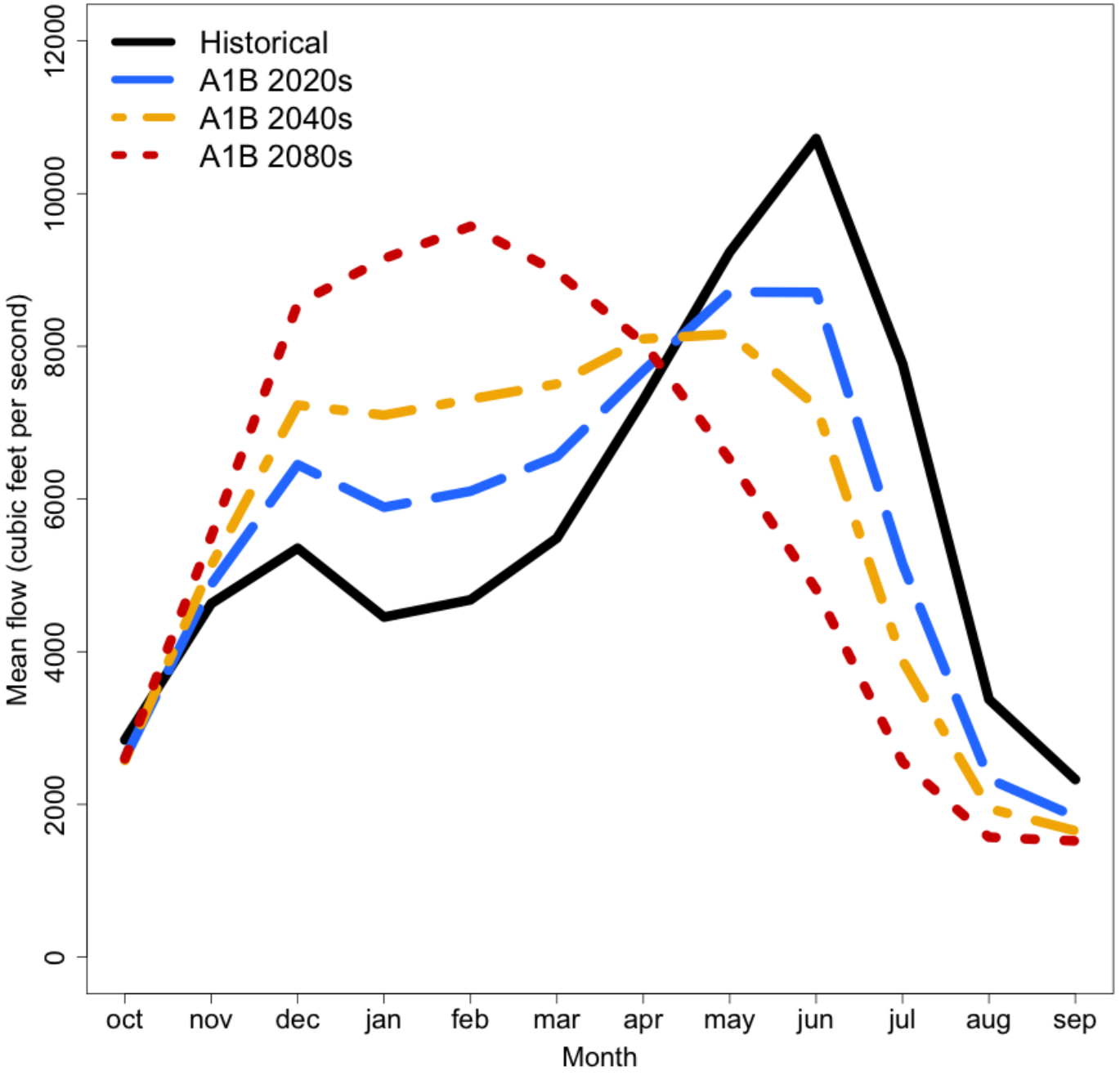


2080s



Snowpack considered the Yakima's 6th reservoir

Other 5 man-made structures can store ~30% of annual runoff (peak storage in June)

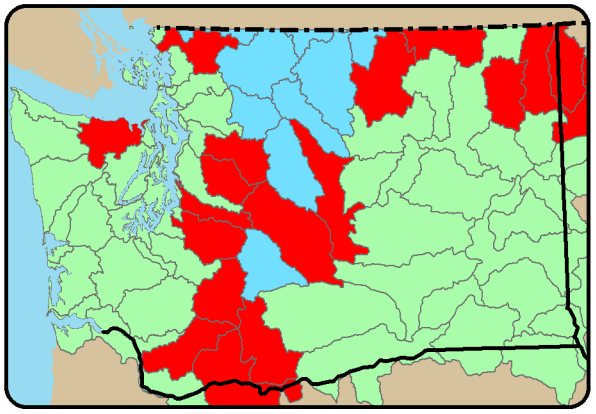

Historical
A1B 2020s
A1B 2040s
A1B 2080s
Mean flow (cubic feet per second)
0
2000
4000
6000
8000
10000
12000
oct
nov
dec
jan
feb
mar
apr
may
jun
jul
aug
sep
Month

Watershed Classification

Ratio of April 1 SWE to October - March Precipitation

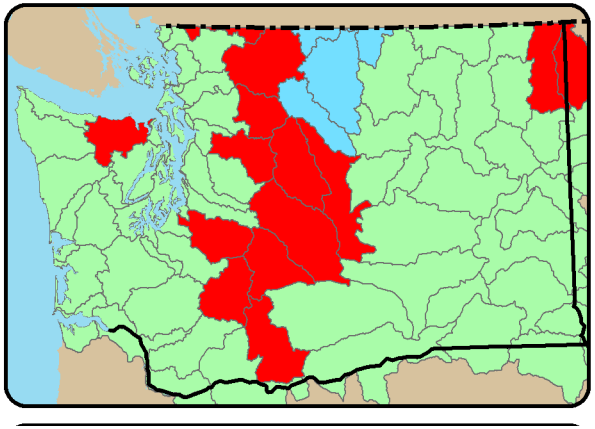
- < 0.1 Rain dominant
- 0.1 - 0.4 Transition
- > 0.4 Snow dominant

Historical

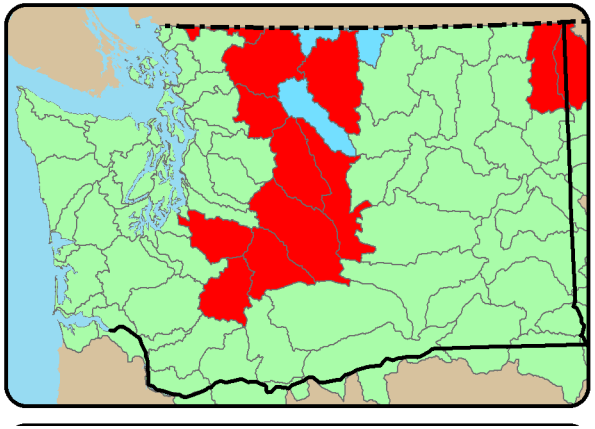


A1B

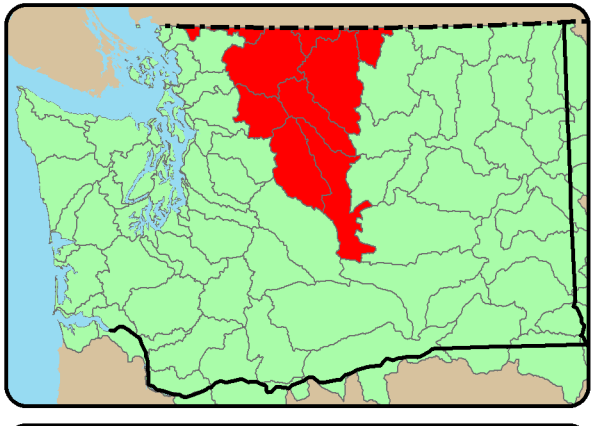
2020s



2040s

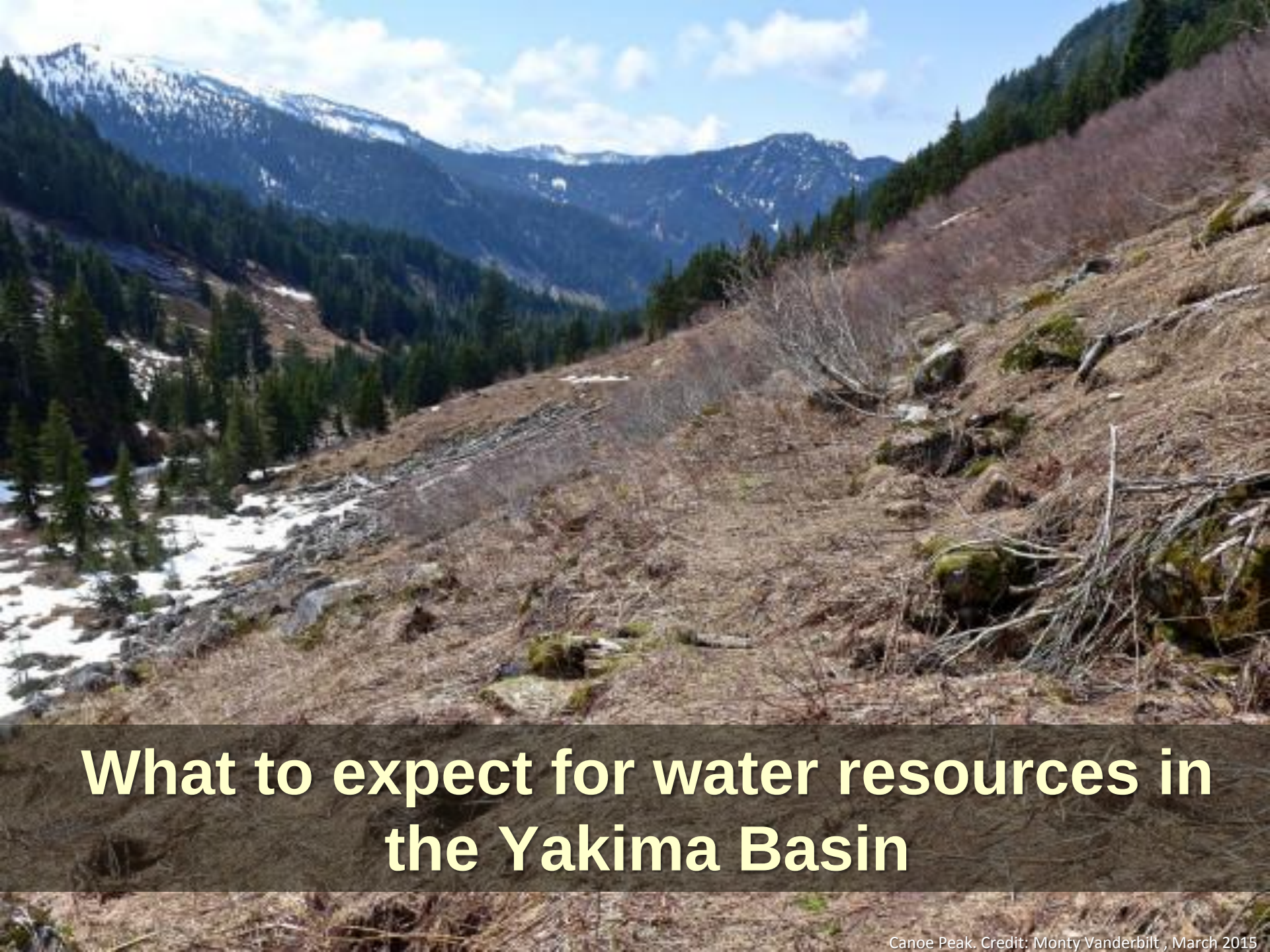


2080s



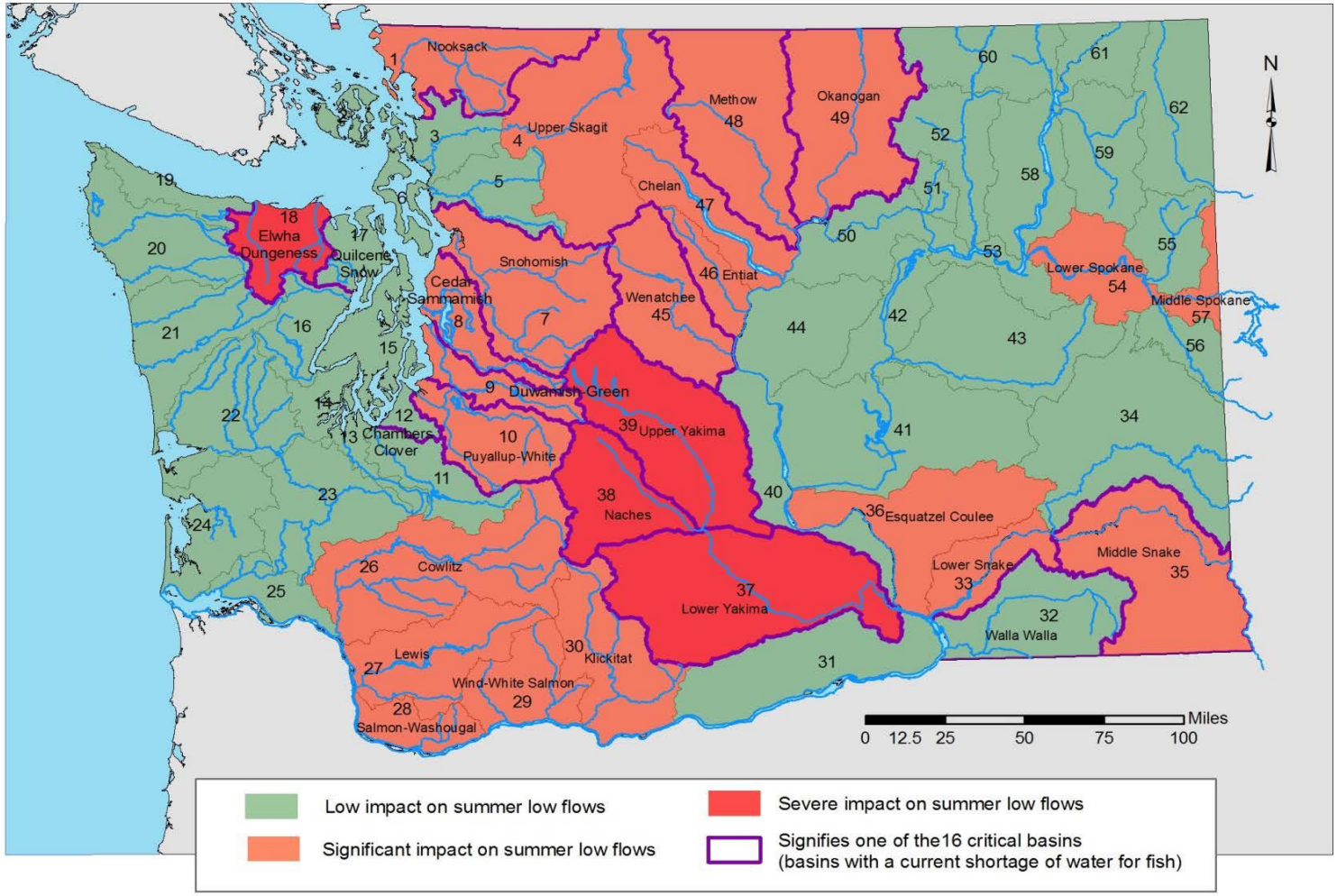
An overall transition from snow-dominant → mixed run-off → rain dominant basins as more precipitation falls as rain

What to expect for water resources in the Yakima Basin



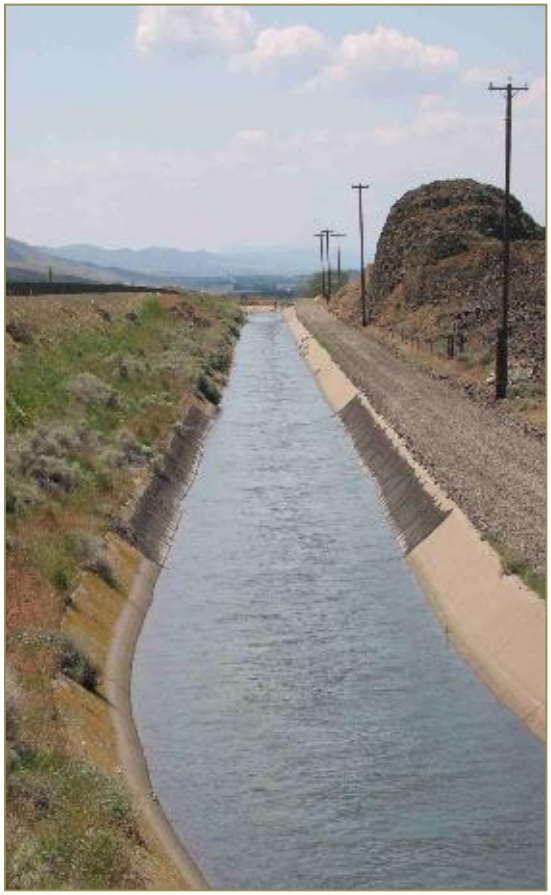
Canoe Peak. Credit: Monty Vanderbilt , March 2015

2040 Projected Climate Change Impact on Summer Flows by WRIA



Source: Yakima Basin Integrated Water Resource Management Plan

Increased Competition for Summer Water Supplies: Irrigation



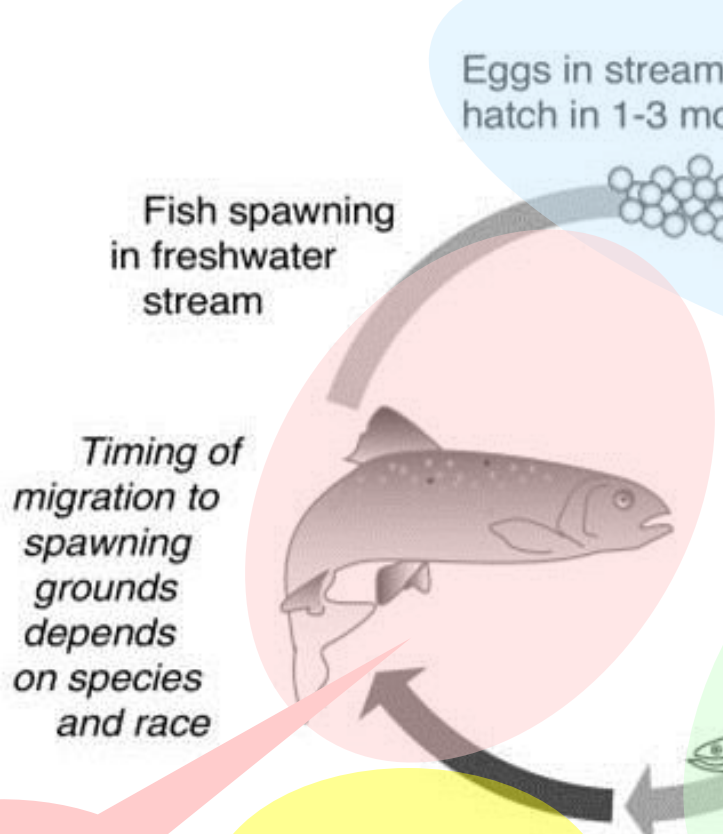
Projected change in water shortage* (% of years) in the Yakima Basin for a moderate greenhouse gas scenario (A1B):

- *Historically (1979-1999):* 14%
- *Projected (2020s): 32%*
- *Projected (2040s): 36%*
- *Projected (2080s): 77%*

*Based on water prorating for junior water users (< 75% of current operations)

(Vano et al. 2010)

Increased Stress for Salmon



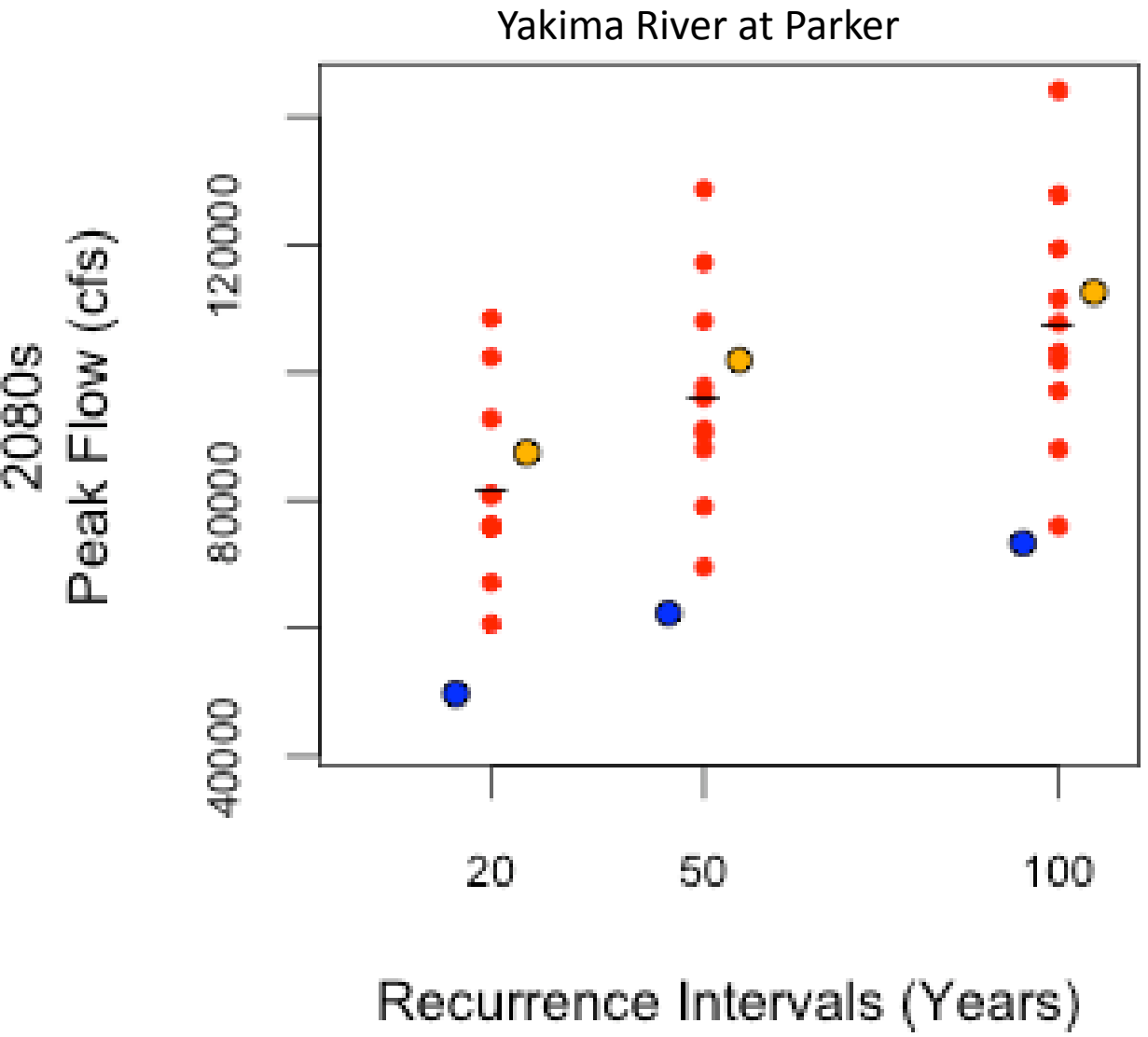
Floods

Early peak flows

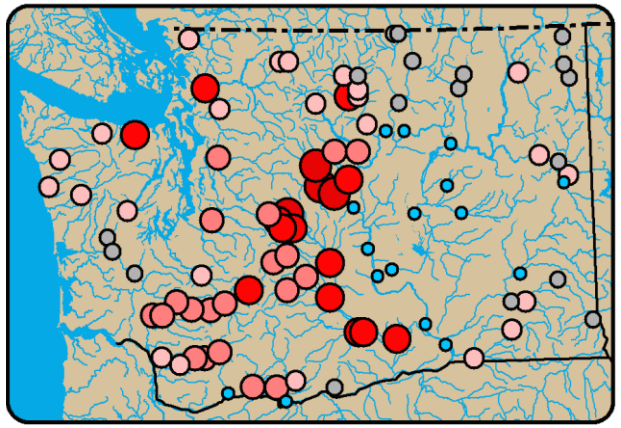
Warm, low streamflow

??

Increased Floods in Sensitive Basins



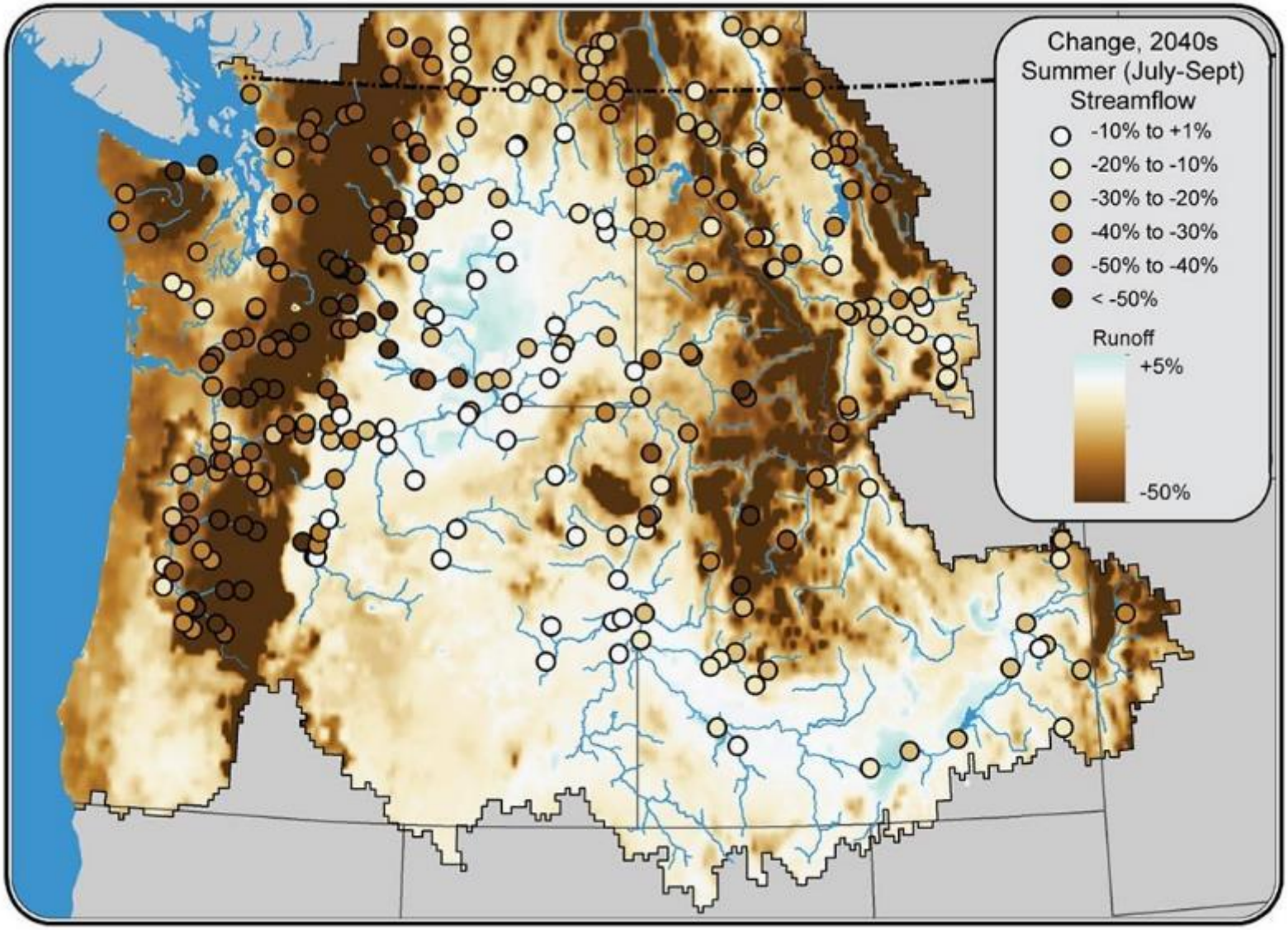
2080s



Yakima 20-year flood magnitudes range +20% to +120% for the 2080s

Mantua et al. 2010, Tohver et al. 2014

Reduced Summer Streamflows

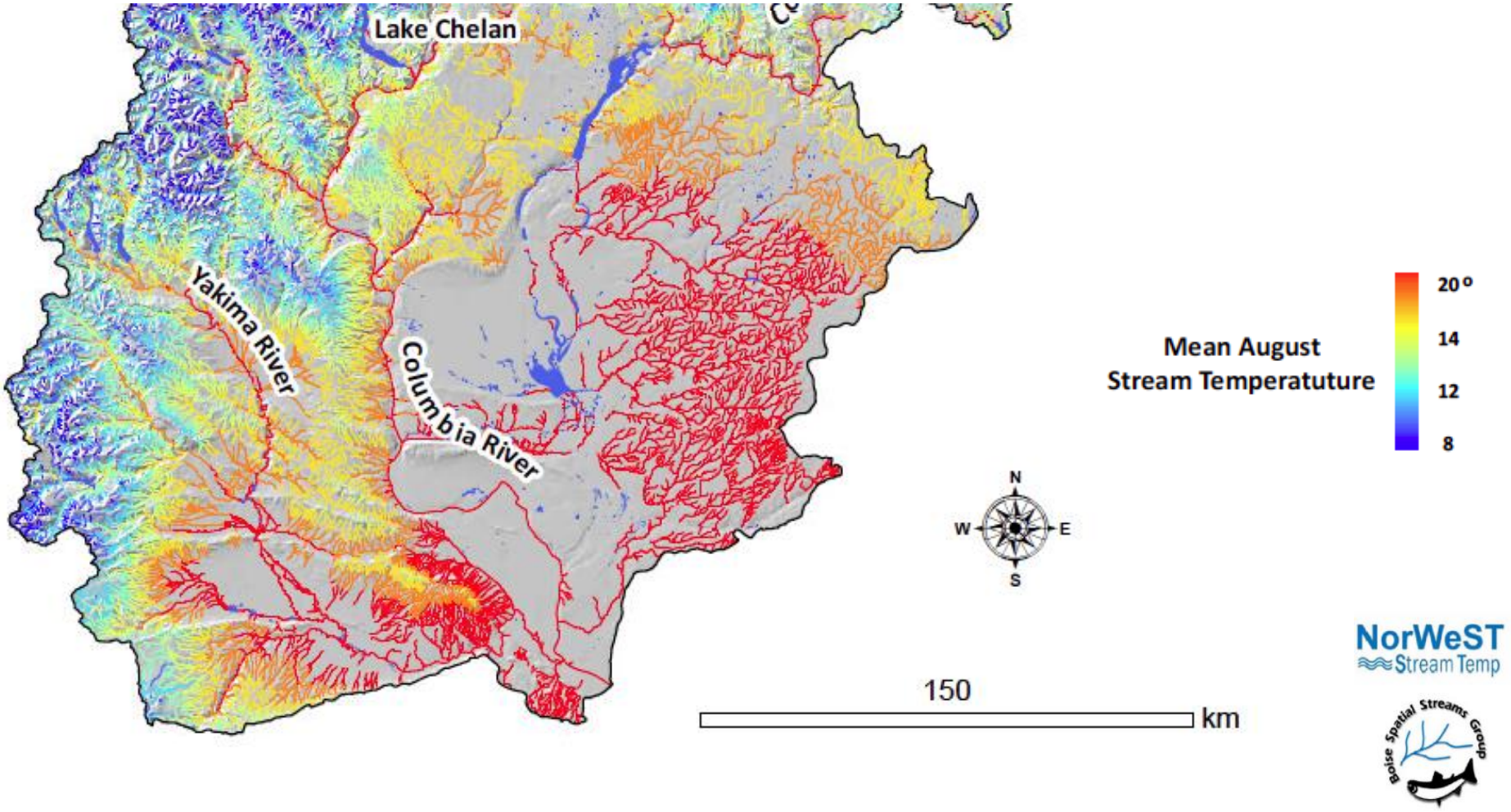


Watersheds with significant groundwater contributions to summer streamflow may be less responsive to climate change than indicated here. Figure source: National Climate Assessment Figure 21.2b.

National Climate Assessment

Summertime Stream Temperature Thresholds for Fish

2080s

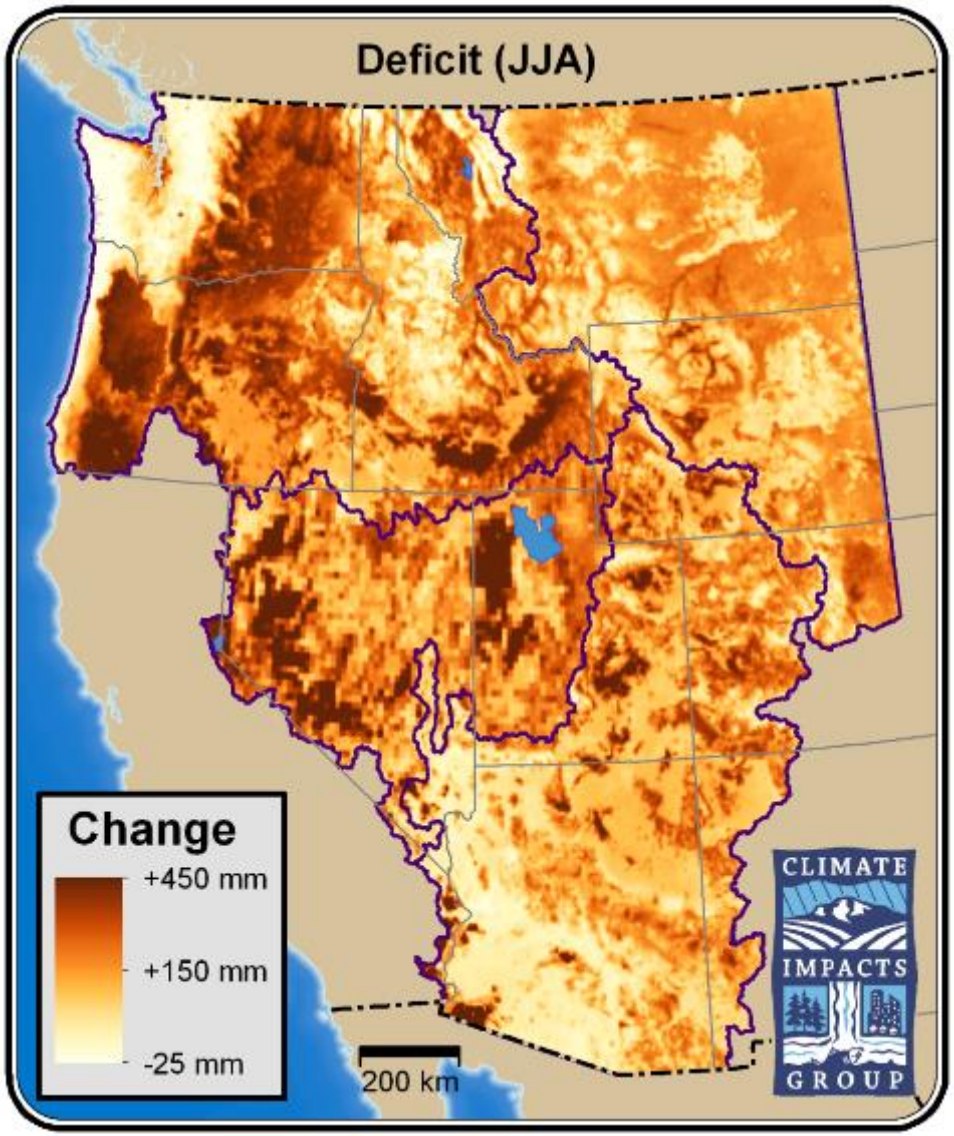


http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html

Increasing Summer Soil Moisture Deficit

450 mm = ~17 inches

25 mm = ~1 inch



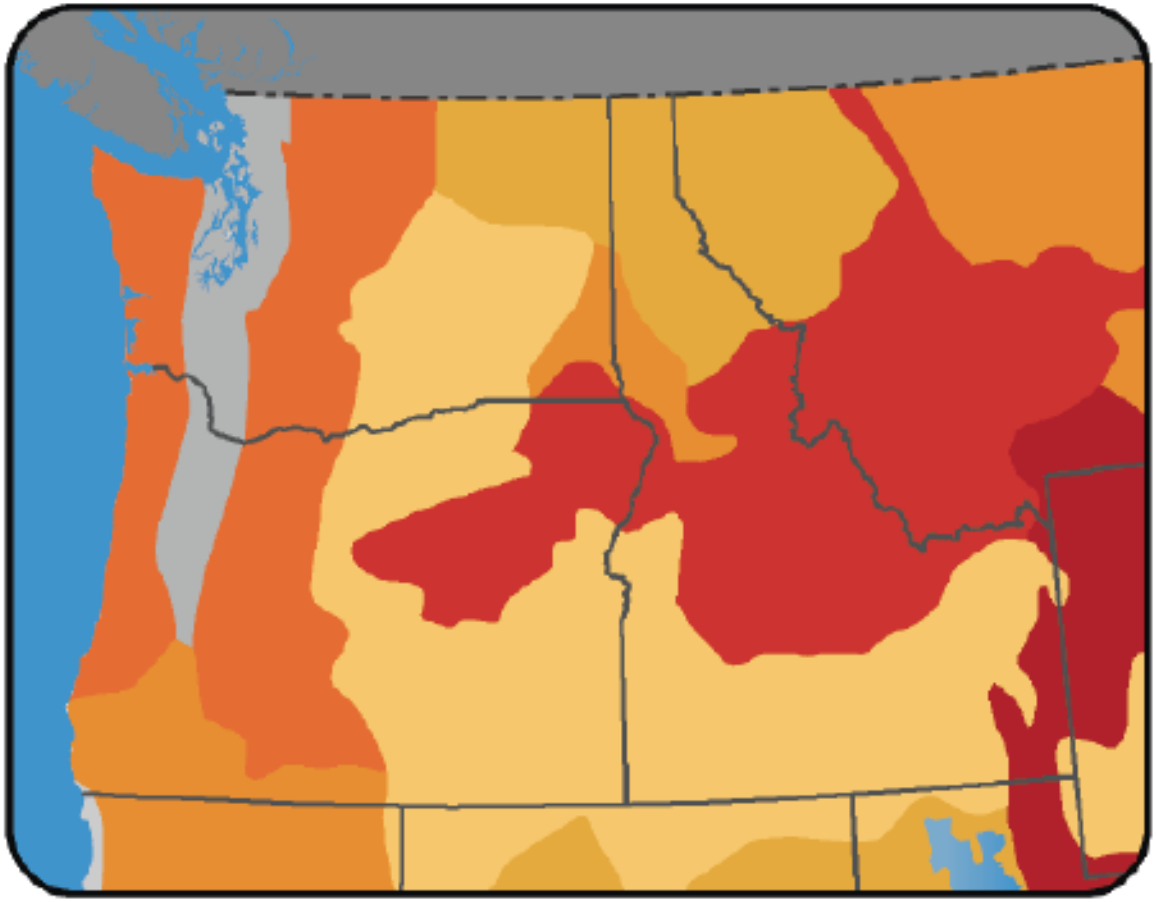
Littell et al 2011; data source: http://cses.washington.edu/cig/data/wus.shtml

Increased wildfire risk

Area burned by fire in the Columbia River Basin is projected to double by 2020s, triple by 2040s, x5 by 2080s (relative to median for 1916-2006).
(Littell et al. 2010, 2012)

Discovery Fire burns near volatile stands of insect-damaged trees, 2009, DNR

Increased wildfire risk: +2.2 F



Projected Increase in Area Burned

- 600% to 700%
- 500% to 600%
- 400% to 500%
- 300% to 400%
- 200% to 300%
- 100% to 200%
- Not modeled

National Resource Council 2011

Examples of Potentially Affected Decisions: Impacts on Water Management and Salmon

- Flow management (timing, volume)
- Habitat restoration project planning, implementation
- Culvert sizing, construction
- Hatchery management
- Invasive species management
- Harvest rates/limits
- Flood management

Yakima River Basin Integrated Water Resource Management Plan: Key Elements

- Fish Passage
- Fish Habitat Enhancement
- Modifying Existing Structures and Operations
- Surface Storage
- Market-based Reallocation
- Groundwater Storage
- Enhanced Water Conservation

The Climate Impacts Group

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