Climate Impacts on Pacific Northwest Water Resources

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Mountain snowpack is the key to understanding Pacific Northwest (PNW) water resources. In most PNW river basins, especially in Washington and Oregon, snow - rather than man-made reservoirs - is the dominant form of water storage, storing water from the winter (when most precipitation falls) and releasing it in spring and early summer, when economic, environmental, and recreational demands for water throughout the region are greatest. Climatic variations and changes that influence spring snowpack, therefore, can have a significant impact on water resource availability in the PNW.

Impacts of Climate Variability

The amount of snow that collects in the mountains is sensitive to both precipitation and temperature. Dry winter weather and warm spring temperatures - a more common occurrence during warm phase El Niño/Southern Oscillation (ENSO) events or a warm phase Pacific Decadal Oscillation (PDO) - lead to lower springtime snowpack and streamflow during spring and summer in snowmelt-driven rivers. As a result, flooding is less likely and drought more likely, during warm phase ENSO (El Niño) and PDO.

The opposite is true for cool phase ENSO (La Niña) and PDO. PNW winters tend to be cooler and wetter during cool phase ENSO and PDO, resulting in higher than average winter snowpack and spring and summer streamflow in snowmelt-driven rivers. ENSO and PDO can also act in combination, with the largest changes observed when the two are "in-phase," i.e., El Niño combined with warm PDO or La Niña combined with cool PDO. These features are evident in Figures 1 and 2.

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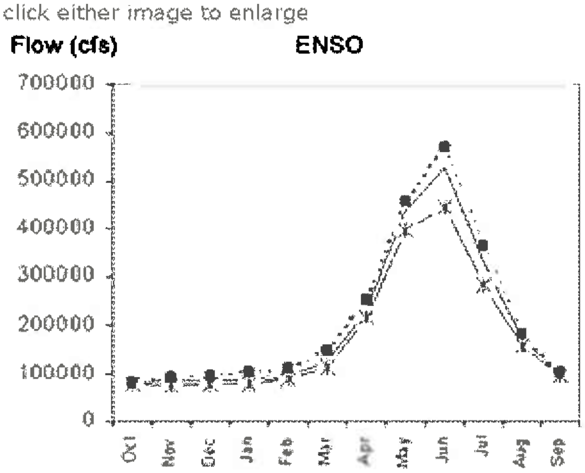

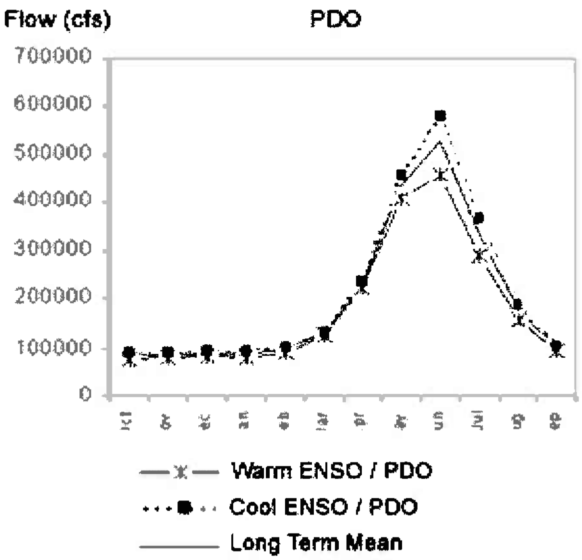

Figures 1 & 2 Effects of ENSO and PDO on Columbia River Flows at The Dalles.

Seasonal climate forecasting has contributed to the development of improved seasonal streamflow forecasting for snowmelt-driven rivers. Using seasonal streamflow forecasts could increase regional hydropower production, improve flood control, and improve instream flow conditions for fish. It is important to note, however, that considerable year-to-year variability still exists, even within categories of ENSO and PDO conditions (Figure 3).

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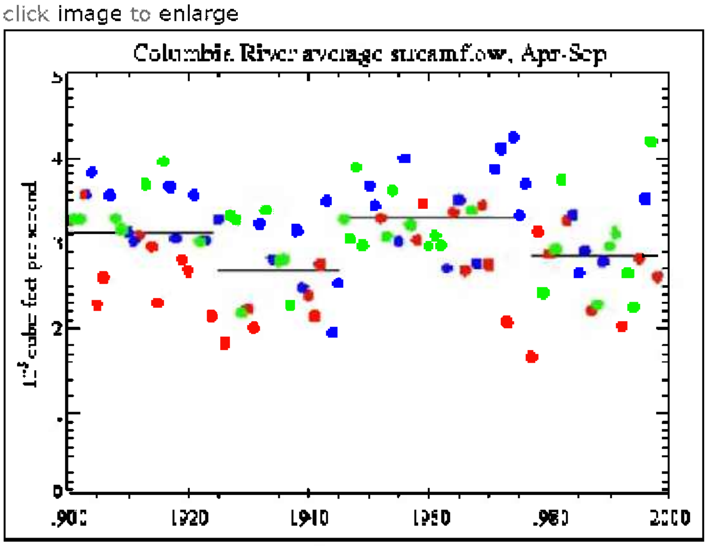

Figure 3 The impact of ENSO and PDO on Columbia River summer streamflow at The Dalles, Oregon for 1900-1999. The horizontal lines show average streamflow over each of the PDO epochs (cool: 1900-1925, warm: 1925-1945, cool: 1945-1977, warm: 1977-1995). The red dots are El Niño years, the blue dots are La Niña years, and the green dots are ENSO neutral years. The figure shows "naturalized" streamflow (i.e., with the effects of the dams numerically removed) for April-September of each year.

Climate Change Impacts

In a future, warmer world, warmer temperatures will result in more winter precipitation falling as rain rather than snow throughout much of the PNW, particularly in mid-elevation basins where average winter temperatures are near freezing. This change will result in:

- less winter snow accumulation,
- higher winter streamflows,
- earlier spring snowmelt,
- earlier peak spring streamflow, and
- lower summer streamflows (Figure 3)

in rivers that depend on snowmelt (i.e., most rivers in the PNW). Such trends have already been observed. Substantial reductions in summer streamflow, which will emerge in coming decades, will adversely affect many water users, including farmers who rely on irrigation, resident and anadromous fish, and summertime hydropower production (Figure 4). These changes are likely to increase existing conflicts among these competing water users, as will projected increases in regional population.

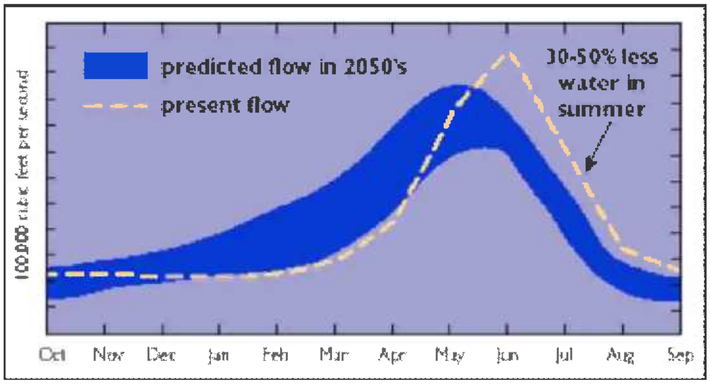

Figure 3 Naturalized Columbia River streamflow at The Dalles (dashed) and in 2050, as simulated by several climate models. The blue band indicates the upper and lower bounds of projected average streamflow in the 2050s. Note the higher winter flows, reduced spring/summer flows, and the shift in the timing of peak spring flows earlier into the spring season. The effects of the Columbia River dams on streamflow have been removed.

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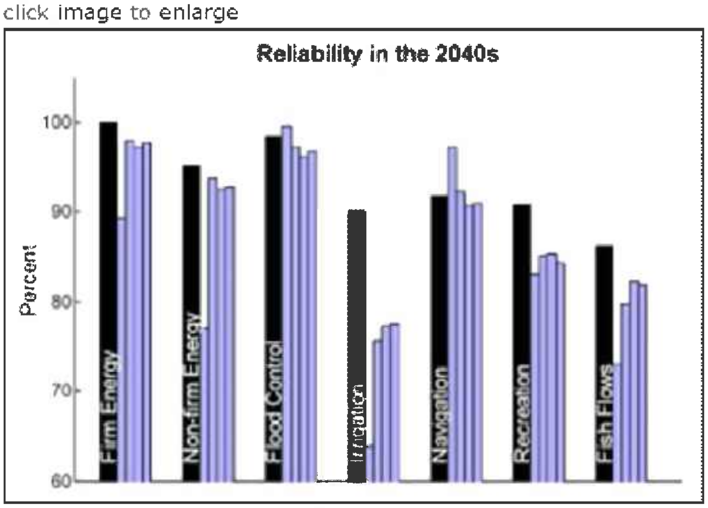

Figure 4 Reliability of Columbia Basin water resources

compared to current, given the current water resources operating system. The black bar shows the simulated present-day reliability of each management objective, while the green bars show the reliability under the four climate change scenarios. Reliability is defined as the modeled (or observed) probability of meeting a particular objective. For example, an objective with 90% reliability will be met in 90% of the months of the simulation. The four scenarios were derived from the global climate models ECHAM4, HadCM2, HadCM3, and PCM3.

Urban water supply systems that rely at least partially on storage of water in mountain snowpack will see diminished inflow to their reservoirs in late spring/early summer. This will be combined with an increased demand for water caused by higher temperatures. For some systems, these impacts will be substantial. For Portland, Oregon, the increased need for water due to climate change will amount to 50% of that required to meet the needs of a growing population (Figure 5, Palmer and Hahn 2002).

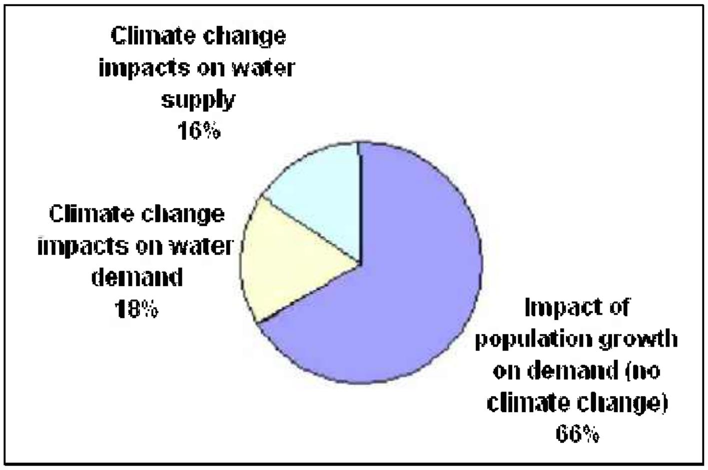

Figure 5 Impacts of 2040 climate change and regional growth on the Bull Run Watershed. In a research partnership with the City of Portland (Oregon), CIG researchers used four global climate models to analyze the impacts of climate change in 2040 on the City's Bull Run watershed. The study found that while population growth has the largest impact on future water supply needs, the additional impact of climate change on supply and demand by 2040 is considerable. Climate change would increase supply needs by 50% of the amount required to meet population growth alone.

For More Information

- More information about CIG's research on climate and PNW water resources
- Planning for climate variability and change
- An overview of the hydrology of PNW rivers
- More details about climate change impacts on different types of river basins

Selected References

For more publications on climate impacts on PNW water resources, please see CIG Publications.

Gamble, J. L., J. Furlow, A. K. Snover, A. F. Hamlet, B. J. Morehouse, H. Hartmann, and T. Pagano. (in press). Assessing the impact of climate variability and change on regional water resources: The implications for stakeholders. To appear in *AGU Monograph*.

Hamlet, A. F. 2001. Effects of climate change on water resources in the Pacific Northwest: Impacts and policy implications. Preparatory White Paper for Climate and Water Policy Meeting, Skamania, Washington, July 2001. Climate Impacts Group, University of Washington, Seattle. 16 pp.

Hamlet, A.F. and D.P. Lettenmaier. 1999. Effects of Climate Change on Hydrology and Water Resources in the Columbia River Basin. *Journal of the American Water Resources Association* 35(6):1597-1623.

Miles, E.L., A.K. Snover, A.F. Hamlet, B. Callahan, and D.L. Fluharty. 2000. Pacific Northwest Regional Assessment: The impacts of climate variability and climate change on the water resources of the Columbia River Basin. *Journal of the American Water Resources Association* 36(2):399-420.

Palmer, R.N. and M. Hahn. 2002. The Impacts of Climate Change on Portland's Water Supply: An Investigation of Potential Hydrologic and Management Impacts on the Bull Run System. Report prepared for the Portland Water Bureau, University of Washington, Seattle. 67 pp.

Snover, A. K., A. F. Hamlet, and D. P. Lettenmaier. 2003. Climate Change scenarios for water planning studies: Pilot applications in the Pacific Northwest. *Bulletin of the American Meteorological Society* 84(11):1513-1518.

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