Climate Change Impacts in the Puget Sound Region

Lara Whitely Binder
Climate Impacts Group
College of the Environment | University of Washington

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The UW Climate Impacts Group

Science for climate resilience

Working since 1995 to....

- Produce scientific information that is both useful to and used by decision makers

- Conduct decision-relevant climate research

- Support the interpretation and application of climate science in decision making
We live in a world of embedded expectations about climate
And it is local, county, and state governments that are **on the front line** when problems occur.
Key Climate Impact “Drivers”

Substantial warming
Increasing heavy rainfall
Changes in hydrology (snow, streamflow)
Sea level rise
Changes in ocean conditions

Also: Natural variability, Human responses to changing conditions
Rapid Warming Projected

All scenarios indicate warming in the 21st century. Warming is expected in all seasons.

<table>
<thead>
<tr>
<th>2050s</th>
<th>Low emissions RCP 4.5</th>
<th>High emissions RCP 8.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2040-2069, relative to 1950-1999)</td>
<td>+4.2°F (2.9-5.4°F)</td>
<td>+5.5°F (4.3-7.1°F)</td>
</tr>
</tbody>
</table>

Figure source: Climate Impacts Group; Data source: Downscaled climate projections developed by Abatzoglou and Brown (2011).
Continued Variability in Precipitation

Modest increases in average *annual* precipitation. *Seasonal* patterns are reinforced.

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<td>Low emissions</td>
<td>+4.2% (+0.6% to +12%)</td>
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<tr>
<td>RCP 4.5</td>
<td></td>
</tr>
<tr>
<td>High emissions</td>
<td>+6.9% (-1.9% to +13%)</td>
</tr>
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<td>RCP 8.5</td>
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Figure source: Climate Impacts Group; Data source: Downscaled climate projections developed by Abatzoglou and Brown (2011).
Our heaviest 24-hour rain events are projected to be more intense (+22%) and more frequent (from 2 to 7 days/yr) by the 2080s.
Sea level is projected to rise

<table>
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<tr>
<th>Year</th>
<th>Projected Rise</th>
<th>Range</th>
</tr>
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<tbody>
<tr>
<td>2050</td>
<td>+6 in.</td>
<td>-1.0 to +19 in</td>
</tr>
<tr>
<td>2100</td>
<td>+24 in.</td>
<td>+4 to +56 in</td>
</tr>
</tbody>
</table>

Values for Seattle, from NRC 2012; Photo: Vashon Island, photo: King County
Are these changes in climate big enough to matter?
Snowpack is expected to decline

Projected loss in April 1 snowpack, Puget Sound region:

2050s: -29%
2080s: - 55%

Mauger et al. 2015; results for a moderate (A1B) greenhouse gas scenario, relative to 1970-99
Streamflow is most affected in basins that historically accumulated snow

**Important caveats:**

Naturalized flows (flows without the influence of dams)

*Does not include atmospheric river events (important in rain, mixed rain-and-snow basins)*

Mauger et al. 2015
Higher Winter, Lower Summer Flows – Nisqually River

Source: CMIP3

Flow (cfs)

Month

2040s

Historical
Moderate Emissions (A1B)
Moderate Emissions range (A1B)

2080s

Historical
Moderate Emissions (A1B)
Moderate Emissions range (A1B)
100 year flood flows increase +18% to +55%, on average, by the 2080s in the 12 largest Puget Sound rivers

Nisqually River: +18% (-7 to +58%)

Mauger et al. 2015; results for a moderate (A1B) greenhouse gas scenario, relative to 1970-99
Lower low flows

Minimum summer streamflows decrease -16% to -51%, on average, by the 2080s in the 12 largest Puget Sound rivers

_Nisqually River:_
-27% (-35 to -17%)

Mauger et al. 2015; results for 7Q10 flows for a moderate (A1B) greenhouse gas scenario, relative to 1970-99. Image: Seattle Times, July 2015
Salmon Impacted Across Full Life-Cycle

- Early peak flows
- Floods
- Warm, low streamflow
- Ocean Acidification? Warmer sea surface temps?
- 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
- Timing of migration to spawning grounds depends on species and race
Increasing Risks for West-side Forests

By the 2080s, the area burned by wildfire in Puget Sound is projected to increase by +150 to +1000% (note: difficult to model)

Potential for insect, disease outbreaks exacerbates risk

Relative to 1970-1999, for a low (B1) and moderate (A1b) GHG scenario; Mauger et al. 2015
Sea Level Rise: Low-lying Areas at Risk

[Map of Olympia and Seattle showing flood zones and sea level rise estimates]

**Legend**
- Flooding Depth (ft.)
  - 0 - 0.5
  - 0.5 - 1.0
  - 1.0 - 1.5
  - 1.5 - 2.0
  - 2.0 - 2.5
  - 2.5 - 3.0
  - 3.0 - 3.5
  - 3.5 - 4.0
  - 4.0 - 4.5

**Sea Level Rise Estimates**
- 38" High + Storm
- 25" High
- 13" Medium

- City Limits (Extent of Analysis)
- Streets
  - Local Street
  - Major Street
  - State and Interstate Highway
- Parks
- Waterbodies
Sea Level Rise is More than Inundation

Sea level rise increases storm surge and the risk of:

- flooding,
- erosion,
- habitat loss
- toxics mobilization

These impacts will affect coastal areas long before permanent inundation.
# Changing Flood Risk: Olympia

<table>
<thead>
<tr>
<th>Sea level rise amount</th>
<th>0 inches</th>
<th>+3 inches</th>
<th>+6 inches</th>
<th>+12 inches</th>
<th>+24 inches</th>
<th>+50 inches</th>
</tr>
</thead>
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<tr>
<td>Return frequency for a storm tide reaching the current 100-year flood level</td>
<td>100-yr event</td>
<td>40-yr event</td>
<td>18-yr event</td>
<td>2-yr event</td>
<td>&lt; 1-yr event</td>
<td>&lt;&lt; 1-yr event</td>
</tr>
<tr>
<td>Equivalent annual probability of occurrence</td>
<td>1%</td>
<td>2.5%</td>
<td>5.5%</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
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City of Olympia
What’s Affected?
What are our options for dealing with this reality?
Option 1 – Not recommended!
Mitigation and adaptation are required

Mitigation
Reducing emissions of greenhouse gases

Adaptation
Preparing for and managing the change that occurs as mitigation strategies are implemented.
Why Now?

- Significant climate change impacts are projected, and impacts over the next few decades are virtually certain.

- Decisions with long-term impacts are being made every day. Today’s choices will shape tomorrow’s vulnerabilities.

- Significant time is required to motivate and develop adaptive capacity, and to implement changes.

- Proactive planning is often more effective and less costly than reactive planning, and can provide benefits today.
Who is working on Adaptation in WA?

[Logos of various organizations]
Key Summary Points

• Regional climate is changing and continued rapid change is expected, absent significant reductions in greenhouse gas emissions. Natural variability will also continue.

• Climate change will have important implications for the build and natural environment in the Puget Sound region.

• We have the knowledge, tools, data, and need to start preparing for climate change.
Projecting Future Climate: Greenhouse Gas Emissions Scenarios

Different scenarios result in different climate change projections.

Figure source: van Vuuren 2011