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# Climate Change and Hazard Mitigation

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CLIMATE IMPACTS GROUP

# Climate Impacts Group

- Advance awareness and understanding of climate risks.
- Support the use of this information by public and private entities shaping our future.

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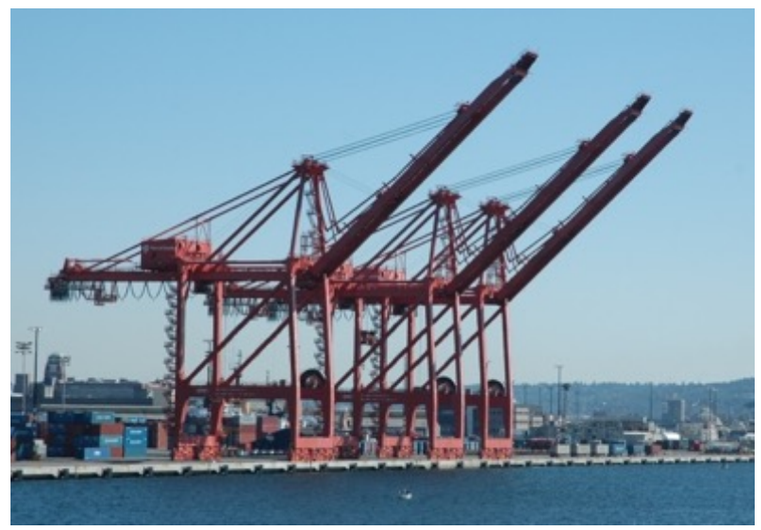
Est 1995

# Climate expectations are embedded in much of what we do, including in hazard mitigation.

- Probability/likelihood of occurrence of hazards
- Severity and magnitude of hazards
- Impact of hazards



# Climate Change Mitigation vs. Adaptation

**Climate Change Mitigation**

Reducing emissions of greenhouse gases

**Adaptation (resilience, preparedness, risk-reduction)**

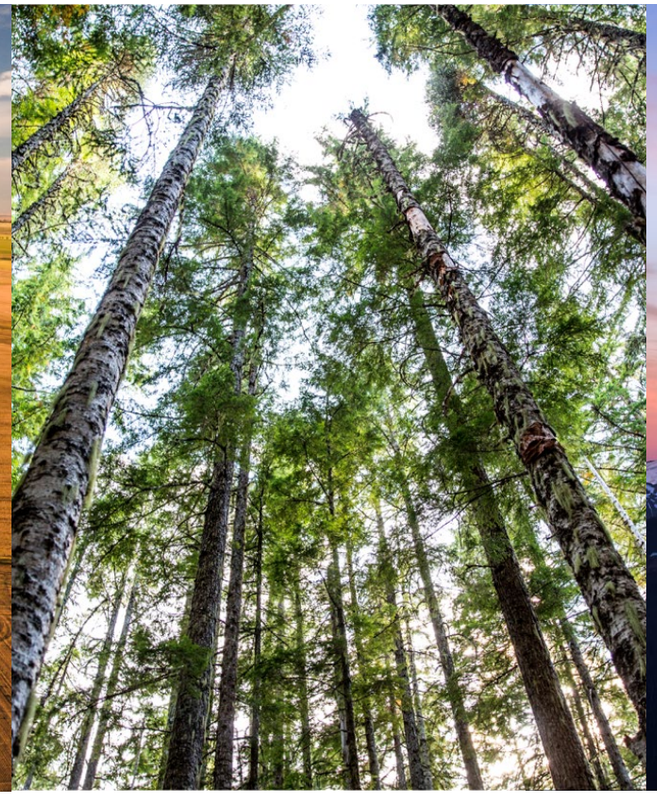
Preparing for the changes that occur as mitigation strategies are implemented.

**Climate adaptation does not assume that the likelihood of future natural hazards can be predicted from the past.**

# Climate change is not a hazard…

# It is a hazard multiplier that will worsen most existing natural hazards.

# Observed Changes



Images: University of Washington

# Puget Sound average annual temperature has increased 1.3°F (1895-2011).

Source: Mauger et al. 2015

# Puget Sound nighttime air temperatures have increased 1.8°F since 1895 and nighttime heat waves have increased.

Source: Mauger et al. 2015

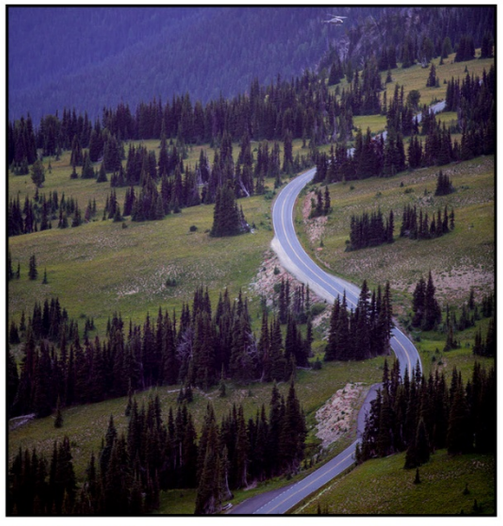
# Washington Cascades snowpack decreased ~25% between the mid-20th century & 2006.

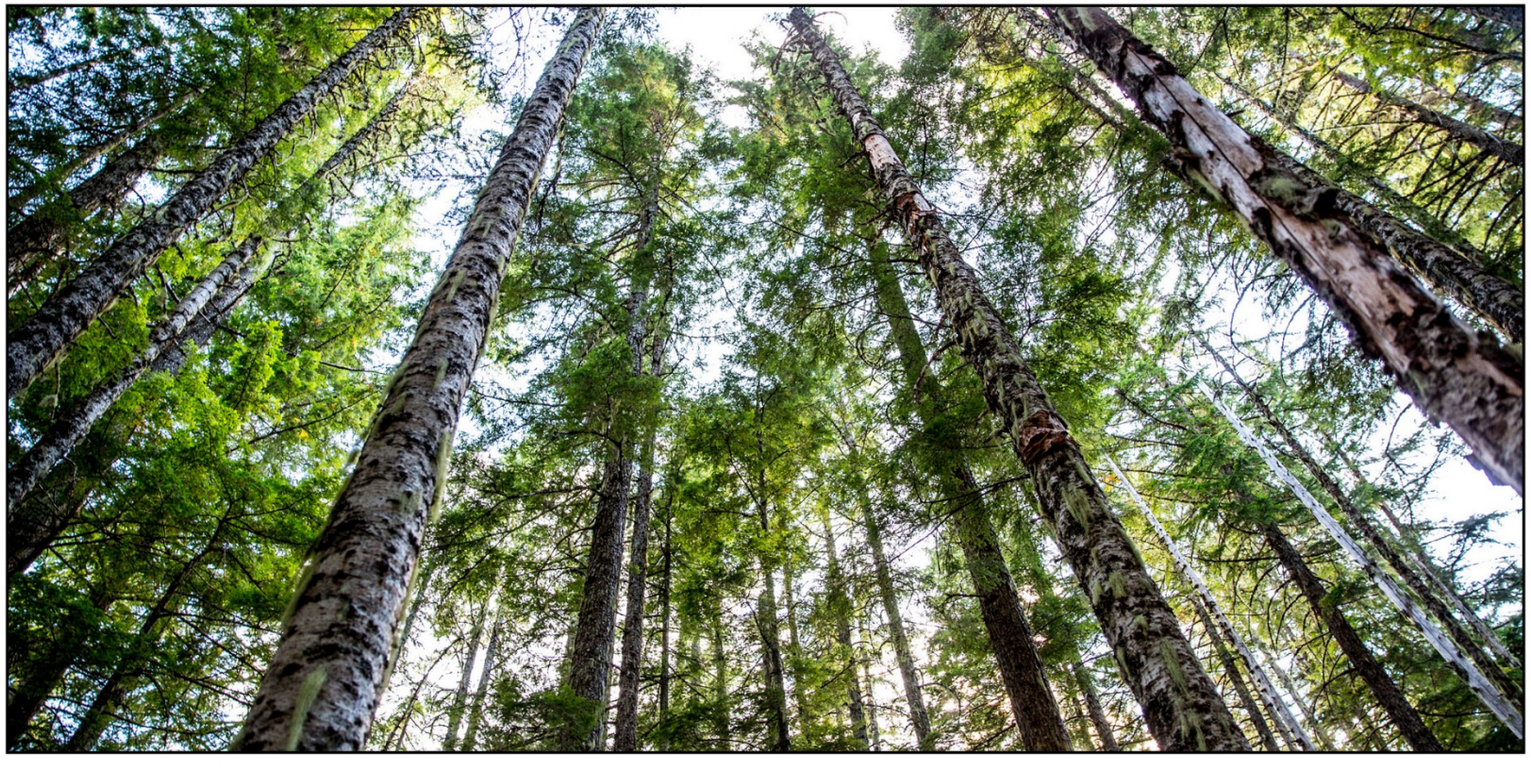
Source: Stoelinga et al. 2009; Mote et al. 2008

# Sea level increased 8.6 inches at the Seattle tide gauge (1900-2008).

Source: Mauger et al. 2015

# Projected Changes





# Key Climate Impact "Drivers"

**Substantial warming**

**Changes in precipitation type, timing, and amount**

**Changes in hydrology** (snow, streamflow)

**Sea level rise**

# Puget Sound Projected Warming

| ***2050s*** *(relative to 1970-1999)* | |
|---|---|
| Lower emissions *(RCP 4.5)* | +4.2°F *(+3.0 to +5.6°F)* |
| Higher emissions *(RCP 8.5)* | +5.7°F *(+4.3 to +7.1°F)* |

| ***2080s*** *(relative to 1970-1999)* | |
|---|---|
| Lower emissions *(RCP 4.5)* | +5.5°F (+4.1 to +7.3°F) |
| Higher emissions *(RCP 8.5)* | +9.1°F (+7.4 to +12°F) |

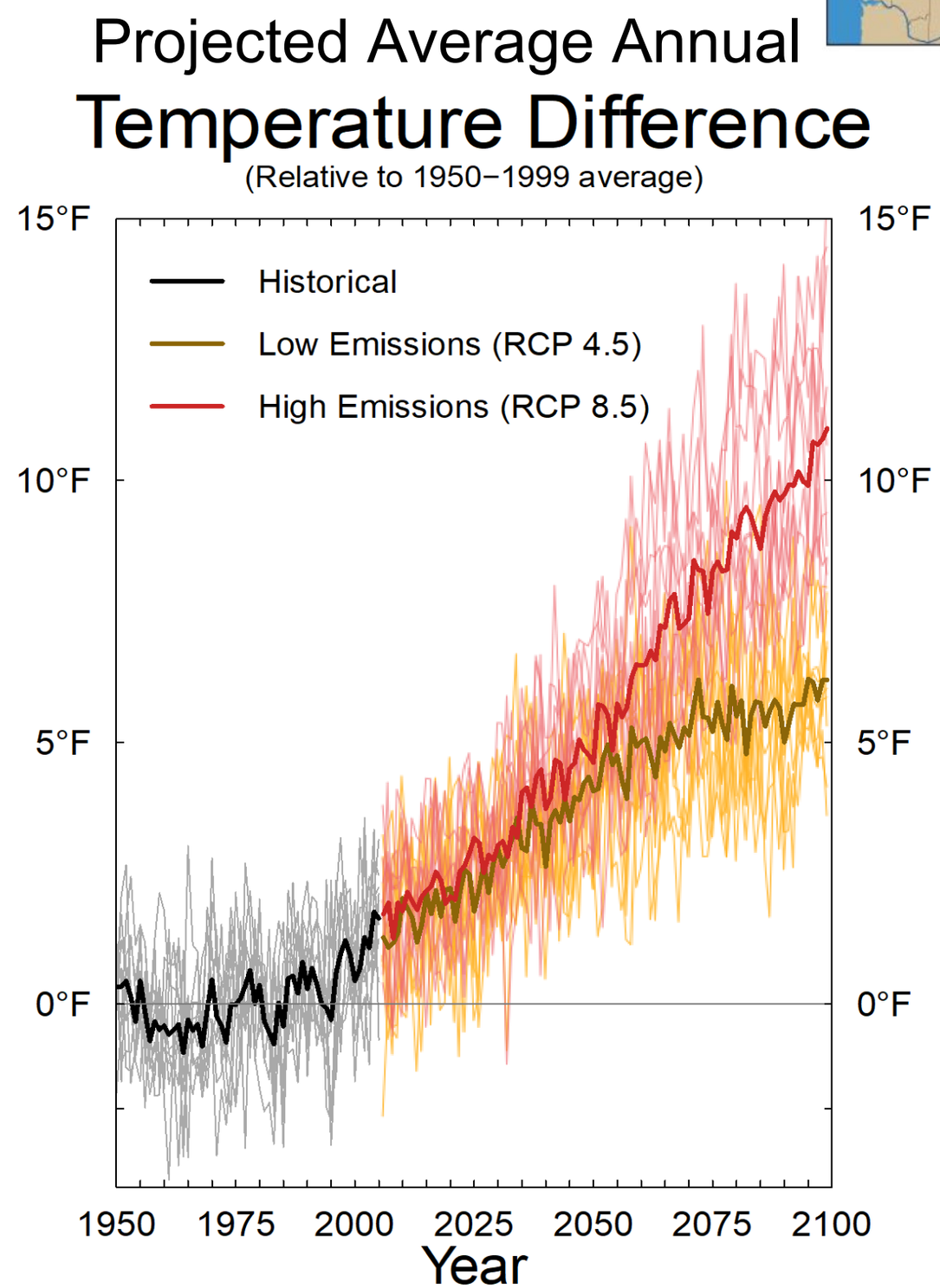



Figure source: Mauger et al. 2015

# Puget Sound Projected Precipitation Change

**Modest increases in average *annual* precipitation** projected in most scenarios.

***Seasonal* patterns reinforced.** Wetter fall, winter, and spring; drier summers likely.

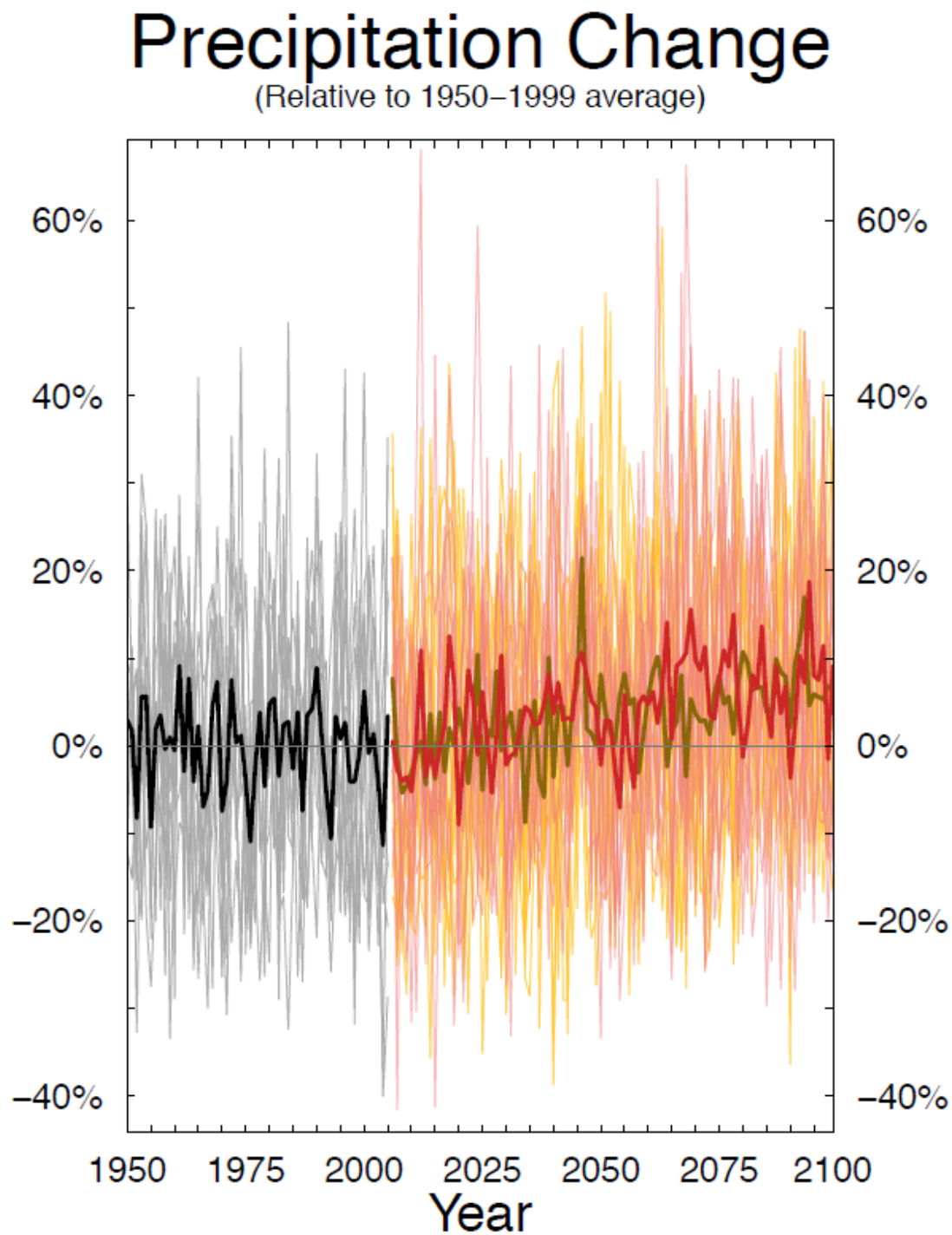



Figure source: Mauger et al. 2015

# More Intense and Frequent Heavy Rain Events

The heaviest 24-hour rain events (e.g., atmospheric rivers) become +22% more intense *(range: +5 to +34%)* by the 2080s

Today's 24-hour events occur more frequently, about 7 days/year by the 2080s compared to about 2 days per year historically (1970-99).

***Changes in Winter Atmospheric Rivers along the North American West Coast in CMIP5 Climate Models***

Warner, Mass, Salathé, J Hydromet, 2014

# Projected Decline in Snowpack

Puget Sound Change:

***2040s:*** -29%

***2080s:*** -55%

**Historical** (inches)

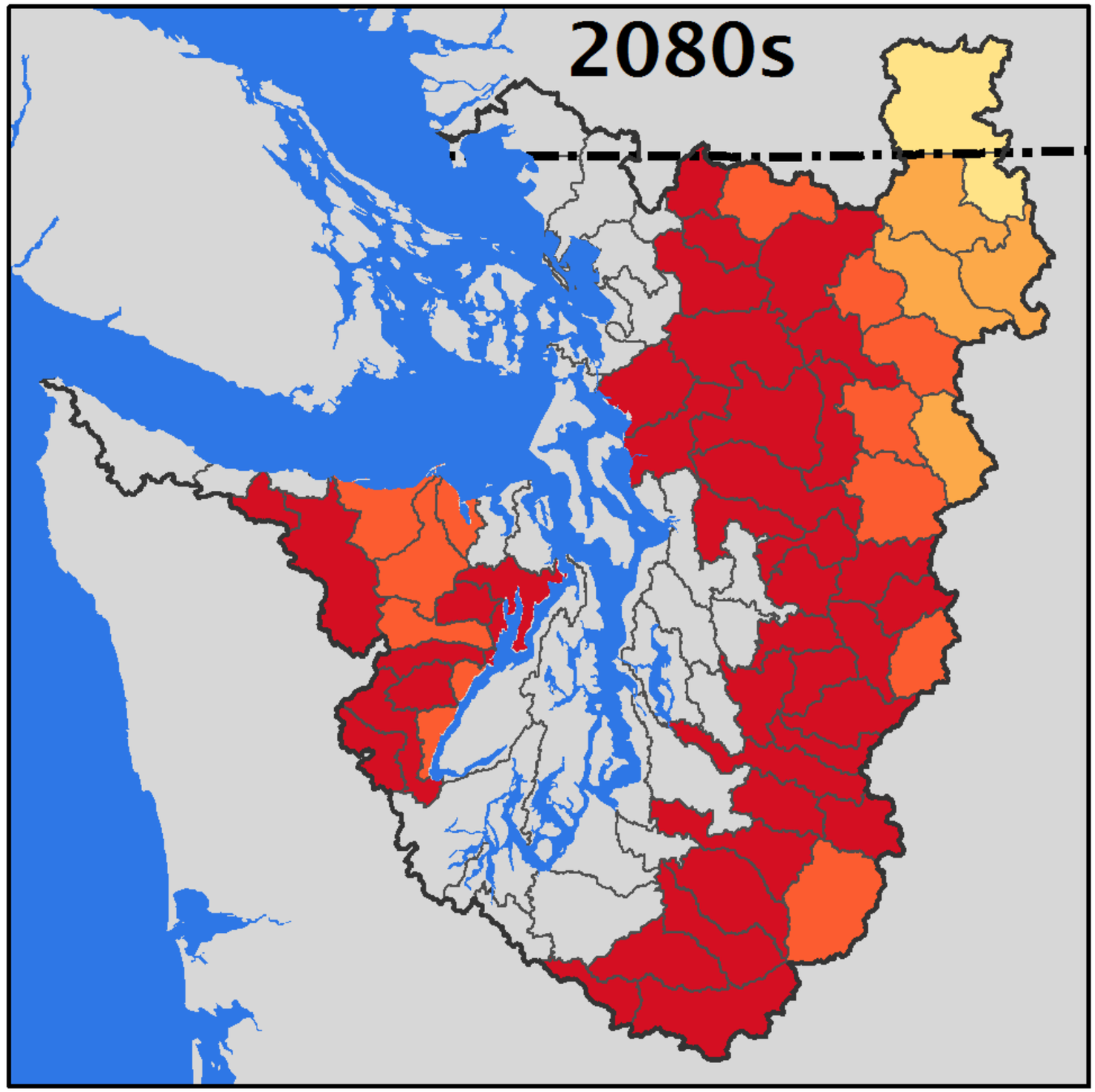
- 0 to 15
- 15 to 30
- 30 to 45
- 45 to 60
- 60 to 75

**Change** (percent)

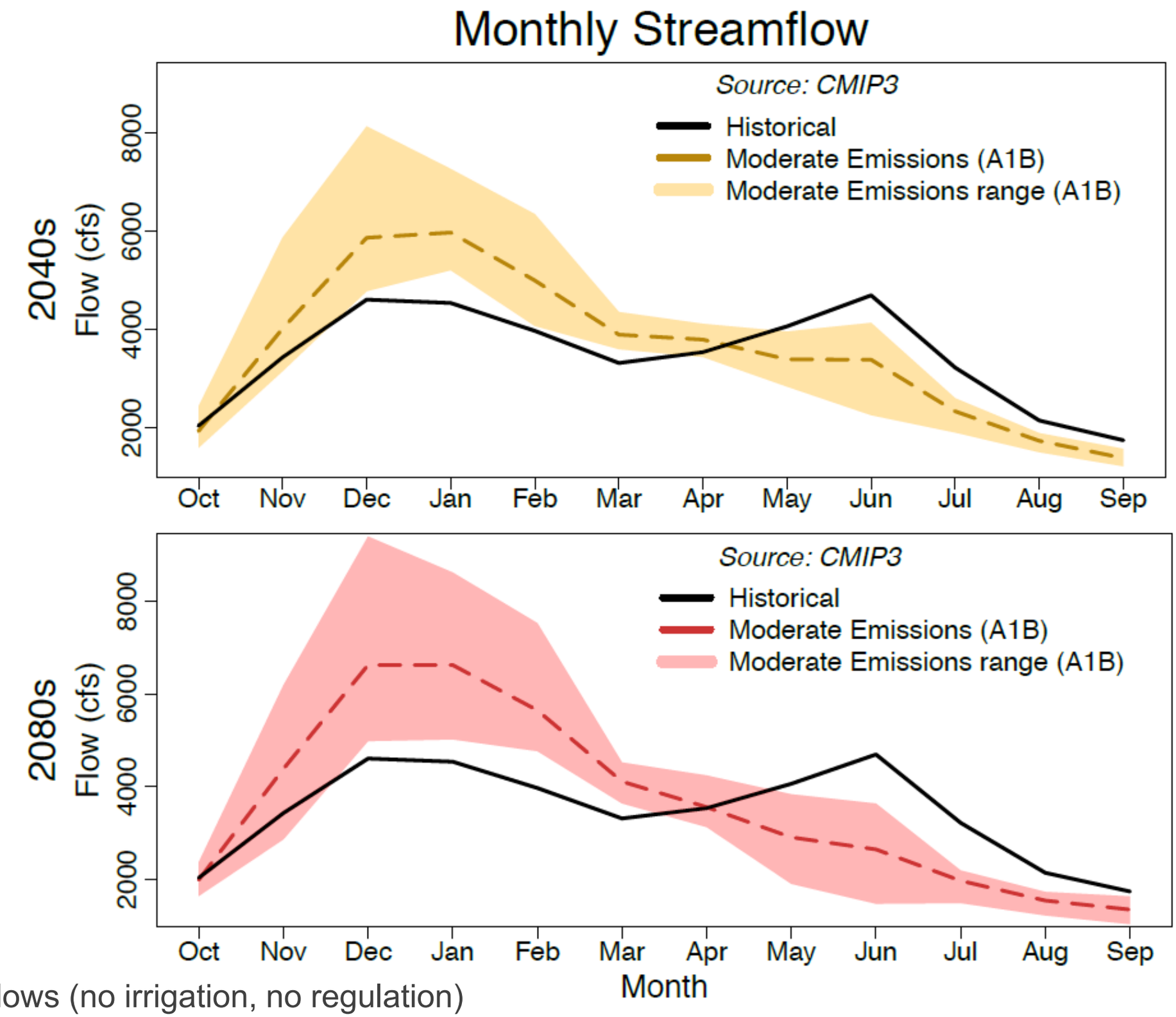
- -100% to -75%
- -75% to -62.5%
- -62.5 to -50%
- -50% to -37.5%
- -37.5% to -25%
- -25% to 0%

Source: CMIP3
**Moderate** (A1B)

## Annual Maximum Snow Water Equivalent



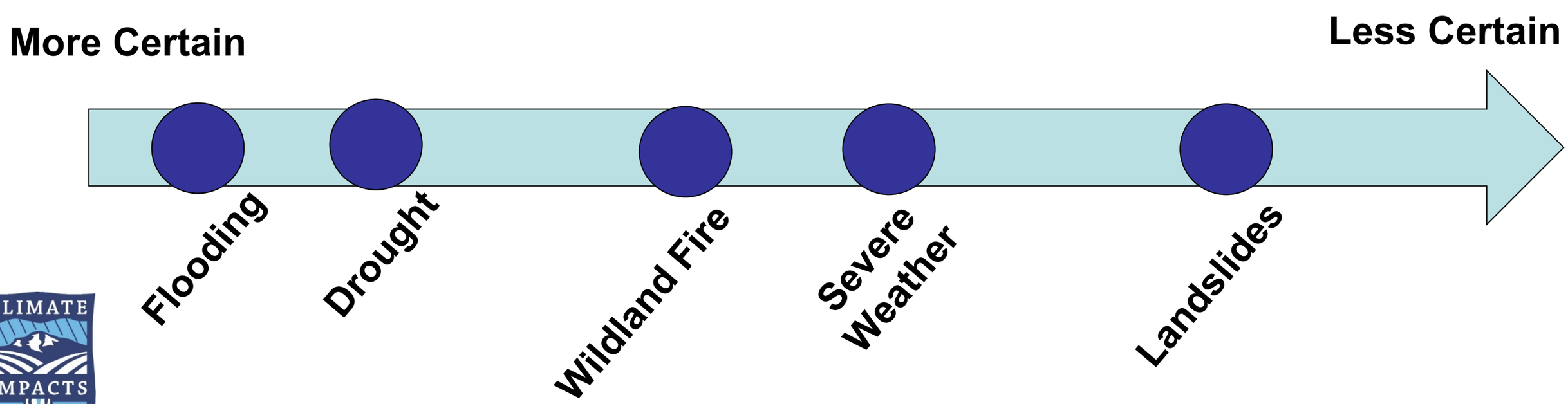
# Puyallup River:
# Projected Change in Monthly Hydrograph




* Naturalized flows (no irrigation, no regulation)

# Climate Impacts and Natural Hazards

- Flooding (riverine, coastal, urban)
- Drought
- Wildland-Urban Interface Fires
- Severe weather (heavy rain, snowstorms, windstorms)
- Landslides



# Flood Hazard

**Urban Flooding**

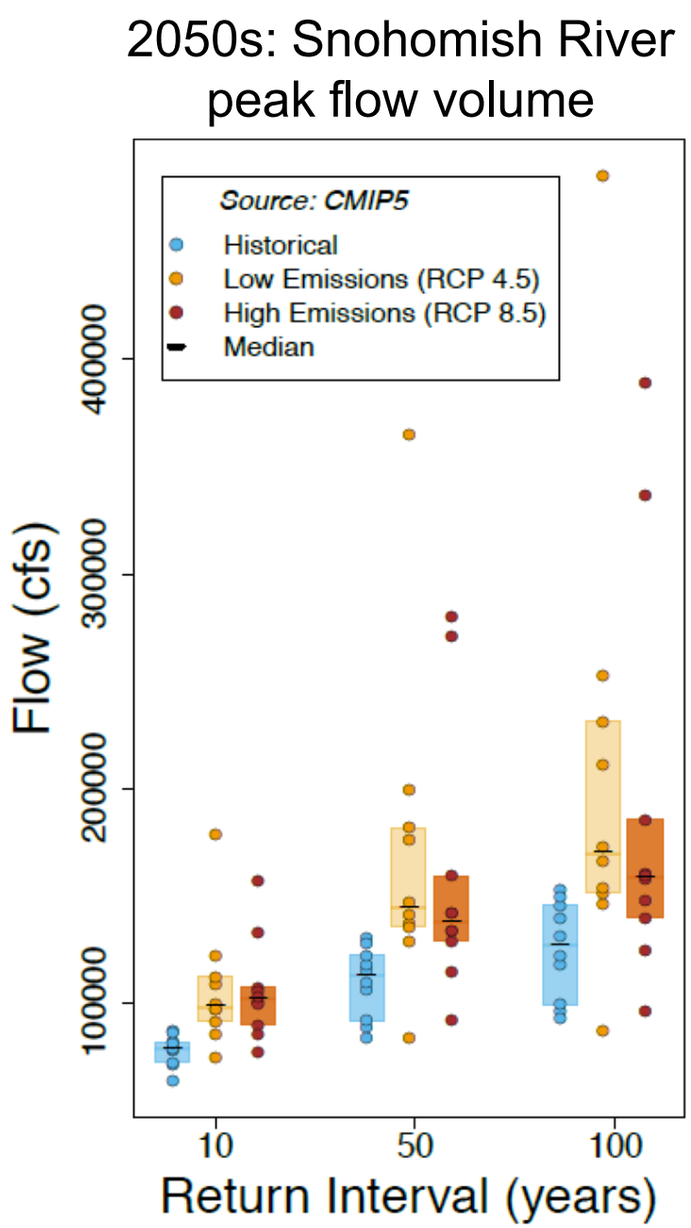
**River Flooding**

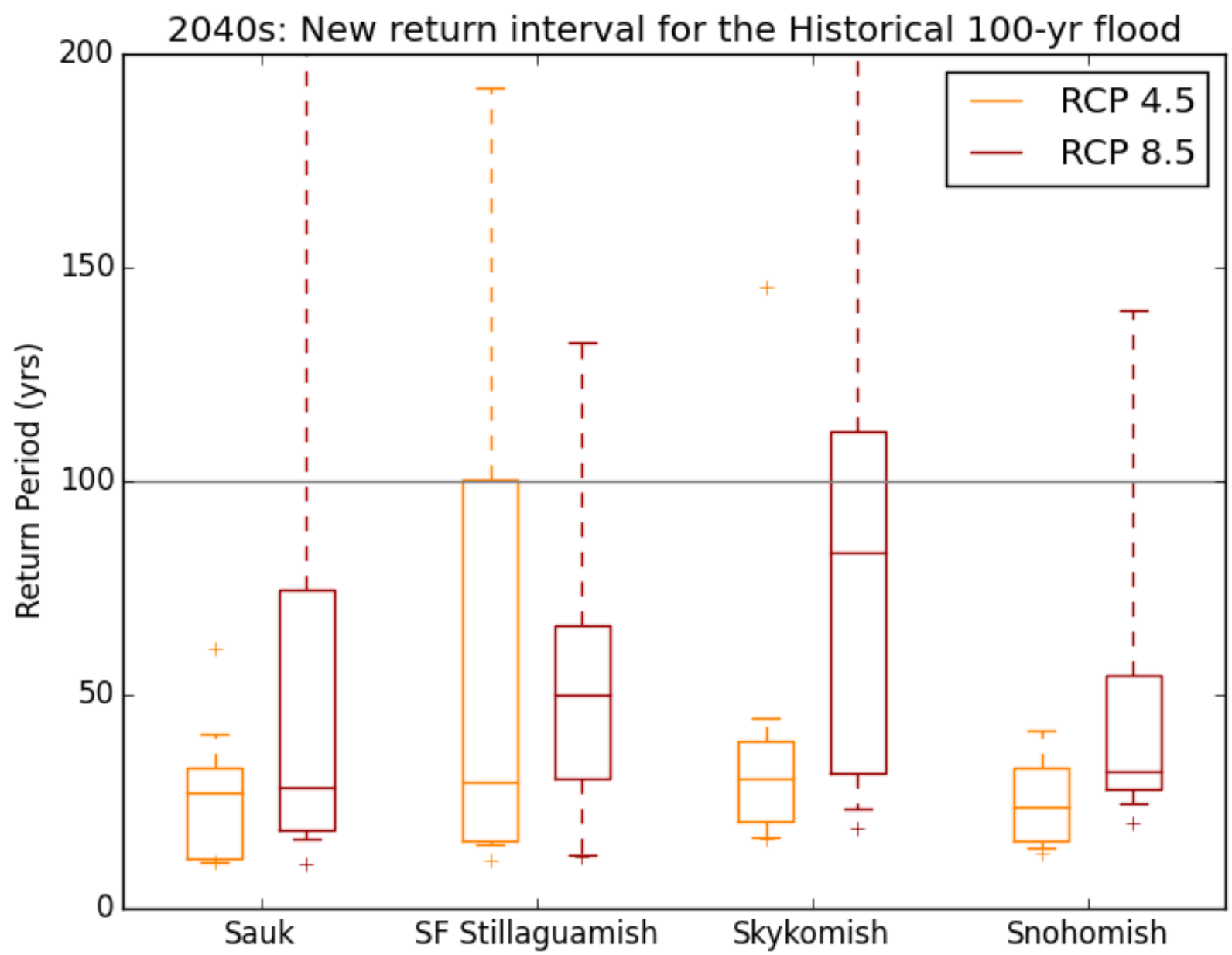
**Coastal Flooding**

# The highest river flows are projected to increase +18% to +55%, on average, by the 2080s in the 12 largest Puget Sound rivers

Mauger et al. 2015; results for a moderate (A1B) greenhouse gas scenario , relative to 1970-99

# Climate change is expected to increase the frequency, volume, and area of riverine flooding.




* Naturalized flows (no irrigation, no regulation)

# Projected Sea Level Rise: Tacoma

**PROJECTED RELATIVE SEA LEVEL CHANGE FOR 2100**
(feet, averaged over a 19-year time period)

| Location | Vertical Land Movement Estimate | Greenhouse Gas Scenario | Central Estimate (50%) | Likely Range (83-17%) | Higher magnitude, but lower likelihood possibilities | | |
|---|---|---|---|---|---|---|---|
| | | | | | 10% probability of exceedance | 1% probability of exceedance | 0.1% probability of exceedance |
| **Tacoma** (47.3N, 122.4W) | -0.5 ± 0.2 | Low | 2.1 | 1.5-2.7 | 3 | 4.6 | 7.9 |
| | | High | 2.5 | 1.9-3.3 | 3.6 | 5.3 | 8.8 |

**Increase in MHHW, does not include waves and storm surge**

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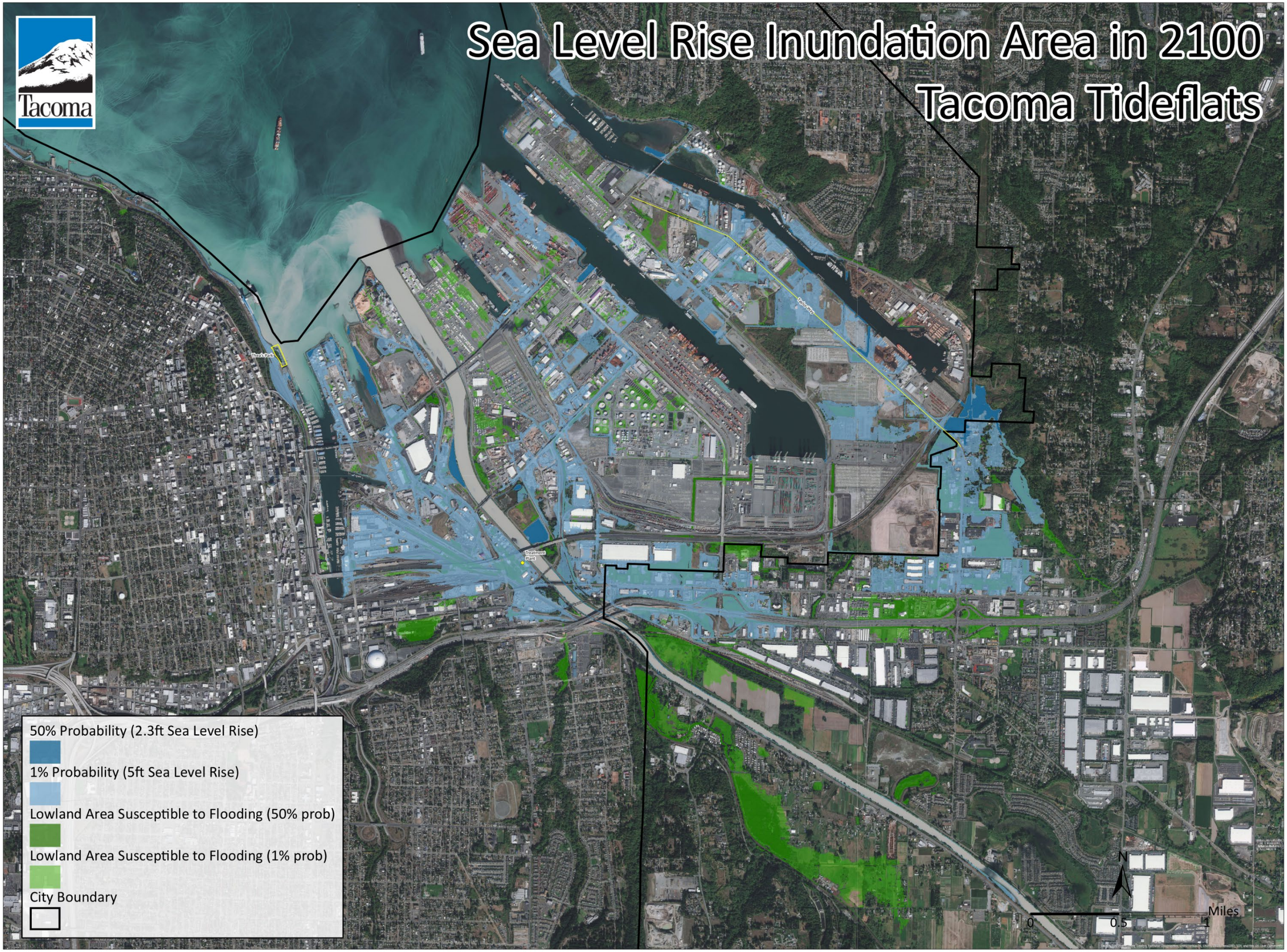


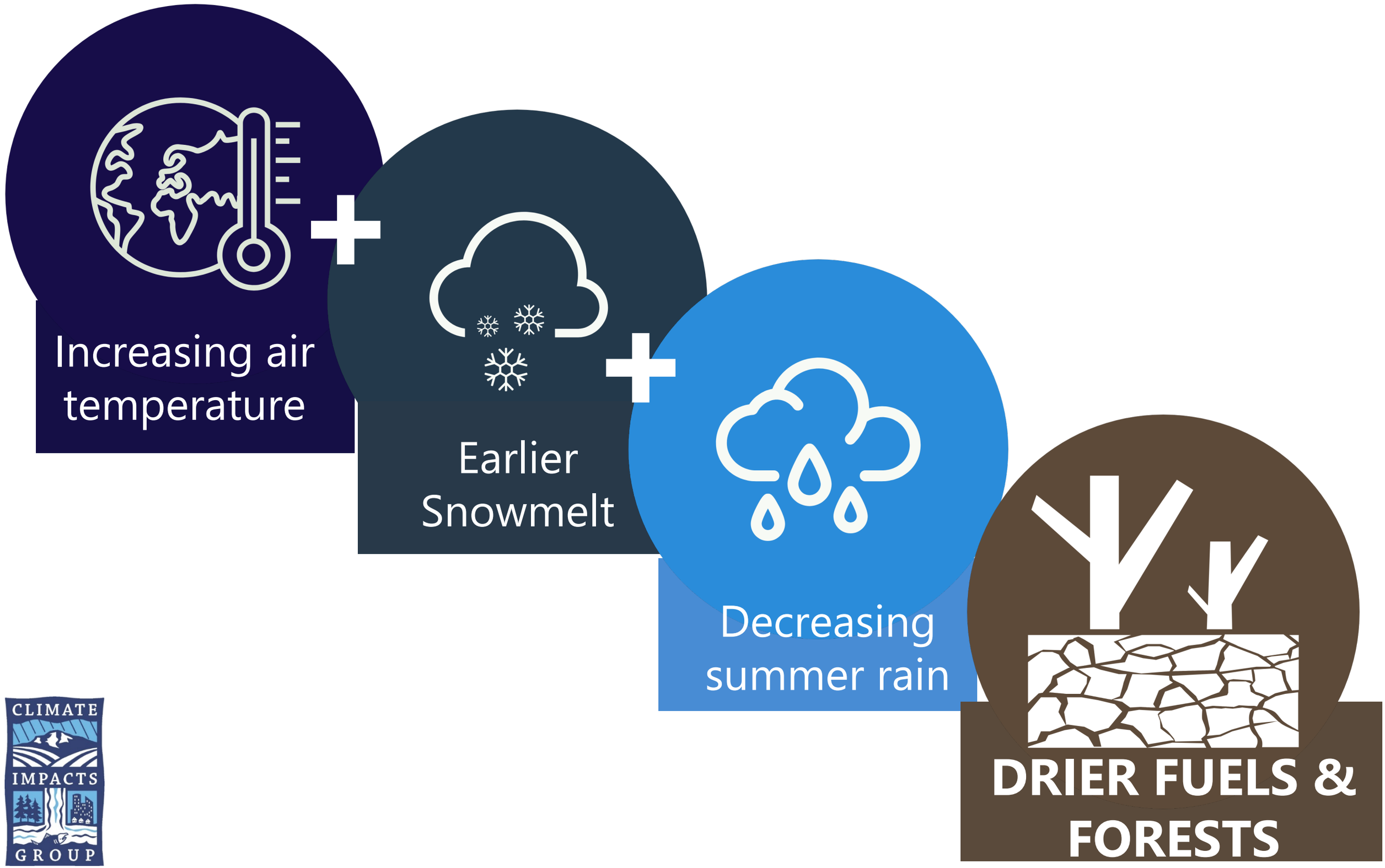

Image: James Parvey, City of Tacoma. Data: Washington Coastal Resilience Project

# By the 2040s, the median annual area burned in the Northwest could more than double relative to 1916-2006.

Littell et al. 2010. Scenario A1B assumes continued increases in emissions through mid-century, then decline.

**Image: H. Roop**

# Changes in the climate drivers of wildland fire are expected to lead to drier fuels and greater potential for wildfires.



# Climate change is expected to increase heavy rain events, decrease snow storms, but not effect windstorms.

wind storms

heavy rain storms

thunderstorms and lightning

snow and ice storms

# Landslides

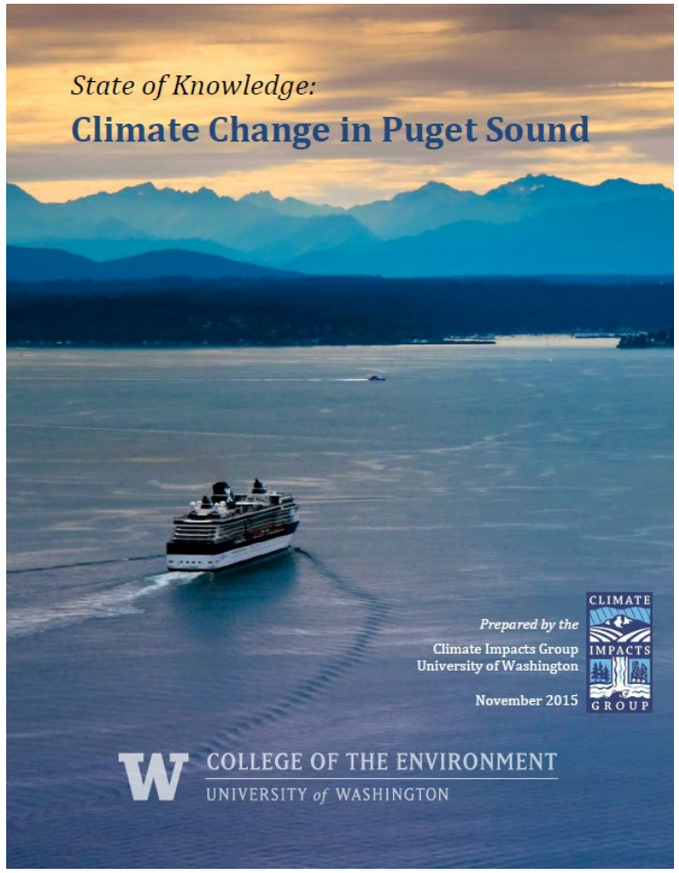
Climate change is expected to increase the size and frequency of landslides.

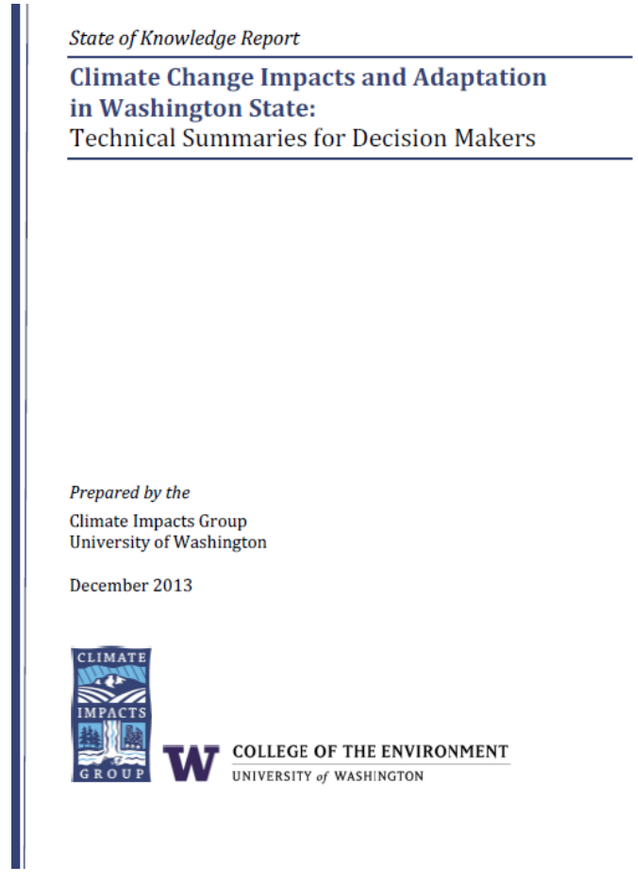
Landslide prone areas are expected to become less stable in winter with more winter precipitation as rain, heavier rainfall, and higher soil water content.

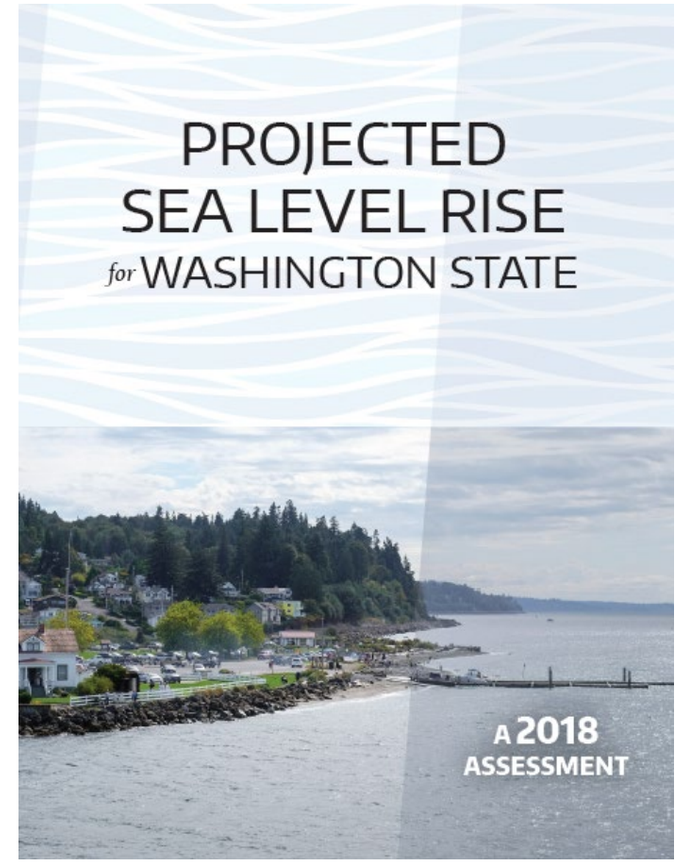
Landslide frequency may increase with wildland fire.

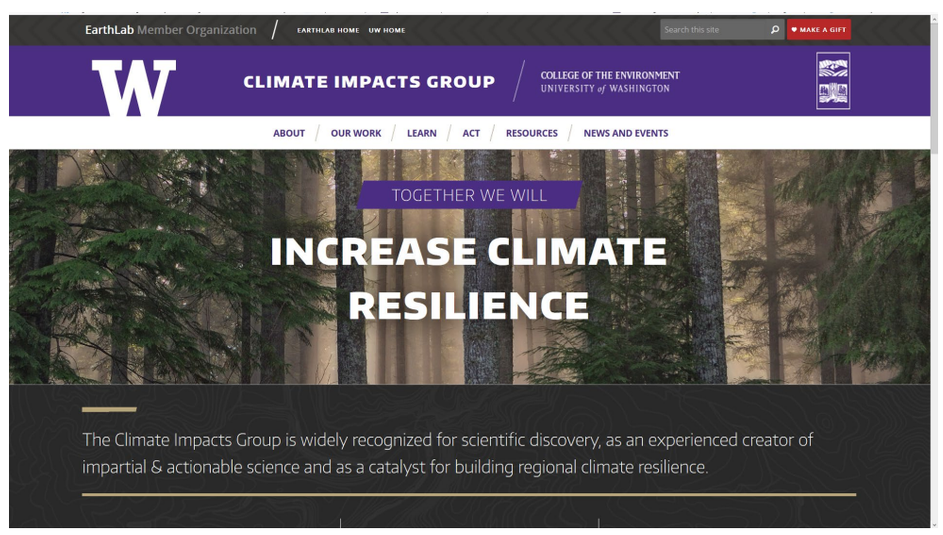
Source: Mauger et al. 2015

# State of the Knowledge Reports




**https://cig.uw.edu/**

The Climate Impacts Group

www.cig.uw.edu

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# Higher winter flood risk

For the Skagit, 2040s:*

- the historical 100-year event becomes a 22-year event
- the historical 30-year event becomes a 7-year event

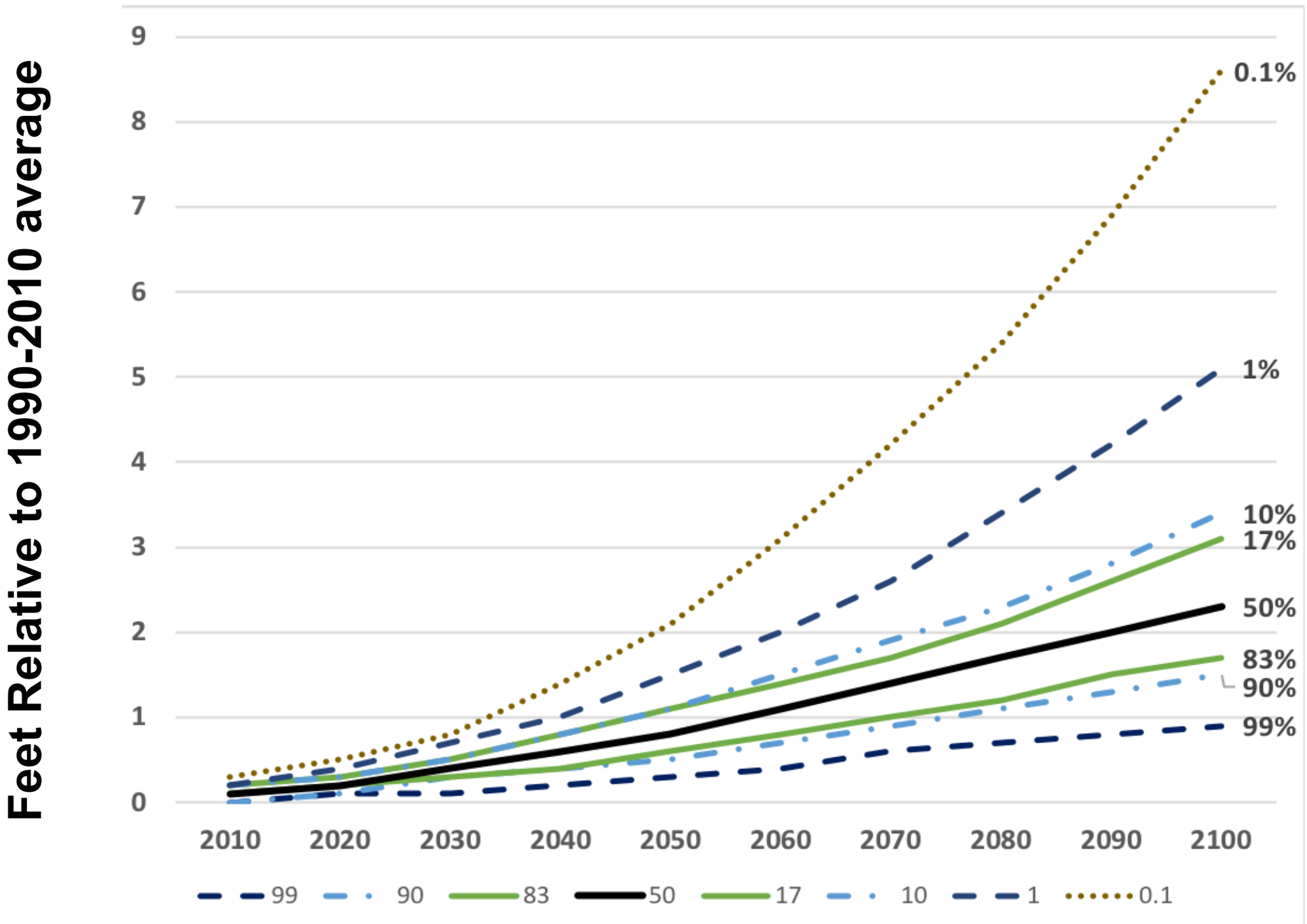
For the Snohomish, 2040s:*

- the historical 100-year event becomes a 30-year event
- the historical 10-year event becomes an 5-year event

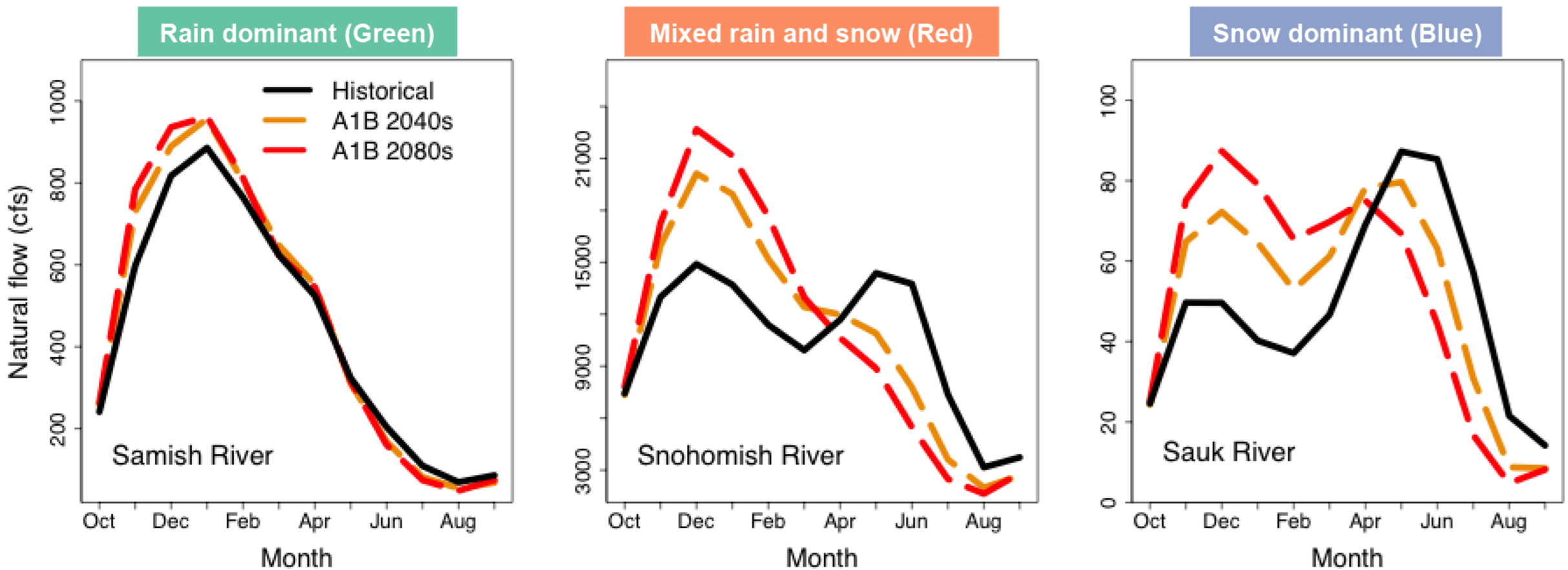
* Naturalized flows (no dams)

Photo source: Seattle Times

# Coastal flooding and sea level rise



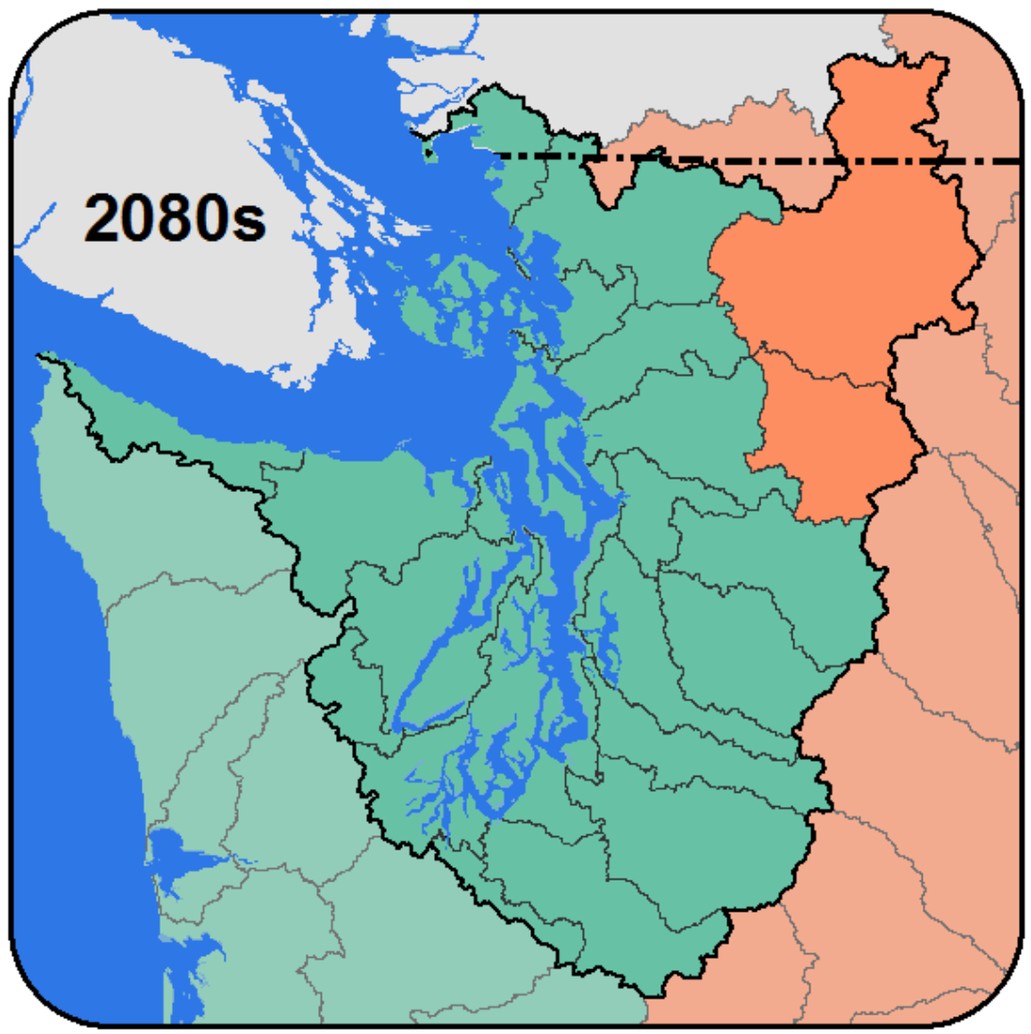
# Hydrographs are projected to change the most in basins that historically accumulated substantial snow.



# The Puget Sound region is almost entirely rain-dominant basin types by end of century

**Percentage of Winter Precipitation Captured in Peak Snowpack**

< 10%: Rain dominant

10% to 40%: Mixed rain and snow

> 40%: Snow dominant