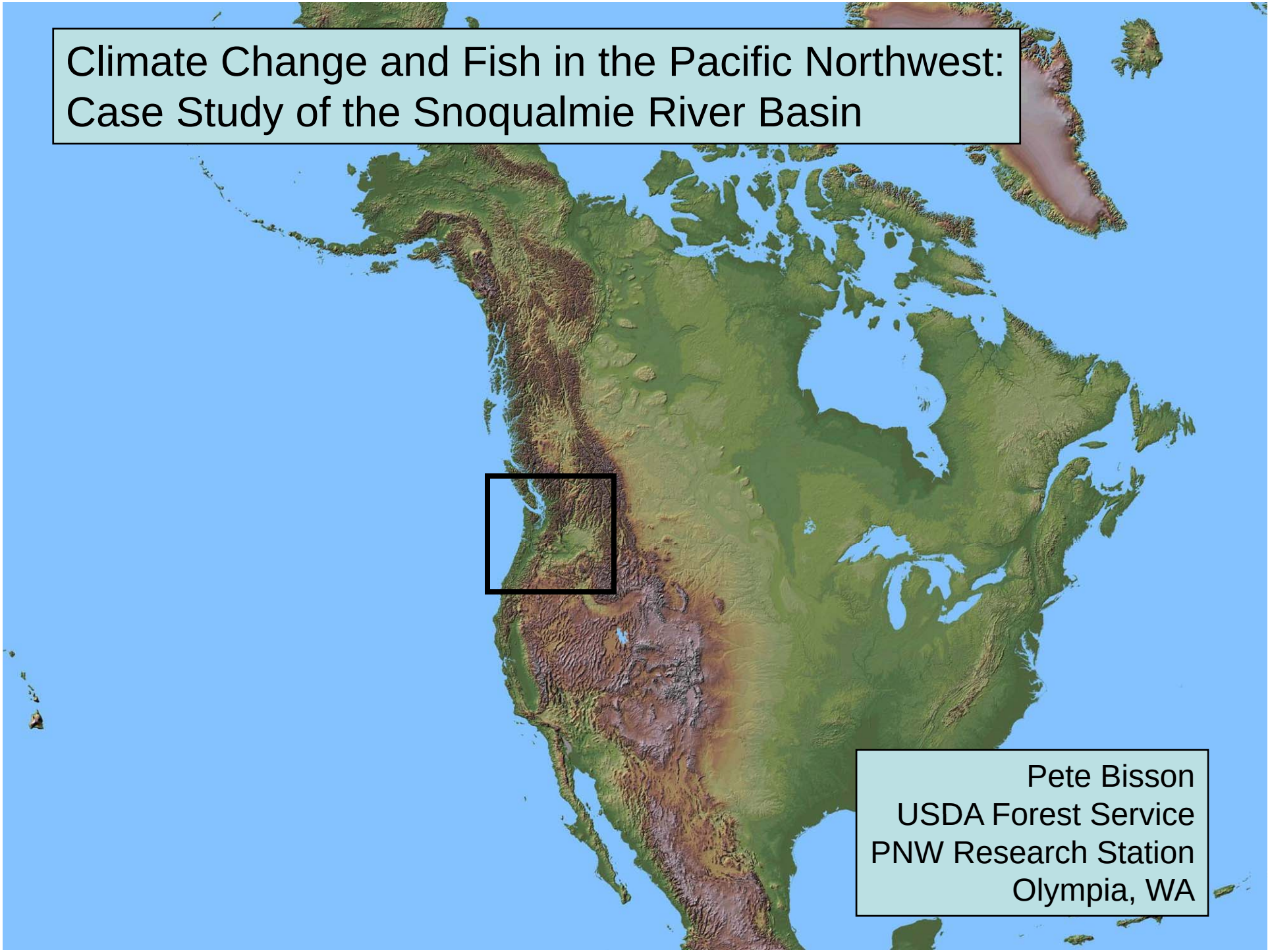
Climate Change and Fish in the Pacific Northwest: Case Study of the Snoqualmie River Basin



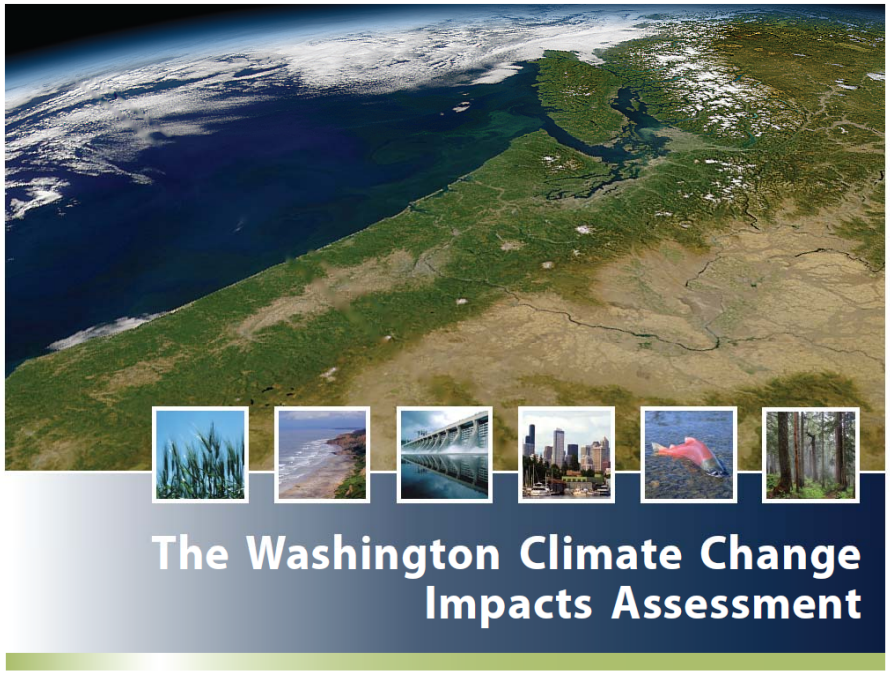
Pete Bisson
USDA Forest Service
PNW Research Station
Olympia, WA

U.S. Forest Service Water Strategy
2009-2019

Water – a precious resource

The water we drink, the recreation we enjoy, and the quality and livability of our communities all depend on the ability of forests to sustain water supplies and water quality long into the future. Over half of all rivers, streams, lakes and wetlands in the 48 contiguous United States begin in forests. They gather and filter water that sustains fish, plants, and wildlife; supports food, energy, and industrial production, and flows from the faucets of our homes and businesses. More than 66 million people in 33 states rely directly on the National Forests and Grasslands for their drinking water.

But fresh water is a resource in crisis. In the United States, invasive species, pollution, and increased urban and rural development are among many immediate concerns affecting water quality and quantity. Across the globe, more than a billion people live without clean drinking water, 2.6 billion live without adequate water sanitation, and almost 4,000 children die every day from water-borne diseases. Finally, everywhere we are seeing and feeling the effects of climate change on water, including floods, hurricanes and changing sea levels.



The Washington Climate Change Impacts Assessment

Evaluating Washington's Future in a Changing Climate

Full Report (Final Draft)

A report by

The Climate Impacts Group
University of Washington

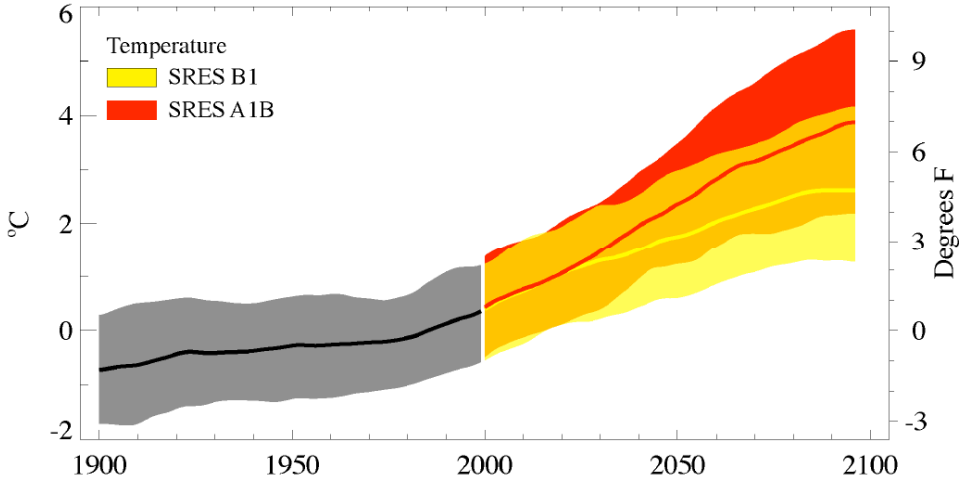
February 2009

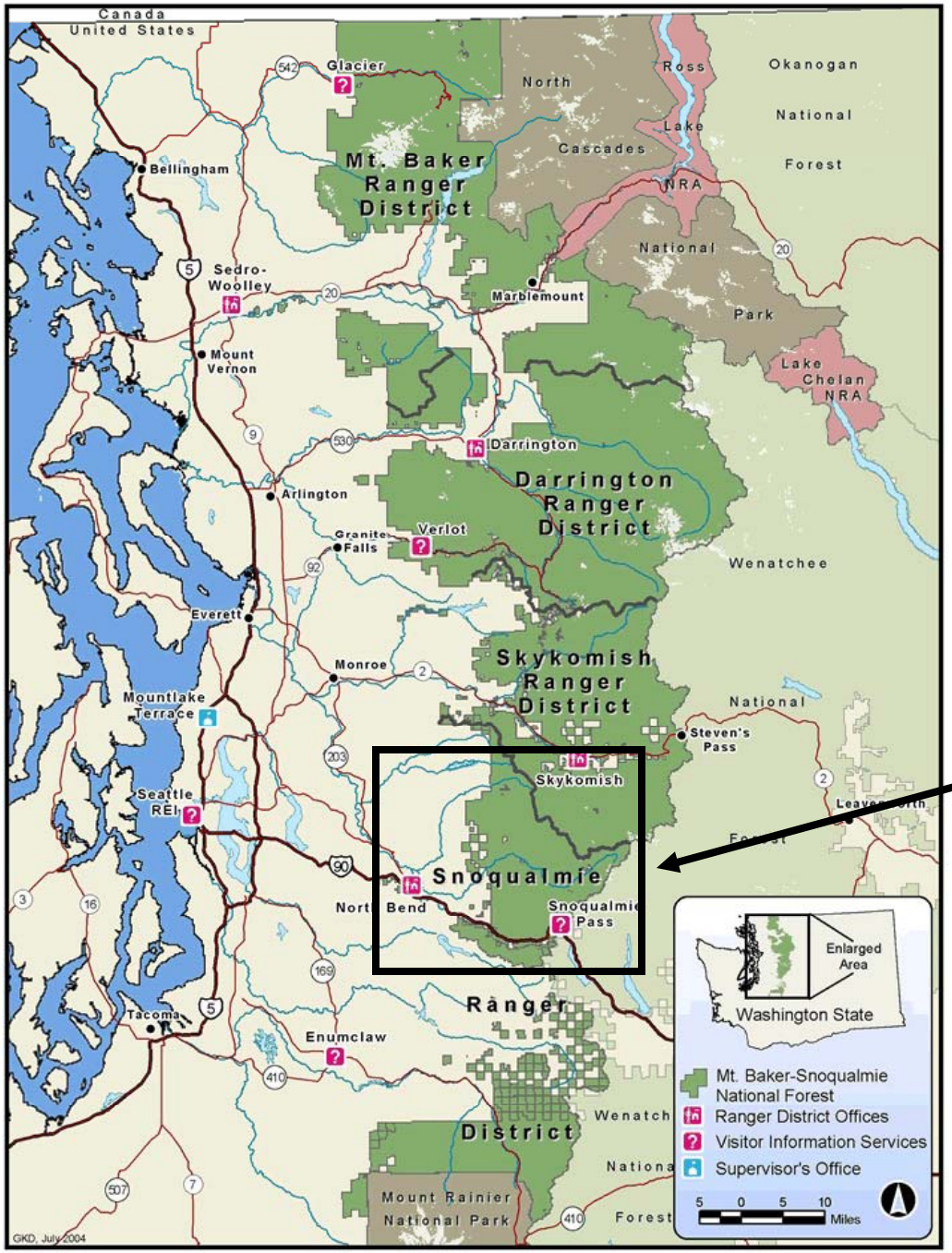
Climate Science in the Public Interest

University of Washington
Climate Impacts Group

summarizes past trends

projects future changes





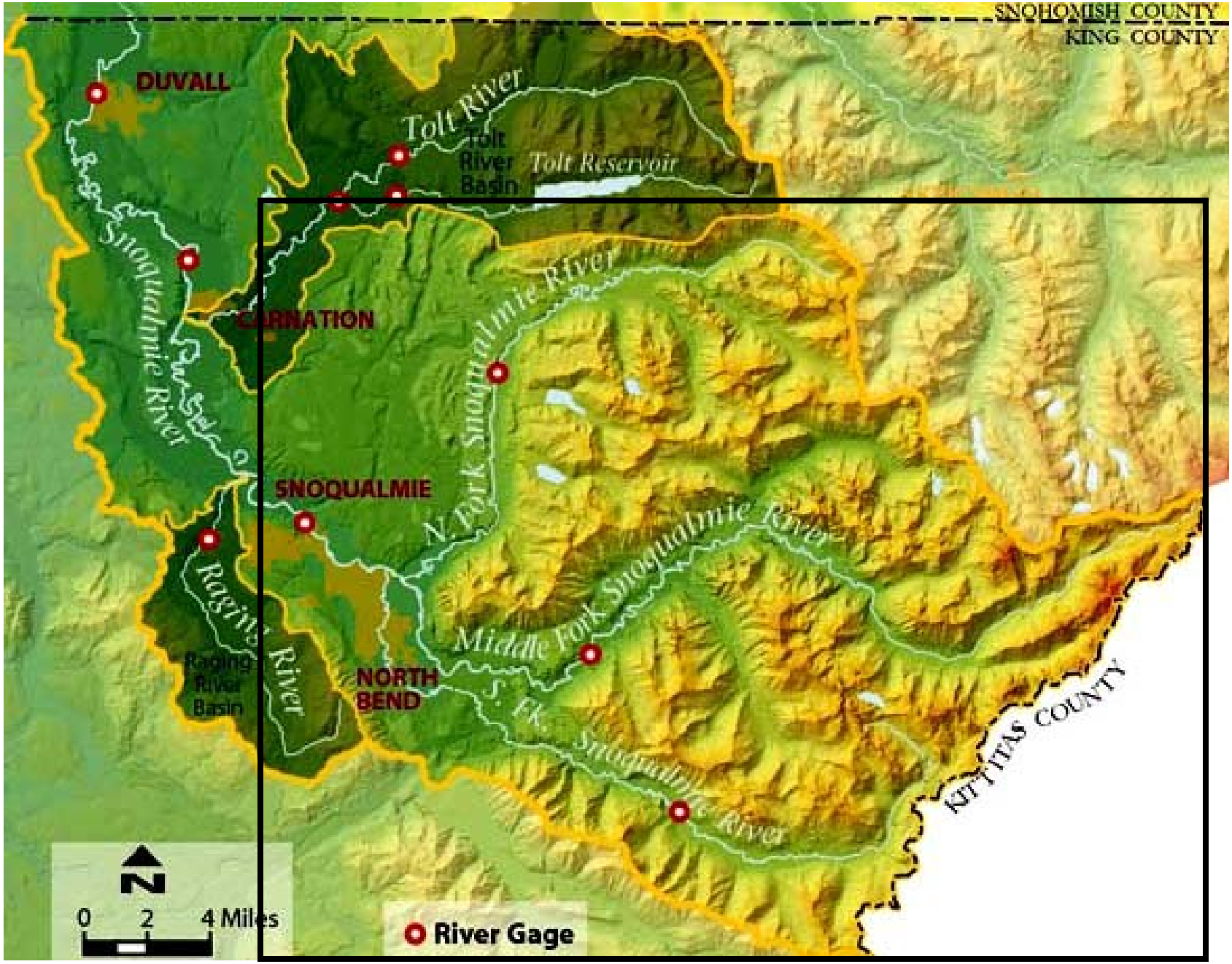
Implications of climate change for the Forest Service

Do historical data for this basin support the Climate Impacts Group's conclusions?

How could climate trends specifically affect fish?

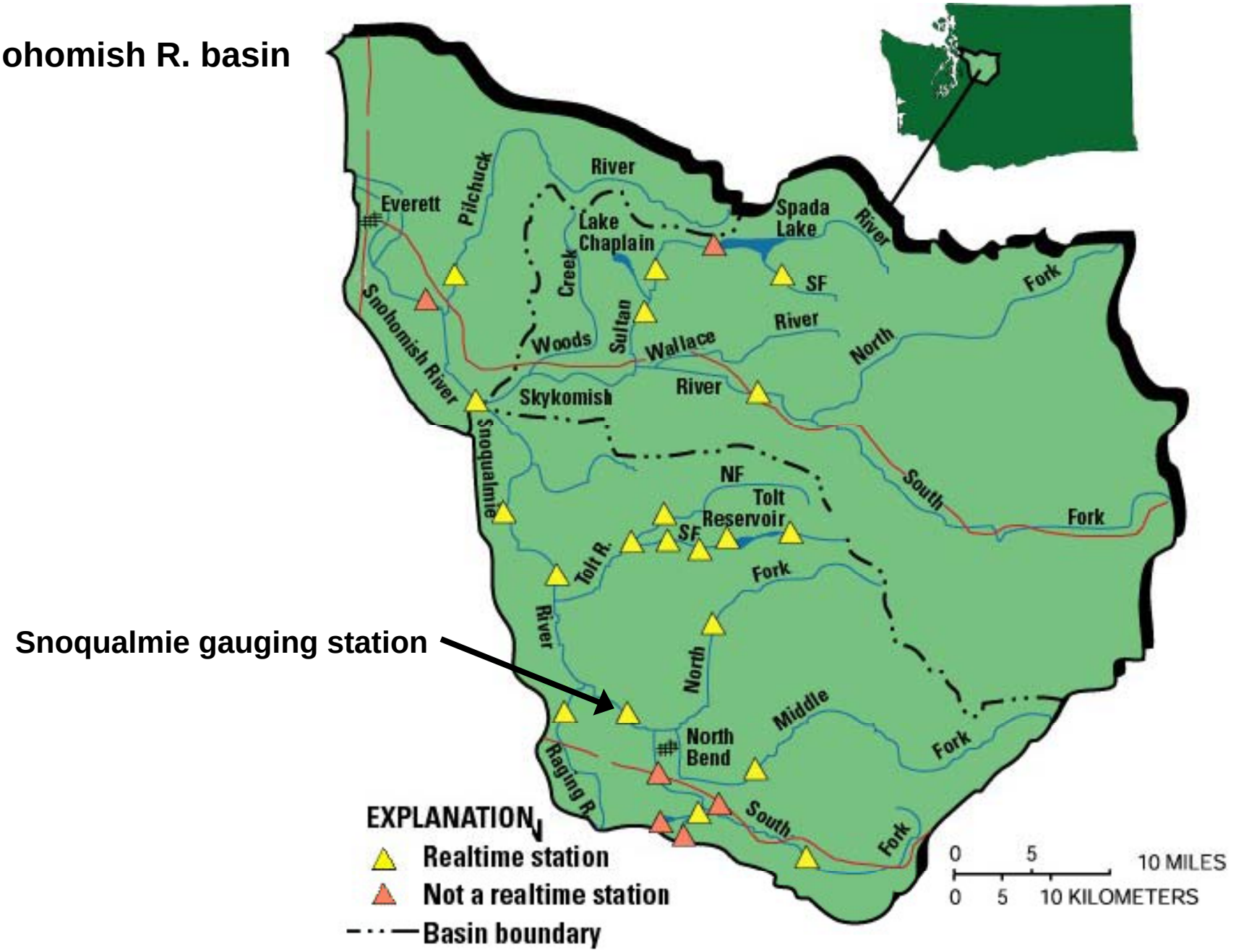
Why the Snoqualmie R. basin?

- *Unregulated*
- *FS predominant land manager*
- *Large wilderness area*
- *Long-term environmental databases*



Metro King County

Snohomish R. basin



Snoqualmie gauging station

USGS

Dan Nutt

Chinook salmon **Threatened**

Coho salmon **“Species of Concern”**

Chum salmon **relatively healthy**

Pink salmon **relatively healthy**

Steelhead **Threatened**

Coastal cutthroat trout **relatively healthy**

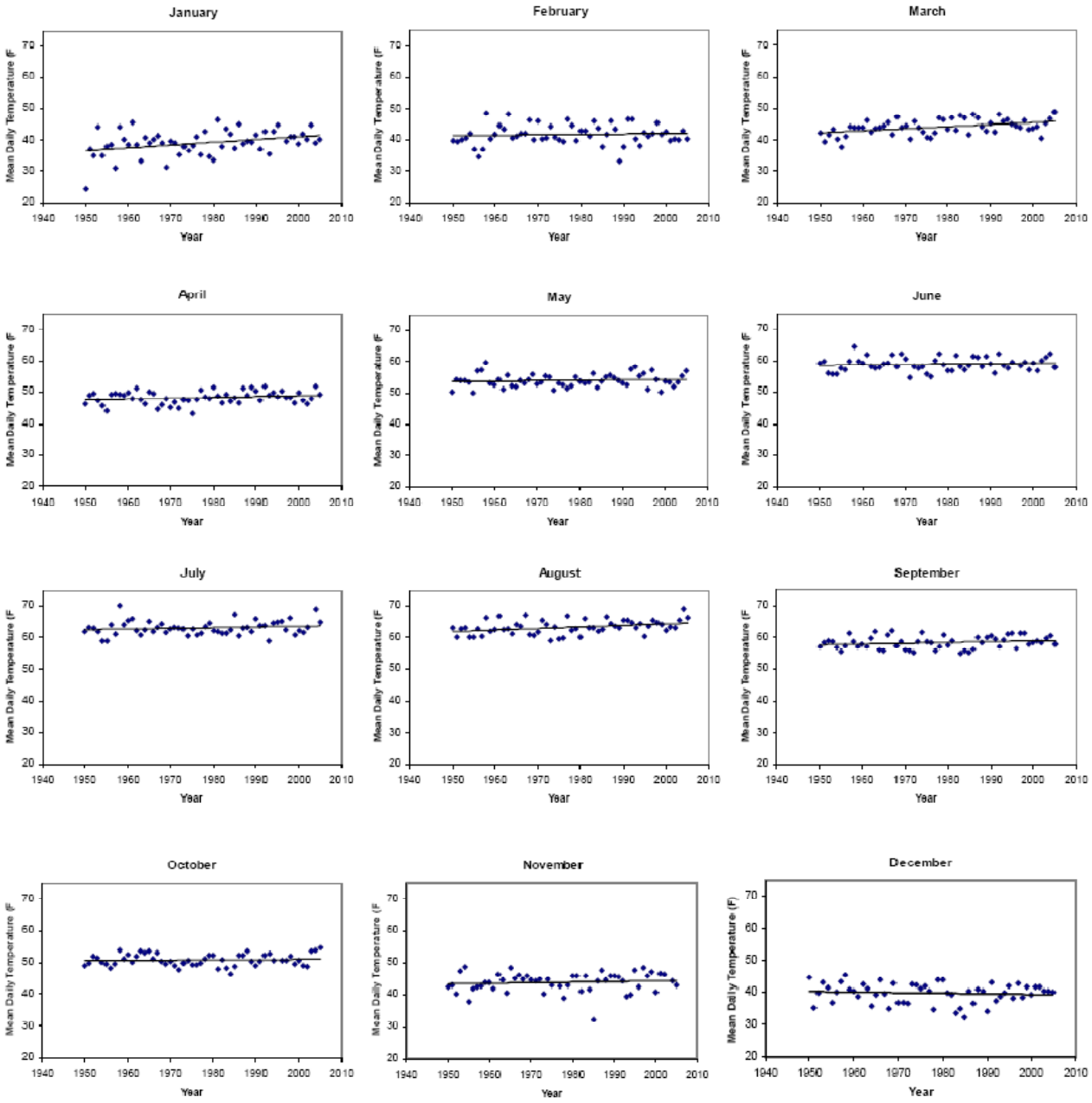
Bull trout **Threatened**

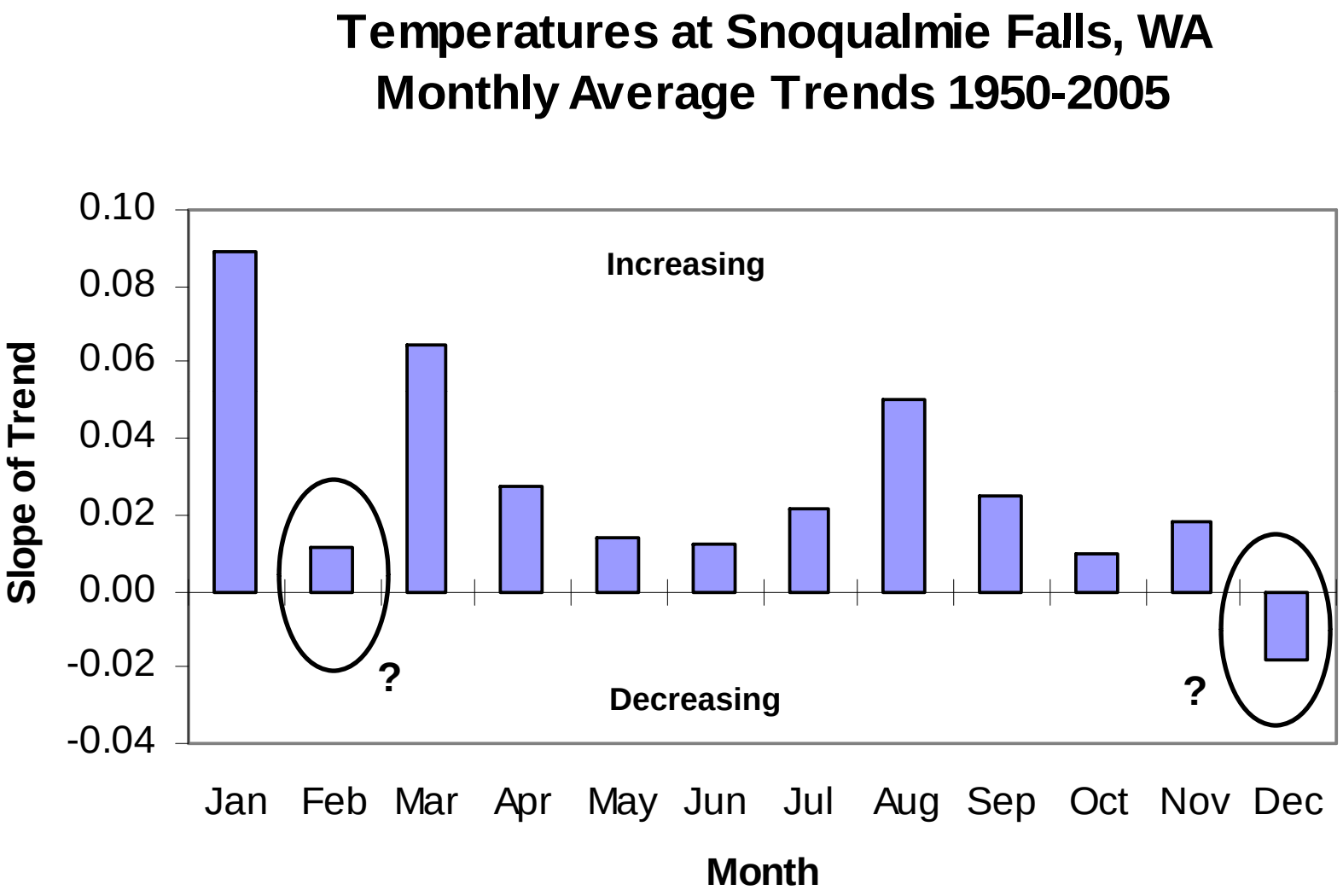
CIG Conclusion:

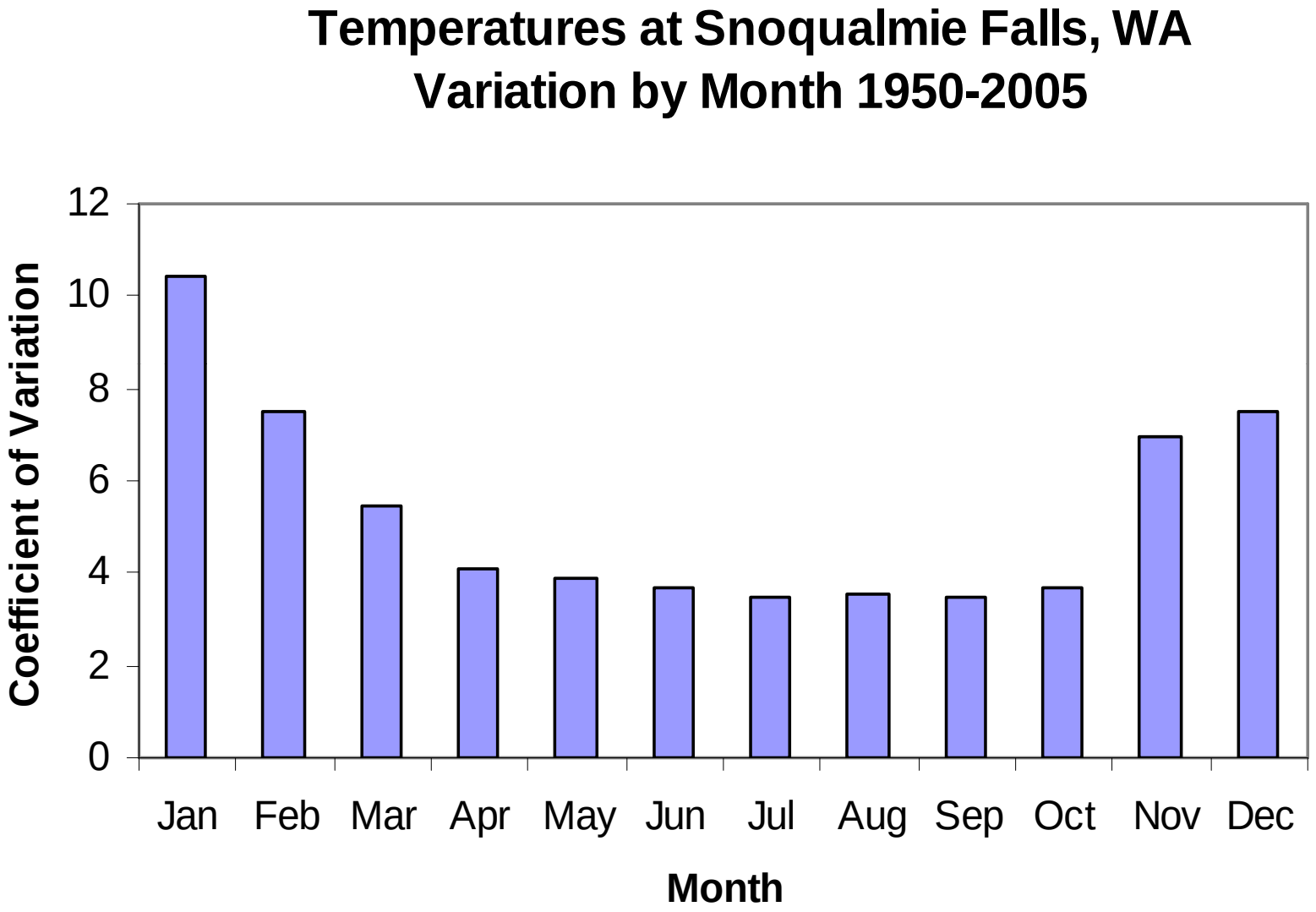
Temperature has increased. Average annual temperature increased 0.7 – 0.9°C (1.5°F) in the Pacific Northwest from 1950-2000.

Trends in winter season and daily minimum temperatures have been largest. Temperature trends from 1916-2003 are largest from January-March, and trends in minimum daily temperatures have been larger than trends in maximum daily temperatures.

Mean Air Temperature at Snoqualmie Falls, WA
1950-2005



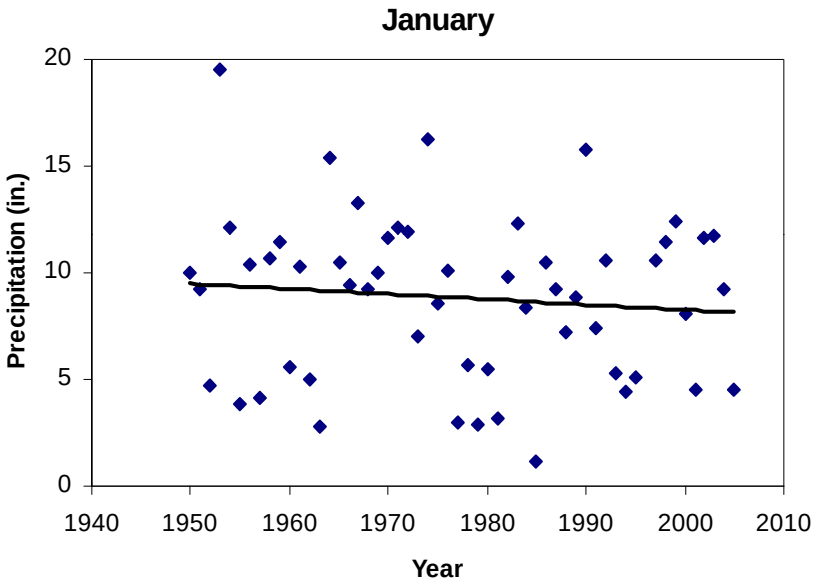

Temperatures at Snoqualmie Falls, WA
Monthly Average Trends 1950-2005
Slope of Trend
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
Increasing
Decreasing
?
?
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

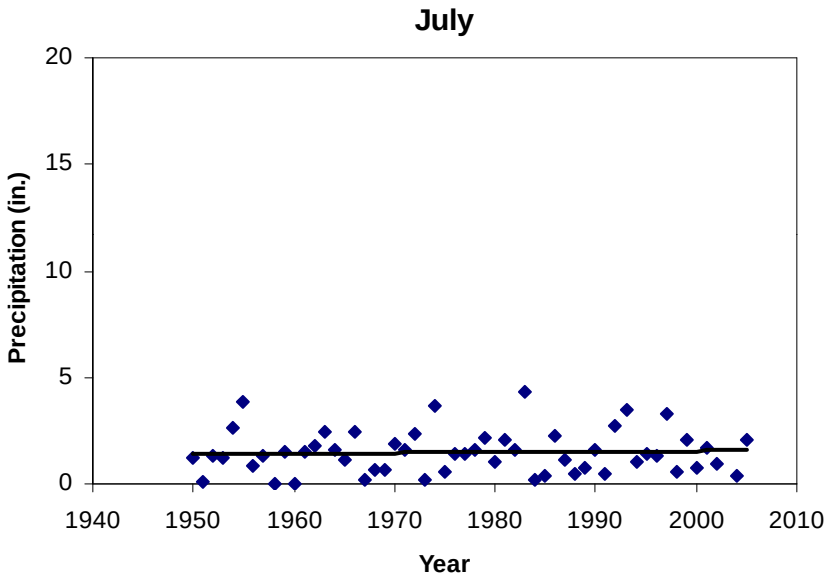

Temperatures at Snoqualmie Falls, WA
Variation by Month 1950-2005
Coefficient of Variation
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

CIG Conclusion:

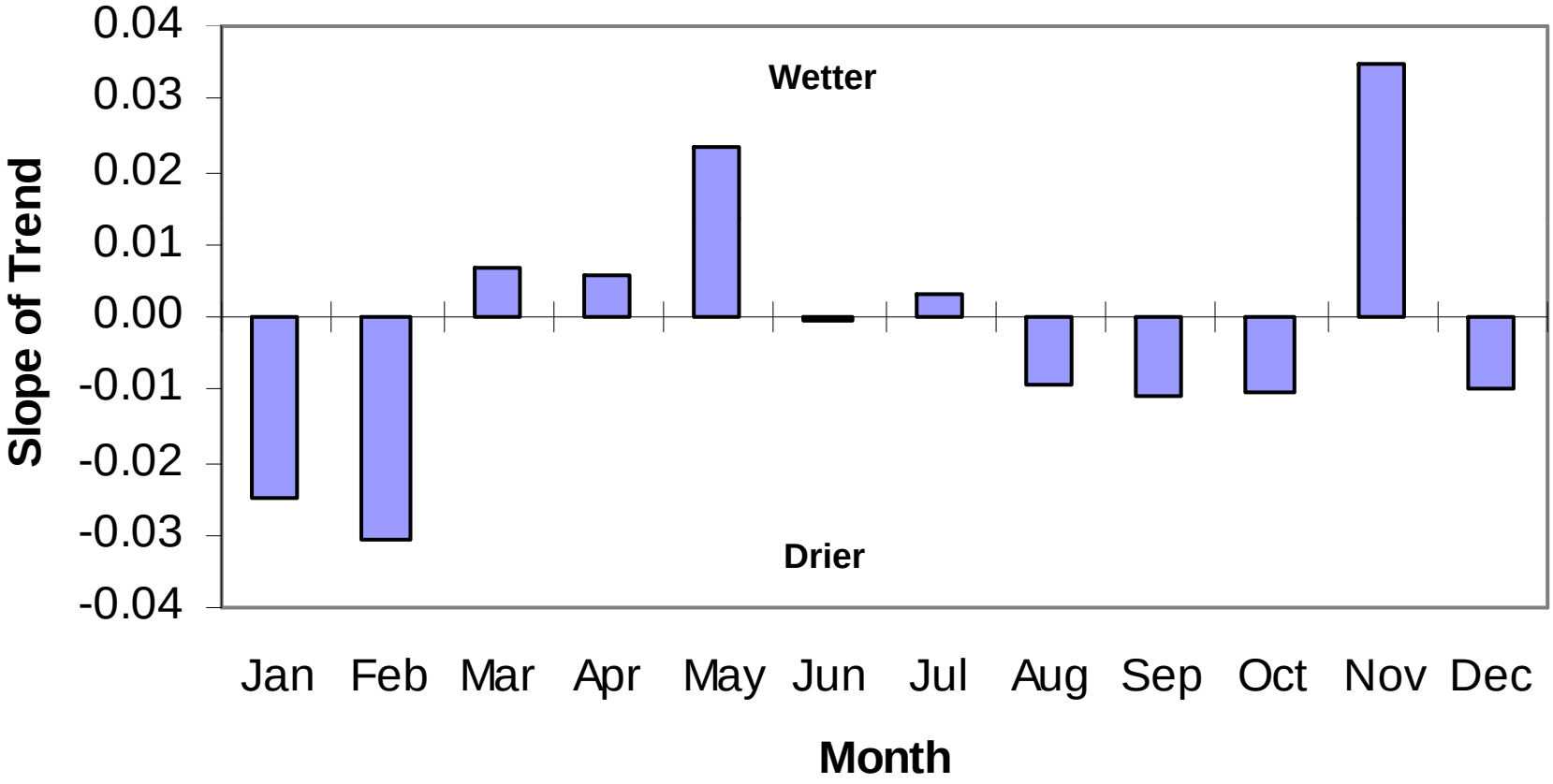
Cool season precipitation variability has increased. Cool season precipitation in the PNW is more variable from year to year, displays greater persistence, and is more strongly correlated with other regions in the West since about 1973.

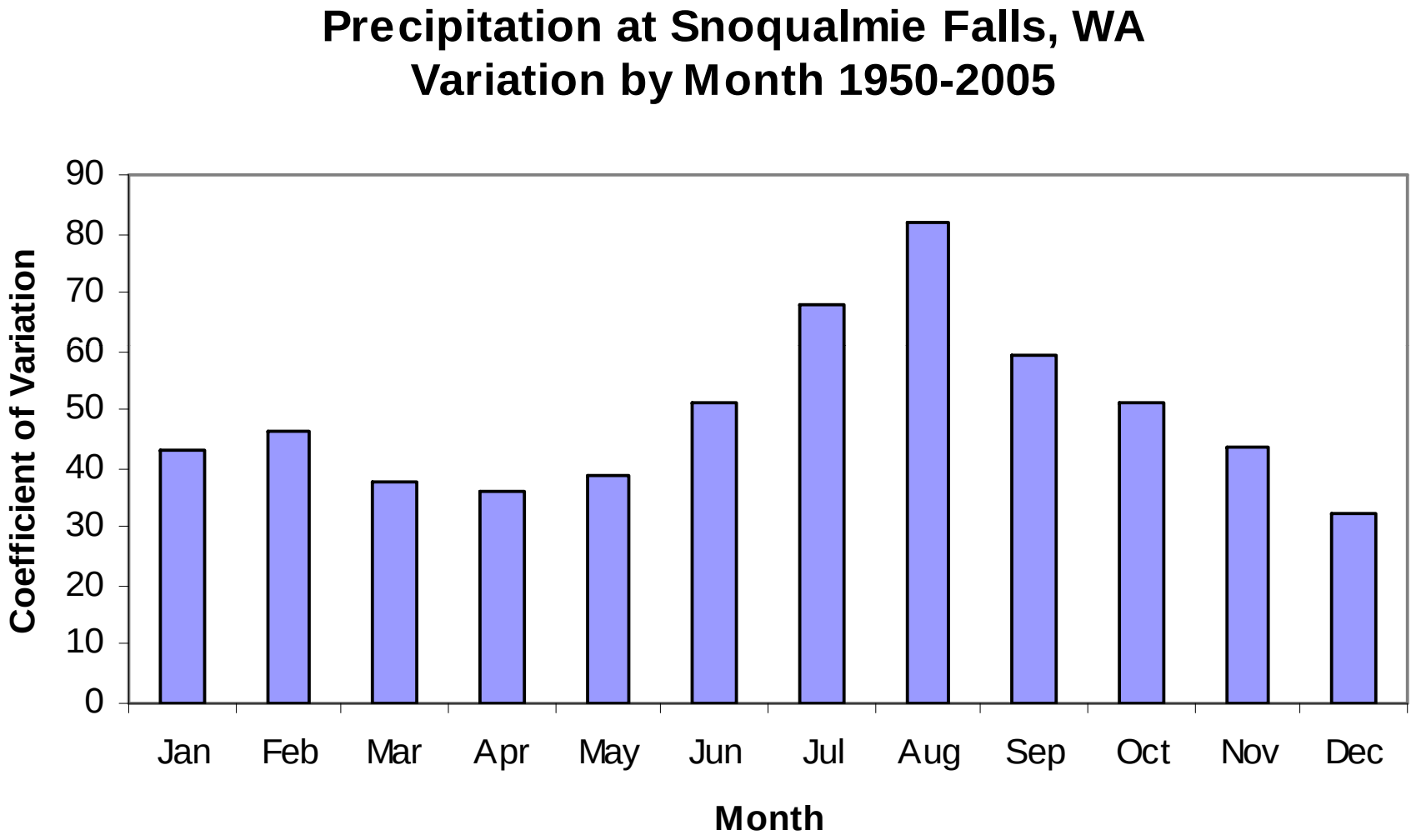
Precipitation trends





Precipitation at Snoqualmie Falls, WA
Monthly Average Trends 1950-2005



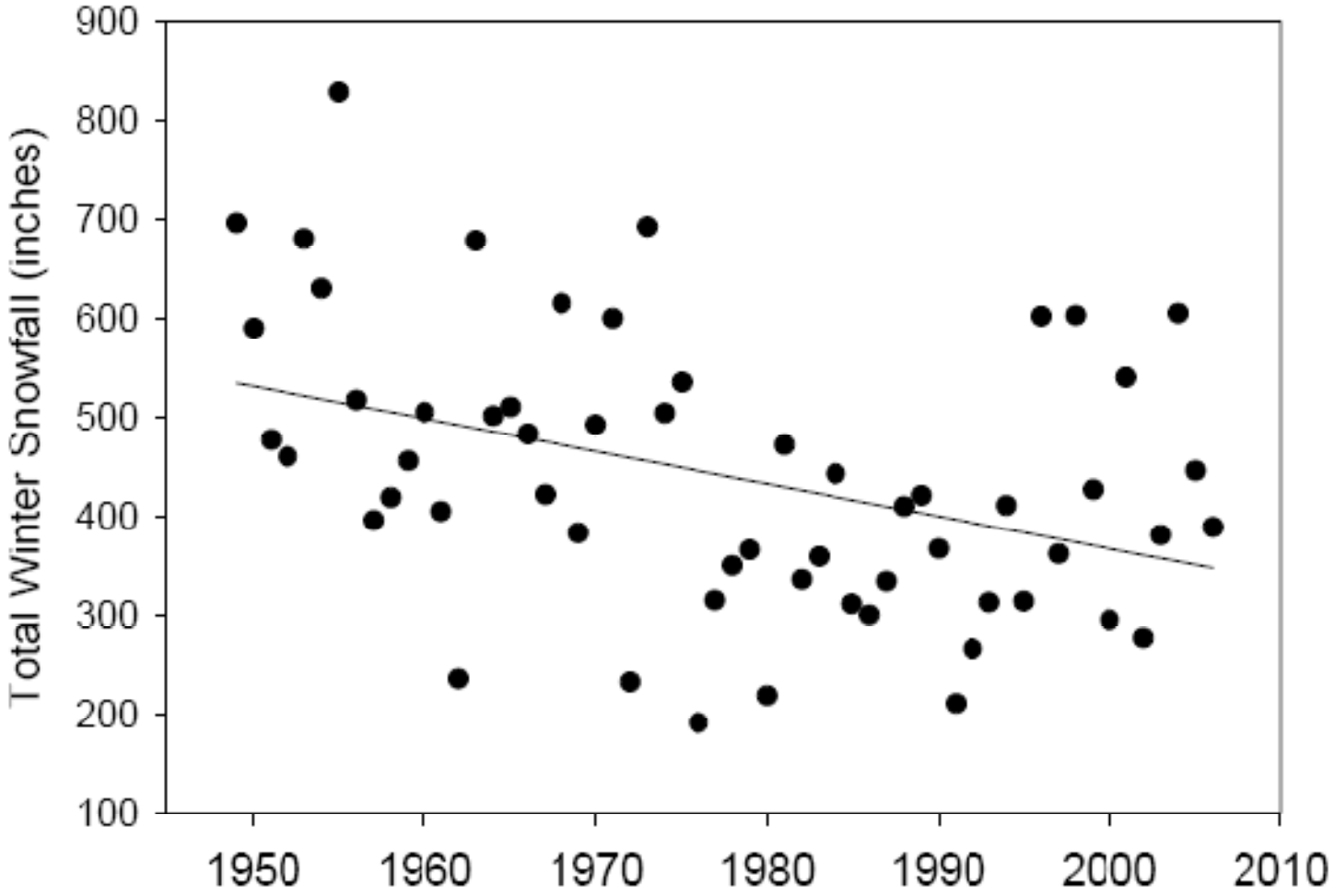

Precipitation at Snoqualmie Falls, WA
Variation by Month 1950-2005
Coefficient of Variation
90
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

CIG Conclusion:

April 1 snow water equivalent (SWE) declined at nearly all sites in the PNW between 1950 and 2000. The declines are strongest at low and middle elevations, and can be explained by observed increases in temperature and declines in precipitation over the same period of record.

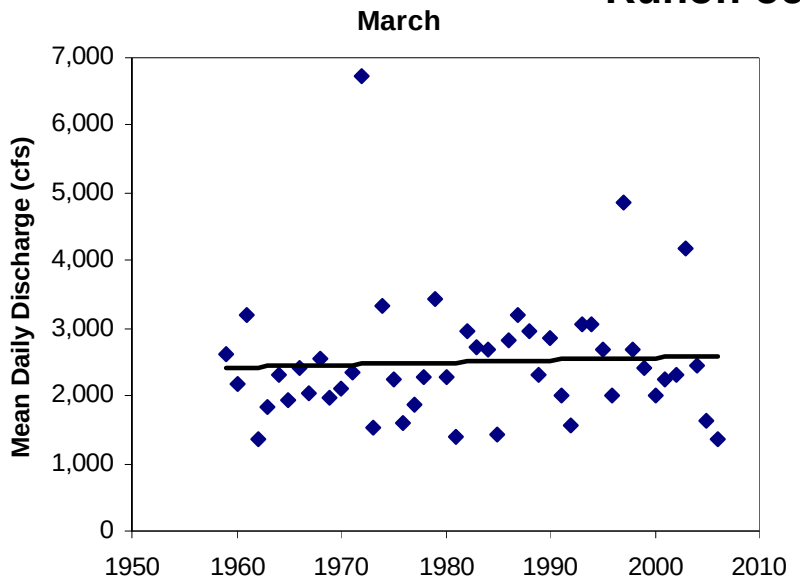
Timing of peak runoff has shifted. Timing of the center of mass in annual river runoff in snowmelt basins shifted 0-20 days earlier in much of the PNW between 1948 and 2002.

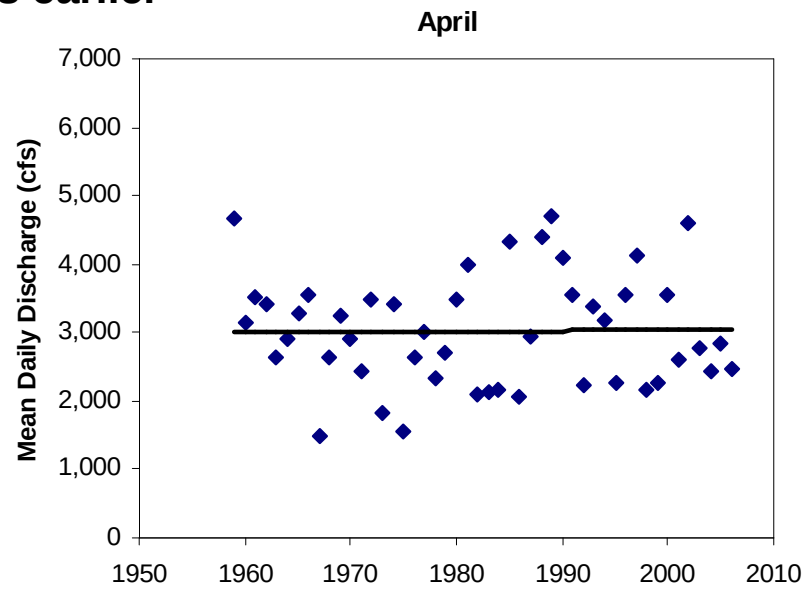
Snowfall at Snoqualmie Pass, WA
1950-2006

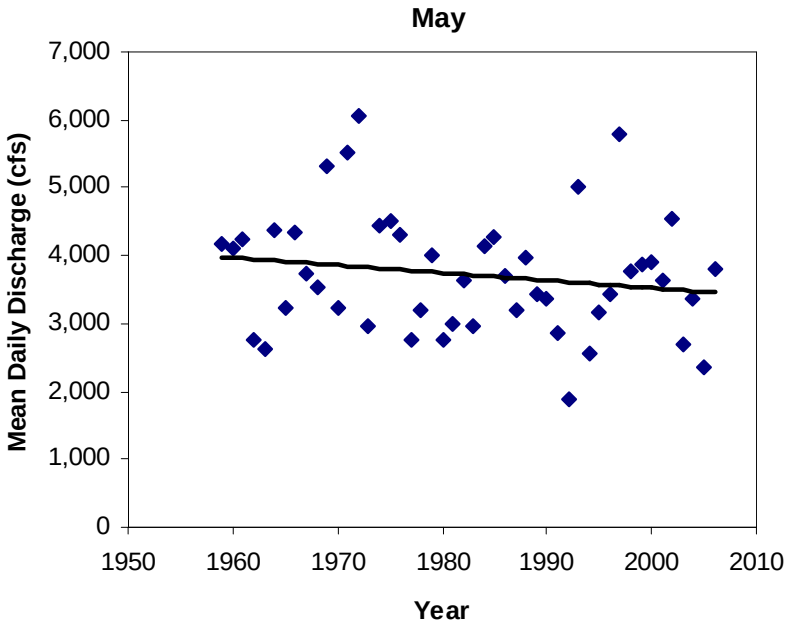


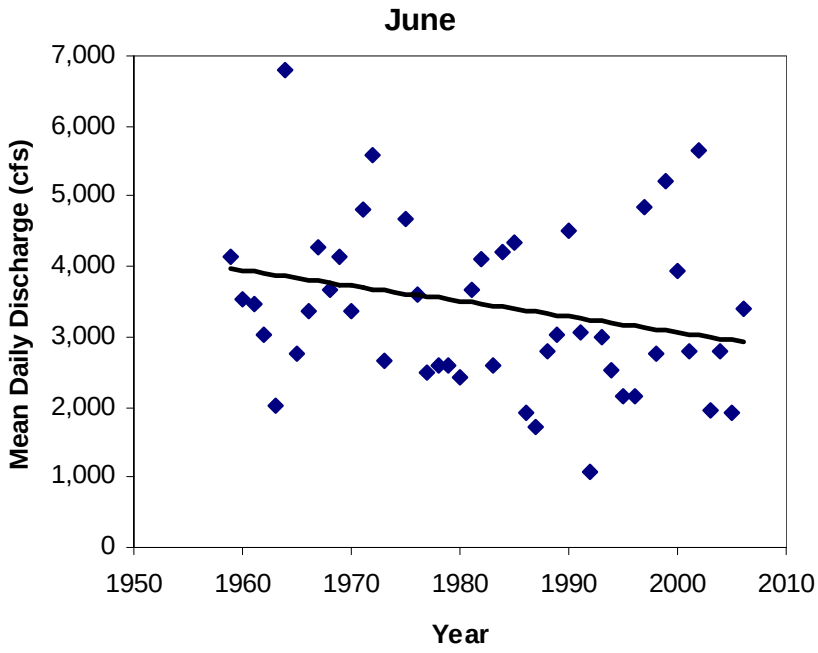
Graph: Steve Wondzell

Runoff occurs earlier

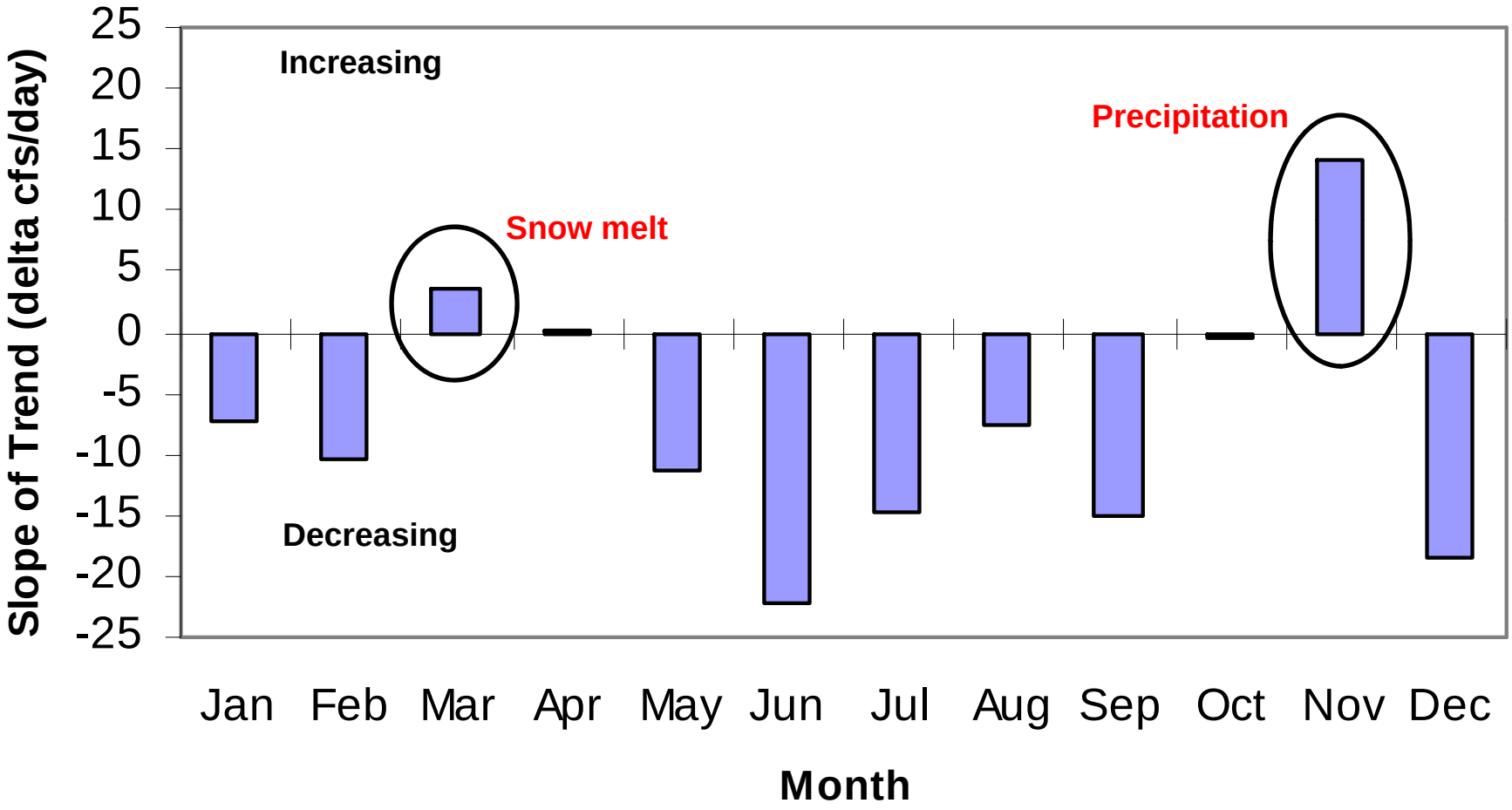




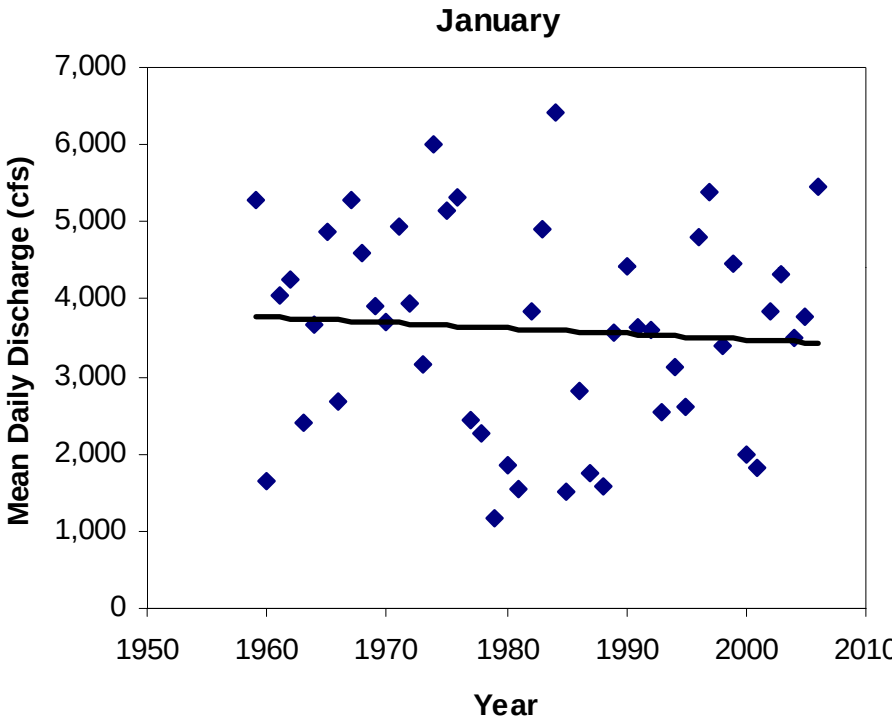


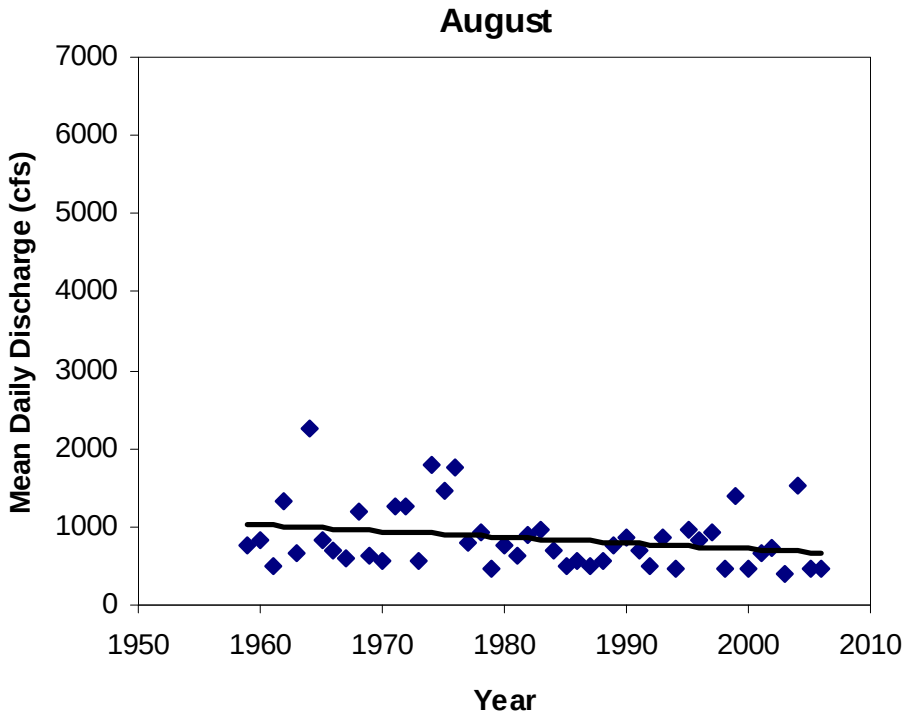


Snoqualmie River at Snoqualmie, WA
Monthly Average Discharge Trends 1959-2006



Decreased flows in mid-winter and mid-summer





CIG Conclusion:

Fish

Projected temperature increases and streamflow changes could create environmental conditions that are inhospitable to many PNW cold water fish populations (e.g., salmon, trout), and the rates of change may outpace their ability to adapt.

Salmon species' unusual life cycles make them sensitive to climate changes in a range of aquatic habitats. **In summer, low flows and high stream temperatures hinder both juvenile growth and survival and adult migration. Changes in the timing of peak streamflow may increase their vulnerability to floods and decrease their ability to migrate to the ocean**.

Effects on Snoqualmie Basin fishes:

Temperature

- *Elevated winter temperatures* will accelerate embryo development in fall spawning species (Chinook, coho, chum, pink salmon, and bull trout), resulting in earlier spring emergence
- *Earlier emergence* (March) may increase fry vulnerability to late winter-early spring storms but gives fish a head start on the growing season
- *Higher spring water temperatures* will be favorable for growth; *higher summer water temperatures* will be detrimental to growth
- *Higher temperatures overall* will favor warm-water species such as minnows and suckers; non-native species not an issue in Snoqualmie R. (yet)
- *Higher summer temperatures* may exacerbate mortality of migrating and holding adults (spring Chinook, summer steelhead)

Effects on Snoqualmie Basin fishes:

Precipitation and Discharge

- *Higher precipitation and discharge in November* could result in egg mortality if the frequency of streambed mobilizing events increases
- *Lower precipitation and discharge in December and January* may hinder access to winter habitats, especially floodplain wintering sites
- *Earlier spring runoff* will favor early migrating smolts at the expense of late migrating smolts AND timing of ocean entry may not correspond with plankton blooms
- *Lower summer flows* will reduce available rearing space and may cut off access to thermal refugia
- *Lower summer and early fall flows* will hinder adult migrations in drought years

Winning strategies	***Losing strategies***
Habitat generalist	**Habitat specialist**
Abbreviated time in fresh water	**Extended freshwater rearing**
High stray rate	**Low stray rate**
Brief temp. exposure	**Extended temp. exposure**
Spring spawning	**Fall spawning**

Cutthroat trout

Chum salmon
Pink salmon
Fall Chinook
Winter steelhead

Sockeye salmon
Coho salmon
Spring Chinook
Summer steelhead

Lower risk

Higher risk

What can land managers do?

- Minimize increases in water temperature by maintaining well shaded riparian areas
- Maintain a forest stand structure that retains snow water and promotes fog drip, but reduces the “rain on snow” effect associated with large forest openings
- Disconnect road drainage from the stream network to soften discharge peaks during intense storms
- Ensure that fish have access to seasonal habitats, e.g., off-channel or cool water areas
- Protect springs and seeps from water appropriation