Climate Change impacts in the Pacific Northwest
Observed Changes
Pacific Northwest average annual temperature has increased more than 2°F since 1895.
The average year in the NW is 1.5°F warmer than during the first half of the 20th century.
The coldest day of the year is 4.78°F warmer
The frost-free season is 16 days longer
WA Cascades snowpack decreased ~ 25% between the mid-20th century and 2006.

Source: Stoelinga et al. 2009; Mote et al. 2008
Peak streamflow from snowmelt is occurring up to 20 days earlier (1948-2002) in the Northwest

Source: Snover et al. 2013
The number of large fires and area burned in the Northwest increased from 1973 to 2012

Source: Westerling 2016
In the 2050s, Washington state is projected to see warming of

- High emissions (RCP 8.5)
  - +5.8°F (3.1-8.5°F)
- Low emissions (RCP 4.5)
  - +4.3°F (2.0-6.7°F)

(Relative to 1950-1999)
More Intense Heavy Rains

Heaviest rain events (top 1% daily) are projected to become +22% more intense (range: +5 to +34%) by the 2080s.
Our primary mechanism for storing water – snow – is sensitive to warming.

The Cascade and Olympic Mountains have the highest fraction of “warm snow” (snow falling between 27-32°F) in the continental U.S. (Mote et al. 2008)
April 1 Snow Water Equivalent

Historical

<table>
<thead>
<tr>
<th>Historical</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 5 cm</td>
<td>-100% to -75%</td>
</tr>
<tr>
<td>5 to 15 cm</td>
<td>-75% to -62.5%</td>
</tr>
<tr>
<td>15 to 35 cm</td>
<td>-62.5% to -50%</td>
</tr>
<tr>
<td>35 to 70 cm</td>
<td>-50% to -37.5%</td>
</tr>
<tr>
<td>70 to 250 cm</td>
<td>-37.5% to -25%</td>
</tr>
<tr>
<td></td>
<td>-25% to 0%</td>
</tr>
</tbody>
</table>

Elsner et al. 2010
Walla Walla River = -66%
(relative to 1970-99)

April 1 Snow Water Equivalent

Elsner et al. 2010
April 1 Snow Water Equivalent

2080s

Walla Walla River = -89%
(relative to 1970-99)

Elsner et al. 2010
Current v Future Flooding in the Skagit Valley

Explore Potential Flood Impacts in the Lower Skagit Watershed through Modeling Scenarios

About This Project:
This tool compares the current floodplain in the Skagit Watershed (specifically, the regulatory 100-year floodplain as defined by FEMA) with a projected future floodplain based on climate change and sea level rise research. The projected future floodplain is based on research developed by a team of SC2 members and focused on 140 square miles of the Lower Skagit River’s floodplain. The researchers used a hydraulic model of the river channel and floodplain including information on runoff from the upper watershed, potential levee scenarios, and tidal water levels to establish projected flood levels for the 2040s and the 2080s. For more information on the modeling, click on the download link at the top-right hand corner of this.

http://www.skagitclimatescience.org/flood-scenario-map/
Salmon Impacted Across Full Life-Cycle

- Early peak flows
- Floods
- Warm, low streamflow
- Fish spawning in freshwater stream
- Eggs in stream gravel hatch in 1-3 months
- Alevins in stream gravel 1-5 months
- Fry emerge in spring or summer
- Juvenile fish in freshwater a few days to 4 years, depending on species and locality
- Smolt migration to ocean usually in spring or early summer
- Fish spend 1-4 years in ocean
- ???
Increased Wildfire Risk

Area burned by fire in the Columbia River Basin is projected to triple by 2040s
Relative to 1916-2006 median; medium emissions scenario (Littell et al. 2010, 2012)

50% more very high fire danger days on average for WA + OR by 2050s
(with fuels as dry as driest 10th percentile of historical, for RCP 8.5. (Abatzoglou et al.)

Discovery Fire burns near volatile stands of insect-damaged trees. 2009, DNR
Food & Agriculture: Higher summer temperatures (heat stress for crops, livestock, workers); decreased natural summer water availability/increased natural water demand; droughts & floods; crop quality; forest & rangeland fires; smoke; invasive species; broader economic changes

Health & Well-being: Heat, smoke, mental health, infectious/vector-borne disease, hazards (flooding, landslides, fires); water quality

Infrastructure: Physical hazards (heat, fire, flooding, landslides;) reduced efficacy and lifetimes, increasing maintenance costs; impacts on provision of services (transportation, energy, water, communication)

Natural Systems: Shifting species & ecosystems; increased stress on coldwater, cold-, snow-dependent species (wolverine & lynx); changing pests, diseases; invasive species; fire

Tourism, Recreation, Economy: Summer heat, fires & smoke; decreasing snowpack; changing timing of wildland access, species availability; all of the above.
Multiplying Effects: Climate Change Impacts on Water Resources

- Heavier Precipitation
- Declining Snowpack
- Wetter Winters
- Drier Summers
- Wildfire
- Longer Growing Season
Exposure to Climate Change is Just One Component of Vulnerability

https://doi.org/10.1111/cobi.12163
Vulnerability = f(Exposure, Sensitivity, Capacity)

- Area impacted by climate hazard(s)
- Severity of climate hazard(s)
- Location of valuable assets

- Habitat loss with 1°C warming
- Acres of crops lost to spring floods
- Percent of homes within the 100-yr floodplain

- Mobilizable response resources
- Information, skills, & communication
- Institutional & social capital

Adapted from: https://www.nab.vu/climate-change-vulnerability-assessment-greater-port-vila
The Flood of the Snohomish River - Snohomish Wn. 1909

Taken from the SLS&E Bridge
Extreme Precipitation Projections

Projected Changes in Extreme Precipitation

Click a grid cell to see extreme precipitation projections.

Projecting Changes in Extreme Precipitation

Projected Change v Duration: 25-year Event, 2050s

Select x-axis:

- **Duration**
  - Duration is how long a precipitation event lasts (e.g., 1-hour, 6-hours, 24-hours)

- **Return Interval**
  - How common or rare storms of different magnitudes are. A larger return period implies a rarer and larger event.

- **Decade**
  - View projected changes over time for a given event duration and return interval

Return Interval:

- 25-year
- Decade

Download All Data For Grid Cell

Download Figure
Download Chart Data

https://cig.uw.edu/our-work/applied-research/heavy-precip-and-stormwater/
Culverts: How big do they need to be?

https://cig.uw.edu/our-work/decision-support/culvert-phase-2/
## It’s Not Just About Climate Science

<table>
<thead>
<tr>
<th>Information / Context</th>
<th>Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Conceptual model:</td>
<td>Manager</td>
</tr>
<tr>
<td>• Understanding of system</td>
<td>Biologist</td>
</tr>
<tr>
<td>• Sensitivity to climate</td>
<td>Engineer</td>
</tr>
<tr>
<td>2. Climate science:</td>
<td>Climate scientist</td>
</tr>
<tr>
<td>• Climate effects on system</td>
<td></td>
</tr>
<tr>
<td>• Able to simulate?</td>
<td></td>
</tr>
<tr>
<td>• Spatial resolution</td>
<td></td>
</tr>
<tr>
<td>• Temporal scales (variability v. trends)</td>
<td></td>
</tr>
<tr>
<td>3. Decision context:</td>
<td>Policymaker</td>
</tr>
<tr>
<td>• Robust v. most likely</td>
<td>Risk Tolerance</td>
</tr>
<tr>
<td>• Best vs. worst case</td>
<td></td>
</tr>
<tr>
<td>• Time horizon</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Snover et al., Cons. Bio., 2013*
More Intense Heavy Rains

More Water Vapor

No change in Winds

Warner, Mass, Salathé, J Hydromet, 2015