

Climate Change in the Puget Sound: Will it Impact the Region's Water Resources?

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SPECIAL REPORT GLOBAL WARMING

TIME

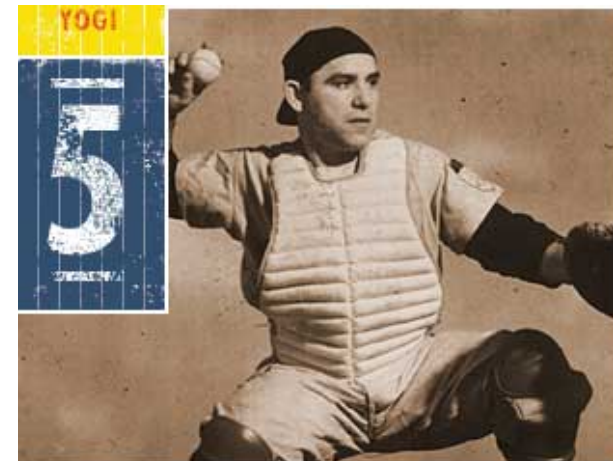
**BE
WORRIED.
BE VERY
WORRIED.**

Climate change isn't some vague future problem—it's already damaging the planet at an alarming pace. Here's how it affects you, your kids and their kids as well

EARTH AT THE TIPPING POINT
HOW IT THREATENS YOUR HEALTH
HOW CHINA & INDIA CAN HELP
SAVE THE WORLD—OR DESTROY IT
THE CLIMATE CRUSADERS



“The future ain't what it used to be.”



Presentation Outline

- Problem in Context
- Overview of climate change: global and regional
- Hydrologic impacts of climate change
- Regional Water Supply
- Impacts on Salmon Recovery
- Involving the Public
- Conclusions



Problem in Context

Context for Water Resources

- Prior to 1970's - Maturing Field
 - Significant investments in infrastructure
 - Develop supplies to meet demands
 - Federal Standards and Guidelines
- Post- Earth Day – Established Paradigm Shift
 - Focus on operations, managing uncertainty, construction canceled or postponed
 - Multidisciplinary collaboration, public engagement
- Recognition of Climate Change
 - Further Paradigm Shift
 - Emphasis on future “Scenarios” rather than the past



Overview of Global Climate Change



Scientific Consensus on Climate Change

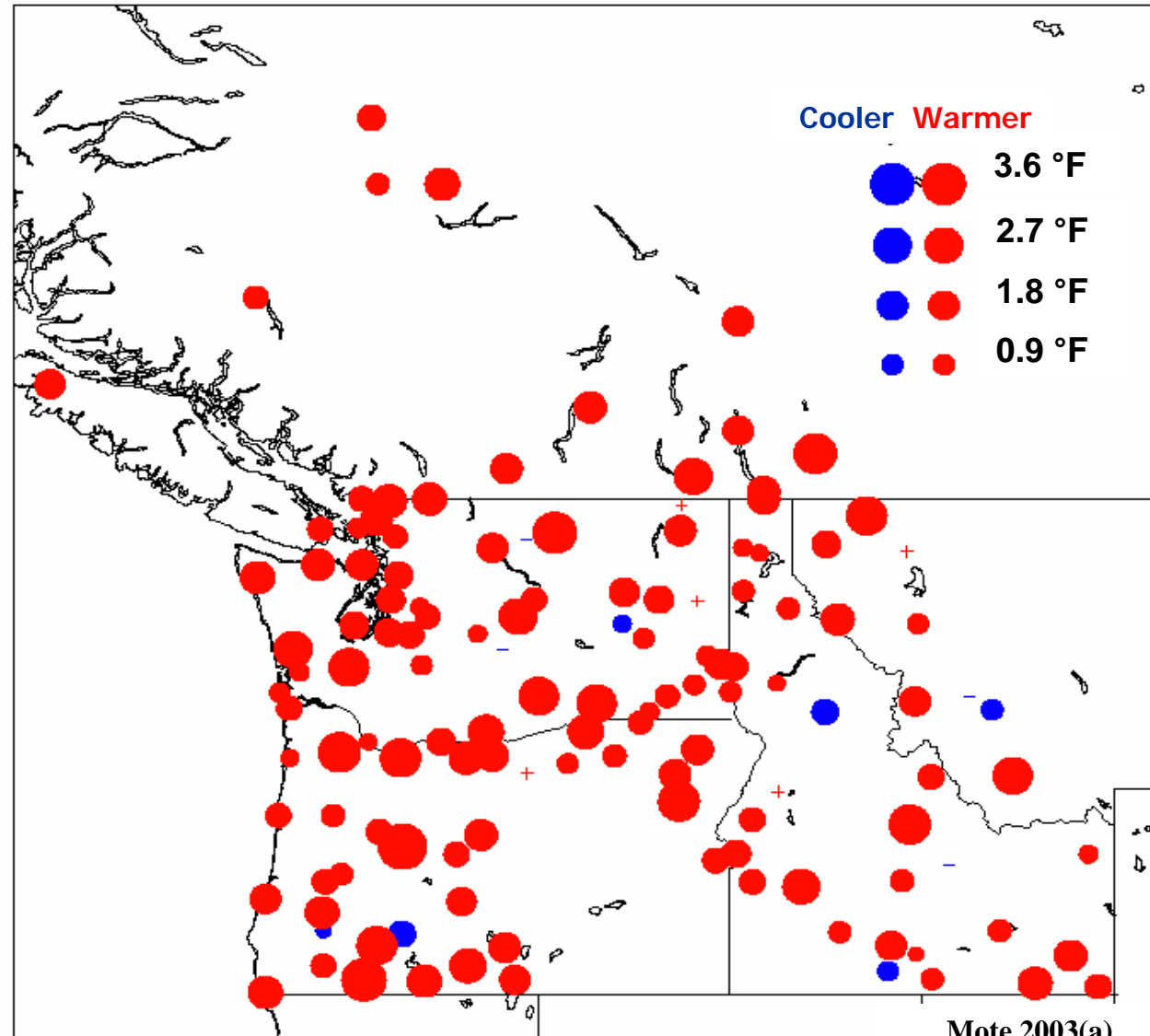
- Carbon dioxide and other greenhouse gases warm the planet
- Greenhouse gases have been increasing at rapid rates since 1750 and will increase in the future
- Human activities have increased the concentrations of the major greenhouse gases
- The planet has warmed $1.1 \pm 0.4^\circ\text{F}$ since 1900. Projected range of global-scale warming: $2.5\text{-}10.5^\circ\text{F}$ by 2100
- Warming expected through 21st century even if CO₂ emissions end tomorrow due to persistence



Temperature Trends by Station

Temperature trends ($^{\circ}\text{C}$ per century), since 1920

- 154 stations with long records
- Almost every station shows **warming**
- Precipitation is similar except trend is increasing (14%)

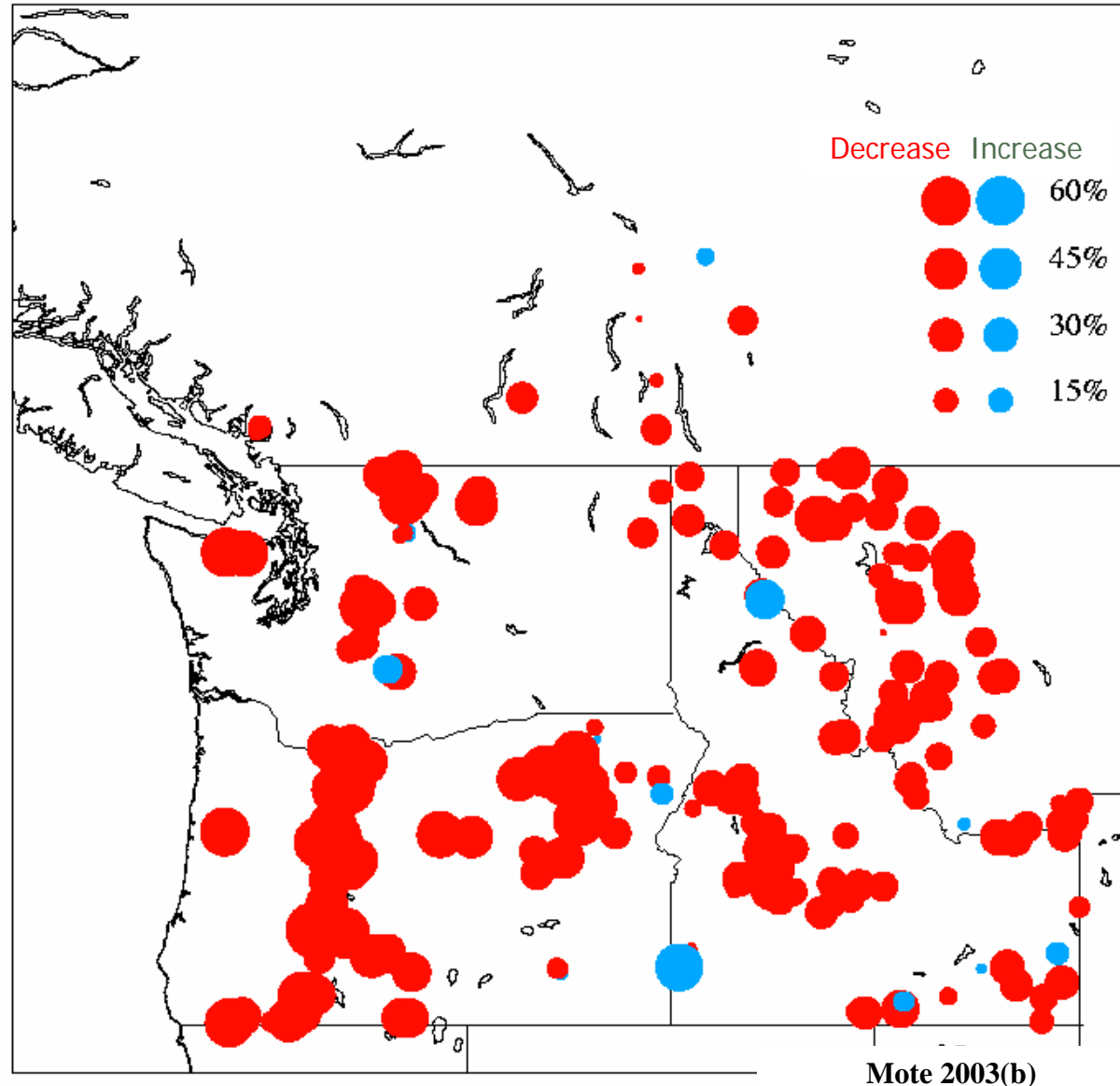




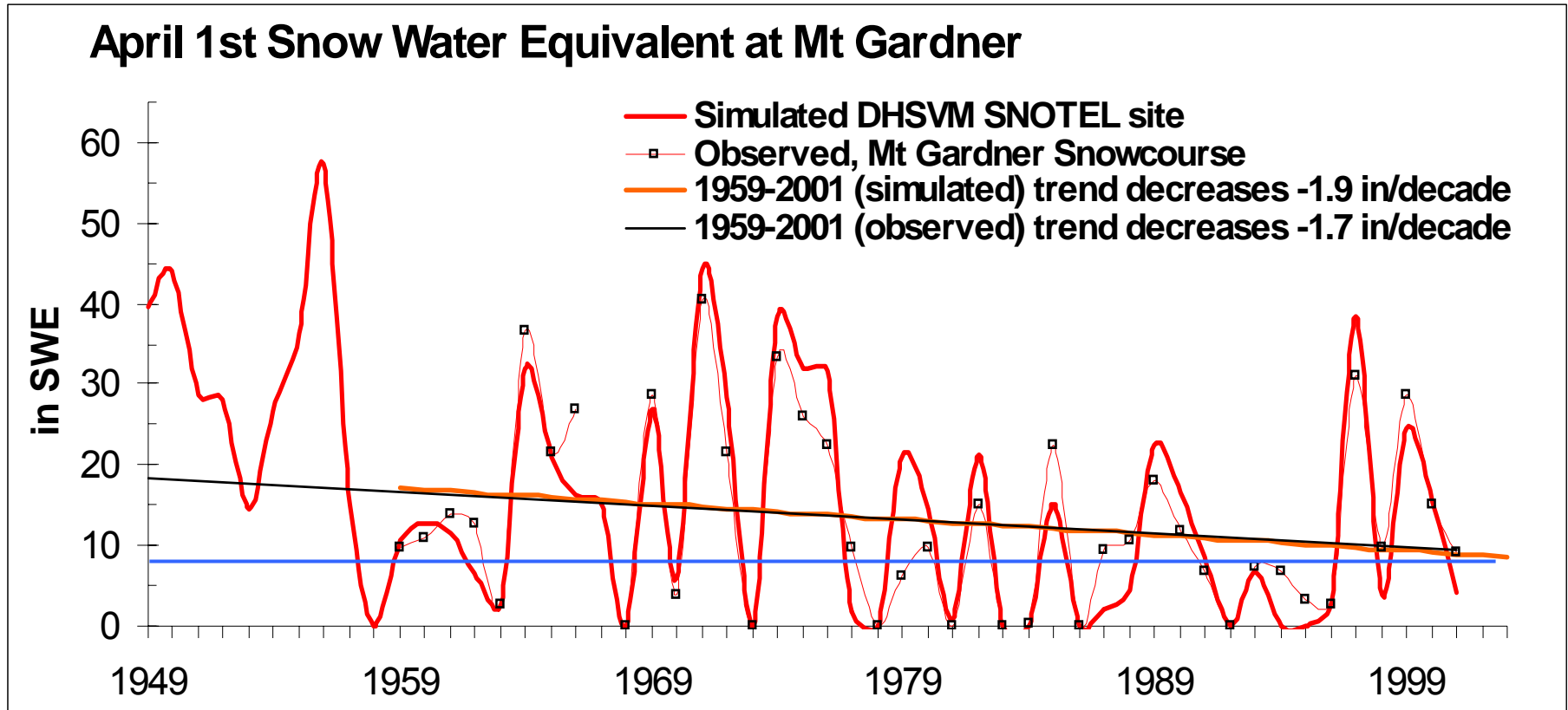
Snow Water Equivalent Trends

- Results based on data from 260 snow course collection sites
- Most stations showing a **decline in snow water equivalent**
- Numerous sites in the Cascades with 30% to 60% declines

Relative trend in Apr 1 snow water equivalent, 1950-2000

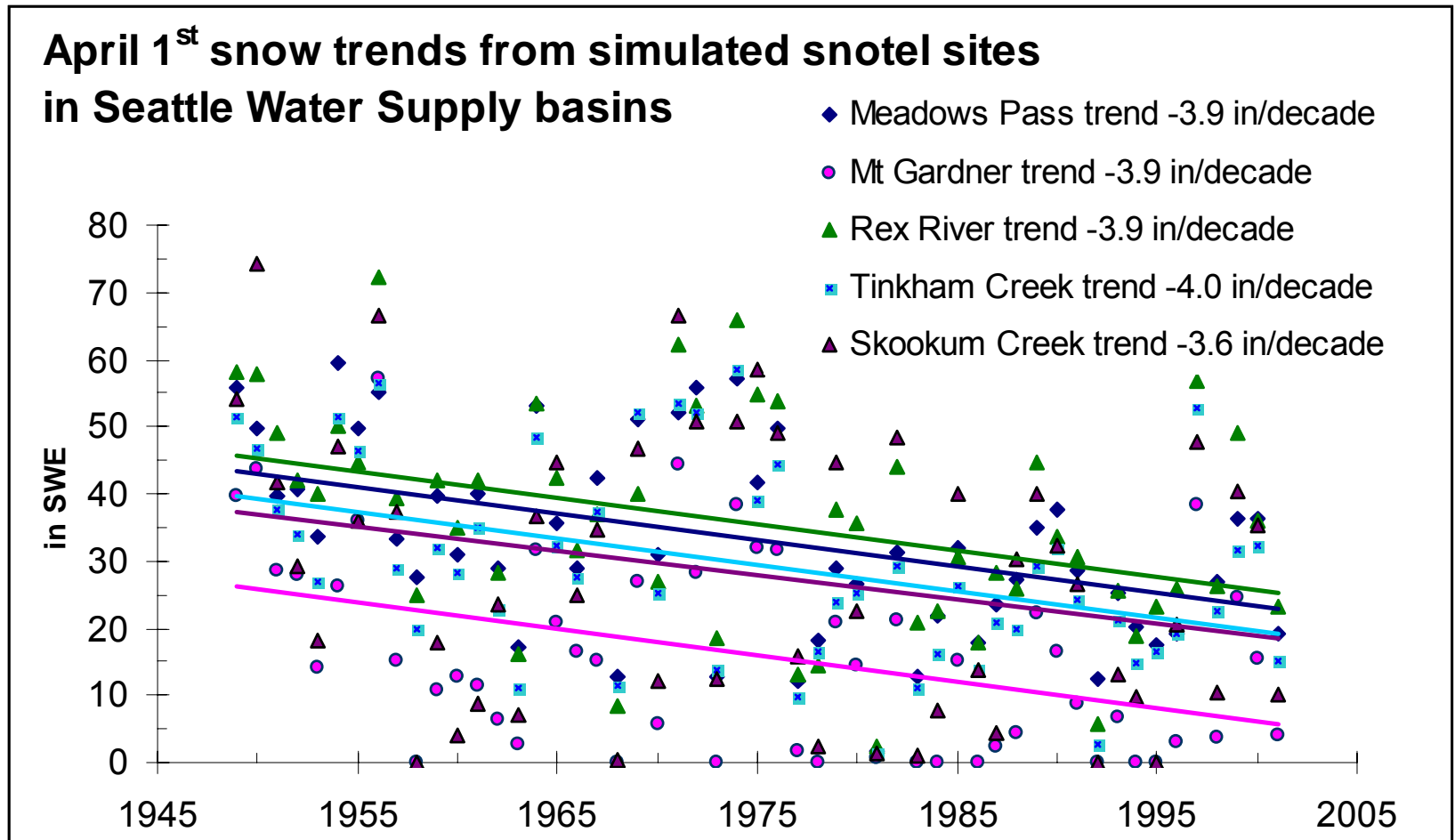


April 1 SWE at Mt. Gardner



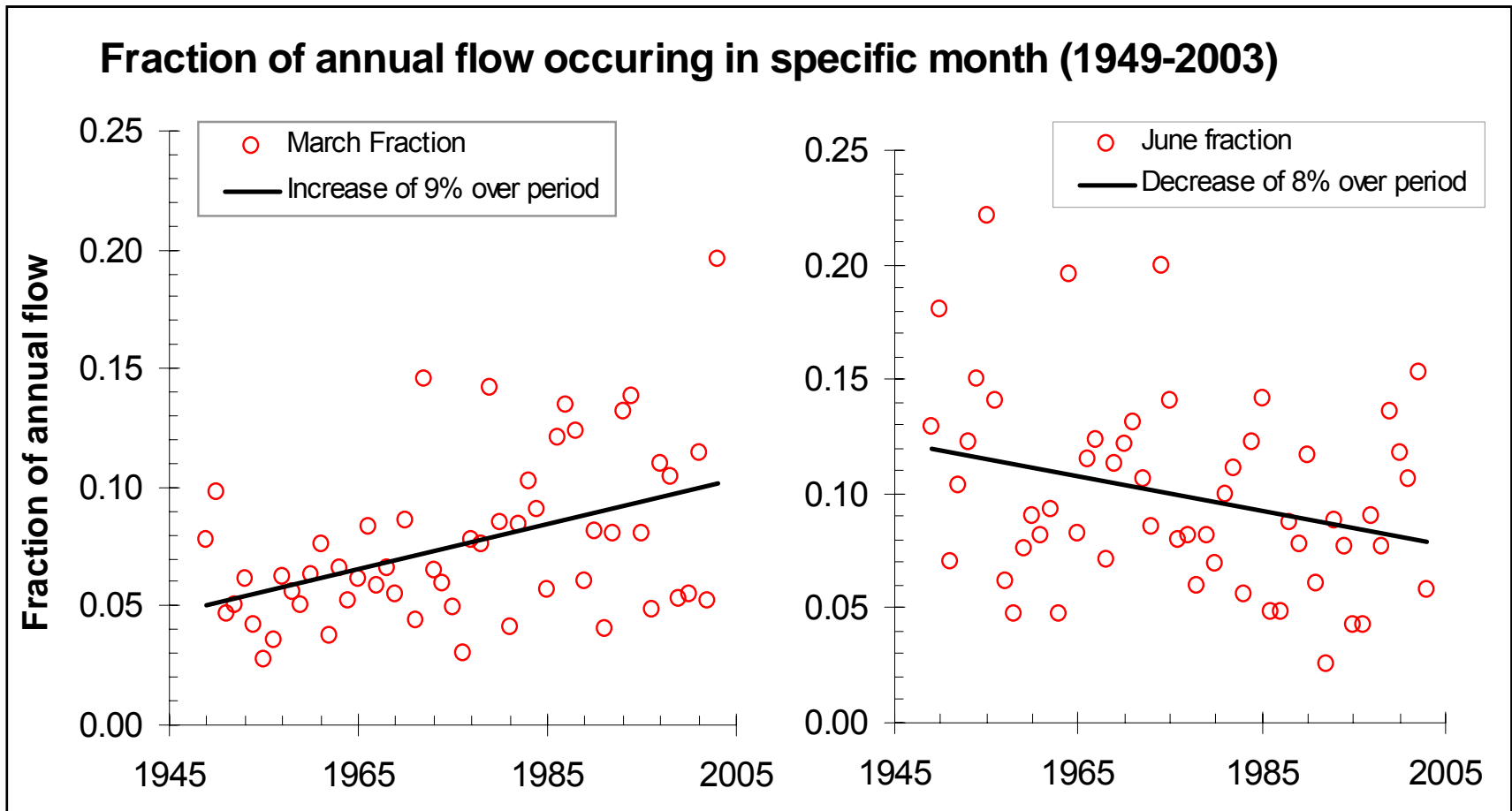
Consistent declining trend between observed and simulated April 1 SWE for Mt. Gardner

April 1 SWE Trends (Simulated) in Seattle Water Supply Basins



Declining trends also seen in other Seattle Water supply basins

Changes in Annual Spring Flow on the Cedar River above Chester Morse Reservoir, 1949-2003



Fractions of annual flow occurring in March and June on the Cedar River above Chester Morse reservoir. Station Elevation 1560 ft.

Where Are We Headed?
**21st Century Climate Change
Projections**

Projected PNW Climate Change

Projected changes in average annual PNW temperature and precipitation for the decades of the 2020s and 2040s

Greatest certainty is temp changes; less certainty in precip changes

2020s	Temperature	Precipitation
Low	+ 0.8 °F	+ 2 %
Mean	+ 2.5 °F	+ 7%
High	+ 3.3 °F	+ 14 %

2040s	Temperature	Precipitation
Low	+ 2.7 °F	- 3 %
Mean	+ 3.8 °F	+ 7%
High	+ 4.9°F	+ 14 %

Based on an increase in equivalent CO₂ of 1% per year. Benchmarked to the decade of the 1990s.

The Bottom Line...

*Climate change is **projected** to bring*

Warmer, wetter
winters

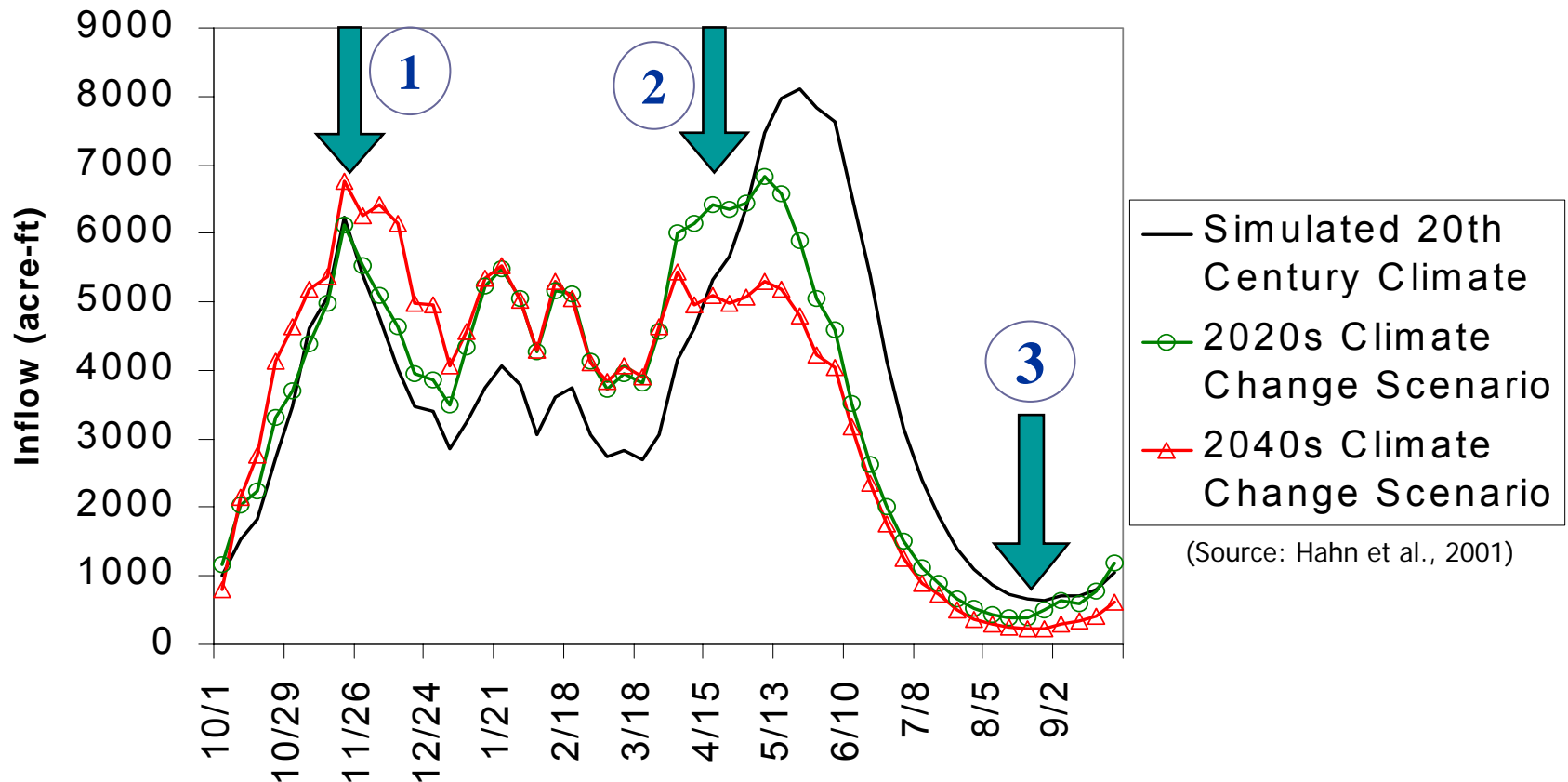
and

Warmer summers

What does this mean for the PNW?

These changes contribute to...

1. Higher winter flows (incr. winter flood risk)
2. Earlier and lower peak flows (longer dry season, less water for salmon)
3. Lower summer flows



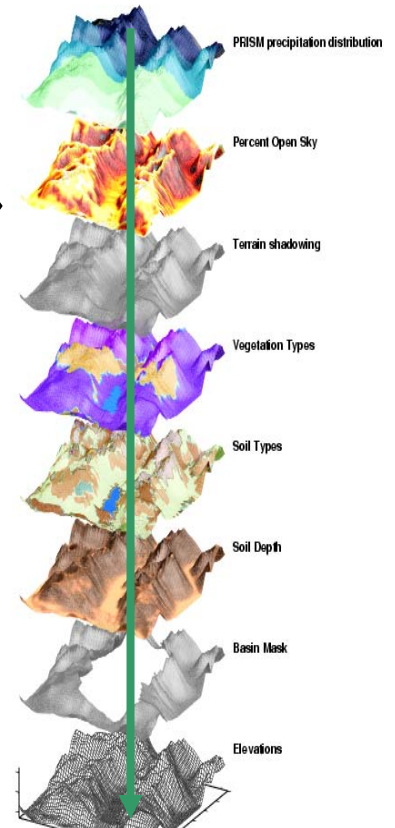
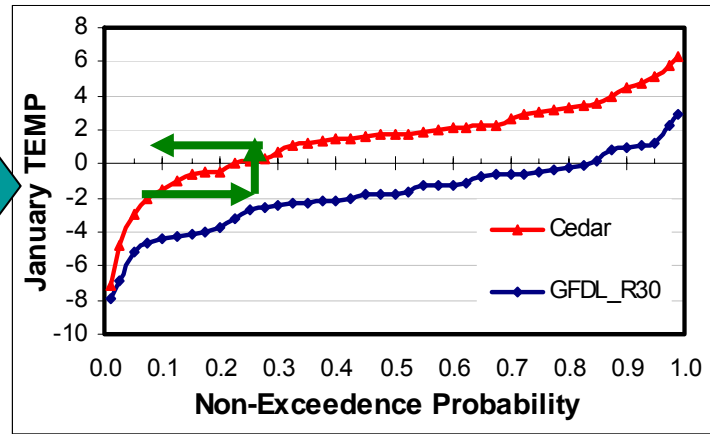
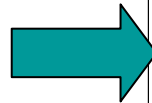
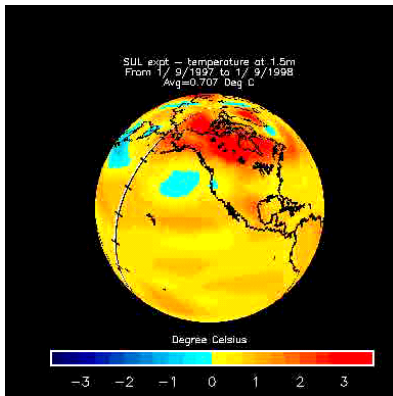
(Source: Hahn et al., 2001)

Projected Climate Change Impacts on Chester Morse reservoir, Cedar River, WA

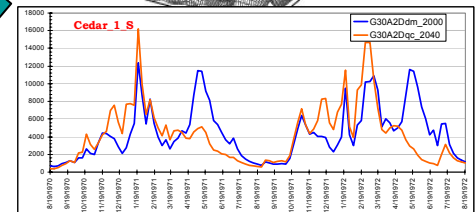
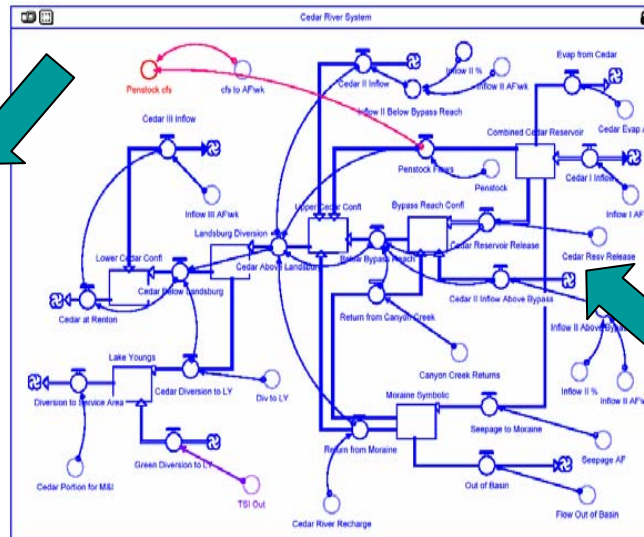
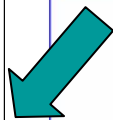
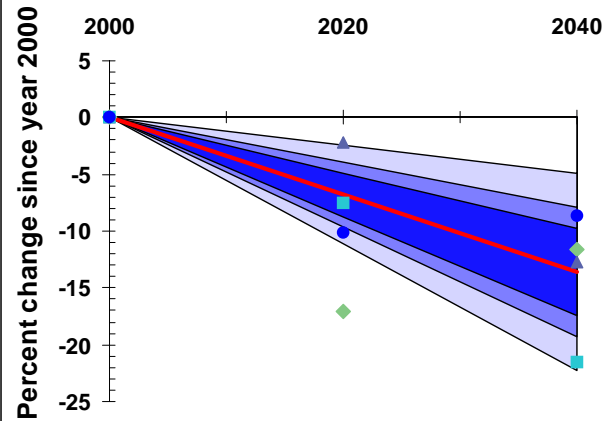
Evaluation Approach



Impact Assessment Method



Rate of Change in Gross Yield as percent of GCM's year 2000 values





Impact Assessment Method

- Use GCMs to simulate future climate conditions on a global scale
- Re-scale global climate data to a river basin scale.
- Model hydrology of downscaled GCM data to simulate stream flows under altered climate conditions.
- Use a systems simulation model to assess the effects of altered stream flows on water resource systems.
- Assess climate impacts the users of water resource systems, including potential changes in demand and demographics under climate change scenarios.

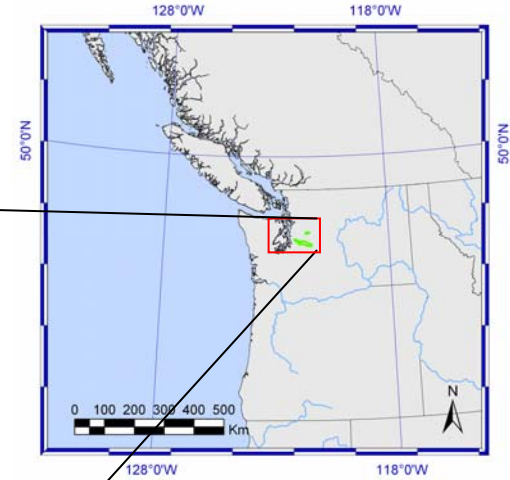
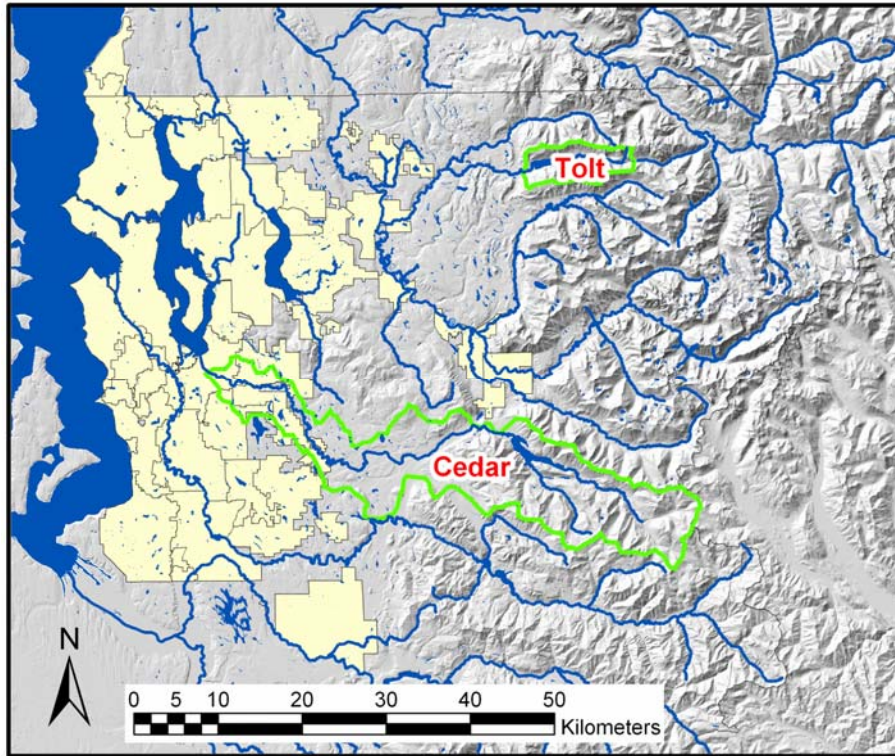
Described by Frederick and Gleick (1999)

Water Resource Impacts





Impacts of Climate Change on Seattle





Impacts of Climate Change on Seattle

- Three sources
 - South Fork Tolt River (29%)
 - Cedar River (70%)
 - Highline well fields (1%)
- Reservoirs
 - Tolt Reservoir 56.2 KAF active storage
 - Chester Morse 48.5 KAF active storage
- Combined storage is approximately 68% of average annual demand
- Storage in snow is important during dry summers !



Concerns

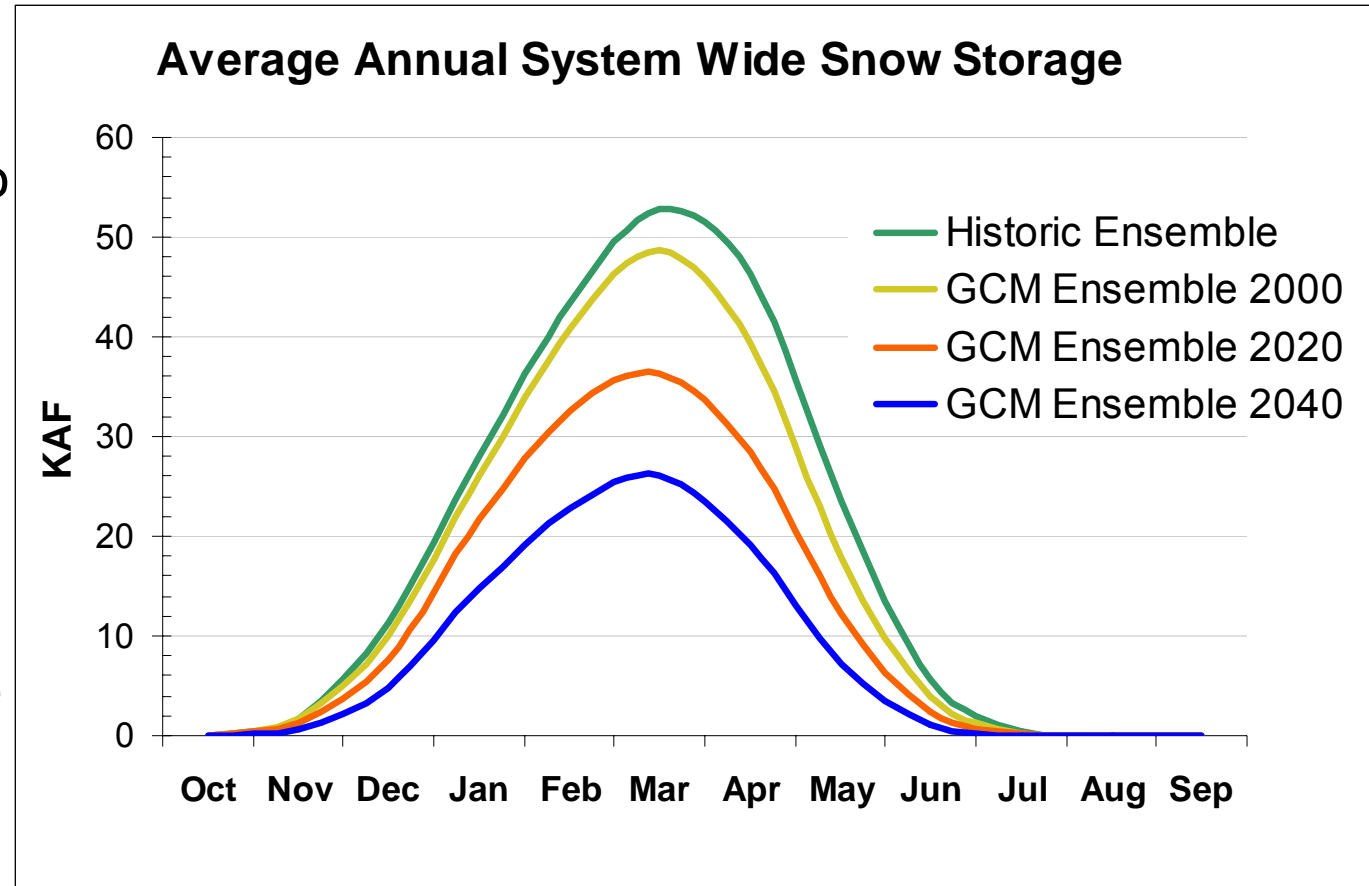
- Due to their elevations, snowpacks for systems are susceptible to climate change
 - Highest snowpack will be least impacted in the beginning
 - Snowpack near the snow line will be impacted first
- Systems that rely most on snowpack will be most impacted
 - Late spring and early summer rains provide needed supply
- Unusual events become more frequent



Impacts of Climate Change on Supplies

Snowpack

- Average annual maximum seen to decrease by as much as 50% by 2040
- Timing of peak shifts earlier in year.
- Extreme events will become more common.

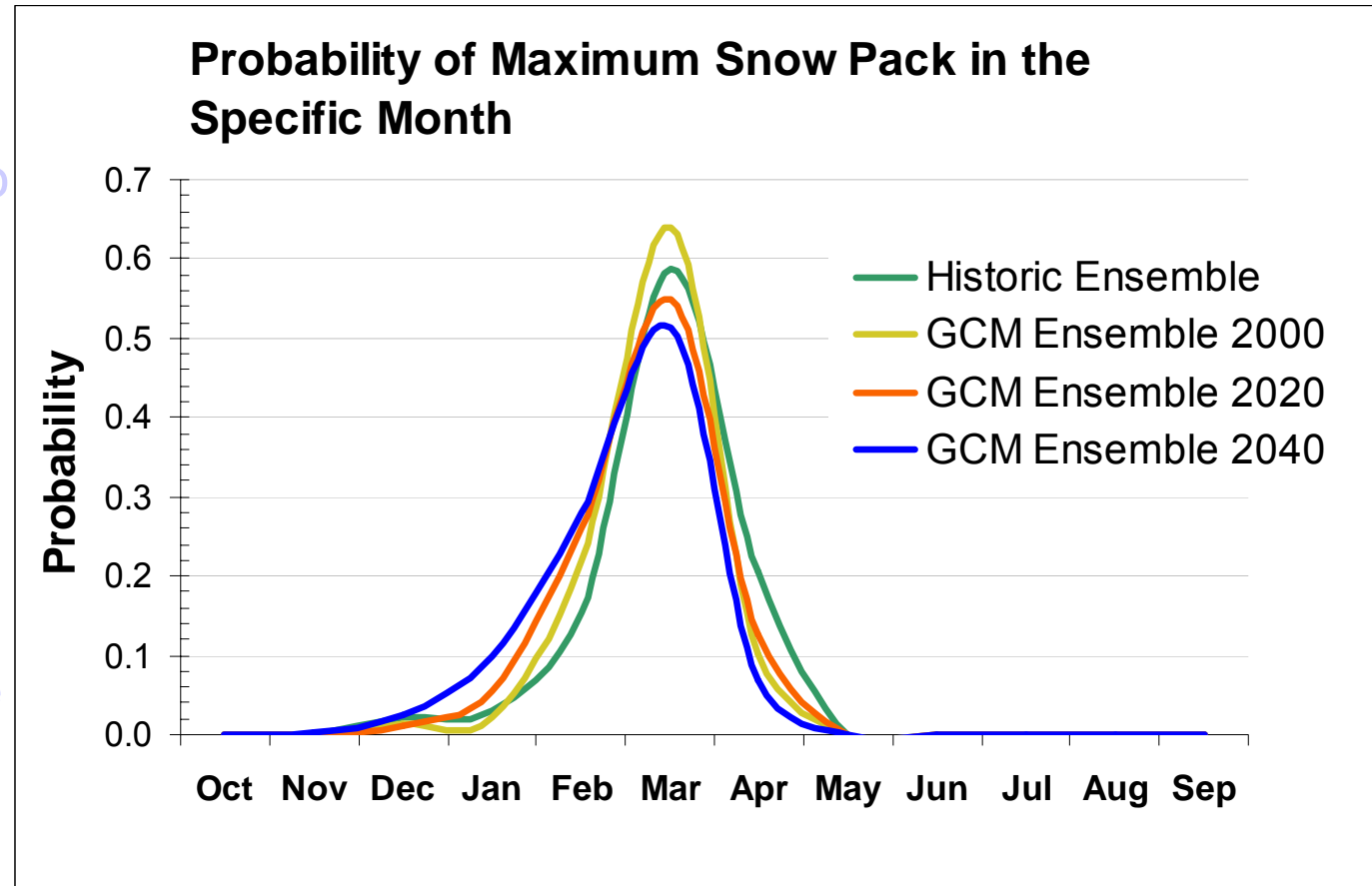




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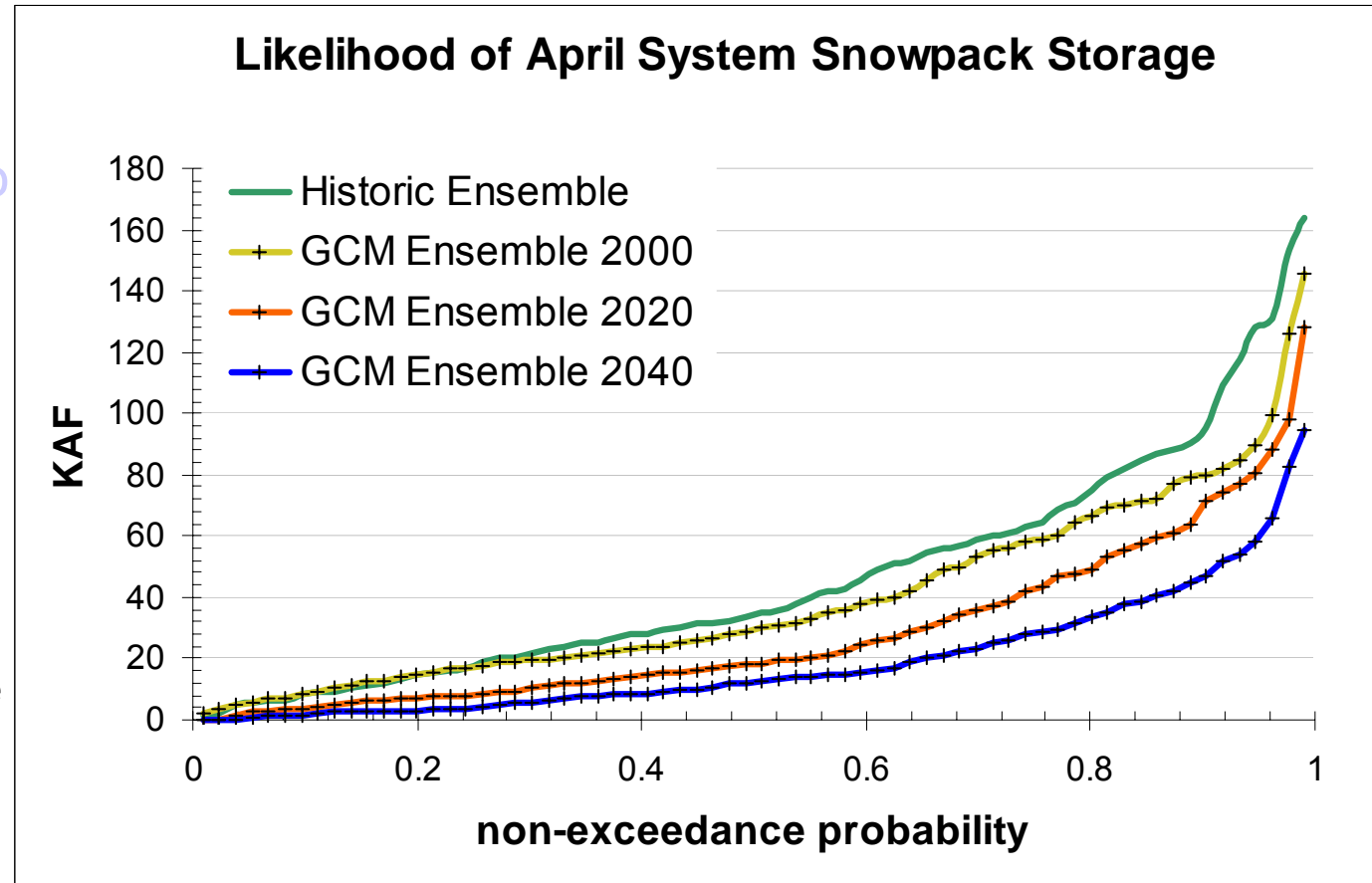




Impacts of Climate Change on Supplies

Snowpack

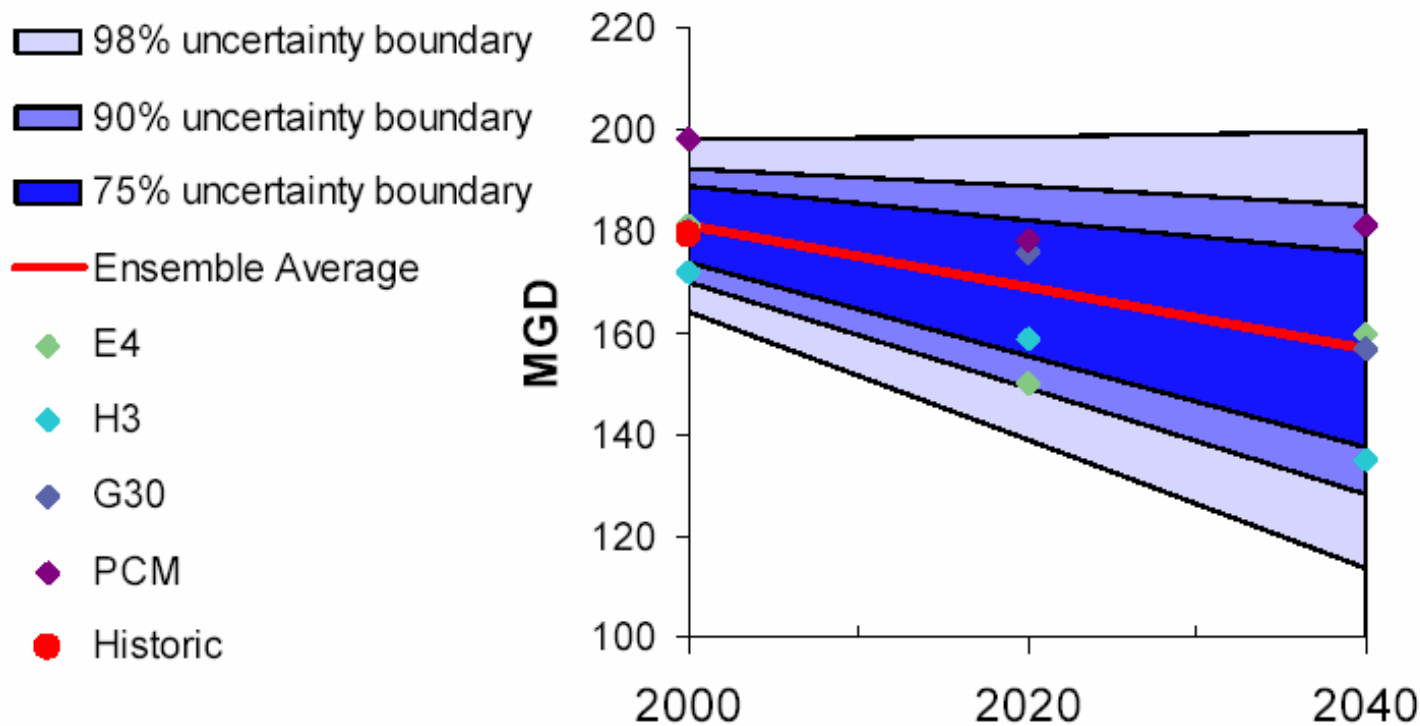
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Impacts of Climate Change on Supplies

Trend in Gross Yield of the Seattle Water Supply System



2040s Climate Impacts

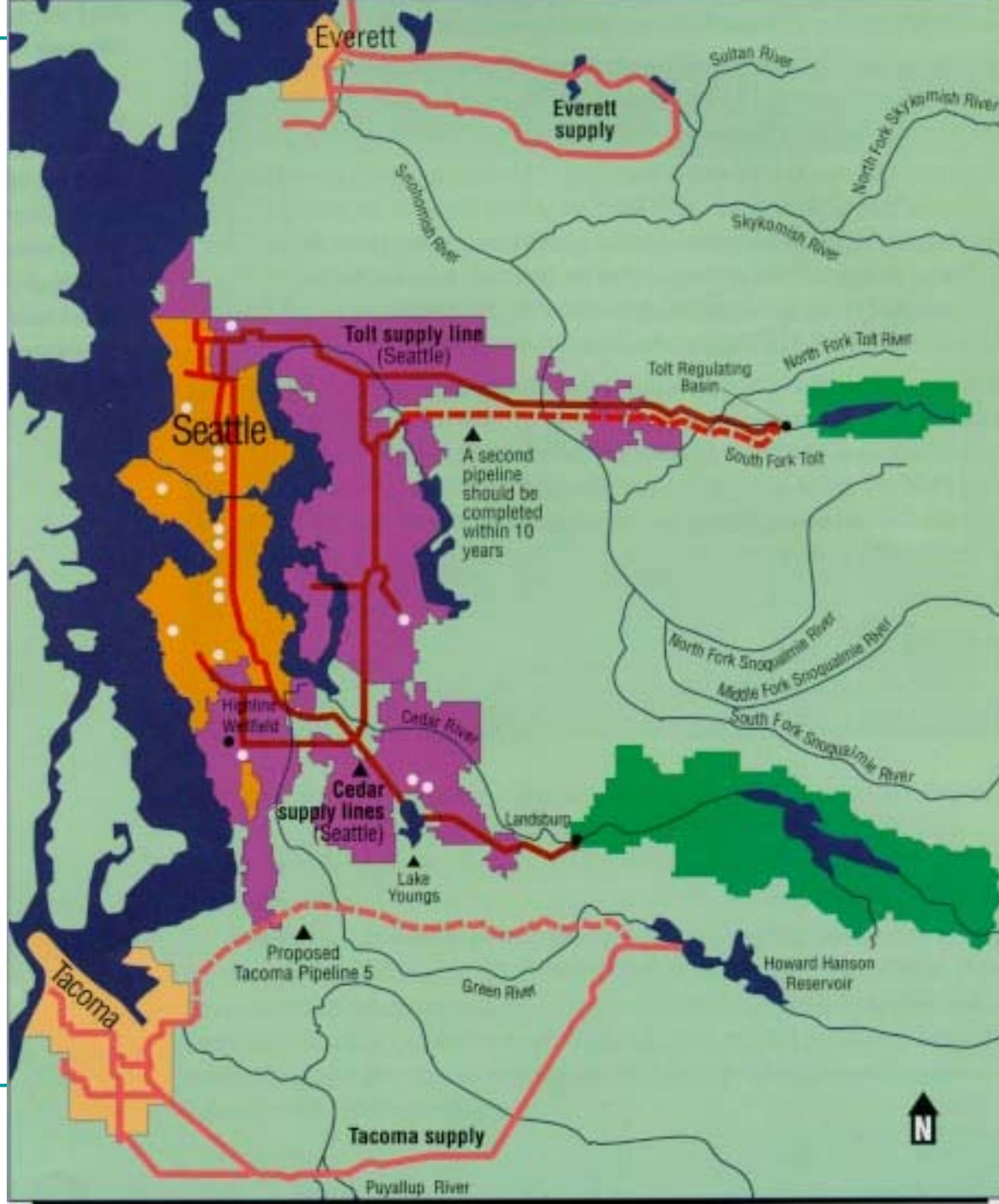
Loss of Gross Yield: ≈ 20 mgd

System water demand has decreased!



Importance of Impacts

- Each system we have studied has lost yield due to climate change
- However, region's infrastructure is extremely complicated and interwoven
- The bottom line is that less water will be available to us during periods when the demand is greatest.





Possible Solutions

- Changes in Rule Curve Operations
 - Move away from fixed rules to more dynamic rules
- Better monitoring of watershed conditions
- Use of voluntary and mandatory restrictions
- Regional inter-ties that seek to optimize synergistic gains between different systems
- Continue emphasis on “conservation”
- Water reclamation
- Water pricing

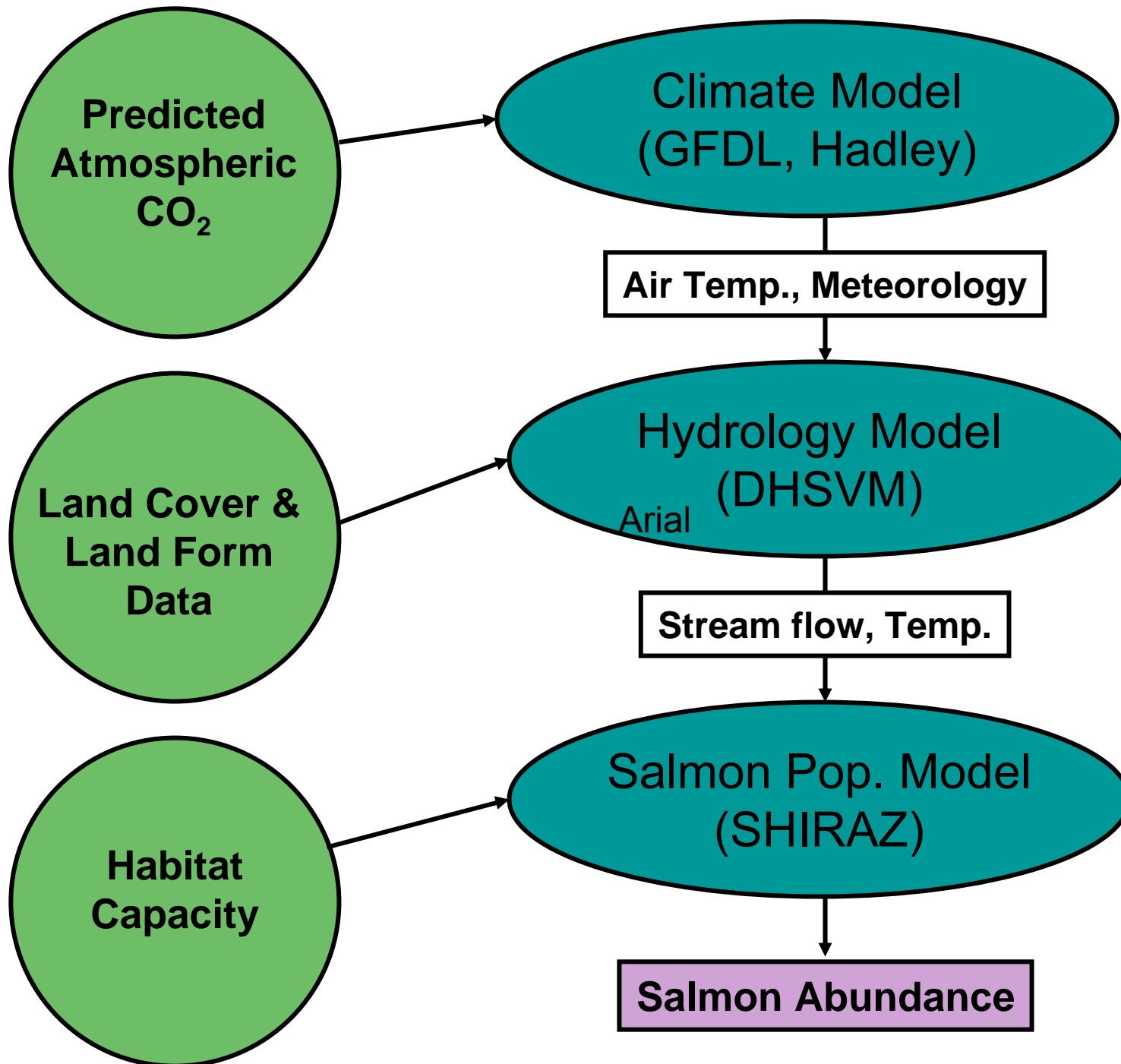
Impacts of Climate Change on Salmon Recovery





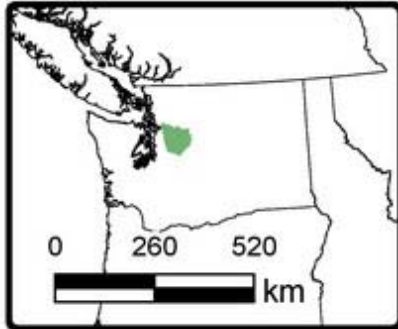
Impacts of Climate Change on Salmon Recovery

- Study performed with NOAA
- Goal – to determine potential climate impacts on Chinook in Snohomish River Basin
- Two climate change models, years 2000, 2025, 2050
- Various land use options
- Look at factors impacting Chinook



Climate and Landcover Impacts on Chinook Salmon

Snohomish River: Climate and Landuse Change Impacts by Subbasin, Year 2050

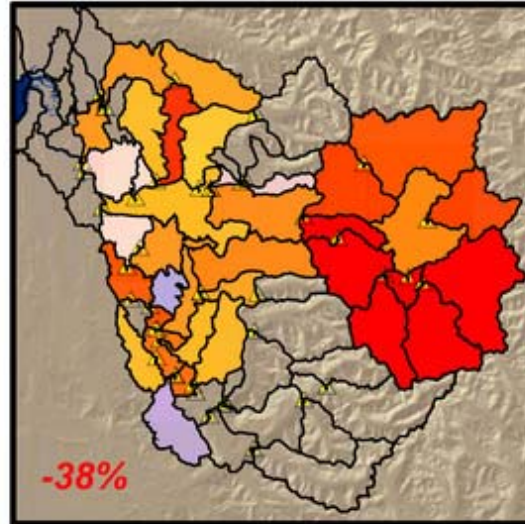
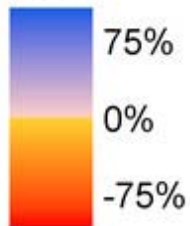


Change in Mean Number of Returning Spawners

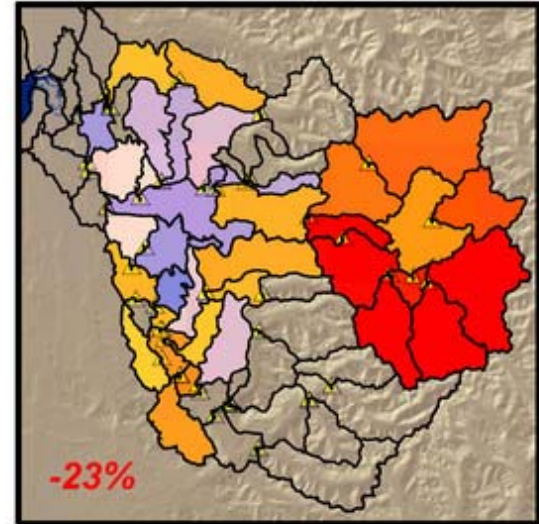
+1% Basinwide average value

▲ Analysis Location

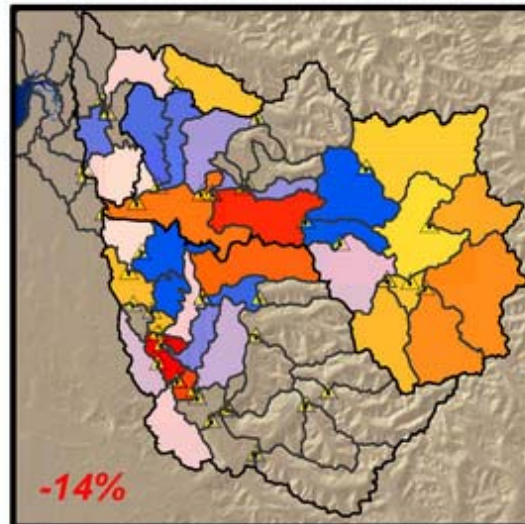
Value



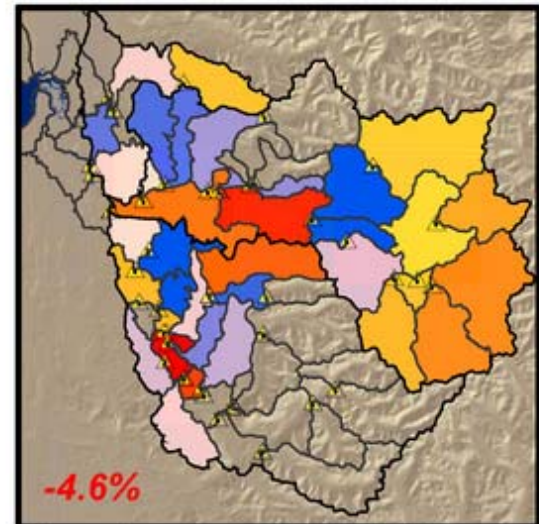
Change from Current with 2050 Climate and Business-As-Usual Landuse: GFDL



Change from Current with 2050 Climate and Restoration Landuse: GFDL



Change from Current with 2050 Climate and Business-As-Usual Landuse: HadCM3



Change from Current with 2050 Climate and Restoration Landuse: HadCM3



Impacts of Climate Change on Salmon Recovery

- Impacts on Peak Flows
 - Increases of between 5%-27%
- Impacts on Low Flows
 - Decreases of between 3%-22%
- Impacts on Temperature
 - Increases of between 1.5%-2.5 degrees

So what do we do about it?....

Engaging the Public





Engaging the Public

- Decisions at local level are driven by resource agencies, utilities, and engaged stakeholders
- Including climate change requires new paradigm
- There is a need to educate the public and professional in the need to include climate change in planning



Engaging the Public

- Multiple agencies and organizations are voluntarily participating to identify, compile information and discuss many of the key issues that relate to or may affect water resources of the region.
- The goal is to develop the best available data, information, and pragmatic tools.
- All information generated will be shared among all those interested in receiving it.
- Each of the participants is free to accept or reject the results of this process.

Building Blocks Document



- Make participants aware of climate change research
- Use peer-reviewed literature to ensure that information was of high quality
- Recognize that uncertainties exist, but much is known

(Source: <http://agexted.cas.psu.edu/FCS/mk/images/BuildingBlocks.jpg>)



Final Comments

- Regional Water Supply
 - Climate change will have a significant impact on water supply and streamflows by 2040
 - These trends place further pressures on already strained systems
 - Decreases in water demand have limited slowed need for new sources of water
 - Regional cooperation offers viable alternatives

Final Comments

■ Salmon Recovery

- It may not be possible to fully mitigate the dual impacts of changes in land use and climate change
- Most significant impacts due to:
 - Peak flows
 - Increased Temperatures
- Clear need for continued efforts

Final Comments

- Public Engagement
 - An opportunity exists to change planning paradigm to consider climate change
 - But to change the paradigm, public engagement is required