Living with limits: Climate, water, salmon and sustainability in the Pacific Northwest

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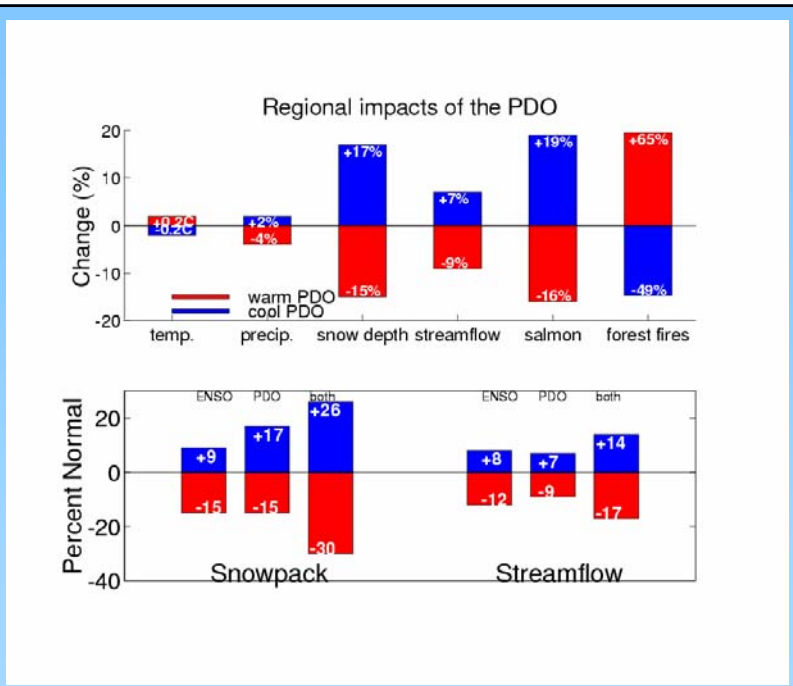
- Amy Snover - CIG

The Background

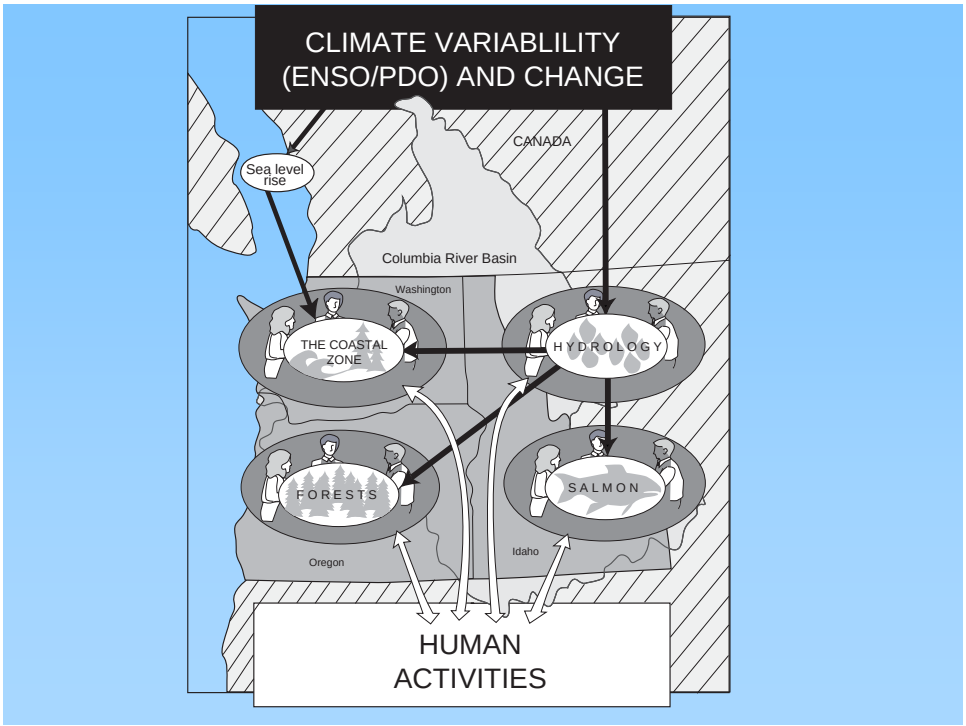
The Cadence of Climate Variability
as a Baseline for Projecting Scenarios
of Climate Change



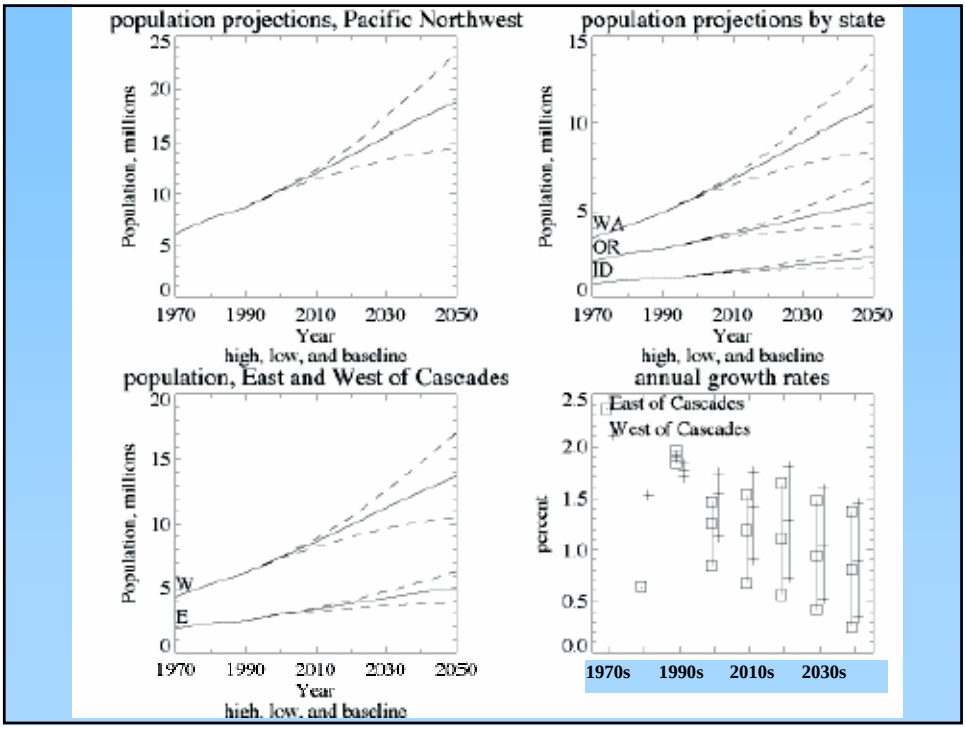
Observed Probability of High and Low Streamflow in the Columbia River Basin Associated with ENSO and PDO

Climate Category	LOW FLOW (%)	HIGH FLOW (%)
All Years (1900-1998)	8	7
warm PDO	14	0
cool PDO	4	12
El Niño	21	0
ENSO neutral	0	9
La Niña	3	12
warm PDO/El Niño	36	0
warm PDO/ENSO neutral	0	0
warm PDO/La Niña	8	0
cool PDO/El Niño	11	0
cool PDO/ENSO neutral	0	18
cool PDO/La Niña	0	19

Apr-Sept average flow at The Dalles, 1900-1998. High/low = +/- 1.5 std dev. Miles et al. 2000

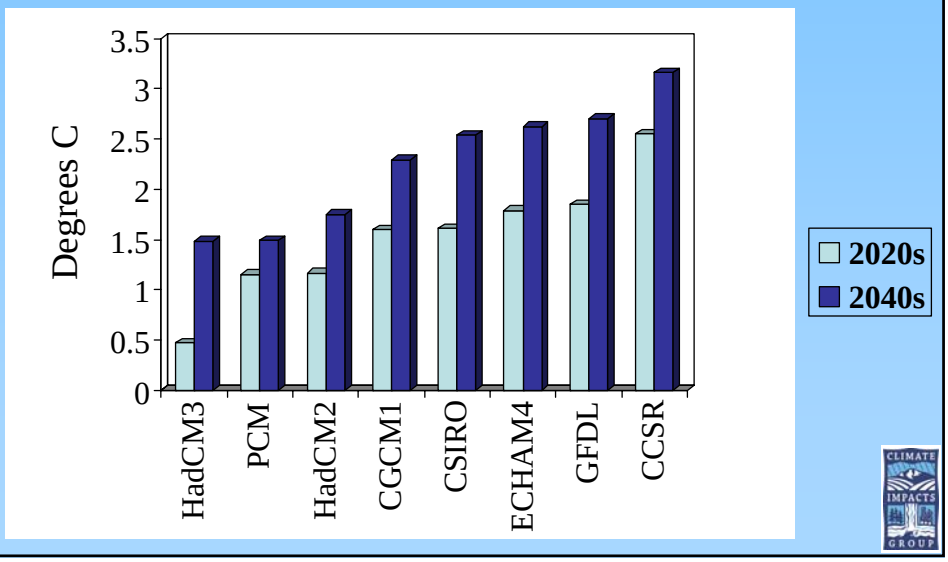


The Projected Future

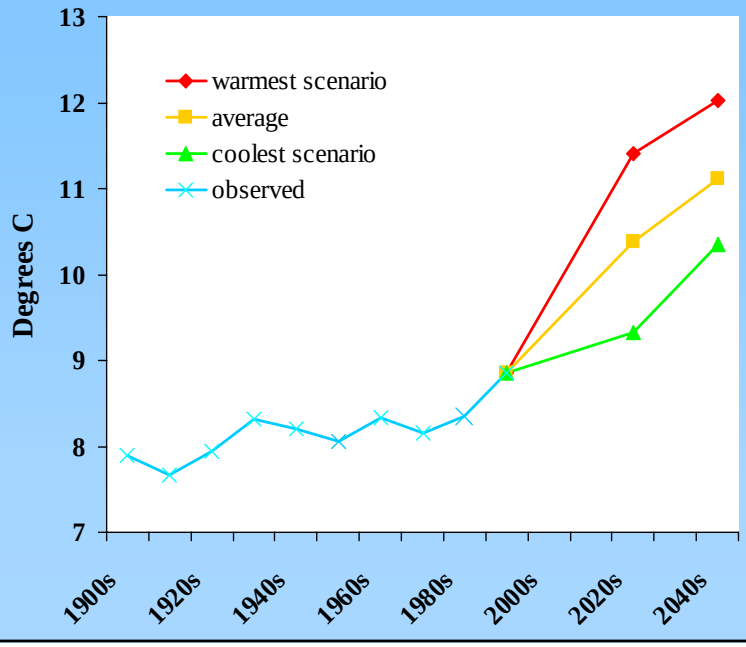


Northwest Warming Scenarios

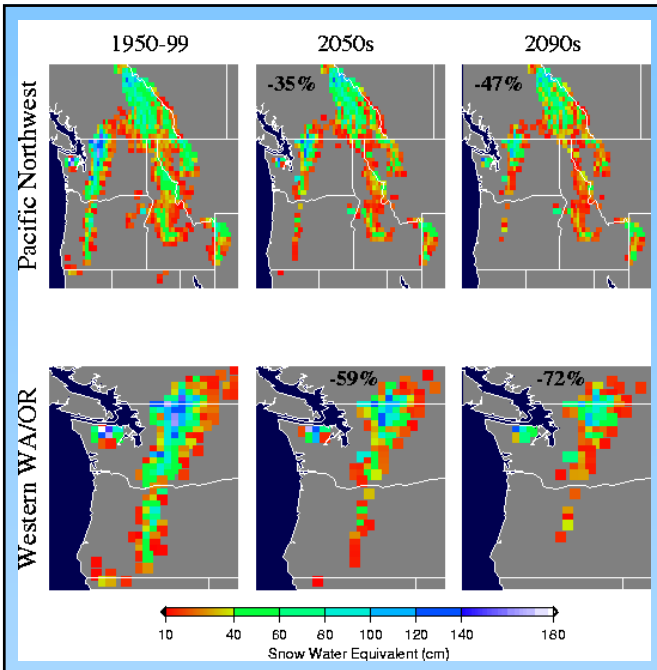
For the decades of the 2020s and 2040s



Northwest Warming



~1.5 to 3°C (~ 3 to 6°F) warmer in the 2040s



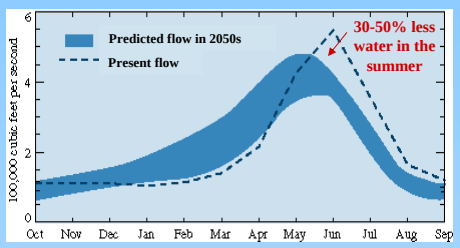
Projected Changes in PNW April 1 Snowpack

- Regional decline - **47% by 2090s**
- Western WA/OR decline – **72% by 2090s**

Provided by Dennis Lettenmaier and Andy Wood, UW Civil Engineering
Accelerated Climate Prediction Initiative, a UW-SIO-PNNL collaboration

Hydrologic Impacts

- **Less snow, earlier melt** means less water in summer. Affects:
  - irrigation
  - urban uses
  - fisheries protection
  - energy production

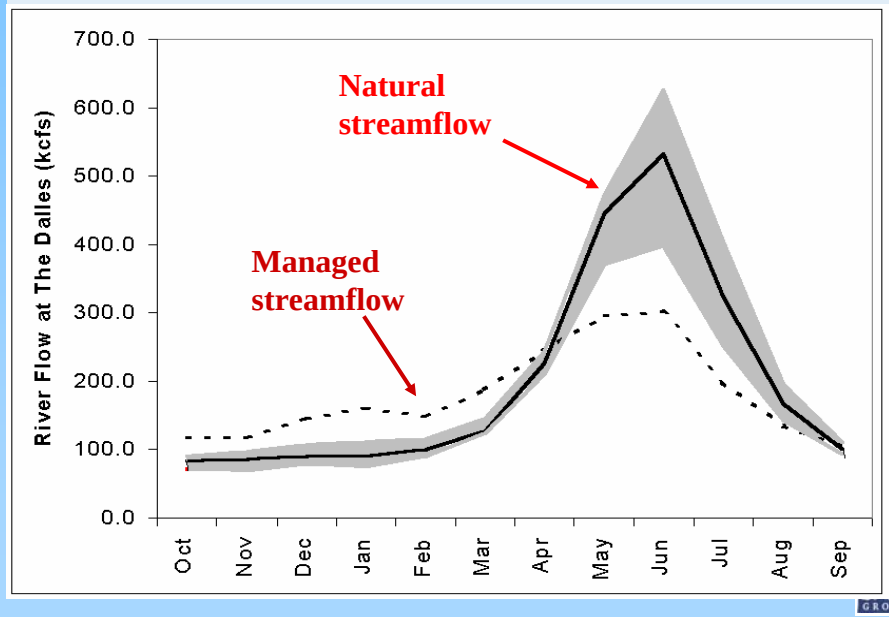


Natural Columbia River flow at the Dalles, OR

- **More water in winter** increases potential for:
  - more hydropower production
  - more winter flooding

Courtesy of Hamlet and Lettenmaier, UW Civil Engineering

The Columbia Basin Hydrosystem

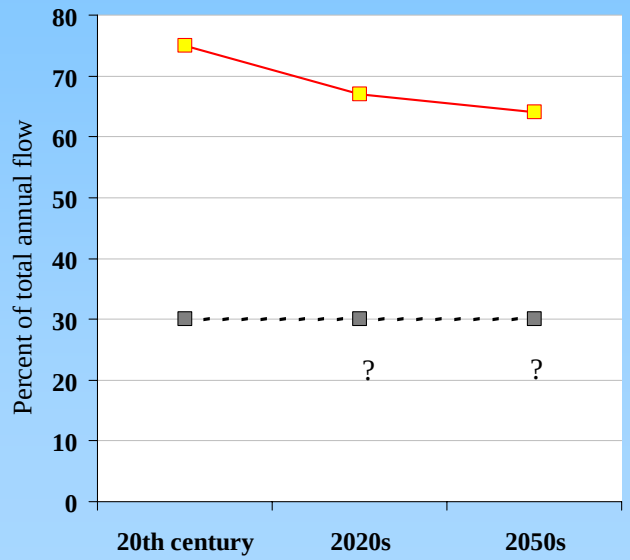


Timing of Migration (Juveniles and Adults) for select groups of PNW salmon (mid-to-upper Columbia and Snake River stocks) (Weitkamp et al. 1995; Busby et al. 1996; Myers et al. 1998).

Evolutionarily Significant Units (ESU's)	Juveniles (smolts): Typical Timing of Outmigration (age)	Adults: Typical Timing of Inmigration
Snake River Spring/Summer Chinook	April-June (1 year)	April-June
Upper and Mid-Columbia River Spring Chinook	April - June (1 year)	April - June
Upper Columbia River Summer and Fall Chinook (Hanford Reach)	Spring to fall (few weeks to months)	August - September
Sockeyes	Spring (April - June) (1-2 years)	May - July
Oregon Coast and Columbia River/ Southwest Washington Coho[a] ESUs (Very large hatchery production in each case)	Spring (March - June) (1 year)	Late summer/fall/winter
Middle Columbia, Upper Columbia, and Snake River Summer Steelhead ESUs	(2-3 years)	October – April
Chum	Late summer/fall/winter (few hours to few weeks)	July - August October - December

[a] Extinct in upper river.

Storage of Columbia River Water



Reservoir capacity only **30%** of current total annual streamflow

The Problem: The System is Already Taxed

Increasing Scarcity and Conflict
2000-2020

- **Little or no room for growth in supply for the Columbia River and much of the PNW**. Patterns of year-to-year and decade-to-decade climate variability may exacerbate or ameliorate potential impacts.
- **Level of water scarcity is relatively new.** Demands on water systems are growing, but supplies remain essentially fixed. *Less margin of safety available to cope with the unexpected.*
- ***Region in severe difficulty even if climate doesn't change***
- **Management system inadequate to task, 2000-2020:**
  - Highly fragmented;
  - No one management entity in charge re droughts;
  - Little or no inter-use coordination;
  - Inconsistent standards, re: water quantity and quality across basins;
  - Conflicting management practices: international, federal, states, counties, private, tribal lands;
  - Large number of largely uncoordinated planning efforts;
  - No official incorporation of climate change scenarios in planning.

Policy Hurdles

- Increasing intensity to trade-off conflicts:
  - East Side trade-offs - Hydro/Fish/Agriculture
  - West Side trade-offs – Municipal & Industrial/Hydro/Fish
  - East Side vs. West Side conflict
- Heavy emphasis on State sovereignty
- Differences Idaho vs. Oregon & Washington
  - *re: application of Prior Appropriation rule.*

Policy Hurdles (cont'd)

- System is top-down. Technical level cannot determine own planning scenarios.
- System currently includes only population growth & ESA applications in long term planning. [Slowly moving towards including CC scenarios & effects].
- Policy level in 2001 said they unlikely to face up to climate change challenge without leadership from white House & U.S. Congress (i.e., system is top-down for them too). Situation now changed--Western & Eastern states out in front.

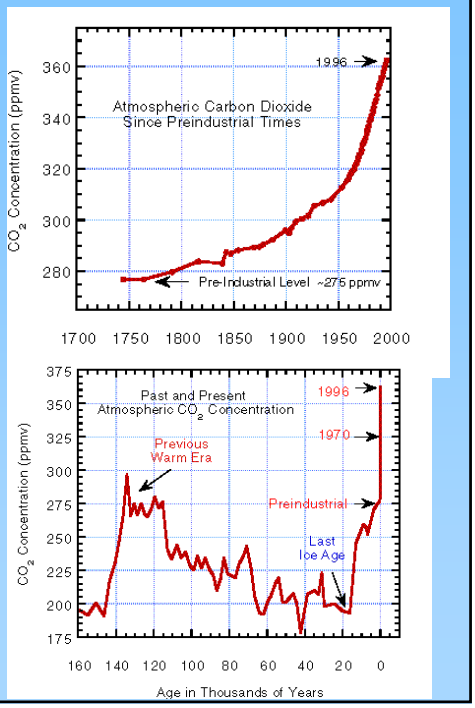
What Are the Principal Vulnerabilities & How Much Risk is Acceptable?

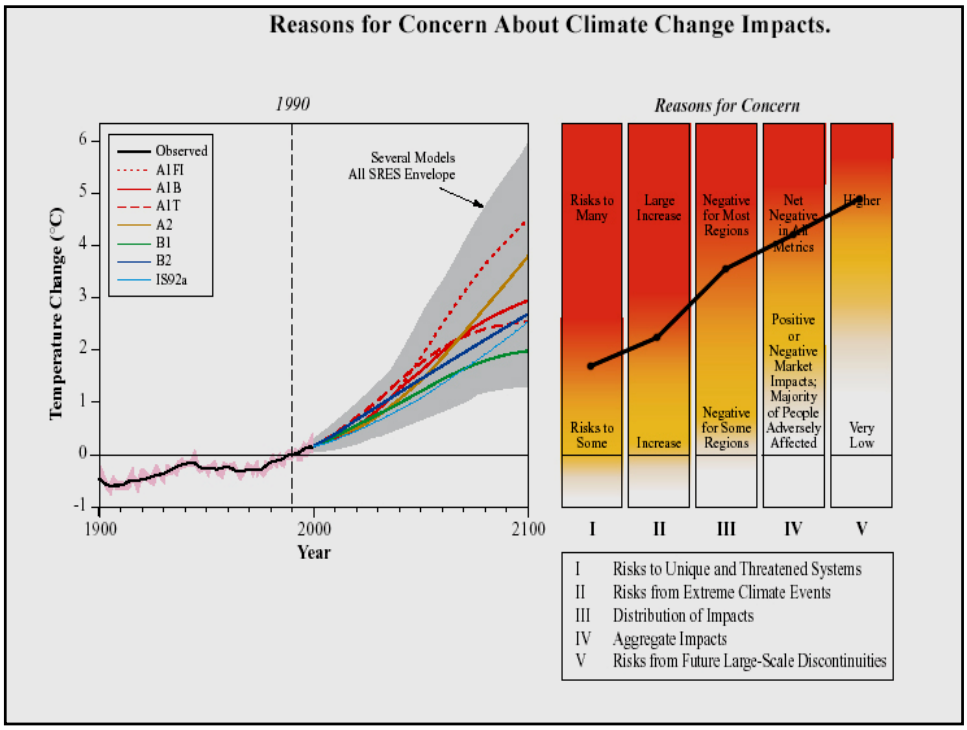
Type of Risk, 2020's

	Type	Magnitude	Probability
1	Increased flooding West-side unmanaged rivers	Limited in area & severity	High
2	4-6 weeks additional summer drought	Severe East-side re: ag. & fish	High
		M&I implications (?)	?
		Supply & quality problems re: M&I and fish West-side (?)	Med. (?)
3	Increased frequency/intensity forest fires & pest infestations	Region-wide. Severe.	High
4	Increased frequency multi-year drought El Niño/PDO in phase	Region-wide. Very severe.	Med.-High (?)
5	Increased coastal erosion/inundation combined effect sea level rise & increased intensity winter storms, esp. El Niño years.	WA/OR coastal regions	High

Humans are altering atmospheric composition

- carbon dioxide concentration has increased by ~32%
- the carbon budget: nature has absorbed roughly half our emissions
- there is no question that the increase is unnatural
- from a very long term perspective, these changes are enormous





Type of Risk, 2050's

	Type	Magnitude	Probability
1	Flooding (West-side unmanaged rivers)	Limited in area. Severity?	High
2	Summer drought	Severe East-side re: ag. & fish. Tight M&I constraints (?)	Very High
		Severe West-side M&I/fish	Very High
		Severity accentuated by population growth/development	
3	Forest fires & pests	Very large region-wide	Very High
4	Multi-year droughts	Increased severity region (?)	High (?)
5	Coastal erosion/inundation	Increased erosion rate & severity (?)	High (?)

What is the Most Severe Regional Vulnerability to Warming?

Historical Patterns of Multi-Year Drought

- 2 mega-droughts in last 250 yrs (Gedalof,, Peterson, & Mantua, 2005): 1840's, duration 12 yrs; 1930's [the "Dust Bowl" years], duration 9 yrs.(?) Flows at least 20% below long term average.
- 4 shorter period events (3-5 yrs) 1775, 1805, 1890, 1925.

On the Frequency of Multi-Year Drought

- 20th century evidence shows that 5 of 6 multiyear droughts occurred when El Niño in phase with warm phase PDO (Gray, 1999).
- 1 event when La Niña in phase with warm phase PDO-- so latter by itself able to generate multiyear droughts.
- Will global warming increase frequency of El Niño's and thereby the frequency of multiyear drought in warm phase PDO regimes??

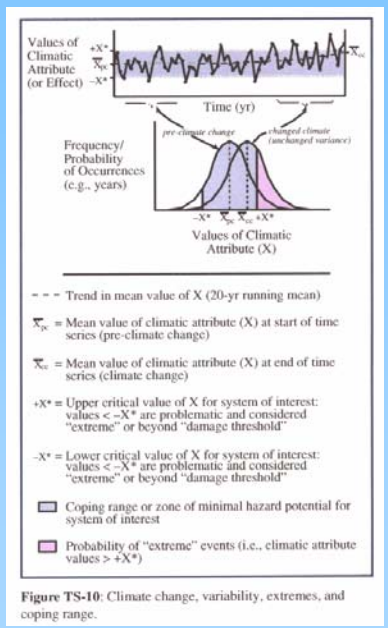


Figure TS-10: Climate change, variability, extremes, and coping range.

What Are Regional Response Capacities to the Challenges Presented, 2000-2020?

What Options Are There for "Buying Insurance"?

- Seek flexibility and efficiency of water resource system as a whole--change rule curves.
- Consider regionalizing approaches already adopted by Idaho:

  --joint reservoir mgmt. Merge Fed., State, & private ownership extending domain to entire basin.

  --Create mechanism to determine natural flow/storage right allocations for entire basin.

  --Facilitate collab. between private rts. holders, Feds., States & power cos. via water banking & rental pools.

  --Move toward conjunctive mgmt. of surface & groundwater.

  --Control growth in demand via regs. & incentives.

"Buying Insurance", cont'd.

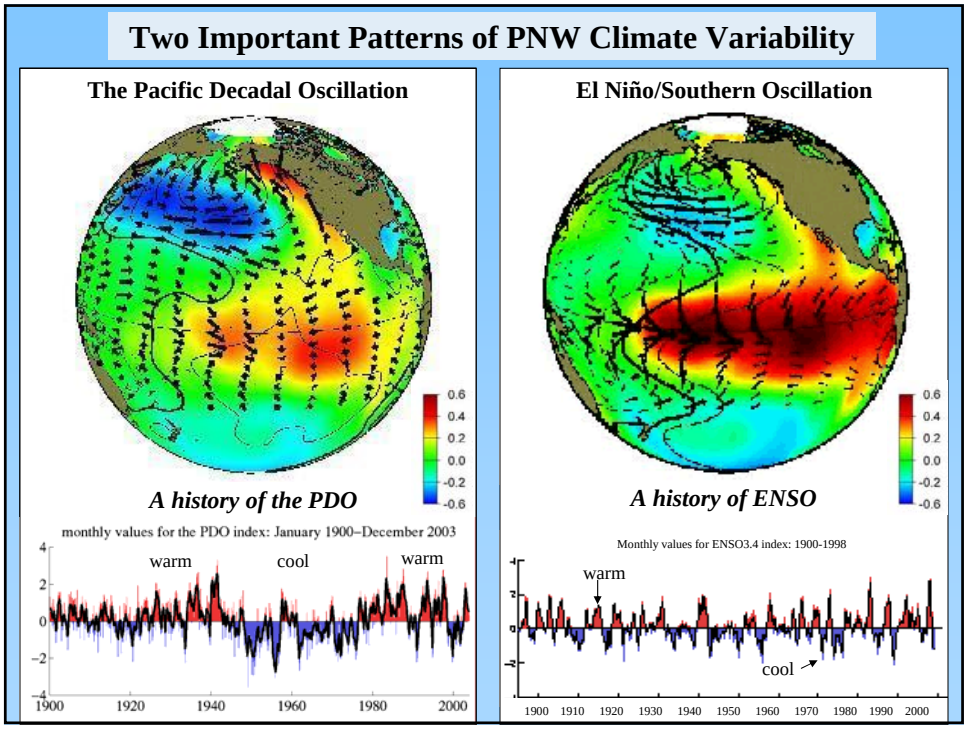
Need to:

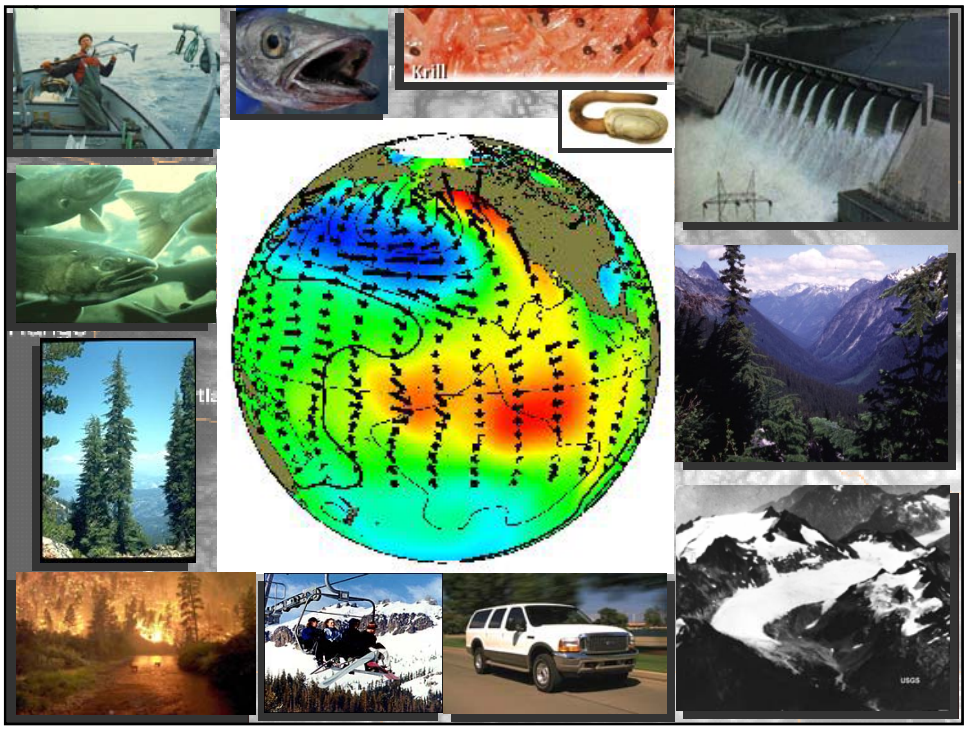
- Consider the probability & direction of regional climate change (more rain, less snow, increased summer droughts in face of higher demand) as a problem in ***risk management.***
- Direct U.S. Army Corps of Engineers to consider scenarios of regional climate change in its long-range plans as the Corps revises its operations manual for the Columbia River.
- Support development and maintenance of a comprehensive regional climate monitoring system.
- Push for a regional/federal discussion re policy dimensions of climate change & water resources.

What Response Capacity Adjustments/Innovations Likely to be Required, 2030-2050?

Vulnerability & Resilience in Post-2020 world

- High probability for regime shift in PDO to warm phase? Not only less snowpack but less P. on decadal scale.
- Increased vulnerability of threatened ecosystems as result of increasing T. and human pop. growth in PNW?
- Severe increases in distributional social conflict as result of declining water supply, now inclu. West side?


Two Important Patterns of PNW Climate Variability
The Pacific Decadal Oscillation
El Niño/Southern Oscillation
0.6
0.4
0.2
0.0
-0.2
-0.6
A history of the PDO
A history of ENSO
monthly values for the PDO index: January 1900–December 2003
warm
cool
warm
4
2
0
−2
−4
1900
1920
1940
1960
1980
2000
Monthly values for ENSO3.4 index: 1900-1998
warm
cool
1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000

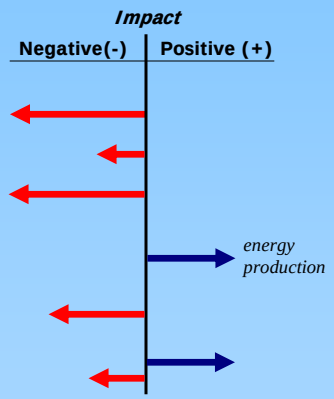

Krill

Impacts of Climate Change on the PNW

Highest confidence

Models: warmer; higher snow line

- summer water supply, drought
- increased demand for water
- conflicts over water resources
- winter streamflow increases in snowmelt-driven basins
- salmon freshwater survival
- reduced energy demand for winter heating, increased demand for summer air conditioning

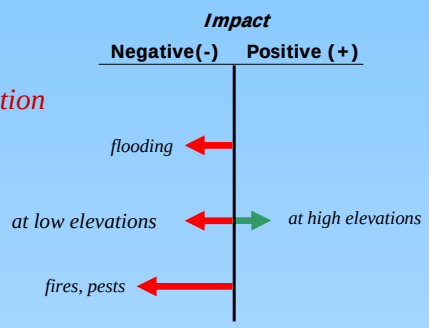


Impacts of climate change on the PNW (cont'd)

Medium confidence, greater uncertainty

Models: higher winter precipitation

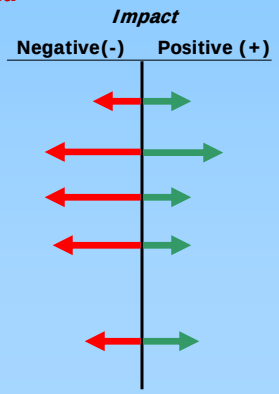
- increased winter runoff
- forest growth and seedling establishment
- forest disturbance



Impacts of climate change on the PNW (cont'd)

Large uncertainty:

Total and summer precipitation, changes in variability, coastal winds and currents



- annual streamflow changes
- forest area
- salmon ocean survival
- coastal ecosystems, poleward range extensions
- human health (diseases, air quality)

West Coast Governors' Initiative on Climate Change

- Research on the impacts of climate change lead to first-ever joint Washington-Oregon-California mitigation initiative in 2003
- Oregon science/policy climate change advisory committee established January 2004 as part of initiative

Washington State Governor Gary Locke, 1 October 2003:

"Climate change is one of the most serious environmental issues facing our planet today… I believe that it is important for us as a state and region to reduce our contribution to the emission of global warming gases. Last week, Governors Davis, Kulongoski and I committed our states to work jointly to reduce global warming gases…"

Planning for Climate Change

1995:

Few managers

- – Saw a role for climate information in planning & decision making
- – Recognized predictability of climate (variability or change)
- –Possessed a contextual framework for applying climate change information

1997:

- First regional-scale examination of climate change impacts on PNW
- Most stakeholders unfamiliar with potential impacts of climate change & unprepared to use this type of information
- Spatial scale of interest << scale of analysis

1997-2001:

- Increasingly focused climate change research
- Intensive region-wide outreach
- **Shift in attitudes:** widespread official recognition of regional water resources systems' lack of capacity to meet present & anticipated future demands even without climate change!
- Out in front: Portland & Seattle

Planning for Climate Change (cont'd)

2001 high level water policy workshop:

- Climate change = potentially significant threat to regional water resources
- Climate change information = critical to future planning
- Significant step forward!

Stakeholders requested:

- Climate change information for use in existing planning models
- Case studies of incorporating climate change projections into basin planning

Requirements of climate change information:

- more detailed, small scale information (catchment, watershed)
- must be "easy to apply to the problem at hand"

Water Resource Impacts: A Major Policy Lever for Change

- Widespread official recognition of the lack of capacity of regional water resources system to meet present and anticipated future demands even without climate change!

Washington State Governor Gary Locke, 19 November 2002:

"Will global climate changes make water shortages a regular fact of life for our state? There is evidence…that our state's climate is changing. What if the summer becomes the norm for us, over time? **Can we adequately prepare for such a fundamental change in our state?"**