Appendix X - Prioritized Adaptation Strategies

Critical Infrastructure Adaptation Strategies

| CI-1: Update emergency management and response planning to include climate change |
|---|---|---|---|
| Score | Type of Strategy | Lead Group(s) | Opportunities or Concerns |
| 20 | Planning | Emergency Managers | Highly adaptive with very good political support for this strategy |

Key Action Steps:
- Prior to a hazard event, identify lead contacts serving vulnerable populations and coordinate actions to maximize safety and information sharing. Leads can assist and provide support during hazard events.
- Establish a network of “block captains” that can be activated to go door to door to check on the health of high-risk neighbors.
- Work with residents to create a home emergency kit that ensures that all residents have the resources they need to survive during an event. This kit should include back-up medications, rations of food, and secondary communication technologies.
- Help individual households to take their own steps to reduce flooding, such as installing rain barrels and back-up power for sump pumps.
- Expand training and education of health and social services systems/providers to identify and treat mental health problems after extreme climate events.

| CI-2: Reduce inflow and infiltration to wastewater systems |
|---|---|---|---|
| Score | Type of Strategy | Lead Group(s) | Opportunities or Concerns |
| 19.5 | Policy | Operations and Maintenance Dept. | Current issue with high levels of political/social support but also higher costs associated with strategy |

Key Action Steps:
- Identify current inflow and infiltration to wastewater system.
- Draft revised inflow and infiltration standards and meet with stakeholders to review standards.
- Formalize standards and conduct education with key stakeholders to make them aware of key changes and new requirements.
- Enhance funding to accelerate repairs and replacement of critical areas.
## CI-3: Planning updates for sea level rise and flooding

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Planning</td>
<td>Multi-Stakeholder</td>
<td>Medium and long-term issue where planning now can help reduce future costs</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Create a sea level risk district for inclusion in Comprehensive Plan and promulgate new codes and code changes associated with managing for sea level risk.
- Incorporate climate change and coastal hazard considerations into building codes by increasing freeboard requirements to two feet (three feet for critical projects) above the current 100-yr flood plain as buildings are redeveloped, developed, or renovated.
- See targeted Adaptation Action Area in Appendix X for more details.

## CI-4: Built community support through outreach and education on climate adaptation

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Awareness</td>
<td>Multi-Stakeholder</td>
<td>Immediately implementable with low cost but only moderate political support</td>
<td>Ecosystems Water Supplies</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Conduct outreach and education on climate issues and adaptation solutions to build political will to support adaptation. Examples include: Public outreach for opportunities in existing relevant stormwater programs (e.g. rain gardens, cisterns).
- Consider real estate disclosures of climate change risk for residential property owners.
- Establish Community Design Centers to assist property owners in designing and retrofitting infrastructure.

## CI-5: Develop decision making tools related to climate change risks

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Planning</td>
<td>Local Governments</td>
<td>Highly adaptable until tools are developed then hard to change. Strategy moderate/low political support</td>
<td>Ecosystems Water Supplies</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Work with key stakeholders to identify the types of resources, tools, and information they need to make climate-appropriate decisions. For instance, a cost analysis tool that could help the Port guide investment decisions in the face of sea level rise may be a valuable tool to develop.

## CI-6: Critical area flood mapping beyond FEMA’s historical flood data

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Planning</td>
<td>Multi-Stakeholder</td>
<td>Low cost with moderate political feasibility</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Conduct outreach and education on climate issues and adaptation solutions to build political will to support adaptation. Examples include: Public outreach for opportunities in existing relevant stormwater programs (e.g. rain gardens, cisterns).
- Consider real estate disclosures of climate change risk for residential property owners.
- Establish Community Design Centers to assist property owners in designing and retrofitting infrastructure.

## CI-5: Develop decision making tools related to climate change risks

<table>
<thead>
<tr>
<th>Score</th>
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<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Planning</td>
<td>Local Governments</td>
<td>Highly adaptable until tools are developed then hard to change. Strategy moderate/low political support</td>
<td>Ecosystems Water Supplies</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Work with key stakeholders to identify the types of resources, tools, and information they need to make climate-appropriate decisions. For instance, a cost analysis tool that could help the Port guide investment decisions in the face of sea level rise may be a valuable tool to develop.
Key Action Steps:
- Cities and Counties should establish a climate change flood overlay as part of the critical area designations specific to their future flood concerns and use it in addition to the FEMA flood maps which are constrained by only using historical data.
- Conduct education to community and developers about the change.

### CI-7: Soft defenses for shoreline infrastructure

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Policy</td>
<td>Local Governments and Private Sector</td>
<td>Likely a medium/long-term action with high cost with moderate political support. Rated highly for environmental benefits.</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Protect and restore natural systems along the shoreline to enhance buffer between coastal storms and development.
- Develop protective green infrastructure in front of the facilities to create a natural buffer to storm surge and flooding.
- Remove hard protection or other barriers to shoreline retreat and replace shoreline armoring with living shoreline protections.
- Adopt soft defense strategies, such as establishing aquatic vegetation beds, using natural or artificial breakwaters and beach nourishment, where appropriate (e.g., sensitive habitats).

### CI-8: Improve on-site stormwater management practices

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Policy</td>
<td>Multi-stakeholder</td>
<td>Adaptable, high cost, and moderate political and social feasibility</td>
<td>Ecosystems Water Supplies</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Create monetary & non-monetary incentives for Stormwater Management or re-use, including within Low Impact Development (LID) projects. Applies to residential, industry, agriculture, and forestry sectors.
- Create pilot projects to demonstrate the value of on-site stormwater management. Examples include green roofs, rain gardens, cisterns, and bioswales.

### CI-9: Participate in FEMA’s Community Rating System (CRS)

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Planning</td>
<td>Multi-stakeholder</td>
<td>Less adaptable, low cost, and with moderate political support</td>
<td></td>
</tr>
</tbody>
</table>

Key Action Steps:
- Dedicate a staff person to learn more about what is involved in participation in the FEMA Community Rating System (CRS - http://www.fema.gov/national-flood-insurance-program-community-rating-system).
• **Explore and if needed, develop** more stringent regulations for homeowners in flood zones, so that the community is eligible for a reduction in insurance rates.
• Implement relevant actions under the CRS to become an official CRS community.

### CI-10: Enhance stormwater retention in upstream areas

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Policy</td>
<td>Multi-stakeholder</td>
<td>Implement over the long term, marginally adaptable, high cost, and marginally politically feasible</td>
<td>Ecosystems Water Supplies</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Review other community policies aimed at stormwater retention.
- Draft and pass policy that uses conservation of natural ecosystems, enhance riparian buffers and land management to increase stormwater retention.

### CI-11: Install tide gates, “duckbill” valves for stormwater outfall infrastructure

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.5</td>
<td>Policy</td>
<td>Operation and Maintenance Departments</td>
<td>Less adaptive, moderate cost, near term implementation, and good political feasibility</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Work with operation and maintenance departments to secure funding (if needed) and install Duckbill valves, which seal a pipe end but still allow water to drain, in order to reduce flooding.

### CI-12: Retrofit infrastructure for coastal flooding and sea level rise

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.5</td>
<td>Policy</td>
<td>Local Governments and Private Sector</td>
<td>Long-term implementation timeframe, moderate cost, with good political support</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Retrofit existing infrastructure to deal with sea level rise (elevate buildings, etc.).
- Downtown Port Townsend will need a new underground water removal system, but in the long term may have to add fill to underground.
- Elevate and seal utilities.

### CI-13: Require education/training/monitoring for homeowners with septic systems

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Awareness</td>
<td>Local Governments</td>
<td>Highly adaptive, low cost, low political support</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Increase monitoring and enforcement for failing septic systems.
• Educate homeowners on options for re-engineering septic systems.

### CI-14: Hard shoreline protection

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Policy</td>
<td>Local Governments and Private Sector</td>
<td>Less adaptable, high cost, and with moderate political support to be implemented over the long term. Ranked very low on environmental benefit due to negative impacts on nearshore habitat.</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Identify locations where hard armoring makes sense. Key types of hard armoring include reinforced rock walls, rip-rap, and other shoreline protection, including seawalls. This strategy is likely cost effective for critical infrastructure, high value assets, or some urban areas. However, it was ranked very low for environmental benefit due to negative impacts on nearshore habitat such as beach scouring, limits to migration for nearshore habitat.
- Secure funding to install hard shoreline protections and conduct all relevant regulatory and environmental reviews.
- Implement and monitor the success of the hard shoreline protection features.

### CI-15: Develop inverted block rate structure for water and sewer

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Policy</td>
<td>Utility Managers</td>
<td>Moderately adaptable, moderate cost, and very little political support</td>
<td>Water Supplies</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Develop and implement an inverted block rate structure for water and wastewater use that incentivizes conservation.

### CI-16: Homeowner outreach to encourage relocation outside floodplains

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.5</td>
<td>Awareness</td>
<td>Multi-stakeholder</td>
<td>Less adaptable, extremely low political support</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Create and distribute educational materials about the risk of living in vulnerable areas such as floodplains.
- Explore creative financing programs or cheaper insurance structures to help incentivize residents to move out of vulnerable areas.
### CI-17: Relocation of infrastructure outside of coastal flood zone

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Policy</td>
<td>Local Governments and Private Sector</td>
<td>Very long term, high cost, and very difficult to achieve politically</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**

- Create redevelopment restrictions, incentives for retreat, and building code changes with enhanced enforcement to move infrastructure from vulnerable locations.
- Determine if it is best to relocate, raise, seal or abandon any infrastructure that will sustain damage by inundation.

### CI-18: Relocate Port Townsend municipal wastewater treatment plant

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Policy</td>
<td>City of Port Townsend</td>
<td>Long-term strategy, high cost, and moderate political feasibility</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**

- While the location where the wastewater treatment plant is located is not likely to be subject to flooding until near the end of the century, the plant itself will eventually need to be repaired or replaced and this is the most cost effective time to plan for and incorporate future projections of sea level rise and changes to the coastal flood risk for the area where the plant will be located. As such, any redevelopment designs for the plant should include projections of future climate change, including sea level rise.

### CI-19: Adopt new flood risk management standards and guidelines

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Scored</td>
<td>Planning</td>
<td>Multi-stakeholder</td>
<td>Mirrors current guidance to federal agencies</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**

- Identify appropriate flood risk acceptance and develop supporting standards and guidelines. Three options include:
  - **Informed Science Approach:** Use the best available climate science data to determine future flood conditions, and elevate structures above that future flood level.
  - **Freeboard Value Approach:** Elevate structures and facilities two feet for standard projects and three feet for critical projects above the 100-year flood level.
  - **500-Year Elevation Approach:** Elevate structures to the 500-year flood level (a flood with a 0.2 percent chance of occurring in any given year).
## CI-20: Install pumps for stormwater outfalls subject to sea level rise

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Scored</td>
<td>Policy</td>
<td>Operation and Maintenance Dept.</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Identify locations where pumps would be viable. Note that pumping would address limitations of tide gates over the long term.

## CI-21: Renovate Clallam Bay/Sekiu wastewater treatment plant

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Scored</td>
<td>Policy</td>
<td>Local Gov</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Identify desired approach - rebuild two plants, interconnect two plants, or build a pump station to the prison. Determine if it is feasible to pump sewage to the prison treatment plant if needed.
- Seek funding for desired approach. Note that system serves economically distressed community so may have adaptation funds available; some funding is potentially already available.

## CI-22: Renovate Elwha lowlands vacuum sewer system

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Scored</td>
<td>Policy</td>
<td>Tribal Gov</td>
<td>Location in lowlands means moving system uphill is probably the central option since the Tribe has upland properties that may be suitable.</td>
<td></td>
</tr>
</tbody>
</table>
Ecosystems

E-1: Encourage breeding and planting of drought tolerant, climate adapted, resilient plant species

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Awareness</td>
<td>Agricultural/Forestry Sectors, Educational Organizations</td>
<td><em>Highly adaptive, feasible, in line with political and social goals</em></td>
<td><em>Water Supplies</em></td>
</tr>
</tbody>
</table>

Key Action Steps:
- Identify most drought tolerant, climate adapted, resilient plant species for the region.
- Work with partners to develop and distribute education materials to homeowners, renters, and businesses.

E-2: Incorporate climate change more explicitly into comprehensive plans and Shoreline Master Programs (SMP)

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Planning</td>
<td>County and City Governments</td>
<td>N/A</td>
<td><em>Critical Infrastructure</em></td>
</tr>
</tbody>
</table>

Key Action Steps:
- Research sample language from other regional and national efforts. One example is the San Juan Islands-[http://www.sanjuans.org/documents/Loring_2014_sea_level_rise_regulatory_review.pdf](http://www.sanjuans.org/documents/Loring_2014_sea_level_rise_regulatory_review.pdf).
- Use best available climate change projections and share relevant information with County and City governments in region.
- See targeted Adaptation Action Area summary in Appendix X for more details.

E-3: Promoted agricultural best management practices

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Awareness</td>
<td>Agricultural Sector, Educational Organizations</td>
<td><em>Highly adaptive, feasible, in line with political and social goals</em></td>
<td><em>Water Supplies</em></td>
</tr>
</tbody>
</table>

Key Action Steps:
- Identify practices most relevant to climate change impacts such as sustaining soil moisture and health, erosion control, conservation irrigation, diversity of crop species, incorporation of efficient water use technologies.
- Develop educational material about best practices and share with those in agricultural sector.
### E-4: Update municipal codes for enhanced fire risk at forest/residential interface

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Policy</td>
<td>Local Governments</td>
<td>Highly adaptive, feasible, in line with political and social goals</td>
<td>Critical Infrastructure</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Use education, incentives, and building codes to minimize fire risk, particularly in forest/residential interface.
- Enforce set-backs on building permits in forested areas.

### E-5: Increase regional capacity for water storage (preferably with natural systems)

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Planning</td>
<td>Multi-stakeholder</td>
<td>High need for additional capacity but facing numerous political barriers</td>
<td>Water Supplies</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Create water storage and usage options at all scales (recharge, mitigation, irrigation).
- Leverage natural systems where possible (wetlands, rainwater collection).
- Explore innovative technologies for water storage (e.g., bladders, engineered wetlands).

### E-6: Encourage FEMA to incorporate climate change in rate maps and guidance

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Planning</td>
<td>State and County Governments</td>
<td>A way to incentivize adaptive measures taken by homeowners in the face of climate change, though FEMA's processes for updates are lengthy and slow.</td>
<td>Critical Infrastructure</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Update scope of flood maps to reflect changing risk associated with climate change (e.g. revisions to frequency of 100 year flood events).
- Update rate maps to reflect areas of continued or emerging risk to flooding under climate change.
- Hold workshop or training to educate residents and businesses on changes.

### E-7: Develop graphical tool to illustrate climate impacts

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.5</td>
<td>Planning</td>
<td>Multi-stakeholder</td>
<td>Complexity will depend on the approach and type of impact modeled</td>
<td>Water Supplies Critical Infrastructure</td>
</tr>
</tbody>
</table>
Key Action Steps:
- Work with key stakeholders to understand their needs and desires for a graphical tool. Consider applying existing graphical models (e.g. sea level rise) to areas of interest. Alternatively, could devise new combinations of models to graphically demonstrate climate impacts.
- Secure funding, if needed, to create tool.

**E-8: Update financing policies for development in high risk areas**

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Policy</td>
<td>Banks and Insurance Groups</td>
<td><em>This action would remedy an inappropriate incentive to build in high-risk areas, though political support would be difficult.</em></td>
<td>Critical Infrastructure</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Work with banks to remove mortgage subsidies (e.g. loans) for areas with high climate change impact risk.
- Work with insurance industry to realistically incorporate risk into the future policies and remove subsidies.
- Educate homeowners about the changes.

**E-9: Incentivize use of native plants in landscaping**

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Awareness, Policy</td>
<td>Local Governments and Private Sector</td>
<td><em>Very feasible, low cost</em></td>
<td>Water Supplies</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Develop financial, regulatory, or other incentive program to promote greater use of native plants at homes and at industrial/commercial sites.
- Integrate regulations requiring the use of native plant use into building codes.
- Provide incentives for removing lawns and invasive species and replacing them with native plans.
- Work with local nurseries to ensure they are stocking more native plants.

**E-10: Utilize low cost citizen science monitoring and analysis technologies**

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Awareness</td>
<td>Research Institutions and Citizen Scientists</td>
<td><em>Highly adaptive, feasible, and in line with political and social goals.</em></td>
<td></td>
</tr>
</tbody>
</table>
invasive/migrating fish species, monitored through trace DNA molecular analysis of seawater collected by citizen scientists.

### E-11: Increase funding for harmful algae bloom monitoring

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.5</td>
<td>Awareness</td>
<td>Public Health Departments and Research Institutions</td>
<td><em>Highly adaptive and feasible</em></td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Work to identify or develop environmental predictors of harmful algal blooms.
- Enhance public health engagement involving beach closures and response to biotoxin events.

### E-12: Complete survey of sensitive submerged habitats and the species that utilize them

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.5</td>
<td>Awareness</td>
<td>Research Institutions, Citizen Scientists</td>
<td><em>Immediate need, low social/political feasibility, would address the ecosystem wide impacts</em></td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Inventory and monitor submerged habitats that may be affected by rising sea levels and ocean acidification.
- Promote submerged native aquatic vegetation preservation and restoration for management of nutrient loading.
- Identify potential future habitats and protect species using or reliant on the habitat.

### E-13: Restore and develop wildlife corridors

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.5</td>
<td>Planning</td>
<td>Multi-stakeholder</td>
<td><em>Technically feasible, but with unknown cost and political support</em></td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Oversee wildlife corridors (acquire, restore, manage) along floodplains/ riparian buffers to ensure “conductivity” along rivers.
- Create an interconnected network of green spaces to support biodiversity and watershed-based water quality management.
- Acquire and preserve existing vegetated, unprotected areas adjacent to river systems.
## E-14: Strengthen enforcement on illegal shoreline uses

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Policy</td>
<td>City and County Governments</td>
<td>This is an action that is already legally required, the need is to analyze existing enforcement limitations and failures</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Enforce professional license consequences for contractors/developers.
- Remove financial incentives associated with illegal shoreline uses.
- Enforce required real estate disclosures.

## E-15: Restructure rural water and sewer systems

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Planning</td>
<td>Local Governments and Community Groups</td>
<td>Implement over the long term, but politically difficult to accomplish</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Bring additional rural areas on-line to centralized systems.
- Evaluate decentralized sewage treatment in neighborhood clusters to transition users away from individual septic tanks.

## E-16: Develop community climate action plans

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.5</td>
<td>Planning</td>
<td>Local Government and Community Groups</td>
<td>Immediate need, highly adaptable, high political barriers</td>
<td>Water Supplies Critical Infrastructure</td>
</tr>
</tbody>
</table>

- Identify key stakeholders to assist with developing climate action plans, which can be useful tools for planning a municipality’s or organization’s overall strategy for climate change, including reducing greenhouse gas emissions as well as preparing for the impacts of climate change. This climate adaptation plan can help jump start part of this work.
- Secure funding to undertake appropriate planning processes and develop community climate action plans. If funding is not feasible, consider using volunteers (as Port Townsend / Jefferson County did) to complete plans.
- Following this model may help win funding at the state level for additional projects (http://app.leg.wa.gov/rcw/default.aspx?cite=70.235.070).

## E-17: Add climate impact overlays to existing “Critical Areas”

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.5</td>
<td>Planning</td>
<td>City and County Governments</td>
<td>Difficult to devise and implement, but would synthesize a range of climate</td>
<td></td>
</tr>
</tbody>
</table>
Key Action Steps:
- Review current land types for vulnerabilities to climate change (e.g. wetlands or areas in the coastal flood risk zone).
- Devise new labels for type of land with climate impact overlay.
- Add specific building/protection requirements to enhance resilience.

### E-18: Support and enhance watershed and nearshore habitat restoration

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.5</td>
<td>Policy</td>
<td>Multi-stakeholder</td>
<td>Adaptable and technically feasible with moderate political support and community co-benefits</td>
<td>Water Supplies</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Identify and prioritize sites in need of habitat restoration.
- Create policy to ensure the restoration of key areas.

### E-19: Monitor and analyze climate change impacts at salmon stream restoration sites

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Research and Awareness</td>
<td>Research Institutions and Citizen Scientists, Salmon Recovery Organizations</td>
<td>Highly adaptive, feasible, potentially facing barriers with political and social goals</td>
<td>Research and Awareness</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Identify appropriate research partners.
- Develop research and monitoring protocol that includes the monitoring of variables such as temperature, turbidity, pH, and flows.

### E-20: Decrease non-climate ecosystem stressors

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Awareness</td>
<td>Multi-stakeholders</td>
<td>Immediate management strategy, difficult to implement</td>
<td>Water Supplies</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Identify appropriate actions that other communities have taken.
- Educate residents, businesses, and major landowners about needed changes. Examples of possible changes include decreasing nutrient and pollution inputs to the nearshore environment.
### E-21: Transition away from use of biosolids and industrial fertilizer on agriculture and forestry lands

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.5</td>
<td>Awareness</td>
<td>Agriculture and Forestry Sector</td>
<td>Unknown cost, political barriers</td>
<td>Water Supplies</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Identify alternatives to the use of biosolids and industrial fertilizer.
- Educate agricultural and forestry sectors about alternatives.

### E-22: Designate and prioritize funding for additional land designated for agriculture

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.5</td>
<td>Planning</td>
<td>Multi-stakeholder</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Identify land that could be prioritized for agriculture.
- Identify funding sources that could be used to assist in transitioning land to agriculture use.

### E-23: Develop a funding program appropriate for acquisition of high-risk structures in coastal or riverine flood zones

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Policy</td>
<td>Multi-stakeholder</td>
<td>Long term strategy, high cost benefit opportunities, difficult social and political barriers</td>
<td>Critical Infrastructure</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Identify high-risk structures in coastal and/or riverine flood zones.
- Identify sources of funding, such as FEMA, to purchase high-risk structures for demolition or flood proofing.

### E-24: Create funding mechanism for conservation projects in Clallam County

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Policy</td>
<td>Multi-stakeholder</td>
<td>Unknown overall cost and potentially low political feasibility</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Potentially enact "Conservation Futures Tax", similar to other WA counties.
- Create educational materials to let people know about funding mechanisms.
### E-25: Provide guidance on right “timeline” for erosion buffers period (50, 75, 150 years) and distance (50ft to 200ft) inclusive of climate change projections

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Planning</td>
<td>Local Government and Community Groups</td>
<td>Difficult to implement and enforce socially and politically</td>
<td>Critical Infrastructure</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Compare and contrast existing buffers with range of climate change risk projections.
- Select level of risk planning entity is willing to assume over project lifespan.

### E-26: Integrate climate change projections into salmon hatchery planning

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5</td>
<td>Planning</td>
<td>Salmon Hatchery Managers</td>
<td>Unknown technical feasibility and overall ability to adapt to climate change</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Explore emerging salmon hatchery technologies and management relevant to climate change impacts of high temperature and altered river flows.

### E-27: Identify and monetize environmental services

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Awareness</td>
<td>Research Institutions and Governments</td>
<td>Long term, technically feasible and politically challenging</td>
<td>Water Supplies</td>
</tr>
</tbody>
</table>

**Key Action Steps:**

### E-28: Inventory and then prioritize shoreline and watershed areas appropriate for defense and retreat

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Planning</td>
<td>Research Institutions and Local Government</td>
<td>Implementation over the long term, politically and socially difficult</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Identify key shoreline and watershed areas in need of defense.
- Prioritize areas based on criteria such as need, available funding, political support, and upland assets.
- Research and secure funding for either protection or retreat.
### E-29: Re-energize efforts to reduce stressors to salmon stream habitats

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Scored</td>
<td>Awareness</td>
<td>Multi-stakeholders</td>
<td><em>Existing attention and structure for salmon restoration. Many current stressors to address.</em></td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Organize convening of key stakeholders to discuss stressors and possible solutions to restoring salmon stream habitats. Ongoing stressors include: urbanization, sedimentation and pollution of streams, changes in streamside vegetation, erosion due to land-use practices such as road building and clear cutting, and the draining of wetlands.

### E-30: Incentivize agricultural water conservation

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Scored</td>
<td>Policy</td>
<td>Multi-stakeholder</td>
<td>N/A</td>
<td><em>Water Supplies</em></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Subsidize new on-demand water technologies.
- Encourage drought tolerant crop varieties.

### E-31: Reduce local land-based pollutants that enhance acidification in marine waters

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Scored</td>
<td>Awareness</td>
<td>Multi-stakeholder</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Reductions could be accomplished through strengthening existing local source control programs.

### E-32: Integrate climate change projections into shellfish hatchery planning

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Scored</td>
<td>Planning</td>
<td>Shellfish Hatchery Managers</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Explore emerging shellfish hatchery technologies; hatcheries can treat water, hang matrices of algae and shellfish to improve water quality, and select species for survival under likely changing climate change.
### E-33: Utilize climate sensitive tree species in riparian buffers

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Scored</td>
<td>Policy</td>
<td>Forestry and Conservation Groups</td>
<td>N/A</td>
<td>Water Supplies</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Partnerships with the Olympic National Forest tree orchard could be strengthened to maintain genetic diversity and make climate sensitive tree species publically available.

### E-34: Replace under-sized culverts to anticipate climate influenced run-off events

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Scored</td>
<td>Policy</td>
<td>Operations and Maintenance Departments</td>
<td>N/A</td>
<td>Water Supplies</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Assess existing vulnerable culverts and levels of climate change run-off risk.  
- Select level of risk entity is willing to assume.  
- Design culverts to withstand future projections of change and install at key locations.
## Water Supplies

### WS-1: Enhance education on drought and water supplies issues for the peninsula

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Awareness</td>
<td>Multi-stakeholder</td>
<td>Highly adaptive, feasible, in line with political and social goals, low cost</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Identify and implement appropriate educational activities. Options could include: tour of existing facilities/locations, targeted messaging around conservation, workshops and peer exchange, enhanced research partnerships.

### WS-2: Adopt new regulations requiring water-efficient appliances

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Policy</td>
<td>State Governments</td>
<td>Immediate and technically and politically feasible, but potentially limited ability to influence state regulations</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Work with state legislators to revise regulations.

### WS-3: Promote and incentivize smart irrigation technologies for agriculture

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Awareness</td>
<td>Agriculture Sector</td>
<td>Immediately implementable, high cost, technical and political feasibility</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Develop and distribute educational materials about smart irrigation technologies.
- Consider working with agricultural sector to host education workshop or convening related to water conservation.

### WS-4: Identify monitoring needs and enhance water supply monitoring

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Awareness</td>
<td>Multi-stakeholder</td>
<td>Highly adaptive, feasible, in line with political and social goals, low cost</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Create a data clearinghouse for water information from universities, cities, non-profits, others, and include both information resources and information needs (potential home is the NOPRC).
- When and where it is needed, install additional flow and snowpack sensors.
The data from all of these could be used to identify water storage sites, establish baseline of use and availability, and to enhance system management.

### WS-5: Educate home and business owners on the value of on-site water conservation and retention

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Awareness</td>
<td>Multi-stakeholder</td>
<td><em>Highly adaptive, feasible, in line with community goals, low cost</em></td>
<td>Critical Infrastructure</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Create outreach materials to explain to home and business owners the value of on-site stormwater retention, availability of incentives, and value to the community and ecosystems.
- Educate on the broader issue of the need for water conservation and retention.

### WS-6: Complete study on ways to enhance water storage and groundwater recharge

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Planning</td>
<td>Water Utilities and Local Governments</td>
<td><em>Highly adaptive, feasible, in line with political and social goals, low cost</em></td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Consider enlarging existing storage and identify locations for new structures.
- Identify off stream storage including conveyance, groundwater infiltration rates, and potential for active recharge of groundwater resources such as infiltration wells.
- Consider potential for “banking” water during high flow events for use in low flow times (Port Angeles and Peninsula College have data on this).

### WS-7: Encourage forestry practices promoting upstream water retention

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Awareness</td>
<td>Forestry Sector</td>
<td>N/A</td>
<td><em>Ecosystems</em></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Identify forestry practices that promote upstream water retention and educate individuals about the practices.
- Consider integrating water retention into forestry practices permits.

### WS-8: Research or develop model to assess sea level rise and saltwater intrusion to groundwater

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Planning</td>
<td>Local Government, PUDs</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Enhance seasonal ground water level monitoring.
- Research what other communities are doing to assess sea level rise and salt water intrusion into groundwater.
### WS-9: Improve forecasting for future water supply and demand

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Planning</td>
<td>Water Utility Managers</td>
<td>Immediate need, politically feasible but technically difficult</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Improve forecasting tools for matching expected demand (including expected growth) with models of water availability including climate change.

### WS-10: Map water retention values for ecosystems

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Planning</td>
<td>Multi-stakeholder</td>
<td>Immediately implementable, technically and politically feasible</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Develop methodology and implement to create a valuation of the water retention services a landscape provides (as opposed to engineering storage systems).

### WS-11: Create an outreach, education, and incentive program for private well users

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Awareness</td>
<td>Multi-stakeholder</td>
<td>Near term, technically and politically feasible, unknown funding resources</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Develop general awareness/educational materials related to water use issues including what aquifer the wells pull from, appropriate conservation techniques for the region, relevant incentive programs.

### WS-12: Develop incentives for low-water use landscaping

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Awareness</td>
<td>Multi-stakeholder</td>
<td>Near term, highly adaptable, low cost, potentially facing political barriers</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Develop outdoor planting incentives (rebates or grants) for native, drought tolerant plants, and rainwater-capturing landscapes.
### WS-13: Adjust rate structure for water use to incentivize conservation

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Policy</td>
<td>Local Governments</td>
<td>Somewhat adaptable to climate change impacts, marginally politically and socially feasible</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Create inverted block rate structure for water use (currently Port Angeles rate structure is flat in the summer).
- Consider developing time of use pricing. Price water on a sliding scale thereby allowing one to charge more for certain uses.

### WS-14: Develop code and infrastructure for a municipal reclaimed water system

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Planning</td>
<td>Local Governments</td>
<td>High cost for new infrastructure, somewhat technically and politically feasible</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Research codes used by other communities.
- Draft code and develop infrastructure for municipal reclaimed water systems in the area.

### WS-15: Enhance residential water conservation through incentives and outreach

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Awareness</td>
<td>Multi-stakeholder</td>
<td>Near term, highly adaptable, low cost, potentially facing political barriers</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Extend incentives (rebates or grants) to use of drip irrigation, rain barrels and cisterns, and other residential conservation methods.

### WS-16: Encourage the State to lift restrictions or permit grey water reuse

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.5</td>
<td>Policy</td>
<td>Local Governments and Community Groups</td>
<td>Medium term, low cost, marginally politically and socially feasible</td>
<td></td>
</tr>
</tbody>
</table>

**Key Action Steps:**
- Lobby government to make necessary changes (potentially revising building codes).
- Create an outreach and incentive program encouraging grey water systems within a property.
WS-17: Create a smart grid water use system and share data with consumers to increase conservation

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Policy</td>
<td>Water Utility Managers</td>
<td>Long term, high cost, lacking political feasibility</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Utilize smart grid technologies that use real time data; the data is available today but displaying the information to users real time is necessary to encourage them to take conservation measures and identify system leaks. Currently required to meter, but not report real time data.
- At water plants, have SCADA (Supervisor Control and Data Acquisition), which is a hardware/software combination, gives turbidity, pH at the intake/treatment source.
- Track water use happening in real time through reduction in water storage levels.

WS-18: Pilot programs for sub-basin management within water rights laws

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Policy</td>
<td>State and County Governments</td>
<td>Long term, high cost, political barriers</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Work with state and county governments to outline criteria associated with a pilot. WA State Department of Ecology has pilot programs with sub-basins managing water rights (sub-basin understandings of inputs/outputs, conservation/re-use), and pilots have been recently approved in Dungeness.

WS-19: Streamline the administrative process for adjusting water rights

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Policy</td>
<td>Local Governments and Community Groups</td>
<td>Long term effort, low cost, minimal political feasibility</td>
<td></td>
</tr>
</tbody>
</table>

Key Action Steps:
- Adjustment could include: the ability to move the point of withdrawal within a service area to minimize impacts; put water rights in trust; trade water rights (permanent vs. temporary). Department of Ecology has the ability to make these changes and has demonstrated examples in eastern Washington.

WS-20: Direct wastewater reuse between municipalities and industries

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Policy</td>
<td>Water Utilities and Local Government</td>
<td>Long term, technically and politically feasible</td>
<td>Critical Infrastructure</td>
</tr>
</tbody>
</table>

Key Action Steps:
• Direct engagement between municipal & industrial water users – evaluation of water reuse would start by studying economics, needs, and capacity.
• Explore potential for connecting water treatment plant in Port Angeles or Port Townsend with the paper mill.

**WS-21: Explore opportunities for artificial recharge of groundwater aquifers**

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Planning</td>
<td>Multi-stakeholder</td>
<td>Minimally adaptable, high cost, facing technical and political barriers</td>
<td></td>
</tr>
</tbody>
</table>

Key Action Steps:
- Research options, including infiltration basins, injection wells, and artificial lakes/ponds.
- Assess water sources (reclaimed water, stormwater, peak river flows).

**WS-22: Research the development and construction of a desalinization plant**

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Planning</td>
<td>Local Governments</td>
<td>High cost, subject to significant political and social barriers</td>
<td></td>
</tr>
</tbody>
</table>

Key Action Steps:
- Work with partners to research feasibility and cost associated with desalinization plant.

**WS-23: Research regulatory framework on water hauling/delivery**

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Scored</td>
<td>Planning</td>
<td>Multi-stakeholder</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

Key Action Steps:
- Research examples from other communities. One example is Chimacum, where they are already receiving water delivered to the area with no regulations in existence.
- Identify the best practices and gauge how they would apply to the North Olympic Peninsula.

**WS-24: Enhance management of septic water quality issues**

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Scored</td>
<td>Policy</td>
<td>Local Government</td>
<td>N/A</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

Key Action Steps:
- Modify on-site septic requirements to anticipate impaired performance as water table levels rise, such as determining the feasibility of replacing traditional septic systems with mound systems or holding tanks.
- In problematic areas known for septic system failures, evaluate alternative wastewater treatment solutions, particularly for properties in areas vulnerable to sea level rise.
WS-25: Manage/enhance upstream watersheds

<table>
<thead>
<tr>
<th>Score</th>
<th>Type of Strategy</th>
<th>Lead Group(s)</th>
<th>Opportunities or Concerns</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not scored</td>
<td>Policy</td>
<td>Multi-stakeholders</td>
<td>Highly adaptable, technically and politically feasible, able to implement immediately</td>
<td>Ecosystems</td>
</tr>
</tbody>
</table>

Key Action Steps:

- Slow down surface water flow to increase water retention rates and infiltration. This will improve water quality as slower runoff means extra filtration.
- Consider increasing buffers and using bioswales so that it recharges into the soil.
- Identify, protect, and restore natural recharge areas including floodplains and wetlands.
- Minimize runoff through: Low Impact Development (LID), forest and vegetation management, floodplain management; and reestablishment of natural surface water off-stream retention ponds and storage areas. Retention ponds could be used for storing water for agriculture while also restoring important waterfowl habitat and increasing groundwater recharge.
- Create new wetlands or wetland banks for water storage and filtration purposes. Utilize historical ditches where appropriate. In the Dungeness area it was found that when some ditches were tight-lined (solid pipes were used to channel the water), the wells went dry, indicating the ditches were good sources for recharging the aquifer.
Conservation Futures Project Selection

The CF Committee evaluates and ranks project applications according to criteria designed to reflect the priorities expressed in the Jefferson County Code, section 03.08.040. This evaluation process has five (5) distinct phases as follows:

1. written project application – each CF Committee member (CFCM) independently reads and assesses each application and prepares any necessary clarification questions,

2. oral presentation of project – each CFCM must attend this meeting in which the Project Sponsor presents the project and answers questions posed by the committee members,

3. site visits – each CFCM must attend the project site visits (or view a video of the site visit), where the Applicant with the Project Sponsor will present the layout of the project with reference to the written application and site maps. Additional questions posed by committee members will be answered during this site visit,

4. submission of project ranking form – each CFCM submits to the committee secretary a form, which consists of twelve questions that ask how well, in the committee member's judgment, an applicant meets the criteria for approval and funding. The committee member assigns a numerical “score” (within a range predetermined by the CF Committee) for each of the twelve questions. These question “scores” are totaled for an overall evaluation “score”. A committee composite “score”, for each project application is obtained by discarding the lowest and highest individual member “scores” and then taking the average of the remaining “scores”. If a project application's composite “score” is \( X \) % of the total possible numerical value for a project “score” the project is considered worthy (ie. eligible for) of funding. Projects “scoring” below \( X \)% of the total possible numerical value for a project “score” are not considered for funding, unless compelling reasons for funding arise in the final evaluation phase, and

5. ranking and recommendation for funding of project applications – each project application judged eligible in phase #4 is discussed, bringing into focus information garnered from phases 1 through 4. All project applications are compared and a final rankings and funding recommendations are determined for each project application.
2015 Jefferson County Conservation Futures Program
Property Acquisition and/or
Operations and Maintenance Project Application

Please complete the following application in its entirety. Be sure to answer “N/A” for questions that
don’t apply to the project. Incomplete applications will not be accepted for consideration.
Unless directed otherwise, use as much space as needed to answer each question.
Contact program staff at 379-4498 or tpokorny@co.jefferson.wa.us with questions.

Background and Eligibility Information

1. Project Title: __________________________________________________________

2a. Conservation Futures Acquisition Request: _____________________________

   b. Conservation Futures O&M Request: ________________________________

3. Total Conservation Futures Request: _________________________________

4. Please indicate the type of interest contemplated in the acquisition process.
   __ Warranty Deed     __ Easement     __ Other (Please describe below.)
   In whose name will the property title be held after acquisition?

5. Applicant Information

   Name of Applicant or Organization: ________________________________
   Contact: _________________________________________________________
   Title: ____________________________________________________________
   Address: _________________________________________________________
   Phone: (____) _____-______, ext. _____ ____________ Fax: (____) _____-______, ext. ____
   Email: ___________________________________________________________

6. Sponsor Information: (if different than applicant) _______________________

   Organization Name: ________________________________________________
   Contact: _________________________________________________________
   Title: ____________________________________________________________
   Address: _________________________________________________________
   Phone: (____) _____-______, ext. _____ ____________ Fax: (____) _____-______, ext. ____
   Email: ___________________________________________________________
This application was approved by the sponsor’s legally responsible body (e.g., board, council, etc.) on ____________________, 20___.

7. Site Location
Street Address or Description of Location:

Driving Directions from Port Townsend:

Section: ___________ Township: _________________ Range: ___________
Assessor’s Parcel Number(s): _____________________________________________
Please differentiate current and proposed ownership of each APN and indicate if the parcel is to be acquired with CF funds or used as match.

8. EXISTING CONDITIONS
New Site: Yes No ___________________________ Number of Parcels: __________
Addition to Existing Site: Yes No _________ Acres to Be Acquired: __________
Total Project Acreage (if different): ___________ Current Zoning: ___________
Existing Structures/Facilities: _____________________________________________
Any current covenants, easements or restrictions on land use: ____________________________

Current Use: ___________________________________________
Waterfront (name of body of water): ________________________________________
Shoreline (linear feet): __________________________________________
Owner Tidelands/Shorelands: ____________________________________________

9. Current Property Owner __ is __ is not a willing seller.

Project Description

10. In 1000 words or less, provide a summary description of the project, the match, overarching goal, and three top objectives. Include information about the physical characteristics of the site that is proposed for acquisition with Conservation Futures Program funds including: vegetation, topography, surrounding land use, and relationship to parks, trails, and open space. Describe the use planned for the site, any development plans after acquisition (including passive development), characteristics of the site which demonstrate that it is well-suited to the
proposed use, and plans for any structures currently on the site. If applicable, describe how the site relates to the larger project, and whether the project has a plan, schedule and funding dedicated to its completion. Please also list any important milestones for the project or critical dates, e.g. grant deadlines. List the dates and explain their importance. Please attach a spreadsheet of the budget.

11. Estimate costs below, including the estimated or appraised value of the propert(ies) or property right(s) to be acquired, even if Conservation Futures funds will only cover a portion of the total project cost. In the case of projects involving multiple acquisitions, please break out appraisals and estimated acquisition costs by parcel.

a. Estimated or Appraised Value of Propert(ies) to be Acquired: ____________________________

b. Total Estimated Acquisition-related Cost (see Conservation Futures Manual for eligible costs): ________________________________________________________________

c. Total Operation and Maintenance Cost: ____________________________

d. Total Project Cost: _________________________________________________________________

Basis for Estimates (include information about how the property value(s) was determined, anticipated acquisition-related costs, general description of operation and maintenance work to be performed, task list with itemized budget, and anticipated schedule for completion of work):

Scored Questions

1a. Sponsor or other organizations ___will ___will not contribute to acquisition of proposed site and/or operation and maintenance activities.

b. If applicable, please describe below how contributions from groups or agencies will reduce the need to use Conservation Futures program funds.

c. Matching Fund Estimate

<table>
<thead>
<tr>
<th>Conservation Futures Funds Requested</th>
<th>Acquisition</th>
<th>O&amp;M</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>___%</td>
</tr>
<tr>
<td>Matching Funds/Resources*</td>
<td></td>
<td></td>
<td>___%</td>
</tr>
<tr>
<td>Total Project Acquisition Cost</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>
If a prior acquisition is being proposed as match, please describe and provide documentation of value, location, date of acquisition and other information that would directly link the match to the property being considered for acquisition.

<table>
<thead>
<tr>
<th>Source of matching funds/resources</th>
<th>Amount of contribution</th>
<th>Contribution approved?</th>
<th>If not, when?</th>
<th>Contribution available now?</th>
<th>If not, when?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$_________</td>
<td>Yes No</td>
<td>__________</td>
<td>Yes No</td>
<td>__________</td>
</tr>
<tr>
<td></td>
<td>$_________</td>
<td>Yes No</td>
<td>__________</td>
<td>Yes No</td>
<td>__________</td>
</tr>
<tr>
<td></td>
<td>$_________</td>
<td>Yes No</td>
<td>__________</td>
<td>Yes No</td>
<td>__________</td>
</tr>
</tbody>
</table>

NOTE: Matching funds are strongly recommended and a higher rating will be assigned to those projects that guarantee additional resources for acquisition. Donation of property or a property right will be considered as a matching resource. Donation of resources for on-going maintenance or stewardship ("in-kind" contributions) are not eligible as a match.

2 a. Sponsoring agency __is __is not prepared to provide long-term stewardship (maintenance, up-keep, etc.) for the proposed project site.

b. Describe any existing programs or future plans for stewardship of the property, including the nature and extent of the commitment of resources to carry out the stewardship plan.

3 a. Describe the sponsoring agency’s previous or on-going stewardship experience.

b. Has the sponsor and/or applicant of this project been involved in other projects previously approved for Conservation Futures funding?

   _____No, neither the sponsor nor applicant has been involved in a project previously approved for Conservation Futures funds.
   _____Yes, the sponsor and/or applicant for this project has been involved in a project previously approved for Conservation Futures funds. Please provide details:

4 a. Property __can __cannot feasibly be acquired in a timely fashion with available resources.

b. Necessary commitments and agreements __are __are not in place.

c. All parties __are __are not in agreement on the cost of acquisition.

If “not” to any of the above, please explain below.

5. The proposed acquisition __is specifically identified in an adopted open space, conservation, or resource preservation program or plan, or community conservation effort. Please describe below, including the site’s importance to the plan. Please reference the website of the plan if available or include the plan with this application.
complements an adopted open space or conservation plan, but is not specifically identified. Please describe below, and describe how the proposed acquisition is consistent with the plan.

is a stand-alone project.

6. Conservation Opportunity or Threat:
a. The proposed acquisition site does does not provide a conservation or preservation opportunity which would otherwise be lost or threatened.

b. If applicable, please carefully describe the nature and immediacy of the opportunity or threat, and any unique qualities about the site.

7. The proposed acquisition:

provides habitat for State of Washington Priority Habitat and/or State or Federal Threatened, Endangered or Sensitive species.

provides habitat for a variety of native flora or fauna species.

contributes to an existing or future wildlife corridor or migration route.

If affirmative in any of the above, please describe and list the Priority Habitat(s) and Threatened, Endangered, or Sensitive species below, and cite or provide documentation of species’ use.1

8 a. Describe the extent and nature of current and planned agricultural use of the proposed acquisition, including any anticipated changes to that use once the property, or property right, is acquired with Conservation Futures funds.

b. Describe any participation by the current property owner in any other agricultural land conservation programs, including the program and nature of the involvement.

9. Describe how the proposed acquisition benefits primarily a local area broad county area including the area served, the nature of the benefit, the jurisdictions involved, and the populations served.

10. Describe the educational or interpretive opportunities that exist for providing public access, educational or interpretive displays (signage, kiosks, etc.) on the proposed site, including any plans to provide those improvements and any plans for public accessibility.2

11. The proposed acquisition includes historic or culturally significant resources3

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1 See, for example, http://www.dnr.wa.gov/researchscience/topics/naturalheritage/pages/amp_nh.aspx
http://www.wdfw.wa.gov/conservation/phs/list/
http://www1.dnr.wa.gov/nhp/refdesk/plants.html

2 The words “education” and “interpretation” are interpreted broadly by the CF Committee.

3 Cultural resources means archeological and historic sites and artifacts, and traditional religious ceremonial and social uses and activities of affected Indian Tribes and mandatory protections of resources under chapters 27.44 and 27.53 RCW.
__ is registered with the National Register of Historic Places, or an equivalent program.
__ is recognized locally has having historic or cultural resources.
__ is adjacent to and provides a buffer for a historic or cultural site.

If affirmative in any of the above, please describe below, and cite or provide documentation of the historical or cultural resources.

12a. Describe the extent and nature of current and planned silvicultural use of the proposed acquisition. Please cite or provide documentation of existing or planned silvicultural activities including forest management plan(s) or forest ecosystem restoration.

b. Describe any participation by current property owner in silviculture conservation programs, including the program and nature of the involvement.

Verification

13. Sponsors of applications that are approved for funding by the Board of County Commissioners are required to submit a brief progress report by October 30 every year for three years after the award is approved, or three years after the acquisition funds are disbursed to the applicant, whichever is later. The progress report must address any changes in the project focus or purpose, progress in obtaining matching funding, and stewardship and maintenance. Sponsors receiving O&M funds will also submit an annual report for each year that O&M funds are expended. The Committee will use the information to develop a project “report card” that will be submitted annually to the Board of County Commissioners.

If this application is approved for funding, I understand the sponsor is required to submit progress reports for three years and for any year in which O&M funds are expended.

______________Initials_________Date

14. If, three years after the date funding is approved by the Board of County Commissioners, the applicants have not obtained the required matching funds, the Committee may request the Board of County Commissioners to nullify their approval of funds, and may require the project to re-apply.

If this application is approved for funding, I understand that we may be required to re-submit the application if the project sponsor does not obtain the necessary matching funding within three years. ________________Initials___________Date
Please note: if none of the answers provided describe the project, answer “N/A” or “0”.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>SCORE</th>
<th>X</th>
<th>WEIGHT</th>
<th>ADJUSTED = SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To what degree does the project leverage contributions for acquisition from groups, agencies or individuals?</td>
<td>______</td>
<td>X</td>
<td>5</td>
<td>______</td>
</tr>
<tr>
<td>(Points awarded based on the following level of contribution)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Leverages significantly = 3 points</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Leverages moderately = 2 points</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Meets requirement = 1 point</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. To what degree does the project sponsor commit to provide long-term stewardship for the proposed project?</td>
<td>______</td>
<td>X</td>
<td>10</td>
<td>______</td>
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<td>a. Stewardship plan with guaranteed long-term stewardship = 5 points</td>
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<td>b. Stewardship plan with guaranteed short-term stewardship = 3 points</td>
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<td>c. Stewardship plan, no guarantee = 1 point</td>
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<td>3. To what degree has the project sponsor demonstrated effective long-term stewardship of a similar project?</td>
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<td>X</td>
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<td>a. Highly demonstrated = 5 points</td>
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<td>b. Moderately demonstrated = 3 points</td>
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<td>c. Slightly demonstrated = 1 point</td>
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<td>d. Effectiveness not demonstrated = 0 points</td>
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<td>4. To what degree is the acquisition feasible?</td>
<td>______</td>
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<td>a. Highly feasible = 5 points</td>
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<td>b. Moderately feasible = 3 points</td>
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<td>c. Slightly feasible = 1 point</td>
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<td>5. To what degree is the project part of an adopted open space, conservation, or resource preservation program or plan, or identified in a community conservation effort?</td>
<td>______</td>
<td>X</td>
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<td>Sliding scale: 1-5 points</td>
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<td>6. To what degree does the project conserve opportunities which are otherwise lost or threatened?</td>
<td>______</td>
<td>X</td>
<td>6</td>
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<td>Sliding scale: 1-5 points</td>
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7. To what degree does the project preserve habitat for flora and fauna?  
(Points awarded in part based on level of documentation.)
   a. State of Washington Priority Habitat and/or State or Federal Endangered, Threatened or Sensitive species = 0–3 points ______ X 4 = _______
   b. Variety of native flora & fauna = 0–3 points ______ X 4 = _______
   c. Provides wildlife corridor or migration route = 0–3 points ______ X 4 = _______

8. To what degree does the project preserve farmland for agricultural use?  
   a. Likely will maintain active agricultural use = 0–3 points ______ X 4 = _______
   b. Participates in other conservation programs = 0–3 points ______ X 4 = _______
   c. Preserves rural cultural heritage = 0–3 points ______ X 4 = _______

9. To what degree does the project serve a significant benefit area?  
   _____ X 4 = _______
   Sliding scale: 1-5 points

10. To what degree will the acquisition provide educational opportunities, interpretive opportunities, and/or serve as a general community resource?  
   _____ X 4 = _______
   a. Public access, with planned or educational/interpretive displays and materials, events or activities = 5 points
   b. Limited public access, available space for signage and educational materials = 3 points
   c. Remote location = 1 point
   d. No opportunity = 0 points

11. To what degree does the project preserve historic or culturally significant resources?  
   _____ X 3 = _______
   a. Project is registered with the National Register of Historic Places, or an equivalent program = 3 points
   b. Project is recognized locally as having historic or cultural resources = 2 points
   c. Project is adjacent to and provides a buffer for a historic or cultural site = 1 point
   d. None of the above = 0 points

12. To what degree does the project preserve forestland for silvicultural use?  
   a. Likely will maintain active forestland for silvicultural use = 0–3 points ______ X 4= _______
   b. Land is enrolled in public and/or private programs which certify long-term sustainable silviculture:  
      Certified = 3 point  
      Uncertified = 0 points  
      _____ X 1 = _______
   c. Participates in other conservation or restoration programs = 0–3 points ______ X 4= _______

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4 Cultural resources means archeological and historic sites and artifacts, and traditional religious ceremonial and social uses and activities of affected Indian Tribes and mandatory protections of resources under chapters 27.44 and 27.53 RCW.
Call to Order
Chair Christian called the meeting to order at 2:00 PM and took the roll call. There was a quorum of members present. Tami Pokorny introduced her colleague Joel Peterson, and each member of the committee introduced themselves. Chair Christian invited Mr. Peterson to provide a bit of personal background. Mr. Peterson described his work with the Nature Conservancy in Utah in various positions before moving to Jefferson County to attend the Wooden Boat School, and most recently his employment in Long Range Planning for Jefferson County.

Amendments to Agenda
There were no amendments to the agenda.

Approval of Minutes
The following corrections were made to the minutes of March 15, 2007:
Page 8 – references to Cow/cap should be Cow/calf.
Page 8 – Previous corrections by Bill Wheeler had been incorporated to explain the meaning of “etc. “
Jerry Gorsline provided technical corrections regarding the age of the Cascades and the Tamanowas Rock fragment mentioned by Sarah Spaeth.

Barbara McColgan Pastore moved for approval of the minutes, as amended; Dennis Schultz seconded. The minutes of March 15, 2007 were approved, as amended, all in favor.

Observer Comments
None. (There were no members of the public present.)

Old Business
None
VI. New Business

A. Ranking Period Protocol Discussion

Chair Christian outlined the goals and procedures for the meeting. He noted that each member had separately and individually ranked/scored the five projects. Today, the group would collect and review all the scores, get a composite score for each project, and then rank them for recommendation to the BoCC. In addition, they would decide on funding, i.e. whether each project should be recommended for partial, full or no funding from the 2007 pool.

Chair Christian noted several issues. 1. Public record shared information: There was a deadline for new information which had now passed. No new information can be brought to the discussion. He noted that if any member had discussions outside the context of the public meeting or recorded site visit, that information may not be considered. All communication must be done through Tami Pokorny, the staff support person, so that a public record is established. Tami Pokorny added that if a non-public piece of information is brought forward as a question or data item so that it is verifiable and becomes public record, it is permitted.

2. Deposition on conflict of interest: Chair Christian reviewed the process for ascertaining conflict of interest. Each committee member will be questioned as to whether he/she has a conflict of interest; there is a standard set of questions for each person for each project. Each person will decide if there is a direct or strongly perceived conflict of interest for a particular project. Bill Wheeler asked this question: If a piece of information is on public record, for instance a tax record for the County, and even though it is not listed on the application, but it pertains as factual information on the project/property, can we consider it? Mr. Christian said no, it cannot be used – unless it was shared with the full committee prior to the deadline. He said that issue had been discussed previously, and that protocol was established. Sarah Spaeth asked if the deposition questions would be posed and answered before each project, or done all at once at the beginning. Chair Christian said they would all be done prior to the first project ranking. Joel Peterson asked for clarification on his status, committee member or visitor/observer. Ms. Pokorny explained that he was considered to be staff, not a voting committee member.

B. Deposition of Committee Members with Ethics Questions – April 10, 2007

Chair Christian asked Ms. Pokorny to begin by reading the Observer question.

For Upper Tarboo, Tami Pokorny read the formal script asking for objections to the participation of any particular committee member in the decision-making process and, if so, for a statement of the reasons for that objection.

Bill Wheeler responded that he objected to Sarah Spaeth participating in this project discussion because she would ultimately be ranking that project against other projects that she is responsible for – without prejudice.

Ms. Pokorny read the portion of the script indicating that the committee member for whom there is an objection must decide whether or not to recuse herself.

Sarah Spaeth then posed the question: "If another member recused him/herself and Sarah Spaeth did not recuse herself, would that somehow constitute a balance?"

After a brief discussion among Bill Wheeler, Barbara McColgan Pastore, Dennis Schultz, Janet Kearsley, and Sarah Spaeth, the possible variations on participation were aired. Bill Wheeler and Dennis Schultz stated that it would be improper for Ms. Spaeth, as a proponent of several projects, to participate in any part of the discussions or decisions for any project.

Janet Kearsley explained she was recusing herself from the Tarboo project because she works for the Department of Natural Resources. She questioned whether she should participate in the final funding allocation decision. Mr. Wheeler said that since she was not a proponent of any project, she need not recuse herself from the funding discussion and decision.

Sarah Spaeth asked and received clarification on how the rankings would be calculated and averaged, i.e. a recusal does not automatically reduce the rank of any project because the scores are averaged.

For Glendale Farm, Tami Pokorny read the formal script asking for objections to the participation of any particular committee member in the decision-making process and, if so, for a statement of the reasons for that objection. Sarah Spaeth acknowledged that there was a general objection because of her role as proponent of this project.

For 50th Street Wetland, Tami Pokorny read the formal script asking for objections to the participation of any particular committee member in the decision-making process and, if so, for a statement of the reasons for that objection. Dennis Schultz voiced the general objection about Sarah Spaeth’s participation because of her role as proponent of this project.
For Winona Phase II, Tami Pokorny read the formal script asking for objections to the participation of any particular committee member in the decision-making process and, if so, for a statement of the reasons for that objection. Janet Kearsley voiced the general objection about Sarah Spaeth’s participation citing the same reasons as for the previous two projects.

For the Tamanowas Rock II project, Tami Pokorny read the formal script asking for objections to the participation of any particular committee member in the decision-making process and, if so, for a statement of the reasons for that objection. Phil Andrus voiced the general objection about Sarah Spaeth’s participation citing the same reasons as for the previous three projects.

At the request of Chair Christian, Ms. Pokorny then read the following “Appearance of Fairness” questions in order to clarify the intent of the question, and the meaning of a “Yes” or "No' response.

1. Do you, as a member of the CFFCOC, stand to gain or lose any financial benefit as a result of the outcome of this hearing? Ms. Pokorny explained that a “Yes” answer would mean that the respondent should immediately recuse him/herself.

2. Are you, as a CFFCOC member, unable to hear and consider this proposal or application in a fair and objective manner, i.e., without bias and without a predisposition to any particular result regarding this proposal or application? A “Yes” answer would, again, be cause for recusal.

3. Have you, as a CFFCOC member, engaged in any communication outside this hearing with either a proponent or opponent of this particular proposal or application? This question could be answered either “Yes” or “No”, with follow up discussion to ascertain if that communication was influential to this process.

4. Are you as a committee member unable to certify that you have attended the project presentation and either attended the site visit or viewed the official video tape? A “Yes” answer would be cause for recusal.

Ms. Pokorny read explanations and procedures for considering and answering the above questions, as stated in Appendix A, attached.

There was a brief discussion about question three; Chair Christian pointed out the assumption that disqualifying conversation would have been post-application, and Ms. Pokorny added "or in anticipation, or related" to the application or project.

In response to the suggestion that questions should have distributed in advance of the meeting, Ms. Pokorny pointed out that the questions and advice are found in the by-laws, which had been provided.

For the first question, with regard to the Upper Tarboo Creek conservation project, responses were recorded as follows:

- Phil Andrus: No
- George Bush: No
- Dennis Shultz: No
- Bill Wheeler: No
- Janet Kearsley: No
- Lige Christian: No
- Sarah Spaeth: No
- Barbara McColgan Pastore: No
- Chris Llewellyn: No
- Jerry Gorsline: No

Question 2, with regard to Upper Tarboo:

- Phil Andrus: Not unable (No)
- George Bush: Not unable (No)
- Dennis Shultz: Not unable (No)
- Bill Wheeler: Not unable (No)
- Janet Kearsley: Yes, and I recuse myself from this project for that reason.
- Lige Christian: Not unable (No)
- Sarah Spaeth: Not unable (No), but because there is a perception of bias against this project because of involvement in competing projects, I recuse myself from ranking.
- Barbara McColgan Pastore: Not unable (No)
- Chris Llewellyn: Not unable (No)
Jerry Gorsline: Not unable (No)

Question 3, with regard to Upper Tarboo:

- Phil Andrus: No
- George Bush: No
- Dennis Shultz: No
- Bill Wheeler: No
- Janet Kearsley: No
- Lige Christian: No
- Sarah Spaeth: No
- Barbara McCollan Pastore: No
- Chris Llewellyn: No

Jerry Gorsline: Yes, I have, following the field trip. By way of explanation, I have known Peter Bahls for many years, but we have not communicated much in the past few years. I had never seen his project laid out the way he did for us, and I was very impressed with the work that the institution has done. So, I did send Peter and Jude an e-mail saying that I appreciated what they were doing in the Tarboo Watershed. So, I don't think that that compromises my judgment of this particular project, but I will wait to hear what the committee thinks. When asked if there was a response, Mr. Gorsline said that Mr. Bahls responded with one word, "Thanks." (Other members then clarified that Mr. Gorsline had to decide whether he should recuse himself. There was a brief discussion verifying that the e-mail did not refer in any way to this application. Mr. Gorsline said that he did not see a reason to recuse himself.)

Question 4, with regard to the Upper Tarboo:

- Phil Andrus: Not unable (No)
- George Bush: Not unable (No)
- Dennis Shultz: Not unable (No)
- Bill Wheeler: Not unable (No)
- Janet Kearsley: Not unable (No)
- Lige Christian: Not unable (No)
- Sarah Spaeth: Not unable (No)
- Barbara McCollan Pastore: Not unable (No)
- Chris Llewellyn: Not unable (No)
- Jerry Gorsline: Not unable (No)

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<th>Glendale Farm:</th>
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<tr>
<td>Spaeth</td>
<td>NO</td>
<td>NO</td>
<td>Yes</td>
<td>NO</td>
<td>Q2: I am not unable, but since Jefferson Land Trust is both applicant and sponsor agency for this application, I will recuse myself due to the perception of conflict of interest Q3: Yes, but only with respect to persons involved with Jefferson Land Trust who are aware of our project and supportive of us.</td>
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<td>Llewellyn</td>
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<td>Gorsline</td>
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### 50th Street Wetlands:

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<td>Christian</td>
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<tr>
<td>Spaeth</td>
<td>NO (See comment)</td>
<td>Yes (See comment)</td>
<td>NO</td>
<td>Q2: I am not unable, but since Jefferson Land Trust is both applicant and sponsor agency for this application, I will recuse myself for the perception of fairness. All of the projects we received this year have merit and none seem to clearly rank above all others.</td>
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<tr>
<td>Llewellyn</td>
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<tr>
<td>McColgan</td>
<td>NO (see comment)</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>Q1: Additional disclosure: Nancy Stelow is listing agent for the property. She is a friend and associate through volunteer work (Seroptimists and PT Parks/Recreation Board) and dog interests. This has no bearing on objectivity or deliberations for this project.</td>
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<tr>
<td>Gorsline</td>
<td>NO</td>
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### Winona Wildlife Phase II:

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<tr>
<td>Spaeth</td>
<td>NO (See comment)</td>
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<td>NO</td>
<td>NO</td>
<td>Q2: I am not unable, but since Jefferson Land Trust is both applicant and sponsor agency for this application, I will recuse myself for the perception of fairness.</td>
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<td>Llewellyn</td>
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<td>McColgan</td>
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### Tamanowas Rock Sanctuary:

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<tr>
<td>Spaeth</td>
<td>NO (See comment)</td>
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<td>Q2: I am not unable, but because Jamestown Tribe had approached Jefferson Land Trust to be a sponsor, I will recuse myself for the perception of fairness.</td>
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<td>Llewellyn</td>
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<td>Gorsline</td>
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<td>NO</td>
<td>YES (See)</td>
<td>NO</td>
<td>Q3: First, I communicated with Leo Gaten by delivering the name of a</td>
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Ms. Pokorny then read the Program Goals and the Preservation Criteria from the ordinance.

Chair Christian expressed his appreciation to Sarah Spaeth for her participation and input on all these projects and his regret that the circumstances are such that she must recuse herself. He also thanked Janet Kearsley for her input, noting that she had recused herself from the rankings on the Tarboo project.

[Sarah Spaeth and Janet Kearsley left the meeting at 3:01]

Chair Christian asked for someone to be scribe of the white board. Joel Peterson volunteered.

[3:02 – 3:07: Break]

Chair Christian called the meeting back to order at 3:08.

RATING PROCESS FOR UPPER TARBOO: Please see Ratings Table, Appendix I

Discussion:
#1. There was unanimity on rating and no additional comments.

#2. Bill Wheeler said he that his rating of 3 was based on the fact that there is no stewardship plan for this property yet. The response to his query was that there may be a transfer to Land Trust, and he said it was not a fully defined plan. Ms. McColgan Pastore said that she understood that they were going with the Legacy Forestry program. Mr. Wheeler said that intention was not backed up with information about the Legacy Forestry plan. Mr. Christian said his rating of 5 was based on this project's participation with the overall watershed stewardship plan; George Bush agreed.

There was additional discussion from new members about the process and sequence of steps in the numerical ranking. Chair Christian explained that process to everyone’s satisfaction.

#3. Phil Andrus, who had assigned a 4 was asked to choose a 3 or 5, and choose 5, which was consistent with all other members.

#4. Barbara McColgan Pastore said that her moderate ranking of 3 was based on the apparent degree of risk regarding the total financing, and the fact that several components had to fall into place to make this happen. Bill Wheeler said his 3 was based on the fact that the DNR funds were two years away. George Bush said he had misunderstood the DNR funding commitment. He questioned the possible escalation of cost each 6 months; the escalation was verified by referring to the supporting documents. After additional consideration, several members changed from 5 to 3 (Schultz, Christian and Llewellyn).

#5. Barbara McColgan Pastore said her rating of 3 was related to “documented and adopted open space”; she said that this was an internally generated plan, rather than state-wide, while still acknowledging the fine track record of NWI. After further discussion about the County backing of the entire project, she and Lige Christian changed their ratings to 5.

#6A. Bill Wheeler said that much of the flora and fauna is already protected, and would continue to be so without this project. George Bush said that premises that forest practice is adequate to protect fish and riparian species, and he does not think that is true. Jerry Gorsline asked if endangered/threatened means listed under ESA, and noted that there are none in this project. There was discussion about the range and reach of this particular project within the larger watershed effort, i.e. the significance of this piece of the overall watershed conservation/protection effort. Lige Christian and Chris Llewellyn emphasized the broad view and the importance of every acre of land and foot of stream in the overall system. The potential for logging was weighed.
#6B. Dennis Schultz noted that this area is already logged and this section of stream is not unique. Phil Andrus said he found nothing to distinguish this particular area. George Bush pointed out that there is great variety in the overall site compared to other areas of Jefferson County. Lige Christian changed his rating to 2.

#6C. Barbara McColgan Pastore noted that the stream itself is a corridor and various species migrate through that stream. Bill Wheeler did not see how this project, in particular, protects habitat. Barbara McColgan Pastore said that she agrees with the NWI argument that if they do not buy this property, it will be otherwise used/developed, in whole or part. Dennis Schultz said that only one house could be built in 20 acres and rules are already in place to protect the surrounding environment. After further discussion, Chris Llewellyn raised her rating to 3.

#7. Phil Andrus noted that many of the same arguments from #6 apply to this. Lige Christian changed his rating to 3. After a brief discussion about the likelihood of development, Chris Llewellyn reduced her rating to 3.

#8.

8A. Dennis Schultz said that this is strictly agriculture. Jerry Gorsline brought up the fact that forestry preserves rural cultural heritage. There was discussion about whether or not trees constitute a crop. Chair C reminded the committee that those with outliers should be given the opportunity to explain their positions, and then others may comment. Chris Llewellyn noted that she had been ambivalent about her rating of 3. Lige Christian said that this project is part of an overall program, and there is some question as to whether this can include forestry. He had rated a 3, but would be willing to change to 0 if the committee decided that this only pertains to agriculture. After further consideration, the committee decided that silvaculture should not, for this rating cycle, be considered agriculture. Outliers Lige Christian and Chris Llewellyn changed their ratings to 0.

8B. All zeros

8C. Barbara McColgan Pastore said she rated this as 2 to recognize rural cultural heritage. Unlike programs in the past, Peter Bahls is talking about legacy forest that includes an active participating program. George Bush said that he had had the same reasoning. Others pointed out that agriculture does not include silvaculture, meaning no points should be assigned. It was agreed that in post mortem analysis, this should be ironed out. All ratings were changed to zero to reflect the strictly agriculture interpretation.

#9. Dennis Schultz questioned whether this property was unique and whether people would drive all the way to Tarboo Creek to see this property. Jerry Gorsline and George Bush pointed out that the benefits to the County did not require the site to be viewed and that this was part of an overall project of ecological project that had far reaching benefits. Chris Llewellyn added that this project actually has state wide benefits. There were no changes to ratings.

#10. Barbara McColgan Pastore said her low rating of 1 could be changed to 3, based on the school tree planting projects. Jerry Gorsline reduced his rating to a 3.

[Break – 3 minutes; end of recording part 1]

RATING PROCESS FOR GLENDALE FARM: Please see Ratings Table, Appendix II

Discussion:
#1. and #2. Agreement and no outliers.

#3. Bill Wheeler, rating of 1, said that there is little demonstrated agricultural stewardship at the Land Trust; he said that despite the Sunfield Farm project, this will be the first year to have a professional stewardship program. George Bush said he would change his rating from 5 to 3. Dennis Schultz said his rating of 3 was because of the learning process still in progress at the Land Trust. Barbara McColgan Pastore, rating of 5, spoke in favor of the Jefferson Land Trust track record and the staying power of the sponsor overall. George Bush pointed out that the question clearly states the qualification, “demonstrated with a similar project”; he said that Jefferson Land Trust had not sponsored a similar project as yet. Dennis Schultz agreed, noting the complexity and duration of this project. After additional discussion about the intention of questions 2 and 3, Bill Wheeler noted the difference between protection and stewardship; he said Jefferson Land Trust had protected land, but not shown their capacity for effective stewardship. There were no further changes.

#4. Bill Wheeler explained his rating of 1. He said the appraiser had said that the highest and best use for this property was as a planned rural development that protected 153 of “ag land”. He wondered why the owner would
Bill Wheeler said that Ms. Spaeth had not obtained a clear agreement from the land owner that they would follow through on this approach. He recalled that she had relayed a discussion with the owner that had occurred before he met with the CFCC. The owner had said at the meeting that his daughter wished to develop 5 acres for more than one house. He quoted Sarah Spaeth as saying, when asked, that she would tell us if he changes his mind.

Lige Christian said that all agreements between owners and sponsors are subject to change, and that this case was not unusual in that regard. George Bush noted that this case has more questions than others, and that he did not understand how a rating of 5 would be justified. Bill Wheeler recalled that there were two issues raised during the visit: development specifics and city water, which was not really considered by the appraiser.

Chris Llewellyn explained her rating; the granting agency is a farmland and ranch preservation fund is specifically for buying development rights and putting conservation easements on farms. In her opinion, that makes the project highly feasible. Dennis Schultz said he would change his rating to a three.

Phil Andrus explained that he had tried to be as true as possible to the questions and the meaning of the words in the questions. He noted that feasible does not mean certain or definite and the project is certainly feasible, hence warranting a 5. He noted that the time for more subjective interpretation would be later in the process, when ranking the projects. There were no further changes.

#5. Dennis Schultz said that his rating of one (1) was because there is no real evidence of a plan. Phil Andrus and Jerry Gorsline responded that the plan is to work with the Farm and Ranch funding agency. Dennis Schultz said that meant it was stand alone, and no other farms were tied to it, including Sunland Farm. Chris Llewellyn said this would be the start of a larger program. Janet Kearsley referred to a statement in the application (page 7, #16) indicating that “the Glendale Farm property is identified in the Jefferson County Comprehensive Plan map...” Dennis Schultz interjected that “he had told her (S. Spaeth) that there is no map in the Comp Plan for Parks and Recreation and stuff like that; there is only one map and that is the one that shows zoning”. There was additional discussion about the ability to change the zoning of this property by Comp Plan amendment. (Lige Christian said that later on, the group would need to review the questions, vocabulary and intentions.) Lige Christian noted that this is part of plan and direction for the Land Trust, i.e. where they will be moving in the future. Also, the farm has been part of a CREP 15-year plan. Dennis Schultz disagreed that there is a plan. Janet Kearsley said that she would change her rating from 5 to 3. Jerry Gorsline also downgraded to a 3.

#6.

For 6A, Lige Christian changed a 3 to a 2. After a brief discussion about Chimacum Creek, the Conservation District, and the reality of “threatened species”, Jerry Gorsline changed his 0 to 1.

6B. Lige Christian noted he was an outlier, and changed his 3 to 2. Dennis Schultz explained that his zero (0) is based on the fact that the land has been grazed down, and the lack of any variety or unique flora and fauna to be restored. Chris Llewellyn raised her 1 to 2, because of the large variety of life forms on a farm. George Bush noted that the only possible justification for a zero is the absence of anything except mice and cows. There were no further changes.

6C. Barbara McColgan Pastore explained her 3 for corridor as based on the presence of stream, marshes, and trumpeter swans. Lige Christian and Chris Llewellyn raised their 1s to 2s.

#7. Lige Christian noted the two outliers. Bill Wheeler said the land owner had expressed frustration with the agricultural business but gave no indication of leaving it, and Janet Kearsley agreed. There were no changes to ratings.

#8, A-C. There was consistency in the initial ratings. Chris Llewellyn reduced her 5 rating to 3 because it was outside the legal range for this question.

#9. There was complete agreement and no changes.
#10. Dennis Schultz was seen to be the outlier. He said he saw tremendous opportunity for education, based on the interest he has seen at his farm. Janet Kearsley noted the limited public access mentioned in the application. Others noted that despite the great potential, education was not a serious part of the plan. Dennis Schultz changed his rating from 5 to 3.

[Break – 2 minutes]

RATING PROCESS FOR 50th STREET: Please see Ratings Table, Appendix III

Discussion:

#1. There was agreement; no changes.
#2. There was agreement; no changes.
#3. Bill Wheeler explained that, as before, his lower rating was due to the lack of experience with stewardship. There were no changes.
#4. No discussion and no changes.
#5. Barbara McColgan Pastore noted that the Quimper Wildlife corridor and the wetlands are there, but this property is at the outside edge of the wetlands. It is part of their plan but not in the high priority area of the plan. George Bush said that Jefferson Land Trust would not be going forward if it was not seen as integral to the overall plan. Barbara McColgan Pastore changed her rating from 3 to 5.

#6A. There was discussion about the pair of bald eagles nesting within 800 feet. Jerry Gorsline raised the rating to 2. Bill Wheeler changed his rating to a 2.

6B. Lige Christian changed his rating to a 2.

6C. No changes

#7. Dennis Schultz explained that there are 4 lots and 2 are not buildable. He does not see the other two as buildable because of the wetland buffer. Jerry Gorsline said that the reasonable use exemption would allow a house to be built. Dennis Schultz and George Bush changed their ratings to 3.

#8. There was agreement and no further discussion.
#9. No discussion and no changes.

#10. Janet Kearsley noted her rating of 5 was based on the plans to have interpretative signage, etc. Bill Wheeler said he had not rated as high as 5 because the property was relatively inaccessible, and it wasn’t clear how it would fit in. Barbara McColgan Pastore raised her rating to 5 based on the proximity to the natural park, and the trailhead for Capi’s Trails.

[Break – 2 minutes]

RATING PROCESS FOR WINONA: Please see Ratings Table, Appendix IV

Discussion:

#1. No discussion
#2. No discussion
#3. No discussion
#4. Barbara McColgan Pastore explained her rating of 3; the owner had been indecisive and had changed her mind in dealings last year with the Jefferson Land Trust.

#5. No discussion

#6A. No discussion.

6B. Dennis Schultz changed his rating from 1 to 2.

6C. Dennis Schultz changed his rating from 1 to 2.

#7. Lige Christian changed his rating from 5 to 3. Bill Wheeler noted that his 5 was based on approval of the project next year. Janet Kearsley did not consider the property to be significantly threatened.

#8. There was agreement and no discussion.
#9. Janet Kearsley and Barbara McColgan Pastore discussed the access for recreation; Barbara McColgan Pastore called it Tier 2. There were no changes.

#10. There were no changes.

RATING PROCESS FOR TAMANOWAS: Please see Ratings Table, Appendix V

Discussion:
#1. Lige Christian explained his zero rating. The sale is 50% on the match; when figures were added the total was less than 50%, i.e. $201,872.50? After a brief discussion of options, all committee members agreed to change their rating for #1 to zero.

#2. George Bush noted that the applicant would be doing the stewardship, and that there was not a good track record. Several others noted projects they have done in Clallam County.

#3. George Bush questioned the evidence that the applicant had been responsible for long-term stewardship. Barbara McColgan Pastore pointed out numerous projects that raised her confidence in their commitment to this project. After further discussion, Dennis Schultz, Phil Andrus and Jerry Gorsline changed their ratings from 5 to 3.

#4. No discussion and no changes

#5. Dennis Schultz said that although there are plans for other parcels, the plan did not exist for this parcel. Beyond getting the Rock, there are 20 acres between this and the Rock. Lige Christian said he agreed with Dennis Schultz, but gave a more moderate rating. Chris Llewellyn said she would change her rating to 3. Janet Kearsley read the portion of the application referring to the Comprehensive Plan. Bill Wheeler said that he believed that a good plan was in hand.

(Barbara McColgan Pastore returned to the subject of the cost of the project, and showed how the cost included the $3500 cost of Operation and maintenance but was not properly included in the application. Chair Christian indicated that the committee would need to use the numbers that were requested in the application.)

Jerry Gorsline changed his rating from 5 to 3.

#6A. After a brief discussion, Jerry Gorsline and Lige Christian raised their ratings to 1.

6B. Dennis Schultz was the outlier, but said he saw nothing unusual there. Jerry Gorsline pointed out the presence of the wetland along with forest, and the rarer species of plants on the top of the rock; however, Bill Wheeler noted the size of the property which contributes to diversity. George Bush and Barbara McColgan Pastore said they would reduce their ratings to 2. Janet Kearsley discussed the diversity of this tract.

6C. Chris Llewellyn said she would raise the rating from 1 to 2. Phil Andrus and Barbara McColgan Pastore spoke about the broad corridor from Four Corners Road on south and the connection to Anderson Lake. Jerry Gorsline raised the rating to a 3. George Bush noted that the upland nature of the parcel and absence of streams, and said he could only justify a 2. Dennis Schultz said that there was nothing particularly compelling about this parcel, nor anything that made it more valuable than parcels around it. Others believed that it was valuable as part of the large unfragmented corridor.

#7. There was considerable spread on the initial rating. Barbara McColgan Pastore said she did not see this as a critical situation; the applicant was basically interested in getting help to strengthen their financial position, i.e. backfill after extending themselves on other projects. She did not see this as a possibility lost. George Bush also noted that the applicant had an acceptable alternative, and changed his rating from 5 to 1. Bill Wheeler said he rated it highly because of its proximity to Anderson Lake. He advocated for supporting them since there is a possibility of the owners shutting this property off from the public, especially if there is no help with funding. The State Park is supportive, but has no money. Jerry Gorsline changed to 3 from 5.

#8. Janet Kearsley pointed out the lines in the application "historical cultural" and "preserved rural cultural heritage"; she said the applicant plans to do extraction which makes it agricultural. Bill Wheeler and Lige Christian each changed their 0 to 1.

#9. (Janet Kearsley suggested that the committee should think about adding a new regional criterion, i.e. does the property have a regional significance? While there was acknowledgement that this parcel may not have regional significance, others agreed with the suggestion.) Jerry Gorsline said that he rated it 5 because it served a larger strategy, to protect the rock and the park and a larger opportunity. Lige Christian agreed.

#10. Barbara McColgan Pastore noted that the applicant had specifically said they would not have educational signs on the site; she rated it 3.
FUNDING

Chair Christian opened a discussion about the committee’s strategy for funding. He described several options: partial funding for all or some; or allocation of full funding to one or two projects; or approving one or more projects but acknowledging the constriction of funds. Bill Wheeler noted that, in his opinion, all of the five applicants are worthy of funding, but it is necessary to understand that for some projects, partial funding may be inappropriate and ineffective. Barbara McColgan Pastore said that she believes it important to give the ranking of the projects based on the rating numbers independently of the funding recommendation. If so, if any project proves to be infeasible, the BoCC will have information to reallocate funds.

Chair Christian summarized by saying that full funding only limits the options and makes Tarboo, Glendale and Tamanowas Rock exclusionary to each other. He said that it is a viable action to consider partial funding for all projects.

Tami Pokorny verified that the total amount of funding available was $380,000 – 29,000 of which can be O & M. Chair Christian noted that based on the raw numbers, the rankings would be: 1. Glendale Farm; 2. Winona; 3. Tarboo; 4. 50th Street; 5. Tamanowas. Barbara McColgan Pastore noted that even if the arithmetic error had not been made and the points for Criteria 1 had been added in, it would not have changed the rank of Tamanowas.

Chair Christian asked if there was anyone who wished to speak for Tamanowas not being 5th in the final ranking.

Tami Pokorny noted that the role of Janet Kearsley in the ranking process should be clarified. It was suggested that Janet Kearsley should not vote on ranking the Upper Tarboo project and should refrain from any comments or references to that project during the discussion. All present were in agreement.

There were no comments regarding the Tamanowas ranking. Chair Christian called for a motion. Phil Andrus moved that Tamanowas be ranked as number 5 in the overall project rankings and Barbara McColgan Pastore seconded that. The motion was unanimously approved.

Chair Christian noted that, of the remaining four projects, three were very close in ratings. Glendale Farm held the highest rating by a margin of about 10%. He asked if anyone wished to speak in favor or against ranking Glendale Farm as number one. Barbara McColgan Pastore said that she endorsed Glendale Farm as the top project. She said that this is a different type of project than has been funded in the past, extremely worthy of CFCC recognition and support, and moved for it to be ranked as number one. Phil Andrus seconded the motion.

Chair Christian opened the floor for discussion. George Bush said the Glendale Farm project is a great project, standing on its own. He said, “However, looking at the county-wide boundaries of these projects, I think the Upper Tarboo project protects a greater extent and amount of wild lands and the dependent wildlife, particularly considering the value of the estuary it feeds. I would rank it ahead of Glendale Farm, but the composite rankings do not support that.” Dennis Schultz said Conservation Futures Fund has several goals; protecting wildlife is one and protecting agriculture is another of equal importance. George Bush said that he believed the farm would remain a farm regardless of what CFCC does. Dennis Schultz responded that that was not the case, that there were serious discussions in other farm families about breaking land up into 20 acre parcels. There was further discussion about the probabilities of losing the farm land to housing developments. Barbara McColgan Pastore discussed the experience of Clallam County and Sequim, noting that zoning or Comprehensive Plans could not block development. She said that there is a clear threat. Barbara McColgan Pastore also mentioned the worth of organic farming and the possibilities that could arise for related small businesses and employment, such as Port Townsend Creamery. She said that Upper Tarboo is a worthy project but she supported the ranking of Glendale Farm as a clear number one.

Jerry Gorsline suggested that the committee seriously consider Upper Tarboo as number two.

Barbara McColgan Pastore noted that acting supportively on the Glendale Farm funding could be a very important first step in changing the direction taken by other farms.

Chris Llewellyn suggested that later on the committee investigate the possibility of giving tax payers the option of directing contributions to the Conservation Futures Fund. There was support from several members for that idea, and agreement that it could be pursued at a later date.

Hearing no further discussion, Chair Christian called for a vote on the motion. The motion carried unanimously.
Chair Christian said that the three other projects should be discussed in the order of raw rank: Winona, Tarboo and 50th Street. Jerry Gorsline and Dennis Schultz spoke in favor of Tarboo as number two. Dennis Schultz said that Winona and 50th Street are more of the same type of project for the Wildlife Corridor. Jerry Gorsline said that the breadth of the Tarboo project and its location in the south part of the County were very important. Barbara McColgan Pastore said that both of the other parcels would be purchased by the Land Trust. For Tarboo, the easement would provide more value for the dollar: it stays on the tax rolls; there is active forestry; and the amount of protected land and estuary is greater. She moved that Tarboo be ranked as number two, Winona as number three, and 50th Street as number four. Phil Andrus seconded. Bill Wheeler said that he agreed with the motion, although he did not think the tax revenue was significant. He noted that he also has some issues with the entire financial arrangement for Upper Tarboo. Chris Llewellyn also spoke in favor of the motion, and of ranking Upper Tarboo as second. She said that the other two projects would likely get support from private funding and Port Townsend citizens.

**Chair Christian restated the motion: Upper Tarboo would be ranked two, Winona would be three, and 50th Street would be ranked four in the overall rankings.** He noted that the impact is that Tarboo and Winona would change places from where they stood in the raw rankings, where they differed by only a few points. **The motion was approved unanimously, with one abstention by Janet Kearsley.**

The final ranking in order from first to last was: (1) Glendale Farm, (2) Upper Tarboo, (3) Winona, (4) 50th Street, and (5) Tamanowas – Phase II. Chair Christian asked for a motion regarding the recommendation of all five projects to the BoCC. **Barbara McColgan Pastore moved that in our communication to BoCC, we endorse all five projects as being worthy of funding, but however specified, on their merits we rated all five projects in the following order: (1) Glendale Farm, (2) Upper Tarboo Creek, (3) Quimper Wildlife Corridor – Winona Wetlands, (4) Quimper Wildlife Corridor – 50th Street, and (5) Tamanowas – Phase II. The motion was seconded by Phil Andrus. All those voting were in favor; Janet Kearsley abstained.**

**Funding Allocation Discussion**

Bill Wheeler said that due to the complexity, long term nature and other steps needed in the Glendale Farm situation, he would not recommend using the bulk of available funds, but would indicate our substantial interest in the project by allocating some amount. Janet Kearsley said that 50% would be $150,000; he responded that that was perhaps more than substantial. Dennis Schultz noted that most of the farm funding available is brand new and that processes are still being worked out. Therefore, those who apply earliest with the most matching funds will probably receive significant funding.

Phil Andrus said he believed Glendale was probably less urgent than Tarboo, so would suggest fully funding the Tarboo request and give the balance to Glendale. Barbara McColgan Pastore said that her initial inclination was to give $300,000 to Glendale Farm, to ensure that the stage was set for the rest of the funding through other agencies. However, she noted that Mr. Andrus’s proposal made sense. That is Upper Tarboo could be funded with $163,000 leaving Glendale Farm with about $200,000, a substantial commitment. She raised the question of whether or not such an arrangement would cause the Glendale deal to fall through.

Chris Llewellyn reported that she had printed out the Farm and Ranch lands protection program information: NRCS would provide up to 50% of the cost of an easement in perpetuity to keep the land in agriculture, with a funding limit of $4,000,000. This confirms that 50% is the upper limit for NRCS; if CFCC does not fund 50%, the applicant must find the shortfall elsewhere. Dennis Schultz noted that arrangements for multiple sources of funding are not unusual.

Bill Wheeler said that it is important to help Glendale start what will likely be a multi-year process, and there may be more funds available next year. Janet Kearsley suggested that some funds be left for Tamanowas wetland protection, i.e. that partial funding for several or all projects be attempted. Chris Llewellyn spoke in favor of funding the top two projects, leaving the other projects for future years. George Bush agreed that partially funding all projects would be less likely to be effective and may not ensure success for any project. He was in favor of funding Glendale and Tarboo, and leaving the others for another year.

Barbara McColgan Pastore said that if CFCC were to give partial funding for Tamanowas Phase II, there is no provision in the application that the protection plan would be carried out, in full or in part. With the limited funds of $380,000, she believes the key question is how to portion that out to Glendale and Tarboo. Additionally, she suggested that it would be cleaner and clearer not to award any O & M funds; they should be left in the pool.
Chair Christian recognized Dennis Schultz to speak and clarified who was in the queue for speaking next. Dennis Schultz noted that 1. the CFCC cannot commit next year’s funds; 2. applicants are aware that there are insufficient funds for all projects; 3. he agrees with Phil Andrus’s proposal to fund Tarboo with the remainder allocated to Glendale.

Lige Christian said that 1. it would be difficult to justify funding Glendale and Tarboo, down to Tamanowas, and would not be able to support that; 2. he is in favor of funding Tarboo at least close to their request, leaving some need for both the Land Trust and Upper Tarboo to stretch. (He noted that he, as Chair, could not make that motion.)

Bill Wheeler said he was concerned that the deliberation end with a solid project, but noted there were significant uncertainties for both Glendale and Tarboo, if not fully funded by CFCC, and neither was likely to get match funds this year by other entities.

Chris Llewellyn added that having been involved in grant funding before, it is normal practice to disqualify the entire application, as in the Tamanowas case. She recommended that funding for it should not be considered. Chair Christian ruled the comment out of order because a preceding and precluding motion had already been passed.

With the intention of helping to focus the conversation, Barbara McColgan Pastore suggested that Glendale Farm be funded for $230,000 and Tarboo at $150,000. She added that this shorts Glendale by about $70,000, which has a longer term to find the funds, and Tarboo by $13,000. Phil Andrus questioned why this apportionment made more sense than fully funding Tarboo, and funding Glendale with the balance – which was determined to be $216,181.

Dennis Schultz said that neither of the two lead projects has commitments, and that this situation has been encountered before, e.g. with Sunfield Farm. There is a time period for using the money, and if not used, the funds revert back to CFCC. Janet Kearsley spoke in favor of funding the Winona wetland (about $31,000) in full, along with Glendale and Tarboo, thus achieving the goal of a successful project for this year, as well as making significant contributions to the other two.

George Bush said that he was in support of Phil Andrus’s notion. He said he had faith that Tarboo would make the project work; he said he would prefer to fund it fully, and award the remainder to Glendale. He was not in favor of lessening the funds for those projects in order to fund Winona.

Bill Wheeler asked if in the previous case of Sunfield, they had a committed source of funding. Dennis Schultz replied that they had not, and confirmed that the case was similar in that way to Glendale Farm.

There was discussion about the variations of funding. Chris Llewellyn spoke in favor of $150,000 for Tarboo, and leaving less of a gap for Glendale, which she believed gave each project a reasonable chance of succeeding.

Jerry Gorsline noted that he had not spoken before, and wished to support Phil Andrus’s proposal to full fund Tarboo and give the remainder to Glendale Farm.

Barbara McColgan Pastore said she was definitely in favor of funding the top two projects. However, she was concerned about funding the second place project fully, while under funding the top project, which received significantly higher raw scores. This may also indicate that there problems with the rating scheme itself.

Lige Christian asked if the committee fully funds the number two, there must be some help with documenting the rationale, so that the process and reasoning can be well presented to the BoCC.

Phil Andrus noted that the rationale or arguments in favor that usually accompany the recommendations of an advisory body are called “findings”; he said the inclusion of findings would definitely be a good idea. Phil Andrus added that the total project cost for Glendale would be $948,000. Therefore, to use the $300,000 figure as the most significant figure is misleading. He said Glendale has significantly more money to raise than the 80,000 in question. **Phil Andrus moved that $216,181 dollars be awarded to the Glendale project and $163,819 be awarded to Upper Tarboo. The motion was seconded by George Bush.** Chair Christian called for discussion.

Bill Wheeler said he would speak further to the justification issue. He said that the Glendale situation is one of providing seed money for a project, whereas the funding for Tarboo would finish up a known funding plan. Therefore, he did not think this would appear unreasonable to the BoCC or others. He noted that the 300,000 for Glendale is somewhat arbitrary in that they do not know how much other sources can or may provide.

Chair Christian said he would argue that the $10,000 spent in the project by the Tarboo applicant should not be included in the CFCC award. After a clarifying discussion to sort out the components of the financial arrangements, it was determined that the 10,000 is 1. not part of the match, and 2. would not be returned to the applicant if the

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CFCC funded the $163,819. (The $10,000 was a non-refundable sum by which NWIS obtained the option to buy within an 18 month period.)

Chair Christian called for the vote. There were 5 ayes. There were 3 nayes, and one abstention. The motion passed: 5 ayes; 3 nayes; and 1 abstention.

Chair Christian asked for verification that the full rationale had been recorded. Phil Andrus noted that he had intended to mention the time constraint that the Tarboo project faces. Barbara McColgan Pastore restated: “You also said that it was the last piece in a funding plan, as opposed to being seed money that the other one was, so therefore it was timelier.”

Chris Llewellyn asked if, in the event that the Upper Tarboo project did not go through, the money could be awarded to Glendale. Committee members responded that there would be no way to know before submitting the recommendation to the BoCC. Chris Llewellyn began to make a motion regarding that eventuality.

At this point, Chair Christian announced that the previous motion had failed. He said that an absolute majority is needed, i.e. six of the full eleven members must be favor of the motion.

**Barbara McColgan Pastore moved that Glendale Farm be funded at $230,000 and Upper Tarboo at $150,000, all in capital funds, with no O & M. Chris Llewellyn seconded. Dennis Schultz called for the question. The motion passed: 7 in favor, 1 opposed and 1 abstention.**

**VII. Other Administrative**

**CALENDAR:**

Tami Pokorny said that if all went in accordance with the schedule, there would be a hearing on the recommendations on May 21.

The next meeting is tentatively scheduled for Thursday, June 7. Several members advised that they may be unable to attend on that date. Tami Pokorny will poll members and arrange an optimal date via e-mail.

Possible additions for the rating sheet and checklist should be sent to Tami Pokorny.

**VIII. Observer Comments:**

Joel Peterson thanked the committee for the opportunity to participate in the meeting. He said he was impressed with the ranking of the sites. He said that he had been through similar processes before and made several suggestions. He noted that it is always helpful to have terms well defined. He also noted that he had some questions about how the criteria were applied, and some disagreements. Mr. Peterson said that there seemed to be some pressure for consensus and/or adjustment of individual ratings, and that it would be better to allow the numbers to flow through to the end. He also advised the committee to document the multipliers very well, noting that sometimes they can obfuscate the final outcome.

**IX. Adjournment**

A motion to adjourn was moved and seconded. Chair Christian adjourned the meeting at 6:40 PM.
## APPENDIX I

### UPPER TARBOO RATINGS

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<th>Phil Andrus</th>
<th>George Bush</th>
<th>Dennis Schultz</th>
<th>Bill Wheeler</th>
<th>Janet Kearsley</th>
<th>Lige Christian</th>
<th>Chris Llewellyn</th>
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**COMPOSITE RATING : 1612/8 = 201.5**
## APPENDIX II

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**Composite Rating: 2152/9 = 239**
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| Total Points | 1848 |

**COMPOSITE RATING: 1848/9 = 205.3**
**APPENDIX IV**

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**COMPOSITE RATING: 1892/9 = 210**
# APPENDIX V

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<td>c. Wildlife corridor</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>7. Conserves opportunities</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>8. Farmland preservation a. Other programs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>b. Active Agriculture Use</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>c. Preserve rural cultural heritage</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>9. Benefit to area</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>39</td>
<td>4</td>
</tr>
<tr>
<td>10. Educational or interpretive</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>27</td>
<td>4</td>
</tr>
<tr>
<td><strong>COMPOSITE RATING:</strong> 1674/9 = 186</td>
<td></td>
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<td></td>
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</tbody>
</table>
APPENDIX A
ETHICS QUESTIONS FROM CHIEF DEPUTY CIVIL PROSECUTING ATTORNEY’S JULY 9, 2002 MEMO TO THE COMMITTEE [INCLUDING FOURTH QUESTION ADDED IN 2005.]

After asking for objections from the audience, then the CFFCOC members should be asked these questions with respect to each DISTINCT application or proposal:

- Do you, as a member of the CFFCOC, stand to gain or lose any financial benefit as a result of the outcome of this hearing?
- Are you, as a CFFCOC member, unable to hear and consider this proposal or application in a fair and objective manner, i.e., without bias and without a predisposition to any particular result regarding this proposal or application?
- Have you, as a CFFCOC member, engaged in any communication outside this hearing with either a proponent or opponent of this particular proposal or application?
- Are you, as a Committee member, unable to certify that you have attended the project presentation and either attended the site visit or viewed the official videotape?

If any CFFCOC member has to answer “yes” to the first, second or fourth of these questions, then they must say so out loud, explain why they have answered “yes,” AND MUST IMMEDIATELY RECUSE themselves from any debate or deliberation regarding that proposal. Recall that if a CFFCOC member holds what is deemed a ‘remote interest’ by state law, then that CFFCOC member need not reply, “yes” to the first question listed above.

A reply of “yes” to the third question listed above must then lead to the CFFCOC member describing the substance and facts regarding that outside conversation, e.g., what was said by whom.

The occurrence of an outside conversation does not mean that the CFFCOC member must recuse himself or herself. In the context of a land use decision this type of “appearance of fairness” problem can be eradicated if it is publicly stated at the meeting not only the substance of the outside conversation BUT ALSO that the person or persons who were disadvantaged by not being present at the outside conversation will have the opportunity to rebut what was said or argued during that outside conversation. In other words, “I’ve heard one side in private, so now I must offer the other side the opportunity to present their arguments.”

If this is done and the opportunity to rebut is truly provided, then the CFFCOC member answering, “yes” to the third question, need NOT recuse him or herself. Again, this is using the rules applicable to land use decisions by analogy. As analogies go, it is not a perfect fit, but it is what we have.

It is true that the need to provide this rebuttal opportunity to those persons or party disadvantaged by the outside conversation could cause a delay in the decision-making process from one hearing to the next hearing, since the occurrence of the outside conversation may come as a surprise to the disadvantaged, who might not even be present at the first hearing.
To: Jefferson County Board of Commissioners  
From: Jerry Gorsline, Chair  
Conservation Futures Citizen Oversight Committee  
Date: May 29, 2009  
Subject: Conservation Futures 2009 Funding Round Recommendations

The Jefferson County Conservation Futures Program and Fund have contributed to the protection of public open spaces in Jefferson County since 2003. Ten projects have been awarded funding to date, and currently eight of these are essentially complete. The projects provide important open spaces and wetlands within the Quimper Wildlife Corridor, riparian and estuarine habitat along Chimacum Creek, productive farms such as Sunfield, Glendale, and Finnriver, a visual buffer at the entrance to the City of Port Townsend, forests and wetlands near Tamanawas Rock, and salmon habitat and working forests in the Tarboo Valley.

This past winter, three conservation futures workshops were held in different locations around the county and a program brochure was developed. The workshops were not well attended. However, a Conservation Futures Program Manual is nearly complete that will provide comprehensive information about the program and its requirements to applicants, sponsors and interested citizens.

As always, our meeting schedule and program information are displayed on our website at: http://www.co.jefferson.wa.us/commissioners/Conservation/conservation.asp. Meetings are always noticed and open to the public. You are cordially invited to attend anytime.

I will now proceed with the Conservation Futures Citizen Advisory Committee’s funding recommendations for 2009.

This year, the Jefferson County Conservation Futures Committee received three applications for conservation futures funding by the March 2 deadline. One project would place a conservation easement on fifty acres of farmland in Center Valley, another would add five acres to Port Townsend’s Quimper Wildlife Corridor and the third would place a conservation easement on ten acres in the Tarboo watershed.

On April 20, 2009, Committee members met to rank the projects and determine funding recommendations.
The projects proposed are as follows:

1. **Brown Dairy Project**, $82,500 towards the purchase of a perpetual conservation easement on 50 acres at 9165 Rhody Drive in Chimacum. This sum includes $5,000 in operation and maintenance costs. Proposed match would be state or federal grants and cash contributions. Jefferson Land Trust is the applicant and sponsor. Project location: Sec. 14, T. 29N, R. 1W.

2. **2009 Quimper Wildlife Corridor**, $137,500 towards the fee-simple purchase of 30 lots in the Fowlers Park Addition of the City of Port Townsend. This sum includes $5,000 in operation and maintenance costs. Proposed match would be land and cash donations. The City of Port Townsend is the applicant. Jefferson Land Trust is the sponsor. Project location: Sec. 33, T. 31N, R. 1W.

3. **Tarboo Wildlife Preserve East Side Addition**, $50,000 towards the purchase of a perpetual conservation easement on 10 acres east of 2151 Dabob Road in the Tarboo Valley north of Quilcene. No operation and maintenance funds are requested. Proposed match would be a contribution from Northwest Watershed Institute and a National Coastal grant. The Northwest Watershed Institute is the applicant. Jefferson Land Trust is the sponsor. Project location: Sec. 28, T. 28N., R. 1W.

Funds available for distribution to projects in the 2009 funding cycle total $275,000 of which up to $36,000 may be allocated to operations and maintenance. Together, the three applications request $270,000 of which $10,000 would be used for operations and maintenance expenses.

The committee members attended project presentations and attended site visits in March. Members weighed the merits of each project individually and submitted scores to the recorder who entered them into a spreadsheet for display at the April 20 meeting. At the meeting, the committee discussed and debated the preliminary scores for each project a question at a time arriving at the following, final, scores:

<table>
<thead>
<tr>
<th>Project</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown Dairy</td>
<td>247</td>
</tr>
<tr>
<td>2009 Quimper Wildlife Corridor</td>
<td>238</td>
</tr>
<tr>
<td>Tarboo Wildlife Preserve East Side Addition</td>
<td>217</td>
</tr>
</tbody>
</table>

The committee voted unanimously in favor of recommending to the BOCC the full funding amounts requested for Brown Dairy and the Quimper Wildlife Corridor. The vote to fund the Tarboo project, East Side Addition, was split, 5 in favor, 3 opposed, and failed for lack of an absolute majority, i.e. 6 out of 10 total members.*
The major reasons cited against Tarboo funding were:

1. This particular Tarboo parcel and project is less worthy/impressive than the two other 2009 candidate projects. It received a lower composite rating, and lower individual ratings in several categories, such as “degree to which project preserves opportunities that are otherwise lost or threatened” and “degree to which project provides educational or interpretive opportunities”.

2. The project is less urgent, i.e. the land has already been acquired by NWI via a loan arrangement; it is not necessary to repay the loan immediately; real estate development and market conditions are depressed and unlikely to improve in the near future.

3. The overall Tarboo conservation program would not be significantly affected if this parcel were not preserved.

4. Even though there are sufficient funds for all applicants this year, it is preferable to set aside the funds sought for this Tarboo project for future projects of higher quality.

The major arguments in favor of funding the project were:

1. This Tarboo parcel has natively regenerated forest land of value and significance; this is the only such parcel in the valley among commercially harvested stands; it is important to prevent the valuable valley riparian area from becoming an ecological island; the connection to the forest land is important even if there are some houses built there.

2. The overall Tarboo project has a proven track record as a highly valuable conservation project. It is important to support this portion because it is a piece of the larger configuration; the total project is greater than the sum of its parts.

3. It is not reasonable to deny a project funding based on a hypothetical future project that the CFFC is unable to evaluate in the present.

4. Projects with comparable and lower ratings have been funded by CFF in the past.

With this report, the Citizens Oversight Committee has discharged its obligation as set forth in the Conservation Futures Ordinance to review project submittals for recommendation to the Board of County Commissioners.

- Excerpt from the Bylaws: Decisions – Decisions to recommend projects to the BOC require an absolute majority, that is, a majority of the total number of appointed committee members. Any dissenting opinions will be recorded and included in the meeting summary. Other decisions of the committee require a simple majority of those committee members present.
Conservation Futures Citizen Oversight Committee
Appearance of Fairness Questionnaire
2015 Funding Cycle

Project applications in the 2015:
  Lower Big Quilcene River Riparian Protection Project
  Midori Farm Project
  Bishop Dairy Preservation Project
  2015 QWC Addition Project

The purpose of this form is to provide an optional written format to comply with the procedure for quasi-judicial decisions as described in Article IIIA of the Conservation Futures Bylaws (REV2012). Committee members may choose to answer these same questions verbally during the meeting to rank project applications.

Your name________________________________________________Date________________________
Please Print

Answer questions 1-5 with respect to the **Lower Big Quilcene River Riparian Protection Project**:

1. Do you object to the participation of any particular Committee member in this decision-making process?
   - [ ] Yes ____________________________________________________ [ ] No
   - Name(s)
   If you answer “yes”, you will be asked to identify the person and state the reasons for your objection(s). The Committee person whose objectivity is questioned will then determine if he or she should excuse him/herself.

2. Do you, as a member of the Committee, stand to gain or lose any financial benefit as a result of the outcome of this hearing?
   - [ ] Yes [ ] No
   An answer of “yes” must be explained at the meeting to rank projects and then you must MUST IMMEDIATELY RECUSE yourself from any debate or deliberation regarding that proposal. There is no need to reply “yes” if you hold what is deemed a ‘remote interest’ by state law found at RCW 42.23.020(2). A typical “remote interest” is the interest a volunteer at a not-for-profit organization has in seeing that his or her organization obtains CFF funding.

3. Are you, as a Committee member, able to hear and consider this proposal or application in a fair and objective manner, i.e., without bias and without a predisposition to any particular result regarding this proposal or application?
   - [ ] Yes [ ] No
   An answer of “no” must be explained at the ranking meeting and then you must MUST IMMEDIATELY RECUSE yourself from any debate or deliberation regarding that proposal.

4. Have you, as a Committee member, engaged in any communication outside this hearing with either a proponent or opponent of this particular proposal or application?
   - [ ] Yes [ ] No
If you answer “yes” you must describe the substance and facts regarding that outside conversation or contact, e.g., what was said by whom at the meeting to rank projects. The occurrence of an outside conversation or contact does not mean that you must excuse yourself. In the context of a land use decision this type of “appearance of fairness” problem can be eradicated if not only the substance of the outside conversation is publicly stated at the meeting, BUT ALSO the person or persons who were disadvantaged by not being present at the outside conversation or contact have the opportunity to rebut what was said or argued during that outside conversation or contact. In other words, “I’ve heard one side in private, so now I must offer the other side the opportunity to present their arguments.” If this is done, and the opportunity to rebut is truly provided, then the Committee member answering “yes” to this question need NOT excuse himself or herself.

5. Are you, as a Committee member, able to certify that you have attended the project presentation and either attended the site visit or viewed the official videotape?  
☐ Yes ☐ No

Answer questions 6-10 with respect to the Midori Farm Project:

6. Do you object to the participation of any particular Committee member in this decision-making process?  
☐ Yes ____________ ☐ No

If you answer “yes”, you will be asked to identify the person and state the reasons for your objection(s). The Committee person whose objectivity is questioned will then determine if he or she should excuse him/herself.

7. Do you, as a member of the Committee, stand to gain or lose any financial benefit as a result of the outcome of this hearing?  
☐ Yes ☐ No

An answer of “yes” must be explained at the meeting to rank projects and then you must MUST IMMEDIATELY RECUSE yourself from any debate or deliberation regarding that proposal. There is no need to reply “yes” if you hold what is deemed a ‘remote interest’ by state law found at RCW 42.23.020(2). A typical “remote interest” is the interest a volunteer at a not-for-profit organization has in seeing that his or her organization obtains CFF funding.

8. Are you, as a Committee member, able to hear and consider this proposal or application in a fair and objective manner, i.e., without bias and without a predisposition to any particular result regarding this proposal or application?  
☐ Yes ☐ No

An answer of “no” must be explained at the ranking meeting and then you must MUST IMMEDIATELY RECUSE yourself from any debate or deliberation regarding that proposal.

9. Have you, as a Committee member, engaged in any communication outside this hearing with either a proponent or opponent of this particular proposal or application?  
☐ Yes ☐ No

If you answer “yes” you must describe the substance and facts regarding that outside conversation or contact, e.g., what was said by whom at the meeting to rank projects. The occurrence of an outside conversation or contact does not mean that you must excuse yourself. In the context of a land use decision this type of “appearance of fairness” problem can be eradicated if not only the substance of the outside conversation is publicly stated at the meeting, BUT ALSO the person or
persons who were disadvantaged by not being present at the outside conversation or contact have
the opportunity to rebut what was said or argued during that outside conversation or contact. In
other words, “I’ve heard one side in private, so now I must offer the other side the opportunity to
present their arguments.” If this is done, and the opportunity to rebut is truly provided, then the
Committee member answering “yes” to this question need NOT excuse himself or herself.

10. Are you, as a Committee member, able to certify that you have attended the project presentation
and either attended the site visit or viewed the official videotape?
☐ Yes  ☐ No

Answer questions 11-15 with respect to the Bishop Dairy Preservation Project:
11. Do you object to the participation of any particular Committee member in this decision-making
process?
☐ Yes ________________________________ ☐ No

Name(s)
If you answer “yes”, you will be asked to identify the person and state the reasons for your
objection(s). The Committee person whose objectivity is questioned will then determine if he or
she should excuse him/herself.

12. Do you, as a member of the Committee, stand to gain or lose any financial benefit as a result of
the outcome of this hearing?
☐ Yes  ☐ No

An answer of “yes” must be explained at the meeting to rank projects and then you must MUST
IMMEDIATELY RECUSE yourself from any debate or deliberation regarding that
proposal. There is no need to reply “yes” if you hold what is deemed a ‘remote interest’ by state
law found at RCW 42.23.020(2). A typical “remote interest” is the interest a volunteer at a not-
for-profit organization has in seeing that his or her organization obtains CFF funding.

13. Are you, as a Committee member, able to hear and consider this proposal or application in a fair
and objective manner, i.e., without bias and without a predisposition to any particular result
regarding this proposal or application?
☐ Yes  ☐ No

An answer of “no” must be explained at the ranking meeting and then you must MUST
IMMEDIATELY RECUSE yourself from any debate or deliberation regarding that proposal.

14. Have you, as a Committee member, engaged in any communication outside this hearing with
either a proponent or opponent of this particular proposal or application?
☐ Yes  ☐ No

If you answer “yes” you must describe the substance and facts regarding that outside conversation
or contact, e.g., what was said by whom at the meeting to rank projects. The occurrence of an
outside conversation or contact does not mean that you must excuse yourself. In the context of a
land use decision this type of “appearance of fairness” problem can be eradicated if not only the
substance of the outside conversation is publicly stated at the meeting, BUT ALSO the person or
persons who were disadvantaged by not being present at the outside conversation or contact have
the opportunity to rebut what was said or argued during that outside conversation or contact. In
other words, “I’ve heard one side in private, so now I must offer the other side the opportunity to
present their arguments.” If this is done, and the opportunity to rebut is truly provided, then the
Committee member answering “yes” to this question need NOT excuse himself or herself.
15. Are you, as a Committee member, able to certify that you have attended the project presentation and either attended the site visit or viewed the official videotape?

☐ Yes ☐ No

**Answer questions 16-20 with respect to the 2015 QWC Addition Project:**

16. Do you object to the participation of any particular Committee member in this decision-making process?

☐ Yes ____________________________________________________________ ☐ No Name(s)

If you answer “yes”, you will be asked to identify the person and state the reasons for your objection(s). The Committee person whose objectivity is questioned will then determine if he or she should excuse him/herself.

17. Do you, as a member of the Committee, stand to gain or lose any financial benefit as a result of the outcome of this hearing?

☐ Yes ☐ No

An answer of “yes” must be explained at the meeting to rank projects and then you must MUST IMMEDIATELY RECUSE yourself from any debate or deliberation regarding that proposal. There is no need to reply “yes” if you hold what is deemed a ‘remote interest’ by state law found at RCW 42.23.020(2). A typical “remote interest” is the interest a volunteer at a not-for-profit organization has in seeing that his or her organization obtains CFF funding.

18. Are you, as a Committee member, able to hear and consider this proposal or application in a fair and objective manner, i.e., without bias and without a predisposition to any particular result regarding this proposal or application?

☐ Yes ☐ No

An answer of “no” must be explained at the ranking meeting and then you must MUST IMMEDIATELY RECUSE yourself from any debate or deliberation regarding that proposal.

19. Have you, as a Committee member, engaged in any communication outside this hearing with either a proponent or opponent of this particular proposal or application?

☐ Yes ☐ No

If you answer “yes” you must describe the substance and facts regarding that outside conversation or contact, e.g., what was said by whom at the meeting to rank projects. The occurrence of an outside conversation or contact does not mean that you must excuse yourself. In the context of a land use decision this type of “appearance of fairness” problem can be eradicated if not only the substance of the outside conversation is publicly stated at the meeting, BUT ALSO the person or persons who were disadvantaged by not being present at the outside conversation or contact have the opportunity to rebut what was said or argued during that outside conversation or contact. In other words, “I’ve heard one side in private, so now I must offer the other side the opportunity to present their arguments.” If this is done, and the opportunity to rebut is truly provided, then the Committee member answering “yes” to this question need NOT excuse himself or herself.

20. Are you, as a Committee member, able to certify that you have attended the project presentation and either attended the site visit or viewed the official videotape?

☐ Yes ☐ No
Please note: If it appears that a Committee member cannot meet the ideal established by the appearance of fairness doctrine, or that the rebuttal opportunity(ies) won’t or can’t be provided, then any Committee member who chooses to excuse himself or herself must also leave the room to prevent his or her non-verbal participation in the deliberation or decision. The Committee member who should have excused himself or herself but does not risks seeing a decision they had hoped for invalidated.

I certify that the information I have provided in this document is true and complete. I have signed this form under penalty of perjury in accordance with the laws of the State of Washington.

________________________________________  _______________
Your Signature          Date
ARTICLE I: NAME
The name of this organization is the Jefferson County Conservation Futures Fund Citizen Oversight Committee, hereafter referred to as the “Committee.”

ARTICLE II: PURPOSE
The purpose of the Committee is to oversee the application process for Conservation Futures Funds, and make acquisition recommendations to the Jefferson County Board of County Commissioners pursuant to the County’s Conservation Futures Funds Ordinance, hereinafter referred to as “Ordinance.”

ARTICLE III: FUNCTIONS & DUTIES
A. Functions
The Committee will exercise both legislative and quasi-judicial functions:

1. The Committee’s legislative functions consist of:
   a) establishing the grading and prioritizing principles that will be used to evaluate the worthiness of proposals, these principles must mesh with the six preservation criteria outlined in §4 of the Ordinance, and
   b) the review and analysis every two years, pursuant to §5.5 of the Ordinance, of the program principles.

2. The Committee’s quasi-judicial function is deciding which applications will be funded. These decisions require the Committee to deal with each application individually, and each application will face a “yea or nay” decision of the Committee.

Procedure for Quasi-Judicial Decisions
Before any hearing where quasi-judicial decisions are to be made by the Committee, County staff should ask the following questions out loud and on the record with respect to each DISTINCT application or proposal then before the Committee:

- “In order to obtain and maintain the appearance of fairness in this decision-making process, the Committee wishes to know if there is anyone in the audience who objects to the participation of any particular Committee member in this decision-making process, and, if so, to state the reasons for that objection.”

If someone objects, then the Committee person whose objectivity is questioned must determine if he or she should excuse him/herself. Votes should not be taken on whether or not the member should excuse himself or herself for fear of bad feelings. The presumption should always be that the Committee member should excuse himself or herself to preserve the legality and fairness of the decision that is finally reached. Ultimately, however, the decision on recusal rests entirely with the Committee member whose objectivity has been questioned. A Committee member who does not excuse himself or herself, but who should have done so, risks having the entire decision invalidated later.

After asking for objections from the audience, then the Committee members should be asked these questions with respect to each DISTINCT application or proposal:

- “Do you, as a member of the Committee, stand to gain or lose any financial benefit as a result of the outcome of this hearing?”
- "Are you, as a Committee member, able to hear and consider this proposal or application in a fair and objective manner, i.e., without bias and without a predisposition to any particular result regarding this proposal or application?"

- "Have you, as a Committee member, engaged in any communication outside this hearing with either a proponent or opponent of this particular proposal or application?"

- "Are you, as a Committee member, able to certify that you have attended the project presentation and either attended the site visit or viewed the official videotape?"

If any Committee member has to answer “yes” to the first of these questions or “no” to the second or fourth of these questions, then they must say so out loud, explain their answer(s), AND MUST IMMEDIATELY RECUSE themselves from any debate or deliberation regarding that proposal. If a Committee member holds what is deemed a ‘remote interest’ by state law found at RCW 42.23.020(2), then that Committee member need not reply “yes” to the first question listed above. A typical “remote interest” is the interest a volunteer at a not-for-profit organization has in seeing that his or her organization obtains CFF funding.

A reply of “yes” to the third question listed above must then lead to the Committee member describing the substance and facts regarding that outside conversation or contact, e.g., what was said by whom.

The occurrence of an outside conversation or contact does not mean that the Committee member must excuse himself or herself. In the context of a land use decision this type of “appearance of fairness” problem can be eradicated if not only the substance of the outside conversation is publicly stated at the meeting, BUT ALSO the person or persons who were disadvantaged by not being present at the outside conversation or contact have the opportunity to rebut what was said or argued during that outside conversation or contact. In other words, “I’ve heard one side in private, so now I must offer the other side the opportunity to present their arguments.”

If this is done and the opportunity to rebut is truly provided, then the Committee member answering “yes” to the third question need NOT excuse himself or herself.

If it appears that the Committee member cannot meet the ideal established by the appearance of fairness doctrine, or that the rebuttal opportunity listed above won’t or can’t be provided, then any Committee member who chooses to excuse himself or herself must also leave the room to prevent his or her non-verbal participation in the deliberation or decision. The Committee member who should have excused himself or herself but does not risks seeing a decision they had hoped for invalidated.

**B. Duties :**

In compliance with (RCW 71A.14.020) it shall be the duty of Committee to:

1. Oversee the annual process to solicit, review and recommend Conservation Futures Fund projects to the Jefferson County Board of County Commissioners.

2. Use the Rating Scale developed by the Conservation Futures Fund Advisory Committee, together with the six preservation criteria outlined in §4 of the Ordinance, to determine which of the applications are most worthy of recommendation.

3. With staff assistance, prepare recommendations for the Jefferson County Board of County Commissioners (BOCC) to acquire the properties identified in the top-ranked project applications.
4. Conduct all business in compliance with Washington State statutes and regulations, with particular attention to:
   a. “Code of Ethics for Municipal Officers-Contract Interests,” RCW 42.23.030, which states, in part: “No municipal officer shall be beneficially interested, directly or indirectly, in any contract which may be made by, through or under the supervision of such officer, in whole or in part, or which may be made for the benefit of his or her office, or accept, directly or indirectly, any compensation, gratuity or reward in connection with such contract from any other person beneficially interested therein.”
   b. The Open Public Meetings Act, codified as Ch. 42.30 RCW
   c. The Public Disclosure Act, codified at Ch. 42.17 RCW is applicable both to the meetings held, and to documents generated by the Committee.

5. The Committee shall review program principles at least once every two years and make recommendation to the Board of County Commissioners for modification to the program.

6. Carry out other duties that the Jefferson County Board of County Commissioners may request, or that the Division Natural Resources may prescribe by rule.

7. Committee members are expected to fully participate in the work and deliberations of the Committee, and to support Committee By-laws.

ARTICLE IV: MEMBERSHIP

A. Members of the Committee shall be Jefferson County residents who are appointed by the Board of County Commissioners. Appointments of members shall be made from a list of applicants who shall submit a letter of interest to the Board of County Commissioners stating their qualifications for serving on the Committee.

B. The Committee shall be comprised of no less than nine (9) citizen members, which includes at least two citizens from each Commissioner district, representing a broad spectrum of interests and expertise, according to §5.3 of the Ordinance. No interest group is automatically and permanently entitled to one of the nine seats according to §5.3 of the Ordinance.

C. Once established, the terms of the members shall be four years, except that at the establishment of the Committee, four (4) members shall serve a two-year term.

D. The Committee shall adopt rules of conduct and abide by the rules of conduct, to include adherence to applicable statutes on issues such as conflict of interest. These By-Laws shall constitute such rules of conduct.

E. A Chair and Vice-chair shall be elected from among the members.

F. Members shall not be compensated for the performance of their duties on the Committee.

G. Committee members are expected to attend all meetings, and to notify the Chair or Staff in advance, if possible, if unable to attend. If a Committee member misses a meeting, it is his/her responsibility to be informed on the issues the next meeting. Attendance at CF Committee meetings by any technology that allows the member not physically present to hear and be heard during the CF Committee meetings shall constitute attendance.

H. Meetings will start and end on time; all members are expected to be prompt and prepared.

I. The Committee may recommend to the Board of County Commissioners the removal of a Committee member for inefficiency, neglect of duty or malfeasance in office. The process for addressing this circumstance is outlined in VII. C. of these Bylaws.
ARTICLE V: OFFICERS—ELECTION OF OFFICERS—SUCCESSION
A. Officers of the Committee shall consist of a Chair and Vice-chair. The Chair and Vice-chair shall be elected annually at the first regular meeting of the new calendar year and shall serve a one-year term. The Chair and Vice-chair may be elected to consecutive terms.

B. The Chair of the Committee shall: preside at all meetings and execute the agenda of such meetings in an orderly manner; when appropriate and necessary, establish Sub-committees and appoint members to them; and officially represent the Committee before other organizations or groups. The Chair will sign documents of the Committee.

C. The Vice-chair shall officiate as Chair in the Chair’s absence. In the absence of both Chair and Vice-chair at a meeting, members shall elect a temporary Chair to perform their duties for that meeting.

D. The Chair and Vice-chair shall be elected by a majority vote from the Committee. Nominees must be active members who have consented to serve.

E. Nomination of officers is from the floor and, where more than one nomination to an office is received, voting will be a secret ballot.

ARTICLE VI: STAFF ROLES
County staff will avail themselves to the Conservation Futures Committee to record the proceedings of all Committee meetings, to conduct outreach and education as requested by the Committee, and as possible, and reasonable within the legislated budget, to be a link between the Committee and the County, and to insure that the Committee operates in compliance with County and State ordinances, statutes and regulations. County staff shall have full discretion to establish or limit the scope or size of their work or participation on Committee matters.

ARTICLE VII: VACANCIES
A. Resignations: A member may resign by submitting written notice to the Jefferson County Board of County Commissioners.

B. Leave of Absence: The Committee may grant a leave of absence for a member not to exceed two consecutive meetings per year.

C. Removal: Members absent without excuse from more than three meetings a year, shall be asked to resign. A member with two unexcused consecutive absences shall be notified of the policy regarding attendance requirement, and asked to decide whether he/she wishes to continue as a member.

The Committee may, by a majority vote of the total membership, recommend the removal of a member to the Board of County Commissioners, provided that thirty days notice of the pending action has been provided to the member.

D. Vacancies may be advertised in the paper of record encouraging qualified county residents to apply.

SECTION VIII: MEETINGS
A. Notification The Committee shall establish meeting times and notify the public as required by Jefferson County policies.
B. **Venue.** Regular meetings shall be held in Jefferson County. The Committee may conduct special meetings and emergency meetings when deemed to be in the best interests of the Committee and the community. Public notice shall be properly given for special meetings, as well as whenever a regular meeting must be rescheduled or relocated.

C. **Meeting materials** will be sent to Committee members in advance.

D. **Preparation.** It is the responsibility of each Committee member to be prepared for each meeting.

E. **Courtesy.** Committee members are expected to be respectful of the person who is speaking, no side conversations.

F. **Minutes:** Minutes of all meetings shall be recorded and a copy sent to each Committee member at least three days prior to the next scheduled meeting. A permanent file of minutes of Committee meetings shall be maintained in County offices. Any recommendations to the Board of County Commissioners, or key action items, will be noted in detail in the summary notes.

G. **Voting:** Voting shall be limited to regular Committee members. Voting shall be conducted by voice, show of hands or by ballot if any member of the Committee so desires. There will be no voting by proxy on any question before the Committee. The Chair is considered a regular voting member.

H. **Attendance:** No member may rate or vote upon any project unless that member has (1) attended the formal project presentation and (2) either attended the site visit conducted by the project sponsor/applicant or viewed the official videotape of that visit.

I. **Quorum.** A quorum must exist to conduct a meeting and/or take a vote. A simple majority of the total of the members currently appointed to the Committee constitutes a quorum for the conduct of Committee business. Voting is by voice vote, except where these rules, or the Committee itself, may require a ballot or roll call vote.

J. **Conflict of Interest:** Once appointed, a member shall not participate in a discussion or vote upon a matter in which he or she has a direct or indirect financial interest. A conflict would arise when 1) the member, 2) any immediate family member or partner, or 3) an organization which employs, or is about to employ, any of the above has a financial or other interest in a firm or organization selected for award. If a conflict of interest arises, the member shall notify the Chair or staff. Committee members must agree to conduct Committee business in compliance with the guidelines provided by the County’s Deputy Prosecuting Attorney in his memo of July 9, 2002.

K. **Rules of Order:** All regular and Committee meetings shall be conducted by the Chair or Vice-chair according to Roberts Rules of Order.

L. **Agenda:** The agenda shall indicate the order of Committee business. The Committee Chair may approve changes to the agenda. Copies of the agenda and relevant supporting materials shall be mailed to Committee members at least three days prior to the meeting. Time shall be scheduled on the regular meeting agenda for public comment.

M. **Public Meetings.** All meetings of the Committee shall be open to the public and all Committee actions shall take place in Committee meetings.

N. **Special meetings** may be called by formal action of the Committee, by order of the Chair or by written request to the Chair by a minimum of three members. Notice of such special meeting is to be
provided to all Committee members at a minimum of 10 days prior to the meeting, and public notice will be provided as specified above.

O. **Sub-committee** work sessions may be scheduled as needed. At such meetings the public is welcome to attend but shall not ordinarily be allowed to participate unless specifically requested by the sub-committee Chair.

P. **Decisions.** Decisions to recommend projects to the BoCC, require an absolute majority, i.e., a majority of the total number of appointed Committee members. Any dissenting opinions will be recorded and included in the meeting summary. Other decisions require a simple majority of those Committee members present, assuming the number of members present constitutes at least a quorum. The Chair will insure that all viewpoints are heard, and if possible, will attempt to achieve consensus among Committee members.

Q. **Order of Business** – Meeting Procedure

- Call to order, roll call and determination of quorum.
- Agenda Items
  1. Minutes of previous meeting
  2. Old business
  3. Sub-Committee Reports
  4. New business
  5. Discussion of next meeting date and agenda
  6. Announcements
  7. Observer comments
  8. Adjournment

- The Chair may alter the regular order of business in preparing the agenda when special circumstances and the efficient use of time dictate.

R. **Open Meetings.** All meetings of the Committee shall be conducted pursuant to the Open Public Meetings Act (RCW 42.30).

**ARTICLE IX: AMENDMENT OF BY-LAWS**

These bylaws may be amended by a two-thirds majority vote of the Committee insofar as such amendments do not conflict with Jefferson County Policy or Washington State Code. Any regular Committee member may propose an amendment to the bylaws. Such proposed amendments must be voted on when a quorum is present. These By-Laws, in their present form or as amended, may be subject to review by the County Commissioners in the fourth calendar year after their enactment by the Committee, and every fourth year thereafter.
Mission of the Conservation Futures Program

The mission of the Jefferson County Conservation Futures Program is to provide a system of public open spaces, those open spaces being necessary for the health, welfare, benefit and safety of the residents of Jefferson County and the maintenance of Jefferson County as a desirable place to live, visit and locate businesses.

Conservation Futures Citizen’s Oversight Committee Membership (as of January 2015)

Phil Andrus, Citizen, District #2
Mary Biskup, Citizen, District #1
Scott Brinton, Interest – Agriculture
Lige Christian, Citizen, District #3
JD Gallant, Citizen, District #3
Jerry Gorsline, Citizen, District #2
Rob Harbour, Interest – Working Lands
Ray Hunter, Interest – Fallow Farms
Richard Jahnke, Interest – Coastal Areas
Craig Schrader, Interest – Climate Change
Lorna Smith, Interest – Ecotourism
Sarah Spaeth, Interest – Jefferson Land Trust

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  Project Agreement Template
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Overview

Jefferson County welcomes your application to the Conservation Futures Program (CF Program). Please do not hesitate to contact Jefferson County Environmental Health Department with questions at Ph: 360/385-9444, Fax: 360/379-4487 or tpokorny@co.jefferson.wa.us. The Conservation Futures Program website address is http://www.co.jefferson.wa.us/commissioners/Conservation/conservation.asp.

In July 2002, the county commissioners approved Conservation Futures Ordinance, now codified at Jefferson County Code Section 3.08 in accordance with the Revised Code of Washington (RCW) Chapter 84.34. The ordinance establishes goals for the county’s Conservation Futures Program and an allocation process for the conservation futures tax levy.

The purpose of the CF Program is to acquire open space lands, including green spaces, greenbelts, fish and wildlife habitat, trail rights-of-ways, agricultural land and timber land (as those terms are defined in Ch. 84.34 RCW). Projects may include fee-simple or any lesser interest or development right with respect to real property as well as operation and maintenance (O & M) activities. O & M projects must be linked to CF-funded acquisitions.

A minimum 50% match is required for all project types. Match must be cash, land trades, the value of land to be traded, or other open spaces linked to the property under application. Open space, wildlife habitat, agricultural and timber lands are all eligible. The project sponsor must sign a grant agreement with the county (see Appendix A). County code (JCC 03.08.030(10)) requires that properties or easements be held by public entities or others as defined in RCW 84.34.210. Government entities may choose to share title of a property with a non-profit nature conservancy corporation or association. Public open spaces must be available on the same conditions to all residents of the county for the benefit of all Jefferson County residents and visitors. Applicants for projects may include the county, municipalities, park districts, state or federal agencies, private non-profit corporations or associations, and private individuals.

Project applicants must be represented by a local sponsoring organization based in Jefferson County. Potential sponsors include local governments, special purpose districts and non-profit corporations. A list of potential sponsors is available by contacting program staff. A project sponsor is responsible for the content and submission of the application, organizing and hosting a site visit, making a formal project presentation to the CF Committee, the stewardship plan and its implementation, and all contracting, reporting, and reimbursement obligations with Jefferson County.

Available funding is announced early in the calendar year and applications are provided by Jefferson County Environmental Health. Conservation Futures Fund monies can be the collateral, revenue stream or security for long-term financing (typically bonds) in a manner consistent with law. Public workshop(s) may be held prior to the start of the funding round. Staff is always available to answer questions from sponsors, applicants, and interested parties.

This year, applications will be due Monday, March 2, 2015 and sponsors present projects to the CF Committee and host site visits in April. Information about the application period is posted on the program website, announced in local newspapers and via email, and available by contacting program staff. In April or May, the CF Committee meets to rank projects, determine recommended funding levels, and compose its overall recommendations to the
BoCC. The BoCC typically makes award determinations in June. Funding for reimbursement is generally not available until August. At least every other year, the BoCC reviews the priorities of the Conservation Futures Program and the project ranking process. All meetings of the Conservation Futures Committee are open to the public. Citizens are encouraged to attend.

Conservation Futures Citizen Oversight Committee (CF Committee)

The CF Committee membership is intended to reflect a broad spectrum of interests and expertise. It includes at least two individuals from each commissioner district and at least nine citizens total. Anyone interested in applying for a seat on the committee is encouraged to contact the Board of County Commissioners Office (jeffbocc@co.jefferson.wa.us) and/or program staff.

Project Selection

The CF Committee ranks projects according to criteria designed to reflect the priorities expressed in Jefferson County Code (JCC 03.08). Please see the code and current application for specifics.

After the site visits and project presentations, each CF Committee member independently scores each project on a preliminary basis. At the next meeting, the scores are discussed and projects are ranked. The committee then develops a recommendation for allocating the available funding between projects and between capital expenses and O & M. Both the rank order and the funding recommendations are presented to the county commissioners and a public hearing is held at a regularly scheduled meeting, usually in June.

Designation of grant awards may be made at this time or at a later date, at the discretion of the commissioners. Funds may be available as early as August. Please contact program staff for more information about the timing of funds.

Information Sources

The Conservation Futures Program is administered by the Commissioners Office with assistance from the Environmental Health Department. Please note that the information contained in this manual does not supersede the statutes governing the Jefferson County Conservation Futures Fund and Program, and should be read in conjunction with them.

Relevant sections of law are found in Revised Code of Washington, Chapter 84.34 (RCW 84.34) and the Jefferson County Code (JCC 03.08).

To access RCW 84.34 online, visit www.leg.wa.gov/Help/helpwithsearch.htm and click on “Laws and Agency Rules.” The Jefferson County Code is available online at http://www.codepublishing.com/WA/JeffersonCounty.

Contact program staff at ph: 360/379-4498, fax: 360/379-4487 or send an email to tpokorny@co.jefferson.wa.us.
Reimbursement

All grants are funded through the Jefferson County Conservation Futures tax levy. Except in the case of escrow payments, sponsors must expend their own funds on eligible and allowable expenditures prior to requesting reimbursement. With sufficient lead time, an approved settlement statement, and a preliminary title report, CF funds may be made available to the title company shortly before closing for the direct costs of property acquisition and closing. Please discuss dates for closings and loan periods with program staff to help ensure that grant funds are ready and available when needed.

The project sponsor will commit to providing a matching contribution of no less than the amount of conservation futures funds awarded to the project before conservation futures tax funds are reimbursed to that sponsor. This contribution may consist of:

- cash
- land trades if the valuation of the land to be traded is established by a valuation arising from an appraisal generated by a Washington State Certified Licensed Appraiser (Member of the Appraisal Institute MAI);
- the cash value of the land to be traded, excluding Jefferson County conservation futures contributions; or
- other open spaces acquired within the previous two years that is situated either directly adjacent to or could, in the sole discretion of the county, be directly linked to the property under application.
- cost of appraisal, title insurance, closing costs, and other miscellaneous fees (See JCC 3.08.030(5)).

The funding request, reimbursement form and back up documentation may be submitted any time during the project period. It is important to implement projects in as timely a manner as possible and also to bill in a timely manner. Deeds and conservation easement documents must be recorded by the Jefferson County Auditor’s Office within 30 days of closing.

If matching funds are not secured within three years, the project may be required to re-apply.

Jefferson County must pre-approve easement language and will add restrictive language to statutory warrantee deeds, or require the use of other legal instruments, to ensure conservation of project and match properties in perpetuity.

Compliance with All Laws

Project sponsors shall comply fully with the project agreement, grant program policies, County policies and all applicable federal, state and local laws, orders, regulations and permits.

Record Retention/Public Records Act

The project sponsor shall retain all books, records, documents, data and other materials relevant to the agreement for a minimum of six (6) years after the completion of the project. Documents related to the expenditure of CF funds, by way of example only, purchase and sale contracts, settlement documents, invoices, e-mails, expert reports and/or appraisals, are Public Records subject to disclosure in accordance with the Public Records Act, Ch. 42.56
RCW, if requested by a citizen or entity. All meetings and activities of the CF Committee are subject to the Open Public Meetings Act, Ch. 42.30 RCW. The public is always invited and encouraged to attend. Two observer comment periods are included in each agenda.

Acquisition Projects

Project applications for the acquisition of property must meet the following threshold criteria in order to be considered for funding. Each application will receive an initial screening to make sure that it is in compliance. Applicants are encouraged to submit pertinent materials and documents, as appropriate, in addition to those items required. Multi-year acquisition projects are permitted but require additional justification.

Project Eligibility

__ Proposed acquisitions must have a willing seller.

__ The property, or property right, must be eligible for purchase as defined by state law, RCW 84.34.210 (i.e. “…protect, preserve, maintain, improve, restore, limit the future use of, or otherwise conserve, selected open space land, farm and agricultural land, and timber land…”).

__ Conservation Futures funds **cannot** be used to acquire property, or a property right, that will be used for active recreation purposes (including but not limited to sports fields, playgrounds, recreation centers, swimming beaches or pools, motorized boat launches).

__ Conservation Futures funds **cannot** be used for passive development of a site. For the purposes of this application, passive improvements include, but are not limited to, trails, interpretive centers, viewpoints, picnic areas, access, restrooms, landscaping and parking.

Applicant Eligibility

Eligible applicants include the County, municipalities, Park Districts, State or federal agencies, private non-profit corporations or associations, and private individuals.

Sponsor Eligibility

All applicants must have a local sponsor. Eligible sponsors include county, municipalities, park districts, or private non-profit corporations based in Jefferson County. A current, but not necessarily comprehensive, list of eligible local sponsors may be requested from program staff.

Eligible Capital Project Expenditures: (See also JCC 3.080.030(7))

Capital project expenditures or match may include:

__ Costs of acquiring real property, including interests in real property
__ Cost of related relocation of eligible occupants (includes administration)
__ Cost of appraisal
__ Cost of appraisal review
__ Cost of title insurance
__Closing costs  
__Pro rata real estate taxes  
__Recording fees  
__Compensating tax  
__Hazardous waste substances reports  
__Directly related staff and administrative costs (These are limited to 5% of the total cost of the project.)  
__Related legal costs excluding the cost of preparing application for conservation futures funds.  
__Baseline documentation  
__Boundary survey  
__Cultural resources review (survey, excavation, on-site monitoring and data recovery)

Conservation futures tax levy funds may not be used to acquire any real property or interest in real property therein through the exercise of the power of eminent domain.

_**Eligible Operations & Maintenance Expenditures**_ — Please note: Total O & M awards are limited to 13% of the conservation futures funding available in any year – contact staff for details.

Operations & Maintenance expenditures or match may include, but are not limited to:

__Cultural resources review (survey, excavation, on-site monitoring and data recovery)  
__Demolition  
__Fencing (if needed for public safety or resource protection)  
__Noxious weed control (initial control, up to $75 per acre)  
__Signage  
__Special site-specific reports (e.g. stewardship reports)  
__Wetland identification and/or delineation

_**Stewardship Plan**_

Prior to reimbursement, sponsors must provide a stewardship plan that describes how the property, or property right, will be maintained over time. Costs for stewardship plans are eligible for operations and maintenance reimbursement only under “Special Reports” (not as a capital acquisition expense).

_**Title Report and Title Insurance**_

Please make county staff aware of issues that could affect the title report and provide updates as they are generated. A title report and title insurance are to be issued in conjunction with the property transaction.

_**Appraisals**_

Successful applicants must provide an independent appraisal (standard, narrative or M.A.I.) from a Washington State Certified Licensed Appraiser if the estimate of value exceeds the assessed value at the time that reimbursement is requested. In no case shall conservation futures funds dispersed exceed the grant amount awarded by the BoCC. No appraisal is required for properties assessed at $20,000 or less.

The appraisal must:
be no more than 1 year old. A Supplemental Update by the original appraiser may be required, at the discretion of the county, if the appraisal is more than six months old.

include a current Title Report provided at the time of the most current appraisal or update.

if timber, mineral or aquatic resources are to be included as value to the appraisal, then the appraisal shall include a separate timber, mineral or aquatic resources evaluation of value,

or

an opinion of value from a qualified representative of the real estate industry or recent valuation from the Jefferson County Assessor’s Office may be used when the total assessed value does not exceed $20,000.

**Review Appraisals**

No appraisal review is required of the sponsor by the CF program. However, the CF Committee and/or the county may choose to select an appraisal for independent review for any reason.

**Project Implementation**

At the time of purchase or the signing of a “purchase and sale agreement”, the appraisal must be no more than a year old unless an extended period is requested and approved by the county, up to a total of 18 months.

**Application and Attachment Requirements for Acquisition Projects**

All materials must be submitted in hard copy except as noted below and specified in the application:

- **Proof of Willing Seller:** A “Willing Seller” letter confirming that the current owner of the property proposed for acquisition is willing to sell.

- **Estimate of Value:** A county assessment, certified appraisal of value, and/or an estimate of value from the project sponsor.

- **Site Location Map:** On a Jefferson County base map, or on a map of the sponsoring agency’s jurisdictional boundaries, clearly identify the location of the proposed acquisition.

- **Project Boundary Map:** On a quarter-section map or other map of sufficiently large scale, identify the boundaries of the proposed project.

- **Color Images:** Provide six (6) different views of the property proposed for acquisition. The images should show vegetation, terrain, waterfront, man-made features, access roads, wetlands, unique characteristics, etc. Please include captions and an aerial view, if available. Provide in hard copy as well as JPEG or PDF.

- **Development Plan or Narrative:** Provide a schematic or master plan map of the project site showing proposed uses and improvements, if applicable.

- In addition, if the application sponsor is a private non-profit organization, attachments must also include:
  - **Proof of 501(c)(3) Status**
  - **Current Budget**
  - **Board Roster**
Organization Chart or Staff Roster
Most Recent Financial Statements (audited if possible)
Copy of minutes or resolution documenting official action to submit application for proposed acquisition. If more than one project is submitted from the same sponsor, the minutes or resolution should indicate the project priority and how it was determined.

Operation and Maintenance Funding

Availability of Funds for O & M

Only projects that are acquired using conservation futures funds are eligible for O & M funding. Requests for O & M funding should not exceed the available limit (consult with program staff). Approved disbursements for operation and maintenance of interests in real property purchased with conservation futures tax levy monies shall not in any particular year be greater than fifteen percent (15%) of the conservation futures tax levy monies raised in the preceding year.

Project Eligibility

Operation and maintenance funding may be used for any property acquired with Conservation Futures funds. Conservation futures tax levy funds appropriated for O & M or interests in real property shall not supplant or replace any existing funding for maintenance and operation of parks and recreational lands.

Applicant Eligibility

Eligible applicants include the County, municipalities, Park Districts, State or federal agencies, private non-profit corporations or associations, and private individuals.

Sponsor Eligibility

All applicants must have a local sponsor. Eligible sponsors include the County, municipalities, Park Districts, or private non-profit corporations based in Jefferson County.

Application and Attachment Requirements for O & M Projects

All requested materials must accompany the application upon submission. If an item is irrelevant to the project at hand, please explain why this is so.

__ Proof of Willing Seller: A “Willing Seller” letter confirming that the current owner of the property proposed for acquisition is willing to sell.
__ Estimate of Value: A County assessment, certified appraisal of value, and/or an estimate of value from the project sponsor.
__ Site Location Map: On a Jefferson County base map, or on a map of the sponsoring agency’s jurisdictional boundaries, clearly identify the location of the proposed acquisition.
__ Project Boundary Map: On a Quarter-section map or other map of sufficiently large scale, identify the boundaries of the proposed project.
Color Images: Provide six (6) digital images of the property proposed for acquisition. The images should show flora, terrain, waterfront, man-made features, access roads, wetlands, unique characteristics, etc. Please include captions and an aerial view, if available.

Development Plan or Narrative: Provide a schematic or master plan map of the project site showing proposed uses and improvements, if applicable.

In addition, if the application sponsor is a private non-profit organization, attachments must also include:

- Proof of 501(c)(3) Status
- Current Budget
- Board Roster
- Organization Chart or Staff Roster
- Most Recent Financial Statements (audited if possible)
- Copy of minutes or resolution documenting official action to submit application for proposed acquisition. If more than one project is submitted from the same sponsor, the minutes or resolution should indicate the project priority and how it was determined.

Budget and Timeline

Attached to the first Annual Reporting Form must be a budget and timeline for expenditure of O&M funding for the succeeding ten (10) years measured from the date of approval by the BoCC.

Documentation of Match

A match of 50% must be documented with each invoice. Match guidelines are identical for acquisition and O & M proposals. In-kind labor cannot be used as match.

Reporting

Any project sponsor receiving O & M funds is required to submit a report each October until those funds are expended. An expenditure summary that provides the following information must accompany billing:

1) Date the payment was made.
2) The vendor and/or employee to whom the payment was made.
3) A description of what was purchased or what work and/or services were performed; provide a description of what service or work was performed for the payroll costs or by the sub-contractor.

Application and Attachment Requirements for O&M Projects

To apply for O & M funding for a project previously purchased using CF Funds, use the standard application form. In question #1, refer to the original project title and year that the project was approved followed by “O & M Request Only”. If you feel that a question is irrelevant to the project at hand, please explain why.
Required Meeting and Site Visit

Project sponsors are required to host a visit to the project site and make a formal presentation to the CF Committee. The presentation must begin with an introductory project description and then be organized according to the sequence of questions listed on the Rating Sheet. Site visits are videotaped by county staff. The site visits and presentations are scheduled in March or April.

Grant Notification and Agreement

Sponsors will be notified by staff of grant awards as soon as possible after the BoCC makes their decision, usually in June. Sponsors will then be asked to sign a project agreement with Jefferson County. An informational template is provided with this manual.

Annual reports

Sponsors are required to submit a brief progress report by October 30 every year for three years after the acquisition funds are disbursed to the applicant, whichever is later. The progress report must address any changes in the project focus or purpose, progress in obtaining matching funding, and stewardship and maintenance. Sponsors receiving O&M funds will also submit an annual report for each year that O&M funds are expended. The Committee will use the information to develop a project “report card” that will be submitted annually to the Board of County Commissioners. A report format template is included with this manual and will be provided to the project sponsor electronically.

Program Suggestions

Suggestions for program improvements are always welcome and may be provided to the Conservation Futures Committee by letter or email via staff at the contact information on page 3. Every CF Committee meeting also includes two public comment periods. Meeting times are provided in newspapers and on the program website.
### Appendix A

**Conservation Futures Funding Request and Reimbursement Form**

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>Date:</th>
</tr>
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<tbody>
<tr>
<td>Project Sponsor:</td>
<td></td>
</tr>
<tr>
<td>Billing Period:</td>
<td></td>
</tr>
</tbody>
</table>

Is this the final billing? Yes [ ] No [ ] Invoice Number [ ]

Sponsor’s Certificate: I hereby certify under penalty of perjury that the items and total listed and attached herein are proper charges for materials, merchandise or services furnished and/or services rendered have been provided without discrimination because of age, sex, marital status, race, creed, color, national origin, handicap, religion or Vietnam or disabled veterans status.

BY ____________________________
Title Date

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<thead>
<tr>
<th>Categories (attach detailed lists and receipts)</th>
<th>To Be Completed By Sponsor</th>
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<tbody>
<tr>
<td>Project Agreement</td>
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<tr>
<td>Previous Expenditures To Date</td>
<td>Costs For This Billing</td>
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<tr>
<td>Expenditures</td>
<td>Non-Reimbursable Match</td>
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<tr>
<td>Non-Reimbursable Match</td>
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<td>Total</td>
<td>Expenditures</td>
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<tr>
<td>Non-Reimbursable Match</td>
<td>Total</td>
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<td>Total</td>
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<th>Land Totals</th>
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<tr>
<td>O &amp; M Totals</td>
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**Funding and Expenditure Formula (For CF Program Staff Use ONLY)**

<table>
<thead>
<tr>
<th>Agreement Information</th>
<th>Previous CF Reimbursements</th>
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<tbody>
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<td>Match Source</td>
<td>Date</td>
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2015 CF Program Manual
http://www.co.jefferson.wa.us/commissioners/Conservation/conservation.asp
JEFFERSON COUNTY CONSERVATION FUTURES PROGRAM
PROJECT AGREEMENT
(template only)

Project Sponsor:
Project Title:
Project Number:
Approval: Resolution No. xxx on xxx, 2015

A. Parties to the Agreement
This Project Grant Agreement (Agreement) is entered into between County of Jefferson
(County), PO Box 1220, Port Townsend, Washington 98368 and
________________(Sponsor), xxxxx, xxxx, WA 983xx, and shall be binding upon the
agents and all persons acting by or through the parties.

B. Purpose of the Agreement
This Agreement sets out the terms and conditions by which a grant is made through the
Jefferson County Conservation Futures Fund. The grant is administered by Jefferson County
Environmental Health for the Sponsor for the project named above.

C. Description of Project
The Project is described in the attached xxx Conservation Futures Program Property
Acquisition and/or Operations and Maintenance Project Application. The Project funds are to
be used towards the purchase of xxxx, Jefferson County Parcel Numbers xxxx. All expenses
are to be incurred prior to xxxx. The conservation easement will permanently protect xxxx.
The easement Grantor xxxx.

D. Term of Agreement
The Project Sponsor’s on-going obligation for the above project funded by this Agreement is
to provide maintenance of the site or facility to serve the purpose for which it was intended in
perpetuity unless otherwise identified in this Agreement.

E. Period of Performance
The Project reimbursement period for acquisition expenses shall begin on xxxx xx, 52015.
The Project reimbursement period for acquisition expenses will end on xxx xx, 2017 unless
proof of match is provided prior to this date. No expenditure made before xxx xx, 52015 is
eligible for reimbursement unless incorporated by written amendment into this Agreement.

F. Project Funding
The total grant award provided by the Conservation Futures Fund (CFF) for the Project shall
not exceed $xxxxxx and Jefferson County CFF shall not pay any amount beyond that approved
herein for funding of the Project. The Sponsor shall be responsible for all total costs for the
Project that exceed $xxxxxx. In no event will the CFF funds expended for this purchase
exceed fifteen percent (15%) of the overall acquisition cost of APN xxx-xxx-xxx. This
Project is eligible for reimbursement of capital project and operations and maintenance
expenditures as described in the Jefferson County Conservation Futures Program Manual for
the 52015 Funding Cycle.

The contribution by the Sponsor toward work on the Project at a minimum shall be as
indicated below. The contribution by the County toward work on the Project is described
immediately above and in “C” above.
<table>
<thead>
<tr>
<th>Acquisition</th>
<th>Percentage</th>
<th>Dollar Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservation Futures – xxxx</td>
<td>xx%</td>
<td>$xx</td>
</tr>
<tr>
<td>Project Sponsor</td>
<td>xx%</td>
<td>$xx</td>
</tr>
<tr>
<td>Total Acquisition Cost</td>
<td>100%</td>
<td>$xx</td>
</tr>
<tr>
<td><strong>Operations and Maintenance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conservation Futures – xxxx</td>
<td>xx%</td>
<td>$xx</td>
</tr>
<tr>
<td>Project Sponsor</td>
<td>xx%</td>
<td>$xx</td>
</tr>
<tr>
<td>Total Operations and Maintenance Cost</td>
<td>100%</td>
<td>$xx</td>
</tr>
</tbody>
</table>

**G. Unexpended Project Allocations**

Should unexpected Project allocations, including, but not limited to project completion at less than the estimated cost or, alternatively, the abandonment of the Project occur, then the Sponsor shall notify the County.

**H. Rights and Obligations**

All rights and obligations of the parties to this Agreement are subject to this Agreement and its attachments, including the Sponsor’s Application and Jefferson County Conservation Futures Program Manual for the 2015 Funding Cycle, all of which are attached hereto and incorporated herein.

Except as provided herein, no alteration of any of the terms or conditions of this Agreement will be effective unless provided in writing. All such alterations, except those concerning the period of performance, must be signed by both parties. Period of performance extensions need only be signed by Jefferson Board of County Commissioners.

**I. Indemnification**

Sponsor shall indemnify, defend and hold harmless the County, its officers, agents and employees, from and against any and all claims, losses or liability, or any portion thereof, including attorneys fees and costs, arising from injury or death to persons, including injuries, sickness, disease or death to Sponsor's own employees, or damage to property occasioned by a negligent act, omission or failure of the Sponsor.

**J. Insurance**

The Sponsor shall secure and maintain in force throughout the duration of this contract:

1. Worker's compensation and employer's liability insurance as required by the State of Washington.

2. Comprehensive general liability insurance with a minimum coverage of $1,000,000 per occurrence and $2,000,000 aggregate in connection with the Sponsor’s performance of this Agreement.

3. Commercial Automobile Liability Insurance providing bodily injury and property damage liability converge for all owned and non owned vehicles assigned to or used in the performance of the work for a combined single limit of not less than $500,000 each occurrence.

4. Sponsor shall provide all required proofs of insurance to the County in care of, Contracts Manager at Jefferson County Public Health,
615 Sheridan St. Port Townsend, WA 98368 prior to fee simple acquisition of APN xxx-xxx-xxx.

5. The insurance required by this section shall be purchased from companies or through sources approved by the State Insurance Commissioner pursuant to Title 48 RCW.

6. The Sponsor’s insurance required by this section shall be in all circumstances primary to any insurance available to the County.

K. Independent Contractor
The Contractor and the County agree that the Contractor is an independent contractor with respect to the services provided pursuant to this agreement. Nothing in this agreement shall be considered to create the relationship of employer and employee between the parties hereto. Neither Contractor nor any employee of Contractor shall be entitled to any benefits accorded County employees by virtue of the services provided under this agreement. The County shall not be responsible for withholding or otherwise deducting federal income tax or social security or for contributing to the state industrial insurance program, otherwise assuming the duties of an employer with respect to Contractor, or any employee of Contractor. The Contractor shall not sublet or assign any of the services covered by this contract without the express written consent of the County or its authorized representative. Assignment does not include printing or other customary reimbursable expenses that may be provided in an agreement.

L. Ownership and Use of Documents
All documents, drawings, specifications and other materials produced by the Sponsor in connection with the services rendered under this agreement shall be the property of the Sponsor whether the project for which they are made is executed or not. The County shall be permitted to retain copies, including reproducible copies, of drawings and specifications for information, reference and use in connection with the Sponsor’s endeavors.

M. Compliance with Applicable Statutes, Rules, and Jefferson County Policies
This Agreement is governed by, and the Sponsor shall comply with, all applicable state and federal laws and regulations, including RCW 84.34.210, and published agency policies, which are incorporated herein by this reference as if fully set forth.

N. Sponsor’s Accounting Books and Records
The Sponsor shall maintain complete financial records relating to this contract and the services rendered including all books, records, documents, receipts, invoices, and all other evidence of accounting procedures and practices which sufficiently and properly reflect all direct and indirect cost of any nature expended in the performance of this contract. The Sponsor’s records and accounts pertaining to this agreement are to be kept available for inspection by representatives of the County and state for a period of six (6) years after the date of the final payment to Sponsor. Copies shall be made available upon request.

O. Licensing, Accreditation and Registration
The Sponsor shall comply with all applicable local, state and federal licensing, accreditation, permitting and registration requirement/standards necessary for the performance of this contract.
P. Disputes
Except as otherwise provided in this contract, when a bona fide dispute arises between Jefferson County and the Sponsor and it cannot be resolved, either party may request a dispute hearing with a mediator assigned by or associated with Jefferson County District Court. Either party’s request for a dispute hearing must be in writing and clearly state:
   a. the disputed issue(s),
   b. the relative positions of the parties, and
   c. the Sponsor’s name, address and Agency contact number
These requests must be mailed to the Project Manager, Jefferson County Environmental Health Department, 615 Sheridan St., Port Townsend, WA 98368, within fifteen (15) days after either party received notice of the disputed issue(s). The parties agree that this dispute process shall precede any action in a judicial or quasi-judicial tribunal. The parties will split evenly the cost of mediation or whatever form of dispute resolution is used.

Q. Termination for funding
Jefferson County may unilaterally terminate this contract in the event funding from state, federal, or other sources are withdrawn, reduced, or limited in any way after the effective date of this contract.

R. Termination for Convenience
The County reserves the right to terminate this agreement at any time by giving ten (10) days written notice to the Sponsor.

S. Assignment
The Sponsor shall not sublet or assign any interest in this Agreement, and shall not transfer any interest in this agreement without the express written consent of the County.

S. Non-Waiver.
Waiver by the County of any provision of this agreement or any time limitation provided for in this agreement shall not constitute a waiver of any other provision.

T. County Does Not Assume Additional Duties
The County does not assume any obligation or duty, except as required by federal or state law, to determine if Sponsor is complying with all applicable statutes, rules, codes ordinances or permits.

U. Agreement Representatives
All written communications sent to the Sponsor under this Agreement will be addressed and delivered to:

<table>
<thead>
<tr>
<th>Sponsor Contact</th>
<th>Conservation Futures Program Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jefferson County Environmental Health – Conservation Futures</td>
<td>Jefferson County Environmental Health – Conservation Futures</td>
</tr>
<tr>
<td>615 Sheridan Street</td>
<td>615 Sheridan Street</td>
</tr>
<tr>
<td>Port Townsend, WA 98368</td>
<td>Port Townsend, WA 98368</td>
</tr>
</tbody>
</table>

These addresses shall be effective until receipt by one party from the other of a written notice of any change.
V. **Entire Agreement/Severability**
This agreement, along with all attachments, constitutes the entire agreement of the parties. No other understandings, oral or otherwise, regarding this Agreement shall exist or bind any of the parties. If any part of this Agreement is ruled or adjudicated to be unlawful or void, all other sections of this Agreement shall continue to have full force and effect.

W. **Effective Date**
This agreement, for the xxxxx (project) shall be effective upon signing by all parties.

X. **Venue:**
Venue for any litigation arising from this Project Agreement shall be only in the Superior Court in and for Jefferson County. Each party to this agreement shall be responsible for their litigation costs, including attorney’s fees.

DATED this _______________ day of _____________________ 2015.

---

**Jefferson County Conservation Futures Program**

**Annual Project Reporting Form (template only)**

1. Project Sponsor:
2. Project Title:
3. Project Number:
4. Status:
5. Approval Date:
6. Project goals and objectives:

7. Parcel number(s):

8. Total acreage:
9. Easement:
   - Title:
   - Seller:
10. Fee Simple
    - Seller:

11. Month and year that CF funding was awarded:

12. a). Purchase price: 
    b). Total project cost:
13. Amount of CF award:
14. Month and year of acquisition:
15. Entity holding title:
16. Entity responsible for stewardship:
17. Plans or agreements pertaining to this acquisition:
18. O& M funds received since acquisition (list by year):

19. Existing and on-going activities and projects (for each O & M activity that has occurred since October 1 of the previous year, please provide supporting documentation):

20. New events, activities, projects (for each O & M activity that has occurred since October 1 of the previous year, please provide supporting documentation):

21. Needs and challenges:

22. General progress towards project’s objectives:

Completed by:
Title:
Organization:

Signature                                          Date
Appendix C

DEFINITIONS

“Conservation futures citizen oversight committee” means the Jefferson County conservation futures citizen oversight committee established under this chapter.

“Conservation futures fund” means the Jefferson County conservation futures fund established under this chapter.

“Conservation futures tax levy” means that Jefferson County tax levy upon all taxable property in Jefferson County authorized by RCW 84.34.230.

“County” means Jefferson County and/or its conservation futures citizen oversight committee.

“Cultural resources” means archeological and historic sites and artifacts, and traditional religious ceremonial and social uses and activities of affected Indian Tribes and mandatory protections of resources under chapters 27.44 and 27.53 RCW. “Open space land” means the fee simple or any lesser interest or development right with respect to real property including, but not limited to, conservation futures, easements, covenants or other contractual rights necessary to protect, preserve, maintain, improve, restore, limit the future use of or conserve selected open space land, farm and agricultural land and timber land (as those terms are defined in Chapter 84.34 RCW).

“Project” means open space land, or any lesser interest or development right in specific real property, to which Jefferson County conservation futures tax levy funds are allocated for acquisition under the procedure outlined under this chapter. [Ord. 1-14 § 1; Ord. 6-02 § 1]

“Silviculture” means the practice of controlling the establishment, growth, composition, health, and quality of forests for the production of forest products.
To: Jefferson County Board of Commissioners

From: Lige Christian, Chair
Conservation Futures Citizen Oversight Committee

Date: May 3, 2007

Subject: Conservation Futures 2007 Funding Round Recommendations

This past March, the Jefferson County Conservation Futures Committee received applications for five capital projects. Three of the projects proposed perpetual conservation easements on properties south of Port Townsend and two proposed fee simple purchases of lots for inclusion in the Quimper Wildlife Corridor. On April 10, 2007, ten of the eleven committee members met and ranked the projects on merit and determined recommendations regarding funding.

The projects proposed are as follows:

1. Glendale Farm: Jefferson Land Trust submitted an application as both applicant and sponsor for $300,000 towards the purchase of a perpetual conservation easement on 180 acres. The project location is 1/4 mile south of the Chimacum intersection between Center and Beaver Valley Roads. This requested sum includes $4,000 in operation and maintenance costs. Proposed match would be potential grants from one or more state and federal agricultural grant programs or the Carolyn Foundation.

2. Quimper Wildlife Corridor – 50th Street Wetland: Jefferson Land Trust submitted an application as both applicant and sponsor for $62,325 towards the fee-simple purchase of four platted lots in Block 5 of the Montana Addition on 50th Street. The project location is between Grant and Sheridan Streets in the City of Port Townsend. This requested sum includes $2,000 for operation and maintenance costs. Proposed match would be contributions from the seller and neighboring landowners.

3. Quimper Wildlife Corridor – Winona Phase II: Jefferson Land Trust submitted an application as both applicant and sponsor for $31,600 towards the fee-simple purchase of four lots in Block 19, Flowers Park Plat. The lots are located near the intersections of Winona and Pearl Streets east of Cook Avenue in the City of Port Townsend. This requested sum includes $2,000 in operation and maintenance costs. Proposed match would be two adjacent lots acquired previously and cash.
4. Tamanowas Rock Sanctuary - Phase II: Jamestown S’Klallam Tribe submitted an application sponsored by Jefferson Land Trust for $203,622.50 towards purchase of a perpetual conservation easement on 66 acres near Anderson Lake State Park and Tamanowas Rock. This requested sum includes $3,500 in operation and maintenance costs. Proposed match is a partial donation of the value of the conservation easement and acquisition-related costs.

5. Upper Tarboo Creek Conservation Project: Northwest Watershed Institute submitted an application as both applicant and sponsor for $163,819 towards purchase of a perpetual conservation easement on 50 acres at the corner of Dabob and Center Roads north of Quilcene. This requested sum includes $1,000 in operation and maintenance costs. Proposed match is a potential grant from the WA Dept. of Natural Resources Forest Legacy program.

The total funds available for distribution to projects in the 2007 funding cycle is $380,000. The total amount requested from the five projects submitted is $761,367. Clearly not all projects could be fully funded. The committee deliberated for five hours weighing the merits of each project. During this process, each project was assigned a raw numerical score. Based on these scores, a preliminary rank order was generated as follows:

<table>
<thead>
<tr>
<th>Rank</th>
<th>Project</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Glendale Farm</td>
<td>239</td>
</tr>
<tr>
<td>2</td>
<td>Winona Phase II</td>
<td>210</td>
</tr>
<tr>
<td>3</td>
<td>Upper Tarboo</td>
<td>206*</td>
</tr>
<tr>
<td>4</td>
<td>50th Street Wetland</td>
<td>205</td>
</tr>
<tr>
<td>5</td>
<td>Tamanowas Phase II</td>
<td>186</td>
</tr>
</tbody>
</table>

*After the meeting had adjourned, the recorder discovered a clerical error in one of the ranking categories for this project. As a result, the actual raw score should be 202 rather than 206.

Following establishment of the preliminary rank order, the committee set about determining which projects, if any, should be funded. During this process, two of the projects (Winona Phase II and Upper Tarboo Creek) were reordered based on the importance of the proposed Tarboo project to the larger Tarboo Creek watershed restoration effort. The recommendation of the committee is that all five projects do have sufficient merit to warrant funding.

The last consideration of the committee was to determine which projects should be funded and how much funding would be recommended for those projects. The committee spent considerable time discussing the amount of funding that each project
should receive. By unanimous vote, the committee decided to recommend funding for the Glendale Farm and Upper Tarboo Creek projects only. The matter of how much funding to recommend for each of these two projects was decided on a 7/1/1 vote to fund as follows:

<table>
<thead>
<tr>
<th>Rank</th>
<th>Project</th>
<th>Acquisition Funding</th>
<th>O&amp;M Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Glendale Farm</td>
<td>$230,000</td>
<td>$0</td>
</tr>
<tr>
<td>2</td>
<td>Upper Tarboo Creek</td>
<td>$150,000</td>
<td>$0</td>
</tr>
<tr>
<td>3</td>
<td>Winona Buffer II</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>4</td>
<td>50th Street Wetland</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>5</td>
<td>Tamanowas Phase II</td>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>
Jefferson County Conservation Futures Committee  
Monday, April 15, 2004  
1:00-5:00 p.m.  
Madrona Room, WSU, Port Hadlock, WA  
Minutes

*Decisions and action items are indicated in bold font.*

<table>
<thead>
<tr>
<th>Members Present</th>
<th>County Staff Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Janet Kearsley, Citizen, District 1</td>
<td>Barbara Bowen, Natural Resources Division</td>
</tr>
<tr>
<td>Kevin Miller, Citizen, District 2, realtors</td>
<td></td>
</tr>
<tr>
<td>Barbara McColgan Pastore, City of Port Townsend, Parks &amp; Recreation</td>
<td></td>
</tr>
<tr>
<td>Eileen Rogers, Jefferson County Parks &amp; Recreation</td>
<td></td>
</tr>
<tr>
<td>Dennis Schultz, Vice Chair, Conservation District</td>
<td></td>
</tr>
<tr>
<td>Sarah Spaeth, Chair, Jefferson Land Trust</td>
<td></td>
</tr>
</tbody>
</table>

Members Absent:  
Herb Beck, District 3  
Will O’Donnell, District 3  
Lige Christian, District 1  

Guests  
Tim Caldwell

I. Call to Order

Chair Barbara McColgan Pastore called the meeting to order at 1:12 p.m., and asked for a roll call. She noted a quorum was present.

II. Approval of Minutes

Eileen Rogers moved to approve the minutes.  
Dennis Schultz seconded.  
The motion passed 6-0.

Sarah Spaeth asked about staff sending information to West End organizations.

III. Observer Comments

None

IV. Amendments to Agenda

Chair, Barbara McColgan Pastore asked for staff updates on items Sarah brought up, and other matters.

V. Old Business

County staff, Barbara Bowen, reported that she had contacted West End organizations and provided information on the 2004 Conservation Futures application round. The organizations included the Hoh Tribe, U.S. Forest Service, and Wild Salmon Center.
Barbara McColgan Pastore mentioned that citizens in a recent Board of County Commissioners had made public comments on the Highway 20 Corridor project.

Janet Kearsley requested county staff to send Committee members a copy of the BOB from March with public comment on the Highway 20 Corridor project.

Staff clarified what’s in the Committee’s Bylaws regarding absences by Committee members.

Pastore said when members are not present, for whatever reason, it’s harder for the Committee to do its work, it’s harder to have a quorum. She recommended changing the Bylaws so that if someone is unable to attend meetings, regardless of the reason, the Committee would ask them to step aside.

A discussion ensued. Kevin Miller mentioned that when a member is absent, his or her constituency is not being represented.

The issue of allowing proxies was raised. County staff mentioned you would have to change the Bylaws to do this. Kevin Miller spoke against allowing proxy because it takes too much time to educate. Dennis Schultz said the appointments are made by the BoCC, and they might not favor proxies that they did not have a voice on.

County staff recommended the Committee undertake its deliberations re absences during its annual review meeting.

Tim Caldwell, Port Townsend Chamber of Commerce, joined the meeting.

Staff reported on the Committee’s question about the BoCC capping the tax rate at .0625%. She reported that she had talked to Jack Westerman, and he had mentioned a “new construction bonus.” A discussion ensued. Barbara Pastore said the amount gathered into the fund each year may be expected to rise slowly given the 1% increase in assed value, and the new construction bonus.

Chair noted that Tim Caldwell had joined the meeting, and invited observer comments. She noted that he could address the Committee or could challenge the participation of particular Committee members in the deliberation process.

Tim Caldwell said he was here representing the Port Townsend Chamber of Commerce, which together with Jefferson County and the Land Trust had submitted an application for the Highway 20 Corridor project. He’s an observer to see the process. The Chair explained the steps in the Committee’s process. Members of the Committee introduced themselves.

VI. New Business
A. Committee members respond to questions from the Chief Deputy Civil Prosecuting Attorney’s memo. See Appendix A.

Quimper Wildlife Corridor: applicant and sponsor, Jefferson Land Trust, contact Sarah Spaeth, program manager.
Barbara McColgan Pastore: “No” to all three questions. She disclosed that Sarah Spaeth is her neighbor and she has talked to Sarah about administrative matters, e.g., filing date. There were no conversations about the content of the project.

Janet Kearsley: “No” to all three questions.
Eileen Rogers: “No” to all three questions.
Dennis Schultz: “No” to all three questions.
Sarah Spaeth: #1 “No,” #2 “Yes,” Spaeth notes the application is from Jefferson Land Trust and she prepared the application, and represents the Land Trust, she will be recusing herself. #3 “Yes.” Sarah disclosed her conversations had been with people contributing financially to matching funds and with the land owners who were sellers of the properties in question, as well as committee members of Jefferson Land Trust’s Land Conservation Committee, as well as its Board. She has had no conversations outside of these.
Kevin Miller: “No” to all three questions.

Tarboo Valley Conservation Project: Northwest Watershed Institute/Jefferson Land Trust
Barbara McColgan Pastore: “No” to all three questions. Sarah is Barbara’s next door neighbor.
Janet Kearsley: “No” to all three questions
Eileen Rogers: “No” to all three questions.
Dennis Schultz: “No” to all three questions.
Sarah Spaeth: “No,” #2 “Yes,” The Land Trust was asked by the applicant to be the sponsor. I do have a bias, and will be recusing myself from deliberations and rating of this application.”  #3 “yes,” I have had communications with the applicant, and with the Land Trust. The content of the conversations is within the application.”
Kevin Miller: “No” to all three questions.

Highway 20 Corridor Project
Barbara McColgan Pastore: “No” to all three questions. Barbara discloses that the applicant contact is Tim Caldwell with whom she has associated on a number of Boards in the past, both Park & Rec. Advisory Board, and Ft. Worden Advisory Council, but those associations don’t bias her one way or the other. Barbara also points out that the City of Port Townsend is contributing $5,000, and she sits on the Committee as a member of the Port Townsend Parks and Rec Advisory Board. She feels that the relationship between what the City contributes and her service as Committee member is remote, per David Alvarez’s memo.
Janet Kearsley: “No” to all three questions. Janet discloses that she is member of the Land Trust, but that won’t bias her decision.
Eileen Rogers: “No” to all three questions.
Dennis Schultz: “No” to all three questions.
Sarah Spaeth: #1 “No” #2 “Yes.” Sarah said she could consider the proposal in a fair and objective manner, but because the Land Trust is listed as a partner on this application, even though they are not an applicant or sponsor, she believes it would be in the Committee’s best interest to recuse herself. #3 “Yes” Sarah reported that early-on when the project came up I had several emails from members of the community who were concerned that the Conservation Futures Funds were going to be used for this type of project. Sarah told them the Land
Trust was not the applicant and that further questions should be pursued with the Chamber or EDC.

Kevin Miller: “No” to all three questions.

B. Discussion of 2004 Applications to Identify Questions

Tim Caldwell says he needs to leave and asked what the total amount of the three proposals is. Barbara Pastore reports the amount is $165,000. The available amount is about $150,000, of which all, none, or part might be granted to projects, the BoCC makes the final decision. The Committee will be identifying questions to obtain additional information at this meeting.

**Quimper Wildlife Corridor**

The Committee identified the following questions:

1. Re the federal grant which was used to purchase Block 94:
   a) Does the federal funding source place any limitations or restrictions on the use and disposition of properties purchased with those funds?
   b) Was it stand-alone grant, e.g., “Give us the money to buy this property,” or is it tied to previous applications or acquisitions?
   c) In its grant application, what did the Land Trust say it was going to do with the land?

2. Do the requirements of the federal funding conflict in any way with the requirements of Jefferson County's Conservation Futures Ordinance?

3. What is the relation of Block 94 to the other blocks and parcels proposed for purchase with Conservation Futures funds? Please clarify the nature of the interconnections of Block 94 and these other parcels.

4. What is the other portion (i.e., lots 1, 5, 6, 7 & 8) of Block 4 in Wildwood 1 being used for?

5. You state that blocks 68 & 69 are “important connective habitat, and have been identified in the project's Tier 1 acquisition strategy since the mid 1990's.” Please describe the Tier 1, Tier 2, and Tier 3 designations.

6. Some Tier 1 property is between the proposed acquisitions that would otherwise make a complete corridor. Is the Land Trust working on acquiring that property?

**Tarboo Valley Conservation Project**

1. The easement is to be purchased now, and the outright purchase of the other property is scheduled for next year. What would be the impact on the project, if the purchase of the conservation easement were postponed to occur at the same time as the outright purchase?

2. How can the purchase of another piece of property by a different party be used to lever a Conservation Futures application?

3. What is the relation between these two projects? Please explain. Are they really going to be one project, or are they two separate entities?
4. What is the status of the other applications for Block 25?

5. What else is a part of the "network of nature reserves" you refer to? Please provide a map that shows this network and identifies the properties in it.

6. How does this project relate to other habitat restoration and protection projects in the area?

7. The application mentions a barn full of skis and "old cars," but there is no mention of how you will deal with the "old cars" or contaminated soils on the site. Do you have a plan for dealing with the cars, and any contaminated soils? If so, please explain what it is.

8. Are there any known underground storage tanks or fuel tanks? If so, what are your plans for dealing with them?

Sarah Spaeth remained during the Committee’s identification of additional questions. A discussion ensued among Committee members about whether this was appropriate.

Chair, Barbara Pastore raised the issue of the applicant for the Tarboo Valley Conservation project. She cites the language of the Ordinance re eligible applicants, and the requirement for local agencies. She noted the address of the Northwest Watershed Institute, was in Portland, OR, and asked if that automatically preclude them. Or does the fact that they also do business in Port Townsend, make them eligible?

County staff noted that she had exchanged emails with Peter Bahls and David Alvarez. She noted that the language in the application guidelines is more specific than it is in the Ordinance. The Ordinance is slightly ambiguous. The intent of the Board was for the applicant organization to be Jefferson County organizations. David Alvarez said that staff should force the issue with the BoCC and ask for clarification. Eileen Rogers said the Committee needs to ask the question now before it spends time deliberating on the application. Pastore notes that the Committee needs to get clarification on the eligibility.

Kevin Miller wanted to determine eligibility before asking follow-up questions, because engaging the applicant might imply that the Committee considered it an eligible application.

**Eileen Rogers made a motion to direct County staff to ask the County Administrator, David Goldsmith, about the eligibility of the application for Tarboo Valley Conservation Project. Does the applicant, Northwest Watershed Institute, meet the eligibility requirements as outlined in the Ordinance? The Northwest Watershed Institute cites both an Oregon and Port Townsend address.**

Dennis Schultz seconded.

A discussion ensued.

Eileen Rogers called the question.

The motion passed by a vote of 4-2.

A discussion ensued.
Sarah Spaeth noted the difference between last year’s process, when she was able to respond to questions, and this process. She noted that she has information on all three applications, and is in a position to answer clarifying questions.

A discussion ensued.

**Highway 20 Corridor Buffer**
1. What is the zoning on both sections of the property?

2. Is it the intention for the whole property to be maintained for conservation purposes in perpetuity?

3. Please provide a copy of the timber cruise that generated the $37,000. valuation for the timber.

4. Are the $37,000. and $10,000. values, gross or net values?

5. What are the standard WDOT and county easements and setbacks on the property? How much cut-back of trees do these easements and setbacks require? Please explain what needs to be done to clear the easements.

6. Do you anticipate that any of the property will be taken for the purpose of road-widening?

7. Please submit a new map that shows the current property boundaries, and draw in the boundaries: a) subject to WDOT tree-thinning, and b) the portion of the interior property that you plan to thin.

8. In question 18, you indicate that the property "contributes to an existing or future wildlife corridor or migration route." Please clarify what existing, or future, wildlife corridor is present on the property.

9. Who determined that tree-thinning is required in order to maintain a healthy forest? Was the person a certified forester? If a report was submitted re the tree-thinning, please submit a copy of the report.

10. What are the plans for long-term stewardship of the property? What will stewardship consist of?

11. Is the Chamber of Commerce a steward for any other parcels in the county?

12. Approximately what percent of the trees on the property will be cut to generate the $10,000?

13. Who will hold the title to the property long-term?

14. What part is the Jefferson County Economic Development Council playing in the project?

15. Please clarify the role the Jefferson Land Trust is playing in the project.
16. Please send the text for the following citations from the City and County Comp Plans: City Comp Plan, Transportation Chap. VI, Goal 1, Goal 2, Policy 2.5 County Comp Plan, Transportation, Chapter 10, Goal TRG 1.0, TRP 1.9, TRP 4.5, TRP 10.7

17. Question 15.b was not answered. Please answer

The Committee decided to schedule site visits for May 5.

VI. Adjourn
Chair, Barbara McColgan Pastore adjourned the meeting at 4:20 p.m.
APPENDIX A
ETHICS QUESTIONS FROM CHIEF DEPUTY CIVIL
PROSECUTING ATTORNEY’S JULY 9, 2002 MEMO TO THE
COMMITTEE.

After asking for objections from the audience, then the CFFCOC members should be asked these questions with respect to each DISTINCT application or proposal:

- Do you, as a member of the CFFCOC, stand to gain or lose any financial benefit as a result of the outcome of this hearing?
- Are you, as a CFFCOC member, unable to hear and consider this proposal or application in a fair and objective manner, i.e., without bias and without a predisposition to any particular result regarding this proposal or application?
- Have you, as a CFFCOC member, engaged in any communication outside this hearing with either a proponent or opponent of this particular proposal or application?

If any CFFCOC member has to answer “yes” to the first or second of these questions, then they must say so out loud, explain why they have answered “yes,” AND MUST IMMEDIATELY RECUSE themselves from any debate or deliberation regarding that proposal. Recall that if a CFFCOC member holds what is deemed a ‘remote interest’ by state law, then that CFFCOC member need not reply, “yes” to the first question listed above.

A reply of “yes” to the third question listed above must then lead to the CFFCOC member describing the substance and facts regarding that outside conversation, e.g., what was said by whom.

The occurrence of an outside conversation does not mean that the CFFCOC member must recuse himself or herself. In the context of a land use decision this type of “appearance of fairness” problem can be eradicated if it is publicly stated at the meeting not only the substance of the outside conversation BUT ALSO that the person or persons who were disadvantaged by not being present at the outside conversation will have the opportunity to rebut what was said or argued during that outside conversation. In other words, “I’ve heard one side in private, so now I must offer the other side the opportunity to present their arguments.”

If this is done and the opportunity to rebut is truly provided, then the CFFCOC member answering, “yes” to the third question, need NOT recuse him or herself. Again, this is using the rules applicable to land use decisions by analogy. As analogies go, it is not a perfect fit, but it is what we have.

It is true that the need to provide this rebuttal opportunity to those persons or party disadvantaged by the outside conversation could cause a delay in the decision-making process from one hearing to the next hearing, since the
occurrence of the outside conversation may come as a surprise to the disadvantaged, who might not even be present at the first hearing.
The Forest Service of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the national forests and national grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

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Cover

Butterfly photo by Betsy Howell, Forest Service (Olympic NF). River photo by Jessica Halofsky (University of Washington). Fish photo courtesy of the National Park Service (Olympic NP). Forest photo courtesy of the U.S. Forest Service (Olympic NF).
Adapting to Climate Change at Olympic National Forest and Olympic National Park

Jessica E. Halofsky, David L. Peterson, Kathy A. O’Halloran, and Catherine Hawkins Hoffman
Editors

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Portland, Oregon
General Technical Report, PNW-GTR-844
August 2011
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Climate change presents a major challenge to natural resource managers both because of the magnitude of potential effects of climate change on ecosystem structure, processes, and function, and because of the uncertainty associated with those potential ecological effects. Concrete ways to adapt to climate change are needed to help natural resource managers take the first steps to incorporate climate change into management and take advantage of opportunities to counteract the negative effects of climate change. We began a climate change adaptation case study at Olympic National Forest (ONF) in partnership with Olympic National Park (ONP) to determine how to adapt management of federal lands on the Olympic Peninsula, Washington, to climate change. The case study began in the summer of 2008 and continued for 1½ years. The case study process involved science-based sensitivity assessments, review of management activities and constraints, and adaptation workshops in each of four focus areas (hydrology and roads, fish, vegetation, and wildlife). The process produced adaptation options for ONF and ONP, and illustrated the utility of place-based vulnerability assessment and science-management workshops in adapting to climate change. The case study process provides an example for other national forests, national parks, and natural resource agencies of how federal land management units can collaborate in the initial stages of climate change adaptation. Many of the ideas generated through this process can potentially be applied in other locations and in other agencies.

Keywords: Adaptation, climate change, fish habitat management, hydrology, road management, science-management partnerships, vegetation management, wildlife habitat management.
Summary

In this report, we describe results of the Olympic Climate Change Case Study, a science-management collaboration initiated to develop climate change adaptation strategies and actions for Olympic National Forest (ONF) and Olympic National Park (ONP). The case study was one of three parallel climate change adaptation case studies on national forests and adjacent national parks in the Western United States as a part of a larger effort, the WestWide Climate Initiative. This initiative was created by scientists of the U.S. Forest Service to address the urgent need to communicate climate change information to land managers and work with them to develop adaptation options.

For the Olympic Climate Change Case Study, we conducted a vulnerability assessment to facilitate development of adaptation strategies and actions for ONF and ONP. The first step in the vulnerability assessment process involved a review of available climate model projections to determine likely levels of exposure to climate change (degree of deviation in temperature and precipitation) on the Olympic Peninsula (chapter 3). In the next step, we reviewed relevant literature on effects of climate change and available projections to identify likely climate change sensitivities in each of four focus areas on the Olympic Peninsula, including hydrology and roads (chapter 4), fish (chapter 5), vegetation (chapter 6), and wildlife (chapter 7). We worked with regional scientists and specialists to interpret available information and apply it more directly to Olympic Peninsula ecosystems. Finally, we reviewed current management activities at ONF and ONP and identified management constraints to evaluate some aspects of institutional capacity to implement adaptive actions. Review of current management activities was done by focus area and is described in the chapter for each focus area.

The vulnerability assessment process set the stage for development of adaptation options at the forest and park through science-management workshops (also described in the chapter for each focus area). The workshop format gave managers an open forum to brainstorm, express initial thoughts and ideas, and vet those ideas among peers. Direct engagement of scientists and managers in the workshop format fostered development of science-based adaptation strategies. During workshop discussions, managers identified general priority actions for adaptation, as well as priorities for species protection, habitat protection, and monitoring.

Although interagency partnerships exist elsewhere to address specific natural resource issues, the Olympic Climate Change Case Study is an unprecedented example of U.S. Forest Service and National Park Service jointly planning for climate change adaptation. The case study process produced specific and tangible ways for ONF and ONP to incorporate climate change adaptation strategies into management. A key finding of the assessment was that the current general management at both ONF and ONP, with restoration as a primary goal, is consistent with managing for resilience to prepare ecosystems for a changing climate. However, the effort highlighted some potential issues related to climate change that challenge current precepts and management guidelines and helped to identify new potential actions and actions that could be increased and reprioritized.
Climate change adaptation requires systematic monitoring and evaluation to detect changes and determine the success of adaptive management activities. Staying abreast of available information on potential climate change effects is essential to determine additional ways to incorporate climate change adaptation into management. Although further effort will be required, the case study described in this report was an essential first step for ONF, ONP, and their stakeholders in preparing for climate change on the Olympic Peninsula.
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Acknowledgments

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Chapter 7: Climate Change, Wildlife Management, and Habitat Management at Olympic National Forest and Olympic National Park

Jessica E. Halofsky, Susan Piper, Kurt Aluzas, Betsy Howell, Paul Griffin, Patti Happe, Kurt Jenkins, Catherine Hawkins Hoffman, Joshua Lawler, Michael Case, and Karen Reagan

Potential Climate Change Effects on Wildlife on the Olympic Peninsula
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Adapting to Climate Change at Olympic National Forest and Olympic National Park

There is strong and growing scientific evidence for human-induced global climate change (Pachauri and Reisinger 2007). Global ecological effects triggered by warming in the late part of the 20th century include earlier snowmelt and decreased spatial extent of snow and ice (Barnett et al. 2008, Hamlet et al. 2005, Mote et al. 2005, Pachauri and Reisinger 2007), shifts in species distributions (Parmesan 2006, Parmesan and Yohe 2003, Mote et al. 2005, Root et al. 2003), and rising sea levels (Parry et al. 2007). Despite current and future greenhouse gas mitigation efforts, changes in the climate system will continue owing to already elevated concentrations of carbon dioxide in the Earth’s atmosphere (Watson and the Core Writing Team 2001). Thus, climate change adaptation, or “the adjustment in ecological, social, or economic systems in response to climate stimuli and their effects” (Pachauri and Reisinger 2007), will be critical in reducing unwanted effects of climate change on both ecosystems and society.

Climate change presents a major challenge to natural resource managers because of the magnitude of potential effects of climate change on ecosystem structure, process, and function, and because of the uncertainty associated with potential ecological effects. Although general guidelines exist (e.g., Julius et. al. 2008, Millar et al. 2007) to proactively incorporate climate change into planning, decisions, and activities, managers require concrete and place-based methods to adapt to climate change.

Scientists and managers must work together to develop and implement strategies that facilitate adaptation to climate change. Resource managers have the skills and local knowledge to incorporate climate change into management. However, there is an overwhelming amount of climate change information to absorb, a steep learning curve with climate change science, and little time for learning owing to managers’ many responsibilities. Given the relative infancy and experimental nature of climate change adaptation strategies, resource managers generally lack specific guidance and directives regarding how to incorporate climate change into program planning and implementation. Scientists have technical knowledge on climate change but often a poor understanding of management and regulatory, policy, and collaborative social processes for resource planning and decisionmaking. Although these two groups of specialists share complementary sets of skills and knowledge, a lack of formal relationships, and differences in work culture, timeframes, and communication styles limit science-management interactions on climate change issues.

In this report, we describe results of the Olympic Climate Change Case Study, a science-management collaboration initiated as part of a larger effort called the WestWide Climate Initiative (USDA Forest Service 2007). Scientists of the U.S. Forest Service created the WestWide Climate Initiative to address the urgent need to provide climate change information and adaptation tools to land managers in the Western United States. As a part of this initiative, parallel case studies were conducted to develop climate change tools and adaptation options at Olympic National Forest (ONF) and Olympic National Park (ONP) (Washington); Tahoe National Forest, Inyo National Forest, and Devils Postpile National Monument (California); and Shoshone National Forest (Wyoming).

The Olympic Climate Change Case Study occurred in two phases. The first phase involved education for managers at ONF on climate change science and potential effects of climate change, and an initial effort to develop...
adaptation strategies (Littell et al. 2011). The second phase, described here, focused on further development of strategies and actions for climate change adaptation. The case study began in the summer of 2008 and continued for 1½ years. The ONP joined with ONF in the second phase of the case study because of the proximity of the park and forest, similarities in management goals, and the importance of collaboration between neighbors in preparing for climate change. Although interagency partnerships exist elsewhere to address specific natural resource issues, this collaborative effort is unprecedented in development of climate change adaptation strategies and actions for a large landscape.

The second phase of the Olympic Climate Change Case Study developed adaptation strategies and actions in four focus areas identified by ONF and ONP managers as being most important: hydrology and roads, fish, vegetation, and wildlife. To develop adaptation actions for each focus area, we conducted a vulnerability assessment, or an assessment of the degree to which geophysical, biological, and socioeconomic systems are susceptible to, and unable to cope with, unwanted impacts of climate change (Parry et al. 2007). Vulnerability is a function of system exposure, its sensitivity, and its adaptive capacity (Gallopín 2006, Parry et al. 2007). In a climate change context, exposure can be thought of as the degree, duration, or extent of deviation in climate to which a system is exposed. Sensitivity is the degree to which a system is affected, either positively or negatively and directly or indirectly, by climate-related stimuli (Parry et al. 2007). Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (Parry et al. 2007).

To determine likely levels of exposure to climate change on the Olympic Peninsula, we reviewed global climate model projections included in the University of Washington Climate Impacts Group Washington State Assessment (Mote and Salathé 2010) (see chapter 3 for further detail). Then, to assess other aspects of climate change vulnerability and develop adaptation options, for each focus area, we used a three-part process that involved:

- An assessment of climate change sensitivity through a topical literature review and review of available climate change impact model output, incorporating information directly applicable to the Olympic Peninsula whenever possible. Sometimes, scientists summarized best-available information in presentations to managers, and scientists and managers worked together to interpret and apply it to Olympic Peninsula ecosystems.
- An assessment of the capacity of ONF and ONP to adapt to climate change through review of current management practices and potential regulatory and institutional constraints.
- Development of adaptation strategies through science-management workshops. The results of the vulnerability assessment provided the starting point for facilitated science-management dialog on possible adaptation strategies in each focus area. The workshop format provided opportunities to transfer information and facilitate discussions between managers and scientists.

In all steps of the case study process, scientists and managers worked together to gather and refine information to identify climate change vulnerabilities and develop adaptation options for ONF and ONP. For consistency across focus areas, two scientists from the Forest Service Pacific Northwest Research Station and the natural resource staff supervisors from ONF and ONP participated in and guided the entire process. Participants in each focus area included forest and park staff specialists, including silviculturists, forest geneticists, botanists, wildlife biologists, engineers, fish biologists, and hydrologists. For each focus area, scientists from the University of Washington Climate Impacts Group and Forest Service scientists provided presentations and participated in discussions of adaptation options. Both the hydrology and roads, and vegetation workshops were limited to forest and park specialists and scientists with specialized knowledge in the focus area because of the need for progress within a specific timeframe, and for continuity and commitment to the process over many months, in addition to the complicated scheduling, logistics, and orchestration of a large-group planning process. However, the wildlife workshops included specialists from other natural
resource organizations, including the Washington Department of Natural Resources, the U.S. Geological Survey, and U.S. Fish and Wildlife Service, to take advantage of their specialized knowledge of wildlife on the peninsula and interest in climate change. A science-focused fish workshop included over 100 participants from a variety of state and federal natural resource agencies, watershed organizations, and tribes. The fish workshop was opened to a broader audience because fish (particularly salmonids) are one of the widest ranging, multijurisdictional organisms inhabiting the peninsula. A critical next step will be to work with these and other partners in climate change adaptation on the peninsula.

During workshop discussions, ONF and ONP identified general priority actions for adaptation, as well as priorities for species protection, habitat protection, and monitoring. In developing these adaptation strategies, the goal was to identify no-regrets strategies and actions that are likely to produce favorable outcomes, are compatible with current management objectives, and are adaptable through time. For the purposes of the workshops, it was assumed that there will be no changes in policy mandates (e.g., land allocation designations, Endangered Species Act ([ESA 1973]) listings, or directives in the Northwest Forest Plan) over the next 5 years. These objectives and constraints yielded realistic and tangible adaptation strategies and actions for ONF and ONP.

References


Chapter 2: Olympic National Forest and Olympic National Park: Biogeographic Setting, Cultural History, and Policy Context

Jessica E. Halofsky, Kathy A. O’Halloran, Catherine Hawkins Hoffman, David L. Peterson, and Jacilee Wray

The Olympic Peninsula

Located in the northwestern portion of Washington state, USA, the Olympic Peninsula comprises an area of 16,800 km² (fig. 2.1). Bounding the peninsula is the Pacific Ocean to the west, the Strait of Juan de Fuca to the north, and Puget Sound and Hood Canal to the east. Elevation on the peninsula ranges from sea level to 2427 m at Mount Olympus, the highest peak of the Olympic Mountains, which dominate the central portion of the peninsula. The steep and dissected topography in the central portion of the peninsula results in temperature and precipitation gradients and varied climatic conditions (Peterson et al. 1997). A wet and humid maritime climate characterizes the western, coastal side of the peninsula, which receives 300 to 500 cm of precipitation per year depending on location, while the crest of the Olympic Mountains receives >600 cm of precipitation per year, making it the wettest location in the coterminous United States (Peterson et al. 1997). In contrast, the north-eastern portion of the peninsula is characterized by a drier, more continental climate owing to the rainshadow effect of the Olympic Mountains (and prevailing winds from the southwest during the winter). Rainfall in the northeastern portion of the peninsula is as low as 50 cm per year at lower elevations (Henderson et al. 1989). Most precipitation falls between October and March, and winter precipitation falls mainly as rain below 300 m, as rain and snow between 300 m and 750 m, and as snow above 750 m. Snow at higher elevations persists through the early part of summer.

Varied climatic conditions on the peninsula result in diverse ecological communities. Vegetation assemblages on the peninsula include temperate rain forests, mixed-conifer forests, prairies, alpine tundra, subalpine parklands, wetlands, rivers, streams, and mountain lakes. There are 1,480 native vascular plant species (Buckingham et al. 1995) on the peninsula, including eight endemic species. Several endemic animal species also inhabit the peninsula, including the Olympic marmot, the Olympic pocket gopher, and the Olympic torrent salamander (See Common and Scientific names).

Land ownership on the peninsula is a mix of federal, state, tribal, and private lands (fig. 2.1). Olympic National Park (ONP) occupies the core of the peninsula and includes much of the higher elevation portion. Olympic National Forest (ONF) surrounds the park. The forest and park cover about one-third of the peninsula.

Cultural History of the Olympic Peninsula

The Olympic Peninsula has a rich cultural history involving extensive interaction between native peoples and their environment. Prior to what European Americans call the historic period (less than 200 years before present), there were about 10,000 people living on the Olympic Peninsula, the ancestors of the tribes here today: the Elwha Klallam, Jamestown S’Klallam, Port Gamble S’Klallam, Quinault, Hoh, Quileute, Makah, Queets, and Skokomish (Wray 2002). The tribes of the Olympic Peninsula maintain close ties to all of their ancestral lands and share concern for resource protection. They are an integral part of the ecosystem, as their traditional practices included land management, such as maintaining prairies by burning them to increase edible and medicinal plant populations.
In 1854, Governor Issac Stevens, who was also Superintendent of Indian Affairs in Washington Territory, began treaty negotiations to unite the numerous bands of Indians into tribes and to extinguish title to their lands for settlement by U.S. citizens. The treaties established formal relationships between the tribes as sovereigns and the United States and established the Quinault, Skokomish, and Makah reservations. The Quileute and Hoh reservations were established by Executive order and the three
Klallam reservations by Congress. Tribal reservation lands on the peninsula comprise over 89,000 ha, ranging from the Quinault Reservation, encompassing 86,000 ha, to the Jamestown S’Klallam Reservation, with only 2 ha.

The peninsula treaties that ceded the land now within ONP include the Treaty of Point No Point 1855 (Skokomish and Klallam), Treaty of Neah Bay 1855 (Makah), and Treaty of Olympia 1856 (Quinault, Quileute, and Hoh). The treaties specify that the tribes have the right to fish at “usual and accustomed grounds and stations… in common with all citizens… together with the privilege of hunting and gathering roots and berries on open and unclaimed lands.” In 1974, Federal District Court Judge George Boldt found that the tribes were guaranteed an equal share or half of the sustainable harvest of anadromous fish in U.S. v. Washington. He also found that the treaties were “not a grant of rights to the Indians, but a grant of rights from them, and a reservation of those not granted” [United States v. State of Washington 384 F. Supp. 312 (1974):323]. In other words, these were not rights given to them, but rights they always had—from time immemorial.

The relationship between the first people and the Olympic Peninsula is recounted in origin legends and mythic events that explain both the creation of the landscape and peoples’ relationship to it. These legends depict a strong reliance upon waterways, forests, and valleys for the acquisition of vital resources, and detailed descriptions of travel into the mountains for pleasure, social interchange such as marriage, and spiritual pursuits [Wray 2002].

Trails were used where canoes could not go, following the river drainages to the open meadows and mountain ridgelines. Trails crossed the mountains between the Hoh and the Elwha Rivers and from the Quileute to the Pysht and the Hoko (Gibbs 1877). Other trails led from Hood Canal to Grays Harbor, and crossed the Olympics from the Skokomish and Dosewallips River drainages to the Quinault. Many of the trail routes are the same routes used today by hikers in the park and forest.

The remains of stone tool manufacture, or lithics, have been documented in the Olympic Mountains and surrounding foothills by archeologists. These tools were used for hunting, butchering, and plant processing. In 1993, portions of a woven cedar basket—part of a pack basket used as a backpack—were found in the alpine reaches of ONP. This discovery provides additional evidence of high-country habitation. The basket has been radiocarbon dated to be about 2,880 years old.

Maritime archeological village sites on the Pacific coast, Strait of Juan de Fuca, and Hood Canal had economies that included intertidal gathering, fishing, sealing, and whaling, dating back thousands of years. Animal remains, along with stone and wood artifacts, indicate the presence of an “Early Maritime” culture on the Olympic Peninsula about 3,000 years ago (Bergland 1983). This culture relied on salmon and shellfish, which had likely increased in abundance in response to stabilization of sea level and increased precipitation during that time period (Henderson et al. 1989).

Native peoples of the Olympic Peninsula used native plant materials extensively (Gunther 1945, Norton 1979, as cited in Henderson et al. 1989). Western redcedar was used for a variety of purposes, including cedar plank houses, canoes, fishing tools, cradles, paddles, and arrowshafts (Henderson et al. 1989). The bark of western redcedar was also used to make clothing, baskets, mats, and eating utensils, among other objects (Gunther 1945). Other plants, such as camas, bracken fern, salmonberry, salal, and huckleberries, provided important food sources (Henderson et al. 1989). Prairies were regularly burned to maintain and cultivate camas and other food plants (Norton 1979).

Native plants were also used for medicine and other purposes. For example, stinging nettle was used for medicine and rope (Henderson et al. 1989). Cattail and beargrass were used in basketry. Sitka spruce roots were also used for nets and cordage, and spruce pitch, limbs, bark, and wood were also used (Henderson et al. 1989).

Olympic National Forest

Created in 1907, ONF encompasses an area of 256,440 ha, 15 percent of which is federally designated wilderness. The mission of the Forest Service, and thus ONF, is “to sustain the health, diversity, and productivity of the Nation’s forest and grasslands to meet the needs of present and future generations” (USDA FS 2007). Timber production and
fresh water were historically the most valued ecosystem services provided by ONF. Timber harvest activities began on ONF in the 1920s. Until the 1990s, timber management generally consisted of clearcutting, broadcast burning, and tree replanting. These management practices resulted in the conversion of over one-third of ONF into relatively young even-aged forests. In addition, over 3500 km of forest roads built for timber harvest remain on the forest road network.

The 1994 Northwest Forest Plan (NWFP) (USDA and USDI 1994) and a change in Forest Service agency management policy led to a movement toward ecosystem management at ONF. Ecosystem management from a Forest Service perspective has four main components including protecting ecosystems, restoring deteriorated ecosystems, providing multiple-use benefits for people within the capabilities of ecosystems, and ensuring organizational effectiveness. The NWFP also mandates management for ecological priorities, mainly the protection, enhancement, and acceleration of late-successional forest conditions. At ONF, a major land allocation under the NWFP is late-successional reserve (LSR), the goal of which is to maintain late-successional and old-growth forest ecosystems. The LSRs are designed primarily to serve as habitat for late-successional and old-growth-related species, including the northern spotted owl.

Olympic National Forest is focused on:

- Managing for native biodiversity and promoting the development of late-successional forests
- Restoring and protecting aquatic ecosystems from the impacts of an aging road infrastructure
- Managing for individual threatened and endangered species as defined by the Endangered Species Act (ESA) (ESA 1973) and related policies

Because of this focus on ecological restoration, forest personnel consider ONF to be a “restoration forest.”

Besides the ESA, other federal statutes guide current management activities at ONF, including the National Forest Management Act (NFMA) (NFMA 1976) and the National Environmental Policy Act (NEPA) (NEPA 1969). The NFMA imposes directives on national forest planning and activities. The NEPA requires all federal government agencies to conduct environmental analyses and prepare environmental documents (environmental assessments or environmental impact statements [EIS]) that assess and disclose the environmental impacts of proposed actions.

The ONF land and resource management plan (LRMP) (as amended by the NWFP; USDA FS 1990) guides management activities at ONF and is revised every 10 years. A key component of the LRMP is the aquatic conservation strategy (ACS), which includes eight objectives for maintaining and restoring watershed processes and functions. To be consistent with the LRMP and the ACS, all management activities at ONF must maintain or help restore watershed conditions.

The ONF also has a forest strategic plan that integrates aquatics, wildlife, silviculture, and fire, helping to identify priority areas for management activities such as habitat restoration, road decommissioning, forest thinning, and fuel reduction treatments. Factors such as habitat improvement potential (specifically for threatened and endangered species and important charismatic species such as Roosevelt elk), economic viability of activities, and existing priorities and land allocation restrictions determine priority actions.

The ONF and the Forest Service in general are just beginning to address climate change and adaptation to climate change. In October 2008, the Forest Service issued the Forest Service Strategic Framework for Responding to Climate Change (USDA FS 2008), which identified climate change adaptation as a key goal for the agency and recommended integrating climate change considerations into agency-wide policies and program guidance. The agency also issued national guidance on how climate change can be incorporated in LMRP revision and analyses of projects. Further guidance for adaptation on national forests is in development at this writing.

**Olympic National Park**

Created in 1938, ONP covers 373 384 ha on the Olympic Peninsula. The park includes both the central, mountainous portion of the Olympic Peninsula, as well as a strip more than 110 km long on the Pacific coast. In 1988, the U.S. Congress designated over 95 percent of the park as a wilderness area. Much of the park is in relatively pristine condition, although effects of past human activities are evident and persistent in some areas.
Adapting to Climate Change at Olympic National Forest and Olympic National Park

The foundation for National Park Service (NPS) policies governing the management at ONP is the 1916 Organic Act, which established an NPS with the purpose to “conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations” (NPS 1916). The fundamental purpose of the NPS is to conserve park resources and values and to provide for enjoyment of parks while avoiding or minimizing adverse impacts. Management within parks focuses on preserving physical and biological processes and preserving the “natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems” (NPS 2006).

The mandate of the NPS requires that parks both conserve natural resources and provide for public enjoyment, although the Redwoods Act (1978) clarified that protecting resources takes precedence over providing for the enjoyment of the public. Nevertheless, this dual mandate entails careful management to avoid conflicts between the two goals. Several other statutes such as the NPS General Authorities Act (NPS 1970), Clean Air Act (1970), ESA (1973), NEPA (1969), Wilderness Act (1964), and Wild and Scenic Rivers Act (1968) constitute additional directives for park management. Management policies of the NPS (2006) provide a stewardship framework and broad guidance to park managers. Individual parks develop long-term management plans and other implementation plans that describe specific management objectives.

The ONP General Management Plan (NPS 2008) established a vision for managing ONP for the next 15 to 20 years and aims to protect natural and cultural resources while improving visitor experiences. The plan designated management zones within the park and established desired resource conditions. The plan also established fundamental objectives including maintaining access to existing developed areas, trails, campgrounds, and facilities; seeking additional partnerships to help provide better visitor access and enjoyment and protection of sensitive resources; making boundary adjustments through purchases or land exchanges to incorporate sensitive resource areas within the park (e.g., fish habitat, wetlands); and providing continued protection of wilderness resources and cultural resources within wilderness. The public participated in the development of this plan.

Other park plans guide management practices, including the ONP backcountry management plan, the fire management plan, and the wilderness management plan (to be developed beginning fall 2010). Besides regulations found in the Code of Federal Regulations (36CFR part 7.28), the ONP superintendent’s compendium establishes regulations that are specific to ONP.

Like ONF, ONP is subject to NEPA. As part of NEPA analyses, park managers evaluate management actions within the park to determine their potential effect on ONP resources, select the action that will meet park management needs with the least impacts, and ensure that no activities will result in impairment. Depending on the nature of the activity, compliance may be relatively informal or may require an EIS under NEPA.

Similar to the Forest Service, the NPS is just beginning to address climate change in agency policy and directives. The U.S. Department of the Interior (DOI) issued Secretarial Order No. 3226 directing bureaus, including the NPS, to “provide leadership by developing timely responses to emerging climate change issues.” The secretarial order requires agencies in the DOI to consider potential impacts of climate change in planning, setting priorities for research, and making decisions affecting resources. The order also calls on DOI agencies to review existing programs and policies to identify potential climate change impacts on areas of responsibility and recommend actions in response to potential impacts.

At the agency level, NPS management policies (NPS 2006) refer to potential effects of climate change on resources and call for parks to gather and maintain climate data for reference and to educate visitors about climate change. Future management directives may consider climate change responses across all aspects of park planning and operations. The NPS Pacific West Region, which includes ONP, is developing mitigation strategies in response to a regional directive that calls on all parks in the region to aim to become carbon neutral. Park planning specialists are developing guidance to include climate change in agency policy and directives.
change in general management plans and other planning documents, as well as draft adaptation concepts for local park units in the Pacific West Region.

**Similarities in Management Between Olympic National Forest and Olympic National Park**

Although differences in policy exist for management at ONF and ONP, similarities in management objectives exist. Crosscutting statutes such as the ESA (1973), NEPA (1969), Clean Air Act (1970), and Clean Water Act (1977) apply to all management activities for both entities. They also have similar policy goals for preservation of biodiversity and native gene pools. Both ONF and ONP practice ecosystem management focused on maintaining ecosystem process and function and use restoration as a tool to maintain process and function. Policies applied to the wilderness areas of the forest and park are very similar. In addition, recreation and benefit to society are key functions of both ONP and ONF. These similarities in management objectives provide a consistent context for how the forest and park adapt to climate change.

**References**


**Clean Air Act of 1970, as amended August 1977; 42 U.S.C. s/s 7401 et seq.**


**National Environmental Policy Act of 1969 [NEPA]; 42 U.S.C. 4321 et seq.**


**National Park Service General Authorities Act of 1970 [NPS]; 1970.84 Stat. 825.**


**Redwoods Act of 1978; 16 U.S.C. §§ 1, 1a-1, Public Law No. 95–250.**
Adapting to Climate Change at Olympic National Forest and Olympic National Park


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Adapting to Climate Change at Olympic National Forest and Olympic National Park

Chapter 3: Future Climate on the Olympic Peninsula: Forest-Relevant Climate Scenarios

Jeremy S. Littell

Introduction

Adaptation to climate change in forest ecosystems requires a robust estimate (or, in the case of substantial uncertainty, multiple estimates) of future climate to use in planning and scenario development. In this section, I borrow heavily from the Washington Climate Change Impacts Assessment (WACCIA) by the University of Washington Climate Impacts Group (Littell et al. 2010), the chapter on future Pacific Northwest Climate (Mote and Salathé 2010), the chapter on regional dynamic climate modeling (Salathé et al. 2010), and the chapter on future hydrologic regimes (Elsner et al. 2010). I first describe emissions scenarios used to constrain the climate models used in this study, then summarize findings on regional climate in the Pacific Northwest and some of the subregional consequences of those climate changes for variables more closely related to forest ecosystems (see box 3.1 for summary).

Emissions Scenarios: A1B (Moderate) and B1 (Low)

To develop plausible estimates of the future climate of the Pacific Northwest, physically based global climate models (GCMs) that incorporate key elements of the climate system (e.g., ocean, atmosphere, cryosphere [snow and ice], and land surface) must be used to project future conditions based on known climate dynamics and changes in the climate forcing factors. The primary forcings likely to affect changes in climate the most in the 21st century are future emissions of greenhouse gases (which increase the heat-trapping capability of the atmosphere, causing warming) and sulfate aerosols (which reflect sunlight and also promote cloud formation, causing local cooling).

Under the direction of the Intergovernmental Panel on Climate Change (IPCC), over 40 emissions scenarios have been published in the Special Report on Emissions Scenarios (SRES) (Nakićenović and Swart 2000). These scenarios have widely varying assumptions about future socioeconomic changes and the resulting changes in greenhouse gas (including carbon dioxide) and aerosol emissions, and represent one constraint on future climate uncertainty. Three

Box 3.1—Summary of projected climate change effects in the Pacific Northwest and on the Olympic Peninsula.

- The Washington Climate Change Impacts Assessment, conducted by the University of Washington Climate Impacts Group, provided detailed information on potential climate changes in the Pacific Northwest and on the Olympic Peninsula.
- Climate models project increases in annual average temperature of +0.6 °C to +1.9 °C by the 2020s; +0.9 °C to +2.9 °C by the 2040s; and +1.6 °C to +5.4 °C by the 2080s for the Pacific Northwest.
- Warming is expected to occur during all seasons, with most models projecting the largest temperature increases in summer.
- Projected changes in annual precipitation in the Pacific Northwest differ considerably between models, but averaged over all models are small (+1 to +2 percent).
- Ensemble means of models for precipitation suggest wetter winters (+3.3 percent in the 2040s, +7.6 percent in the 2080s) and drier summers (-8.5 percent in the 2040s, -12.8 percent in the 2080s).
- Summer potential evapotranspiration (one component of water balance and closely related to fuel moisture and tree stress) is expected to increase by 5 to 18 mm by the 2040s, with much of the largest increases in lower elevation forests in the northeastern portion of the peninsula.
- Winter precipitation on the Olympic Peninsula is likely to increase by 4.5 to 5 percent, on average and depending on location.
- In addition to increased precipitation quantity, regional climate models show significant increases in the intensity of winter precipitation in the western portion of the Olympic Peninsula.

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of these SRES scenarios were commonly chosen for forcing GCMs used in the IPCC Fourth Assessment Report: B1, A1B, and A2. The climate forcing of all scenarios is similar until the 2020s because of a long lifetime of coal-fired electric powerplants and of the major greenhouse gases. Of these three scenarios, A2 produces the highest emissions by the end of the century, but before mid-century, none of the scenarios is consistently the highest. Because more modeling groups use A1B than A2, and because the focus for this study was on mid-century change, A1B was used as the higher emissions scenario and B1 as the low emissions scenario for analysis of 21st-century Pacific Northwest climate. Though B1 is the lowest of the IPCC illustrative scenarios, it still produces changes in climate that many scientists call “dangerous” (Schellnhuber et al. 2006). At the high end, scenario A1FI results in even higher climate forcing by 2100 than A1B. Mid-2000s global emissions of carbon dioxide exceeded even the A1FI scenario (Raupach et al. 2007).

Whether these exceedingly high emissions will continue into the future is uncertain, but in any case, the projections described here are potentially conservative.

**Pacific Northwest Future Regional Climate**

Mote and Salathé (2010) used 20 different climate models to explore the consequences of two different greenhouse gas emissions scenarios for the Pacific Northwest. All of the models indicate that the future climate will be warmer than the past (fig. 3.1) and, together, they suggest that Pacific Northwest warming rates will be greater in the 21st century than those observed in the 20th century. All changes below are relative to the period 1970–1999, and all are regionally averaged changes that apply to the Pacific Northwest. Climate models project increases in annual average temperature of +1.1 °C, range +0.6 °C to +1.9 °C by the 2020s; +1.8 °C, range +0.9 °C to +2.9 °C by the 2040s; and +3.0 °C, range +1.6 °C to +5.4 °C by the 2080s. Climate models are
able to match the observed 20th-century warming (0.8 °C since 1920, or +0.1 °C per decade for 1920 to 2000) in the Northwest, and project a warming rate of roughly +0.3 °C per decade in the 21st century. Projected changes in annual precipitation (fig. 3.2) differ considerably between models, but averaged over all models are small (+1 to +2 percent).

Seasonal changes in climate are arguably more important for projecting the impacts of climate change on forests. Warming is expected to occur during all seasons, with most models projecting the largest temperature increases in summer (fig. 3.3). Seasonal changes in precipitation early in the 21st century may not be separable from historical conditions given the large natural variations between wetter and drier years. Some GCMs suggest large seasonal changes (fig. 3.4), but the ensemble means point toward wetter winters (+3.3 percent in the 2040s, +7.6 percent in the 2080s, averaged over all A1B and B1 scenarios) and drier summers (-8.5 percent in the 2040s, -12.8 percent in the 2080s, averaged over all A1B and B1 scenarios).

Regional climate modeling (weather models forced with GCMs in the future, Salathé et al. 2010) points out areas and seasons that get drier even as the region gets wetter. The
that some local changes in temperature and precipitation may be quite different than average regional changes projected by the global models. For example, the two global models examined suggest winter precipitation will increase in many parts of the Pacific Northwest, but potentially decrease in the Cascade Range. Future research is required to understand if this trend is consistent across many global models.

These comparisons between global and regional models are not yet developed to the point that they are a strong basis for decisionmaking; additional models would be needed to characterize the likely seasonal trends expected in the future. Currently, their chief use is as a research tool to better understand where the inferences derived from global models are likely to hold up best, which process may influence rates of change differently within a region, and which changes might be expected to exacerbate extreme events (e.g., prolonged droughts or high-intensity storms). On the Olympic Peninsula, for example, it is possible that decreases in snowpack in spring will lead to higher rates of warming in spring than the regional average owing to the loss of the snow albedo feedback, an effect that the GCMs would not likely capture.

Climatic Downscaling: Winter Precipitation and Water Deficit

The GCMs produce output at relatively coarse scales (100 km or greater) and do not yet operate at scales that provide future climate estimates useful for subregional planning. However, downscaled future climate projections at more local scales are based on the relationship between finer scale historical observations and the GCM during the same historical period. The best way to constrain uncertainty in future regional climate associated with the high number of potential GCM futures is to use the fidelity of each model to the 20th century observed record to gage its usefulness for regional projection (Mote and Salathé 2010). In the WACCIA comparison of GCMs (Mote and Salathé 2010), models were weighted according to their fidelity to construct an ensemble average or an average of all models that gives more weight to models that did well in predicting past climate in the region. However, another approach to this problem (Hamlet et al. 2010, Overland and Wang 2007) is to constrain the average to models that best estimate observed climate (i.e., models that have the smallest bias in temperature and precipitation and that simulate the
most realistic annual cycle in these parameters). Hamlet et al. (2010) evaluated a pool of 20 GCMs run for the A1B scenario in IPCC Fourth Assessment Report (Solomon et al. 2007) and selected 10 models, eliminating models that do a poor job of estimating climate change already known to have occurred. In this section on deficit, the average (ensemble) is composed of this subset of the available GCMs: UKMO-HadCM3, CNRM-CM3, ECHAM5/MPI-OM ECHO-G, PCM, CGCM3.1(T47), CCSM3, IPSL-CM4, MIROC3.2(medres), and UKMO-HadGEM.

Elsner et al. (2010) described methods and results for future climatic downscaling and incorporation into hydrologic modeling by using the Variable Infiltration Capacity (VIC) hydrologic model. Littell et al. (2010) showed that Washington forest ecosystem processes such as tree growth and fire are directly associated with potential evapotranspiration, actual evapotranspiration, and their difference (water balance deficit [$DEF$]), particularly in summer. The $DEF$ is effectively the difference between water demand by the atmosphere and water supply in the soil profile; when demand exceeds supply, there is deficit. These variables are derived from temperature, precipitation, and other physical variables in VIC. Future changes in June to August (JJA) water balance deficit on the Olympic Peninsula (2040s, scenario A1B) are greatest in the northeast, east, and southeast, with increases (effectively drier) of 0.4 in (10 mm) to 2.4 in (60 mm) depending on location, likely because of increased evapotranspiration associated with increased temperature (fig. 3.5). Some of the highest elevations suggest decreases in deficit of similar magnitude, likely owing to increased snowmelt.

Winter (December to February [DJF]) precipitation on the Olympic Peninsula is likely to increase (fig. 3.6) by about 4.5 to 5 percent, on average and depending on location. Precipitation increases suggested by the GCM ensemble should be considered as general estimates of future trends, because the GCMs do not have sufficient topographic detail to describe fine-scale differences in future precipitation. However, Salathé et al. (2010) presented results from regional climate models (weather models forced with GCMs) that show significant increases in the intensity of winter precipitation in the western portion of the Olympic Peninsula. Although there is some uncertainty in this projection because relatively few climate models were used, these results suggest that portions of the Olympic Peninsula will receive not only more precipitation, but that it will come in the form of more intense storms.
Summer (June to August [JJA]) potential evapotranspiration (one component of water balance and closely related to fuel moisture and tree stress) is expected to increase by 5 to 18 mm by the 2040s (fig. 3.7), with most of the largest increases in lower elevation forests in the northeastern portion of the peninsula.

**Literature Cited**

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Hamlet, A.F.; Salathé, E.P.; Carrasco, P. 2010.


Figure 3.7—(A) Future (2040s) June to August (JJA) potential evapotranspiration (PET) and (B) change from 1916 to 2006 June to August baseline PET for the Olympic Peninsula based on downscaled climate projections and Variable Infiltration Capacity hydrologic modeling (Elsner et al. 2010). Olympic National Park and Olympic National Forest are outlined in black. Increased PET is related to decreased soil moisture and increased drought stress. The largest increases in PET are in the northeastern Olympic Peninsula.


Chapter 4: Climate Change, Hydrology, and Road Management at Olympic National Forest and Olympic National Park

Jessica E. Halofsky, William S. Shelmerdine, Robin Stoddard, Robert Metzger, Alan F. Hamlet, and Catherine Hawkins Hoffman

Potential Effects of Climate Change on Hydrology on the Olympic Peninsula: Temperature, Snowpack, and Timing of Streamflow

Across the Western United States, increasing temperatures over the last 50 years have led to more precipitation falling as rain rather than snow, earlier snowmelt (Hamlet et al. 2007, Stewart et al. 2005), and reduced spring snowpack (Barnett et al. 2008, Hamlet et al. 2005, Mote 2003, Mote et al. 2005). Further reductions in snowpack and shifts in timing of snowmelt are expected with increasing temperatures in the 21st century. April 1 snow water equivalent (a measure of water in snowpack) is projected to decrease by an average of 27 to 29 percent across Washington state by the 2020s, 37 to 44 percent by the 2040s, and 53 to 65 percent by the 2080s (Elsner et al. 2010) (fig. 4.1). The greatest reductions in snowpack are expected for lower elevations (<1000 m) because of warmer midwinter temperatures at these elevations (Elsner et al. 2010, Hamlet et al. 2005).

Changes in snowpack are particularly important for the mountainous regions of the Western United States, including the Pacific Northwest, because snowmelt provides about 70 percent of annual streamflow in these regions (Mote et al. 2008). Warming temperatures affect the timing of snowmelt and associated seasonal streamflow. Both increased winter rain (as opposed to snow) and shifts to earlier spring snowmelt result in higher winter and spring streamflows and lower summer streamflows in snowmelt-dominated and transient (rain/snow mixed) watersheds (Elsner et al. 2010, Stewart et al. 2005). Snowmelt-dominant watersheds store most winter precipitation in snowpack. This snowpack melts in the spring and early summer, resulting in peak

![Figure 4.1—Summary of projected changes in April 1 snow water equivalent (SWE), an indication of snow amount, compared to historical for the 2020s, 2040s, and 2080s (A1B and B1 emissions scenarios) by the Variable Infiltration Capacity model. Percentage change values represent spatially averaged April 1 SWE across Washington state (Elsner et al. 2010).](image-url)
streamflow in the late spring or early summer and lower streamflow during the winter months (Elsner et al. 2010). Transient watersheds are primarily at mid elevations and receive some snow and some rain. Of the snow that these watersheds receive, some melts in the winter months, and some is stored in the winter months and melts with warming temperatures in the spring (Elsner et al. 2010). Thus, streams and rivers draining transient watersheds often have one streamflow peak in fall or early winter owing to runoff generated by precipitation falling as rain, and another peak in late spring when the snowpack accumulated in midwinter melts (Elsner et al. 2010). Projections for Washington state show that by the 2080s, there will be widespread transformation of transient watersheds to rain-dominant behavior, with essentially no snowmelt-dominant watersheds remaining in Washington by the end of the 21st century (Elsner et al. 2010). In response to these changes in natural storage processes, seasonal streamflow timing will shift significantly in both snowmelt-dominant and transient watersheds, resulting in increased winter and decreased spring and summer streamflows.

Examples of projected shifts in timing of streamflow for river systems on the Olympic Peninsula are shown in figures 4.2 through 4.7. Some river systems on the peninsula, such as the Satsop River (not shown), are rain-dominant watersheds. Warming temperatures will not likely have a significant impact on timing of streamflow in rain-dominant watersheds. Several Olympic Peninsula river systems, such as the Queets, Skokomish, Quinault, and Hoh River basins (figs. 4.2 through 4.5), receive most precipitation as rain but also some as snow at higher elevations, and thus warming will likely have moderate impact on the timing of streamflow in these watersheds. Other river systems, such as the Elwha and Dungeness Rivers, are in transient watersheds. Increasing temperatures in the 21st century will likely lead to significant increases in the winter and early spring peak streamflows and significant decreases in the summer low flows in these transient watersheds (figs.

![Figure 4.2—Simulated combined monthly average total runoff and baseflow over the entire Queets basin expressed as an average depth (millimeters). This variable is a primary component of the simulated water balance, and is one of the primary determinants of streamflow. The blue line shows the simulated historical values. Light red bands show the range of all future scenarios from 10 global climate models for the A1B (left column) and B1 (right column) emissions scenarios, and the dark red lines show the ensemble average for the future projections. See http://www.hydro.washington.edu/2860 for a detailed description of the methods used to generate these outputs.](image-url)
Figure 4.3—Simulated combined monthly average total runoff and baseflow over the entire Skokomish basin expressed as an average depth (millimeters). This variable is a primary component of the simulated water balance, and is one of the primary determinants of streamflow. The blue line shows the simulated historical values. Light red bands show the range of all future scenarios from 10 global climate models for the A1B (left column) and B1 (right column) emissions scenarios, and the red lines show the ensemble average for the future projections. See http://www.hydro.washington.edu/2860 for a detailed description of the methods used to generate these outputs.

Figure 4.4—Simulated combined monthly average total runoff and baseflow over the entire Quinault basin expressed as an average depth (millimeters). This variable is a primary component of the simulated water balance, and is one of the primary determinants of streamflow. The blue line shows the simulated historical values. Light red bands show the range of all future scenarios from 10 global climate models for the A1B (left column) and B1 (right column) emissions scenarios, and the red lines show the ensemble average for the future projections. See http://www.hydro.washington.edu/2860 for a detailed description of the methods used to generate these outputs.
Figure 4.5—Simulated combined monthly average total runoff and baseflow over the entire Hoh basin expressed as an average depth (millimeters). This variable is a primary component of the simulated water balance, and is one of the primary determinants of streamflow. The blue line shows the simulated historical values. Light red bands show the range of all future scenarios from 10 global climate models for the A1B (left column) and B1 (right column) emissions scenarios, and the red lines show the ensemble average for the future projections. See http://www.hydro.washington.edu/2860 for a detailed description of the methods used to generate these outputs.

Figure 4.6—Simulated combined monthly average total runoff and baseflow over the entire Elwha basin expressed as an average depth (millimeters). This variable is a primary component of the simulated water balance, and is one of the primary determinants of streamflow. The blue line shows the simulated historical values. Light red bands show the range of all future scenarios from 10 global climate models for the A1B (left column) and B1 (right column) emissions scenarios, and the red lines show the ensemble average for the future projections. See http://www.hydro.washington.edu/2860 for a detailed description of the methods used to generate these outputs.
4.6 and 4.7). Decreased summer flow will likely be most evident in the headwaters of watersheds, where flows will likely become increasingly ephemeral or cease altogether in the summer months (fig. 4.8). However, such effects are sometimes strongly linked to changes in groundwater in the basin, which are not included in the projections discussed above (Tague et al. 2008). Locations where deep groundwater may mediate streamflow responses on the Olympic Peninsula could potentially be identified through interpretation of a geological map and locating areas where intense fracturing has occurred. However, groundwater effects are unlikely to be a major influence on hydrologic changes as they are in regions with porous and young volcanic soils, such as central Oregon.

Precipitation, Storm Intensity, and Flooding

Changes in precipitation have a direct influence on streamflow and the frequency and magnitude of flooding events. Model projections for precipitation in the 21st century are much more uncertain than those for temperature. Elsner et al. (2010) analyzed precipitation projections of 20 global climate models and two future carbon dioxide scenarios for the Pacific Northwest, and they found that annual projected precipitation changes range from -9 to +12 percent for the 2020s, -11 to +12 percent for the 2040s, and -10 to +20 percent for the 2080s (Elsner et al. 2010, Mote and Salathé 2010). Projections of seasonal precipitation changes, however, show increases in winter precipitation and decreases in summer precipitation (Elsner et al. 2010, Mote and Salathé 2010). Projections of cool season precipitation (combining both A1B and B1 emission scenarios) range from +2.3 to +3.3 percent for the 2020s, +3.9 to +5.4 percent for the 2040s, and +6.4 to +9.6 percent for the 2080s (Elsner et al. 2010). These increases in cool season precipitation are projected to lead to overall increases in annual runoff across Washington (0 to 2 percent by the 2020s, 2 to 3 percent by the 2040s, and 4 to 6 percent by the 2080s), although the effects differ for individual watersheds (Elsner et al. 2010).

Besides potential increases in winter precipitation, precipitation intensity is projected to increase in some parts of Washington, including the west slopes of the Olympic
Peninsula, in the 21st century (Salathé et al. 2010). Increases in winter precipitation, increases in precipitation intensity, and changes in timing of peak streamflow in transient watersheds will contribute to increased flood risk in some of Washington’s rivers. Flooding magnitude and frequency are projected to increase most in December and January and in historically transient watersheds in Washington (Mantua et al. 2010). Rain-dominant watersheds will likely see small increases in flood frequency, whereas many snowmelt-dominant watersheds will likely see decreases in flooding owing to decreases in snowpack and corresponding decreases in snowmelt-driven peak flows in the spring (Mantua et al. 2010). On the Olympic Peninsula, increases in flood frequency are projected for many river systems (fig. 4.8), with greater increases in flood frequency projected in historically transient watersheds such as the Elwha. At the opposite extreme, earlier snowmelt and timing of runoff is projected to lead to decreased low flows in the summer in many Olympic Peninsula watersheds (fig. 4.9). As noted above, effects of groundwater on summer streamflows may mitigate these impacts in some watersheds.

Effects of Changing Hydrology on Physical Watershed Processes

Projected hydrologic effects of climate change, including more precipitation falling as rain rather than snow, decreased snowpack, earlier snowmelt, increased winter precipitation and runoff, increased storm intensity, increased winter and spring streamflows, reduced summer streamflows, increased flood frequency and magnitude, and elevation shifts in transition (rain on snow) zones, will likely affect physical watershed processes (table 4.1). Increased precipitation and storm intensity, higher snowlines (increasing effective basin area), and loss of snow
Adapting to Climate Change at Olympic National Forest and Olympic National Park

Cover are expected to lead to increased rate and volume of water delivery to channels, increased mass wasting and debris flows, and increased sediment and wood delivery to streams (Benda and Dunne 1997). Increased winter and spring flow volume in streams will lead to increased flood-plain inundation, increased channel migration, and increased channel erosion and scour. Other climate-related stressors, such as fire and tree mortality (see chapter 6), could also exacerbate these hydrologic effects of climate change on physical watershed processes.

Road Management at Olympic National Forest and Olympic National Park

The following section provides information on road management at Olympic National Forest (ONF) and Olympic National Park (ONP) including (1) the context in which ONF and ONP manage roads, (2) the guidance and constraints on road management at ONF and ONP, and (3) the primary issues around and activities currently conducted in road management at ONF and ONP. This information, coupled with the likely impacts of climate change on hydrology on the Olympic Peninsula (described above), provides a basis on which to develop climate change adaptation options for road management at ONF and ONP.

Road Management at Olympic National Forest

Olympic National Forest has 3500 km of roads. Most of these roads were built between 1950 and 1980, primarily for logging purposes, by using practices that are not consistent with today’s standards. The high number of roads, heavy rainfall, steep slopes, frequent storm damage, and high recreational demand for well-maintained forest roads all lead to high road maintenance costs at ONF. However, funding allocated for road maintenance, upgrading, and decommissioning at ONF is limited.
<table>
<thead>
<tr>
<th>Program</th>
<th>Project</th>
<th>Projected climate change effects&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Projected effects on physical watershed processes</th>
<th>Current and expected sensitivities</th>
<th>Adaptation management options and strategies</th>
<th>Barriers and information needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road maintenance&lt;sup&gt;b&lt;/sup&gt; Planning</td>
<td>2, 6–10</td>
<td>• Increased flow volume</td>
<td>• Culvert capacity</td>
<td>• Prioritize road treatment by watershed risk and road risk (the roads with the most sensitivities and that are most connected to streams)</td>
<td>• National Highway Safety Act fund requirements (ONF)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased mass wasting and avalanches</td>
<td>• Water diversion</td>
<td></td>
<td>• Maintenance funding limitations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased sediment delivery</td>
<td>• Fill-slope failures</td>
<td></td>
<td>• Need assessments to refine links to physical process and response</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased floodPLAIN inundation</td>
<td>• Stream-adjacent road failure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased channel migration</td>
<td>• Assess possibilities to design more sustainable road types for the future</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Implementation</td>
<td>1, 5–9</td>
<td>• Increased flow volume</td>
<td>• Culvert capacity</td>
<td>• Prioritize road treatment by watershed risk and road risk (the roads with the most sensitivities and that are most connected to streams)</td>
<td>• National Highway Safety Act fund requirements (ONF)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased mass wasting/debris flows</td>
<td>• Water diversion</td>
<td></td>
<td>• Maintenance funding limitations</td>
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<tr>
<td></td>
<td></td>
<td>• Increased sediment delivery</td>
<td>• Fill-slope failures</td>
<td></td>
<td>• Need assessments to refine links to physical process and response</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased sediment delivery to culvert inlets and ditches</td>
<td>• Extension of channel network (development of first-order channels)</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>• Increased rate and volume of water delivery to channels</td>
<td>• Assess possibilities to design more sustainable road types for the future</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>• Increased transport of wood in channels</td>
<td>• Assess possibilities to design more sustainable road types for the future</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road operations Planning</td>
<td>2, 5–10</td>
<td>• Increased flow volume</td>
<td>• Culvert capacity</td>
<td>• Prioritize road treatment by watershed risk and road risk (the roads with the most sensitivities and that are most connected to streams)</td>
<td>• National Highway Safety Act fund requirements (ONF)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased mass wasting and avalanches</td>
<td>• Water diversion</td>
<td></td>
<td>• Road funding limitations</td>
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<tr>
<td></td>
<td></td>
<td>• Increased sediment delivery</td>
<td>• Fill-slope failures</td>
<td></td>
<td>• Need assessments to refine links to physical process and response</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• Increased floodPLAIN inundation</td>
<td>• Stream-adjacent road failure</td>
<td></td>
<td>• Need feasibility studies for mass transit options (ONP)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• Increased channel migration</td>
<td>• Encroachment from stream-adjacent road segments</td>
<td></td>
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</tr>
</tbody>
</table>
### Table 4.1—Projected climate change effects and adaptation options in the context of road management at Olympic National Forest (ONF) and Olympic National Park (ONP) (continued)

<table>
<thead>
<tr>
<th>Program</th>
<th>Project</th>
<th>Projected climate change effects&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Projected effects on physical watershed processes</th>
<th>Current and expected sensitivities</th>
<th>Adaptation management options and strategies</th>
<th>Barriers and information needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design: Water crossing</td>
<td>2, 5–10</td>
<td>• Increased flow volume</td>
<td>• Culvert capacity</td>
<td>• Design more resilient structures (design resilient bridges and larger structures, and incorporate channel geomorphic attributes in structure design)</td>
<td>• Need method to calculate Q&lt;sub&gt;100&lt;/sub&gt; (historical or recent data?) or an alternative</td>
<td></td>
</tr>
<tr>
<td>Fish passage</td>
<td></td>
<td>• Increased sediment and wood transport</td>
<td>• Foundation scour</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• Increased channel migration</td>
<td>• Lateral channel adjustments</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>• Increased mass wasting and avalanches</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design: Bank protection</td>
<td>7–10</td>
<td>• Increased flow volume</td>
<td>• Stream-adjacent road failure</td>
<td>• Relocate road segment, decommission road segment, or accept higher maintenance costs (ONF)</td>
<td>• Revisit access and travel management plan and develop better resolution in identifying sensitive stream-adjacent roads</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased erosion and scour</td>
<td>• Cut-bank failures on montane and subalpine roads</td>
<td></td>
<td></td>
<td>• Need geomorphic analyses of other (park) rivers bordered by roads (ONP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased channel migration</td>
<td></td>
<td></td>
<td></td>
<td>• No funding source for proactive, sustainable bank protection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased mass wasting and avalanches</td>
<td></td>
<td></td>
<td></td>
<td>• Emergency Relief for Federally Owned Roads</td>
</tr>
<tr>
<td>Design: New construction</td>
<td>7–10</td>
<td>• Potential increase in capture and concentration of water</td>
<td>• Increased potential for ditch or culvert plugging and diversion</td>
<td>• Decrease reliance on drainage structures</td>
<td>• May have to adjust thinking regarding design life and therefore life cycle costs in alternative comparisons</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Potential decrease in slope stability</td>
<td>• Increased potential for erosion and scour at pipe outlets</td>
<td>• Increase frequency of drainage discharge points</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Increase redundancy or backup features</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Limit consequence of failure</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Adjust alignment, roll with topography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Program</td>
<td>Project</td>
<td>Projected climate change effects$^a$</td>
<td>Projected effects on physical watershed processes</td>
<td>Current and expected sensitivities</td>
<td>Adaptation management options and strategies</td>
<td>Barriers and information needed</td>
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</tr>
<tr>
<td>Design</td>
<td>Reconstruction</td>
<td>7–10</td>
<td>• Increased flow volume</td>
<td>• Culvert capacity</td>
<td>• Implement more conservative design elements (more intensive treatments such as larger diameter culverts, closer spacing between ditch relief culverts and waterbars)</td>
<td>• Revisit access and travel management plan and develop better resolution for identifying road vulnerability (consider rain-on-snow and increased storm intensity) (ONF)</td>
</tr>
<tr>
<td></td>
<td>Drainage upgrades</td>
<td></td>
<td>• Increased rate and volume of water delivery to channels</td>
<td>• Culvert plugging; water diversion</td>
<td>• Increase maintenance-frequency of drainage features</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stabilization</td>
<td></td>
<td>• Increased sediment and wood transport</td>
<td>• Fill-slope failures</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Storm-proofing</td>
<td></td>
<td>• Increased mass wasting/debris flows</td>
<td>• Extension of channel network (development of first-order channels)</td>
<td>• Increase maintenance-frequency of drainage features</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Increased sediment delivery to culvert inlets and ditches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design:</td>
<td>Decommis-</td>
<td>7–10</td>
<td>• Increased runoff</td>
<td>• Increased erosion with sediment delivery to channels</td>
<td>• Implement more conservative design elements (bigger channels, more drainage, more outsloping, increased armoring of outlets)</td>
<td>• Region 6 is currently developing a road storm-damage risk reduction guide (ONF)</td>
</tr>
<tr>
<td></td>
<td>ioning (ONF)</td>
<td></td>
<td>• Increased flow volume; increased channel migration</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>• Increased sediment transport</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Increased mass wasting and debris flows</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Increased floodplain inundation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road</td>
<td>Implementation</td>
<td>1, 5–9</td>
<td>• Increased flow volume</td>
<td>• Increasing number of projects needed to reduce resource risk and road failures</td>
<td>• Continue efforts to improve, stabilize, and reduce existing road system</td>
<td>• National Highway Safety Act requirements (ONF)</td>
</tr>
<tr>
<td>operations</td>
<td></td>
<td></td>
<td>• Increased mass wasting/debris flows</td>
<td>• Limited funding</td>
<td>• Focus road improvements in priority areas</td>
<td>• Funding limitations</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Increased sediment delivery to culvert inlets and ditches</td>
<td>• Changes in project work periods</td>
<td></td>
<td>• Physical barriers to road access owing to storm damage</td>
</tr>
</tbody>
</table>
Road maintenance activities ensure that existing roads function correctly (defined by policy).

To help prioritize road management activities at ONF,
a road management strategy (RMS) was developed in 2000
that assessed the risks that individual road segments posed
to various resources, especially aquatic resources, against
the need for access that the road provided. The RMS was
developed at least partly in response to the aquatic restoration mandate of the Northwest Forest Plan (USDA and
USDI 1994). The RMS is used for setting priorities for road
maintenance, upgrading, and decommissioning (see box
4.1 for specific activities in these categories) and considers
five factors, each of which incorporates particular indicators. These five factors include aquatic risk, access needs,
wildlife concerns, high-value watersheds, and silvicultural
opportunities (box 4.2). In general, roads that present high
risk to aquatic systems, are needed for access (by the public
or for activities such as restoration thinning), impact threatened or endangered species, and are located in high-value
watersheds are prioritized for maintenance, stabilization,
and upgrading. Roads that meet the above criteria but are
not necessary for access are prioritized for decommissioning (e.g., fig. 4.10).
In addition to being guided by the RMS, road management at ONF is guided by the access and travel management (ATM) plan, which is a strategic management tool
that describes the proposed future road system. The ATM
was updated by forest managers in 2003. By using RMS
information as a starting point, managers conducted a
road-by-road evaluation on about 3300 km of road, during
which RMS data were supplemented by the site-specific
knowledge of interdisciplinary ONF District ATM teams
to generate draft proposals for the long-term management
of forest roads. Public and tribal involvement was also a
critical component of the ATM plan update. The updated
ATM plan proposes substantial reductions in road mileage
throughout many watersheds at ONF owing to declining
road maintenance funding, reduced need for access, and
high risk to aquatic habitat. Nearly one-third of the forest’s
roads are proposed for decommissioning.

Road Management at Olympic National Park
There are more than 225 km of paved and unpaved visitor
use roads at Olympic National Park (ONP). There are no

b

Projected climate change effects relevant to road management:
(1) Increased winter air temperatures/fluctuation above and below freezing
(2) More precipitation falling as rain rather than snow
(3) Decreased snowpack
(4) Earlier snowmelt
(5) Increased winter and spring streamflows in some types of watersheds
(6) Decreased summer streamflows in some types of watersheds
(7) Increased winter precipitation and runoff

a

			
			
			
			
			

• Increased rate and 		
volume of water 		
delivery to channels		
• Increased wood
transport

• Seek out additional
funding to implement
improvements

(8) Increased storm intensity
(9) Increased flood frequency and magnitude in some types of watersheds
(10) Elevation shifts in transition (rain-on-snow) zones

Barriers and
information needed
Adaptation
management
options
and strategies
Projected			
climate
Projected effects on
Current
change
physical watershed
and expected
effectsa
processes
sensitivities
		
		
		
Program
Project

Table 4.1—Projected climate change effects and adaptation options in the context of road management at Olympic National Forest (ONF)
and Olympic National Park (ONP) (continued)

Adapting to Climate Change at Olympic National Forest and Olympic National Park

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cross-park roads; however, roads do penetrate the park’s perimeter and front-country areas, often along major river drainages. Roads and other infrastructure located within flood plains of the Olympic Peninsula have a high risk of being damaged during storm events. Coastal rivers located in the temperate rain forest exhibit a broad range of flows. For example, the summer low flow in the Queets River for the 2007 water year was about 10 m$^3$/s, while the peak flow for the year was 1190 m$^3$/s, or two orders of magnitude higher (USGS 2008). The record flow for the Queets River is 4080 m$^3$/s, which approximates the mean annual flow of the Columbia River (USGS 2008).

The ONP General Management Plan (GMP) (NPS 2008) calls for all existing roads to be maintained in a sustainable manner and for improving mass-transit opportunities. Objectives and desired conditions described in the plan relevant to the road system include the following:

- Park managers will use the most current and feasible engineering methods and techniques that minimize adverse effects on natural river processes to protect park roads and facilities located in flood plains.
- Park managers will inventory flood-prone areas near facilities and roads, and develop a program to proactively protect or relocate these facilities by using the most current techniques that minimize adverse effects on aquatic and riparian habitats and fluvial processes.
- Park managers will work with area partners, including tribes, federal, state, and county agencies, and others, to develop restoration plans for at-risk river systems, and for incorporating current technologies, over time, to restore or improve flood-plain and riparian functions altered in the past by bank-hardening techniques.

If park facilities are damaged or destroyed by a hazardous natural event, park managers will thoroughly evaluate options for relocation or replacement by new construction at a different location. If a decision is made to relocate or replace a severely damaged or destroyed facility, it will be placed, if practicable, in an area believed to be free from natural hazards.

The GMP specifically calls for road management plans to be developed in cooperation with federal, state,
Box 4.2—Critical factors and associated indicators considered in road work prioritization under
the Olympic National Forest road management strategy.

Aquatic risk:

**Geologic hazard**—This factor identifies those roads located within potentially unstable terrain or within areas with high sensitivity to erosion. In this context, it is used as an aquatic habitat and water quality risk factor. It evaluates the terrain that the road is located on, not the terrain above the road. It is intended to be a reflection of the potential to initiate erosion or mass wasting from roads themselves rather than the potential for impacts to roads from processes initiated upslope.

**Proximity (delivery) to fish habitat**—This factor uses a combination of sediment delivery efficiency and physical distance from the fish-bearing portions of the stream network. It provides an estimate of how direct any road effects would be on fish and fish habitat.

**Stream crossing density**—The stream crossing density factor determines the relative hazard associated with stream crossings(s) within the road segment, defined as the frequency.

**Riparian zone/stream proximity**—The riparian zone factor determines the relative degree of connectivity between the road system and the stream system. This factor considers the portion of the road segment within the riparian zone or near a stream. Riparian zones are defined as a 100-m buffer width, which spans both sides of the channel, as measured from the center of the channel.

**Upslope hazard**—The upslope hazard factor identifies those roads located downslope of steep converging topography or terrain designated to have a high potential for landslides. These hazard elements may initiate new hill slope failures or increase the magnitude of initial mass wasting events. This factor differs from the geologic hazard factor in that the road itself may not be on the terrain that is considered hazardous, and the problems or disturbances affecting the road or the aquatic system may not be initiated from the road itself.

Access:

**Private access**—This factor identifies roads that provide access to non-National Forest System lands or special use permit sites.

**Public access**—This factor identifies roads that provide access to national forest-developed recreation sites.

**Administrative access**—This factor identifies roads that provide access to administrative sites (facilities, rock sources, and communication sites).

Wildlife:

**Threatened and endangered species**—The wildlife factor identifies roads that lie within or intersect a 0.40-km radius of a known northern spotted owl activity center, a marbled murrelet occupied site, or a bald eagle activity center.

High-value watersheds:

These factors are used to determine whether the road segment lies within or is within areas contributing to:
- Northwest Forest Plan key watersheds
- Municipal watersheds
- Clean Water Act 303(d) listed water bodies
- Habitat for listed fish stocks

Silvicultural:

**Terrestrial habitat development (commercial thinning)**—This factor considers whether the road provides access to stands with potential for terrestrial habitat development through commercial thinning.

**Terrestrial habitat development (precommercial thinning)**—This factor considers whether the road provides access to stands with potential for terrestrial habitat development through precommercial thinning.
and tribal partners for at-risk roads near rivers and within the flood plains of the Hoh, Queets, and Quinault Rivers. These plans may include geomorphic investigations (such as that prepared for a section of the Quinault River) (see Bountry et al. 2005), restoration, feasibility studies, and as appropriate, recommendations for road relocations and potential wilderness boundary changes that may be needed as rivers respond to changing hydrology associated with climate change. The plan includes development of a North Shore Road/Finley Creek management plan (Quinault) to address the hydrologic and geomorphic issues associated with maintaining year-round vehicle access in this unstable environment, and to return Finley Creek to a more naturally functioning and stable condition. Finally, related to rising sea levels associated with climate change, the GMP calls for a risk-assessment study for Highway 101 along the coastal portion of the park to be conducted in cooperation with the Washington State Department of Transportation. This study will identify at-risk portions of the highway and determine suitable areas for reroutes or road relocations.

Specific road management goals for ONP, including considerations for potential effects of climate change, include:

- Hurricane Ridge—Road access to Hurricane Ridge will continue to be provided year round, and alternative methods of transportation (transit) will be provided if studies indicate it is feasible. The unpaved road to Obstruction Point will be maintained seasonally.
- Staircase—The Staircase road will be maintained by using methods that minimize adverse effects on river processes and aquatic and riparian habitats to the extent possible (NPS 2008).
- Elwha—Road access will be retained to the Boulder Creek and Whiskey Bend trailheads; methods will minimize adverse effects on river processes and aquatic and riparian habitats to the extent possible (NPS 2008).
- Sol Duc—Seasonal road access will be provided by using methods that minimize adverse effects on river processes and aquatic and riparian habitats to the extent possible (NPS 2008).
- Mora—The last 0.8 km of road will be retained unless lost to a catastrophic event and reconstruction is infeasible because of topography. This section of the road lies within a tsunami zone in an area of very high sensitivity to future sea level rise. Access to the Rialto Beach area will be by trail should this section of road be lost (Pendleton et al. 2004).
- Hoh—Year-round road access will be provided by using methods that minimize adverse effects on river processes and aquatic and riparian habitats to the extent possible (NPS 2008). In the event of a flood with associated road loss or damage, if road relocation away from river meander areas is feasible, wilderness boundary changes that result in no net loss of ONP wilderness acreage will be sought as necessary (NPS 2008). Alternative methods of transportation (transit) would be provided if studies indicate it is feasible.
- Kalaloch—The ONP will work with the Washington Department of Transportation to determine options to relocate all or portions of Highway 101 outside the active coastal erosion zone as needed to maintain access, and for the protection of the coastal portion of the park. Kalaloch is also in an area of very high sensitivity to future sea level rise (Pendleton et al. 2004).
- Queets—Vehicular access will be retained, but the road or portions of the road may be moved or closed as needed in response to river meandering and changing
Adapting to Climate Change at Olympic National Forest and Olympic National Park

conditions, by using methods that minimize adverse effects on river processes and aquatic and riparian habitats to the extent possible (NPS 2008). The ONP will develop a plan to address long-term access options, and existing facilities may be removed or relocated in response to changing river and road conditions.

- **Quinault**—The loop drive will be retained and will provide access to the North Fork and Graves Creek areas. ONP will seek options to redesign or relocate the Finley Creek bridge, including moving and possibly redesigning the North Shore Road. The North Fork and Graves Creek roads will be retained; relocations may be necessary because of river movement and river restoration goals. Year-round road access would be retained by using methods that minimize adverse effects on river processes and aquatic and riparian habitats to the extent possible (NPS 2008). If road relocation away from river meander areas is feasible, wilderness boundary changes that result in no net loss of ONP wilderness acreage would be sought as necessary.

- **Dosewallips**—Road access will be provided by using methods that minimize adverse effects on river processes, aquatic and riparian habitats, and old-growth forests, to the extent possible.

- **Deer Park**—No change is expected for Deer Park Road; the road will remain unpaved and opened seasonally as weather conditions permit.

**Climate Change Adaptation Strategies and Action Items for Road Management at Olympic National Forest and Olympic National Park**

**Process Used to Develop Adaptation Strategies for Road Management**

In January 2009, ONF and ONP natural resources and engineering staff, and scientists from the Forest Service Pacific Northwest Research Station (PNW) and University of Washington Climate Impacts Group (CIG) convened to discuss adapting road management activities to climate change and related hydrologic changes on the Olympic Peninsula. Objectives of the workshop were to (1) learn about the latest climate and hydrology model projections, and (2) use an interactive dialogue between scientists and managers to explore options to incorporate climate change information into road management at ONF and ONP. The workshop began with a presentation from Alan Hamlet on climate and hydrologic model projections, and a presentation from ONF engineer William Shelmerdine on current road management at ONF. A facilitated discussion on potential adaptation strategies for road management at ONF and ONP followed. Table 4.2 and the “General Adaptation Strategies for Road Management” section below describe key points from the discussion.

Building on the January workshop, ONF natural resources and engineering staff and PNW scientists further examined the ideas brought forth in the workshop and developed a strategy to use climate change information in road management at ONF, in particular, and to further inform road management activities at ONP. Participants concluded that climate change predictions could affect all aspects of road management, including (1) planning and prioritization, (2) operations and maintenance, and (3) design. A discussion of adaptation strategies developed for each of these areas is below, after a description of more general adaptation strategies for road management in the forest and park. See box 4.3 for a summary of projected climate change effects on hydrology on the peninsula and related adaptation strategies for road management at ONF and ONP.

**General Adaptation Strategies for Road Management**

The goal of road management at ONF and ONP is to provide a safe and economical transportation system to meet the access needs of various users while minimizing potential adverse impacts to other resources. Recent road management actions at ONF have focused on reducing potential risk to aquatic resources by removing unstable roads, relocating roads and infrastructure out of valley bottom areas, and at both ONF and ONP, correcting culvert fish passage barriers (fig. 4.11), and increasing the size and number of drainage structures, or replacing culverts with bridges where appropriate. Anticipated climate change effects tend to validate the current road management
efforts. In many ways, climate change will not necessitate large modifications of road management at ONF and ONP because the majority of current practices are focused on increasing the resilience of infrastructure and ecosystems. However, potential climate change effects underscore the need to increase activity and be proactive in priority areas to avoid impacts associated with infrastructure failure.

To deal with the uncertainty associated with climate change, strategic planning and efforts to increase flexibility in road management policies will be critical. Strategic approaches to resource allocation and utilizing no-regrets strategies will likely reduce vulnerability to future climate change and also help to better meet current objectives. Increasing flexibility in forest road management policies will allow management actions to shift more rapidly in response to new information on climatic changes and ecosystem response.

Managers will likely need to evaluate the density, location, design, and maintenance intensity of roads and related structures in the context of climate change to avoid escalating road maintenance costs associated with impacts discussed above. For example, roads in valley bottoms are particularly susceptible to flood damage, and moving these roads to other locations, when possible, may be desirable. Roads within or downslope of transient snow zones or snow-dominated areas will likely be subjected to increased flood damage because of more precipitation in the form of rain and increased storm intensity. These roads may require more intense treatments or more frequent maintenance. Also, current methods to size culverts and guidelines to determine design life may no longer be appropriate under changing climate.

The concept of $Q_{100}$ (the peak flow anticipated in a 100-year flood event) is a key factor currently used for road design.
Table 4.2—Methods to incorporate climate change into road management at Olympic National Forest and Olympic National Park

<table>
<thead>
<tr>
<th>Adaptation principle</th>
<th>Example adaptation strategies and actions</th>
</tr>
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</table>
| Be strategic and flexible | • Use selectivity in allocating resources.  
• Identify no-regrets strategies that do not require an accurate design standard but meet multiple criteria (e.g., for fish and streamflow). For example, with culvert design, bigger culverts could be put in every location to accommodate higher flows and fish passage, thus avoiding the development of new engineering design standards every decade. A standard design that works most of the time does not require constant updating and the large cost associated with the updating process.  
• Work under a new climate change paradigm in road management that is less prescriptive and more flexible.  
• Develop strategies and actions that are adaptable over time.  
• Focus on management actions that are robust to multiple future scenarios.  
• Broaden options and consider which option is more prudent for time and cost: new design, relocation, or increased maintenance.  
• Conduct management experiments on national forests to learn valuable lessons and contribute to the broader interest of all land and resource managing agencies.  
• Consider potential alterations to desired future conditions and alternative management pathways to achieve those conditions. |
| Reexamine road locations and entire design | • Rethink the design-life guidelines (usually <50 years) for roads and other structures.  
• Redo culvert size analysis based on peak flow data from only the last 30 years (as opposed to the period of record) or by using a physically based hydrology model (such as Variable Infiltration Capacity).  
• Consider whether existing roads are in the right locations (e.g., valley bottom roads).  
• Consider sediment problems in glacier-fed rivers that can make some valley bottom roads at risk or unsafe (such as in Mount Rainier National Park, or potentially the Hoh and Quinault valleys).  
• Consider future repair and maintenance needs in evaluating relocation options. |
| Use information selectively | • Use empirical data first and models second in analysis and planning. Assess sensitivities and trends in failures over the last 30 years and determine whether the sensitivities/failures were due to increased precipitation intensity or snowpack. Use the causes and consequences of past failures to determine where future failures will be and where actions should be focused. Consider new information and model predictions for the future only after that analysis.  
• Use expert knowledge when reliable quantitative data are not available. For example, instead of quantitative calculations of expected peak flow based on historical data, look at actual channel size on the ground and base culvert size on expert judgment. |
| Manage risk | • Expect that there will be some road failures. For example, failure can be expected in debris-prone areas. Without proactive action to manage risk, the anticipated failure rate will increase in response to climate change.  
• Conduct more up-front analysis and have plans in place to protect the most at-risk resources.  
• Use “What if it fails?” scenarios to address risk and uncertainty in evaluating road management alternatives. Failures that will result in the most severe impacts are the ones to be avoided. |
| Increase communication and foster partnerships | • Foster science-management partnerships.  
• Engage scientists in communicating new science for management.  
• Communicate with the Federal Highway Administration about projected climate change effects and associated needs to widen programmatic capability and resources to respond. |
management and stream crossing design. Calculation of this metric may need to shift under a changing climate. For example, instead of quantitative calculations of expected peak flow based on historical data, culvert size could be based on a qualitative ground-based assessment within an expert systems framework. Alternatively, physically based hydrologic models that incorporate changes in climate could provide quantitative estimates of changes in $Q_{100}$ or other factors affecting design decisions. Assessing changing sensitivities and trends over the last 30 years (and their relationship to projected 21st century impacts) may also give a more accurate picture of future sensitivities and trends than the entire period of record. Looking for evidence of precession of peak flows or of the temporal centroid of the hydrograph, and determining the rate at which any change is occurring, may be useful to managers in determining how rapidly hydrologic effects of climate change are being realized. Observed trends may also provide important information needed to augment and validate model predictions (further discussion below).

Regardless of forward-thinking design or restoration methods used for roads, uncertainties associated with rainfall, steep slopes, and the transport of water, sediment, and wood in stream channels make some level of road failure inevitable. Climate change will exacerbate these uncertainties and associated risks. However, several strategies can minimize risk and failure. For example, inventorying and analyzing high-risk areas, such as debris-prone sites, can support development of plans to prevent or manage issues in these areas. In addition, “what if it fails?” scenario analyses can identify likely failures that will result in the most adverse consequences. This information can help to target sensitive areas in strategic planning to emphasize specific actions to avoid these impacts (e.g., specifying more robust design criteria for these areas).

Communication and partnerships are needed for adapting road management to climate change on the peninsula. Topography constrains potential road-access options; roads can affect important resource values such as fish and riparian resources; and forest management, recreation, tourism, and residential access are essential. The present case study serves as an example of the utility of science-management partnerships that facilitate communication and help to address challenges and barriers to climate change adaptation.

Adaptation Strategies for Road Management Planning and Prioritization at Olympic National Forest

The RMS at ONF is a tool to evaluate the use or need for all of the roads in the transportation system against the potential risks the roads pose to other resources. Identified through analysis with RMS criteria, priority roads for decommissioning are those determined to be of low use volume or need, and high environmental impact. A major category in evaluating road risk is risk to aquatic resources. The RMS applies five rating factors to assess aquatic risk: (1) geologic hazard, (2) proximity (delivery) to fish habitat, (3) stream crossing density, (4) riparian zone proximity, and (5) upslope hazard. Climate change will likely influence all of these aquatic risk factors. The ONF engineering and natural resources staff identified three of the aquatic risk factors to focus discussion of adaptive strategies for road management planning and prioritization: proximity (delivery) to fish habitat, riparian zone proximity, and upslope hazard.
Adapting to Climate Change at Olympic National Forest and Olympic National Park

The upslope hazard factor developed in the RMS incorporates geologic hazard and delivery conditions within the hill slope immediately upslope of the road segment being evaluated. It identifies roads located downslope of either steep converging topography or terrain designated as having a high potential for landslides. These hazard elements may initiate new hill slope failures or increase the magnitude of initial mass wasting events. To incorporate climate change predictions, ONF proposes to modify the upslope hazard factor to consider the amount of area upslope that is in the transient snow zone or rain-on-snow (ROS) zone. With increasing temperatures, there will be shifts in the location and extent of ROS zones. High rates of water delivery to soils in ROS zones can be associated with mass wasting of hill slopes, and thus hill slopes with increasing area of ROS are potentially more susceptible to slope failure (Swanson and Dyrness 1975, Swanson et al. 1998, Wemple et al. 2001), which will affect use and maintenance of the adjacent road.

Scientists and engineers can predict future locations of ROS zones by using a model that accounts for factors such as climate, snow cover, and elevation. The ONF proposes to model the area within the ROS zone in hill slope areas above and connected to road segments, and evaluate road segments for ROS under current conditions and future projected conditions (e.g., 2040). Assessment of current and future hazard evaluations will flag areas with a higher hazard rating under projected future conditions as priorities for maintenance, upgrading, or decommissioning. This comparative evaluation will support recommendations for increased frequency and intensity of road treatments for some roads, as well as recommendations to decommission other road segments rather than continue efforts to maintain them.

Riparian area and stream proximity are also used to evaluate the risks that roads present to aquatic systems under the 2000 RMS. Managers consider stream-adjacent or riparian area roads to be risky owing to their often direct and deleterious effects on aquatic habitats. Stream-adjacent roads also have high potential for frequent damage from floods and stream channel changes, resulting in higher maintenance costs. To incorporate climate change predictions, ONF proposes to modify the riparian area/stream proximity factor in the RMS by manually validating the locations of stream-adjacent roads and degree of connectivity of these roads to streams. Olympic National Forest engineers will assess roads under current and future projected conditions, and assign a higher (riparian zone proximity) hazard rating to those that are determined to be within a projected flood hazard corridor (in a potential area of inundation or channel migration zone, or in a geotechnical setback buffer). Highest priorities for maintenance, upgrading, or decommissioning will focus on roads with higher hazard ratings under future projected conditions (e.g., roads at higher risk owing to increased flood risk).

Adaptation Strategies for Road Operations and Maintenance at Olympic National Forest and Olympic National Park

Assessing current road maintenance and operations tasks conducted at ONF and ONP in the context of climate change can inform managers of necessary changes. For example, climate change will likely influence watershed processes, resulting in increased flow volume, increased mass wasting and debris flows, increased sediment delivery to culvert inlets and ditches, increased rate and volume of water delivery to stream channels, and increased transport of wood. These changes will likely increase the incidences of culvert capacity being exceeded, fill slope failures, and development of first-order channels that can affect roads and related structures (e.g., fig. 4.12). A response to these potential changes could involve prioritizing maintenance preparation and response, including increased frequency of culvert cleaning, installing more and larger culverts where appropriate, and installing water bars and drivable dips.

Table 4.1 lists potential climate change effects and affected watershed processes and sensitivities associated with major road maintenance and operations tasks, along with potential strategies to address climate change issues.

Adaptation Strategies for Road Design

Anticipating the effects from changes in watershed processes also informs the design of roads and related structures. Design of water crossing structures in the context
of climate change, specifically culvert design, is an area of particular interest to both the forest and the park because of the increased potential for higher fall and winter flow volumes to exceed culvert capacity. Stream simulation is a method used to design culverts on fish-bearing streams that applies attributes of streams (geometry and geomorphology) to size and select water crossing structures. This method leads to designs that are relatively resilient to a range of conditions. Consequently, no changes to this method are proposed at this time.

Culverts on non-fish-bearing streams are designed principally by analyzing predicted runoff and flow capacity. Standard methods applied at ONF and elsewhere include sizing culverts for the predicted 100-year flood and associated debris ($Q_{100} + \text{debris}$). The Northwest Forest Plan aquatic conservation strategy (ACS) established this standard in 1994. The standard requires that an understanding of watershed process and channel functions be incorporated in culvert design, and thus, culverts designed by using this standard are considerably more resilient than those designed under pre-ACS standards. However, there is a question as to whether the methods used to predict $Q_{100}$ should be altered according to expected hydrologic effects of climate change.

Engineers currently use the period of record to predict the $Q_{100}$. However, flood magnitude will likely increase in the transient snow zone with warming temperatures. Predictions based on the period of record may be even less accurate for predicting large flows if future precipitation or runoff patterns change. In many Olympic Peninsula streams, the largest flows on record at gauged sites are clustered in the later part of the record (i.e., the last 20 years). For example, at the Duckabush River gauge, the five largest flows in the 70-year record occurred in the past 12 years. Deriving the same predictive equations based on the late, early, or entire record gives entirely different predictions of $Q_{100}$.

There are several possible ways to modify the current method used for prediction of design discharge ($Q_{100}$ flow). Suggested alternatives include calculations based on the later part of the record, such as the past 30 years. Alternatively, the Variable Infiltration Capacity (VIC) hydrologic model can provide future runoff estimates under different scenarios of climate change, which could be used to supplement information from the period of record. The VIC model uses a physically based simulation of runoff processes combined with a unit hydrograph approach that would provide a more physically based analysis than the current $Q_{100}$ calculation method. The VIC model has predictive capabilities related to temperature and snowpack changes, which the current method does not. In considering climate change, ONF proposes to conduct an analysis of both the current method and the proposed VIC-based method and compare results, selecting the most appropriate option based on hazard and consequence for a particular site.

These analyses would not address several potential issues with culvert design based on predictions of $Q_{100}$. Predictions of $Q_{100}$ have been and likely will continue to be associated with much uncertainty, regardless of the method used for prediction. Predictions of $Q_{100}$ also do not address sediment and wood, which are most frequently the cause of culvert failures (not excessive water) (Furniss et al. 1998). Thus, continued and potentially increased focus on geomorphic culvert design on non-fish-bearing streams will be important with climate change. Besides an increase in magnitude, the frequency of moderate floods will likely increase with climate change; five 20-year flood events may in fact cause more damage to road infrastructure than one 100-year flood event. As noted above, increased focus on design of resilient structures will help avoid adverse effects of climate change on road systems.

### Challenges and Opportunities in Climate Change Adaptation in Road Management

There are many potential challenges in the implementation of adaptation strategies and actions in road management on the Olympic Peninsula (table 4.2). For example, the National Highway Safety Act sets specific requirements for heavily used roads, arterials and collectors (maintenance level 3 and above), and most appropriated road operations and maintenance funds focus on these higher standard roads. Valley bottom and stream-adjacent roads are well represented, but other roads are not. In general, lower standard roads at the head of the transportation and drainage network have higher hazards when it comes to slope and runoff processes, but
funding generally does not target operations and maintenance on these lower standard and higher hazard roads.

Another potential policy challenge is the Federal Highway Administration Emergency Relief for Federally Owned Roads (ERFO) Program. This program is the principal source for storm damage repair funds. However, at present, use of these funds is generally limited to in-kind replacement (although there have been some recent exceptions). For example, if storm damage occurs owing to culvert failure, ERFO funds will cover replacement of the same size culvert but not a larger one that could accommodate higher flows and be more resilient to future floods. Such policies limit the ability to design replacement structures that accommodate changing conditions with climate change or other factors. Further collaboration with the Federal Highway Administration may help to alleviate these limitations.

Budgets and the need for economic efficiency present further challenges in climate change adaptation in road management. Competing with the need to implement resilient designs is the objective to be economically efficient. Although long-term costs may be reduced by implementing more resilient designs for a changing climate, costs at the time of construction will likely be higher than current designs (especially in the case of in-kind replacement guidelines discussed above). Thus, strategic planning and prioritization efforts to identify areas where more robust designs would be most advantageous will make the best use of limited financial resources for climate change adaptation.

Acknowledgments
We thank the individuals from ONF and ONP who participated in the workshop on climate change and road management in January 2009; their thoughts and ideas guided the development of this chapter. This chapter was improved with helpful reviews by Michael Furniss and Gordon Grant.

Literature Cited


Chapter 5: Climate Change, Fish, and Fish Habitat Management at Olympic National Forest and Olympic National Park

Nathan J. Mantua, Robert Metzger, Patrick Crain, Samuel Brenkman, and Jessica E. Halofsky 1

Potential Climate Change Effects on Hydrology, Summer Stream Temperatures, and Fish on the Olympic Peninsula

Climate plays a crucial role in aquatic ecology, but the relative importance of climatic factors is quite different for different species, and even different populations of the same species. For example, key limiting factors for freshwater salmon productivity include thermal and hydrologic regimes that depend on species, their life history, watershed characteristics, and to a great extent, stock-specific adaptations to local environmental factors (e.g., Beechie et al. 2008, Crozier and Zabel 2006, Farrell et al. 2008, Richter and Kolmes 2005). Those stocks that typically spend extended rearing periods in freshwater (steelhead, stream-type chinook salmon, sockeye salmon, and coho salmon) are likely to have a greater sensitivity to freshwater habitat changes than those that migrate to sea at an earlier age (ocean-type chinook salmon, pink salmon, and chum salmon). Because they spend almost all of their life cycle in freshwater, resident rainbow trout, cutthroat trout, and bull trout are also likely to be sensitive to freshwater habitat changes. Effects of changes in marine conditions with climate change could interact with effects of changes in freshwater conditions to further affect fish populations that spend part of their life cycle in the marine environment.

Mantua et al. (2010) reported on a few direct, well-understood mechanisms whereby more easily predicted physical properties of the freshwater habitat for salmon directly influence salmon reproductive success (or overall fitness) at certain stages of their life cycle. Those physical properties are warm season stream temperature and the volume and time distribution of streamflow. They did not, however, assess the impacts of climate change on cold season water temperatures and related impacts on salmon, and this choice directed their focus on negative, rather than positive, impacts of climate change on the freshwater habitat for Washington’s salmon.

We describe in a report by Mantua et al. (2010) qualitatively assessed the potential effects of climate change on the reproductive success for salmon in Washington’s watersheds by combining salmon sensitivities described in the scientific literature with future scenarios for changes in the statistics of stream temperature and streamflows. Climate also influences estuarine and marine habitat for salmon. See reviews of climate effects on marine habitat for Pacific Northwest salmon in ISAB (2007), Loggerwell et al. (2003), and Pearcy (1992).

Summertime Stream Temperature Projections

Maximum weekly water temperatures in Washington are typically observed from late July through late August, similar to the period of climatologically warmest air temperatures. Figure 5.1 shows downscaled historical averages for August surface air temperatures and simulated annual maximum weekly water temperatures (Tw) for the 1970–99 (1980s) period (left panel) and for a multimodel ensemble average under A1B greenhouse gas emissions for 2030–2049 (2040s) (right panel). Although air temperatures are not the only influence on water temperatures, air temperature can provide an accurate indicator of water temperature in many cases (Mohseni et al. 1998; see Mantua et al. [2010] for detailed modeling methods). Under historical conditions, August mean surface air temperatures on the Olympic Peninsula are below 17 °C everywhere except a narrow corridor in the lowlands along Hood Canal. Two of

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Figure 5.1—August mean surface air temperature and maximum stream temperature for the Olympic Peninsula. Color shading shows mean surface air temperatures for August, and shaded circles show the simulated mean of the annual maximum for weekly water temperatures for select locations. Historical air temperature and simulated water temperature for the 1980s (1970–99) are in the left panel, while a future scenario derived from a multimodel average under A1B medium level emissions is shown in the right panel. Olympic National Park and Olympic National Forest are outlined in dark gray. (Adapted from Mantua et al. 2010.)

The three water temperature sites on the Olympic Peninsula have $T_w < 17 ^\circ C$, while one has $T_w$ approximately $20 ^\circ C$. For the 2040s scenario, the encroachment of summertime air temperatures with $T_a > 20 ^\circ C$ becomes the norm for western Washington’s lowlands, and for this period only, the higher elevations of the Cascades and Olympics have temperatures like those characteristic of the western Washington lowlands in the 1980s.

For A1B emissions scenarios in the 2020s, annual maximum $T_w$ at most stations on the Olympic Peninsula is projected to rise less than 1 °C, but by the 2080s, several stations on the Olympic Peninsula warm by 1 to 2 °C (not shown). Water temperatures projected under the A1B emissions scenarios become progressively warmer than those projected under the B1 emissions, and by the 2080s the differences are approximately 1 °C (projected summertime air temperatures under A1B emissions are, on average, 1.8 °C warmer than those under B1 emissions for the 2080s).

Increases in stream temperature with climate change are likely to differ across landscapes. Locations that currently experience high summer air temperatures are likely to have the largest increases in water temperature (ISAB 2007). A study by Daly et al. (2009) suggests that complex patterns of temperature change may occur in locations with complex terrain; locations with cold air drainage and pooling will likely experience the lowest temperature increases, whereas exposed hill slope and ridge top locations will likely experience the highest temperature increases. In the John Day River basin in northeastern Oregon, Torgersen et al. (1999) found water temperatures to be warmest in downstream (low-elevation) stream reaches and in locations where the cooling effects of subsurface flow are less apparent. These and locations with channel conditions prone to heating (wide, shallow, lack of riparian vegetation) (Crozier and Zabel 2006) are likely to experience further warming with climate change. Changes in water temperature will also differ with hydrologic changes. Decreases in summer low flows will make streams more susceptible to increased air temperature, and earlier snowmelt will result in warming beginning earlier in the year in basins affected by snowmelt (ISAB 2007).

**Climate Change Effects on Snowpack and Streamflow**

Figure 5.2 classifies runoff in Washington’s watersheds (at the level 4 hydrologic unit code) for historic and future periods as either snowmelt dominant, transient, or rain dominant based on their basin-averaged ratio of simulated April 1st snowpack to their October to March total precipitation (Elsner et al. 2010). Rain-dominant basins (where the ratio is <0.1) are the most common type on the Olympic Peninsula (for the 1980s). There is one transient basin (mixed rain and snow basin where the ratio lies between 0.1 and 0.4) in the northeastern portion of the Olympic Peninsula, and there are no snowmelt basins (where this ratio >0.4 for the 1980s). As projected climate warms, the historically transient basin on the Olympic Peninsula is projected to become rain dominant by the 2040s under the A1B emissions scenario, and by the 2080s under the B1 emissions scenarios.

The recently completed Hydrologic Climate Change Scenarios for the Pacific Northwest Columbia River Basin and Coastal Drainages project (project homepage http://
Adapting to Climate Change at Olympic National Forest and Olympic National Park

www.hydro.washington.edu/2860) includes future snowpack and streamflow scenarios from 10 global climate models under two greenhouse gas emission scenarios for the 21st century. A sample of hydrologic model output for select watersheds on the Olympic Peninsula is provided in figures 4.2 to 4.7 in chapter 4. The magnitude and frequency of flooding are predicted to increase for watersheds on the Olympic Peninsula, most dramatically in the months of December and January, and most dramatically for the coldest basins that in the late 20th century typically collected significant amounts of snow in their upper reaches. Hydrologic models indicate that warming trends will substantially reduce seasonal snowpack on the Olympic Peninsula (Elsner et al. 2010), thereby decreasing the risk of springtime snowmelt-driven floods.

The shifts in flood risk in each basin tend to monotonically increase or decrease through time. In other words, the increases or decreases in flooding magnitude of each basin generally become larger, with the same sign from the 2020s to the 2080s, with the greatest impacts occurring at the end of the 21st century. Emissions scenarios also play a strong role in the rate of change in flooding magnitudes, with the changes for A1B emissions in the 2040s being similar to those for the B1 emissions in the 2080s.

Reductions in the magnitude of summer low flows are projected to be widespread for the Olympic Peninsula’s rain-dominant and transient runoff river basins (not shown). Future estimates of the annual average low flow magnitude (7Q10, which is the 7-day average low flow magnitude with a 10-year return interval) are projected to perhaps increase by a few percentage points or decline by up to 50 percent, with most climate model scenarios leading to declines by the 2080s under both the A1B and B1 emissions scenarios. As indicated by the simulated runoff graphs shown in figures 4.2 through 4.7, the duration of the summer low flow period is also projected to increase significantly in all but the most rain-dominant watersheds, which include the Skokomish, Queets, and Hoh watersheds.

Projected Effects of Altered Hydrology on Olympic Peninsula Salmon, Steelhead, and Bull Trout

Waples et al. (2008) noted that existing salmon popula-

tions should have the capacity for responding to habitat changes that fall within the bounds of historical disturbance regimes, specifically episodic disturbances that most often impact relatively small habitat patches relative to the spatial extent of evolutionarily significant population groups that are typically influenced by regional physiographic features. It remains an open question whether present-day salmonid fish populations on the Olympic Peninsula can adapt (either through phenological, phenotypic, or evolutionary responses) at rates required to deal with the combination of anthropogenic climate change and other habitat and ecosystem changes that will come in the next century (Crozier et al. 2008).
Our assessment of future stream temperature, stream-flow changes, and limiting factors indicates widespread declines in the quality and quantity of freshwater habitat for many Olympic Peninsula salmon, steelhead, bull trout, and resident fish populations, unless they are able to quickly adapt to changing habitat conditions. Increases in stream temperature alone point to significant increases in thermal stress (fig. 5.1) for Washington’s salmonid fish populations having a stream-type life history that puts them in freshwater during summer for spawning migrations, spawning, rearing, or seaward smolt migrations. Temperature impacts on adult spawning migrations are projected to be most severe for stocks having summertime migrations. These include summer-run coho salmon in the Sol Duc watershed, and summer run chum salmon in several Hood Canal streams. Increased stream temperatures pose risks to the quality and quantity of favorable rearing habitat for stream-type chinook and coho salmon and steelhead (summer and winter run) because these stocks spend at least one summer (and for steelhead typically two summers) rearing in freshwater.

Increased stream temperatures on the Olympic Peninsula will also affect bull trout. This species, which is listed as threatened under the federal Endangered Species Act (ESA) (ESA 1973), is highly sensitive to stream temperature, generally requiring stream temperatures below 15 °C (USFWS 2004). There are six core areas of spawning bull trout on the peninsula (USFWS 2004). Unlike other areas of their range, bull trout on the peninsula are found only within the anadromous portion of watersheds, below anadromous migration barriers. Increased stream temperatures and reduced summer streamflows could particularly affect bull trout by reducing the quantity and quality of rearing habitat.

In addition to increased stream temperatures, reductions in the volume of summer/fall low flows in transient and rain-dominated basins might also affect summer-run steelhead migration and reduce the availability of spawning habitat for bull trout and salmon populations that spawn early in the fall (e.g., Healey 1991). Predicted increases in the intensity and frequency of winter flooding will likely negatively impact the egg-to-fry survival rates (table 5.1) for pink, chum, sockeye, chinook, and coho salmon and bull trout owing to an increased intensity and frequency of redd and egg scouring. However, the effects of scour will differ, in part, by channel type and location in the stream network. Confined streams that are high in the network will likely be most susceptible to scour, which will likely impact the steelhead and bull trout that inhabit them. Lower gradient streams in unconfined settings, such as those typically inhabited by chinook, will likely be least vulnerable to scour. In addition, the impact of increasing winter flooding will likely differ across species or populations because redd depth is a function of fish size (deeper redds will be less vulnerable to scouring and the deposition of fine sediments).

Parr-to-smolt survival rates may be reduced for coho and stream-type chinook salmon and steelhead with climate change because increases in peak flows can reduce the availability of slow-water habitats and cause increases in the displacement of rearing juveniles downstream of preferred habitats (table 5.1). However, the effects of increased peak flows will depend on the particular geomorphic setting and on whether the fry will have emerged before or at the time of the high flows. The effects of increased peak flows will be more pronounced in constrained reaches (i.e., narrow valleys and higher gradient streams), which are used by steelhead and bull trout for spawning, than in unconstrained reaches (i.e., wide valleys and lower gradient streams), which are used by coho and chinook. In the latter, the fish may be able to move to off-channel areas that would not be available at normal flows. Displacement could be a problem in the former situation. Displacement could be exacerbated if fish emerge earlier because of elevated winter water temperatures. The effects of high flows may be minimal for some fish, such as winter steelhead that spawn after peak flow events. However, for some species, reductions in springtime snowmelt may negatively impact the success of smolt migrations from snowmelt-dominant streams where seaward migration timing has evolved to match the timing of peak snowmelt flows.

Summer chum salmon stocks in Hood Canal are listed as threatened under the ESA. These populations have a unique life history that makes them especially vulnerable to the impacts of climate change. Adults return to spawn in
Table 5.1—Salmon life cycle stages and climate change effects that will likely impact each salmon life cycle stage

<table>
<thead>
<tr>
<th>Salmon life cycle stage</th>
<th>Climate change effects that will likely impact salmon life cycle stage</th>
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<tbody>
<tr>
<td>Eggs in stream gravel; hatch in 1 to 3 months</td>
<td>Increased winter flooding and mean flows; warmer water</td>
</tr>
<tr>
<td>Alevins in stream gravel; 1 to 5 months</td>
<td>Increased winter flooding and mean flows; warmer water</td>
</tr>
<tr>
<td>Fry emerge in spring or summer</td>
<td>Increased winter flooding and mean flows; warmer water</td>
</tr>
<tr>
<td>Juvenile fish in freshwater; a few days to 4 years depending on species and locality</td>
<td>Warmer water and lower streamflows in summer; increased winter flooding in transient basins</td>
</tr>
<tr>
<td>Smolt migration to ocean; usually in spring and early summer</td>
<td>Warmer water and lower streamflows in summer; increased winter flooding in transient basins</td>
</tr>
<tr>
<td>Fish in ocean; 1 to 4 years</td>
<td>Sea level rise; altered river discharge</td>
</tr>
<tr>
<td>Migration to spawning grounds; timing depends on species and race</td>
<td>Warmer water and lower streamflow</td>
</tr>
<tr>
<td>Fish spawning in freshwater stream</td>
<td>Warmer water and lower streamflow</td>
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small shallow streams in late summer, and eggs incubate in the fall and early winter before fry migrate to sea in late winter. The predicted climate change effects for the low-elevation Hood Canal streams used by summer chum include multiple negative impacts stemming from warmer water temperatures and reduced streamflow in summer.

It is possible that climate-induced warming in winter and spring will lead to earlier and perhaps longer growing seasons, increased aquatic food web productivity, and more rapid juvenile salmon growth and development rates that benefit parts of the freshwater life cycle of the Olympic Peninsula’s salmon and steelhead (Schindler and Rogers 2009). This could potentially increase the full life cycle productivity for salmon populations if the positive impacts outweigh the negative impacts described above. For example, in watersheds that are currently minimally affected by snowmelt (rain-dominant basins), the changes in the timing of streamflow with climate change will likely be minimal. Thus, without substantial increases in winter flooding and reductions in summer low flows, increased winter stream temperatures could have a net positive impact on salmon in these watershed types, depending on the magnitude of late-spring through fall stream temperature changes.

Potential benefits of warmer stream temperatures for coho salmon were shown in studies of clearcut logging impacts in the Carnation Creek watershed of Vancouver Island, British Columbia (Holby 1988). Logging in this watershed led to stream warming of 0.7 °C in December and over 3 °C in August, which in turn contributed to positive growth responses in juvenile coho salmon, accelerations in the freshwater component of coho salmon life histories, and increases in overwinter survival rates for rearing juveniles. However, these changes in freshwater development appear to have been offset by reduced marine survival rates associated with earlier smolt migrations to the ocean (because of warmer spring stream temperatures) that may have been mismatched to the optimal timing for ocean prey availability and predator avoidance. Holtby (1988) estimated that warmer stream temperatures increased the full life cycle coho production in this system by about 9 percent. Modeling from the same study system suggested that effects of warmer stream temperatures as a result of logging may be greater on chum than coho salmon (Holby and Scrivener 1989).

Because of the earlier timing of snowmelt and increased evaporation, some of the Olympic Peninsula’s river basins (including the Elwha and Dungeness) are projected to experience reduced streamflow in summer and early fall that results in an extended period of summer low flows, and many basins are also projected to have substantially lower base flows. In combination with increased summertime stream temperatures, reduced summertime flow is likely to limit rearing habitat for salmon with stream-type
life histories (wherein juveniles rear in freshwater for 1 or more years) and increase mortality rates during spawning migrations for summer-run adults (table 5.1).

**Fish Habitat Management at Olympic National Forest and Olympic National Park**

This section provides information on the biogeographic context, guiding policies and legislation, and primary activities in fish habitat management at Olympic National Forest (ONF) and Olympic National Park (ONP), including (1) the context in which ONF and ONP manage fish habitat, (2) the guidance and constraints on fish habitat management at ONF and ONP, and (3) the primary issues around and activities currently conducted in fish habitat management at ONF and ONP. This information, coupled with the likely impacts of climate change on fish on the Olympic Peninsula, provides a basis on which to develop climate change adaptation options for fish habitat management at ONF and ONP.

**Biogeographic Context**

The ONF contains portions of 17 major drainages on the Olympic Peninsula and manages about 560 km of anadromous fish streams and another 685 km of streams that provide habitat for resident fish populations. At least 40 small alpine lakes and two reservoirs exist on the forest.

The streams, rivers, and lakes at ONF provide habitat for seven anadromous fish species including chinook, coho, chum, and pink salmon; steelhead trout; sea-run cutthroat trout; and bull trout. Resident salmonids include cutthroat trout and rainbow trout. Four of the fish stocks on the forest are listed as threatened under the ESA: Puget Sound chinook, Puget Sound steelhead, Hood Canal summer chum, and bull trout.

Rainfall, geology, and management legacies present some challenges for fish habitat management at ONF. Some parts of the Olympic Peninsula receive more than 5 m of rain per year. Long, steep slopes, underlying geology, and heavy rainfall result in unstable ground on some parts of ONF. The ONF also has an extensive legacy of timber harvest. About 50 percent of the suitable land base was harvested between the 1960s and the mid 1990s. Over 3500 km of forest roads initially built for timber harvest remain on the forest road network. Unstable slopes combined with an extensive road network can result in sedimentation and aquatic habitat degradation.

The ONP contains over 5600 km of rivers and streams that support 70 unique salmonid stocks as well as numerous nonsalmonid species. The park also includes two large natural lakes and over 300 smaller alpine lakes and lower elevation ponds. In addition to the federally listed fish stocks at ONF, ONP also has the Lake Ozette sockeye fish stock, which is listed as threatened under the ESA.

There are 225 km of roads located in the park, along with many visitor facilities (visitors’ centers, campgrounds, and way points). With the exception of the Hurricane Ridge Road and Deer Park Roads that access alpine areas, the park’s road system and many visitor facilities occur within the flood plains of the park’s major river systems (Elwha, Sol Duc, Hoh, Queets, Quinault, and North Fork Skokomish); segments of these roads lie immediately adjacent to the rivers. Maintenance and repair activities associated with these road systems constitute (historically) a major impact to fish and aquatic communities.

**Guiding Policies and Legislation**

The ONF Land and Resource Management Plan (LRMP) (USFS 1990) as amended by the 1994 Northwest Forest Plan (USDA and USDI 1994) guides current management activities at ONF. A key component of the plan is the Aquatic Conservation Strategy (ACS), which includes nine objectives for maintaining and restoring watershed processes and functions. To be consistent with the LRMP and the ACS, all management activities at ONF must maintain or help restore watershed conditions. In line with these broader mandates, the goal of fish habitat management at ONF is to maintain or restore watershed processes and functions and provide diverse, resilient fish habitats capable of supporting populations of native fishes over the long term.

At ONP, fish habitat management programs and decisions are guided by the National Park Service Management Policies (NPS 2006), as well as the ONP General Management Plan (GMP) (NPS 2008), the ONP Backcountry Management Plan (NPS 1980), and the ONP Superintendent’s Compendium. The park’s planning and compliance process
guides preservation of fish habitat within ONP by prescribing measures to prevent or minimize the impact of all park management activities. Usually, particularly within wilderness areas, limiting the construction of new facilities within flood plains avoids impacts to fish habitat. The park’s GMP (NPS 2008) calls for potential relocation of existing roads, campgrounds, or other visitor facilities out of flood plains as feasible, or when a road or facility cannot be relocated, directs that measures to protect and maintain the facility must be designed to minimize the effect on fish habitat to the extent possible. The ONP recently evaluated a variety of road and facility hazards within the park, and will evaluate protection measures designed to be more environmentally sensitive than traditional engineered designs.

Primary Fish Habitat Management Issues and Activities

Olympic National Forest—
The primary management issues for fish and fish habitat at ONF include:

Sedimentation from forest roads
Road-related landslides can cause sedimentation in streams (Fredriksen 1970, Harr and Nichols 1993) and influence fish habitat (Harr and Nichols 1993). Road-related sedimentation is a major issue impacting fish habitat at ONF. In response, ONF decommissions unneeded roads, and removes sidecast material and improves drainage on the remaining roads.

In 2000, the forest completed a Road Management Strategy (RMS). This geographic information system based analysis evaluated the risk each road segment presented to fish habitat and water quality based on its location, geomorphic factors, distance to stream channels, and number of stream crossings. About 34 percent of the roads on the forest are rated as “high” or “very high” risk to aquatic resources.

In 2003, the forest used the new aquatic risk information, coupled with an assessment of the access needs and anticipated future funding levels, to revise the Access and Travel Management (ATM) Plan. The plan proposes decommissioning of over 1270 km of forest roads, or about one-third of the road system. The ATM and aquatic risk information helps to prioritize road treatment locations as funding becomes available. In previous actions and following the new ATM plan, ONF decommissioned about 700 km of road since 1990.

Fish passage and culverts
Currently, 77 culverts block fish passage on the forest including five anadromous sites blocking a total of 13 km of anadromous fish habitat, 16 high-priority resident sites blocking more than 1.6 km of resident fish habitat each, 14 moderate-priority resident sites blocking between 0.8 and 1.6 km of resident fish habitat each, and 42 low-priority resident sites that block less than 0.8 km of resident fish habitat each. Since 2002, forest managers completed 18 fish passage barrier correction projects, restoring access to 39 km of fish habitat. Anadromous barriers are the top priority for correction. Biologists prioritize resident barriers based on the amount of fish habitat that would be reconnected.

Instream large wood
Past stream clearing and splash damming activities at ONF removed large wood from many stream channels. Placing large wood in key stream reaches restores watershed processes and functions and improves fish habitat by providing structure, creating cover, scouring pools, and trapping spawning gravels. The forest completed numerous small-scale large-wood placement projects in the past and is planning an extensive logjam construction project on the South Fork Skokomish River in 2010. Increasing landslides with climate change (see chapter 4) could also potentially increase upslope sources of wood to streams.

Riparian vegetation
Logging activities in the past removed conifers from many streambanks at ONF. Conifers regenerated in some riparian areas, but many riparian corridors have few conifers to provide large wood to streams. In these areas, reestablishment of conifers will help to provide a long-term source of large wood in channels. However, these projects require long commitments over time, are costly, and are consequently not a high priority for forest managers.

Nutrient supplementation
Marine-derived nutrients carried back into anadromous streams by returning adult salmon carcasses are a key
element in the productivity of many streams (Helfield and Naiman 2001, Naiman et al. 2002). Extirpation of salmon stocks and extremely low escapements of anadromous fish have likely reduced potential productivity in forest streams. Supplementing nutrient supplies, either by distributing salmon carcasses or adding slow-release fertilizers, has the potential to increase the numbers and condition of juvenile salmon, steelhead, and bull trout in forest streams. Although carcass supplementation has not yet been demonstrated to improve salmonid productivity or riparian vegetation growth on the Olympic Peninsula, Cederholm et al. (1989) showed that carcasses are utilized by a large number of wildlife species. The forest has been distributing surplus chum salmon carcasses throughout the upper South Fork Skokomish watershed. The Pacific Salmon Coalition distributes salmon carcasses throughout the Quileute system.

**Invasive species**
Some exotic species such as Japanese knotweed are considered invasive owing to their potential to outcompete native vegetation. Invasive infestations in riparian areas reduce future sources of large wood by outcompeting tree species and change the terrestrial food inputs into streams. Removal and control of priority invasive weed species helps to maintain riparian function. There are also public education efforts for aquatic invasive species. However, ONF has not identified aquatic species on the forest that warrant intensive control or monitoring efforts.

**Olympic National Park—**
At ONP, fish habitat management activities fall into three general categories: (1) habitat preservation, (2) habitat restoration, and (3) management planning. Within the past 5 years, the park has conducted several restoration projects, including removal or replacement of numerous undersized culverts that were partial or complete barriers to fish migration. A significant habitat restoration project is the upcoming removal of two dams from the Elwha River. However, with the exception of the Elwha project, habitat restoration within ONP is opportunistic as opposed to strategic, and has no sustained funding source. Park biologists work to rectify this through numerous activities, including participation in various salmon recovery forums, interagency planning for watershed water use strategies, cooperation with the National Oceanic and Atmospheric Administration National Marine Fisheries Service and local tribes to develop and implement ESA recovery plans, and development of a prioritized list of culverts targeted for replacement.

It will be critical for ONP to consider climate change in the future management of fish habitat. Whether management activities involve protection, restoration, or unknown and undecided manipulative actions, the changing climate will dictate measures needed to preserve “unimpaired” the fisheries resources of the park. Although today’s conditions will change, through careful consideration and evaluation of the effects of climate change on the aquatic environment, adaptation strategies may help to sustain processes that shape and maintain viable aquatic ecosystems.

**Climate Change Adaptation in Fish and Fish Habitat Management at Olympic National Forest and Olympic National Park**

**Process Used in Development of Adaptation Strategies for Fish Management**
To develop adaptation strategies and action items for fish management on federal lands on the Olympic Peninsula, scientists, managers, and other stakeholders collaborated and shared information and perspectives at two workshops. In November 2009, a workshop on “Climate Change Impacts on Olympic Peninsula Salmon” provided scientific information to a broad audience of stakeholders regarding vulnerabilities of aquatic habitats and salmonids on the Olympic Peninsula under a changing climate. Twelve scientists spoke on a variety of topics, including scenarios for the Olympic Peninsula’s climate and landscape in the 21st century, climate change effects on freshwater aquatic ecosystems, climate change effects on coastal marine systems, and planning for climate change (presentations are available online at: http://www.fs.fed.us/ccrc/video/olympic_climate_change.shtml). Panel discussions followed the presentations in each topic area, and the workshop concluded with an open discussion focused on key vulnerabilities and adaptation strategies for aquatic ecosystems on the peninsula. The
Adapting to Climate Change at Olympic National Forest and Olympic National Park

nearly 100 participants included representatives from ONF, ONP, and a variety of state and federal natural resource agencies, watershed organizations, and tribes.

A subsequent, smaller workshop focused on developing adaptation strategies and action items for fish management at ONF and ONP. Participants in this second workshop included ONF and ONP natural resources staff and scientists from the Forest Service Pacific Northwest Research Station (PNW) and the University of Washington Climate Impacts Group. Objectives of the workshop were to (1) use the latest scientific information on climate change and effects on fish to identify adaptation actions for fish management that should be taken by ONF and ONP in the short term (over 1 to 5 years), (2) identify priorities and priority areas (e.g., key watersheds, stream reaches, and species) for climate change adaptation on the forest and park, and (3) identify policy issues and regulatory barriers to climate change adaptation in fisheries and fish habitat management. The workshop began with a presentation from Nathan Mantua on key aquatic vulnerabilities with climate change on the Olympic Peninsula. Fish biologists Patrick Crain (ONP) and Robert Metzger (ONF) provided presentations on fish habitat management at ONP and ONF, respectively. Gordon Reeves (PNW) also gave a presentation on the potential utility of the NetMap tool (Benda et al. 2009; http://www.netmaptools.org) in adapting fish habitat management to climate change. A facilitated discussion on adaptation options for fisheries and fish habitat management with climate change followed. A description of potential adaptation strategies and action items appears in the section below, with a summary in table 5.2. See box 5.1 for a general summary of projected climate change effects on fish on the peninsula and related adaptation strategies for fish habitat management at ONF and ONP.

Adaptation Strategies and Actions for Hatcheries and Harvest

Olympic National Park has exclusive federal jurisdiction with the authority to determine regulations for sport fishing and recreational shellfish harvest in the park, and thus can consider resilience to climate change among other factors used to set regulations. For example, it is anticipated that Sol Duc summer coho will be affected by climate change. Although the summer coho in the Sol Duc River is not a federally listed population, the population is known by the park to be depressed. Current park regulations for the Sol Duc River allow for a catch-and-release fishery from June 1 to October 31, with a minor area closure associated with a summer coho prespawning staging area below the Salmon Cascades. However, minor but measurable mortality occurs with all catch-and-release fisheries. Therefore, in the face of climate change, it may be appropriate for the park to consider a complete closure of fisheries in the Sol Duc River when summer coho are present to eliminate all harvest mortality and thus help the population remain viable.

As warranted by climate change and associated stressors, the park will foster fish population protection through recreational harvest management, considering potential area or time closures for fish or shellfish as necessary, and protecting any identified cold water refugia (using stream temperature information or modeling tools such as NetMap; Benda et al. 2009; http://www.netmaptools.org; and G. Reeves2). Biologists will consider fish life history in determining when and where these management actions would be most effective. As it does currently, the setting of fishing regulations within the park in the future will occur in consultation with the state of Washington and the affected Olympic Peninsula tribes to ensure that the park’s regulations are consistent with, or not in opposition to, fishing regulations set by the state or federal government.

Besides the authority to manage recreational fisheries within the park’s boundaries, there is also National Park Service guidance (NPS 2006) for the use of hatcheries within the park. National Park Service 2006 Management Policies require that, whenever possible, native plants and animals should be relied upon to maintain their own populations, although management intervention is allowed to protect rare, threatened, or endangered species. In these

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Table 5.2—Current and expected sensitivities of fish to climate change on the Olympic Peninsula, associated adaptation strategies and actions for fisheries and fish habitat management at Olympic National Forest (ONF) and Olympic National Park (ONP)*

<table>
<thead>
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<th>Current and expected sensitivities</th>
<th>Adaptation strategies and actions</th>
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| Novel ecosystem response to shifting climate and hydrology                                       | • Shift to a new paradigm in fish habitat management that recognizes that pre-existing channel conditions may no longer be an accurate representation of the potential state.  
  • Incorporate climate change into the ONF Strategic Plan.                                         |
| Changes in fish distribution, population size, and viability                                    | • Implement strategic monitoring; build from existing monitoring programs.                                                                                                                                |
| Changes in timing of fish life history events                                                    | • Use tools such as NetMap to identify areas most likely to exhibit a climate change signal.                                                                                                         |
| Changes in habitat quantity and quality                                                          | • Monitor restoration projects to determine strengths and weaknesses of existing projects, and improve design of future restoration projects. |
|                                                                                                  | • Look for early indications of change to determine how quickly some of the climate-related changes are occurring, and use that information to adjust management priorities. |
| Increase in culvert failures, fill-slope failures, stream adjacent road failures, and encroach-   | • Decommission unneeded roads.                                                                                                                                                                           |
| ment from stream-adjacent road segments                                                          | • Remove sidecast, improve drainage, and increase culvert sizing on remaining roads.                                                                                                                   |
| Greater difficulty disconnecting roads from stream channels                                       | • Relocate stream-adjacent roads.                                                                                                                                                                           |
| Major changes in quantity and timing of streamflow in transitional watersheds                   | • Design more resilient stream crossing structures.                                                                                                                                                       |
| Increased erosion and sediment delivery to channels                                              | • Make road and culvert designs more conservative in transitional watersheds to accommodate expected changes.                                                                                           |
| Increased thermal stress on cold-water-adapted fish species                                      | • Consider adding large wood to small headwater channels to restore natural sediment routing (ONF lands).                                                                                                 |
| Decreased fish numbers owing to reductions in suitable habitat and productivity                  | • Consider thinning in steep landslide-prone areas to accelerate development of large wood inputs to streams (ONF lands).                                                                                  |
| Increased risk of disease introduction from hatchery fish                                        | • Limit mortality associated with recreational fishing through time and area closures as necessary.                                                                                                        |
| Increased disease virulence with warmer stream temperatures                                      | • Encourage implementation of Hatchery Scientific Review Group recommendations for hatchery reforms.                                                                                                      |
|                                                                                                  | • Follow 2006 National Park Service policies regarding the planting of hatchery fish within parks.                                                                                                         |
|                                                                                                  | • Control spread of exotic species.                                                                                                                                                                          |
Table 5.2—Current and expected sensitivities of fish to climate change on the Olympic Peninsula, associated adaptation strategies and actions for fisheries and fish habitat management at Olympic National Forest (ONF) and Olympic National Park (ONP)\(^a\) (continued)

<table>
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<tr>
<th>Current and expected sensitivities</th>
<th>Adaptation strategies and actions</th>
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| Decline in native fish populations owing to increased competition from exotic species | • Monitor to detect increases in invasive populations; initiate control measures aggressively.  
• Educate the public about measures to prevent the spread of invasive species.  
• Focus habitat protection and restoration efforts on existing wild fish strongholds and streams that are less influenced by hatcheries. |
| Increased spread of aquatic invasive species | |
| Loss of cold water refugia for cold-water-adapted fish species | • Identify and protect cold water refugia. |
| Decrease in area of headwater streams. | • Continue to correct culvert fish passage barriers.  
• Consider re-prioritizing culvert fish barrier correction projects. |
| Decrease in habitat quantity and connectivity for species that use headwater streams. | • Restore habitat in degraded headwater streams that are expected to retain adequate summer streamflow (ONF). |
| Increased sensitivity for species that spawn in late summer (e.g., summer chum, summer coho, spring chinook) | • Limit mortality associated with recreational fishing through time and area closures as necessary. |

\(^a\) Sensitivities are based on projected climate change effects on the Olympic Peninsula, including increased winter precipitation and runoff, more precipitation falling as rain rather than snow, increased storm intensity, greater winter and spring streamflows in some types of watersheds, increased flood frequency and magnitude in some types of watersheds, elevation shifts in transition (rain-on-snow) zones, reduced summer streamflows, and increased stream temperatures.

cases, animals (including fish) can be subjected to a captive breeding program (hatchery) to maintain or increase their abundance. However, the park must follow all planning procedures and provide for public comment and review before initiating such a program. In the future, this review will include an analysis of the appropriateness of management intervention in the face of climate change.

Olympic National Forest does not have jurisdiction over fishing regulations, seasons, or closures on national forest lands, nor do they control hatchery supplementation in streams and rivers that flow through the national forest. Authority for these activities resides solely with the state of Washington and the Olympic Peninsula tribes as co-managers. As in the past, ONF will continue to work with the state of Washington and the tribes to help identify and promote regulations needed to limit harvest mortality on high-priority species in key areas. The ONF will also continue to work with the co-managers and the National Marine Fisheries Service to help evaluate and implement hatchery supplementation programs, where necessary, to maintain viable populations of high-priority fish species on ONF lands.

Both the forest and park can continue to encourage the state, tribes, and U.S. Fish and Wildlife Service to implement the Hatchery Scientific Review Group recommendations (HSRG 2004) for hatchery reforms on the peninsula. The intent of these science-based recommendations is to redesign hatchery programs to help conserve wild salmon and steelhead populations and support sustainable fisheries. Implementation of these reforms will likely help salmon on the Olympic Peninsula remain viable in the face of climate change.

**Adaptation Strategies and Actions for Fish Habitat Management**

The goal of fish habitat management on ONF and ONP is to maintain or restore diverse, resilient habitat capable of supporting native fish populations over the long term.
Recent habitat restoration efforts have typically attempted to maintain or re-create key watershed processes and functions, assuming that doing so would eventually re-create the historical river morphology and habitat conditions. Current restoration efforts are generally consistent with actions that will lead to increased ecosystem resilience under changing climate. However, increased restoration efforts and proactive management in priority areas will likely increase ecosystem resilience to climate change. Further effort will be required to reevaluate priorities in light of climate change.

Preexisting channel conditions and locations may no longer be an accurate representation of the potential future state of fish habitat. To increase ecosystem resilience to climate change, ONF and ONP will emphasize maintaining and reestablishing ecosystem processes and functions, considering how past and current management practices contribute to current and future habitat conditions. Olympic National Forest and ONP will also consider how the magnitude of potential changes in climate and streamflow regimes will differ both between and within watersheds and assess how anticipated changes in climate will alter future stream characteristics. For example, increased frequency and magnitude of high-intensity rainfall events will likely increase the number of landslides and debris torrents, thus increasing sediment loading and subsequent stream aggradation.

Numerous management actions can be taken to reduce the incidence of human-induced landslides, such as decom-
Adapting to Climate Change at Olympic National Forest and Olympic National Park

missioning unstable roads, removing sidecast material, and increasing the size and number of culverts to reduce the potential for plugging or flow diversion. At ONF, erosion on hill slopes and in steep headwater stream areas once intensively managed for timber production could potentially be reduced by adding large wood to channels to reestablish the sediment storage and routing function that large wood provides in streams. In addition, if trees are left along debris flow channels, they will cause the debris flow to behave differently and have much different effects on the channel. However, because an increased rain:snow ratio will likely amplify both natural and human-induced landslides, and associated higher runoff will alter the stream channel morphology, management actions are unlikely to fully offset climate change effects on erosion and stream morphology.

Consideration of synergisms among changing processes with climate change will also be important. For example, increased snowmelt and associated higher runoff will alter the stream channel morphology, management actions are unlikely to fully offset climate change effects on erosion and stream morphology.

Roads and associated channel crossings are a major issue for fish habitat quality. Many adaptation actions for road management discussed in chapter 4 are also relevant to adaptation in fish habitat management. For example, roads adjacent to streams or the marine environment are particularly susceptible to flood and storm damage and are more likely to alter natural ecosystem function through restrictions in channel meanders, acceleration of flow velocity, and alteration of large wood recruitment. Thus, whenever possible, managers will consider moving roads out of flood plains (ONF and ONP) and marine coastal zones (ONP). Similarly, undersized channel crossings (either bridges or culverts) affect the natural function of stream channels through increased channel velocity and associated channel degradation, disruption of downstream transport of sediment and large wood, and increased potential for plugging and initiating landslides or debris torrents. Therefore, to the extent practicable, ONF and ONP will attempt to construct any new stream crossings with structures sized to meet the needs for natural channel function under flows anticipated with climate change. This may require larger structures than have been used in the past. Olympic National Forest and ONP will continue to remove or replace existing undersized stream crossings with appropriately-sized structures as opportunities arise and funding is available (see chapter 4 for further detail).

Reduced summer streamflows in headwater tributaries will likely reduce the amount of resident fish habitat available in many upper stream reaches during dry periods. The magnitude of stream habitat reductions will differ from watershed to watershed. Intermittent streamflows may increase the importance of providing barrier-free migration corridors in the upper watersheds so that resident fish can reoccupy intermittent stream reaches when flow returns. The ONF currently prioritizes resident fish culvert barrier correction projects based on the total amount of habitat that would be reconnected. Culvert barrier corrections tend to focus on the larger, longer streams first and then up into the headwaters. The ONF will continue to correct culvert fish passage barriers as funds are available. Considering potential streamflow reductions in small high-gradient resident fish streams associated with climate change, ONF may need to reconsider how to prioritize removal of culvert barriers to facilitate passage of resident fish.

Increased cooperation and strong partnerships can help natural resource agencies and other groups address ecosystem stressors and climate change more effectively through a shared vision and pooling of resources. Olympic National Forest and ONP will increase communication and coordination on fisheries research, habitat restoration, and monitoring between the park and forest. They will also work to increase communication with neighboring tribes, the state of Washington, other government entities, and local watershed groups on restoration priorities and climate change issues, seeking opportunities to collaborate with other landowners and managers in priority watersheds.

Reduced summer streamflows will create challenges in meeting adequate instream flows for fish in some watersheds. The city of Port Townsend has already experienced problems in meeting their required instream flows for summer chum as specified in the Biological Opinion for
their special use permit. The forest will work with the city to encourage them to adopt adequate water conservation measures and increase efficiency of their delivery systems so that the Big Quilcene River water levels do not fall below specified levels. The ONF could also review existing water withdrawal permits and review how users are withdrawing water from the streams across the forest to provide an early warning for fish habitat issues as summer streamflows decline.

Owing to resource limitations and differences in anticipated climate change effects between watersheds, a strategic focus of efforts and use of resources is essential to most effectively deal with fish habitat issues related to climate change. The ONF and ONP identified some general priority actions for adaptation, as well as some preliminary priorities for species protection, habitat protection, and monitoring. One general priority for ONF and ONP is to control, to the extent possible, exotic aquatic species, invasive riparian plants, and fish diseases. Many exotic fish species introduced to the Pacific Northwest are well-suited to warmer water temperatures (e.g., American shad, bass, perch, channel catfish, etc.). American shad is an Atlantic Ocean species that prefers slightly warmer waters than salmon. Populations of American shad in the Columbia River have increased substantially in the last several decades and are likely competing with native fishes for habitat and food resources during the summer and fall (Petersen et al. 2003). Invasive New Zealand mud snails and zebra mussels occur in other parts of Washington. Several knotweed species (especially Japanese knotweed) currently thrive in some watersheds on the peninsula. Detecting the presence of, or increases in, invasive species populations requires monitoring and prompt action to effectively control or eliminate them. Preventing the spread of exotic fish and shellfish and keeping stream temperatures as low as possible through shading will help to keep the potential spread of fish disease to a minimum, because exotic species may spread diseases to native fish and diseases become more virulent with increasing stream temperatures. Ensuring that stocked fish meet health guidelines will also help to control disease spread. Finally, educating the public about invasive species and disease will further minimize the spread of those factors.

Olympic National Forest will explore ways to incorporate climate change in the Forest Strategic Plan. The Forest Strategic Plan identifies focus areas for restoration and areas where projects, such as commercial thinning, may achieve multiple objectives. In prioritizing thinning activities, increased attention could be given to the positive impacts that thinning activities can have on riparian and aquatic habitat quality. For example, thinning in high-risk landslide-prone areas may help to accelerate the establishment of large trees that provide wood to streams.

Several fish species, including spring chinook salmon, Ozette Lake sockeye salmon, resident trout, bull trout, Olympic mudminnow, summer coho salmon, and summer chum salmon, are proposed as potential priorities for protection because of their sensitivity to changes in stream temperature and hydrology expected with climate change. Climate change effects will differ between watersheds, and a variety of habitat types and locations will be particularly sensitive. These areas can be prioritized for restoration and protection. For example, transitional watersheds (which receive some precipitation as rain and some precipitation as snow) are likely to have the greatest increases in winter streamflow with climate change. Thus, road and culvert designs on both ONF and ONP could be modified to accommodate expected changes in transitional watersheds. Extent of headwater streams will likely be reduced with climate change-related changes in hydrology. On ONF, maintaining and restoring connectivity and fish passage in headwater areas that are likely to go dry, and restoring damaged habitat in headwater streams that are expected to retain adequate streamflows, will help maintain viable resident fish populations in as many areas as possible. Protection of cold water refugia will be critical for many species as summer water temperatures increase. Streams with cold water refugia could be prioritized over streams that are currently warm and are likely to become too warm with changing climate. Wild fish strongholds, such as the Sol Duc, Calawah, and Hoh River watersheds, and streams that are less influenced by hatcheries could be prioritized over other watersheds for a wide range of actions to help ensure
Adapting to Climate Change at Olympic National Forest and Olympic National Park

continued viability of wild fish populations in the face of climate change.

Monitoring will be critical to document current status and detect changes that are occurring with warming temperatures, and thus, implementation of strategic monitoring will be important for ONF and ONP in adapting to climate change. Olympic National Park has a long-term ecological monitoring program that can be used as a foundation for a more extensive monitoring program designed to interpret effects of climate change on fish populations in both fresh and salt water areas of the Olympic Peninsula. Tools such as NetMap (Benda et al. 2009; http://www.netmaptools.org) can also be used to identify areas that are most likely to exhibit a climate change signal. Finally, monitoring of restoration projects (e.g., culvert fish passage corrections, road decommissioning, engineered logjams, and the Elwha dam removal) will continue to be key in determining strengths and weaknesses of existing projects, and improving design of future restoration projects.

Priorities for monitoring at ONF and ONP include effects of changing climate on fish life history (e.g., emergence timing, and fitness of juvenile fish over the course of a growing season), which will be important in determining how climate change is influencing fish on the peninsula. Collection of otoliths could help identify changes in life history patterns. Monitoring of habitat loss, particularly in headwaters and at higher elevations, will also help to determine what types and how fast habitat is being lost so that management activities can be tailored accordingly.

Challenges and Future Directions in Adaptation in Fish and Fish Habitat Management

Clear actions can be taken by ONF and ONP to adapt to climate change. However, implementation of adaptation in fish and fish habitat management also faces some challenges. As noted in chapter 4, the predominant Emergency Relief for Federally Owned Roads Program policy of replacing existing infrastructure with the same infrastructure after a failure makes it difficult for ONF and ONP to improve infrastructure to meet current standards and accommodate effects of climate change. Similarly, restrictions on activities in wilderness areas sometimes prevent both agencies from being able to move high-risk roads out of flood plains without Congressional action. Both ONF and ONP have limited funding for activities that would contribute to adaptation. Other state and federal policies may become limiting in the future. For example, the state of Washington has historically overallocated water, although the full allocated rights have not yet been used. New water rights may be allocated based on existing summer flows and channel conditions, which are likely to change in the future. At the federal level, there is no clear pathway to bring climate change information into Endangered Species Act [ESA 1973] consultations, National Environmental Policy Act (1969) analyses, or Clean Water Act (1977) degraded waterbody designations. Olympic National Forest and ONP will communicate these challenges to state and federal decisionmakers and seek solutions that will help overcome these challenges and facilitate climate change adaptation.

Olympic National Forest and ONP may also need to initiate research and explore new types of actions to adapt fisheries and fish habitat management to climate change. For example, more information will be needed on how the effects of climate change differ across the landscape, and an understanding of this variation will be a key factor in the development and implementation of new adaptive actions. It is possible that forest structure and composition could be managed to reduce evapotranspiration and maximize water retention and summer base flow. Stand structure could be manipulated to retain snow, and it is possible that forest structural conditions could be managed to promote increased fog drip. Determining whether these and other potential actions could help ONF and ONP adapt to climate change will require experimentation, monitoring, and feedback to management.

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Literature Cited


Adapting to Climate Change at Olympic National Forest and Olympic National Park


Vegetation on the Olympic Peninsula

The Olympic Peninsula has steep and dissected topography, which results in temperature and precipitation gradients and varied climatic environments (Peterson et al. 1997). The western, coastal side of the peninsula is characterized by a wet and humid maritime climate. Higher elevations on the western side of the peninsula receive as much as 5 m of precipitation per year (Henderson et al. 1989). The northeastern portion of the peninsula, in contrast, is characterized by a drier, more continental climate owing to the rain-shadow effect of the Olympic Mountains (and prevailing winds from the southwest during the winter), and rainfall in this area is as low as 0.5 m per year at lower elevations (Henderson et al. 1989). Most precipitation falls between October and March, resulting in low summer soil moisture, particularly in the northeastern portion of the peninsula.

Dominant forest species differ with climatic conditions found on the peninsula (Buckingham et al. 1995) (fig. 6.1). Lower elevation forests on the western side of the peninsula are dominated by Sitka spruce, with western hemlock and western redcedar as common associates (Sitka spruce zone in fig. 6.1) (See a "Common and Scientific Names"). Red alder and bigleaf maple are also abundant in some locations. At lower to middle elevations, western hemlock and Douglas-fir are the dominant overstory species (western hemlock zone in fig. 6.1). Pacific silver fir dominates mid to upper slope forests, except in very dry locations, sometimes sharing dominance with Douglas-fir and western hemlock (Pacific silver fir zone in fig. 6.1). Mountain hemlock is dominant at higher elevations (mountain hemlock zone in fig. 6.1) in all but the driest locations, where subalpine fir is dominant (subalpine fir zone in fig. 6.1) (Henderson et al. 1989).

In the northeastern portion of the peninsula, distributions with elevation differ. Lower elevation forests are dominated by western hemlock and Douglas-fir (western hemlock zone in fig. 6.1). Grand fir, western redcedar, and Pacific silver fir share dominance with Douglas-fir and western hemlock at many mid-elevation sites on the east side of the peninsula (western hemlock and Pacific silver fir zones in fig. 6.1), but Douglas-fir is dominant on south-facing slopes in dry areas (Douglas-fir zone in fig. 6.1). Subalpine fir is a major overstory species at higher elevations, with lodgepole pine dominant in some areas (subalpine fir zone in fig. 6.1). Mountain hemlock and subalpine fir give way to subalpine meadows at the highest elevations (parkland mountain hemlock zone in fig. 6.1).

Potential Climate Change Effects on Vegetation on the Olympic Peninsula

Climate, in concert with landscape and local-scale variables, dictates vegetation distribution across landscapes by placing both thermal and water constraints on plant regeneration, establishment, and growth. Past species response to changing climate observed in the paleoecological (pollen and fossil) record shows that the abundance and distribution of plant species shift individualistically in response to climate fluctuations (Davis and Shaw 2001, Delcourt and Delcourt 1991, Whitlock 1992); different species respond in varied ways to changing climate, leading to new species assemblages and communities. Increasing temperatures associated with climate change, and corresponding increases in summer drought stress and fire frequency in
the Pacific Northwest, will probably lead to changing species distribution in the region, resulting in forest types different from those we see today (Zolbrod and Peterson 1999). There are several information sources useful for predicting potential climate change impacts on vegetation and future forest composition and structure, including long-term paleoecological records, modern tree ring records of tree growth and establishment, current trends with recent warming, and model predictions for the future. The following section reviews these information sources for the Olympic Peninsula.
Paleoecological Records of Climate and Species Distribution

Paleoecological records from the Pacific Northwest and elsewhere show that during historical warm periods, many tree species moved poleward and upward in elevation. Poleward and upward shifts in elevation of species distributions involve changes in species abundance, rather than a species extirpation in areas where it was formerly dominant; shifting distributions represent leading edge dynamics rather than trailing edge contraction. For example, during a warmer period in the 19th century, western hemlock became dominant in areas where Pacific silver fir and mountain hemlock were dominant on Mount Rainier in the Washington Cascade Range (Dunwiddie 1986), suggesting that western hemlock will move up in elevation in a warmer climate (Zolbrod and Peterson 1999). Several studies have shown the range expansion of subalpine fir into alpine tundra at higher elevations in the northeastern portion of the Olympic Peninsula during historical warm periods (Burbaker and McLachlan 1996, Gavin et al. 2001, McLachlan and Burbaker 1995). The range expansion of subalpine fir around Moose Lake in the northeastern portion of the peninsula during a warm period around 11,000 BP was also associated with increased charcoal content in lake sediments, suggesting fire size and frequency increased near the lake (Gavin et al. 2001).

During the warm and dry Holocene period circa 10,000 to 6,000 BP, red alder, Douglas-fir, and lodgepole pine were abundant in forests of primarily western hemlock and spruce at lower elevations on the Olympic Peninsula (Henderson et al. 1989, Heusser 1977, Peterson et al. 1997, Whitlock 1992). The abundance of these species in the Pacific Northwest has been associated with higher fire frequency (Cwynar 1987, Prichard et al. 2009). A study in the nearby north Cascade Range also found increased abundance of lodgepole pine, in association with high fire frequency, circa 10,500–8,000 BP (Prichard et al. 2009). In addition, western white pine became locally important in the Pacific Northwest during this period (Cwynar 1987), and Oregon white oak, a species usually associated with drier climates, was very common during this period in the northeastern Olympics (Petersen et al. 1983, Peterson et al. 1997). The range expansion of western redcedar, and further range expansion of western hemlock and Sitka spruce, occurred only after a period of lower temperatures and higher precipitation during the Holocene warm period, suggesting that the range of these species on the peninsula was limited by drought during that warm period (Whitlock 1992).

The paleoecological record from the Pacific Northwest shows that species with life history traits that allow survival during periods of frequent disturbance and in stressed environments have persisted during past periods of rapid climate change (Brubaker 1988, Whitlock 1992). For the Pacific Northwest, these species include red alder, Douglas-fir, and lodgepole pine, suggesting that these species will be successful in a rapidly warming climate (Whitlock 1992). Other examples of species that have persisted over millions of years of climatic change on the Olympic Peninsula include Oregon white oak, giant chinquapin, bigleaf maple, and Pacific madrone (Henderson et al. 1989).

Warmer and drier conditions at lower elevations on the Olympic Peninsula would likely result in expansion of the range of Douglas-fir and lodgepole pine. Other species that may expand their ranges under these conditions include western white pine, Oregon white oak, giant chinquapin, and Pacific madrone. Increased disturbance frequency may lead to the range expansion of red alder. The paleoecological record for the Pacific Northwest also suggests that many species, including western hemlock and subalpine fir, will become more abundant at higher elevations with warming on the peninsula.

Modern Records of Climate, Tree Growth, and Fire

Before climate-induced changes in species distribution become apparent, changes in patterns of species establishment, growth, and mortality occur that eventually lead to broader range shifts (Littell et al. 2008). Dendroecological (tree ring) records from the past several hundred years allow observation of changes in growth of tree species with climate variation. Tree ring records show that individual tree growth and net primary productivity are sensitive to annual changes in climate in the Pacific Northwest.

At higher elevations on the Olympic Peninsula, tree growth and establishment are limited by snowpack amount and duration and associated growing-season length; greater snowpack amount and duration lead to a shorter growing season and decreased growth in high-elevation trees. For example, tree growth at the mid- and high-elevation subalpine fir-mountain hemlock and Pacific silver fir-western hemlock forests of the Hoh watershed on the western Olympic Peninsula is limited by snowpack and associated growing-season length (Holman and Peterson 2006, Nakawatase and Peterson 2006). Mountain hemlock growth in the Pacific Northwest is limited by spring snowpack depth and low summer temperatures (Peterson and Peterson 2001). Similarly, subalpine fir at high-elevation, wetter sites on the Olympic Peninsula grows more slowly during years with lower summer temperature (Ettl and Peterson 1995), and regionally, growth of subalpine fir in the wetter portions of its range is negatively correlated with winter precipitation and spring snowpack depth (Peterson et al. 2002). Increasing temperatures with climate change will lead to more precipitation falling as rain rather than snow, earlier snowmelt, and thus lower snowpacks and longer growing seasons on the peninsula (Holman and Peterson 2006). Longer growing seasons on the peninsula will alleviate growth-limiting factors and likely result in increased growth and productivity in high-elevation forests. Longer growing seasons will likely also lead to higher tree establishment at higher elevations.

In the dry northeastern Olympics, tree growth and establishment are limited by low summer soil moisture. For example, tree growth in the Dungeness watershed in the northeastern portion of the Olympic Peninsula has been shown to be limited by summer soil moisture, although less so at higher elevations (Nakawatase and Peterson 2006). Douglas-fir, although more drought tolerant than other major Olympic Peninsula tree species such as western hemlock, is limited by water supply at lower elevations in the Pacific Northwest (Littell et al. 2008).

Increasing temperatures, lower winter snowpack, and early snowmelt with climate change will likely result in decreased soil moisture in parts of the Pacific Northwest, including many areas west of the Cascade Range in Washington state (Elsner et al. 2010). For the state of Washington, soil moisture content on July 1st is projected to decrease through the 21st century; for mean historical values (from the 1915 to 2006 period), July 1st soil moisture content is defined as 50 percent and is projected to be in the 38th to 43rd percentile by the 2020s, 35th to 40th percentile by the 2040s, and 32nd to 35th percentile by the 2080s (Elsner et al. 2010) (fig. 6.2). These decreases in summer soil moisture will likely lead to increased stress to tree species in some portions of the Pacific Northwest.

Increased drought stress will likely result in decreased tree growth and forest productivity in the northeastern forests of the Olympic Peninsula. In the Sitka spruce forests on the west side of the peninsula, carbon dioxide fertilization could lead to increases in productivity (Norby et al. 2005), if other factors, such as nutrient availability, do not limit growth. However, growth may also decrease in these Sitka spruce forests if summer soil moisture becomes sufficiently limiting with warming (Holman and Peterson 2006, Nakawatase and Peterson 2006).

Tree ring and modern fire records both show that years with widespread fire and fire extent are associated with warmer and drier spring and summer conditions in the Western United States (Heyerdahl et al. 2008, Littell et al. 2009, McKenzie et al. 2004, Taylor et al. 2008, Westerling et al. 2006). Warmer spring and summer conditions in the Western United States lead to relatively early snowmelt, and lower summer soil and fuel moisture, and thus longer fire seasons (Westerling et al. 2006). Wildfire area burned in mountainous areas in the Western United States was positively related to low precipitation, drought, and high temperatures in the 20th century (Littell et al. 2009). Increased temperatures and drought occurrence in the Pacific Northwest from climate change will likely lead to increased fire frequency and extent. In addition, the intensity and severity
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of fires may increase in some areas if higher temperatures exacerbate low moisture content in fine fuels.

Climate and fire on the Olympic Peninsula have been closely related in the past (Henderson et al. 1989). Warmer and drier periods of the past were likely characterized by increased fire frequency, particularly on the east side of the Olympic Peninsula (Gavin et al. 2001, Henderson et al. 1989). Historical fires have been most frequent in the drier western hemlock, subalpine fir, and Douglas-fir vegetation types in the eastern half of the Olympic Peninsula (Henderson et al. 1989, Pickford et al. 1980). Henderson et al. (1989) calculated the average fire-return period for the last 800 years in these vegetation types on the peninsula and found that the Douglas-fir zone had a fire-return period of 138 years, the subalpine fir zone had a fire-return period of 208 years, and the western hemlock zone had a fire-return period of 234 years. Decreases in fire-return intervals in these forest types would likely favor tree species that can survive fires or regenerate after fires, such as Douglas-fir and lodgepole pine, at the expense of less fire-tolerant species, such as western hemlock. Individual trees can withstand climatic variation, but disturbance events that result in mortality of mature trees could trigger changes in distribution and abundance of forest species on the peninsula.

Trends With Recent Warming

Plant and animal species in different ecosystems across the world have begun to respond to recent warming over the last few decades (Parmesan 2006, Parmesan and Yohe 2003, Root et al. 2003). Most plant responses to recent warming have involved alteration of species’ phenologies, or timing of life history stages (Bradley et al. 1999, Menzel 2000, Menzel et al. 2001, Parmesan 2006). Advances in timing of flowering, for example, have been reported for plant species in Great Britain (Fitter and Fitter 2002), and evidence exists that the growing season has lengthened in the Northern Hemisphere in the last 50 years (Menzel and Fabian 1999, Parmesan 2006). Shifts in timing of flowering and the abundance of insect pollinators could lead to the decline of some plant species if pollinators are absent during times of peak flowering.

Shifts in species’ distribution with warming in recent decades have been documented at several locations, including mountain ranges in western Europe (Grabherr et al. 1994, Lenoir et al. 2008) and southern California (Kelly and Goulden 2008). Consistent with paleoecological records, these shifts have generally involved movement upward in elevation or poleward (Parmesan 2006). Upward movement of tree lines has been documented in numerous mountainous locations across the world, including locations in Canada (Lescop-Sinclair and Payette 1995, Luckman

Figure 6.2—Summary of projected July 1 soil moisture (volumetric soil water content) for the 2020s, 2040s, and 2080s (A1B and B1 Intergovernmental Panel on Climate Change emissions scenarios) as a percentile of simulated historical mean from 1916 to 2006 (by using the Variabile Infiltration Capacity model). For future projections, percentiles less than 50 (browns) represent a decrease in soil moisture, and percentiles greater than 50 (blues) show an increase in soil moisture. Percentage change values represent spatially averaged July 1 soil moisture across Washington state. (Adapted from Elsner et al. 2010.)
and Kavanagh 2000), Sweden (Kullman 2001), Bulgaria (Meshinev et al. 2000), Russia (Moiseev and Shiyatov 2003), and New Zealand (Wardle and Coleman 1992). However, tree-line dynamics are complex and dependent on precipitation and microsite patterns in addition to temperature (Malanson et al. 2007, Parmesan 2006). A meta-analysis of response of tree lines at 166 sites (from around the world, but mostly in North America and Europe) to recent warming found that tree lines at sites with more winter warming were more likely to have advanced than tree lines at sites with less warming. In addition, tree lines with a diffuse form, characterized by decreasing tree density with increasing altitude or latitude, were more likely to have advanced than those with an abrupt form, characterized by a continuous canopy with no decline in density right up to tree line (Harsch et al. 2009). It is possible that diffuse tree lines are more responsive to warming because tree growth, but not survival, is limited by climatic factors. In contrast, winter stress factors that cause plant damage and limit survival may have a stronger influence on abrupt tree lines (Harsch et al. 2009).

The frequency of some drought-related disturbance events has increased with recent warming. Tree mortality events in the Southwestern United States have been attributed to late 20th-century warming and related drought (Breshears et al. 2005, 2009). Increased temperatures have led to drier fuel levels, longer fire seasons, and an increase in years with widespread fire across the Western United States (Littell et al. 2010, Westerling et al. 2006).

Insect outbreaks, such as that of the mountain pine beetle, have been recorded across a broad spectrum of latitude and temperature regimes in the past in western North America. However, the severity and distribution of some recent outbreaks differ from what can be inferred from historical records, and higher temperature associated with climate change is believed to be a significant factor in these differences (Aukema et al. 2008, Carroll et al. 2004, Logan and Powell 2001). For example, the expansive mountain pine beetle outbreak in British Columbia has expanded into northern areas and into areas east of the Rocky Mountains in Alberta, where mountain pine beetles were not successful in the past because of cold winter temperatures (Carroll et al. 2004). Current conditions on the Olympic Peninsula do not preclude mountain pine beetles from infesting and killing hosts, and the suitability for mountain pine beetle outbreaks at higher elevations in the Olympics is expected to increase under moderate warming (Littell et al. 2010). Besides the effects of changing climate on insect reproductive cycles, timing and severity of outbreaks will depend on availability of susceptible ages and sizes of lodgepole pine, western white pine, and whitebark pine and the stand conditions within which they reside.

The exotic balsam woolly adelgid can infest both Pacific silver fir and subalpine fir on the Olympic Peninsula. This insect generally does not kill trees quickly, but will result in the slow demise of infested trees. Mitchell and Buffam (2001) observed that 3 to 4 years of warmer than average summers resulted in increased adelgid damage in subalpine fir at higher elevations in Oregon and Washington. They stated that, “If there was a permanent or long-term (decades) increase in summer temperatures, it is likely we would see an expanded range for the balsam woolly adelgid within the subalpine fir ecotypes—upward in elevation and to other new environments.” This suggests that, with warmer temperatures, balsam woolly adelgid will have greater effect on subalpine fir than is now being experienced on the Olympic Peninsula.

Besides the increased fire risk in drought-stressed forests, increased moisture stress may leave forests in the Western United States more susceptible to insect attack (Allen and Breshears 1998, Breshears et al. 2005, Hicke et al. 2006, Shaw et al. 2005). As temperature increases, any increase in moisture stress will increase the susceptibility of Douglas-fir on the peninsula to attack by Douglas-fir beetle. On the Olympic Peninsula, Douglas-fir beetle outbreaks are generated by wind events, which result in significant amounts of blowdown. Beetle populations build up in the downed trees, and then can attack and kill standing green Douglas-firs. These outbreaks will subside within 3 years if no subsequent blowdowns occur, and the numbers of standing trees that are killed will depend on the relative moisture stress of these trees. Historically, after blowdowns, mortality has been higher in the drier, eastern habitats of the peninsula than in the wetter, western habitats. Any
changes in moisture regimes would affect the distribution of Douglas-fir beetle-caused mortality from a wind event on the peninsula. Recently burned forests may also lead to increases in Douglas-fir beetle populations, and subsequent mortality of additional green trees. In turn, these insect outbreaks can alter fuel and forest stand conditions which, at certain points after infestation, could result in increased risk of high-severity fire (Jenkins et al. 2008). All of these disturbances may increase opportunities for establishment by exotic species (Joyce et al. 2008). In this way, disturbances could act synergistically to drive ecosystem change on the Olympic Peninsula (McKenzie et al. 2009).

Tree disease could also potentially increase with warming on the peninsula. The effects of climate change on host physiology, adaptation or maladaptation, and population genetics that affect host-pathogen interactions is uncertain (Kliejunas et al. 2009). However, based on existing knowledge of tree disease in western North America, it can be inferred that climate change will result in reductions in tree health and advantageous conditions for some pathogens (Kliejunas et al. 2009). Any drought stress that is realized owing to changing conditions will exacerbate the impacts of many pathogens (Kliejunas et al. 2009).

Model Predictions for Future Vegetation Patterns With Climate Change
Along with past records, models can be used to project future ecosystem response to changing climate. Output from three different types of climate change impact models—gap, climate envelope, and mechanistic dynamic

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Box 6.1—Model types that assess potential effects of climate change on vegetation. Adapted from Robinson et al. (2008)

**Gap models**
- Gap models simulate forest interactions and dynamics on a small, gap-sized patch of land (usually 0.01 ha and larger).
- The geographic extent of analysis ranges from forest stands to regions.
- Ingrowth, growth, and death of individuals of one or more species on the patch are simulated over time.
- Dynamics in gap models are based on species-specific parameters, competition (e.g., relative height), light, temperature, and soil moisture.
- Output includes density, basal area, biomass, and leaf area index by species and by stand. Information on each live tree is also available (e.g., species and diameter).
- Gap models use monthly temperature and precipitation, and so can respond to novel climate.
- Some gap models have recently been adapted to be sensitive to changes in soil moisture and carbon dioxide concentrations.

**Climate envelope models**
- Climate envelope models (CEMs) are statistical models that predict future species distribution based on the relationship between current species distribution and climate variables (and sometimes other variables).
- CEMs use basic climate information as input.
- The geographic extent of analysis is variable, but regional analyses are typical. Modeling unit differs with input information.
- CEMs represent a snapshot in time and do not show variability in species distribution over time.
- These models assume that climate is the primary determinant of a species distribution and that the current relationship between a species and climate will hold under changing climate.
- CEMs do not account for competition, dispersal, or evolutionary change in vegetation communities.
- CEMs do not account for increases in carbon dioxide (CO₂) and changes in disturbance regimes.

**Dynamic global vegetation models**
- Dynamic global vegetation models (DGVMs) simulate key physiological processes in plant communities to infer vegetation type over time.
- DGVMs use soil and climatic information (hourly to yearly).
- DGVMs can respond to novel climate and are sensitive to changes in CO₂ and fire regimes.
- The geographic extent of analysis ranges from landscape to global, with modeling unit ranging from a 30 m² to several-square kilometer pixel.
- Output shows distribution of broad vegetation functional types over time but not individual species.
- DGVMs can identify limiting factors in different regions.
- DGVMs do not consider complex topography, land use change, management, pests, or herbivores.
global vegetation models (box 6.1)—has been produced for the Olympic Peninsula. All of these model types have strengths and limitations but can be conceptually useful in assessing potential climate change effects on vegetation. Output from these different model types for the Olympic Peninsula is described below.

**Gap model results for the Olympic Peninsula**
A gap modeling study for the subalpine and upper montane zones of the Olympic Mountains under a warming climate (Zolbrod and Peterson 1999) suggested that in the wetter southwest areas, dominant tree species will shift upwards 300 to 600 m; gap model study results predict that Pacific silver fir will increase in subalpine meadows and mountain hemlock forests and western hemlock will increase in Pacific silver fir forests. In the drier northeast, study results suggest that drought-tolerant species will become dominant at lower elevations. At higher elevations, subalpine fir will dominate north aspects, and lodgepole pine will dominate south aspects. In general, productivity will increase in the southwest owing to longer growing seasons (and lack of moisture limitations), and productivity will decrease in the northeast owing to increased evapotranspiration and lower soil moisture content during the summer.

**Climate envelope model results for the Olympic Peninsula**
Statistical ecological models, also known as climate envelope models, were developed for the state of Washington by Littell et al. (2010 with data from Rehfeldt et al. 2006) to determine the potential for climate change to alter distribution of important tree species, including Douglas-fir, lodgepole pine, ponderosa pine, and whitebark pine. Under a moderate carbon dioxide-emission scenario (1 percent per year increase in greenhouse gases after 1990) (Rehfeldt et al. 2006), the envelope models suggested that there will be a significant decline in the area of suitable climate for Douglas-fir at lower elevations and in the southern portion of the Olympic Peninsula. A decrease in area of suitable climate for pine species, which could include whitebark pine and lodgepole pine, is also projected to occur at higher elevations on the Olympic Peninsula.

As noted in box 6.1, several assumptions and limitations are associated with climate envelope models. First, climate envelope models assume that climate is the primary determinant of a species distribution and that the current relationship between a species and climate will hold under changing climate. In addition, these models do not account for several important determinants of plant species distribution, including competition, dispersal, evolutionary change in vegetation communities, and changes in disturbance regimes.

**Dynamic global vegetation model results for the Olympic Peninsula**
The MC1 (Bachelet et al. 2001) dynamic global vegetation model (DGVM) is based on fundamental ecological processes and provides projections of future change in broad vegetation types with changing climate. Vegetation types in MC1 are based on life form (e.g., tree, shrub, or grass; evergreen or deciduous; broadleaf or needleleaf) and biome physiognomy (e.g., forest, savanna, or shrub-steppe) (see Neilson 1995). Species-level information is not included in MC1 output but can be inferred at coarse scales based on modeled vegetation type and local vegetation information. Additional limitations of MC1 are that it does not include complex topography, which may be important with changing climate in mountainous regions such as the Olympic Peninsula, or the effects of land use change, management, insects, or herbivores (see box 6.1).

MC1 model projections are based on future climate projections from global climate models (GCMs). The Mapped Atmosphere-Plant-Soil System (MAPSS) Team (Forest Service, Pacific Northwest Research Station, Corvallis, Oregon) ran the MC1 model for the Pacific Northwest region, at a scale of 800 m, with inputs from three GCMs under three future carbon dioxide emissions scenarios. The three GCMs used in the analysis included the CSIRO-MK3.0 model from Australia (Dix et al. 2009, Gordon et al. 2002), the Hadley CM3 model from the United Kingdom (Gordon et al. 2000, Pope et al. 2000), and the MIROC 3.2 medium-resolution model from Japan (Hasumi and Emori 2004). These three GCMs were chosen to bracket the range of scenarios available for the Western United States. In general, the Commonwealth Scientific and Industrial Research
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Figure 6.3—Projected modal vegetation types on the Olympic Peninsula for the 2010–20 period compared to modeled historical vegetation types. Projections are from the MC1 model for three global climate models (GCMs) (rows) and two Intergovernmental Panel on Climate Change (IPCC) carbon dioxide emissions scenarios (columns). The Commonwealth Scientific and Industrial Research Organization’s (CSIRO) GCM projects a relatively cool and wet Pacific Northwest, whereas the Model for Interdisciplinary Research on Climate (MIROC) projects a hot and wet Pacific Northwest, and the Hadley model projects a hot and dry Pacific Northwest. The carbon dioxide emissions scenarios used in the analysis included the Intergovernmental Panel on Climate Change (IPCC) special report on emissions scenarios (Nakićenović and Swart 2000) B1 (relatively low future carbon dioxide emissions), A1B (moderate future carbon dioxide emissions), and A2 (relatively high future carbon dioxide emissions) scenarios.

Here we present MC1 output on vegetation shifts and fire dynamics on the Olympic Peninsula through the end of the century for the three GCMs described above and the B1 and A2 emissions scenarios (relatively low and high emissions scenarios, respectively) (figs. 6.3 through 6.8). The MC1 output is based on model runs that included a relatively high carbon dioxide fertilization effect (Norby et al. 2005) and potential nitrogen limitation. Changes in vegetation type in figures 6.3 through 6.5 indicate that the climate will no longer be suitable for the former vegetation type and that changes in species composition and abundance are likely. However, changes in species composition and abundance will likely be gradual because of...
Table 6.1—Dominant and associated species for current vegetation (elevation/moisture) zones on the Olympic Peninsula with potential dominant species in 2100\(^a\)\(^b\)

<table>
<thead>
<tr>
<th>Current vegetation zones</th>
<th>Current dominant species</th>
<th>Current associates</th>
<th>Potential dominant species in 2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitka spruce</td>
<td>Sitka spruce (-), western hemlock (-), western redcedar (+)</td>
<td>Douglas-fir (+), red alder (+), Pacific silver fir (+), bigleaf maple (+)</td>
<td>Douglas-fir, western redcedar, red alder</td>
</tr>
<tr>
<td>Western hemlock</td>
<td>Western hemlock (-), Douglas-fir (+)</td>
<td>Western redcedar (-), lodgepole pine (+), western white pine (+), grand fir (-), bigleaf maple (-)</td>
<td>Douglas-fir, lodgepole pine, western white pine</td>
</tr>
<tr>
<td>Douglas-fir</td>
<td>Douglas-fir (+), lodgepole pine (+)</td>
<td>Western hemlock (-), western redcedar (-), madrone (+), western white pine (+), Rocky Mountain juniper (+), golden chinquapin (+)</td>
<td>Douglas-fir, lodgepole pine, western white pine</td>
</tr>
<tr>
<td>Pacific silver fir</td>
<td>Pacific silver fir (-), western hemlock (+)</td>
<td>Alaska yellowcedar (-), western redcedar (+), Douglas-fir (+), mountain hemlock (-), western white pine (+)</td>
<td>Western hemlock, western redcedar, Douglas-fir, western white pine</td>
</tr>
<tr>
<td>Mountain hemlock</td>
<td>Mountain hemlock (-), Pacific silver fir (+)</td>
<td>Subalpine fir (+), Alaska yellowcedar (+), western white pine (+), western hemlock (+), Douglas-fir (+)</td>
<td>Pacific silver fir, western hemlock, western white pine</td>
</tr>
<tr>
<td>Alpine</td>
<td>—</td>
<td>—</td>
<td>Subalpine fir, mountain hemlock, Alaska yellowcedar, whitebark pine</td>
</tr>
</tbody>
</table>

\(\text{—} = \text{no tree species present.}\)

\(\text{\(a\)}\) Potential dominant species were determined assuming that the next century will be hotter, with increasing summer drought stress, and that disturbance frequency (either fire on the east side of the peninsula or windstorms on the west side of the peninsula) will increase over the next century to facilitate species transition. It was also assumed that species dispersal would not be a limiting factor for movement in response to changing climate. Expected increases or decreases in abundance of current dominant and associate species are indicated with a (+) or (-), respectively.


the high tolerance of mature trees to climatic variation; disturbances such as fire will likely be the main triggers for major compositional change. To interpret the MC1 output for the Olympic Peninsula, we focused on coarse-scale changes in vegetation type and disturbance, and the factors that led to those changes, and related them to likely changes in species composition and abundance (table 6.1).

In many of the future scenarios in MC1, there is a decline in the extent of the high-elevation tundra and subalpine vegetation types on the Olympic Peninsula by 2040–2060 (fig. 6.4), and there is also an almost complete loss of the tundra and subalpine vegetation types under most scenarios by 2070–2099 (fig. 6.5). This suggests that suitable conditions for tundra and subalpine vegetation will decline substantially or disappear by the end of the 21st century with warming on the peninsula. Large-scale dispersal of plant species to the Olympic Peninsula will likely be limited because of isolation from mainland areas by water and lower elevation zones (Peterson et al. 1997, Zolbrod and Peterson 1999). Thus, changes in distribution and abundance of plant species must occur within the existing populations and communities on the peninsula, and species adjustments to changing climate are expected to be mainly altitudinal or between aspects (Zolbrod and
Adapting to Climate Change at Olympic National Forest and Olympic National Park

Figure 6.4—Projected modal vegetation types on the Olympic Peninsula for the 2040–60 period compared to modeled historical vegetation types. Projections are from the MCI model for three global climate models (GCMs) (rows) and two Intergovernmental Panel on Climate Change IPCC carbon dioxide emissions scenarios (columns). The Commonwealth Scientific and Industrial Research Organization’s (CSIRO) GCM projects a relatively cool and wet Pacific Northwest, whereas the Model for Interdisciplinary Research on Climate (MIROC) projects a hot and wet Pacific Northwest, and the Hadley model projects a hot and dry Pacific Northwest. The B1 emissions scenario is characterized by relatively low future emissions, whereas the A2 scenario is characterized by relatively high future emissions. Olympic National Park and Olympic National Forest are outlined in black. (Data from R. Neilson and the MAPSS Team, USDA Forest Service and Oregon State University, Corvallis, Oregon.)

Peterson 1999). In the former range of tundra and subalpine vegetation types, other species will likely become dominant, including tree species from lower elevations (see subalpine fir and alpine vegetation types in table 6.1).

Under the CSIRO GCM A2 scenario (cool and wet Pacific Northwest), there is a range expansion of the temperate warm mixed-vegetation type in the northwestern portion of the peninsula in the 2040–60 period (fig. 6.4). This vegetation change is in response to increased precipitation (specifically in the summer compared to the rest of the year), which allows for range expansion of deciduous broadleaf species. In the northwestern portion of the peninsula, this could include species such as vine maple, bigleaf maple, and red alder. However, by the end of the century, the maritime evergreen needleleaf forest again becomes more dominant than the temperate warm mixed-vegetation type (fig. 6.5). This is because precipitation increases under the CSIRO A2 scenario toward the end of the century, but the summers are not as wet relative to the rest of the year as they were in mid century. Evergreen needleleaf species are likely to maintain dominance under those conditions (Neilson 1995).

Although the CSIRO scenarios are generally characterized by a relatively cool and wet Pacific Northwest, the distinct seasonality in rainfall and lower summer precipitation levels under the
CSIRO scenarios lead to increased fire activity at lower elevations on the eastern side of the peninsula by the end of the century (fig. 6.8). Fire-tolerant species, such as Douglas-fir and lodgepole pine, will likely expand their ranges on the east side of the peninsula with increased fire.

With the MIROC GCM (hot and wet Pacific Northwest) as input to MC1, there is a range expansion of the temperate warm mixed-forest and subtropical mixed forest vegetation types by the end of the 21st century, mainly on the west side of the Olympic Peninsula (fig. 6.5). The range expansion of these temperate and subtropical forest types is at the expense of the currently dominant maritime evergreen needleleaf forest. This shift to temperate and subtropical vegetation types is a response to increases in average monthly temperatures and a decrease in winter frosts. Higher summer temperatures may eventually lead to drought stress in forest types that are not currently stressed in the summer months, mainly Sitka spruce forests, leading to shifts in dominance to more drought-tolerant species, such as western redcedar (table 6.1).

Under the hot and dry scenario with the Hadley model, MC1 shows a range expansion of the temperate evergreen needleleaf forest on the east side of the Olympic Peninsula by mid 21st century, with even greater expansion by the end of the century (figs. 6.4 and 6.5). This

Figure 6.5—Projected modal vegetation types on the Olympic Peninsula for the 2070–99 period compared to modeled historical vegetation types. Projections are from the MC1 model for three global climate models (GCMs) (rows) and two Intergovernmental Panel on Climate Change (IPCC) carbon dioxide emissions scenarios (columns). The Commonwealth Scientific and Industrial Research Organisation’s (CSIRO) GCM projects a relatively cool and wet Pacific Northwest, whereas the Model for Interdisciplinary Research on Climate (MIROC) projects a hot and wet Pacific Northwest, and the Hadley model projects a hot and dry Pacific Northwest. The B1 emissions scenario is characterized by relatively low future emissions, and the A2 scenario is characterized by relatively high future emissions. Olympic National Park and Olympic National Forest are outlined in black. (Data from R. Neilson and the MAPSS Team, USDA Forest Service and Oregon State University, Corvallis, Oregon.)
Adapting to Climate Change at Olympic National Forest and Olympic National Park

Figure 6.6—Projected average annual fraction of cell burned on the Olympic Peninsula for the 2010–20 period compared to modeled historical fire activity. This output is derived by averaging the area of a cell that is burned over the period of interest. Number are not shown in the legend because they are not intuitive. However, darker colors indicate more fire. Projections are from the MC1 model for three global climate models (rows) and two Intergovernmental Panel on Climate Change carbon dioxide emissions scenarios (columns). The B1 emissions scenario is characterized by relatively low future emissions, and the A2 scenario is characterized by relatively high future emissions. CSIRO = Commonwealth Scientific and Industrial Research Organization; MIROC = Model for Interdisciplinary Research on Climate. Olympic National Park and Olympic National Forest are outlined in black. (Data from R. Neilson and the MAPSS Team, USDA Forest Service and Oregon State University, Corvallis, Oregon.)

Vegetation Management at Olympic National Forest and Olympic National Park

The following section provides information on vegetation management at Olympic National Forest (ONF) and Olympic National Park...
Figure 6.7—Projected average annual fraction of cell burned on the Olympic Peninsula for the 2040–60 period compared to modeled historical fire activity. This output is derived by averaging the area of a cell that is burned in a year over the period of interest. Number are not shown in the legend because they are not intuitive. However, darker colors indicate more fire. Projections are from the MC1 model for three global climate models (rows) and two Intergovernmental Panel on Climate Change carbon dioxide emissions scenarios (columns). The B1 emissions scenario is characterized by relatively low future emissions, and the A2 scenario is characterized by relatively high future emissions. Olympic National Park and Olympic National Forest are outlined in black. CSIRO = Commonwealth Scientific and Industrial Research Organization; MIROC = Model for Interdisciplinary Research on Climate. Olympic National Park and Olympic National Forest are outlined in black. (Data from R. Neilson and the MAPSS Team, USDA Forest Service and Oregon State University, Corvallis, Oregon.)

Native Plants and Revegetation

The ONF has instituted a native plant program that aims to maintain biodiversity and ecosystem health through the use of locally adapted, self-perpetuating populations of native plant species. Olympic National Forest uses both internal capacity and contractors to develop and maintain locally adapted sources of native plant seed and plant material to ensure these materials are available when needed for revegetation (fig. 6.9). Several grass seed production fields have been established. All propagule sources (seeds, cuttings, transplants) across the forest are mapped to help ensure that genetically appropriate native plant materials are used for site restoration. On-forest expertise has been developed to help in creating and implementing revegetation and restoration plans that maximize use of native plants.
Adapting to Climate Change at Olympic National Forest and Olympic National Park

Olympic National Park conducts revegetation activities in a variety of locations. Staff specialists conduct regular inventory and monitoring in wilderness areas, particularly along trails and at campsites, to determine if areas require revegetation. Park teams carefully select, plan, execute, and monitor success of restoration projects. Projects involve obtaining plant material, staging, site preparation, planting, mulching, and site protection/facilities improvement. Most restoration projects require plant seeds, cuttings, or transplants produced from native plant materials collected in the immediate vicinity.

**Exotic Species Management**

Exotic plants have become established in many locations at ONF. Some exotic species are considered invasive because their introduction causes or is likely to cause economic or environmental harm, and control efforts are focused on these invasive species. Invasive species infestations are primarily located in disturbed areas along road systems, in timber sale units, at administrative sites, in high public use areas (e.g., parking areas, viewpoints), in previously disturbed areas such as plantations, and in areas used for recreation such as campgrounds and dispersed recreation sites. Integrated manual, mechanical, herbicide, and restoration treatments are used at ONF to treat invasive plant infestations. Ongoing invasive
plant management efforts include prevention practices such as cleaning heavy equipment, using weed-free straw and mulch, using pelletized or certified weed-free animal feed, and restoring disturbed areas. Olympic National Forest is also involved in invasive species working groups to coordinate control efforts, including the Olympic Knotweed Working Group.

Similar to ONF, exotic plants occur in many locations at ONP, and 190 known exotic plant species occur in the park (Buckingham et al. 1995). To combat this problem, the North Coast and Cascades Network of the National Park Service established an exotic plant management team (EPMT) in 2002. The EPMT and park natural resources staff work together to prevent introduction and control the spread of all exotic plants. Prevention involves working with park staff to increase knowledge, minimizing and repairing soil disturbance; preventing spread on equipment, tools, and boats; regulating wilderness stock use; working with park maintenance staff to ensure outside contractors use weed-free gravel sources; and collaborating with other agencies and neighbors. Exotic plant control methods include hand pulling, mowing, girdling, and targeted spraying of glyphosate and narrow-spectrum, low-toxicity herbicides. In addition, exotic plant monitoring is included in the North Coast and Cascades Network plan for long-term ecological monitoring.

**Sensitive and Rare Plants**

Olympic National Forest has 70 sensitive flora species, including 37 vascular plants, 17 fungi, 12 lichens, and 4 bryophytes (mosses). The ONF runs a sensitive species program that includes biological evaluations of proposed actions on national forest lands to avoid and minimize negative impacts on the viability of sensitive species or a trend toward federal listings. The forest develops and implements conservation assessments and other tools for sensitive species, and develops and implements management practices to ensure that species do not become threatened or endangered because of Forest Service actions.

The Olympic Peninsula has the highest concentration of rare plants in Washington, owing to the broad range of habitats and the geographic isolation of the peninsula. Rare plants at ONP include endemics or near-endemics, isolated populations, and species more common to the north (or east). Five of the seven peninsula endemics occur exclusively in subalpine and alpine zones, and the other two species occur from montane to alpine zones (Buckingham et al. 1995). Rare plant conservation actions at ONP include surveys of areas of proposed management or research activities, detailed surveys of distribution, and site-specific protection plans.

**Prescribed Fire, Wildland Fire Use, and Hazardous Fuel Treatment**

Olympic National Forest conducts slash pile burning for brush disposal and hazardous fuel reduction, and occasionally uses prescribed fire for restoration purposes. For example, in 2005, a prairie restoration burn was conducted in the Skokomish watershed.

The Olympic National Park fire program is directed by a fire management plan, approved in 2005 (NPS 2003). Under the plan, prescribed burning is occasionally used, and fire managers may choose to monitor natural lightning-ignited fires to meet specific objectives. The park must complete a burn plan before any prescribed fire is permitted, and each planned fire must meet a specific set of conditions.
When fire cannot be used, hazardous fuel reduction is done by using manual removal or other means.

Vegetation Monitoring

Vegetation monitoring at ONF includes several different efforts. Botanists conduct rare plant monitoring in association with the University of Washington, Botanic Gardens Rare Plant Care and Conservation Program. Botanists intermittently monitor status of known populations of rare (to ONF) tree species. Silviculturists conduct informal ongoing silvicultural prescription effectiveness monitoring that includes monitoring of treatments such as understory precommercial thinning, commercial thinning, precommercial thinning with skips and gaps (skips are areas without tree harvest within a thinned stand; gaps are areas where all trees are harvested within a thinned stand), tree planting, and logging system effects on vegetation. Annual aerial surveys of insects and disease are also conducted regionally.

Olympic National Park conducts forest monitoring as a part of the National Park Service North Coast and Cascades Network. The goal of this monitoring is to determine trends in tree mortality, recruitment, and growth in forests representing the range of environments in network parks. Attributes monitored include tree species, diameter, indicators of health, and factors contributing to death. Forest ecologists monitor three forest types (Sitka spruce, western hemlock-Douglas-fir, and subalpine fir) in the network in stands at least 80 years old. At this time, subalpine fir forests are monitored at Mount Rainier and North Cascades National Parks but not at ONP.

Forest Thinning Program at Olympic National Forest

Timber harvest activities began on the Olympic Peninsula in the mid 1800s and at ONF in the 1920s. Until the 1990s, timber management generally consisted of clearcutting, broadcast burning, and tree replanting. Douglas-fir was the primary tree species chosen for artificial regeneration. These management practices resulted in the regeneration of over one-third of ONF into relatively young even-aged forests. These resulting plantations and managed forests were designed to maximize the production of wood products and are therefore densely stocked and structurally and compositionally simplified. The 1994 Northwest Forest Plan (NWFP) (USDA and USDI 1994) led to a movement toward management for ecological priorities, mainly the protection, enhancement, and acceleration of late-successional forest conditions. Timber production became a collateral opportunity rather than a primary objective.

Olympic National Forest has instituted a multiple-objective commercial thinning program with the purpose of accelerating the process of late-successional forest development by creating conditions that encourage the growth of a diverse understory and multilayered stand structure. This thinning is conducted primarily in forest stands between 40 and 80 years old that are designated as late-successional reserves (fig. 6.10); stands in this age range are the most economically viable stands to thin given the age limitations under the NWFP in late-successional reserve management. However, thinning in adaptive management areas is concentrated in stands 40 to 120 years old (fig. 6.11). The thinning treatments at ONF are prioritized based on habitat improvement potential for the northern spotted owl, marbled murrelet, and Roosevelt elk; aquatic species needs; and economic considerations. Priority is generally given to young-growth forest located near old-growth forest to increase the area of contiguous late-successional habitat.

To promote structural diversity, tree thinning prescriptions include variable-density thinning (thinning with skips and gaps) and provisions for snags and coarse woody debris for wildlife habitat. The skips (no thinning) are designed to function as small reserves distributed across the treatment area, providing a refuge for plant and animal species sensitive to disturbance. The variation in the landscape created by the gaps and the thinned areas are designed to provide for the habitat needs of other species. When adjusted for...
Figure 6.10—Location and age of late-successional reserve (LSR) and adaptive management area (AMAs) stands on Olympic National Forest (ONF). Thinning, with the goals of increasing forest structural diversity and improving wildlife habitat, is one of the primary vegetation management activities on ONF. Thinning on ONF is conducted primarily in LSR forest stands between 40 and 80 years old, as stands in this age range are the most economically viable stands to thin, and thinning in LSRs more than 80 years in age is not permitted. Although thinning is not permitted in LSRs older than 80 years, thinning in AMAs is concentrated in stands greater than 40 but less than 120 years old. Thus, 40- to 80-year old LSR stands (in light green) and the 40- to 120-year old AMA stands (in orange) are the locations where ONF has the most opportunity for active management in adapting to climate change.

Tree species, initial tree size, and crown class, variable-density thinning generally increases average tree growth by about 25 percent (Roberts and Harrington 2008). Thinning in young stands is also often associated with improved tree health, vigor, long-term wind firmness, and possibly resilience to climate change. The redistributed sunlight, moisture, and nutrients can also further promote understory vegetative diversity and vigor (Thysell and Carey 2001).

Precommercial thinning at ONF is conducted primarily in single-story stands that are 15 to 35 years old, depending on tree form, tree density, and stand accessibility. Some thinning has also been conducted on understory tree canopy layers in young stands, and skips have also been used.
Adapting to Climate Change at Olympic National Forest and Olympic National Park

Figure 6.11—Thinning activities on Olympic National Forest. The forest has instituted a multiple-objective commercial thinning program with the purpose of accelerating late-successional forest development by creating conditions that encourage the growth of a diverse understory and complex multilayered stand structure. (Photo courtesy of USDA Forest Service, Olympic National Forest.)

This thinning enhances or maintains species diversity by reducing competition around ecologically important minor tree species and other vegetation that would normally be eliminated through suppression mortality by faster growing tree species. In addition, precommercial thinning is used to improve tree growth, vigor, form, and rate of development of late-successional forest characteristics.

Genetic Resources Program at Olympic National Forest

Olympic National Forest established a conifer orchard in 1957 to maintain a seed bank of high-quality seed for use in reforestation and restoration. Orchard trees are grouped in blocks not only by species but also based on seed zones (by elevation, latitude, and longitude) so that collected seed is adapted to the areas in which it is planted. Douglas-fir, Sitka spruce, western hemlock, western white pine, and Pacific silver fir blocks are included. To plant trees resistant to the introduced disease white pine blister rust, western white pine and whitebark pine tree selections are tested through a regional disease resistance program (fig. 6.12). All the white pine seed harvested from the orchard has exhibited disease resistance, and the forest has developed a partnership with the Washington Department of Natural Resources, and the

Figure 6.12—Whitebark pine seedlings tested for resistance to white pine blister rust at Dorena Genetic Resource Center. (Photo courtesy of USDA Forest Service, Olympic National Forest.)

Figure 6.13—Whitebark pine cone collection as a part of the Olympic National Forest gene conservation program. (Photo courtesy of USDA Forest Service, Olympic National Forest.)
Adapting Vegetation Management to Climate Change at Olympic National Forest and Olympic National Park

Process Used to Develop Adaptation Strategies for Vegetation Management

To develop adaptation strategies for vegetation management on the Olympic Peninsula, the geneticist, silviculturists, and natural resources staff officer from ONF and forest ecologist and other natural resources staff from ONP engaged in a year-long exchange of ideas with scientists from the Forest Service Pacific Northwest Research Station (PNW), University of Washington (UW), and UW Climate Impacts Group (CIG). These exchanges involved discussion of potential impacts of climate change on vegetation on the Olympic Peninsula and discussion of various models that project potential impacts of climate change on vegetation. This exchange contributed to the development of vegetation management strategies described below.

Participants identified limited experience with various models and model output as a challenge for managers in thinking about how to address potential effects of climate change, and as a result, ONF and ONP natural resources staff and UW and PNW scientists met to review various model types, model output, and the strengths and weaknesses of different models. A subsequent workshop focused on reviewing potential vegetation sensitivities to climate change and developing adaptation strategies and actions for vegetation management on the peninsula. Participants in the second workshop included regional scientists and natural resources staff from ONF and ONP. The workshop included a presentation from CIG scientist Jeremy Littell on climate projections for the state of Washington. Other presentations addressed the potential impacts of climate change on vegetation communities (J. Halofsky, UW) and on plant phenology and physiology (Connie Harrington, PNW), as well as current vegetation management at ONF (Carol Aubry) and ONP (Steven Acker). David L. Peterson (PNW) also gave a presentation on developing strategies for adaptation to climate change. The facilitated dialogue between scientists and managers that followed focused on development of adaptation options and action plans for vegetation management at ONF and ONP. The discussion was specifically focused on the following questions: (1) What are the principal vegetation sensitivities (e.g., tree growth, disturbance, geographic locations) on the Olympic Peninsula? (2) What are your priorities for adaptation? (3) Which approaches and techniques would you use to facilitate adaptation? and (4) How might the park and forest collaborate to adapt to climate change? Key points from the discussion are described in the section below and in table 6.2. See box 6.2 for a general summary of projected climate change effects on vegetation on the Olympic Peninsula and related adaptation strategies for vegetation management at ONF and ONP.

Key Vegetation Sensitivities With Climate Change on the Olympic Peninsula

Workshop participants identified several vegetation assemblages on the Olympic Peninsula, and the species that inhabit them, as being particularly sensitive to climate change. Establishment of trees and other woody species will likely increase with warming and decreased snowpack in subalpine and alpine meadows (Zolbrod and Peterson 1999). Tree encroachment and increased establishment of lower elevation species in alpine and subalpine plant communities may put some species that currently inhabit these locations at risk, especially rare and relict species. Warming temperatures and changes in hydrology with climate change could have significant impacts on moisture levels and species composition in wetlands on the peninsula, especially bogs and fens (Burkett and Kusler 2000). Increased drought stress and disturbance frequency may also put Sitka spruce rain forests at risk for compositional change (Holman and Peterson 2006, Nakawatase and Peterson 2006).

Changing disturbance regimes with climate change will likely affect vegetation on the Olympic Peninsula. Storm intensity is projected to increase (Salathé et al. 2010),
<table>
<thead>
<tr>
<th>Current and expected vegetation sensitivities to climate change</th>
<th>Adaptation strategies and actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased opportunity for exotic species establishment</td>
<td>• Continue to implement early detection/rapid response for exotic species treatment (ONF).</td>
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<tr>
<td></td>
<td>• Increase exotic species control efforts (ONP).</td>
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<tr>
<td></td>
<td>• Continue to exchange information on exotic species spread and control between ONF and ONP.</td>
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<tr>
<td>Potential for mortality events and regeneration failures, particularly after large disturbances</td>
<td>• Develop a gene conservation plan for ex situ collections for long-term storage.</td>
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<td></td>
<td>• Identify areas important for in situ gene conservation.</td>
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<td></td>
<td>• Maintain a tree seed inventory with high-quality seed for a range of species, particularly species that may do well in the future under hotter and drier conditions.</td>
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<td>• Increase production of native plant materials for postflooding plantings.</td>
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<tr>
<td>Increased forest drought stress and decreased forest productivity at lower elevations</td>
<td>• Consider increasing the amount of thinning and possibly altering thinning prescriptions to reduce forest drought stress (ONF).</td>
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<tr>
<td></td>
<td>• Use girdling, falling and leaving trees, prescribed burns, and wildland fire (ONP) to reduce stand densities and drought stress.</td>
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<td>• Maximize early successional tree species diversity by retaining minor species during precommercial thinning activities to promote greater resilience to drier conditions.</td>
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<td></td>
<td>• Consider including larger openings in thinning prescriptions and planting seedlings in the openings to create seed sources for native drought-tolerant species.</td>
</tr>
<tr>
<td>Altered ecosystem structure and potential disruption of process and function</td>
<td>• Prioritize actions that will help maintain ecosystem function.</td>
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<tr>
<td></td>
<td>• Focus on actions that will help minimize mass die-off and effects of major disturbances.</td>
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<tr>
<td></td>
<td>• Create structures and processes that are viable over the long term.</td>
</tr>
<tr>
<td>All of the above</td>
<td>• Conduct integrated and consistent inventory and monitoring of vegetation.</td>
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<td></td>
<td>• Focus monitoring on sensitive locations such as wetlands and high elevations, on endemic or at-risk species, and on plant phenology.</td>
</tr>
<tr>
<td></td>
<td>• Use feedback from monitoring in implementation of adaptive management.</td>
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*Sensitivities are based on projected climate change effects on Olympic Peninsula, including decreased summer soil moisture, changing patterns of vegetation establishment, growth and mortality, shifting species distributions, shifting phenology, increased fire frequency, increased winter flood frequency and magnitude, and potential for increased insect outbreaks.*

| potentially leading to increased frequency of landslides and windthrow. Fire frequency and extent are projected to increase on the peninsula (see MC1 model output figs. 6.6–6.8). There is potential for more frequent and more severe disturbances owing to insects, including mountain pine beetle (Littell et al. 2010), and possibly Douglas-fir |
Box 6.2—Summary of projected climate change effects on vegetation on the Olympic Peninsula and related adaptation strategies for vegetation management at Olympic National Forest Olympic National Park

- Increased temperatures with climate change, and corresponding increases in summer drought stress and fire frequency in the Pacific Northwest, will lead to changing species distribution in the region, resulting in forest types different from those we see today.
- Increased temperatures with climate change will lead to longer growing seasons on the peninsula, which will alleviate growth-limiting factors and likely result in increased growth and productivity in high-elevation forests.
- Increased drought stress with climate change will likely result in decreased tree growth and forest productivity in the northeastern forests of the Olympic Peninsula.
- Paleoecological (pollen and fossil) records from the Pacific Northwest and elsewhere show that during historically warm periods, many tree species moved poleward and upward in elevation, suggesting that on the Olympic Peninsula, species distributions will shift to higher elevations with warming.
- With warming on the Olympic Peninsula, warmer and drier conditions at lower elevations will likely result in expansion of the range of Douglas-fir and lodgepole pine.
- Increased temperatures and drought occurrence with climate change will likely lead to increased fire frequency and extent on the Olympic Peninsula, particularly in the northeastern portion.
- Species phenology, or timing of life history events, is also likely to shift in response to climate change on the peninsula.
- Olympic National Forest (ONF) and Olympic National Park (ONP) identified alpine and subalpine meadows, wetlands, and Sitka spruce rain forests as being particularly vulnerable to warming climate.
- Both the forest and park affirmed the maintenance of functioning ecosystems in the face of climate change as a primary goal to continue to provide ecosystem services. Management actions that will help to maintain ecosystem function, such as restoration activities that create structures and processes that are viable over the long term, will be prioritized, when possible.
- To conserve genetic resources, ONF will maintain a tree seed inventory with high-quality seed for a range of species, especially those that are adapted to a drier climate or greater variation in climate, and will develop a plant conservation framework for forest trees and habitats at risk under changing climate that includes a plan for ex situ seed collection.
- Both the forest and park will be prepared to treat increases in exotic plant species after disturbances by continuing to implement the early detection, rapid response program.
- The forest and park will work to conduct more integrated and consistent inventory and monitoring of vegetation.
- At ONF, increasing the amount and prioritization of thinning activities in forest stands could potentially increase resilience to climate change, because thinning can increase water availability and tree growth and vigor by reducing competition.
- At ONP, prescribed fire and wildland fire in wilderness could be managed to reduce stand density and drought stress.

beetle, and balsam woolly adelgid (Mitchell and Buffam 2001). Increases in these disturbances will increase opportunities for exotic species establishment (Joyce et al. 2008). Disturbances may also interact to drive ecosystem change (McKenzie et al. 2009).

Changes in plant phenology (Parmesan 2006), increased drought stress (Elsner et al. 2010, Littell et al. 2010), and changing disturbance regimes (Littell et al. 2010) could lead to significant changes in plant regeneration patterns on the Olympic Peninsula. Workshop participants suggested that propagule production could be reduced owing to a warmer climate and associated stresses. In addition, site availability for seedling establishment may be limited under changing climate; an increase in tree mortality could result in increased cover of clonal species such as salal, which can limit opportunities for other species to become established. However, warming may lead to increased fire frequency (Littell et al. 2009, Westerling et al. 2006), which will likely increase opportunities for seedling establishment, including seedlings of species that
were not dominant on a site before a fire event. Changes in regeneration patterns may lead to changing distribution and abundance of currently common species on the peninsula, leading to changes in ecosystem structure and function.

Goals and Priorities for Adaptation in Vegetation Management

Both ONF and ONP affirmed the maintenance of functioning ecosystems in the face of climate change as a primary goal to continue to provide ecosystem services. Management actions that will help to maintain ecosystem function will be prioritized, when possible. Examples include actions to help minimize extensive tree mortality and effects of major disturbances, and restoration activities that create structures and processes that are viable over the long term. In addition, restoration planning will consider the functional role of species and habitats. For example, Sitka spruce may serve the same functional role as Douglas-fir in terms of stand structure (large trees or wood, or both) but not in terms of seed production and type of seed for wildlife (Peter and Harrington 2010).

Biodiversity is the sum of species, ecosystem, and genetic diversity (Lovejoy and Hannah 2005). Maintenance of native plant biodiversity is an ongoing priority for ONF and ONP and includes such actions as protection, restoration, and monitoring of rare plant species or populations; planting a variety of species; and in situ and ex situ gene conservation. However, it is unclear which levels of biodiversity should be maintained in a changing climate. The definition of exotic species will also need to be reexamined periodically, and possibly modified, because of shifting species distribution with climate change. The definition of exotic species will likely influence how vegetation and biodiversity are managed with climate change.

Adaptation Strategies and Actions for Vegetation Management at Olympic National Forest and Olympic National Park

Olympic National Forest will implement the following actions to maintain biodiversity and increase ecosystem resilience. These actions are likely to be effective under a variety of possible future scenarios.

- Maintain a tree seed inventory with high-quality seed for a range of species. One way to maintain seed inventory for tree species is to collect seed from the ONF conifer seed orchard, where seed is collected and stored by individual tree or by seed zone to maximize flexibility.
- Working in partnership with ONP and other land managers, develop a plant conservation framework for forest trees and habitats at risk under changing climate, with an emphasis on nontree species associated with those habitats. An essential component of the framework will be a gene conservation plan for ex situ seed collections for long-term storage, including seed collections from rare species and encompassing the range of variation in widespread species. New areas that may become important for in situ gene conservation will be identified. Forest tree species will be evaluated for relative sensitivity to climate change, and tools and options, such as assisted migration, will be reviewed. A 5-year action plan will be the result of this effort.
- Continue to increase disease resistance in western white pine and whitebark pine. Both of these species are threatened by white pine blister rust, which has caused mortality and reduced vigor in susceptible conifer hosts in many parts of the Western United States (McDonald and Hoff 2001).
- Increase the capacity to restore forest lands after large disturbances:
  - Increase seed production and storage for native tree species that are adapted to a drier or more variable climate. Lodgepole pine, western white pine, western redcedar, and Oregon white oak are candidate species.
  - Be prepared to treat increases in exotic plant species after disturbances by continuing to implement the early detection/rapid response program.
  - Be prepared to seed/plant appropriate native plant species after flooding by increasing the ONF native plant materials program.
Monitoring will be critical in detecting changes in phenology and plant species regeneration, growth, and mortality on the peninsula with changing climate (Joyce et al. 2008). Both ONF and ONP currently conduct vegetation inventory and monitoring, but the forest and park will conduct more integrated and consistent inventory and monitoring of vegetation. Monitoring can be focused on sensitivities identified through expert knowledge of Olympic Peninsula vegetation and climate-sensitive vegetation model projections (such as MC1 projections described previously). For example, monitoring could be focused on sensitive locations such as wetlands and high elevations, on endemic or at-risk species, and on plant phenology (both vegetative and reproductive events). Identifying species and ecosystems that are most susceptible to climate change through monitoring can inform prioritization of protection and restoration activities.

Control of exotic species will maximize the resilience of native vegetation on the peninsula with changing climate (Joyce et al. 2009). The ONF will continue to implement their strategy of early detection/rapid response for exotic species treatment, and ONP will increase exotic species control efforts. Treatment of species that have the potential to delay development of desired forest structure will be prioritized. For example, treatment of Japanese knotweed may be prioritized because this species prevents establishment of conifers in riparian forests and thus has a negative effect on coarse wood input to streams and on stream habitat quality. The ONF and ONP could undertake an explicit process to identify desired future forest structure and composition in different locations. The forest and park will also continue to exchange information on exotic species spread and control.

Thinning forest stands at ONF is another potential way to increase resilience to climate change, because thinning can increase water availability and tree growth and vigor by reducing competition (Roberts and Harrington 2008). The ONF currently has a forest thinning program focused on promoting late-successional forest conditions and improving wildlife habitat in young-growth stands, which could help to increase forest and wildlife resilience to climate change. Approximately 0.7 percent of the young-growth stands on the forest are treated annually, and increasing the amount of thinning could help to further increase resilience to climate change. However, funding for thinning at ONF is limited, and ONF has limited options on where thinning can occur owing to restrictions under the NWFP (fig. 6.10).

In addition to considering an increase in amount of thinning, shifting the strategy in placement of thinning treatments could help to increase broad-scale resilience to climate change. Thinning treatments could be prioritized in locations where climate change effects, particularly increased summer drought, are expected to be most pronounced. Thinning for climate change resilience may also require changes in thinning prescriptions, primarily decreases in forest density and increases in gap size to provide for establishment and vigorous growing conditions for desired tree, shrub, and herbaceous species.

Currently, many unthinned young-growth forests at ONF are characterized by high intertree competition, low tree and plant species diversity, low structural complexity, and declining structural stability (as compared to unmanaged old-growth forests) (Roberts and Harrington 2008). In young-growth forest stands under age 35, tree thinning could be used to reduce intertree competition that causes reductions in species diversity and suppression mortality and stress on trees. This thinning would be conducted to maximize tree growth and vigor by utilizing a uniform thinning with some skips to provide variation in understory growing conditions. This prescription could increase early successional tree species diversity by favoring retention of minor tree species regardless of their size. A wider range of tree species and more complex forest structure may provide resilience to a broader range of climatic conditions (Puettmann et al. 2009).

If the severity of wind events increases with climate change, thinning activities can initially result in increased wind damage until the trees become adapted to the new environment (Roberts et al. 2007). However, over the long term, thinning of young growth can improve tree resistance to wind damage by decreasing tree height-to-diameter ratios (an indicator of the slenderness or taper of a tree bole) (Cremer et al. 1982). Uniformity of young-growth size and density, owing to their even age and high stocking, reduces
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the rate of crown differentiation, resulting in high height-to-diameter ratio development (Mitchell 2000, Roberts et al. 2007). Forests developing at these higher densities and located in wind-exposed areas may be too structurally unstable to survive disturbance to old age.

In young-growth forest stands over age 40, thinning could be used to increase structural stability, individual tree vigor, and variability in overstory and understory growing conditions to improve resilience of vegetation to climate change. An initial commercial thinning entry could be used to reduce intertree competition and maximize individual tree growth and vigor. A second commercial thinning entry could be implemented 10 to 20 years later and use variable-tree spacing with skips and gaps. This would likely further release individual trees from competition and provide variability in growing conditions for understory vegetation to improve plant vigor and increase plant diversity (Carey and Wilson 2001).

To favor some of the tree species that may increase in abundance with climate change, such as relatively shade-intolerant western white pine, thinning prescriptions may include larger openings than those created in past thinnings. The ONF could also plant trees in openings to create seed sources for native species expected to increase in abundance with climate change.

Other tools can also be used to improve vegetative growth and vigor by increasing water availability. Within wilderness areas of ONF and ONP, managers employ minimal active management to protect wilderness values and ecosystem processes. In this context, ONP will focus on managing wildland fire in wilderness to create gaps and reduce stand density. In addition, at both ONF and ONP, girdling and prescribed burns could be used to reduce stand density and thus drought stress. To improve wildlife habitat, girdled, thinned, and fire-killed trees can be left as structure rather than being removed.

Key Questions and Future Directions
Climate change is one of many factors that must be considered by managers at ONF and ONP. Thus, projects will not be focused on climate change alone. However, expected effects of climate change can be incorporated into management strategies and the project planning process.

Climate change adaptation in vegetation management is essentially a long-term management experiment. Many of the proposed changes in vegetation management discussed above, such as the potential changes in thinning prescriptions, will provide opportunities to implement adaptive management, where feedback from monitoring provides direction for future management. It will be necessary for ONF and ONP to continue to support research, conduct monitoring, and develop tools to address effects of climate change. For example, a sensitivity rating for vegetation based on expected compositional changes could be developed to prioritize management actions. Identifying important triggers for life history events will also be critical in predicting likely vegetation change. These triggers will inform decisions in the future on such activities as assisted migration of plant species that are not currently found on the Olympic Peninsula. Until that time, ONF and ONP will work to increase ecosystem resilience and maintain ecosystem function by using the strategies and actions that have been outlined here.

Acknowledgments
We thank Ron Neilson, Brendan Rogers, Dominique Bachelet, and Ray Drapek from the MAPSS team in Corvallis, Oregon, for use of MC1 output and help with mapping and interpretation of the output. We thank the scientists and managers that participated in the adaptation workshop, including Kurt Aluzas, Cheryl Bartlett, Tim Davis, Connie Harrington, Roger Hoffman, Chris Lauver, Jeremy Littell, Toni Lyn Morelli, Jeff Muehleck, Larry Nickey, Bob Obedzinski, Regina Rochefort, and Mark Senger. Dick Carlson and Mark Senger helped develop table 6.1. Paul Anderson, Connie Harrington, and Bruce Hostetler provided helpful reviews of this chapter.

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Chapter 7: Climate Change, Wildlife Management, and Habitat Management at Olympic National Forest and Olympic National Park

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Potential Climate Change Effects on Wildlife on the Olympic Peninsula

Although wildlife, or native animals, have some ability to cope with changing climate, human-caused climate change, in combination with other stressors to wildlife such as habitat loss and fragmentation, can greatly affect wildlife species and biodiversity (Hannah et al. 2005, Inkley et al. 2004). Similar to plant species, wildlife species will respond individually to climate change, with some species responding negatively and some positively. Species will respond to both direct and indirect effects of climate change. For example, increasing temperatures and changing precipitation will have direct physiological effects on some species. Other species will be affected mostly indirectly through climate-induced changes in phenology (timing of life history) relative to forage plants and invertebrate prey; shifts in geographic ranges and the density and ranges of competitor, forage, prey, and symbiotic species (and subsequent changes in biotic interactions); and effects from other stressors such as disturbance, insects, and disease. Related changes in habitat characteristics and quality will affect animal species viability. These effects will interact with existing stressors, leading to complex responses of wildlife populations to changing climate.

Change is already evident in some wildlife species in response to warming over the last few decades. Changes in species physiology, distribution, and phenology are widely documented and directly attributed to recent warming (Parmesan 2006, Parmesan and Yohe 2003, Root et al. 2003). These recent responses, along with past responses evident in the paleoecological record, and existing knowledge of species physiology and biogeography, can help in projecting how wildlife species will respond to future climate change. By using these lines of evidence, we discuss the potential direct and indirect effects of climate change on wildlife species and populations on the Olympic Peninsula and summarize potential climate change effects on Olympic Peninsula habitats.

Direct Effects of Climate Change on Wildlife

Climate change will lead to warmer temperatures and likely drier summers on the Olympic Peninsula, and these changes will have direct physiological effects on some species. Many species on the peninsula rely on specific microhabitats or microclimates to maintain metabolic functions within physiological parameters. Structural habitat components that mediate microclimate include forest canopy that reduces evaporation and solar radiation; large decaying logs, hollow snags, and leaf litter; and alpine...
environments in which slope, aspect, geologic attributes, and microtopography are controlling factors. Changes in the macroclimate or macrohabitat could either place more importance on these features or negate their ability to meet an animal’s needs. For example, species such as the American marten (See "Common and Scientific Names") rely on thermal cover provided by snow in subalpine and montane habitats during winter (Buskirk et al. 1989, Taylor and Buskirk 1994). Reduced snowpack on the Olympic Peninsula because of climate change (Elsner et al. 2010) could expose the marten and other species to lethally cold temperatures during winter.

Bats also rely on specific microclimates in winter hibernacula. Hibernating bats require a cool, stable temperature in the winter to maintain a reduced metabolic rate (Brigham 1993, Fenton 1983, Fenton and Barclay 1980). Bats that either delay entering winter torpor because of higher ambient temperature or are aroused from torpor early because of unseasonably warm weather patterns could face energetic stress if insect prey is unavailable at those times (Humphries et al. 2002).

Endothermic (warm-blooded) species, such as birds and mammals, may have to expend more energy to maintain constant temperature (homeostasis) with higher ambient temperatures in the summer months (Root and Hughes 2005). Thus, higher temperatures may lead to changes in endothermic species’ microhabitat choices (e.g., increased retreat to shady habitats) during the summer. However, warmer winters and springs will likely result in less thermal stress on some species. Furthermore, changes in the spatial distribution of preferred habitat (with specific vegetation structure and species composition) will likely have a more direct effect on vertebrate species spatial distribution than on behavioral changes that are directly related to temperature.

Ectothermic (cold-blooded) species, such as reptiles, may benefit from increased temperatures on the peninsula because the peninsula has a relatively cool environment, and reptiles rely on the environment to warm themselves. Other ectothermic species, such as amphibians, rely on cool, moist microhabitat conditions to prevent overheating and desiccation. High temperatures can be lethal to amphibians, but amphibian species are generally adapted to a range of temperatures typical for their environment, making direct mortality from high temperatures rare (Carey and Alexander 2003). However, the amount and timing of precipitation can greatly affect the yearly reproductive output of an amphibian population (Carey and Alexander 2003). For example, because most amphibians lay eggs in standing water (Duellman and Trueb 1985), too little rainfall can result in egg and larval desiccation (Carey and Alexander 2003). At the opposite extreme, too much precipitation at certain times during egg and larval development can lead to egg and larval mortality (Carey et al. 2005). Adult terrestrial amphibians are also susceptible to desiccation because of high rates of water loss from the skin and respiratory systems (Shoemaker et al. 1992). Survivorship may further decline during severe drought because low moisture levels can limit amphibian activity, mobility, ability to evade predators, and food supply (Carey and Alexander 2003).

These examples illustrate that the extremes in temperature and precipitation, rather than the means, often have major effects on animal species. Because events such as drought and intense precipitation are expected to increase on the Olympic Peninsula, species will need to cope with increased frequency of extreme events. The Olympic torrent salamander (fig. 7.1), Cascades frog (fig. 7.2), and Van Dyke’s salamander are examples of species that may be directly affected by extremes in temperature and precipitation, and related changes in hydrology.

Indirect Effects of Climate Change on Wildlife Phenological shifts—
Warming temperatures with climate change will likely alter seasonal climate patterns. For example, on the Olympic Peninsula and in temperate ecosystems in general, climate change will likely result in earlier snowmelt, a shorter winter season, earlier onset of spring, and a longer growing season (Elsner et al. 2010, Menzel et al. 2003). Plant and animal life cycles are closely linked with changing seasons, and changes in seasonality with climate change will likely lead to altered phenology, or timing of life history events, of both plant and animal species. These phenological shifts
Adapting to Climate Change at Olympic National Forest and Olympic National Park

Figure 7.1—The Olympic torrent salamander is endemic to the Olympic Peninsula and is an example of a species that will likely be sensitive to extremes in temperature and precipitation, and related changes in hydrology, with climate change. (Photo by Betsy Howell, USDA. Forest Service, Olympic National Forest.)

Figure 7.2—The Cascades frog will likely be sensitive to changes in hydrology and wetland habitats that occur with climate change on the Olympic Peninsula. (Photo by Betsy Howell, USDA Forest Service, Olympic National Forest.)

will likely influence wildlife, their food sources, and habitat attributes on the Olympic Peninsula.

Animal life history events that can be affected by changing seasonality include emergence from hibernation, mating, and migration. Plant species also respond to changing seasonality by shifting the timing of bud break, flowering, and fruiting, and insects respond by varying timing of emergence. However, the shifts in timing of life history events between trophic levels (e.g., plants, herbivores, predators) may not be proportionate or parallel. Varied phenological response to warming between trophic levels could result in mismatches in formerly coordinated phenology of animals and their food sources, leading to decreasing fitness and possibly mortality in some wildlife populations (Both et al. 2006, ISAB 2007, Parmesan 2006, Root and Hughes 2005). For example, for species that have specialized diets and carefully balanced energy budgets, such as bats, a shift in the timing of invertebrate prey availability could result in reduced survival or fecundity.

Concurrent with a 1.4 °C rise in local temperatures at the Rocky Mountain Biological Laboratory in Colorado between 1975 and 1999, yellow-bellied marmots began emerging from hibernation about 23 days earlier (Inouye et al. 2000). However, the flowering plant phenology did not shift in that period because warmer temperatures were coupled with increased precipitation and snowpack. Thus, the change in marmot behavior decoupled the relative phenology of marmots and their food plants (Inouye et al. 2000). Analogous mismatches could occur on the Olympic Peninsula. In contrast to the Colorado example, however, warmer temperatures on the Olympic Peninsula will likely lead to decreased snowpack, regardless of changes in precipitation, owing to the relatively warm conditions on the peninsula (Elsner et al. 2010). Thus, plant emergence and growth could remain synchronous with emergence of the Olympic marmot (fig. 7.3) and other hibernating wildlife species. Shifts in timing of migration could also impair foraging efficiency of some species. For example, some bird species are arriving earlier at summer breeding grounds in response to warming in the second half of the 20th century (Butler 2003, Inkley et al. 2004, Inouye et al. 2000, Sparks 1999, Tryjanowski et al. 2002). However, food resources at summer breeding grounds may not be as available earlier in the spring (Inouye et al. 2000) because warming patterns differ spatially and species respond individualistically to changing climate.

Changes in seasonality could also influence habitat suitability. For example, some amphibians produce eggs and move to breeding ponds based on temperature and moisture.
These species may encounter mismatches between breeding phenology, pond drying, and arrival at the pond (WGA 2008).

Examples of species shifting phenology in response to climate change in the late 20th century are not isolated (ISAB 2007). Rather, substantial evidence exists that phenological shifts are already underway for a variety of plant, animal, and insect species (e.g., Parmesan 2006, Parmesan and Yohe 2003, Root et al. 2003, Walther et al. 2002). A meta-analysis by Parmesan and Yohe (2003) concluded that most of 677 species studied show trends toward spring advancement in the last few decades, with earlier frog breeding, bird nesting, first flowering, tree budburst, and arrival of migrant birds and butterflies. These consistent and directional responses to warming of about 0.6 °C (Pachauri and Reisinger 2007) over the last century suggest that there will be even more far-reaching effects on species as the climate warms at an increasing rate (Root et al. 2003). Although quantitative data on phenological shifts on the Olympic Peninsula are lacking, peninsula species likely have and will be similarly affected by increasing temperatures.

**Distribution shifts**—
Species occurrence (range) partially depends on the availability of suitable climatic conditions, along with other factors such as habitat suitability, food availability, and interactions with other species (MacArthur 1972). Wildlife species respond to climate and habitat variability in the short term through shifts in geographic range (migration) when suitable conditions are not present in the former range. Where suitable climates and habitat are no longer present, mortality and local population contraction and extirpation often occur in parts of a species’ former range (Grayson 2006). For example, contraction or local population extirpations may occur at the southern end of a species range with warming, while at the same time, there are increases in northward colonization. Over time, extirpation and colonization events cumulatively result in shifts of species’ distribution ranges. Shifts in animal species’ geographic ranges owing to physiological constraints and changes in plant species distribution and habitat structure, as well as shifts in the abundance and phenology of associated species (competitors, predators, prey, and forage species) will interact to determine how climate change affects species and communities.

Species ranges will probably move northward and to higher elevations as temperature increases (Parmesan 2006). However, range shifts will depend on factors such as degree and speed of vegetation change, specific habitat conditions, shifts in distribution of competitors and predators, changes in precipitation patterns, species’ physiological requirements, and species’ differential sensitivity and response to various aspects of changing climate (e.g., increase in minimum temperature versus maximum temperature) (Inkely et al. 2004). The ability of wildlife species to disperse or migrate will depend on the availability of migration corridors and suitable habitats, and the concurrent movement of forage, prey, and cover (Inkely et al. 2004). For example, high-elevation species will likely be particularly sensitive to warming temperatures and experience range contractions (Moritz et al. 2008) because contiguous, higher elevation habitat may not be available to colonize. Soil formation at higher elevations is a slow process, and vegetation establishment at higher elevations...
may not occur quickly enough to provide habitat under rapid warming. Snowpack at higher elevations may also be prohibitive. Similarly, it may be more difficult for endemic and specialist species with strict habitat requirements or dependencies on specific forage species to find suitable habitat conditions under changing climate, whereas generalist species with high climatic tolerance, broad habitat and forage requirements and high dispersal ability will likely increase in abundance under a changing climate (Pounds et al. 2005). Barriers such as topographic features and habitat fragmentation could further inhibit potential range shifts (Inkley et al. 2004). For example, the Strait of Juan de Fuca will inhibit northward movement of terrestrial species on the peninsula, although new species could move onto the peninsula from the south.

Recent observed shifts in species ranges are consistent with those expected under a warming climate, and examples of shifts in species ranges from around the world are numerous (Parmesan 2006, Parmesan and Yohe 2003, Root et al. 2003, Walther et al. 2002). An analysis of recent range shifts of 99 species of birds, butterflies, and alpine herbs in the Northern Hemisphere showed an average shift in species’ range boundaries of 6.1 km northward or 6.1 m upward in elevation per decade (Parmesan and Yohe 2003). Similarly, an analysis of 40 years of Audubon Society Christmas Bird Count observations showed that 177 of 305 bird species seen in North America during the first week of winter have moved northward (Audubon 2009). The average distance moved was 56 km, but more than 60 species moved more than 160 km north. Annual altitudinal shifts were correlated with annual temperature.

There is also evidence that small mammals are shifting their ranges in response to warming; an analysis by Moritz et al. (2008) in Yosemite National Park showed that half of 28 small mammal species monitored over the last century shifted their elevation limits upward an average of about 500 m, consistent with the observed warming trend in the region. As expected, range shifts are associated with population losses for some species, and other species’ extinctions are attributed to recent climate change (Beever et al. 2003; Parmesan 1996; Pounds et al. 1999, 2006). Moritz et al. (2008) found that range contractions were more likely for high-elevation small mammal species, whereas range expansions were more likely for lowland species that are short lived and more productive than their long-lived, less fecund counterparts.

Some Olympic Peninsula species will probably respond similarly to increasing temperature by shifting their ranges upward in elevation. The degree and rate of species’ distribution changes will depend on several factors, including species’ physiological constraints, the speed and nature of vegetation change, habitat suitability, barriers to dispersal, and interactions with other species. For subalpine meadow and alpine meadow habitat specialists such as the Olympic marmot (fig. 7.3), western heather vole, and Olympic pocket gopher, there may not be any suitable habitat conditions available at higher elevations. These species are found at the highest elevations of many ridge systems; on other ridge systems or mountains, these species will not be able to survive unless snowpack is sufficiently low in summer and deep soils and meadow vegetation develop. However, declines in snowpack with warming will be lower at the highest elevations (>2000 m): (Elsner et al. 2010), and soil development may take decades to centuries. Furthermore, it is not clear if these rodents will be able to establish new populations if there are barriers to their dispersal.

Biotic interactions—
As species individualistically shift their ranges in response to a warming climate, novel predator-prey interactions and new interspecific interactions will develop among species (ISAB 2007, Schmitz et al. 2003). Predicting future interspecific interactions is very difficult, although clearly new interspecific interactions, as with all climate change effects, will positively affect some species and populations, and negatively affect others. For example, movement of a predator out of portions of a prey species’ range will allow the prey species to expand but may reduce predator fitness owing to decreased prey availability. In contrast, the movement of a predator into new areas could negatively affect prey species. The range expansion of the coyote into high-elevation areas on the peninsula, for example, may be having a negative impact on Olympic marmot (fig. 7.3) populations (Griffin et al. 2008, Witczuk 2007). Bobcat
populations could have similar effects on prey species if they begin spending more time at higher elevations with warming temperatures and reduced snowpack. Movement of competitors could also influence species abundance and viability. Although not necessarily related to climate change, the negative influence of the barred owl (native to North America but relatively new to western North America) on the specialist northern spotted owl is a good example of how new competitive interactions can lead to pronounced effects on species distributions and viability (Kelly et al. 2003).

Changes in interspecific interactions with climate change will include changing interactions with exotic species, as well as pests and pathogens. New exotic species will likely establish with changing climatic conditions (Hellmann et al. 2008). Some existing exotic species will likely expand with climate change, because ecosystem disturbance and shifts in native species ranges will provide opportunities for exotic establishment. Some exotic species are invasive, with characteristics that facilitate their expansion and dominance under changing climate, such as broad climatic tolerances and high dispersal ability (Hellmann et al. 2008).

Parasites, pests, and pathogens are also expected to respond to climate change. Forest pests and pathogens could have widespread effects on wildlife habitat quality on the peninsula (see chapter 6 for more details). Increased temperatures and moisture at mid-latitudes could accelerate parasite vector and pathogen life cycles, improve survival by relaxing overwintering restrictions, and lead to northward expansion of tropical and subtropical pathogens (Harvell et al. 2002, Inkley et al. 2004). Shifting ranges of wildlife species will lead to new disease exposures (Brooks and Hoberg 2007), and shifts in parasite vectors will introduce new diseases (Kovats et al. 2001, WGA 2008). Climate warming can also increase host susceptibility to diseases (Harvell et al. 2002). Increases in parasites and infectious diseases associated with climate change have the potential to influence the size of wildlife populations and accelerate species extinctions (Harvell et al. 2002, WGA 2008).

Interaction with other stressors—
Climate change will not act alone in influencing wildlife populations on the Olympic Peninsula in the coming decades. Instead, climate change will act synergistically with other stressors to affect wildlife populations (Inkley et al. 2004, WGA 2008). Current stressors that influence wildlife on the peninsula and many ecosystems across the Western United States include land use legacies, ongoing habitat loss and fragmentation, altered disturbance regimes, disease, and exotic species. Land use changes and introduction of exotic species can impede the ability of species to adaptively respond to climate change (Hansen and DeFries 2007). For instance, many land use changes impose barriers to species’ migration to favorable new environments, small population sizes and isolation resulting from land uses impedes gene flow, and landscape fragmentation reduces corridors for movement (Joyce et al. 2008). At Olympic National Forest (ONF), historical widespread logging activity reduced the area of late-successional forest and isolated existing late-successional forest patches, which could impede adaptive response of species with low dispersal ability. Highways and land converted to agricultural, residential, or industrial uses further fragments the Olympic Peninsula. The spread of exotic species on the peninsula may cause a reduction in forage plants on which some wildlife species depend, thus making it more difficult for these species to respond adaptively to climate change. These interactions increase uncertainty and complicate actions to mediate climate change effects, but also suggest that treatment of other stressors (e.g., exotic species and habitat fragmentation) may help alleviate the negative effects of climate change.

Potential Genetic Responses to Climate Change
It is possible that wildlife species will respond to changing climate through genetic change. However, the expected rates of increase in temperature with climate change are greater than those of the past, making it difficult to predict genetic response (ISAB 2007). Evidence exists for adaptive genetic change in some species in response to changing climate, including mosquitoes, fruit flies, birds, and squirrels (Bradshaw and Holzapfel 2006, ISAB 2007). The adaptive
genetic changes all involved adaptation to the timing of seasonal events or to season length (Bradshaw and Holzapfel 2006). In mosquitoes, which have the shortest generation times of this group, evolutionary change occurred in as little as 5 years. Changes for squirrels and birds were smaller and became apparent only over longer periods (10 to 30 years), suggesting that larger and longer lived species may experience population decline or be replaced by other species (Bradshaw and Holzapfel 2006). Habitat fragmentation and resulting population isolation that prevents gene flow is a barrier to this type of genetic response. Although such evolutionary responses occur, there is little evidence that the responses are of the type or magnitude to prevent species extinctions (Parmesan 2006), because the rate and magnitude of climate change may overwhelm a species’ capacity for genetic change (Barnosky and Kraatz 2007).

Potential Climate Change Effects on Olympic Peninsula Habitats

Related to the potential direct and indirect effects of climate change on wildlife, there are also many potential climate change effects on wildlife habitats on the Olympic Peninsula. A description of potential effects of climate change on Olympic Peninsula habitat types and related species follows (see chapter 6 for more detailed information on potential vegetation changes).

Varied climatic conditions on the peninsula result in highly varied ecological communities, and thousands of years of geographic isolation have resulted in fauna that are distinct from those in the Cascade Range to the east. There are several endemic wildlife species, including the Olympic marmot (fig. 7.3), the Olympic pocket gopher, and Roosevelt elk. Wildlife on the Olympic Peninsula is noteworthy not only for its endemic species, but also for species missing from the Olympics yet found elsewhere in western mountains, including American pika, white-tailed ptarmigan, ground squirrels, Canada lynx, red fox, wolverine, grizzly bear, and bighorn sheep. Historically, mountain goats and coyote did not occur on the Olympic Peninsula.

Glaciers and snowfields—

At the highest elevations on the Olympic Peninsula, warming temperatures will likely cause loss of snowpack and snowfields and recession of glaciers (Elsner et al. 2010). The greatest effects of reduced snowpack and glacial recession will be hydrologic; loss of glaciers, decreased snowpack, and earlier snowmelt with warming temperatures will reduce water availability in summer months in glacier- and snowmelt-fed streams, lakes, and wetlands (Elsner et al. 2010). Although glaciers and snowfields currently provide habitat for only a few species, such as the gray-crowned rosy finch, the loss of snowpack with warming may allow vegetation establishment in these areas, leading to improved habitat conditions for other high-elevation wildlife species. In the short term, vegetation establishment will be limited to areas with substrate that is favorable to rapid soil development, such as shallow-gradient slopes with deep layers of fine-grained glacial till. The more rocky (scree, talus, boulder) areas from which snow or glaciers retreat will not be hospitable to soil development in the short term.

Alpine tundra—

Alpine tundra provides seasonal habitat for a variety of wildlife species on the Olympic Peninsula, including Roosevelt elk, North American black bear, and the western heather vole (table 7.1). Similar to effects on glaciers and snowfields, warming temperatures will likely reduce snowpack and cause earlier snowmelt in alpine tundra habitats. These conditions could favor tree establishment, provided that the soils in tundra areas can sustain trees. Several paleoecological studies show the expansion of subalpine fir into alpine tundra in the northeastern portion of the Olympic Peninsula during historically warm periods (Brubaker and McLachlan 1996, Gavin et al. 2001, McLachlan and Brubaker 1995). Warmer temperatures and increased tree establishment may lead to loss of tundra habitat (see MC1 model output in chapter 6). The paleoecological record does not provide evidence that the highest (>1800 m in elevation) alpine habitats underwent great change during past warm periods (Gavin et al. 2001, McLachlan and Brubaker 1995), suggesting that only high levels of warming (>1–2 °C) may result in major changes in the highest alpine areas. However, anthropogenic climate change may be characterized by more extreme temperature increases than past warming periods, and warming greater than 1.0 to 2.0 °C is projected...
Table 7.1—Olympic Peninsula habitat types, generally from highest to lowest elevation, and associated species most likely to be influenced by climate change and related changes in habitat

<table>
<thead>
<tr>
<th>Habitat type</th>
<th>Associated species likely to be influenced by climate-induced habitat changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpine tundra</td>
<td>Black bear, mountain goat, Olympic marmot, Olympic pocket gopher, Roosevelt elk, western heather vole</td>
</tr>
<tr>
<td>Talus fields</td>
<td>Gray-crowned rosy finch</td>
</tr>
<tr>
<td>Subalpine</td>
<td>Black bear, bobcat, coyote, mountain goat, snowshoe hare, Clark’s nutcracker</td>
</tr>
<tr>
<td>Wet meadows</td>
<td>Black bear, coyote, Olympic marmot, Roosevelt elk, western heather vole, dog star skipper butterfly</td>
</tr>
<tr>
<td>Dry meadows</td>
<td>Black bear, coyote, Olympic marmot, Olympic pocket gopher, Roosevelt elk, dog star skipper butterfly, Taylor’s checkerspot butterfly</td>
</tr>
<tr>
<td>Montane forest</td>
<td>American marten, black bear, bushy-tailed woodrat, coyote, mountain beaver, northern flying squirrel, Pacific fisher, Roosevelt elk, snowshoe hare, barred owl, Northern spotted owl, ensatina</td>
</tr>
<tr>
<td>Lowland forest</td>
<td>American marten, black bear, bushy-tailed woodrat, coyote, mountain beaver, northern flying squirrel, opossum, Pacific fisher, porcupine, Roosevelt elk, barred owl, marbled murrelet, northern spotted owl, northern alligator lizard, ensatina, Van Dyke’s salamander, warty jumping slug</td>
</tr>
<tr>
<td>Riparian and flood-plain habitat</td>
<td>Pacific fisher, American dipper, hairy woodpecker, harlequin duck, hooded merganser, red-breasted sapsucker, wood duck, chorus frog, red-legged frog, Van Dyke’s salamander, western toad, warty jumping slug</td>
</tr>
<tr>
<td>Lakes, wetlands, and bogs</td>
<td>Garter snake, Cascades frog, long-toed salamander, northwestern salamander, western toad, Makah copper butterfly</td>
</tr>
<tr>
<td>Prairies and balds</td>
<td>Roosevelt elk, American kestrel, pallid horned lark, dog star skipper butterfly, Taylor’s checkerspot butterfly</td>
</tr>
<tr>
<td>Caves and mines</td>
<td>Keen’s myotis bat, little brown bat</td>
</tr>
</tbody>
</table>

Species are grouped by vertebrate phylogenetic class (mammals, birds, reptiles, amphibians) and invertebrates, and listed alphabetically within group. The species included in this table were identified by Olympic National Forest; Olympic National Park; Forest Service, Pacific Northwest Research Station; and U.S. Geological Survey specialists as being high profile or most likely to be influenced by climate change, or both. This is not an exhaustive list of species that will be influenced by climate change on the peninsula.

to occur in the Pacific Northwest by the middle to late part of the 21st century (Mote and Salathé 2010). Even in the persistent alpine tundra habitats, increased summer drought could decrease berry production, likely causing reduced fitness of berry-dependent species such as North American black bear. Decreased berry production and berry crop failures may also force species such as black bear to search for other food sources, which could bring them into greater conflict with humans.

**Talus fields—**
Decreased snowpack and earlier snowmelt will likely cause changes in microenvironments in talus fields, particularly decreased moisture in the later parts of the growing season. However, cover of talus fields may increase with decreased snow cover, providing additional habitat for species such as the gray-crowned rosy finch (table 7.1).

**Subalpine habitat—**
Subalpine habitats on the Olympic Peninsula will likely experience decreased snowpack and earlier snowmelt with warming temperatures. These conditions will cause changes in vegetation community composition, with likely increases in tree establishment and growth, and thus loss of meadow habitat. Mortality of whitebark pine caused by white pine blister rust, and potentially by climate-induced outbreaks of mountain pine beetle (see chapter 6), will impact species that depend on whitebark pine, most notably the Clark’s nutcracker (fig. 7.4).
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Figure 7.4—Species such as the Clark’s nutcracker that depend on whitebark pine will be impacted by mortality of whitebark pine caused by white pine blister rust, and potentially by climate-induced outbreaks of mountain pine beetle. (Photo courtesy of USDA Forest Service, Olympic National Forest.)

Figure 7.5—Taylor’s checkerspot butterfly is a federally listed sensitive species that uses meadow and prairie habitat on the Olympic Peninsula. (Photo by Betsy Howell, USDA Forest Service, Olympic National Forest.)

Figure 7.6—Cope’s giant salamander inhabits headwater streams and may be affected by decreased summer low flows on the Olympic Peninsula with climate change. (Photo by Betsy Howell, USDA Forest Service, Olympic National Forest.)

Meadows—

Wet meadow habitat, which occurs primarily in high snow areas on the west side of the Olympic Peninsula, will likely decrease with warming because of changes in hydrology (decreased snowpack and earlier snowmelt leading to earlier runoff and increased summer drought). Decreases in this habitat could influence wet meadow-dependent species, such as the western heather vole (table 7.1). However, dry meadow habitat, which occurs primarily in the rainshadow in the northeastern portion of the Olympic Peninsula, may increase with increased fire frequency and increased drought limitations on tree species distribution (Littell et al. 2010). Increased area of dry meadows could provide additional habitat for species such as the Olympic marmot (fig. 7.3), Olympic pocket gopher, and Taylor’s checkerspot butterfly (fig. 7.5) (table 7.1). Alternatively, upward-elevation shifts in tree line could result in tree encroachment of meadows and decreased meadow habitat. Also, increased temperatures may lead to changes in species composition in both wet and dry meadows, with the potential for increases in exotic species.

Montane forests—

Montane forest habitats on the Olympic Peninsula, including forests dominated by Pacific silver fir, Douglas-fir, and western hemlock, will likely experience a variety of changes with a changing climate. Reduced snowpack and more precipitation falling as rain rather than snow will shift the timing of runoff and increase summer drought (Elsner et al. 2010), and thus potentially decrease the area of headwater riparian habitat in montane forests. Decreases in headwater habitat could influence species that depend on this habitat, such as the Olympic torrent salamander (fig. 7.1) and Cope’s giant salamander (fig. 7.6). Increased summer drought and reductions in soil moisture could influence species such as the mountain beaver (fig. 7.7) that require...
Figure 7.7—Increased summer drought and reductions in soil moisture with climate change could influence species such as the mountain beaver that require moist soils for digging burrows. (Photo by Betsy Howell, USDA Forest Service, Olympic National Forest.)

moist soils for digging burrows (table 7.1). Changes in hydrology may also affect seeps and springs, which provide critical habitat for peninsula species such as Van Dyke’s salamander and the Olympic torrent salamander (table 7.1).

Increased temperatures with climate change will likely lead to shifts in plant species distribution, influencing the composition and thus habitat characteristics of montane forests on the Olympic Peninsula. Species such as western hemlock and Douglas-fir will likely increase in abundance in forests currently dominated by Pacific silver fir. Species such as Douglas-fir and lodgepole pine may increase in abundance in forests currently dominated by western hemlock and Douglas-fir. Changes in species phenology, and related changes in production of wildlife food sources such as berries, will likely influence the quality of habitat provided by montane forests for species such as the North American black bear. Increased frequency of disturbances, such as fire, insect outbreaks, wind events, and drought, will also influence montane forest habitat. Initially (and without management intervention) increased disturbance frequency will likely lead to increases in snags and coarse woody debris, which will benefit some species such as birds, amphibians, and mammals that use these habitat elements. Drought- and fire-induced reduction in forest density may lead to more open-canopied forests and larger residual trees. However, repeated fires may eventually lead to a reduction in legacy structures and an increase in early seral forest, with negative consequences for species that rely on large trees and mature forest conditions, such as the northern spotted owl and marbled murrelet.

Prairies and balds—
Some prairies on the Olympic Peninsula were created and maintained by Native American burning (Peter and Shebitz 2006). Without fire, tree and shrub encroachment can reduce prairie habitat quality. Increased fire with warming on the peninsula may increase the quality of prairie habitat for dependent species such as the Taylor’s checkerspot butterfly (fig. 7.5). However, increased temperatures could also lead to changes in plant species composition, with the possibility of increased exotic species and reduced habitat quality.

The presence of balds on the Olympic Peninsula is primarily controlled by edaphic conditions; balds largely exist in areas where soils are too shallow and dry to support trees (Chappell 2006). Increased fire frequency with climate change could increase the area of balds by killing small young trees on the margins (Chappell 2006). However, increased drought and fire frequency associated with climate change may also affect composition in the unique and relatively species-rich plant communities that inhabit balds, possibly increasing establishment of exotic species.

Lowland forests—
Similar to the outlook for montane forests, a variety of potential effects of climate change may occur in lowland forests of the Olympic Peninsula, including forests dominated by Douglas-fir, western hemlock, and Sitka spruce. Climate-induced changes in hydrology, phenology, forest species composition, and increased disturbance will affect these lowland forests. Increased drought could decrease forest productivity in lowland forests and increase abundance of more drought-tolerant species, such as Douglas-fir and western redcedar. Also, projected increases in winter precipitation and precipitation intensity on the peninsula (Elsner et al. 2010, Salathé et al. 2010) and the effects on hydrologic regimes (see chapter 4) will affect lowland
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forests through increased frequency and magnitude of flooding and disturbance in riparian areas (scouring, removal of off-channel areas, deposition, and transport of woody debris). The current prevalence of exotic plant species in this forest type on the peninsula, coupled with projections for increased disturbance, suggest that exotics may become even more common with climate change in lowland forests. Because some exotic plants are also invasive and can outcompete native species on which wildlife species depend, an increase in exotic plants may have negative consequences for some wildlife species.

Increases in disturbances such as wind events and flooding may decrease the area of late-successional forests, on which species such as the northern spotted owl and marbled murrelet depend. However, increased disturbance may also lead to increased abundance of sprouting deciduous hardwoods, such as red alder and bigleaf maple, which can provide nesting and foraging habitat for some woodpecker species and Neotropical migrants, as well as leaf litter that increases habitat quality for some mollusks and salamander species. Increased disturbance and drought may also lead to increased abundance of mast-producing species, such as Pacific madrone and Oregon white oak (see chapter 6).

Riparian habitat—
As described above, altered hydrologic regimes will likely increase flood frequency and disturbance in riparian areas. Additional scouring, sediment deposition, and transport of woody debris from flooding will influence habitat characteristics in streams and adjacent riparian forests. Increased flooding severity may decrease flood-plain complexity and sinuosity of rivers, thereby reducing flood-plain habitat complexity and habitat quality for amphibian species. Increased disturbance frequency and severity in riparian areas could also reduce the area of mature riparian conifer forests and increase area of younger riparian forests dominated by deciduous hardwoods, which could degrade habitat quality for some birds and other species that use older conifers. However, deciduous hardwoods can provide valuable nesting habitat for cavity-nesting ducks and nesting and foraging habitat for some woodpecker species and Neotropical migrant birds.

Besides increased flooding, changes in hydrology with climate change will exacerbate summer drought, reduce streamflow, and produce drier conditions in adjacent riparian areas. These increases in extremes (both flooding and drought) may make riparian and flood-plain habitat less hospitable for wildlife species, such as the Pacific chorus frog, western toad, and red-legged frog (table 7.1). More frequent disturbance may also make these areas more prone to exotics, such as Japanese knotweed, which may outcompete native species and influence habitat quality for species such as songbirds. However, increased heat and drought may improve habitat for some species, such as the northern alligator lizard, because the peninsula is currently a relatively cool environment, and reptiles rely on the environment to warm themselves.

Lakes, wetlands, and bogs—
Reduction in snowpack and changes in timing of runoff with warmer temperatures will likely lead to drying of some wetland habitats, such as alpine ponds and wetlands, reducing habitat quality for dependent species such as the Cascades frog (fig. 7.2), northwestern salamander, long-toed salamander, and garter snakes. Wildlife species that depend on wetlands may be particularly sensitive to changing habitat conditions with climate change because there is little opportunity for migration to other suitable habitat (Burkett and Kusler 2000).

Cliffs, caves, and mines—
Increases in air temperatures with climate change could affect the temperatures of cliff habitats, thus affecting nesting conditions for birds that rely on cliff habitats. However, cave and mine habitats, along with other forest structures with similar microclimates, will likely remain thermal refugia, and for this reason, may become more important with climate change.

Wildlife and Habitat Management at Olympic National Forest and Olympic National Park
This section provides information on wildlife and habitat management at ONF and ONP, including (1) the context in which ONF and ONP manage wildlife and habitat,
Policy Guidance and Goals

Both ONF and ONP manage wildlife habitat to maintain biodiversity, prevent extinctions of native species that are federally listed as threatened or endangered, and maintain healthy populations of all native species. Olympic National Forest manages wildlife habitat under the direction of the Northwest Forest Plan (NWFP) (USDA and USDI 1994) and the 1990 Olympic Land and Resource Management Plan (USDA FS 1990). At ONF, a major land allocation under the NWFP is the late-successional reserve (LSR) allocation in which the goal is to maintain interactive, late-successional and old-growth forest ecosystems. A fundamental goal of LSRs is to provide habitat for late-successional and old-growth-related species, including the northern spotted owl. Other goals for managing wildlife habitat at ONF include maintaining biodiversity and sufficient habitat to ensure viable populations and prevent extinctions of all native species. Special attention is given to native species that are federally listed as threatened, endangered, or sensitive

Table 7.2—Federally listed threatened (T) and endangered (E), and state (WA-S) and federally listed sensitive (S) terrestrial wildlife species on the Olympic Peninsula

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Townsend’s big-eared bat</td>
<td>Corynorhinus townsendii</td>
<td>S</td>
</tr>
<tr>
<td>Olympic marmot</td>
<td>Marmota olympus</td>
<td>WA-S</td>
</tr>
<tr>
<td>Pacific fisher</td>
<td>Martes pennanti</td>
<td>S</td>
</tr>
<tr>
<td>Keen’s myotis</td>
<td>Myotis keenii</td>
<td>WA-S</td>
</tr>
<tr>
<td>Olympic pocket gopher</td>
<td>Thomomys mazama melanops</td>
<td>WA-S</td>
</tr>
<tr>
<td>Marbled murrelet</td>
<td>Brachyramphus marmoratus</td>
<td>T</td>
</tr>
<tr>
<td>Common loon</td>
<td>Gavia immer</td>
<td>WA-S</td>
</tr>
<tr>
<td>Bald eagle</td>
<td>Haliaeetus leucocephalus</td>
<td>S</td>
</tr>
<tr>
<td>Harlequin duck</td>
<td>Histrionicus histrionicus</td>
<td>S</td>
</tr>
<tr>
<td>Northern spotted owl</td>
<td>Strix occidentalis caurina</td>
<td>T</td>
</tr>
<tr>
<td>Cope’s giant salamander</td>
<td>Dicamptodon copei</td>
<td>S</td>
</tr>
<tr>
<td>Van Dyke’s salamander</td>
<td>Plethodon vandykei</td>
<td>WA-S</td>
</tr>
<tr>
<td>Olympic torrent salamander</td>
<td>Rhyacotriton olympicus</td>
<td>WA-S</td>
</tr>
<tr>
<td>Johnson’s hairstreak butterfly</td>
<td>Callophrys johnsoni</td>
<td>S</td>
</tr>
<tr>
<td>Puget Oregonian snail</td>
<td>Cryptomastix devia</td>
<td>S</td>
</tr>
<tr>
<td>Evening fieldslug</td>
<td>Deroceras hesperium</td>
<td>S</td>
</tr>
<tr>
<td>Taylor’s checkerspot butterfly</td>
<td>Euphydryas editha taylori</td>
<td>S</td>
</tr>
<tr>
<td>Kneed jumping-slug</td>
<td>Hemphillia burringtoni</td>
<td>WA-S</td>
</tr>
<tr>
<td>Warty jumping-slug</td>
<td>Hemphillia glandulosa</td>
<td>S</td>
</tr>
<tr>
<td>Malone jumping-slug</td>
<td>Hemphillia malonei</td>
<td>WA-S</td>
</tr>
<tr>
<td>Oregon megomphix mollusk</td>
<td>Megomphix hemphilli</td>
<td>WA-S</td>
</tr>
<tr>
<td>Olympic arctic butterfly</td>
<td>Oeneis chryxus valerata</td>
<td>WA-S</td>
</tr>
<tr>
<td>Dog star skipper</td>
<td>Polites sonora siris</td>
<td>WA-S</td>
</tr>
<tr>
<td>Blue-gray taildropper slug</td>
<td>Prophysaon coeruleum</td>
<td>WA-S</td>
</tr>
<tr>
<td>Hoko vertigo snail</td>
<td>Vertigo n. sp. (new unnamed species)</td>
<td>WA-S</td>
</tr>
</tbody>
</table>

Species are grouped by vertebrate phylogenetic class (mammals, birds, reptiles, amphibians) and invertebrates, and listed alphabetically by scientific name within group.
Adapting to Climate Change at Olympic National Forest and Olympic National Park

(TES) or classified as sensitive under the Pacific Northwest regional forester’s sensitive species program (table 7.2).

Besides managing for TES species, ONF manages for species classified as management indicator species. Indicator species are chosen to reflect an assemblage of species having similar habitat or ecosystem affinities and requirements, with an assumption that management that maintains or enhances the habitat of indicator species will also benefit the larger assemblage of species. Seven species, or groups of species, have been selected as indicators at ONF. These include primary excavators as indicators for snag-dependent cavity nesters; Roosevelt elk and Columbia black-tailed deer as game species indicators; American marten and pileated woodpecker as mature coniferous forest species indicators; northern spotted owl as an old-growth forest species indicator; and bald eagle as a riparian/mature forest species indicator. Additional management direction guides habitat maintenance for game species. The park’s wildlife management program promotes sustaining a full range of natural genetic variability and long-term viability through maintenance of wildlife population age-structures, abundance, density, and distributions within normal ranges.

When adequate habitat exists and several additional criteria are met, National Park Service management policies (NPS 2006) direct park managers to restore extirpated native species such as the Pacific fisher, which is believed to have been extirpated from the state of Washington. In 1988, the Pacific fisher was listed as a state endangered species in Washington state, and in 2004 as a federal candidate species (west coast distinct population segment). In 2004, the Washington State Department of Fish and Wildlife completed a feasibility study, concluding that the Olympic Peninsula was best suited as a release site for the initial restoration of Pacific fisher to the state. In 2008, a multiyear, interagency program began to restore Pacific fishers to the Olympic Peninsula, with releases over a 3-year period in ONP. This program also addressed a National Park Service policy objective of restoring a full complement of native species to ONP. At present, the only native species absent from the park is the gray wolf. Although there are no current proposals to reintroduce the wolf, the return of wolves could influence populations and distributions of herbivores, which would affect riparian vegetation communities (Beschta and Ripple 2008), and potentially ecosystem resiliency to climate change.

Habitat Improvement and Restoration Activities

Activities to improve wildlife habitat quality at ONF include snag and coarse wood creation, pruning, cavity treatments, forage plantings, and mechanical treatments to maintain open habitats. Snag creation, often conducted in thinning treatments, can include blasting or removing the tops of trees with chain saws, inoculation with local stem decay fungi, or girdling. Biologists also install nest boxes for northern flying squirrels. Coarse wood treatments include creating furrows in felled trees, piling fine or coarse downed wood, and bundling logs together from felled trees to create coarse wood structures. Pruning treatments include pruning of understory shrubs or hardwood trees to stimulate sprouting and increase availability of big game browse or suitability for shrub-nesting birds. Treatments include creating artificial cavities in topped or live trees to benefit cavity-using wildlife. Forage plantings for large game include planting willow and red-osier dogwood. Mechanical treatments (chain saws and loppers) include removing salmonberry and some small conifers from areas that were once meadow or openings created from earlier management practices.

Within ONF, road decommissioning and culvert installation improve habitat for fish and aquatic species, as well as some terrestrial wildlife species. For example, road decommissioning and culvert installation can improve water quality and access to habitats for species that have an aquatic phase, such as the Olympic torrent salamander (fig. 7.1), tailed frog, and Cope’s giant salamander (fig. 7.6). Many vegetation management activities (described in chapter 6) can also be considered wildlife habitat restoration activities at ONF. For example, thinning in young stands (40 to 80 years old) focuses on creating forest structural diversity intended to accelerate the development of late-successional forest characteristics used by old-growth-dependent species such as the northern spotted owl and marbled murrelet. Young plantations that are proximal to old-growth forests receive priority for thinning treatments to increase the area
of contiguous old-growth habitat. Habitat improvement for Roosevelt elk is also a factor in setting priorities for thinning. Wildlife habitat provisions in silvicultural prescriptions focus on snag and coarse woody debris density and distribution at the watershed scale.

Olympic National Park works to restore ecosystems, habitats, and disturbance regimes altered by human activities or exotic species. As the park acquires private properties from willing sellers within the park boundaries, biologists work to restore these sites by planting native species propagated from adjoining areas.

Within aquatic systems of the park, management priorities include pollution prevention, protection of riparian and lake habitat, and water quality maintenance to meet the needs of aquatic organisms. A major restoration effort is underway to remove two dams from the Elwha River. Dam removal will occur over a 2-year period beginning late in 2011, with active fish and vegetation restoration projects occurring during several years thereafter. After this restoration project, the river will support all five species of Pacific salmonids that inhabited the river before dam construction. Succession of riparian communities over the next several years to decades will provide habitat for a variety of mammals and birds. In preparation for dam removal, biologists conducted baseline surveys in the Elwha valley to assess occurrence and distribution of North American black bear, riparian carnivores, small mammals, beavers, otters, amphibians, and birds. Prior studies on prey base adequacy for wolves examined Roosevelt elk and Columbia black-tailed deer distribution and density in the Elwha and other drainages in the park (Jenkins and Manley 2008).

Surveys and Monitoring

The ONF conducts surveys to assess wildlife populations on the forest. Surveys for wildlife species by ONF personnel in the last decade have generally focused on species listed as sensitive and included aerial surveys for bald eagles, documenting nesting success, and also searching for new nests. In 2009, the forest began the first formal surveys for Taylor’s checkerspot butterfly (fig. 7.5). Biologists conduct surveys for other species opportunistically and sometimes not to any strict protocol. There is also documentation of egg masses, larvae, and adult pond breeding amphibians in some areas, as well as surveys for the northern goshawk. The forest installed remote cameras to monitor the recently reintroduced Pacific fisher on the peninsula and is working with ONP, the Washington State Department of Fish and Wildlife, the U.S. Geological Survey, and the Forest Service Pacific Northwest Research Station to establish a survey protocol for Pacific fisher. Annual bat surveys in one portion of the ONF include bridge and building inspections to document use by Townsend big-eared bat and Myotis species.

Forest staff discontinued surveys for marbled murrelet and northern spotted owl in the late 1990s after the forest began to switch its harvest program to second-growth stands instead of old growth. However, the Forest Service Pacific Northwest Research Station oversees the Olympic Demography Study, which involves annual surveys by scientists at selected northern spotted owl activity centers on the forest. Olympic National Park biologists conduct surveys for northern spotted owl within the park boundaries at about 50 sites. Annual survey data from this work dates to the early 1990s.

Olympic National Park protects the largest population of Roosevelt elk in its natural environment in the world. Decades of protection from human harvest and habitat manipulation not only sustained high densities of elk, but also preserved the natural composition, social structure, and dynamics of this unique coastal form of elk found nowhere else. Population surveys and other studies of park elk populations since 1985 documented that herds on the west side of the park generally reside for most of the year wholly within the park, whereas east-side herds spend a portion of the year out of the park (Houston et al. 1987, 1990). Understanding these differences may be even more important with climate change as biologists work across boundaries to conserve species and their habitats.

Biologists monitor elk populations at ONP as a part of the National Park Service North Coast and Cascades Network monitoring program. Other components of the monitoring program address plant communities, landscape change, climate, high-elevation lakes, fish in large rivers, and land birds. Monitoring protocols are peer reviewed, and
Adapting to Climate Change at Olympic National Forest and Olympic National Park

Adapting Wildlife and Habitat Management to Climate Change at Olympic National Forest and Olympic National Park

Process Used to Develop Adaptation Strategies for Wildlife and Habitat Management

During 2009, a series of three workshops was held to discuss potential effects of climate change on Olympic Peninsula wildlife species and habitats, examine anticipated wildlife sensitivities to climate change, and develop potential adaptation strategies and actions for wildlife management at ONF and ONP. Workshop participants included natural resources staff from ONF and ONP, specialists from the Washington Department of Natural Resources and U.S. Fish and Wildlife Service, and scientists from the Forest Service Pacific Northwest Research Station, U.S. Geological Survey, and University of Washington.

The first workshop focused on potential climate change effects on wildlife on the peninsula, including general climate change effects, as well as effects anticipated within each Olympic Peninsula habitat type. Based on the anticipated climate change effects, participants identified species on the peninsula most likely to be impacted by climate change (table 7.1).

Participants in the first workshop concluded that further analysis of Olympic Peninsula wildlife species sensitivity to climate change would be useful in developing climate change adaptation strategies and actions for wildlife habitat management at ONF and ONP. During a second meeting, biologists participated in a climate change sensitivity assessment process for select wildlife species on the Olympic Peninsula, applying methods developed by Joshua Lawler (School of Forest Resources, University of Washington). The climate change sensitivity assessment involved wildlife experts answering a series of questions about a particular species based on their knowledge and experience. Participants were asked to (1) classify a species’ maximum annual dispersal; (2) determine whether barriers to dispersal exist for a given species; (3) rate a species’ dependence on disturbance regimes; (4) rate a species’ dependence on other species (i.e., interspecific dependencies); (5) rate a species’ physiological sensitivity to temperature; (6) rate a species’ sensitivity to changing precipitation; (7) rate a species’ sensitivity to salinity, pH, and carbon dioxide; (8) classify a species reproductive strategy (on an r-selected to K-selected scale); and (9) identify any sensitive habitats that a given species occupies (see table 7.3 for specific questions). An automated electronic system collected and tallied responses and provided summary results to participants. Participants then rated how confident they were in the summary response, thus quantifying the degree of certainty in the group response to a given question. In addition, each participant subjectively rated each species’ overall sensitivity to climate change.

Participants completed the sensitivity assessment for a limited number of species during the workshop, and individual experts conducted additional species assessments through an online database after the workshop. A sensitivity score for each species incorporated mean group responses from the workshop as well as responses from individuals in the online database. An additive function (sum scores for each question) (table 7.3), divided by the maximum possible score, and multiplied by 100) produced the sensitivity scores, on a 0 to 100 scale. Figure 7.8 illustrates results of the sensitivity assessment for the 21 Olympic Peninsula species analyzed by the group, as discussed below.

A third meeting focused on development of adaptation strategies and actions for wildlife management at ONF and ONP. Objectives of this third workshop were to (1) review Olympic Peninsula wildlife habitat and species sensitivities to climate change identified in the first two workshops and (2) through an interactive dialogue between scientists and managers, use the latest scientific information on climate change and impacts to wildlife to develop adaptation...
Table 7.3—Questions posed to participants in the process used to assess the sensitivity of wildlife species to climate

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1. Maximum annual dispersal distance for this species is:</td>
<td>(0) N/A (1) &gt;100 km (2) 75–100 km (3) 50–75 km (4) 25–50 km (5) 5–25 km (6) 1–5 km (7) &lt;1 km</td>
</tr>
<tr>
<td>Question 2. Do barriers to dispersal exist? Are there landscape elements</td>
<td>(0) No (3) Yes</td>
</tr>
<tr>
<td>Question 3. How dependent is this species on one or more disturbance</td>
<td>(1) not dependent on the nature of any disturbance regime (2) slightly dependent (3) somewhat dependent (4) moderately dependent (5) more dependent (6) definitely dependent (7) highly dependent on the nature of one or more disturbance regimes</td>
</tr>
<tr>
<td>Question 4. Broadly, where does this species fall on the spectrum of</td>
<td>(0) N/A (1) generalist (2) (3) (4) (5) (6) (7) specialist</td>
</tr>
<tr>
<td>Question 5. Species' sensitivity to temperature:</td>
<td>(0) N/A (1) low (2) (3) (4) (5) (6) (7) high sensitivity</td>
</tr>
<tr>
<td>Question 6. Species' sensitivity to precipitation:</td>
<td>(0) N/A (1) low (2) (3) (4) (5) (6) (7) high sensitivity</td>
</tr>
<tr>
<td>Question 7. Species' sensitivity to salinity:</td>
<td>(0) N/A (1) low (2) (3) (4) (5) (6) (7) high sensitivity</td>
</tr>
<tr>
<td>Question 8. Species' sensitivity to pH:</td>
<td>(0) N/A (1) low (2) (3) (4) (5) (6) (7) high sensitivity</td>
</tr>
<tr>
<td>Question 9. Species' sensitivity to CO₂:</td>
<td>(0) N/A (1) low (2) (3) (4) (5) (6) (7) high sensitivity</td>
</tr>
<tr>
<td>Question 10. Species' reproductive strategy:</td>
<td>(0) N/A (1) r-selection (can exploit empty niches/ reproduce quickly) (2) (3) (4) (5) (6) (7) K-selection (present as strong competitors in crowded niches/ invest heavily in fewer offspring)</td>
</tr>
</tbody>
</table>
Adapting to Climate Change at Olympic National Forest and Olympic National Park

### Table 7.3—Questions posed to participants in the process used to assess the sensitivity of wildlife species to climate\(^a\)

<table>
<thead>
<tr>
<th>Question 11. Occupies the following sensitive habitat types(^b)</th>
<th>Coastal lowlands/marshes/estuaries</th>
<th>Perennial streams</th>
<th>Shallow wetlands/shallow pools</th>
<th>Vernal pools or seasonal wetlands</th>
<th>Ecotones</th>
<th>Alpine/subalpine</th>
<th>Other</th>
</tr>
</thead>
</table>

\(^a\) The number in parentheses before each answer choice represents the score that answer would produce for the calculation of the climate change sensitivity score. Sensitivity scores are on a scale of 0 to 100 and based on an additive function. In addition to the calculated sensitivity scores, after each question, each participant was asked to rate their level of confidence in the value that was collectively reached through this process, giving a measure of uncertainty to collective answers for each question.

\(^b\) Sensitivity to temperature is directly related to a species' physiological ability to tolerate temperatures that are higher or lower than the range that it currently experiences. If a species can tolerate a wide range of temperatures, it would be deemed less sensitive.

Sensitivity to precipitation should be based on the species' ability to tolerate higher or lower levels of precipitation than that which it currently experiences. If a species can tolerate a great deal more or less precipitation than usual, they should be deemed less sensitive.

Sensitivity to salinity refers to the species' ability to tolerate either higher or lower levels of salinity than it currently experiences. The ability to tolerate a wide range of salinity indicates that the species is less sensitive.

Sensitivity to pH refers to a species' ability to tolerate either higher or lower pH than it currently experiences. (This is most applicable to aquatic organisms.) If a species can tolerate a wide range of pH, it should be deemed less sensitive.

Sensitivity to carbon dioxide (CO\(_2\)) refers to the ability of a species to tolerate greater or lesser amounts of CO\(_2\) than it currently experiences (this may be most important in plant species). If a species can tolerate a wide range of CO\(_2\) levels, it should be deemed less sensitive.

If the species occupies none of these habitats, then the score is 0. If the species occupies one or more of these habitats, then the score is 7.
Figure 7.8—Modeled and subjective climate change sensitivity scores for selected species on the Olympic Peninsula. Modeled sensitivity scores were determined from experts’ answers to questions and calculated based on an additive function (see table 7.3). Subjective sensitivity scores were experts’ opinions on how sensitive a given species will be to climate change.

The sensitivity assessment process assisted in initially identifying species and groups of species that will likely be most sensitive to climate change on the peninsula. The process also led to useful discussion and deeper thinking about how individual and groups of species may be affected by climate change. However, the sensitivity assessment is still under development, and participants identified several limitations of the tool. For example, there was a large discrepancy between the modeled sensitivity and the subjective sensitivity scores for some species, likely because there are effects of climate change and other factors that make species sensitive to climate change that are not captured in the assessment. Alternatively, experts’ expectations for wildlife sensitivities to climate change are greater than the model suggests. In either case, the assessment process left a high level of uncertainty about the actual sensitivity of any of the species considered. Developers received critiques of
Table 7.4—Projected climate change sensitivities, and associated adaptation strategies and actions for wildlife and habitat management at Olympic National Forest (ONF) and Olympic National Park (ONP)\(^a\)

<table>
<thead>
<tr>
<th>Current and expected sensitivities</th>
<th>Adaptation strategies and actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited connectivity of late-successional forests</td>
<td>• Collaborate with neighbors about priority areas for treatments, and increase extent of protected areas.</td>
</tr>
<tr>
<td>Limited ability of species to respond to climate change owing to current stressors, such as habitat loss and fragmentation</td>
<td>• Increase thinning treatments in young-growth forests that promote late-successional forest conditions and improve habitat quality and suitability for some wildlife species at ONF.</td>
</tr>
<tr>
<td></td>
<td>• Focus thinning treatments (to promote late-successional conditions) around existing late-successional forests to increase landscape connectivity and increase wildlife habitat quality at ONF.</td>
</tr>
<tr>
<td></td>
<td>• Increase restoration treatments in, and protection of, headwater streams to increase late-successional habitat connectivity at ONF.</td>
</tr>
<tr>
<td></td>
<td>• Add a climate layer to ONF’s 10-year plan that shifts priorities for thinning treatments and road decommissioning and leads to increased habitat quality and connectivity.</td>
</tr>
<tr>
<td>Risk of large, high-severity fire</td>
<td>• Determine how to jointly manage fire (ONF and ONP).</td>
</tr>
<tr>
<td></td>
<td>• Consider allowing fires to burn more frequently.</td>
</tr>
<tr>
<td></td>
<td>• Monitor postfire regeneration to determine what can be expected after large fires.</td>
</tr>
<tr>
<td></td>
<td>• Decrease stand densities and increase use of prescribed fire to lower wildfire severity.</td>
</tr>
<tr>
<td>Reduced late-successional habitat area and habitat quality</td>
<td>• Continue to create and protect legacy structures at ONF.</td>
</tr>
<tr>
<td></td>
<td>• Increase density of legacy structures in younger forest near late-successional forest to increase habitat quality and connectivity at ONF.</td>
</tr>
<tr>
<td></td>
<td>• Continue to thin stands at ONF to promote tree vigor and produce future legacy structures.</td>
</tr>
<tr>
<td></td>
<td>• Continue to restore degraded sites.</td>
</tr>
<tr>
<td>Reduced habitat quality, particularly in riparian areas and wetlands</td>
<td>• Restore habitat in degraded headwater streams at ONF that are expected to retain adequate summer streamflow.</td>
</tr>
<tr>
<td>Increased spread of aquatic exotic plant species</td>
<td>• Control spread of exotic species.</td>
</tr>
<tr>
<td>Loss of cold water refugia for cold-water adapted amphibians</td>
<td>• Consider creating wetland habitats.</td>
</tr>
<tr>
<td>Change in wetland, bog, and fen distribution</td>
<td>• Consider inventory and monitoring opportunities to address questions for species sensitive to climate change, including listed species.</td>
</tr>
<tr>
<td>Increased risk of species extinction, particularly for endemics</td>
<td>• Conduct integrated surveys and monitoring for key species to obtain baseline information and determine when population changes are occurring.</td>
</tr>
<tr>
<td></td>
<td>• Reduce existing pressures on species from sources other than climate change.</td>
</tr>
</tbody>
</table>

\(^a\) Sensitivities are based on projected climate change effects on the Olympic Peninsula, including changing habitat distribution and quality with changing vegetation patterns, shifts in geographic ranges of wildlife species, shifts in ranges of competitor, forage, prey, and symbiotic species (and biotic interactions), changing species phenology, increased fire frequency, potential for increased insect and disease outbreaks, changing hydrology, and reduced summer streamflows.
Box 7.1—Summary of projected climate change effects on wildlife on the Olympic Peninsula and related adaptation strategies for wildlife and wildlife habitat management at Olympic National Forest (ONF) and Olympic National Park (ONP).

• Climate change, in combination with other stressors to wildlife such as habitat loss and fragmentation, has the potential to greatly affect wildlife species and biodiversity on the Olympic Peninsula.

• Species will respond to both direct and indirect effects of climate change. For example, increasing temperatures and changing precipitation will have direct physiological effects on some species, such as amphibians. Other species will be affected mostly indirectly through:
  ○ Climate-induced changes in phenology (timing of life history) relative to forage plants and invertebrate prey
  ○ Shifts in geographic ranges and the density and ranges of competitor, forage, prey, and symbiotic species (and subsequent changes in biotic interactions) in response to changing climate
  ○ Effects from other stressors such as disturbance, insects, and disease
  ○ Climate-induced changes in habitat characteristics and quality

• Some Olympic Peninsula species will likely respond to increasing temperature by shifting their ranges upward in elevation. High-elevation species will likely be particularly sensitive to warming temperatures and experience range contractions because contiguous, higher elevation habitat may not be available to colonize.

• It may also be more difficult for endemic and specialist species with strict habitat requirements or dependencies on specific forage species to find suitable habitat conditions under changing climate.

• Active management by restoration thinning in existing young-growth forest at ONF is a strategy that may help to ensure maintenance of enough forest with desired late-successional habitat characteristics (currently rare) across the landscape. Thinning to promote late-successional conditions at ONF may be most effective around existing late-successional forests to increase landscape connectivity and increase wildlife habitat quality.

• Protection and restoration of headwater streams and encouraging vigorous conifer growth could help to prevent increasing stream temperatures with climate change and increase habitat connectivity.

• At the stand scale, ONF can continue to increase wildlife habitat quality through creation and protection of legacy structures, including old-growth trees, snags, and large downed wood, as these legacy structures have disproportionate habitat value for a large number of species.

• Because many actions that could help increase wildlife species’ resilience to climate change will be most effective at large spatial scales and with consideration of landscape context, ONF and ONP will increase collaboration with neighbors to develop and increase the extent of a landscape strategy.

the assessment during the workshops and will consider the critiques in further refinement of the assessment tool and associated database. However, issues with the sensitivity assessment tool and database may stem from a fundamental lack of empirical data on wildlife species and their likely responses to changing climate. Additional empirical data and baseline assessments are needed to track changes in species’ response in the early phases of climate change. Such early assessments will be vital as we attempt to forecast long-term changes in response to climate change.

Adaptation Strategies and Actions for Wildlife and Habitat Management at Olympic National Forest and Olympic National Park

Many actions that could help increase wildlife species’ resilience to climate change will be most effective at broad spatial scales (Millar et al. 2007), especially for management targeted at increasing habitat connectivity. Given the many landowners on the peninsula, increasing habitat quality and connectivity will require collaboration with neighbors about where to apply treatments to benefit wildlife habitat. Dialogue with the Washington Department
Adapting to Climate Change at Olympic National Forest and Olympic National Park

of Fish and Wildlife, Washington Department of Natural Resources (a major landowner on the peninsula), and other federal agencies could help to develop and increase the extent of a landscape strategy. The ONF and ONP will also seek opportunities for collaboration with other peninsula landowners.

Logging activities through the end of the 20th century left a scarcity of late-successional forest at ONF. Late-successional forests provide high-quality habitat for many species, including the northern spotted owl. Some late-successional forests may decline with climate change and be replaced by natural regeneration. Active management by thinning in existing young-growth forest at ONF is a strategy that may help to ensure maintenance of enough forest with desired habitat characteristics across the landscape. Thinning can reduce habitat quality and suitability for certain species that prefer dense forest conditions typical of the stem exclusion phase of forest succession (Hagar et al. 1996, Hayes et al. 2003, Suzuki and Hayes 2003). However, thinning in structurally simple young-growth forests can also improve habitat quality and suitability for a variety of other species by promoting tree growth, species and structural diversity, and understory development (Carey and Wilson 2001, Hagar et al. 1996, Hayes et al. 2003, Suzuki and Hayes 2003). Young-growth thinning increases tree vigor by increasing availability of water, light, and nutrient resources; enhances tree species diversity by providing growing space for less competitive minor species; and provides growing space for understory vegetation to increase in abundance and diversity (Roberts and Harrington 2008).

Thinning to promote late-successional conditions at ONF may be most effective adjacent to existing late-successional forests to increase landscape connectivity and increase wildlife habitat quality (the exception to this would be around known owl and murrelet nesting sites, where concern for short-term disturbance could outweigh long-term habitat improvement). Alternatively, thinning treatments could be focused in areas dominated by young forests. For example, young forests dominate the northwestern corner of ONF, which is the least connected to the park. Focusing treatments in that portion of the forest may have the greatest effect on habitat quality.

Areas selected for thinning also need to be strategically located with the consideration of climate-altering disturbance processes and growing conditions. Some treatments may be a combination of habitat characteristic development and fire fuel reduction, depending on the location. Fuel reductions may be particularly important to high-value riparian areas, where habitat value would be susceptible to fire.

Another way to potentially increase late-successional habitat connectivity is through restoration thinning treatments and protection of headwater stream areas at ONF, because forests that surround headwater streams are widespread and connected. Protection of headwater streams, and encouraging vigorous conifer growth, could help to prevent increasing stream temperatures with climate change and prevent sediment movement downstream. Management activities that promote forest resilience around non-fish-bearing headwater streams could also improve habitat for amphibians, which are likely to be highly sensitive to climate change. For example, during thinning treatments, some trees could be dropped into streams to create instream structures that provide habitat and improve water holding capacity.

Currently, ONF uses a 10-year strategic plan to direct locations of thinning and road decommissioning activities (among others). The strategic plan emphasizes restoring and connecting fragmented terrestrial and aquatic habitats. The plan does not currently consider potential effects of climate change, but modifying treatment prioritization could help to incorporate climate change in the plan. For example, thinning treatments could be prioritized around existing late-successional forest and around headwater streams to increase late-successional habitat connectivity. A geographic information system analysis could be used to identify gaps in desirable conditions and determine where treatments would be most effective. Also, habitat surveys could help to determine where the best corridors for movement exist on the peninsula, and treatments could be positioned accordingly. Wildlife could also be given greater consideration in prioritization of road decommissioning on the forest; roads that inhibit species movement could be prioritized for decommissioning.
Another step for ONF and ONP is to determine how to jointly manage fire. The ONP will revise their fire plan in the near future and broaden the scope of the planning effort to include ONF. Allowing wildfires to burn more frequently at ONF and ONP may have some benefits, such as maintenance of alpine meadows, which will likely see increased tree encroachment with warming temperatures. Monitoring of recent burns and postfire regeneration could help determine if forage species are likely to regenerate after fire (e.g., Do important meadow species return after fire?). Management could also be tailored to decrease fire intensity. For example, decreasing stand density and increasing use of prescribed fire could help to decrease wildfire intensity, and firebreaks could be created to slow wildfire spread. These activities could be particularly useful in productive areas in the northeastern portion of the peninsula, where fire is more frequent and stands would likely respond to thinning through increased tree growth and vigor.

At the stand scale, ONF could continue to increase wildlife habitat quality through creation and protection of legacy structures, including old-growth trees, snags, and large downed wood. Legacy structures have disproportionate habitat value for a large number of species. Although not a specific habitat type, these structures may mediate structural deficiencies in younger stands by providing for critical habitat needs. Old-growth trees have furrowed bark, cavities or basal hollows, large limbs, and defects that can provide nesting or roosting substrate, prey, or resting cover for species that might not otherwise be able to inhabit a younger stand. For example, long-legged bats, pygmy nuthatches, violet-green swallows, and Vaux’s swifts were documented reproducing in individual old-growth redwood trees with basal hollows or other cavities that were located in younger managed stands, and a variety of other bat and bird species used them for foraging or roosting (Mazurek and Zielinski 2004, Zielinski and Gellman 1999). Large standing hollow trees or fallen logs can provide hibernation dens for bears, natal and maternal dens for meso-predators such as the American marten and Pacific fisher, and cool, moist conditions for amphibians (such as Van Dyke’s salamander) and mollusks. Overall, snags and coarse wood are very important to a variety of wildlife because of the food or prey they provide, protection from the elements, or structures for rearing young.

Olympic National Forest currently induces mortality of large trees for snag creation. This practice could be continued and possibly increased for further habitat quality improvement. Increasing density of legacy structures in younger forests may be particularly effective near late-successional forest to increase habitat quality and connectivity. Protection of existing legacy structures will also be important in providing critical habitat elements for a variety of species that may help them to respond adaptively to climate change.

Although there is a need for legacy structure creation in the short term, there is also a need for high tree vigor for creation of future legacy structures. At ONF, stands could be thinned and trees left on site to elicit both a growth response and a positive effect on habitat quality. Thinning could also help forests to be more resilient to drought and disturbance with climate change.

Besides legacy structure protection and creation, other measures could be taken to further increase habitat quality at the stand scale. For example, creation of habitat structures, such as brush piles, could provide habitat for salamander species under increasing summer drought. Restoring currently degraded sites could also help to increase the area of high-quality habitat at ONF and ONP.

Policy Considerations and Next Steps

Policy will be highly relevant to wildlife management at ONF and ONP with climate change. Both ONF and ONP currently focus resources on species that are sensitive, threatened, endangered, or iconic, but it is uncertain what will happen in the future when climate-related changes could lead to many more extinction possibilities. Because of the number of endemic species on the peninsula, there will be an opportunity for the forest and park to direct the discussion on what to do about many species at risk of extinction. The forest and park will keep up-to-date on the federal threatened and endangered list, as well as the Washington sensitive species list. Integrated surveys and monitoring can be conducted for key species to obtain baseline information and determine when population changes are occurring (e.g.,
Adapting to Climate Change at Olympic National Forest and Olympic National Park

the endemic Olympic marmot and amphibians in the high lakes areas). The forest and park will consider expanded data sharing and joint or expanded monitoring projects with common protocols, involving other adjacent landowners whenever possible. Specific recommendations for managing the effects of climate change can be developed for species for which a large amount of information already exists.

Reducing existing pressures on species from sources other than climate change will also be important to protect TES species. The ONF and ONP will work to evaluate current activities to determine if stresses can be reduced for species that will be most impacted by climate change (e.g., focus on keeping streams cool for the Olympic torrent salamander, and increase coordination on exotic species control).

In the future, depending on agency policies and partnerships, ONF and ONP may also consider assisted migration and captive breeding for species that may otherwise go extinct. It is possible that the peninsula will be a refuge for species from other parts of the Pacific Northwest over the long term. However, criteria and methods for conducting assisted migration as a strategy, as well as potential ecosystem impacts, are unclear.

Although ONF and ONP are mandated to protect TES species, there are currently policy limitations on the actions that can be taken to protect these species. Under current policies, management actions that would affect native species to protect or restore TES species must be undertaken through a careful planning process and in a way that will not produce unacceptable impacts on resources or natural processes. For ONP, policy guidance on when or whether to intervene in ecosystem processes in the face of climate change is limited. For example, the population of Olympic marmot (fig. 7.3), an endemic species to the peninsula, is declining on the peninsula owing in part to unsustainable levels of coyote predation (Griffin et al. 2008), and warming temperatures may enhance coyote presence in the high-elevation marmot habitat. Potential options for coyote control are complicated under existing policies. Policy guidance regarding how or if to manage the situation is imprecise. Reintroduction of a top predator, the gray wolf, could decrease coyote numbers but would likely have other ecosystem impacts and raise controversy. Similarly, there are limitations to actions that can be taken to control the barred owl and its negative impact on the northern spotted owl. Other similar situations may arise in the future with species ranges that may shift in response to climate change.

The Endangered Species Act (ESA 1973) guides agencies to consider the needs of individual species in their management activities, and conservation of individual species under the Endangered Species Act will likely continue for some time. In some cases, management for particular species whose presence is crucial to the maintenance of current ecosystem dynamics (e.g., top predators and major herbivores) may be required to maintain ecosystem function with changing climate. However, other efforts to maintain and restore ecosystem function will be important with the changes in forest species composition and disturbance that will likely occur with warming. With climate change, it may be particularly important to focus management on habitats, habitat structural components, and headwaters and cold water flows. Monitoring these habitats and habitat components will be particularly useful for detecting changes in habitat attributes and taking management action, when possible, to limit negative consequences for the species that use the habitats.

To garner public support for policies and actions related to climate change, ONF and ONP may need to expand outreach to explain the reasoning behind policies and actions. The park and forest can increase interaction with local communities about how they are addressing climate change in management and how climate change may affect the public. Education about potential changes in wildlife may be especially necessary because, for example, black bear conflicts increase when there are berry crop failures, which may become more frequent with climate change.

Overall, current wildlife management at ONF and ONP is consistent with strategies and actions that would help to increase species and ecosystem resilience to climate change. For example, ONP currently manages for ecosystem function, and ONF focuses much of their management on restoration. However, there are ways, outlined here, that
ONF and ONP could shift their strategies and foci to better address potential changes with warming temperatures.

Acknowledgments
We thank the individuals who participated in the series of workshops that led to this chapter, including Keith Aubry, Brian Biswell, and Marty Raphael (Forest Service Pacific Northwest Research Station), Kim Mellen-McLean (Forest Service, Pacific Northwest Region), John Fleckenstein (State of Washington, Department of Natural Resources), Jim Michaels (U.S. Fish and Wildlife Service), and Aaron Wirsing (University of Washington). This chapter was improved by helpful reviews by Nicole Maggiulli, Marty Raphael, and Aaron Wirsing.

Literature Cited


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Chapter 8: Synthesis and Conclusions

Catherine Hawkins Hoffman, Kathy A. O’Halloran, Jessica E. Halofsky, and David L. Peterson

Utility of the Adaptation Planning Process

The Olympic Climate Change Case Study illustrated the utility of place-based vulnerability assessments and science-management workshops in facilitating climate change adaptation planning. We built on climate change education, and initial science-management discussions to develop specific and tangible ways for Olympic National Forest (ONF) and Olympic National Park (ONP) to incorporate climate change adaptation strategies into management. Development of science-based adaptation strategies was fostered by direct engagement of scientists and managers in the workshops. Presentations describing results of science-based vulnerability assessments helped to spur dialogue. The workshop format gave managers an open forum to brainstorm, express initial thoughts and ideas, and vet those ideas among peers. Careful facilitation of workshop discussions led to a productive dialogue (Schmoldt and Peterson 1991).

This study is an unprecedented example of collaboration by the U.S. Forest Service and National Park Service in preparation for climate change. The process used, involving sensitivity assessments, reviews of current management and management constraints, and adaptation workshops, can provide an example for other land and resource managers on how to initiate the climate change adaptation process. Many ideas from the case study could apply to other locations or agencies, and contribute to current planning processes and management programs.

Lessons Learned

Where Is the Recipe?

For climate change adaptation, there is no recipe, no road map, and yet no time to lose; science and management partners must tackle the climate change issue in a timely way, despite uncertainty.

It is challenging for agency managers to stay abreast of the rapidly evolving field of climate change science that contains as many questions as answers, further complicating decisionmaking. Consequently, the temptation is strong to wait for ready-made templates or fully developed, tried-and-true examples of how to adapt to climate change. There are numerous efforts underway nationally and internationally to develop adaptation concepts and processes. Comparing and contrasting these to learn from other examples is critical to advancing climate change adaptation. However, this issue must be addressed as soon as possible to limit unwanted effects of changing climate.

Timing

The case study was timed to build on the momentum of a previous effort and was sufficiently long to enable the completion of a critical step in the adaptation process.

The case study was timed to build on the momentum of previous adaptation work on ONF and to take advantage of available funding for the effort. The case study was conducted over a 1½ year period. Although this period was not sufficient to fully incorporate all resulting ideas into forest and park management, it was sufficient to complete a step in the adaptation process in which relevant science was presented and summarized, vulnerabilities were assessed, and initial adaptation strategies and options were developed.

Scale and Participants

For all workshops, we encountered the challenge of balancing between soliciting input from many people and having a group small enough to facilitate discussion.

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The need for progress within a specific timeframe, and for continuity and commitment to the process over many months, in addition to the scheduling, logistics, and orchestration of a large-group planning process, were primary factors that led to limiting this initial effort to the forest and park. The structure of the workshops, which differed in size and composition depending on the topic, engaged program managers and resource specialists, and efficiently used the time of all participants while also ensuring ample time for discussion. To keep the meetings to a reasonable size, the majority of participants at most workshops were personnel of ONF and ONP (including regional-level staff), and invited scientists. The wildlife workshop included staff from the Washington Department of Natural Resources, the U.S. Geological Survey, and the U.S. Fish and Wildlife Service. The first fish workshop was larger by design because fish (particularly salmonids) are one of the widest ranging, multijurisdictional organisms inhabiting the peninsula. Over 100 representatives from other federal agencies, the state, tribes, universities, and nongovernmental organizations attended this workshop. A clear next step is to include these and other partners in a broader climate change adaptation effort on the peninsula.

Scope
Framing the planning discussions around discrete topics allowed participants to discuss ideas within a group size that allowed all to contribute.

This was especially beneficial because some of the ideas and concepts were new, and participants ranged in knowledge of or engagement in climate change discussions. Participants were able to vet their ideas among peers and found it helpful to either validate or challenge their thinking.

How to Deal With Copious New Information
A common foundation and understanding of information needs to be developed among personnel to proceed in the adaptation process. This can be a time-consuming process.

The workshop format was useful to begin the conversation on how climate change may influence land management and to consider appropriate actions. However, there is much uncertainty associated with climate change, and an enormous amount of climate change information for managers to absorb. Consequently, the planning process should include sufficient time to establish a common foundation of information among participants. In other words, personnel need to be on the same page before they are able to take the next step in the adaptation process, which is to directly incorporate adaptation ideas into projects and planning. Establishing that degree of understanding among all personnel can be a time-consuming process.

Structure for Results
Having more structure to the initial workshops, more prework, or having the workshops expand to several days may help in crafting more specific adaptation actions.

Initial discussions in group settings are often broad and general to explore different perspectives and solicit ideas. Additional steps may be required to distill and refine ideas and consider how these may affect management decisions and priorities. We dealt with this issue through iterative small group (three to four individuals) discussions after workshops. Additional structure may help in developing more specific adaptation options and would also enable more consistent partner participation, as several of the subsequent, small group discussions occurred opportunistically.

The Case for Splitting
The more focused the study emphasis, the more specific the adaptation strategies that resulted.

Bracketing specific disciplines (i.e., hydrology/roads, fish, vegetation, and wildlife) helped to move discussions from generic adaptation ideas, such as increasing ecosystem resilience, to more specific strategies that the agencies can more easily implement. In the vegetation focus area, ONF considered the idea of planting more drought-tolerant species to increase forest resilience, and determined that there are several drought-tolerant, native species that will likely do well in the future on the peninsula, including lodgepole pine and disease-resistant western white pine.
In the hydrology and roads focus area, forest and park engineers discussed the idea of resizing culverts to accommodate increasing streamflow volumes, and ONF proposed two alternative methods for culvert sizing—by using a hydrologic model to predict future peak flows, and by using the last 30 years of record to estimate future peak flows instead of the entire period of record. Plans are underway to explore these approaches.

These focus-area discussions produced tangible strategies. We are not certain that the engineers would have relished the Olympic marmot discussions, nor the wildlife biologists the culvert discussions. Some degree of splitting seemed advantageous.

The Case for Lumping—Synthesis Across Disciplines

Integrating the concepts and plans from various program areas was an important step that should be expanded in future work.

After the various workshops were conducted, we held a synthesis session to compile ideas from the different focus areas, identify common approaches, and determine if any adaptation strategies and actions presented potential conflicts with one another. The synthesis workshop and subsequent small meetings gave resource specialists the opportunity to provide input on adaptation strategies developed in areas outside of their primary area of expertise. For example, the fish biologists could give input on adaptation strategies developed for vegetation management and identify any potential conflicts with fish resources. This synthesis of adaptation options for different focus areas helped refine the adaptation ideas and focus on key strategies that were common across focus areas (see themes section below). The strategies that were common across focus areas are most likely to be implemented, because these strategies are most likely to have the biggest impact. In future adaptation planning, this synthesis portion of the work could be expanded, with periodic integrated discussions (across focus topics) held at regular intervals throughout the planning process.

Making It Real—Incorporate Geospatial Planning

The Olympic Climate Change Case Study process is an excellent first step as the agencies move forward in preparing for a changing climate, but scaling to local actions requires additional work.

To apply results from the workshops, more detailed and site-specific examples would assist managers and other landscape planning efforts. Ideally these adaptation concepts would have geospatial references. For example, the next iteration of planning for fish resources would include delineation of high-priority restoration sites. However, that level of effort was not possible within our funding and time limits.

Dealing With Uncertainty

We used several approaches to work with or around uncertainty, including focusing on changes that have been observed in the past and with recent warming; focusing on similarities between different climate and impacts scenarios, and the most likely and plausible trends; using local knowledge of forest and park specialists to predict system response to climate change; and focusing on no-regrets strategies.

A key lesson learned about dealing with uncertainty is that the full range of future climate and climate change effect projections must be considered when developing adaptation strategies. We quickly realized it was impossible to know the best future projection for any particular area (e.g., hydrology and vegetation), so adaptation strategies must be robust. Adding scenario planning to the exercise would be a useful next step. However, we used several other approaches to work with or around uncertainty to develop tangible adaptation strategies. First, in assessing sensitivity to climate change in each focus area, we considered ecological changes that have been observed with climatic variability in the past or that have already been observed with recent warming. When assessing projected effects of climate change, we focused on similarities between the various future climate and effects scenarios, and the most likely trends. We used local knowledge of ONF and ONP staff and regional scientists to help predict species
and system response to changing climate on the Olympic Penisula. Finally, in developing adaptation strategies, we always focused on no-regrets approaches, or strategies that will increase ecosystem function and resilience regardless of the exact nature of future climate. Additional work will be needed to build on these results, and to integrate with neighboring lands.

Rethinking Management Goals
Climate change challenges current precepts and guidelines, and determining management goals within what may be entirely new ecosystems will be needed.

In the long term, yet still within planning horizons for both agencies, ecosystem changes and disturbances may occur more quickly in systems that have been relatively stable for hundreds or thousands of years. Determining management goals within what may be entirely new ecosystems will be needed. When once we might have observed or monitored, we may now need to undertake manipulative experiments that are different from any current management practices, particularly in the park. Goals that will be appropriate for fire management in environments modified by climate change are unclear. Similarly unclear are goals for wilderness management in potentially highly altered environments of the future. These and other questions indicate the limits of current understanding.

The case study exercise highlighted other situations that challenge our precepts and current guidelines. For example, although specialists may readily accept new concepts of ecosystem change, imagining how to address anticipated new conditions within current guidelines and definitions was sometimes a challenge. This was particularly evident at the wildlife workshop in which participants readily acknowledged that communities will be disrupted, that there will likely be different species assemblages in the future, and that managing for processes may be more important than managing for particular species. In this context, the question of whether the definition of exotic species will be altered with climate-induced changes in species distributions is, as yet, unanswered by ecologists and policymakers. For example, the barred owl arrived relatively recently on the peninsula and scientists have hypothesized that human-caused landscape changes or even recent climate change enabled its population expansion to the west coast of the United States (Kelly et al. 2003). Under current policies, biologists view the barred owl as an invader as opposed to a member of a new faunal assemblage. Climate change, like human structural development, is a human-caused modifier of habitats and ecosystems. As species move in response to habitat loss or gain caused by climate change, new management goals and a new definition for exotics will be needed.

Capacity
The climate change adaptation process benefits from having an individual or individuals dedicated to facilitating the process and also requires focused time from staff specialists.

This case study project had the benefit of full-time assistance from a research ecologist associated with the University of Washington’s School of Forest Resources who organized and facilitated the workshops, invited and scheduled speakers, took notes, synthesized literature, provided presentations of projected climate change effects, and prepared draft manuscript chapters for the case study report. This effort was essential for developing science-based adaptation strategies with sufficient depth for clear application to agency management.

In addition to managing the workload associated with organizing a planning process, focused time from staff specialists is essential. Adaptation or scenario planning added to existing workloads is challenging to implement. To fully develop robust, place-based adaptation strategies, either the responsibilities of staff specialists’ day jobs must be temporarily relieved, or a process established and funded much like watershed analysis conducted under the Northwest Forest Plan (USDA and USDI 1994) to develop adaptation strategies. Climate change could also be incorporated into other appropriate planning efforts. Appropriate facilitation and strong commitments by all parties are essential. Lack of funding or support may hinder progress, but in the face of potential effects of climate change, postponing discussions on adaptation may reduce options for managing potentially adverse conditions in some ecosystems.
Raising Awareness

The workshops helped foster a cultural shift needed to incorporate climate change considerations into thoughts, plans, and actions for managers. This will be an ongoing, continually evolving process.

In some respects, at this early stage, it is less about developing the best adaptation plans and more about raising awareness, engaging a full range of participants, and enabling federal land managers to collectively think in new ways.

Themes in Climate Change Adaptation Strategies at Olympic National Forest and Olympic National Park

Several themes in adaptation strategies and actions emerged during the case study. In all four focus areas, contemplating the projected effects of climate change made the new management paradigm obvious—decisions can no longer assume a future that mirrors historical ecosystem conditions. Given the dynamic nature of climate and ecosystems, maintaining ecosystem function and biodiversity and increasing ecosystem resilience are often cited as suitable goals for adaptation in a changing climate (e.g., Baron et al. 2008, Blate et al. 2009, Dale et al. 2001, Joyce et al. 2009, Millar et al. 2007, Spittlehouse and Stewart 2003). The case study identified numerous ways to maintain ecosystem function and biodiversity and increase resilience to climate change at ONF and ONP. However, the looming questions of determining conditions for considering assisted migration, or redefining exotics, remain for discussion across broader spatial scales.

Workshop participants frequently remarked on the importance of monitoring as a critical element in tracking ecosystem change, and in serving adaptive management efforts to determine effects of management actions. Monitoring, restoration, and protection were often proposed for the most climate-sensitive habitats on the peninsula, including headwater streams and high-elevation ecosystems.

Assessment of current management activities revealed that management strategies at ONF and ONP are generally consistent with those that are likely to increase species and ecosystem resilience to climate change. The case study also helped identify new potential actions, and actions that could be increased or reprioritized, or both. For example, an adaptation strategy for both agencies is to plan for larger and additional culverts on roads. A new strategy for ONF, where managers currently conduct forest thinning to promote late-successional conditions, may be to alter the nature and increase the extent of thinning activities to further increase forest resilience to drought. Prioritization of thinning activities around existing late-successional forest could also help to increase habitat quality for some wildlife species. And although ONF does not currently place large wood in headwater channels to restore natural sediment routing, this will be considered as a way to help restore and protect headwater streams and the species that depend on them. These and other ideas will require more indepth and integrated analysis before implementation.

Next Steps

Collaboration between land and resource management agencies in response to climate change is critical. The Olympic Climate Change Case Study illustrated the utility and success of agency collaboration in climate change adaptation planning. Although differences in mandates and management approaches exist between the forest and park, many ideas were developed about ways that ONF and ONP can work together to adapt to climate change.

Some adaptation ideas can be implemented right away, whereas others may be inappropriate until some of the projected effects of climate change are realized. Alternatively, small-scale experiments can be considered in the near term as a hedging strategy. Scenario planning to describe plausible futures, associated management strategies, and conditions that would trigger one decision over another, is a next logical step to build on this case study. Continual evaluation of the realized and projected effects of climate change will help determine appropriate triggers for specific actions. Future iterations of a process such as the one used in this case study will also likely lead to better informed adaptation actions by natural resource agencies.

Agency policies may either help or hinder collaboration and the adaptation process in general. Except for actions proposed in small areas, or for species that have very
limited range, many adaptation strategies may fail unless managers of large landscapes concur on goals and objectives more broadly than at present. Although it is uncertain exactly how regulations, agency policies, or guidelines may change in the future, they may need to evolve to encourage greater agency collaboration in addressing climate change. Climate change adaptation is a process that requires continued awareness and attention by managers. Staying abreast of available information on potential climate change effects is essential to determine additional ways to incorporate climate change adaptation into management. This case study is a beginning; in the future, we plan to expand its scope and create additional partnerships that will improve the process and products from this work.

Acknowledgments
We thank Ellen Eberhardt for her helpful editing of the entire publication. We also thank Charisse Sydoriak, Karen Bennett, and Jill Dufour for their careful reviews of the report. Robert Norheim created the maps in this publication. Jeffrey Muehleck also helped develop the maps in chapters 2 and 6.

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Climate change and forests of the future: managing in the face of uncertainty. Ecological Applications. 17: 2145–2151.


Adapting to Climate Change at Olympic National Forest and Olympic National Park

English Equivalents

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Van Dyke’s salamander  
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(Van Denburgh, 1906)

Vaux’s swift  
*Chaetura vauxi*  
(J.K. Townsend, 1839)

Violet-green swallow  
*Tachycineta thalassina*  
Swainson

Virginia Opossum  
*Didelphis Virginiana*  
Kerr

Warty jumping slug  
*Hemphillia glandulosa*  
Bland & Binney

Western heather vole  
*Phenacomys intermedius*  
Merriam

Western hemlock  
*Tsuga heterophylla* (Raf.)  
Sarg.

Western redcedar  
*Thuja plicata* Donn ex  
D. Don.

Western toad  
*Bufo boreas* Baird &  
Girard

Western white pine  
*Pinus monticola*  
Douglas ex D. Don

White-tailed ptarmigan  
*Lagopus leucura*  
Richardson

Willow  
*Salix spp.*

Wolverine  
*Gulo gulo* L.

Yellow-bellied marmot  
*Marmota flaviventris*  
Audubon & Bachman

Zebra mussel  
*Dreissena polymorpha*  
Pallas
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Glossary

Adaptation—(1) An adjustment in ecological, social, or economic systems in response to climate stimuli and their effects, which moderates harm or exploits beneficial opportunities; (2) a process, action, or outcome in a system (household, community, organization, sector, region, country) in order for the system to better cope with, manage, or adjust to some changing condition, stress, hazard, risk, or opportunity.

Adaptive capacity—The ability of a system to adjust to changes in climate (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Biodiversity—The sum of species, ecosystem, and genetic diversity

Average conditions (mean and variability) in the atmosphere, ocean, and ice sheets and sea ice over a period of time, ranging from months to thousands or millions of years.

Climate change—Change in climate (in mean state or variability) over time. Climate change can occur as a result of changes in the Earth’s orbit around the sun, cyclical patterns in circulation of the oceans and atmosphere, cycles in the ocean-atmosphere system, or human-caused activities.

Climate envelope models—Statistical models that predict future species distribution based on the relationship between current species distribution and climate variables (and sometimes other variables).

Climate forcing—A mechanism that affects climate (e.g., changes in the composition of the Earth’s atmosphere through greenhouse gas emissions).

Dynamic global vegetation model—Model that is based on soil and climate information that simulate key physiological processes in plant communities to infer vegetation type over time.

Ecosystem—A system of interacting living organisms together with their physical environment. The boundaries of what could be called an ecosystem are somewhat arbitrary, depending on the focus of interest or study, and thus, the extent of an ecosystem may range from very small spatial scales to the entire Earth.

Ecosystem management—(1) Management that integrates scientific knowledge of ecological relationships within a complex sociopolitical and values framework toward the general goal of protecting native ecosystem integrity over the long term; (2) any land-management system that seeks to protect viable populations of all native species, perpetuate natural disturbance regimes on the regional scale, adopt a planning timeline of centuries, and allow human use at levels that do not result in long-term ecological degradation.

Ecosystem resilience—The amount of change or disturbance that can be absorbed by an ecosystem before the ecosystem is redefined by a different set of processes and structures (e.g., the ecosystem recovers from the disturbance without a major phase shift).

Ecosystem services—Ecological processes or functions that have value to individuals or society.

Exotic species—Also referred to as “alien,” “nonnative,” and “introduced” species. These terms refer to any species that is not native to a particular ecosystem. Nonnative species may or may not be invasive.

Exposure—The character, magnitude, and rate of climate change and variation to which a system is exposed.

Gap model—Model that simulates forest interactions and dynamics on a small, gap-sized patch of land (usually 0.02 acre [0.01 hectare] and larger). Gap models can be used to project potential forest response to climate change.

Global climate models—Global climate models (GCMs) are coupled global climate models of the Earth’s atmosphere, oceans, sea ice, and terrestrial biosphere. These computationally intensive numerical models have been under development for many decades and are based on the integration of fluid dynamics, chemical, and sometimes biological equations. They spontaneously exhibit interannual and interdecadal oscillations like those observed in the real Earth system. They are run under different starting conditions and using different amounts of solar, volcanic, and greenhouse gas forcing of the atmospheric dynamics. Using this ensemble approach, various GCMs have successfully simulated the Earth’s climate over the past 1,000 years.
Greenhouse gases—Gases that trap heat in the atmosphere. The main greenhouse gases in the Earth’s atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

Invasive species—A species, usually exotic, with the potential to spread rapidly and cause economic or environmental harm.

Intergovernmental Panel on Climate Change (IPCC)—A scientific intergovernmental body that evaluates the risks associated with human-caused climate change. The United Nations established the panel in 1988. The IPCC has published a series of special reports and periodic assessment reports (approximately every 5 years since 1990).

Native species—A species that historically occurred or currently occurs in a given ecosystem and that has not been introduced through human activities.

Phenology—The timing of an organism’s life history events (e.g., flowering in plants) that are cued by the organism’s environment.

Rain-dominant watershed—A watershed that receives most precipitation as rain. Climate change will likely have minimal impact on timing of streamflow in rain-dominant watersheds.

Restoration—Manipulation of the physical and biological environment in order to restore a desired ecological state or set of ecological processes.

Sensitivity—The degree to which a system will respond to a given stimulus.

Snowmelt-dominant watershed—A watershed that stores most winter precipitation in snowpack. This snowpack melts in the spring and early summer, resulting in peak streamflow in the late spring or early summer and lower streamflow during the winter months. Both increased winter rain (as opposed to snow) and shifts to earlier spring snowmelt with climate change will result in higher winter and spring streamflows and lower summer streamflows in snowmelt dominant watersheds.

Snow water equivalent—The depth of water in the snowpack, if the snowpack were melted.

Special Report on Emissions Scenarios (SRES) emissions scenarios—The SRES was published by the Intergovernmental Panel on Climate Change for their third assessment report in 2001. The report gave details on potential future greenhouse gas emissions scenarios, which are dependent on current and future human activities, to drive global climate models. There are 40 emissions scenarios, all making different assumptions about technological and economic development. Of these 40, the three most commonly used scenarios are the B1 (relatively low future emissions), A1B (moderate future emissions), and A2 (relatively high future emissions).

Stressor—An agent, condition, or other stimulus that can reduce the vigor or functionality of biological entities ranging from species to ecosystems.

Transient watershed—Watersheds located primarily at mid elevations that receive some snow and some rain. Streams and rivers draining transient watersheds often have one streamflow peak in fall or early winter owing to runoff generated by precipitation falling as rain, and another peak in late spring when the snowpack accumulated in midwinter melts. Both increased winter rain (as opposed to snow) and shifts to earlier spring snowmelt with climate change will result in higher winter and spring streamflows and lower summer streamflows in transient watersheds.

Vulnerability—The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climatic variability and extreme.
Disclaimer
To the extent this document mentions or discusses statutory or regulatory authority, it does so for informational purposes only. This document does not substitute for those statutes or regulations, and readers should consult the statutes or regulations to learn what they require. Neither this document, nor any part of it, is itself a rule or a regulation. Thus, it cannot change or impose legally binding requirements on EPA, States, the public, or the regulated community. Further, any expressed intention, suggestion or recommendation does not impose any legally binding requirements on EPA, States, tribes, the public, or the regulated community. Agency decision makers remain free to exercise their discretion in choosing to implement the actions described in this Plan. Such implementation is contingent upon availability of resources and is subject to change.
Preface

The U.S. Environmental Protection Agency (EPA) is committed to identifying and responding to the challenges that a changing climate poses to human health and the environment.

Scientific evidence demonstrates that the climate is changing at an increasingly rapid rate, outside the range to which society has adapted in the past. These changes can pose significant challenges to the EPA’s ability to fulfill its mission. The EPA must adapt to climate change if it is to continue fulfilling its statutory, regulatory and programmatic requirements. The Agency is therefore anticipating and planning for future changes in climate to ensure it continues to fulfill its mission of protecting human health and the environment even as the climate changes.

In February 2013, the EPA released its draft Climate Change Adaptation Plan to the public for review and comment. The plan relies on peer-reviewed scientific information and expert judgment to identify vulnerabilities to EPA’s mission and goals from climate change. The plan also presents 10 priority actions that EPA will take to ensure that its programs, policies, rules, and operations will remain effective under future climatic conditions. The priority placed on mainstreaming climate adaptation within EPA complements efforts to encourage and mainstream adaptation planning across the entire federal government.

Following completion of the draft Climate Change Adaptation Plan, each EPA National Environmental Program Office, all 10 Regional Offices, and several National Support Offices developed a Climate Adaptation Implementation Plan to provide more detail on how it will carry out the work called for in the agency-wide plan. Each Implementation Plan articulates how the office will integrate climate adaptation into its planning and work in a manner consistent and compatible with its goals and objectives.

Taken together, the Implementation Plans demonstrate how the EPA will attain the 10 agency-wide priorities presented in the Climate Change Adaptation Plan. A central element of all of EPA’s plans is to build and strengthen its adaptive capacity and work with its partners to build capacity in states, tribes, and local communities. EPA will empower its staff and partners by increasing their awareness of ways that climate change may affect their ability to implement effective programs, and by providing them with the necessary data, information, and tools to integrate climate adaptation into their work.

Each Program and Regional Office’s Implementation Plan contains an initial assessment of the implications of climate change for the organization’s goals and objectives. These “program vulnerability assessments” are living documents that will be updated as needed to account for new knowledge, data, and scientific evidence about the impacts of climate change on EPA’s mission. The plan then identifies specific priority actions that the office will take to begin addressing its vulnerabilities and mainstreaming climate change adaptation into its activities. Criteria for the selection of priorities are discussed. An emphasis is placed on protecting the most vulnerable people and places, on supporting the development of adaptive capacity in the tribes, and on identifying clear steps for ongoing collaboration with tribal governments.
Because EPA’s Programs and Regions and partners will be learning by experience as they mainstream climate adaptation planning into their activities, it will be essential to evaluate their efforts in order to understand how well different approaches work and how they can be improved. Each Implementation Plan therefore includes a discussion of how the organization will regularly evaluate the effectiveness of its adaptation efforts and make adjustments where necessary.

The set of Implementation Plans are a sign of EPA’s leadership and commitment to help build the nation’s adaptive capacity that is so vital to the goal of protecting human health and the environment. Working with its partners, the Agency will help promote a healthy and prosperous nation that is resilient to a changing climate.

Bob Perciasepe
Deputy Administrator
September 2013
The U.S. Environmental Protection Agency (EPA) Region 10 serves Alaska, Idaho, Oregon, Washington, and 271 federally-recognized tribes.
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Brooks Stanfield and Andrea Westenberger - Office of Management Programs
“Adaptation” refers to efforts by society or ecosystems to prepare for or adjust to future climate change. These adjustments can be protective (i.e., guarding against negative impacts of climate change), or opportunistic (i.e., taking advantage of any beneficial effects of climate change).

Section 1: Introduction

Executive Order EO13514 directed the U.S. Government to address the impacts of climate change, and form an Interagency Climate Change Adaptation Task Force. This task force is co-chaired by the White House Council on Environmental Quality (CEQ), the White House Office of Science and Technology Policy, and the National Oceanic and Atmospheric Administration. There are over 20 federal agencies represented on the task force, including the Environmental Protection Agency (EPA). The task force developed recommendations to the President regarding the integration of climate adaptation into planning, operations, policies, and programs, and each agency was required to develop a climate change adaptation plan.

In response, EPA issued a climate change adaptation policy statement in June 2011, and completed an agency-wide Climate Adaptation Plan in June 2012. These documents directed every Program and Regional office within EPA to develop an Implementation Plan detailing how they will integrate climate adaptation into their work, and address the priorities identified in the agency-wide plan.

To promote consistency, these Implementation Plans have common areas of focus, as outlined below.

Common Areas of Focus for Implementation Plans

1. Vulnerability assessments
2. Priority actions on climate adaptation
3. Agency-wide strategic measures on climate adaptation
4. Legal and enforcement issues
5. Training and outreach
6. Partnerships with tribes
7. Evaluation and cross-office pilot projects

The Implementation Plans are complementary and are meant to work in conjunction with the Agency’s Strategic Plan and Sustainability Plan, and the climate change plans developed by the individual EPA Program Offices. The Implementation Plan for Region 10 will be a living document to be updated over time.

I. Regional Overview

Region 10 serves Washington, Oregon, Idaho, Alaska and 271 Federally Recognized Tribes. In this report, Washington, Oregon, and Idaho are often referred to as the Pacific Northwest. EPA Region 10 represents a diverse geographic region with varying climate, geographic features, social, and ecological
conditions. Region 10 is composed of eight landscape conservation cooperative\(^1\) areas (five in Alaska and 3 in the Pacific Northwest) out of twenty-two Nationwide. This attests to the wide diversity of geographic regions within Region 10. The Pacific Northwest is bordered by the Pacific Ocean to the west and Canada to the north. The region includes the cities of Seattle, Portland, Spokane, Boise, and Tacoma with susceptible populations that are particularly vulnerable to a changing climate.

The Cascade Mountain Range runs north-south through Washington and Oregon, splitting the region. The climate on each side of the mountain range is very different. West of the mountains, temperatures are mild year-round (days below freezing or above 90°F are relatively rare), winters are wet, and summers are dry. East of the mountains, it is typically sunnier and drier over the course of the year, winters are colder, and summers can be significantly hotter. The Pacific Northwest contains many miles of coast line, contains high sage deserts, is composed of large tracks of forest, and consists of several mountain ranges that are critical to maintaining the water resources in the Region.

Alaska presents unique challenges given its geographic location, and that it is the only arctic region in United States. Issues related to permafrost thawing and sea ice melting are unique to Alaska and climate change impacts are being seen in many areas of Alaska and threatening coastal communities, habitats, and infrastructure. Alaska contains more coastline than the other 49 states combined. Alaska contains almost 40% (229 tribes) of the federally recognized tribes in the United States that are particularly vulnerable to climate change given their proximity to coastal areas.

II. Overview of Climate Change Impacts in Region 10

The climate of the Northwest is changing. According to the United States Global Change Research Program (USGCRP) the following changes have or are anticipated to occur in the region.\(^2\) Over the last century, the average annual temperature rose by 1.5°F, with increases in some areas up to 4°F. Changes in snowpack, streamflows, and forest cover are already occurring. Future climate change will likely continue to influence these changes. Average annual temperature in the region is projected to increase by 3-10°F by the end of the century. Winter precipitation is projected to increase while summer precipitation is projected to decrease, though precipitation projections are less certain than those related to temperature. Future climate change impacts would be compounded by pressures related to the region's rapidly growing population.

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\(^1\) Landscape Conservation Cooperatives are public-private partnerships composed of states, tribes, federal agencies, non-governmental organizations, universities and others.

Impacts from climate change are being observed in Alaska. According to the Alaska Climate Change Strategy\(^3\), recent decades of warmer temperature have produced extensive thawing of permafrost, which has resulted in increased coastal erosion, landslides, and sinking of the ground surface, as well as consequent disruption and damage to forests, buildings, infrastructure, and coastal communities. Sea ice off the Alaskan Coast is retreating and thinning, with widespread effects on marine ecosystems, coastal climate, human settlements, and subsistence activities. The Arctic Region, particularly Alaska, is already experiencing major ecological impacts such as the northward expansion of boreal forest in some areas, significant increases in fire frequency and intensity, and unprecedented insect outbreaks.

### Section 2: Region 10 Vulnerability Assessment

This section contains an assessment of the vulnerabilities of Region 10 programs to the impacts of climate change. It builds on the work presented in Part 2 of EPA’s Agency-Wide Implementation Plan, as well as the individual assessments completed by various Program Offices in Region 10. It also draws heavily from existing efforts from the four states in Region 10, as well as the work from the Landscape Conservation Cooperatives in Region 10 and from Tribal assessments. A summary of those efforts is provided below and a more detailed discussion can be found in Appendix A. The vulnerability assessment is structured by the goals in EPA’s FY 2011-2015 Strategic Plan and includes a vulnerability assessment of EPA Region 10 facilities and Tribes. A more detailed discussion of the vulnerabilities and impacts is included in Appendix B. Appendix D provides a comparison of the vulnerabilities identified below with existing Region 10 actions. This information could be used to help focus future actions.

It is important to note that EPA Region 10 did not conduct a quantitative vulnerability assessment, but has qualitatively evaluated the nature and magnitude of risks associated with climate change impacts. The vulnerability assessment is based on the best available information, state and tribal vulnerability assessments, and our own best professional judgment. The assessment does not specifically distinguish timeframes (current, near-term, long-term) for impacts, although it mentions where impacts are already occurring, and it does provide judgments on the likelihood of the impact occurring in the Region. The assessment will need to be updated as our understanding of climate science evolves, and the Region will need to identify the important gaps in our scientific knowledge and technical analyses that are needed to assist in decision-making.

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The overall goal of the Region 10 vulnerability assessment and the detailed discussion of specific vulnerabilities contained in Appendix B and the comparison with vulnerabilities and existing actions in Appendix D are to:

1. Inform staff and managers in Region 10 about the most critical impacts from climate change for their programs;

2. Motivate staff and managers to continue with existing climate change and sustainability work and integrate climate change adaptation into their program work;

3. Serve as a starting point to engage in conversations with EPA partners, especially Tribes, on future actions that are needed to adapt to climate change; and

4. Serve as a qualitative assessment of the baseline set of vulnerabilities, which can be refined as new regional information on climate science and adaptation alternatives become available.

Vulnerable populations are mentioned throughout the document. Certain parts of the population, such as children, the elderly, minorities and the poor, persons with underlying medical conditions and disabilities, those with limited access to information, and tribal and indigenous populations, can be especially vulnerable to the impacts of climate change. Tribes may be more vulnerable to climate change impacts because of dependence upon a specific geographical area for their livelihood; and their unique cultural, economic, or political characteristics and contexts.4

Also, certain geographic locations and communities are particularly vulnerable, such as those located in low-lying coastal areas. One of the principles guiding EPA’s efforts to integrate climate adaptation into its programs, policies and rules calls for its adaptation plans to prioritize helping people, places and infrastructure that are most vulnerable to climate impacts, and to be designed and implemented with meaningful involvement from all parts of society.

I. Region 10 General Vulnerabilities

All four States in Region 10 have identified vulnerabilities specific to their State. A summary of what is included in each State assessment is included below with a more detailed discussion in Appendix A.

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• The State of Oregon has developed a framework that condenses specific vulnerabilities and risks from climate change into 11 overarching categories. They then ranked these into three groups: very likely, likely, and more likely than not.\(^5\)

• The Washington State Department of Ecology has summarized climate impacts in their response strategy.\(^6\) Washington examined projected impacts for sector groupings – e.g., built infrastructure, wildlife & habitat, etc.

• Climate change planning in Idaho is conducted by the Idaho Experimental Program to Stimulate Competitive Research (EPSCoR).\(^7\) The EPSCoR work addresses concerns about how the hydrology in Idaho will change as climate changes in the western U.S.

• The State of Alaska Adaptation Advisory Group describes vulnerabilities including effects that are already occurring in their document *Alaska’s Climate Change Strategy: Addressing Impacts in Alaska*.\(^8\)

• In an effort to understand Tribal cultural resource vulnerabilities, Region 10 reviewed the Swinomish Climate Change Initiative Impact Assessment Technical Report.\(^9\)

• The Tribal Climate Change Adaptation Plan Template provides a summary of the Arctic vulnerabilities and those related to Alaskan Tribes.\(^10\)

The following suite of climate change vulnerabilities and impacts, and their effects on Region 10 Programs is discussed in the sections below. They are discussed individually, or in combinations based on the focus of the Strategic Plan Goal under consideration. A more detailed discussion of the vulnerabilities is in Appendix B.

Based on the assessments described above we developed the following list of the most significant regional vulnerabilities.

1. Increase in average annual air temperature.
2. Decreased/loss of snowpack.
3. Sea level rise.
4. Permafrost thawing.

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\(^{6}\) [http://www.ecy.wa.gov/climatechange/ipa_responsestrategy.htm](http://www.ecy.wa.gov/climatechange/ipa_responsestrategy.htm)


\(^{9}\) [http://www.swinomish.org/departments/planning/climate_change/climate_main.html](http://www.swinomish.org/departments/planning/climate_change/climate_main.html)

5. Sea ice melting.
6. Increase in wildfire frequency and intensity.
7. Increase in ocean temperatures.
8. Increase in ocean acidification.
9. Increase frequency of extreme precipitation events and flooding.
10. Increase in and changing mix of pests.
11. More frequent and severe drought.
12. Increase health impacts.

In addition to the vulnerabilities above, several cultural vulnerabilities were identified in the Swinomish Impact Assessment that may be relevant to other Tribes including:
- Shrinking land base (sea level rise).
- Inundation of coastal sites/artifacts.
- Exposure of burial sites and human remains from strong storm events.
- Loss of cultural use plants.
- Impacts within traditional use areas.
- Historic subsistent natural resources used by indigenous tribes such as fishery resources, wildlife, traditional foods, native plants, and holistic medicines are vulnerable.

These vulnerabilities are discussed when evaluating potential impacts on Regional Office programmatic areas of responsibility. The five goals discussed below are taken from the National Goals to facilitate comparisons across regions. The relationships to Region 10 Goals are also given. Two additional areas of responsibility beyond the five National Goals that are addressed under vulnerabilities are facilities and operations and Tribes and vulnerable populations.

<table>
<thead>
<tr>
<th>Cross Walk between National and Region 10 Goals</th>
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<td><strong>National Goal</strong></td>
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1. Goal 1: Taking Action on Climate Change and Improving Air Quality

Many of the impacts from climate change including increased summer temperatures, increased wildfires, changes in precipitation, and severe weather events are likely to impact both ambient and indoor air quality in the Pacific Northwest and Alaska. These impacts will present new challenges to EPA Region 10 and its partners to ensure the continued protection of public health and the environment.

A. Increase in tropospheric ozone pollution may occur in certain areas due to increased average summertime temperature

There is the possibility that higher summertime temperatures would increase ozone productivity as well as emissions of volatile organic contaminant (VOC) precursors and, there is scientific consensus that climate change will decrease the background ozone in the lower troposphere where the water vapor effect is dominant.\textsuperscript{12} However, from the available academic literature that includes results for the Pacific Northwest, there is no consistent finding about whether climate change will increase, decrease, or have no change on ozone in this region.\textsuperscript{13,14} Potential ozone increases are more likely to occur in the larger metropolitan areas including Spokane, Tacoma, Portland, and Boise. Whether or not these increases will result in violations of the NAAQS health standards however is unknown.

B. Increase in air toxics from anthropogenic sources is uncertain due to variability in effects of temperature increase on individual air toxics.

Many hazardous air pollutants volatilize at higher temperatures, creating the potential for higher emission rates and higher concentrations in ambient air.\textsuperscript{15} The higher concentrations could increase public health risks, including risks for the young, the elderly, the chronically ill, and socioeconomically disadvantaged populations. There is uncertainty however as to actual impacts on hazardous air pollutants (HAPs) concentrations since the boundary layer height will also likely be higher, adding more

\textsuperscript{13} Ibid Jacob and Winner 43 (51-63).
volume of air for the HAPs to mix into. It is also possible for pollutant removal mechanisms to increase as a result of climate change.

C. Increase in particulate matter levels is occurring now and is very likely to increase due to increased frequency or intensity of wildfires due to increased summertime temperatures, prolonged droughts, and decreased soil moisture.

Larger and more frequent wildfires are predicted throughout the region as a result of warmer summertime temperatures, decreased soil and fuel moisture, and increased pest infestations. For example, in the Columbia Basin, the acres of forest burned are projected to double by the 2020s, and triple by the 2040s compared to average burned from 1916 to 2006. This could complicate Agency efforts to protect public health and the environment from risks posed by particulate matter pollution in areas affected by more frequent wildfires. All four Region 10 States have a high percent of forested areas (about 50% for Washington and Oregon) and would all be adversely affected by an increase in wildfires.

D. Indoor air quality is very likely to be impacted, especially in Alaska, due to changes in precipitation, extreme temperatures, more frequent wildfires, and severe weather events.

Deterioration in indoor air quality will increase public health risks including those from respiratory illnesses such as asthma. Public health risks from poor indoor air quality may also increase for susceptible populations - the young, the elderly, the chronically ill, and socioeconomically disadvantaged populations across the region. Alaska’s native and rural populations are very vulnerable to worsening indoor air quality with more insulated housing reducing air circulation - thereby increasing levels of both indoor and ambient pollution. Increased flooding and melting permafrost also worsen indoor air quality by supporting mold growth. This is an issue across the Region, but particularly important in environmental justice (EJ) areas and areas with a high density of more susceptible populations such as in Alaska’s native villages and on tribal reservations in Washington, Oregon and Idaho.

E. Stratospheric ozone layer is likely to be impacted in Alaska due to climate change effects.

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This issue is important in the Arctic (Alaska) where severe depletion of stratospheric ozone has been observed during winter months.\textsuperscript{20} While there currently are no EPA Region 10 programs that directly deal with monitoring or restoring the stratospheric ozone layer, there is enforcement activity against violators related to use and disposal of chlorofluorocarbons (CFC's) and hydrochlorofluorocarbons (HCFC's).

F. Increased rate and deposition of sulfates, nitrates, and mercury is uncertain due to changes in precipitation patterns.

Increased concentrations of sulfates, nitrates, and mercury could cause adverse effects on ecosystems throughout the region, particularly mountain ecosystems and freshwater ecosystems, and could contribute to accumulation of mercury in fish tissue. However, overall effects are uncertain because higher temperatures drive increased chemical reactions and possibly more secondary organic carbon. At the same time, there might be changes to the boundary layer height, airmass ventilation rate, and precipitation. We do not know the relative importance of these effects in Region 10 states.

2. Goal 2: Protecting America's Waters

There are many impacts that climate change may have on our water resources including drinking water and wastewater infrastructure, freshwater fisheries, terrestrial and marine ecosystems, water quality and water quantity, and agricultural and forestry production. These impacts will present challenges as there will be competing demands in some areas for water resources for agriculture, energy production, drinking water, and maintaining streamflows for fish. The section below highlights the main vulnerabilities and impacts identified in Region 10.

A. Drinking water, wastewater, stormwater, and agricultural infrastructure is likely to be impacted by increased heavy precipitation, more frequent flood events, storm surge, coastal erosion, and drought.

Impacts on water infrastructure may result in flooded facilities, an increased number of sewer overflows and wastewater bypasses, as well as increased pollutant loads in runoff, increased pollution of streams and threats to public health.\textsuperscript{21} Climate change impacts drinking water by heightening risk of contamination of surface water sources due to higher temperatures, lower flows, and increased erosion/sedimentation.\textsuperscript{22} Problems of safety as well as access to clean and safe water will be exacerbated for Tribal communities, and other vulnerable and economically depressed communities.


\textsuperscript{22} Ibid. USGCRP.
who have limited access to clean water supplies. Agricultural productivity may be impacted in areas with inadequate water storage capacity and limited agricultural irrigation systems. Adequate summertime water supply for irrigation of crops is essential to agricultural communities east of the Cascades in Oregon, Washington, and Idaho. For tribes, who lack irrigation infrastructure and rely primarily on lakes and streams as water sources, availability of water for agriculture may be more severely impacted by climate change.

B. Impacts to freshwater fisheries is occurring now and is likely to increase due to earlier stream runoff and scouring of streambeds due to earlier snow melt, decreased summer stream flows and increased steam temperatures, and longer periods of low stream flow.

Impacts include loss of salmon habitat and increased stress on salmon reproduction throughout their entire lifecycle. Salmon and other cold water fish constitute a large part of the marine fishery business in the Pacific Northwest, and loss of these fish would have a substantial impact on the Pacific Northwest economy. Coastal Native Americans depend on salmon as an essential part of their diets. There will be secondary impacts on other species in the ecosystem that benefit from salmon – e.g., forests that rely on decaying salmon for nutrients, and bears, eagles, others that feed on salmon. This also applies to other fresh cold water fish. Water resource decision-makers will need to modify watershed planning efforts to include projected impacts of altered stream flows and increased temperatures due to climate change.

C. Estuarine watersheds, aquatic ecosystems, and wetlands are likely to be impacted by sea-level rise, sea surface temperature and increasing heavy precipitation events during the winter months, and decreasing precipitation days and increasing drought intensity during the summer months.

Changes in precipitation patterns, and increased drought intensity will cause stress on wetlands, and forest and mountain ecosystems, and pose challenges to migration of species in these ecosystems to more suitable habitats. Warmer sea surface temperature contributes to sea level rise, increased storm intensity, and greater stratification of the water column. For the Washington, Oregon, and California

coasts north of Cape Mendocino, sea level is projected to change between -4 cm (sea-level fall) and +23 cm by 2030, -3 cm and +48 cm by 2050, and 10–143 cm by 2100.  

D. Forest ecosystems will likely be impacted by warming temperatures and more frequent and intense drought conditions.

Forest tree species are expected to shift their ranges northward and upslope in response to climate change and existing ecosystems will breakup as different species shift at different rates, resulting in the formation of new ecosystems, with unknown consequences. Breakup of existing ecosystems and loss of biodiversity, in combination with increased drought conditions, can make forests more susceptible to destruction by wildfires and insect infestation. In the western United States, both the frequency of large wildfires, and the length of the fire season have increased substantially in recent decades, due primarily to earlier spring snowmelt and higher spring and summer temperatures. Adverse effects are likely in forests across the region, but more immediately in low elevation forests, and forests in drier parts of the region, such as in Idaho eastern Washington and Oregon, and the interior of Alaska.

E. Loss of sea ice is occurring now and will very likely increase in Alaska due to warming air and water temperatures.

Loss of arctic ice in the Bering Sea is adversely affecting Arctic sea ice ecosystems. The Bering Sea fishery is a very important source of seafood and an important factor to Alaska’s economy. The earlier ice melt resulting from warming, however, leads to later phytoplankton blooms that are largely consumed by microscopic animals near the sea surface, vastly decreasing the amount of food reaching the living organisms on the ocean floor. This will radically change the species composition of the fish and other creatures, with significant repercussions for both subsistence and commercial fishing. Sea ice is forming later in the fall in Alaska, making the coastal communities more vulnerable to extreme storms causing coastal erosion in villages.

34 http://www.stormsurge.noaa.gov/event_history.html
F. Ocean acidification is occurring now and is very likely to increase due to increasing concentrations of CO₂ in the atmosphere.

Ocean acidification can lead to substantial decline of marine organisms that form their shells and skeletons from calcium carbonate in ocean waters.³⁵ Adverse effects of ocean acidification on marine organisms have already been documented.³⁶ Specifically, adverse effects of ocean acidification have been documented in pteropods (sea snails),³⁷ a primary food source for salmon in the Pacific Ocean, and in oyster larvae in estuaries on the coast of OR.³⁸ This is an important issue in coastal areas of the Pacific Northwest and Alaska.

G. Change in vegetation is likely in eastern Washington and Oregon and Idaho due to pest outbreaks, invasive species, increased fire, shifts in species ranges and increased erosion, drier soils, and depletion of water.

Climate warming is likely to increase the severity of West Nile Virus (WNv) outbreaks and to expand the area susceptible to outbreaks into areas that are now too cold for the WNv vector.³⁹ Observed and projected decreases in the frequency of freezing temperatures, lengthening of the frost-free season, and increased minimum temperatures can alter plant species ranges and shift the geographic and elevational boundaries of many arid lands. These changes are particularly relevant to the intermountain regions in western North America, the Palouse grassland bioregion, southeastern Washington, and northeastern Oregon.

3. Goal 3: Cleaning Up Communities and Advancing Sustainable Development

Contaminated site cleanup and waste/petroleum management occur under a variety of EPA programs, most commonly Superfund (i.e., remedial, time-critical and non-time critical removals, and emergency response), Resource Conservation and Recovery Act (RCRA), Toxic Substance Control Act (TSCA) (e.g., polychlorinated biphenyls – PCBs), Clean Air Act (CAA) (e.g., asbestos), and the Oil Pollution Act (OPA).

³⁸ Barton, Alan, et. al. 2012. The Pacific oyster, Crassostrea gigas, shows negative correlation to naturally elevated carbon dioxide levels: Implications for near-term ocean acidification effects. Limnology and Oceanography. 57(3).
There are over 100 hazardous waste sites listed on the National Priority List, and many RCRA permitted and corrective action sites in Region 10. Many of these sites are especially vulnerable to impacts from climate change and the potential impacts to infrastructure and in place remedies at corrective action, remedial, removal, and brownfield sites. Also, there may be an increased need for Emergency Response as part of FEMA response.

Region 10 recognizes the importance of sustainable development, and the overlap and intersection with climate change issues. The Region is focusing on coordinating its sustainability efforts internally as well as with our external partners with a specific consideration of climate change.

A. Remedial, removal, brownfield, corrective action or permitted sites may be impacted due to flooding, sea level risk, storm surges, extreme events, and landslides.

There could be an increased risk of contaminant release from hazardous waste sites. Remedial project managers and corrective action project managers may need to alter selected remedies to ensure hazardous substances are not released. In situ remedies (e.g., stabilization, reactive barriers) and on-site above ground treatment systems (e.g., pump & treat, air sparging) could be compromised or overwhelmed if they are not designed to withstand the climate-related events. The net result could be release of contaminants.

Groundwater and subsurface contamination could be impacted by drought and flood conditions. There may be an increased risk of migration of contaminants from flooded containment facilities. Remedies such as caps in contaminated industrial waterways in Washington and Oregon could be subject to (and not designed to withstand) unanticipated scour events.

Possible issues of nuclear waste disposal related to climate change (e.g., locations of storage facilities, appropriate containment, and risk management issues) would also be important at the DOE Hanford facility in Washington State, and the DOE Idaho National Lab facility in Idaho.

B. Increase in work for Alaska’s Tribal and emergency response programs is occurring now and likely to increase due to thawing permafrost and changes in sea ice that leads to damage of roads, runways, water and sewer systems, and other infrastructure.

Melting sea ice and late formation in the fall is causing storms to move in close to shore as the natural buffering system disappears. That is causing rapid coastal erosion, with houses and infrastructure falling into the ocean in several communities. That, along with higher storm, tidal surges flood communities, is requiring more immediate evacuation needs. Open dumps are also impacted by storm surges, and flooding, which increases contamination risk. Permafrost temperatures have increased.
throughout Alaska since the late 1970s. Land subsidence (sinking) associated with the thawing of permafrost presents substantial challenges to engineers attempting to preserve infrastructure in Alaska.

C. EPA Region 10, Tribal and state partners will have increasing workloads in many aspects of site and waste management as well as work related to the formation and implementation of sustainable development and materials management programs, partnerships and initiatives.

Existing trends will exacerbate the challenges of climate adaptation. For example, accelerating development (sustainable or otherwise) and the expected migration of people to Region 10 are issues of concern. It is projected that the population of the States in Region 10 will increase from 11.2 million in 2010 to 13.1 million in 2025. Communities are struggling with how to manage the new people while protecting the environment and providing basic services like energy, water and waste management. In support of the increased sustainability of our communities, our investments in partnerships related to more sustainable materials management are increasing. Waste management can be especially challenging in remote tribal communities in Alaska.

D. Availability of raw materials may decrease and the cost of mining and refining raw materials, producing products, transporting products, and disposing products may increase due to impacts of climate change.

EPA Region 10 will need to put more effort into advocating for sustainable materials management and pollution prevention with States, industry, communities and tribes as climate change affects the availability and cost of raw materials and products. This issue will impact the entire region but may have a greater impact on remote cities and villages in Alaska where transportation and disposal of products is more difficult and costly. For example, increasing pest infestations and forest fires can result in millions of acres of dead, dying, and burned trees in the Pacific Northwest and Alaska. This decreases the availability and drives up the costs of wood products. Thawing permafrost in Alaska results in infrastructure damage in the form of compromised or impassible haul roads for timber and ore, reducing the availability of these natural resources and driving up transportation costs.

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4. Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution

EPA and the states (usually the State Department of Agriculture) register or license pesticides for use in the United States. In addition, EPA must be notified of the importation of pesticides for use in the U.S. EPA receives its authority to register pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Climate change may lead to an increase in pesticide use, due to an increase in pests and diseases which favor warm and humid climates. Also, a changing climate can affect exposures to a wide range of chemicals not just pesticide. Exposures may change because of changing environmental conditions or changing use patterns.

A. Increased exposure and risk to hazardous chemicals may occur due to increasing extreme temperatures and heavy precipitation events, changes in storm intensities, and increasing frequency of floods.

The increased exposures and risk may require adjustments to the relevant risk assessment framework to determine public risk due to modified exposure scenarios and modified toxicity of chemicals due to climate change. Altered weather and severe climate events could also affect the interpretations of risk at RCRA/TSCA and Superfund sites. This is very relevant for permitting and planning activities, where facilities may not have previously required an awareness of risk management for water/flooding, or other climate change impacts. In particular, Puget Sound is vulnerable to these potential impacts of chemical pollution; restoration of Puget Sound is a key ecosystem-level activity in EPA Region 10.\(^4^4\) This is more relevant near sites with large densities of chemical manufacturers, processors and formulators, and RCRA and Superfund sites.

5. Goal 5: Enforcing Environmental Laws

EPA Region 10’s Office of Compliance and Enforcement (OCE) is charged with ensuring compliance with environmental requirements and enforcing against violations to those requirements in the Pacific Northwest and Alaska. In that capacity, OCE’s vulnerabilities are uniquely tied to interactions with the regulated community. Some types of vulnerabilities (e.g., difficulties with maintaining staff functionality due to power outages and physical damage to facilities due to extreme weather) would be similar to those experienced by all EPA programs and regions.

Other vulnerabilities are more specific to OCE, such as those which impact the ability of regulated entities to comply with environmental requirements and with our ability to determine such compliance.

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and take appropriate action. The vulnerabilities of greatest importance for OCE are conditions/events which would compromise our ability to ensure compliance with environmental requirements by regulated entities and, where necessary, to take effective enforcement action in case of violations. The activities impacted would include: compliance assistance; compliance monitoring and civil enforcement.

A. **Non-compliance at regulated entities may increase due to extreme weather events and changing weather patterns.**

Compliance and enforcement programs under the Clean Water Act (CWA) have the potential to see an increase in violations from many situations including sanitary sewer and combined sewer overflows, violations of percent removal at wastewater treatment plants (due to limited water flow as a result of drought), violations in bypasses due to the inability of wastewater treatment plants to treat a flow in excess of the design capacity, and increased violations in numerous programs due to failure of existing infrastructure protecting against extreme weather events. In addition, CWA section 311 (Spill Prevention Control Countermeasures) may see an increase in non-compliance along Alaskan coastal areas that have oil storage containers, as a result of sea ice melting (thereby increasing storm surges along those coastal areas) and increased flooding.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) compliance and enforcement programs may see violations at Pesticides Producing Establishments as there is a shift toward increasing pesticide usage, productions and imports. As weather patterns change in the Region, the habitats of insects and pests may also change, bringing different pests and diseases to areas.

The RCRA program may see increased non-compliance at landfills due to changes in precipitation patterns (including more precipitation in some cases and more extreme precipitation events in other cases). Landfills may generate excessive hazardous leachate, see unexpected mobilization of contaminants in the waste column, and/or experience failure of the liner or leachate collection systems.

B. **Shift in regional enforcement priorities due to changes in compliance (both increased compliance and non-compliance in different sectors) and increased number of inquiries from industry about maintaining compliance due to extreme weather events and changing weather patterns.**

If an increase in violations in various programs and industry are identified, OCE may shift the enforcement focus to address those violations. Conversely, OCE may use discretion to refocus enforcement priorities when localized extreme weather events (e.g., flooding) greatly impact the regulated community or when a change in weather patterns decreases the potential for non-compliance (e.g., less precipitation could decrease surface runoff). This will be most important in states where EPA has direct implementation of an enforcement program (e.g., Idaho for NPDES program), on Tribal lands, and non-delegable programs (e.g., Chlorofluorocarbons, CWA 311 (SPCC), and PCBs). In states with
authorized program implementation, OCE’s work share could change as a result of climate change shifting states’ priorities.

OCE may need to make adjustments to normal workload to address an increase in industry’s compliance inquiries. There may need to be reassignment or delay of normal work duties as staff provides response support to those inquiries in a timely manner. Requests may also be received from Regional state counterparts regarding guidance to address unique enforcement issues as a result of extreme weather events or changing weather patterns.

C. Increased permitting of Class VI Underground Injection Control (UIC) wells for Carbon Dioxide sequestration and Class V UIC wells for stormwater management.

EPA has developed criteria for Class VI wells, used specifically for the injection of carbon dioxide into underground subsurface rock formations for long-term storage. As the need to reduce carbon dioxide emissions into the atmosphere increases, various technologies including Class VI wells will be deployed. OCE may need to reassign or delay other UIC permitting and enforcement work, as permit requests for Class VI wells increase. This will be seen across the Region, until permitting and enforcement of the Class VI well program is delegated to the states.

As the amount of stormwater increases with increased precipitation levels, industries regulated to manage stormwater and associated discharges may be faced with challenges surrounding the volume of stormwater to manage. Class V wells are designed to receive stormwater, as a substitution for or in addition to discharging stormwater through more traditional means. OCE may see an increase in permitting Class V wells, as challenges managing high volumes of stormwater increase. Permitting will be focused on Class V wells in Alaska and Tribal lands, as the Region implements this program in these areas.

D. An increase in regulated industrial activities in Alaska may result as the melting of sea ice opens new areas for activities.

Sea ice off the Alaskan Coast is retreating and thinning. This reduction of sea ice is very likely to increase the navigation season and create a seasonal opening of the Northern Sea Route to likely make trans-arctic shipping and transport feasible during summer months. As areas and routes become more accessible, there is a potential for industrial activity (e.g., oil and gas extraction) to become more active in these areas. As a result, OCE may see an increase in regulated entities.

E. An increase in non-compliance at facilities with Underground Storage Tanks (UST) holding ethanol-blended fuels.
Storage of ethanol-blended fuels in USTs requires compatibility with the materials and equipment of the tank system. The ethanol fuel blends may be more aggressive to certain UST tank systems, compared to petroleum, due to their chemical and physical properties. As the need increases to use and store fuels that produce fewer greenhouse gas emissions, the UST enforcement program may see an increase with incompatibility.

6. EPA Facilities and Operations

The main EPA Region 10 building is in Seattle with field offices in Olympia, Portland, Boise, Anchorage, and Juneau. The Region also maintains an environmental laboratory in Manchester, Washington. The Region has a Continuity of Operations Plan (COOP) that describes efforts to prepare and react to issues affecting the operation of our facilities and a Regional Incident Command Team (RICT) who is responsible for responding to any emergency situation. In general, the EPA Region 10 facilities are not uniquely vulnerable to climate change impacts. The Manchester Lab is located on the shoreline and could be more susceptible. They have an emergency operation plans in the event of extreme weather events or other possible impacts from climatic change.

A. Drinking water may be limited and an increase in demand for air conditioning is possible due to increasing drought frequency and intensity.

Facilities could be located in areas with water shortages, requiring water rationing. There is likely to be a greater demand for electricity for air conditioning during the summer months. Increased extreme temperature at any Region 10 office would put higher demand on drinking water and electricity for cooling. This could impact the regional office and all the operations office.

B. Operations of Region 10 facilities may be impacted by increasing risk of floods and increasing intensity of storms.

Facilities in flood-prone areas may have to temporarily close. Personnel engaged in field work may be more vulnerable to extreme temperatures or storm events. Personnel and real property supporting emergency response and management may be at risk during flooding or extreme weather events. Ongoing work at the Manchester Environmental Laboratory may be disrupted with effects on many different programs. Closure of regional offices due to climate change related damage could prevent staff from carrying out important functions. The Regional Office in Seattle is located in an area with low probability for flooding or sea level rise. Region 10 has flexiplace options available to staff and a COOP in place in case any Region 10 office is damaged by flooding or storms or transportation to/from offices are affected (e.g., flooded roadways; landslides on commuter train tracks).
7. Tribal and other Vulnerable Populations

As part of the EPA’s direct federal implementation and oversight responsibilities, EPA Region 10 has a trust responsibility to each of the 271 federally recognized Indian tribes within the Region. Many Tribes are especially vulnerable to climate change impacts due to their reliance on traditional hunting and fishing and their connections to the land and sea. Climate change is threatening access to traditional foods such as salmon, marine mammals, shellfish, and terrestrial and aquatic plants which are used for cultural, medicinal, and economic purposes as well as a primary food source. Tribes have already experienced many climate-related changes including changes in salmon habitat, drought, declining water tables, increased wildfires that impact crops, wildlife, traditional foods and medicines, earlier spring snow melt, a decrease in sea ice, and permafrost thawing. EPA Region 10 is committed to work with the Tribes to adapt to these changing conditions.

The impacts of climate change can have unique effects on the health of children. Children are different from adults in how they interact with their environment and how their health may be affected. Because of their unique physical, biological, and social characteristics they are likely to suffer disproportionately from both the direct and indirect adverse health effects of climate change. The impacts of climate change raise environmental justice issues. Climate change is likely to exacerbate existing and introduce new environmental burdens and associated health impacts in communities dealing with environmental justice challenges across the nation.

A. Food security for native Alaskans and Tribal people in the Pacific Northwest who live a subsistence lifestyle may be at risk due to warming associated with climate change.

Warming due to climate change reduces the availability and accessibility of many traditional food sources for Native Americans. People face losing their healthiest foods, their communities, and in some cases, their culture, since each of these depends on traditional ways of collecting and sharing food. Climate change will continue to impact and put stress on salmon in the Pacific Northwest along with other traditional foods such as wildlife, berries, and roots. In Alaska, climate change will reduce the availability and access to ice seals, walrus and caribou and access to shellfish and plants used for medicinal and cultural ceremonies.

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45 Pediatrics, Global Climate Change and Children’s Health, Committee on Environmental Health. 2007. Available at http://pediatrics.aappublications.org/content/120/5/1149.full.pdf
B. Increased erosion of shorelines is likely to increase risk to coastal native communities due to increased intensity of coastal storms and rising sea levels.

Coastlines and shorelines throughout the Pacific Northwest and Alaska are increasingly threatened by a combination of increasing storm activity, loss of its protective sea ice buffer, declining habitat, and thawing coastal permafrost. In Alaska, over 100 villages on the coast and in low-lying areas along rivers are subject to increased flooding and erosion due to warming. Federal, state, and tribal officials have identified 31 villages that face imminent threats. At least 12 of the 31 threatened villages have decided to relocate—in part or entirely—or to explore relocation options. Federal programs to assist threatened villages prepare for and recover from disasters and to protect and relocate them are limited and unavailable to the majority of villages. At least one Pacific Northwest Tribe, the Hoh Tribe is planning to relocate due to erosion and storm security.

C. Decreased access to clean drinking water is very likely due to loss of permafrost and reduced snowpack.

In many rural Alaskan tribal communities, the loss of permafrost can cause many problems including the loss of drinking water sources because tundra lakes, from which drinking water is drawn, are disappearing with the permafrost. Also, melting permafrost destabilizes foundations, endangering the sewer and water infrastructure in these communities and without permafrost, the untreated leachate from open dumps may be a contamination risk for their water supply. Pacific Northwest Tribes may also experience water scarcity, due to failing aquifers and less rainfall. With the reduced snow pack and increased seasonal drought, many traditional drinking water sources are not being replenished.

D. Reduced availability of fish and shellfish resources is occurring now and is likely to increase due to changing water conditions.

Climate change is bringing rapid and adverse habitat challenges, from changing stream flows to warming waters that are having an impact on the viability of juvenile salmon to the impacts of ocean acidification on salmon, crustacean, and shellfish food sources. Seafood is central to diet, physical, and cultural well-being of Tribal lifeways. Increasing ocean acidification threatens shellfish beds that Tribes have harvested for millennia. Ocean acidification may reduce rates of shellfish larval survival and weaken the shells of the adults, thus making them more vulnerable as well.


E. Vulnerable population such as children, the elderly, poor, and the infirm may be at increased health risk due to increased temperatures, failing infrastructure, and extreme weather events.

Children playing in areas with higher ozone levels resulting from increased temperature will be at higher risk for experiencing asthma symptoms. The elderly are more vulnerable to heat stress because they are often in poorer health and are less able to regulate their body temperature during periods of extreme heat. Economic constraints can also place low-income households at disproportionate risk to extreme heat events due to lack of air condition or failure to use air-conditioning to cut down on associated energy costs.

Section 3: Region 10 Priority Existing Actions

The sections below present the existing actions EPA Region 10 is taking to address the identified vulnerabilities and their associated impacts. These existing actions are from commitments in the EPA Region 10 Strategic Alignment Plan and existing actions identified by the program offices in EPA Region 10. The actions are summarized below for each EPA Region 10 office. A more complete description of the actions can be found in Appendix C. Also, Appendix D compares the vulnerabilities identified in Section 2 with the existing Regional actions by National or Regional goals.

Appendix D indicates that there are Regional vulnerabilities where there are no existing actions. Since this document’s focus is existing actions, EPA Region 10 will evaluate how to address critical vulnerabilities in the future. In addition, Region 10 will evaluate how to better integrate climate change into its existing core programs along with engaging states, Tribes and other partners to adapt to changing environmental conditions.

EPA Region 10 has developed the following criteria that can be used for evaluating priority actions in the future.

- Actions that address an identified vulnerability in Region 10.
- Actions that align with EPA national or regional priorities for climate change.
- Actions that will assist tribes in adapting to climate change.
- Actions that are linked to sustainability and environmental justice.
- Actions that increase awareness of climate change for EPA Region 10 staff.
- Actions that promote integration of climate change into EPA Region 10 program operations.
- Actions that increase awareness and collaboration with outside partners including tribes.
- Actions where EPA has a unique role or capacity to address the issue.
1. Office of Air, Waste, and Toxics (OAWT)

EPA Region 10’s Office of Air, Waste, and Toxics (OAWT) carries out air, waste and chemicals management programs under statutory authorities such as the Clean Air Act (CAA), Resource Conservation and Recovery Act (RCRA), the Toxic Substances Control Act (TSCA), the Pollution Prevention (P2) Act, and the Diesel Emission Reduction Act (DERA), and carries out TSCA enforcement actions dealing with lead-based paint and asbestos. Many of OAWT activities reduce greenhouse gas emissions. OAWT is currently also involved in the following Region-specific actions that address the climate change vulnerabilities identified in the previous section for Goals 1, 3 and 4.

Air Toxics (Goal 1)
• Work with the West Coast Collaborative to reduce evaporative losses of air toxics from fossil fuels.

Indoor Air (Goal 1)
• Develop and host training for professionals (housing, medical, schools) on making indoor environments healthier for the most vulnerable.

Materials Management and Pollution Prevention (Goals 3 and 4)
• Work with our partners through the West Coast Climate and Materials Management Forum and our pollution prevention technical assistance providers and grants to assist in the transition to sustainable materials management processes and source reduction.
• Recruiting and retaining participants for the Federal Green Challenge and for the Food Recovery Challenge in support of the EPA’s Sustainable Materials Management (SMM) Program.

Tribal Waste Management (Goal 3)
• Work with federally recognized tribes in Region 10 to address landfills and unconfined open dumps which are impacted by climate change and help develop appropriate responses to these threats.

RCRA Corrective Action and Permitting (Goal 4)
• Incorporating green remediation in corrective action decision-making.
• Raising issues nationally regarding the potential impacts of climate change on alternative landfill covers.

2. Office of Water and Watersheds (OWW)

EPA Region 10’s Office of Water and Watersheds (OWW) implements programs under the CWA, Safe Drinking Water Act (SDWA), and parts of the National Environmental Policy Act (NEPA). Also, OWW provides funds for Puget Sound via the National Estuary Program to support climate change adaptation projects. OWW’s current focus is on increasing awareness for Regional staff and partners on the science
of climate change and strategies for adaptation to meet this goal. Many of these actions will benefit from the development and implementation of appropriate national guidance to promote consistency across the states. The Region will implement these actions in coordination with any related national guidance. The actions mainly focus on addressing the vulnerabilities for Goal 2.

**Drinking water, wastewater, and stormwater infrastructure (Goal 2)**
- Work with the State of Alaska to identify alternative technologies for providing first time service to unserved homes in a more sustainable way compared to a traditional piped system.
- Work with the Water Sense program to encourage water efficiency in homes, landscaping and commercial buildings with a focus on new homes.
- Continue implementing the Sustainable Energy Management Program with a Western Washington cohort of drinking water and wastewater utilities.

**Freshwater fisheries (Goal 2)**
- Continue with pilot program examining how to integrate climate change in an ongoing total maximum daily load (TMDL) by examining how temperature can be improved in the Nooksack watershed in order to support salmon restoration.

**Puget Sound (Goal 2)**
- Continue to support projects in Puget Sound related to climate change. There are several on-going projects that are highlighted in Appendix C.
- Work with the University of Washington to develop a system for visualizing and analyzing a variety of climate change-related features that are shifting with time and probability across the Region.

**Training and Outreach (Goal 2)**
- Inform and educate water program managers in the public and private sectors on climate change and water issues and EPA related activities such as the National and Regional climate change adaptation strategies.
- Work with States, Tribal governments, municipalities, non-profit organizations and businesses to promote the Climate Ready Water Utilities (CRWU) and Climate Ready Estuaries (CRE) Programs and new Climate Ready Resilience and Awareness (CREAT) Version 2.0.
- Support Development of a Climate Change Section in the “Green” Paper for the State Revolving Loan Funds and Annual Review Checklists.

### 3. Office of Ecosystems, Tribal, and Public Affairs (ETPA)

EPA Region 10’s Office of Ecosystems, Tribal, and Public Affairs (ETPA) implements cross-program efforts to protect the environment and engage communities and leads Regional efforts related to Freedom of Information Act requests, environmental justice, and sustainable agriculture. ETPA’s focus is to ensure
consideration of climate change on projects via NEPA review process, incorporating climate change science in wetlands management, providing assistance to Region 10 Tribes for climate change activities, and supporting activities that address children’s health and other vulnerable populations.

NEPA Review (Goal 2)
- Through the NEPA review process ensure consideration of climate change in review of all federal projects and incorporate climate change adaptation into land management planning and other projects as appropriate.
- Include ocean acidification language in NEPA review comment letters as appropriate and develop template language in letters and example NEPA analyses that include ocean acidification information.

Wetlands (Goal 2)
- Coordinate a Wetlands and Climate Change Research Meeting focused on new approaches and tools to better understand, manage, and conserve wetlands in a changing climate.
- Incorporate climate change considerations into the CWA 404 regulatory program as they relate to permit reviews and compensatory mitigation.
- As resources allow, improve baseline information on wetland extent, condition and performance to inform effective adaptation to climate change.
- Integrate climate adaptation in the FFY13/14 Region 10 Wetland Program Development Grants RFP by considering how the design and installation of demonstration projects would take relevant potential impacts from climate change into account when considering long-term viability.53

Ocean Programs (Goal 2)
- Participate in interagency development and implementation of federal strategies through the National Ocean Council (NOC) and the National Ocean Policy Implementation Plan

Tribes (Multiple Goals)
- Support Tribes to develop adaptation actions (plans), to document impacts from climate change and to engage in the collaboration with local, state and federal agencies working on broad based adaptation plans.
- Provide Indian General Assistance Program (IGAP) funding as appropriate to Tribes with climate change in their IGAP workplans to do baseline environmental assessments and support adaptation planning.
- Raise awareness by providing educational outreach, training, and webinars to Tribes and work with the Institute for Tribal Environmental Professionals on tribal climate change adaptation models and resources.
- Support Tribal projects on climate change in Puget Sound through the National Estuary Program. A listing of those projects is included in Appendix C.

• Assist Tribes to build capacity and knowledge and assess and address air quality concerns including those related to climate change through the Regional Clean Air Act Grants.

• Support the Rural Alaska Children’s Health Initiative which works to protect children from harmful environmental exposures in rural Alaska, including factors related to climate change.

Community Health (Regional Goal 7)

• Through work on children’s health, develop and host training for professionals in the housing, health and educational fields on making indoor environments healthier for the most vulnerable populations.

• Provide technical assistance and training to affected communities on risks associated with poor outdoor air quality (e.g., work with Tribal Air Program and convene Rural Alaska Children’s Environmental Initiative).

• Outreach/risk communication to vulnerable and economically deprived communities.

• Work with Department of Housing and Urban Development, Department of Transportation, and Urban Sustainability Directors Network on promoting sustainable communities via housing, transportation, and transit.

4. Office of Environmental Clean-Up (ECL)

EPA Region 10’s Office of Environmental Clean-Up (ECL) is responsible for investigating contaminated properties; cleaning up contaminated land, sediment, and water for appropriate uses; emergency response; emergency planning and spill prevention; and Homeland Security and counter terrorism preparedness. ECL works closely with communities and interested stakeholders, providing funding in some cases to facilitate meaningful engagement in the Superfund process. ECL has focused on green remediation strategies for specific sites, and the reduction of carbon and toxic emissions and reducing overall environmental footprint of clean-up activities. There are no specific adaptation activities currently underway in ECL.

5. Office of Compliance and Enforcement (OCE)

EPA Region 10’s Office of Compliance and Enforcement (OCE) provides enforcement, compliance monitoring, and compliance assistance for ground water, pesticides and toxics, wastewater (NPDES), air, and solid and hazardous waste (RCRA) programs. Regional and national enforcement priorities change. OCE is positioned to be flexible and use discretion when deciding those enforcement priorities, even as those priorities are influenced by climate change. OCE has several ongoing activities all of which fall under Goal 5.

• Continue to use an Environmental Justice Screening tool to identify regulated facilities located in overburdened communities.
• Continue enforcement in small programs that have climate change influence such as the Clean Air Act Mobile Source Enforcement Program.
• The UIC program will continue to permit several Class I wells for underground injection of wastes to reduce the need to establish waste retention ponds on the increasingly vulnerable permafrost.
• Continuing to support the Regional Support Corps by deploying staff for varying emergency response efforts.
• RCRA enforcement is evaluating land-based units which have received hazardous waste and determining the extent to which changes in precipitation amounts and evaporation levels must be considered in protective management standards and closure requirements.
• Continue to look for opportunities to encompass green infrastructure as part of settlement agreements.

6. Office of Regional Counsel (ORC)

The Region has broad legal mandates to protect human health and the environment and therefore, broad legal authority to support adaptation work. In the course of adaptation planning, specific questions will likely arise that will need legal review. As there is variation among the statutes EPA administers, as well as the regulatory programs EPA designs, implements, and enforces under those laws, the best way for ORC to support adaptation efforts is to provide legal analysis on a case by case basis. ORC will also support each of the regional program offices by coordinating with the Office of General Counsel, offices of Regional Counsel in other regions, and the Office of Enforcement and Compliance Assurance, as necessary to provide legal advice to the regional program offices.

7. Office of Environmental Assessment (OEA)

EPA Region 10’s Office of Environmental Assessment (OEA) provides scientific and technical expertise in assessing the condition of the environment to support program decision-making and scientific initiatives. OEA collects and analyze data to characterize the environment, investigate environmental problems, and evaluate proposed solutions. A major emphasis of the OEA’s activities are related to raising awareness on the science of climate change to staff in the Regional office, to integrate climate change into the core program work, and to work with external partners to better coordinate the work and increase collaboration. OEA has several ongoing activities that address of the goals.

• Provide outreach/trainings to increase awareness of climate science to regional staff and partners.
• Work with individual programs and cross-office projects to integrate climate science into core program work.
• Communicate with the public about hazards posed by climate change and actions being taken by the EPA to address climate change.
• Coordinate with other federal agencies by participating on the Climate Change Cooperative and supporting the Regional Landscape Conservation Cooperatives.
• Participate on the National Tribal Science Council, and support actions related to climate change and tribes.

Section 4: Developing Measures, Monitoring and Evaluating Performance

Evaluating progress is important because there will be “learning by doing” over time as we mainstream climate adaptation planning into our programs. We will monitor the outputs and outcomes of our actions so we can learn what works – and why, and what doesn’t work – and why not. This will allow us to continually improve the effectiveness of our mainstreaming efforts and share our lessons learned with other regions and our national programs. An evaluation process will be developed during the first year of implementation to learn how to best capture desired outcomes, some of which will come as staff integrates climate science into programmatic work. Appendix C provides more details on the Region 10 approach to develop and measure specific metrics.

Section 5: Legal and Enforcement Issues

The legal and enforcement issues were discussed in Sections 2 under Goal 5: Enforcing Environmental Laws and in Section 3 under the Office of Compliance and Enforcement and Office of Regional Counsel.

Section 6: Training and Outreach

The specific actions related to training and outreach is discussed in Section 3. Training and outreach is a critical part of Region 10’s Implementation Plan. One of the primary tasks of the Regional Climate Change Advisor is to provide training and outreach for both Regional staff and partners. The goal of the training and outreach is to provide the foundation for programs to integrate climate science into their core program work.

Section 7: Partnerships with Tribes

As part of the EPA’s direct federal implementation and oversight responsibilities, EPA Region 10 has a trust responsibility to each of the 271 federally recognized Indian tribes within the Region. EPA values
its unique government-to-government relationship with Indian tribes in planning and decision making. This trust responsibility has developed over time and is further expressed in the 1984 EPA Policy for the Administration of Environmental Programs on Indian Reservations and the 2011 Policy on Consultation and Coordination with Indian Tribes. These policies recognize and support the sovereign decision-making authority of tribal governments.

Supporting the development of adaptive capacity among tribes is a priority for the EPA. Indigenous peoples are particularly vulnerable to the impacts of climate change due to the integral nature of the environment within their traditional lifeways and culture. There is a strong need to develop adaptation strategies that promote sustainability and reduce the impact of climate change on Tribes and tribal members.

EPA engaged tribes through a formal consultation process in the development of the Agency’s Climate Change Adaptation Plan. Tribes identified some of the most pressing issues as erosion, temperature change, drought and various changes in access to and quality of water. Tribes recommended a number of tools and strategies to address these issues, including improving access to data and information; supporting baseline research to better track the effects of climate change; developing community-level education and awareness materials; and providing financial and technical support. At the same time, tribes challenged EPA to coordinate climate change activities among federal agencies so that resources are better leveraged and administrative burdens are reduced.

EPA Region 10 plans to partner with tribal governments, in collaboration with other Federal agencies, on an ongoing basis to increase their adaptive capacity and address their adaptation-related priorities. These collaborative efforts will benefit from the expertise provide by our tribal partners and the Traditional Ecological Knowledge (TEK) they possess. TEK is a valuable body of knowledge in assessing the current and future impacts of climate change and has been used by tribes for millennia as a valuable tool to adapt to changing surroundings. Consistent with the principles in the 1984 Indian Policy, TEK is viewed as a complementary resource that can inform planning and decision-making.

Networks and partnerships already in place will be used to assist tribes with climate change issues, including Regional Tribal Operations Committees, the Institute for Tribal Environmental Professionals and IGAP. Additionally, efforts will be made to coordinate with other Regional and Program Offices in EPA and other partners such as other federal agencies, since climate change has many impacts that transcend media and regional boundaries. Transparency and information sharing will be a focus, in order to leverage activities already taking place within EPA Offices and tribal governments.

Section 8: Vulnerable Population and Places
As mentioned in Sections 1, 2 and 3, certain parts of the population, such as children, the elderly, minorities, the poor, persons with underlying medical conditions and disabilities, those with limited access to information, and tribal communities, can be especially vulnerable to the impacts of climate change. Also, certain geographic locations and communities are particularly vulnerable, such as those located in low-lying coastal areas. One of the principles guiding EPA’s efforts to integrate climate adaptation into its programs, policies and rules calls for its adaptation plans to prioritize helping people, places and infrastructure that are most vulnerable to climate impacts, and to be designed and implemented with meaningful involvement from all parts of society.

This Implementation Plan identifies key programmatic vulnerabilities and the priority actions that will be taken to address those vulnerabilities over time. As the work called for in this Plan is conducted, the communities and demographic groups most vulnerable to the impacts of climate change will be identified. The Agency will then work in partnership with these communities to increase their adaptive capacity and resilience to climate change impacts. These efforts will be informed by experiences with previous extreme weather events (e.g., Hurricane Katrina and Superstorm Sandy) and the subsequent recovery efforts.

Section 9: Cross-Office Pilot Projects

Developing cross-office pilot projects is a vital role for the Region 10 Climate Change Advisor. Region 10 has a TMDL pilot project described in Appendix C on the Southfork of the Nooksack River. We anticipate building on that success using the same approach of outreach at the unit or office/program level to increase awareness of vulnerabilities and available science. At the same time, we will collect input on climate science needs and ideas on how the science might be incorporated into day-to-day decisions. To keep the process sustainable, OEA provides some initial assistance and looks for partners to provide some further assistance.
APPENDICIES

Appendix A: Vulnerabilities Identified by Region 10 States and Tribes

Appendix B: Detailed Description of EPA Region 10 Program Vulnerabilities

Appendix C: Detailed Description of EPA Region 10 Existing Actions

Appendix D: Comparison of Vulnerabilities and EPA Region 10 Existing Actions

Appendix E: EPA Region 10 Approach for Measuring Success
Appendix A: Vulnerabilities Identified by Region 10 States and Tribes

Oregon
The State of Oregon has developed a framework that condenses specific vulnerabilities and risks from climate change into 11 overarching categories. They then ranked these into three groups: very likely, likely, and more likely than not. While the framework does not indicate a formal peer review was conducted, the Oregon Climate Change Research Institute (OCCRI) assisted in the development of the framework and the risks are fully documented with extensive citations. The categories and ranked risks are:

**Very Likely Risks:**
- Increase in average annual air temperatures and likelihood of extreme heat events that also increase water temperatures
- Changes in hydrology and water supply; reduced snowpack and water availability in some basins; changes in water quality and timing of water availability

**Likely Risks:**
- Increase in wildfire frequency and intensity
- Increase ocean temperatures, with potential for changes in ocean chemistry and increased ocean acidification
- Increased incidence of drought
- Increased coastal erosion and risk of inundation from increasing sea levels and increasing wave heights and storm surges
- Changes in abundance and geographical distributions of plant species and habitats for aquatic and terrestrial wildlife
- Increase in diseases, invasive species, and insect, animal, and plant pests
- Loss of wetland ecosystems and services

**More likely than not Risks:**
- Increased frequency of extreme precipitation events and incidence and magnitude of damaging floods
- Increased incidence of landslides

Washington
Similarly, Washington State Department of Ecology has summarized climate impacts in Preparing for a Changing Climate: Washington States’ Integrated Climate Response Strategy. The information below is a summary of the Ecology document and the references are included in their document and they are not repeated here. Washington examined projected impacts for sector groupings – e.g., Built Infrastructure, Wildlife & Habitat, etc. They also worked with University of Washington’s Climate Impacts Group to understand how the impacts might affect the different sector groups, with the goal of prioritizing actions within those groups and developing coordinated strategies. The impacts include the scientific evidence and are summarized into the following groups:

**Warmer temperatures and more severe heat waves:** In the Pacific Northwest, average annual temperature rose 1.5 °F between 1920 and 2003. Climate scientists’ project average annual temperatures in the Pacific Northwest will rise 2°F by the 2020s and 3.2°F by the 2040s, compared with 1970-1999 averages. Heat waves are projected to occur more often and last longer.

**Larger and more intense wildfires:** Researchers project that the area burned by fire each year in the Columbia Basin will double or triple by the 2080s, compared to the 1916-2006 average. Costs of fighting wildfires are expected to rise and risks to communities, the environment, and wildlife are expected to increase.

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55 http://www.ecy.wa.gov/climatechange/ipa_responsestrateg.htm
Drier summers and wetter autumns and winters: Downscaled climate models project that summer precipitation will decrease and autumn and winter precipitation will increase. Washington could experience more intense rainfall events more often.

Decreased snowpack and loss of natural water storage: In Washington’s Cascades, average snowpack declined about 25 percent between 1950 and 2006. Spring snowpack across Washington State is projected to decrease 28 percent by the 2020s and 40 percent by the 2040s relative to the 1916-2006 average, and snowmelt is expected to occur earlier in the spring.

More frequent and severe drought: Increasing temperature, declining snowpack and earlier snowmelt will increase the risk of summer water shortages and increase the demand for water. The amount of water available for communities, irrigation, fish, hydropower generation, recreation, and other uses will be affected and competition for water will increase.

More severe winter flooding: Although the risks vary by location, Washington is expected to experience more severe winter flooding during the winter due to more precipitation falling as rain instead of snow in the mountains. More severe winter flooding poses challenges for managing reservoirs for flood control, fish, and hydropower production. Damages and repair costs for vulnerable homes, roads, and other infrastructure could increase. Extreme rainfall may place more stress on our stormwater infrastructure.

Sea level rise: Global sea level has risen about 7 inches during the 20th century and is projected to rise at a higher rate in the future. For the Washington, Oregon, and California coasts north of Cape Mendocino, sea level is projected to rise 24 inches over the next century. In addition, an earthquake magnitude of 8 or greater along the Cascadia Subduction Zone would suddenly raise sea level along the coast of Washington and Oregon by an additional 3-7 feet, exacerbating the effects of sea level rise due to climate change.

Idaho
Climate change planning in Idaho is mainly led by the Idaho Experimental Program to Stimulate Competitive Research (EPSCoR). Two major river basins of national significance are in Idaho, the Snake River Plain (Snake) and the Salmon River Basin (Salmon). The EPSCoR work addresses concerns about how the hydrology in Idaho will change as climate changes in the western U.S. Of particular interest to EPSCoR is how the connection between surface water and groundwater in the Snake River Plain may change.56

According to EPSCoR, the National Ground Water Association has stressed that groundwater supplies might be used in the future to balance large swings in water supplies caused by drought and climate change. Despite this, the connections between climate change and groundwater is largely unexplored and poorly understood. The projected changes in the timing and magnitude of stream flows will affect ecosystems in sensitive areas. In addition, because Idaho’s economy is strongly coupled to water and snowmelt, the proposed research has direct application to Idaho’s citizens and implications for decision makers.

Concerns in Idaho center on:
Hydroclimatology and the connections between surface water and groundwater; understand how projected climate change might affect the timing and magnitude of mountain snow packs and snowmelt.
Hydro-economics/policy and changes in the timing and variability of water supply on land use, economic production, urban growth, and water management, and water rights.
Hydroecology and effects of climate change on natural ecosystems such as species shifts, and integrated relationships between climate, hydrology, fire, insects, ecology, and changing landscapes.

Alaska
The State of Alaska Adaptation Advisory Group describes vulnerabilities including impacts that are already occurring in their document, Alaska’s Climate Change Strategy: Addressing Impacts in Alaska.57 The information

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below is from the executive summary of the document. The references are included in the document and are not repeated in this document.

**Permafrost Thawing and Sea Ice Melting**

Permafrost underlies most of Alaska. Air temperature, snow cover, and vegetation affect the temperature of the frozen ground and the depth of seasonal thawing. Recent decades of warmer temperatures have produced extensive thawing, which has resulted in increased coastal erosion, landslides, and sinking of the ground surface, as well as consequent disruption and damage to forests, buildings, infrastructure, and coastal communities. In addition, many industrial activities depend on frozen ground surfaces, and many northern communities rely on ice roads for transport of groceries and other materials. Continued warming will further impair transport by shortening the seasonal use of ice roads. Thawing is projected to accelerate under future warming, with as much as the top 10 to 30 feet of discontinuous permafrost thawing by 2100.

Sea ice off the Alaskan Coast is retreating and thinning, with widespread effects on marine ecosystems, coastal climate, human settlements, and subsistence activities. Recent studies estimate arctic-wide reductions in annual average sea-ice extent of about 5-10% and a reduction in average thickness of about 10-15% over the past few decades. Retreat of sea ice allows larger storm surges to develop, increasing the risk of inundation and increasing erosion on coasts already made vulnerable by permafrost thawing. Loss of sea ice also causes large scale changes in marine ecosystems, and threatens populations of marine mammals and polar bears that depend on ice. At the same time, the continued reduction of sea ice is very likely to increase the navigation season, and within several decades a seasonal opening of the Northern Sea Route is likely to make trans-arctic shipping feasible during summer months, although increasing ice movement will initially make shipping more difficult in some channels of the Northwest Passage.

**Threats to Coastal Communities, Habitats, and Infrastructure**

Alaska has more coastline than the other 49 states combined. Increases in the frequency and intensity of storm surges have triggered increased coastal erosion that is threatening a number of coastal villages. A recent report from the Government Accountability Office (GAO) indicated that 31 villages face imminent threats. Storm surges have also reduced the protection that barrier islands and spits provide to coastal habitats. Both coastal and inland infrastructure face threats due to the climate change. Thawing permafrost threatens water and sanitation infrastructure, and roads, buildings, pipelines, power lines and other infrastructure are threatened by coastal erosion and degrading permafrost.

**Forest and Vegetation Changes**

The Arctic region, particularly Alaska, is already experiencing major ecological impacts as a consequence of warming. Rising temperatures have caused northward expansion of boreal forest in some areas, significant increases in fire frequency and intensity, and unprecedented insect outbreaks. Current projections suggest that, due to increases in burn area per decade, the tundra-dominated landscape on Seward Peninsula will eventually be replaced by deciduous forest. In other areas, forested areas are likely to convert to bogs as permafrost thaws. Growing-degree days have increased by 20%, with benefits for agriculture and forest productivity on some sites, and reduced growth on others.

**Sensitivity of Marine Ecosystems and Fisheries**

The Gulf of Alaska and Bering Sea support marine ecosystems of great diversity and productivity as well as the nation’s largest commercial fishery. Perhaps one of the most daunting threats lies in increasing acidification of the cold Alaskan waters. This would affect all organisms that possess calcifying shells, and these organisms play an integral role in the food web. Recent climate-related impacts observed in the Bering Sea include significant reductions in seabird and marine mammal populations, unusual algal blooms, abnormally high water temperatures, and low harvests of salmon on their return to spawning areas. Future projections for the Bering Sea suggest productivity increases at the base of the food chain, poleward shifts of some cold-water species, and negative effects on ice-dwelling species. Warmer temperatures will also affect commercial fisheries by inducing
large northward shifts of fish and shellfish species. This would result in decreased harvesting of cold-water species such as salmon and pollock, and increased harvesting of other species.

**Changes in the Diversity, Ranges, and Distributions of Species**

The Arctic sub-region that includes Alaska, Chukotka, and the Western Canadian Arctic is home to over 70 percent of the rare plant species that occur only in the Arctic and a number of plant and animal species already classified as “threatened.” Species concentrated in small areas, such as Wrangell Island, are particularly vulnerable to the direct effects of climate change combined with competition from migrating non-native species.

**Increased Stress on Subsistence Livelihoods and Lifestyles**

Subsistence makes an important contribution to livelihood in many isolated rural communities, especially but not exclusively for native peoples. Livelihoods that sustain indigenous communities include hunting, trapping, gathering, and fishing. These activities not only make significant contributions to the diet and health of many indigenous populations, but also play large and important social and cultural roles. Reduced or displaced populations of marine mammals, seabirds, and other wildlife, together with continuing thinning of sea-ice, have affected the safety and the dietary and economic well-being of subsistence communities.

**Tribes**

Among other effects of climate change, Tribes are concerned about declining stocks, changes in migration patterns, and other impacts on natural resources including endangered species. In an effort to begin an understanding of Tribal cultural resource vulnerabilities, Region 10 reviewed the Swinomish Climate Change Initiative Impact Assessment Technical Report as a very useful resource. Although peer review was not described, this report represents the work of a multidisciplinary team led by staff of the Swinomish Office of Planning & Community Development, in partnership with the University of Washington Climate Impacts Group (CIG), and with further scientific assistance from Skagit River System Cooperative (SRSC). CIG staff played a crucial role in reviewing scientific data, reports, and project documents, advising on the use of scientific data and information in the project, and in identifying probable local impacts and climate change scenarios. Scientific expertise was also provided by Skagit River System Cooperative, which partnered with Western Washington University and Battelle Northwest to model hydrologic impacts at the local level.

The cultural vulnerabilities identified in the Swinomish Impact Assessment included:
- Shrinking land base (sea level rise);
- Inundation of coastal sites/artifacts;
- Exposure of burial sites and human remains from strong storm events;
- Loss of cultural use plants; and
- Ecological Impacts on resources within the Swinomish traditional use areas.

In addition, Region 10 has funded two Indian General Assistant Program (IGAP) grants for the Jamestown and Port Gamble S’Klallam Tribes to develop a climate change vulnerability assessment template that other tribes could use. The work began in January 2012. The Jamestown Tribe Tribal Advisory committee was formed and identified four areas of concern for which they developed subcommittees: facilities/roads; economics; natural resources; and human health. The Tribe’s process will be reported in a short stand-alone document that may be used by other Tribal Governments.

Another useful description of vulnerabilities related to Alaskan Tribes, in particular, is the Tribal Climate Change Adaptation Plan Template which references three sources. A summary of the findings from the Template are included below. The specific references are included in the Template and are not repeated here.

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58 James Woods, Region 10 Senior Tribal Policy Advisor
59 [http://www.swinomish.org/departments/planning/climate_change/climate_main.html](http://www.swinomish.org/departments/planning/climate_change/climate_main.html)
Alaska has already experienced many climate-related changes including earlier spring snow melt, a decrease in sea ice, thawing permafrost, glacier retreat, changes in precipitation levels, and an increase in drought and wild fires. The annual average temperature has increased by 3.4°F, while winter temperatures have increased by 6.3°F during the last half century. The snow-free season lengthened by an average of 10 days throughout the state between 1970 and 2000; this continues to impact Alaska’s soil moisture and consequently vegetation that is not accustomed to drought-like conditions.

Rising temperatures are creating a more hospitable habitat for spruce beetles resulting in a severe infestation in spruce forests in the south-central portion of Alaska; there has also been an increase in catastrophic wildfires throughout the state due to the warmer and drier conditions. Additionally, Alaska is beginning to witness a thaw in permafrost which is affecting not only human-made infrastructure, but also forest health and lake area in wetland ecosystems.

Continued future warming in this region is inevitable, even if all greenhouse gas emissions were halted today. Temperatures are projected to increase anywhere between 5°F and 13°F by the end of the 21st century, depending on different emission scenarios. These increasing temperatures are expected to have major consequences on the different ecosystems in Alaska. This includes the warming of sea surface temperatures, further reductions in sea ice (impacting not only marine mammals but also eliminating a natural buffer to coastal storms), increased coastal erosion and flooding, an increase in catastrophic wildfires (models suggest that the yearly average area that burns may double by the middle of the century), and the warming and thawing of permafrost (Karl et al., 2009).

The changes that are already occurring in Alaska, and that will continue to occur, have the potential to alter the landscape considerably and may have immeasurable implications for Alaska’s plants, animals and people.

Alaska has already experienced many climate-related changes including: earlier spring snow melt; decrease in sea ice (important to marine mammals and a natural buffer to coastal storms); thawing permafrost, which makes tribal infrastructure (water, sewer, and foundations) designed for permafrost conditions extremely vulnerable to failure; glacier retreat; changes in precipitation levels; increase in drought, vegetation stress, and wild fires; severe infestation of spruce beetles in the south-central portion of Alaska; and increased coastal erosion and flooding.

Appendix B: Detailed Description of EPA Region 10 Program Vulnerabilities

In general, where possible, the sources cited by Region 10 use the Intergovernmental Panel on Climate Change (IPCC) likelihood of outcome terminology where ‘very likely’ means 90-100% probability, and the term ‘likely’ means 66-100% probability. Some likelihoods are noted as “Occurring now” where appropriate.

In addition, the use of terms are as follows: "High" assumes the program will be affected by the impact; "Medium" assumes the program could be affected under some conditions by the impact; "Low" assumes that there is a potential for the program to be impacted or uncertainty currently exists as to the potential nature and extent of the impact.

Goal 1: Taking Action on Climate Change and Improving Air Quality

1.A. Increased tropospheric ozone pollution in certain areas due to increased average summertime temperatures

**Likelihood of Impact:** Likely. Projections of future tropospheric ozone levels in the literature for the Pacific Northwest and Alaska are inconclusive at this time but the level of impact could change as new information becomes available. See further discussion below.

**Focus of Associated EPA Program:** Protecting public health and the environment by attaining the National Ambient Air Quality Standards (NAAQS) by implementing programs in States and Indian Country to help meet the standards.

**Likelihood of EPA Program Affected:** High in large urban areas in the Pacific Northwest – Washington, Oregon, and Idaho, and Low in remaining rural areas and in Alaska.

**Example of Risks if Program were Impacted:** Could become more difficult to attain NAAQS for ozone in metropolitan areas where ozone design values are close to the NAAQS.

**Regional Importance of Vulnerabilities:** Washington, Idaho, and Oregon each have at least 1 metropolitan area that has ozone design values close to the ozone NAAQS. There is the possibility that higher summertime temperatures would increase ozone productivity as well as emissions of VOC precursors and, there is scientific consensus that climate change will decrease the background ozone in the lower troposphere where the water vapor effect is dominant.\(^\text{64}\) Ozone in NOx-limited areas is projected to decrease as well as a result of climate change. From the available academic literature that included results for the Pacific Northwest, there is no consistent finding about whether climate change will increase, decrease, or have no change on ozone in this region.\(^\text{65,66}\) Of potential greater concern for the Pacific Northwest and Alaska over the next several decades is the increase in transported ozone precursors from Asia. Asian transport of ozone will decrease with an increase in water vapor over the Pacific, but hydroxyl radicals will increase, potentially increasing ozone formation in PNW urban areas.\(^\text{67}\)

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\(^\text{64}\) Jacob, DJ., and D.A. Winner. 2009. Effect of climate change on air quality, Atmos. Environ., 43, 56.

\(^\text{65}\) Ibid Jacob and Winter 51-63.


Variation in importance across the Region: Ozone is more likely to increase with climate change in inland Idaho rather than Washington and Oregon due to coastal airflow. It is not an issue for Alaska since ozone formation is limited by relatively low summertime temperatures. Potential ozone increases are more likely to occur in the larger metropolitan areas including Spokane, Tacoma, Portland, and Boise. Whether or not these increases will result in violations of the NAAQS health standards however is unknown.

1.B. Increase in average summertime temperatures and extreme temperature events resulting in increased concentrations of air toxics from anthropogenic sources.

Likelihood of Impact: Impact uncertain due to variability in effects of temperature increase on individual air toxics in Region 10.

Focus of Associated EPA Program: Reducing risk from emissions of air toxics through Maximum Achievable Control Technology (MACT), National Emission Standards for Hazardous Air Pollutants (NESHAPS) and residual risk programs

Likelihood of EPA Program Affected: There is insufficient literature available on air toxics and climate change to project this likelihood for Region 10.

Example of Risks if Program were Impacted: Could increase public health risks, including risks for the young, the elderly, the chronically ill, and socioeconomically disadvantaged populations

Regional Importance of Vulnerabilities: Many HAP chemicals volatilize at higher temperatures, creating the potential for higher emission rates and higher concentrations in ambient air. There is uncertainty however as to actual impacts on HAP concentrations since the boundary layer height will also likely be higher, adding more volume of air for the HAPs to mix into. It is also possible for pollutant removal mechanisms to increase as a result of climate change. There is still considerable uncertainty about the effect of climate change on air toxics in Region 10.

Variation in importance across the Region: Although we would expect air toxics to be most important in urban areas near large sources or a high density of sources, we cannot say that this will be the norm in Region 10. Potential variations by individual air toxic, location, and season were indicated in a continuous monitoring of atmospheric mercury study comparing high arctic, sub-Arctic, and temperate sites. While background mercury levels were shown to be decreasing at sub-Arctic and temperate sites, the levels at Alert (Nunavut, Canada – locationally and climatically comparable to arctic Alaska) indicated increases in both RGM (reactive gaseous mercury) and TPM (total particulate mercury) from 2002 – 2009 in the spring when concentrations are the highest. Background mercury had decreased at all other locations.

1.C. Increased frequency or intensity of wildfires due to increased summertime temperatures, prolonged droughts, and decreased soil moisture impact Particulate Matter levels.

Likelihood of Impact: Very Likely – Already Occurring

Focus of Associated EPA Program: Protecting public health and the environment by assuring that the National Ambient Air Quality Standards (NAAQS) are attained and assisting States and Tribes in the implementation of programs to help meet these standards.

Likelihood of EPA Program Affected: High.

Example of Risks if Program were Impacted: Could complicate Agency efforts to protect public health and the environment from risks posed by particulate matter (PM) pollution in areas affected by more frequent wildfires.


69 Cole, A.S., et. al. 2013. Ten year trends of atmospheric mercury in the high Arctic compared to Canadian sub-Arctic and mid-latitude sites, Atmospheric Chemistry and Physics, 13, 3, 1535-45.
Implications: increased concentrations of PM resulting in public health impacts and increasing responsibility of public agencies to protect public health.

Regional Importance of Vulnerabilities: Larger and more frequent wildfires are predicted throughout the region as a result of warmer summertime temperatures, decreased soil and fuel moisture, and increased pest infestations. For example, in the Columbia Basin, the acres of forest burned are projected to double by the 2020s, and triple by the 2040s compared to average burned from 1916 to 2006. These large increases in annual acres burned will increase the number of airsheds and communities impacted by high summertime concentrations of Pm10 and PM2.5 from wildfires, impacting the health of more individuals who have preexisting respiratory conditions such as asthma, and preexisting heart conditions. State, local, and Tribal air agencies will also be impacted by these events and Region 10 will be obligated to assist them. More frequent and larger wildfires could result in agricultural and forestry slash burning permits not being issued at all, or issued later into the winter, where permitted burning would more likely overlap with home heating season and add to emissions from woodburning stoves. Although increased wildfire will have little impact on the attainment of the National Ambient Air Quality Standards (NAAQS) or the SIP State Implementation Plan (SIP) program, the Region 10 impact would be in workload to process Exceptional Event documentation and potentially in assisting States, local communities, and land managers in minimizing the impact of increased wildfire smoke on human health.

Variation in importance across the Region: All four R10 States have a high percent of forested areas (about 50% for States of WA and OR) and would all be adversely affected by an increase in wildfires

1.D. Changes in precipitation, extreme temperatures, more frequent wildfires, and severe weather events will impact indoor air quality.

Likelihood of Impact: Very Likely

Focus of Associated EPA Program: Protection of public health from exposure to indoor air pollutants which are concentrated in indoor environments many times above ambient air levels. Potential for increased mold growth, particularly among buildings without access to air conditioning. Indoor Air Quality, Children’s Health and outreach programs will be impacted due to increased need for public education and guidance on reducing exposures to both indoor and ambient air pollutants.

Likelihood of EPA Program Affected: High.

Example of Risks if Program were Impacted: Will increase public health risks including those from respiratory illnesses including asthma, and risks for susceptible populations - the young, the elderly, the chronically ill, and socially disadvantaged populations across the region. Alaska’s native and rural populations are very vulnerable to worsening indoor air quality with more insulated housing reducing air circulation- thereby increasing levels of both indoor and ambient pollution - and increasing flood risk and melting permafrost that will support more mold growth. Also, though not directly related to climate change, increasing use of wood combustion as an indoor heat source (due to rising cost of home heating oil) further impairs indoor air quality.

Regional Importance of Vulnerabilities: Important across the Region. Susceptible individuals will be impacted by elevated temperatures, increasing pollutant levels, and therefore increasing exposures to both indoor and ambient air pollution.

Variation in importance across the Region: Particularly important in environmental justice (EJ) areas and areas with a high density of more susceptible populations such as in Alaska’s native villages and on tribal reservations in Washington, Oregon and Idaho.

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1.E. Depletion of the stratospheric ozone layer due to climate change effects on the atmosphere

Likelihood of Impact: Likely – changes continue over the arctic.

Focus of Associated EPA Program: Restoring the stratospheric ozone layer, preventing UV-related disease, and providing a smooth transition to safer refrigerants than CFCs and HCFCs

Likelihood of EPA Program Affected: Low – there is no stratospheric ozone monitoring or restoration program in R10.

Example of Risks if Program were Impacted: May be unable to restore ozone concentrations to benchmark levels as quickly at some latitudes.

Regional Importance of Vulnerabilities: Not uniformly important across the region. Important in the Arctic (Alaska) where severe depletion of stratospheric ozone has been observed during winter months. While there currently are no EPA Region 10 programs that directly deal with monitoring or restoring the stratospheric ozone layer, there is enforcement activity against violators related to use and disposal of CFC’s and HCFC’s.

Variation in importance across the Region: Most important in Alaska, particularly in Arctic regions.

1.F. Changes in the rate and distribution of deposition of sulfates, nitrates, and mercury as a result of changes in precipitation patterns.

Likelihood of Impact: Impact potentially ranges from Unlikely to Likely. Much uncertainty exists re: the overall impacts of changes in precipitation on sulfates, nitrates and mercury deposition in Region 10. We assume that there would be increased deposition of available sulfates, nitrates, and mercury with increased precipitation, but the availability of these pollutants in the atmosphere may be decreasing due to control measures.

Focus of Associated EPA Program: Agency programs to protect ecosystems from atmospheric deposition of pollutants such as sulfates, nitrates, and mercury. Deposition of pollutants may also impact compliance with water quality standards and Total Maximum Daily Loads (TMDLs).

Likelihood of EPA Program Affected: There is insufficient research on sulfate, nitrate, and mercury deposition and climate change to project this likelihood for Region 10, particularly in light of increasing wildfires and transport from Asia.

Example of Risks if Program were Impacted: Could cause adverse effects on ecosystems throughout the region, particularly mountain ecosystems and freshwater ecosystems, and could contribute to accumulation of mercury in fish tissue. This would disproportionately affect populations of people whose diet consists of a high percent of fish. Water quality impacted during summer due to lower stream flows. TMDLs may be more difficult to attain. An accurate assessment of impacts is difficult to determine at this time.

Regional Importance of Vulnerabilities: Accumulation of sulfates and nitrates may kill sensitive plant species and alter richness of species in sensitive ecosystems through the region. Mercury deposition in freshwater habitats could contribute to bioaccumulation of mercury in fish tissue, posing risks to humans who consume these freshwater fish. Lower stream flows during the summer months could make attainment of TMDLs associated with release of pollutants from point sources more difficult to attain, negatively impacting ecosystem health.

Atmospheric deposition of sulfates, nitrates and mercury from Region 10 sources are expected to decrease over time due to compliance with the new air toxics rules (i.e. the Mercury Air Toxics Standard – MATS), the attainment of additional reductions through the residual risk and technology review program, and mobile source controls.

Additional compliance activities resulting in decreases over time include sources meeting permit requirements or closing down. There is some uncertainty in this expected downward trend however due to potential increased mercury releases due to wildfires and transport from Asia. Global emissions of mercury continue to change at the same time as the Arctic is experiencing ongoing climatic changes. Multi-year trends analysis in reactive gaseous mercury (RGM) and total particulate mercury (TPM) at a Canadian Arctic site indicated increases from 2002 to 2009 in both RGM and TPM in the spring when concentrations are highest.

Variation in importance across the Region: Sulfate and nitrate deposition is important across the region. Mercury deposition is highest close to mercury sources, such as mining operations. The issue is more important for parts of

the Region containing mountain ecosystems and freshwater ecosystems and for parts of the Region where people’s diets consist of a high percent of fish. While studies have shown that on the East Coast, sulfate concentrations increase with temperature due to faster SO2 oxidation (higher rate constants and higher oxidant concentrations)\textsuperscript{76,77} no studies are available to indicate that the same is true for the Pacific Northwest and Alaska. In contrast, nitrate and organic semi-volatile components shift from the particle phase to the gas phase with increasing temperature.\textsuperscript{78} Overall effects are uncertain however because higher temperatures drive increased chemical reactions and possibly more secondary organic carbon. At the same time there might be changes to the boundary layer height, airmass ventilation rate, and precipitation. We do not know the relative importance of these effects in R10 states.

Goal 2: Protecting America’s Waters

2.A. **Regional focus:** Increasing heavy precipitation events and more frequent flood events may impact water systems and infrastructure.

**Likelihood of Impact:** Very Likely

**Focus of Associated EPA Program:** Protecting Water infrastructure: drinking water, wastewater, stormwater, and agricultural irrigation systems and infrastructure.

**Likelihood of EPA Program Affected:** High

**Example of Risks if Program were Impacted:** Water infrastructure could be overwhelmed or damaged. Impacts on water infrastructure may result in an increased number of sewer overflows and wastewater bypasses, as well as increased pollutant loads in runoff, increased pollution of streams and threats to public health. Drinking water and wastewater utilities will need an integrated approach to planning for emergencies and extreme weather events. Problems of safety as well as access to clean and safe water will be exacerbated for Tribal communities, and other vulnerable and economically depressed communities who have limited access to clean water supplies. Agricultural productivity may be impacted in areas with inadequate water storage capacity and limited agricultural irrigation systems.

**Regional Importance of Vulnerabilities:** The Region will work with the Tribes and States to assist in water planning by sharing information on available downcaled models and tools and provide technical assistance, outreach, and education to further assist in the implement of state and tribal voluntary programs. Climate change impacts drinking water by heightening risk of contamination of surface water sources due to higher temperatures, lower flows, and increased erosion/sedimentation. For example, in Alaska, melting permafrost is causing sources of drinking water for rural communities to disappear altogether, plus increased erosion is causing more sediment. Also road and bridge failures from more storms, erosion, etc. will result in more accidents and spills that threaten drinking water supplies. Groundwater sources could be impacted by changes in hydrology, also impacting changes in transport of potential contaminants.

**Variation in importance across the Region:** Important across the region, but especially in areas with ageing or inadequate water infrastructure. Adequate summertime water supply for irrigation of crops is essential to agricultural communities east of the Cascades in OR, WA, and ID. For tribes, who lack irrigation infrastructure and rely primarily on lakes and streams as water sources, availability of water for agriculture may be more severely impacted by climate change.

2.B. **Regional focus:** Earlier stream runoff and scouring of streambeds due to earlier snow melt, and decrease summer stream flows and increased stream temperatures will adversely impact fresh water fisheries

**Likelihood of Impact:** Occurring Now and very likely to increase

**Focus of Associated EPA Program:** Protection of Fresh water Fisheries: Loss and extinction of salmon species and other cold water fisheries due to seasonal changes in stream flows and increasing surface water temperatures. Important to the TMDL program, and salmon recovery programs

**Likelihood of EPA Program Affected:** High

**Example of Risks if Program were Impacted:** Loss of salmon habitat and increased stress on salmon reproduction throughout their entire lifecycle. This also applies to other fresh cold water fish. Watershed planning efforts will

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80 Ibid. USGCRP. 2009.


need to be modified to include projected impacts of altered stream flows and increased temperatures due to climate change.83,84

**Regional Importance of Vulnerabilities:** Salmon and other cold water fish are a large part of the marine fishery business in the Pacific Northwest (PNW), and loss of these fish would have a substantial impact on the economy of the (PNW). Coastal Native Americans depend on salmon as an essential part of their diets. There will be secondary impacts on other species in the ecosystem that benefit from salmon – e.g., forests that rely on decaying salmon for nutrients, and bears, eagles, others that feed on salmon.

**Variation in importance across the Region:** Important across the region.

2.C. **Regional focus:** Sea-level rise, sea surface temperature and increasing heavy precipitation events during the winter months, and decreasing precipitation days and increasing drought intensity during the summer months, may have adverse impacts on estuarine watersheds, aquatic ecosystems, and wetlands.

- **Likelihood of Impact:** Very Likely
- **Focus of Associated EPA Program:** Restoring and protecting watersheds, aquatic ecosystems, and wetlands
- **Likelihood of EPA Program Affected:** High

**Example of Risks if Program were Impacted:** Changes in precipitation patterns, and increased drought intensity will cause stress on wetlands, and forest and mountain ecosystems, and pose challenges to migration of species in these ecosystems to more suitable habitats. Sedimentation rates and organic matter (vegetative) accumulation rates also need to be taken into account for inland marine influenced ecosystems such as estuaries. Nyman et al.85 found that the vegetative component is the most significant of the two factors for the coasts of Oregon and Washington—i.e., accretion varied with organic accumulation rather than mineral sedimentation. Warmer sea surface temperature contributes to sea level rise, increased storm intensity, and greater stratification of the water column.

**Regional Importance of Vulnerabilities:** EPA may need to examine the use of more sophisticated models, and training to use the models, so that impacts to ecosystems due to Climate Change are addressed. Impact to states/tribes. Climate change impacts would make it more difficult for EPA to protect these ecosystems.

**Variation in importance across the Region:** Especially important in coastal areas of WA, OR, and Alaska due to increased extreme storm events and rising ocean levels and their impacts on coastal ecosystems. For the Washington, Oregon, and California coasts north of Cape Mendocino, sea level is projected to change between -4 cm (sea-level fall) and +23 cm by 2030, -3 cm and +48 cm by 2050, and 10–143 cm by 2100.86 The effects will also be important to all non-coastal watersheds, aquatic ecosystems, and wetlands across the region.

2.D. **Regional focus:** Warming temperatures and more frequent and intense drought conditions will have adverse impacts on Forest Ecosystems

- **Likelihood of Impact:** Very Likely
- **Focus of Associated EPA Program:** Protecting Forest Ecosystems
- **Likelihood of EPA Program Affected:** High

**Example of Risks if Program were Impacted:** Forest tree species are expected to shift their ranges northward and upslope in response to climate change and existing ecosystems will break up as different species shift at different

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rates, resulting in the formation of new ecosystems, with unknown consequences.\textsuperscript{87} Interactions among impacts of climate change and other stressors can increase the risk of species extinction.\textsuperscript{88} Breakup of existing ecosystems and loss of biodiversity, in combination to increased drought conditions, can make forests more susceptible to destruction by wildfires and insect infestation.

**Regional Importance of Vulnerabilities:** In the western United States, both the frequency of large wildfires and the length of the fire season have increased substantially in recent decades, due primarily to earlier spring snowmelt and higher spring and summer temperatures.\textsuperscript{89} Simulations of the impact of Climate Change on forest production in North America indicate that North American producers of lumber may suffer losses averaging $1 billion to $2 billion/yr over the 21st century.\textsuperscript{90}

**Variation in importance across the Region:** Adverse effects are likely in forests across the region, but more immediately in low elevation forests, and forests in drier parts of the region, such as in ID, eastern WA and OR, and the interior of AK.

2.E. **Regional focus:** Loss of sea ice in Alaska due to warming air and water temperatures associated with Climate Change

**Likelihood of Impact:** Occurring Now and very likely to increase

**Focus of Associated EPA Program:** Protecting Marine Ecosystems and shorelines

**Likelihood of EPA Program Affected:** High

**Example of Risks if Program were Impacted:** Loss of arctic ice in the Bering Sea is adversely affecting Arctic sea ice ecosystems. Algae that bloom on the underside of the sea ice form the base of a food web linking microscopic animals and fish to seals, whales, polar bears, and people. The earlier ice melt resulting from warming, however, leads to later phytoplankton blooms that are largely consumed by microscopic animals near the sea surface, vastly decreasing the amount of food reaching the living organisms on the ocean floor.\textsuperscript{91} This will radically change the species composition of the fish and other creatures, with significant repercussions for both subsistence and commercial fishing.\textsuperscript{92} Sea ice is forming later in the fall in Alaska, making the coastal communities more vulnerable to extreme storms (e.g., the storm in 2011 that was a record low atmospheric pressure and caused winds up to 90 mph).\textsuperscript{93}

**Regional Importance of Vulnerabilities:** Adverse impacts to the Bering Sea marine ecosystem would have profound effects on mammals and birds that migrate to feed in this area during the summer months. The Bering Sea fishery is a very important source of seafood and an important factor to Alaska’s economy. Species composition in the Bering Sea ecosystem could be radically changed.

**Variation in importance across the Region:** This impact is specific to Alaskan ecosystems and shorelines, but could also have adverse effects on associated terrestrial ecosystems in Alaska.

2.F. **Regional focus:** Acidification of ocean water due to increasing concentrations of CO2 in the atmosphere

**Likelihood of Impact:** Occurring Now and very likely to increase


\textsuperscript{88} Millennium Ecosystem Assessment, 2005: Ecosystems and Human Well-being: Biodiversity Synthesis. World Resources Institute, Washington, DC, 86 pp.

\textsuperscript{89} Westerling A.L, et. al. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science, 313(5789), 940-943.

\textsuperscript{90} IPCC, 2007, chapter 14

\textsuperscript{91} USGCRB. 2009. Regional Impacts: Alaska. EPA/600/R-07/094F, Office of Research and Development, Washington, D.C.


\textsuperscript{93} http://www.stormsurge.noaa.gov/event_history.html
Focus of Associated EPA Program: Protecting Marine Ecosystems
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Substantial decline of marine organisms that form their shells and skeletons from calcium carbonate in ocean waters. Adverse effects of ocean acidification on marine organisms have already been documented.
Regional Importance of Vulnerabilities: Specifically, adverse effects of ocean acidification have been documented in pteropods (sea snails), a primary food source for salmon in the Pacific Ocean, and in oyster larvae in estuaries in Washington State and on the coast of OR.
Variation in importance across the Region: Important in coastal areas of WA, OR and AK.

2.G. Regional focus: Pest outbreaks, invasive species, increased fire, shifts in species ranges and increased erosion, depletion of water and changes in riparian vegetation in Columbia basin Shrubsteppe/grassland eastern WA, OR, and ID.
Likelihood of Impact: Likely
Focus of Associated EPA Program: Protecting watershed ecosystems.
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Under projected future temperature conditions, the cover of sagebrush within the distribution of sage-grouse is anticipated to be reduced due to non-native grass invasions making the areas prone to destructive fires. Observed and projected decreases in the frequency of freezing temperatures, lengthening of the frost-free season, and increased minimum temperatures can alter plant species ranges and shift the geographic and elevational boundaries of many arid lands. The extent of these changes will also depend on changes in precipitation and fire. Increased drought frequency could also cause major changes in vegetation cover. Losses of vegetative cover coupled with increases in precipitation intensity and climate-induced reductions in soil aggregate stability will dramatically increase potential erosion rates. Transport of eroded sediment to streams coupled with changes in the timing and magnitude of minimum and maximum flows can affect water quality, riparian vegetation, and aquatic fauna. In particular, the climate-driven dynamic of the fire cycle is likely to remain the single most important feature controlling future plant distribution in U.S. arid lands. Riparian vegetation in arid lands can occur at scales from isolated springs to ephemeral and intermittent watercourses and perennial rivers. This habitat is tightly associated with stream dynamics and hydrology. The net result of climate warming is greater depletion of water along the riverine corridor.
Regional Importance of Vulnerabilities: Note that the direct climate change effects of CO2 fertilization and increasing average temperatures may have contrasting influences on dominant functional types. Trees and C3 grasses may benefit from rising CO2 but not from warming, whereas C4 grasses may benefit from warming but not

from CO2 fertilization. This may mean that uncertain, non-linear, and rapid changes in ecosystem structure and carbon stocks could occur.\textsuperscript{101} The changes in the cycling of Nitrogen and to some extent Carbon due to climate change could alter the microbial and plant community structure and function of this ecosystem and cause it to move in the direction of desertification.\textsuperscript{102} Large-scale conversion of grasslands to shrublands, coupled with anticipated changes in climate in the coming decades, and increases in wind speed, temperature, drought frequency, and precipitation intensity, contribute to greater wind erosion and dust emission from arid lands. In arid regions, erosion has been shown to increase sediment delivery to large rivers (e.g., the Rio Grande), and can change the flow conditions of those rivers. Transport of eroded sediment to streams can change conditions in waterways, impacting water quality, riparian vegetation, and water fauna.\textsuperscript{103}

\textbf{Variation in importance across the Region:} specific to the shrubsteppe and grassland ecosystems which include (1) intermountain regions in western North America (well-vegetated semi desert scrub in lower elevations in basins, valleys, and lower plateaus foothills and lower mountain slopes and (2) the Palouse grassland bioregion covers approximately 6,200 mi\textsuperscript{2} in west central Idaho, southeastern Washington, and northeastern Oregon between the western edge of the Rocky Mountains and the Columbia River basin. It encompasses the hills of the Palouse Prairie, the southerly Camas Prairie, and the forested hills and canyonlands of the area's rivers.\textsuperscript{104}

\textsuperscript{101} Parry et al.  2007, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC Fourth Assessment Report, section 4.4.3.

\textsuperscript{102} Smith et al.  2002. Soil properties and microbial activity across a 500m elevation gradient in a semi-arid environment. Soil, Biology, and Biochemistry. 34(1749-1757).


\textsuperscript{104} McWethy et al.  2010. Climate and Terrestrial Ecosystem Change in the U.S. Rocky Mountains and Upper Columbia Basin: Historical and Future Perspectives for Natural Resource Management. (NPS report).
Goal 3: Cleaning Up Communities and Advancing Sustainable Development

3.A. **Regional focus**: Flooding, sea-level rise, storm surges, extreme events and landslides could mean site characterizations, risk assessments and selection of remedies are not protective or that existing remedies may be vulnerable

**Likelihood of Impact**: Likely

**Focus of Associated EPA Program**: Removal program, corrective action or permitted sites, cleanup of hazardous waste sites (Superfund), and management of waste containment facilities (RCRA).

**Likelihood of EPA Program Affected**: Medium

**Example of Risks if Program were Impacted**: Increased risk of contaminate release from hazardous waste sites. RPMs and corrective action RPMs may need to alter selected remedies to ensure containment of hazardous substances. In situ remedies (e.g., stabilization, reactive barriers) and on-site above ground treatment systems (e.g., pump & treat, air sparging) could be compromised or overwhelmed if they are not designed to withstand the climate-related events. The net result could be release of contaminants.

**Regional Importance of Vulnerabilities**: Groundwater and subsurface contamination could be impacted by drought and flood conditions. There may be an increased risk of migration of contaminants from flooded containment facilities. Remedies such as caps in contaminated industrial waterways in WA and OR could be subject to (and not designed to withstand) unanticipated scour events. Any infrastructure whether for treatment or, say, green stormwater management such as pump and treat systems protecting drinking water wells have a potential to be at risk. Areas where permafrost has been assumed to work as a containment barrier would also be at risk.

**Variation in importance across the Region**: A high potential for impact could occur in the industrial waterways of WA and OR where industrial wastes have been capped in place, however could be a potential concern anywhere contaminants have been left in place. Possible issues of nuclear waste disposal related to climate change (e.g., locations of storage facilities, appropriate containment, and risk management issues) would also be important at the DOE Hanford facility in WA, and the DOE Idaho National Lab facility in ID.

3.B. **Regional focus**: Thawing permafrost and changes in sea ice leads to damage of roads, runways, water and sewer systems, and other infrastructure in Alaska affecting Tribal and Emergency Response

**Likelihood of Impact**: Occurring Now

**Focus of Associated EPA Program**: Emergency Response and Tribal Programs, Village Safe Water Program

**Likelihood of EPA Program Affected**: High

**Example of Risks if Program were Impacted**: Melting sea ice and late formation in the fall is causing storms to move in close to shore as the natural buffering system disappears. That is causing rapid coastal erosion, with houses and infrastructure falling into the ocean in several communities. That, along with higher storm, tidal surges flood communities, is requiring more immediate evacuation needs. Open dumps are also impacted by storm surges, flooding, which increases contamination risk. Permafrost temperatures have increased throughout Alaska since the late 1970s.105 Land subsidence (sinking) associated with the thawing of permafrost presents substantial challenges to engineers attempting to preserve infrastructure in Alaska.106

**Regional Importance of Vulnerabilities**: Substantial infrastructure damage in areas of Alaska built on permafrost. Release of methane contained in permafrost into the atmosphere would accelerate global warming since methane is a GHG.

**Variation in importance across the Region**: Important only in Alaska.

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3C. Regional focus: Region 10, Tribal and state partners will have increasing workloads in many aspects of site and waste management as well as work related to the formation and implementation of sustainable development and materials management programs, partnerships and initiatives.

Likelihood of Impact: Likely

Focus of Associated EPA Program: Sustainability and Materials Management

Likelihood of EPA Program Affected: Medium

Example of Risks if Program were Impacted: Accelerating development (sustainable or otherwise) and the expected migration of people to Region 10 are issues of concern. It is projected that the population of the States in Region 10 will increase from 11.2 million in 2010 to 13.1 million in 2025. Communities are struggling with how to manage the new people while protecting the environment and providing basic services like energy, water and waste management.

Variation in importance across the Region: In support of the increased sustainability of our communities, our investments in partnerships related to more sustainable materials management play an increasing role in preventing waste, conserving energy and reducing emissions of toxics as well as greenhouse gases. Waste management can be especially challenging in remote tribal communities in Alaska.

3D. Regional focus: Climate change impacts on the availability of raw materials and the cost of mining and refining raw materials, producing products, transporting products, and disposing products.

Likelihood of Impact: Likely

Focus of Associated EPA Program: Sustainability and Materials Management

Likelihood of EPA Program Affected: Medium

Example of Risks if Program were Impacted: EPA Region 10 will need to put more effort into advocating for sustainable materials management and pollution prevention with States, industry, communities and tribes as climate change affects the availability and cost of raw materials and products. Climate Change increasing temperature-related pest infestations and forest fires result in millions of acres of dead, dying, and burned trees in the Pacific NW and Alaska which decreases the availability and drives up the costs of wood products. Thawing permafrost in Alaska results in infrastructure damage in the form of compromised or impassible haul roads for timber and ore, reducing the availability of these natural resources and driving up transportation costs. Transportation of raw materials and products also becomes more costly and risky as thawing permafrost damages remote Alaskan airfields, and coastal erosion from storm surges and increased springtime flooding of river valleys damages coastal and inland river valley rail transport lines. Finally, damage to landfill infrastructure from thawing permafrost in Alaska makes disposal more costly due to the need for clean-up and fortification.

Variation in importance across the Region: This issue will impact the entire region but may have a greater impact on remote cities and villages in Alaska where transportation and disposal of products is more difficult and costly.


Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution

There are concerns for which we do not have sufficient scientific or programmatic information at this time to evaluate in our vulnerability analysis, some examples are:
(1) increased use of pesticides in response to increase in pests and vector borne diseases (see 2.G. which mentions invasive species, West Nile virus) and requests for emergency waivers.
(2) movement of volatile contaminants (pesticides, PCBs, mercury, etc.) into Alaska via global distillation.

4.A. Regional focus: Increasing extreme temperatures, increasing heavy precipitation events, changes in storm intensities, and increasing frequency of floods may increase the exposure to and risk associated with hazardous chemicals regulated by certain EPA programs

Likelihood of Impact: Likely

Focus of Associated EPA Program: Protecting human health and ecosystems from chemical releases regulated by the Resource Conservation and Recovery Act (RCRA), Toxic Substances Control Act (TSCA), and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) programs

Likelihood of EPA Program Affected: Medium

Example of Risks if Program were Impacted: Adjustments to the relevant risk assessment framework to determine public risk due to modified exposure scenarios and modified toxicity of chemicals due to climate change.

Regional Importance of Vulnerabilities: Altered weather and severe climate events could also affect the interpretations of risk at RCRA/TSCA and Superfund sites. Very relevant for permitting and planning activities, where facilities may not have previously required an awareness of risk management for water/flooding, or other climate change impacts. In particular, Puget Sound is vulnerable to these potential impacts of chemical pollution; restoration of Puget Sound is a key ecosystem-level activity in R10.109

Variation in importance across the Region: More relevant near sites with large densities of chemical Manufacturers, Processors and Formulators (MPFs), and RCRA and Superfund sites

109 (see the 2012/2013 Action Agenda for Puget Sound)
Goal 5: Enforcing Environmental Laws

EPA Region 10’s Office of Compliance and Enforcement (OCE) is charged with ensuring compliance with environmental requirements and enforcing against violations to those requirements. In that capacity, OCE’s vulnerabilities are uniquely tied to interactions with the regulated community. Some types of vulnerabilities (e.g., difficulties with maintaining staff functionality due to power outages, physical damage to facilities due to extreme weather) would be similar to those experienced by all EPA programs and regions. Other vulnerabilities are more specific to OCE such as those which impact the ability of sources to comply with environmental requirements and with our ability to determine such compliance and take appropriate action.

The vulnerabilities of greatest importance for OCE are conditions/events which would compromise our ability to ensure compliance with environmental requirements by regulated entities and, where necessary, to take effective enforcement action in case of violations. The programs impacted would include: compliance assistance; compliance monitoring and civil enforcement.

5.A. Regional focus: Increased non-compliance at regulated entities as a result of extreme weather events and changing weather patterns

Likelihood of Impact: Likely
Focus of Associated EPA Program: All regulatory programs
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Compliance and enforcement programs under the Clean Water Act (CWA) have the potential to see an increase in violations from many situations including sanitary sewer and combined sewer overflows, violations of percent removal at wastewater treatment plants (due to limited water flow as a result of drought), violations in bypasses due to the inability of wastewater treatment plants to treat a flow in excess of the design capacity, and increased violations in numerous programs due to failure of existing infrastructure protecting against extreme weather events. In addition, CWA section 311 (Spill Prevention Control Countermeasures) may see an increase in non-compliance along Alaskan coastal areas that have oil storage containers, as a result of sea ice melting (thereby increasing storm surges along those coastal areas) and increased flooding.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) compliance and enforcement programs may see violations at Pesticides Producing Establishments if there is a shift toward increasing pesticide usage, productions and imports. As weather patterns change in the Region, the habitats of insects and pests may also change, bringing different pests and diseases to areas.

The Resource Conservation and Recovery Act (RCRA) programs may see increased non-compliance at landfills due to changes in precipitation patterns (including more precipitation in some cases and more extreme precipitation events in other cases). Where more precipitation is seen in traditionally arid climates and little rainfall is assumed during landfill design, landfills may generate excessive hazardous leachate, see unexpected mobilization of contaminants in the waste column and/or experience failure of the liner or leachate collection systems.

Regional Importance of Vulnerabilities: May be most important in states where EPA has direct implementation of an enforcement program, on Tribal lands, and non-delegable programs.
Variation in importance across the Region: Relevant across the Region.

5.B. Regional focus: Shift in regional enforcement priorities due to changes in compliance (both increased compliance and non-compliance in different sectors) and increased number of inquiries from industry about maintaining compliance

Likelihood of Impact: Likely
Focus of Associated EPA Program: All regulatory programs.
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: If an increase in violations in various programs and industry are identified, OCE may shift the enforcement focus to address those violations. Conversely, OCE may use discretion
to refocus enforcement priorities when localized extreme weather events (e.g., flooding) greatly impact the regulated community or when a change in weather patterns decrease the potential for non-compliance (e.g., less precipitation could decrease surface runoff). This will be most important in states where EPA has direct implementation of an enforcement program (e.g., Idaho for NPDES program), on Tribal lands, and non-delegable programs (e.g., Chlorofluorocarbons, CWA 311 (SPCC), PCBs). OCE may need to make adjustments to normal workload to address an increase in industry’s compliance inquiries. There may need to be reassignment or delay of normal work duties as staff provides response support to those inquiries in a timely manner. Requests may also be received from Regional state counterparts regarding guidance to unique enforcement issues as a result of extreme weather events or changing weather patterns.

Regional Importance of Vulnerabilities: May be most important in states where EPA has direct implementation of an enforcement program, on Tribal lands and non-delegable programs.

Variation in importance across the Region: Relevant across the Region

5.C. Regional focus: Increased permitting of Class VI Underground Injection Control (UIC) wells for Carbon Dioxide sequestration and Class V UIC wells for stormwater management.

Likelihood of Impact: Likely
Focus of Associated EPA Program: UIC permitting and enforcement programs
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: EPA has developed criteria for Class VI wells, used specifically for the injection of carbon dioxide into underground subsurface rock formations for long-term storage. As the need to reduce carbon dioxide emissions into the atmosphere increases, various technologies including Class VI wells will be deployed. OCE may need to reassign or delay other UIC permitting and enforcement work, as permit requests for Class VI wells increase. This will be seen across the Region, until permitting and enforcement of the Class VI well program is delegated to the states. As the amount of stormwater increases with increased precipitation levels, industries regulated to manage stormwater and associated discharges may be faced with challenges surrounding the volume of stormwater to manage. Class V wells are designed to receive stormwater, as a substitution for or in addition to discharging stormwater. OCE may see an increase in permitting Class V wells, as challenges managing high volumes of stormwater increase. Permitting will be focused on Class V wells in Alaska and Tribal lands, as the Region implements this program in these areas.

Regional Importance of Vulnerabilities: Across the Region, until permitting and enforcement of the Class VI well program is delegated to the states.

Variation in importance across the Region: Relevant across the Region.

5.D. Regional focus: Increase in regulated industrial activities in Alaska may result as the melting of sea ice opens new areas for activities.

Likelihood of Impact: Likely
Focus of Associated EPA Program: Oil and gas extraction.
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Sea ice off the Alaskan Coast is retreating and thinning. This reduction of sea ice is very likely to increase the navigation season and create a seasonal opening of the Northern Sea Route to likely make trans-arctic shipping and transport feasible during summer months. As areas and routes become more accessible, there is a potential for industrial activity (e.g., oil and gas extraction) to become more active in these areas. As a result, OCE may see an increase in regulated entities.

Regional Importance of Vulnerabilities: Relevant in Alaska.

Variation in importance across the Region: Relevant in Alaska.

5.E. Regional focus: Increase in non-compliance at facilities with Underground Storage Tanks (UST) holding ethanol-blended fuels.

Likelihood of Impact: Likely
Focus of Associated EPA Program: Underground Storage Tank program.
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Storage of ethanol-blended fuels in USTs requires compatibility with the materials and equipment of the tank system. The chemical and physical properties of ethanol fuel blends may make these fuels more aggressive to certain UST tank systems, compared to petroleum. As the need increases to use and store fuels that produce fewer greenhouse gas emissions, the UST enforcement program may see an increase with incompatibility.

Regional Importance of Vulnerabilities: Relevant across the region.

Variation in importance across the Region: Relevant across the region.
EPA Facilities and Operations

6.A. **Regional focus:** Increasing drought frequency and intensity may **limit drinking water at EPA facilities.**
Increased demand for air conditioning.

**Likelihood of Impact:** Likely
**Focus of Associated EPA Program:** Personnel Safety and security. Operations of Agency facilities, and ability to carry out emergency response actions
**Likelihood of EPA Program Affected:** Low
**Example of Risks if Program were Impacted:** Facilities could be located in areas with water shortages, requiring water rationing. There is likely to be a greater demand for electricity for air conditioning during the summer months. Increased extreme temperature at any R10 office would put higher demand on drinking water and electricity for cooling.
**Regional Importance of Vulnerabilities:** Could affect the regional office and all the operations offices
**Variation in importance across the Region:** Operation offices may not be as vulnerable as the regional office due to a smaller staff and less demand for cooling water, drinking water, and water for other personal uses.

6.B. **Regional focus:** Increasing risk of floods and increasing intensity of storms may adversely affect **operations of agency facilities**

**Likelihood of Impact:** Unlikely
**Focus of Associated EPA Program:** Operations of Agency facilities, personnel safety, physical security, and ability to carry out emergency response actions. In particular, Region 10 operates the Manchester Environmental Laboratory in Port Orchard. The lab is adjacent to Puget Sound.
**Likelihood of EPA Program Affected:** Low
**Example of Risks if Program were Impacted:** Facilities in flood-prone areas may have to temporarily close. Personnel engaged in field work may be more vulnerable to extreme temperatures or storm events. Personnel and real property supporting emergency response and management may be at risk during flooding or extreme weather events. Ongoing work at the Manchester Environmental Laboratory may be disrupted with effects on many different programs.
**Regional Importance of Vulnerabilities:** Closure of regional offices due to climate change related damage could prevent staff from carrying out important functions. The Regional Office in Seattle is located in an area with low probability for flooding or sea level rise.
**Variation in importance across the Region:** R10 has flexiplace options available to staff and a Continuity of Operations Plan in place in case any R10 office is damaged by flooding or storms or transportation to/from offices are affected (e.g., flooded roadways; landslides on commuter train tracks).
Tribal and other vulnerable populations

7.A. **Regional focus:** Food security for Tribal communities that live a subsistence lifestyle may be at risk due to warming associated with climate change  
**Likelihood of Impact:** Likely  
**Focus of Associated EPA Program:** All R10 Programs working on issues that affect Tribal populations, potential link to permitting programs and actions  
**Likelihood of EPA Program Affected:** Medium  
**Example of Risks if Program were Impacted:** Warming due to climate change reduces the availability and accessibility of many traditional food sources such as ice seals, walrus and caribou. For example, climate change decreases the amount and quality of food that grows in the summer months, preventing caribou from storing enough fat to survive the winter. People face losing their healthiest foods, their communities, and in some cases, their culture, since each of these depends on traditional ways of collecting and sharing food.  
**Regional Importance of Vulnerabilities:** The most vulnerable population would be the native Alaskan people. They face losing their current livelihoods, their communities, and in some cases, their culture.  
**Variation in importance across the Region:** To some degree, this is also relevant to all the tribes in the rest of Region 10 (WA, OR, and ID).

7.B. **Regional focus:** An increase in intensity of coastal storms and rising sea levels would increase erosion of shorelines and pose risks to coastal native villages.  
**Likelihood of Impact:** Occurring Now  
**Focus of Associated EPA Program:** Tribal Programs, emergency response  
**Likelihood of EPA Program Affected:** High  
**Example of Risks if Program were Impacted:** Alaska’s coastline, much of which is close to sea level, is increasingly threatened by a combination of the loss of its protective sea ice buffer, increasing storm activity, and thawing coastal permafrost. In Alaska, over 100 villages on the coast and in low-lying areas along rivers are subject to increased flooding and erosion due to warming. Federal, state, and tribal officials have identified 31 villages that face imminent threats. At least 12 of the 31 threatened villages have decided to relocate—in part or entirely—or to explore relocation options. Federal programs to assist threatened villages prepare for and recover from disasters and to protect and relocate them are limited and unavailable to the majority of villages. The Federal Emergency Management Agency has several disaster preparedness and recovery programs, but villages often fail to qualify for them, generally because they may lack approved disaster mitigation plans or have not been declared federal disaster areas.  
**Regional Importance of Vulnerabilities:** Erosion of shorelines may require relocation of native villages. Loss of water infrastructure would require emergency water supplies. Flooding and storm events will require emergency management plans.  
**Variation in importance across the Region:** Greatest risks are to the shorelines in Alaska, but shorelines in WA and OR are also at a moderate risk.

7.C. **Regional focus:** Loss of permafrost and reduced snowpack threatens access to clean water  
**Likelihood of Impact:** High

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Focus of Associated EPA Program: Tribal Programs, Clean Water Indian set-aside program  
Likelihood of EPA Program Affected: High

Example of Risks if Program were Impacted: In many Alaskan rural tribal communities, their water is drawn from tundra lakes and these are disappearing with the permafrost.\(^{115}\) Another impact of melting permafrost is the loss of a stable foundation, endangering the sewer and water infrastructure that EPA, and the American taxpayer, has invested billions of dollars in.\(^{116}\) Tribes in other parts of Region 10 may experience water scarcity, due to failing aquifers. With reduced snow pack and increased seasonal drought, traditional drinking water sources are not being replenished. This can affect individuals: a small well fails, or communities: a large aquifer does not recharge. In general, without access to clean water, tribal communities across Region 10 have greatly increased respiratory and gastrointestinal infections and skin diseases including methicillin-resistant Staphylococcus aureus (MRSA). These risks are increased by the open dumps that exist in close proximity to most rural communities. There is often human waste and solid waste comingled and when there are floods or storm surges from the loss of protective ice, viable bacteria and contaminants are carried through the community and into people’s homes. Often times running water is not available for sanitation so these contaminants are making significant and dangerous impacts to both the environment and human health of rural Alaska communities. Most dumps are unlined, but permafrost has partially contained their toxic materials. Without permafrost, the untreated leachate may be a contamination risk for their water supply.

Regional Importance of Vulnerabilities: High. Costs to repair or replace water/sewer infrastructure damaged by thawing permafrost has been estimated at well over 6 billion dollars.\(^{117}\)

Variation in importance across the Region: Permafrost thawing affects Alaskan tribes, some of whom already do not have access to clean water.

7.D. Regional focus: Changing water conditions reduce availability of fish & shellfish resources.

Likelihood of Impact: Occurring Now

Focus of Associated EPA Program: Tribal Programs, Ecosystems and public affairs.

Likelihood of EPA Program Affected: High

Example of Risks if Program were Impacted: Salmon of the PNW are central to the lives of all native peoples, they bring spiritual, physical and cultural well-being. Climate change is bringing rapid habitat challenges, from rapidly changing stream flows to warming waters that can no longer protect salmon fry. Agricultural runoff and clear-cut forests further degrade water quality. It is a mystery what is happening to the salmon in the ocean and scientists are concerned about the threat of ocean acidification to salmon food sources. Addressing these issues will require large scale cooperative restoration and enhancement projects between many partners.

The R10 Tribes’ traditional shellfish use areas are on reserves, in ceded customary and traditional use areas. Increasing ocean acidification threatens shellfish beds that Tribes have harvested for millennia. Ocean acidification may reduce rates of shellfish larval survival and weaken the shells of the adults, thus making them more vulnerable as well.

Regional Importance of Vulnerabilities: High (Ocean acidification was a high priority in discussion groups at the 2012 Tribal Leaders Summit and was presented by both Makah and Tulalip tribes)

Variation in importance across the Region: high priority to all coastal tribes.

7.E. Regional focus: Vulnerable population such as children, the elderly, poor, and the infirm may be at increased health risk due to increased temperatures, failing infrastructure, and extreme weather events.

Likelihood of Impact: Occurring Now


Focus of Associated EPA Program: Tribal Programs, Ecosystems and public affairs.
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Children playing in areas with higher ozone levels resulting from increased temperature will be at higher risk for experiencing asthma symptoms and exacerbations. The elderly are more vulnerable to heat stress because they are often in poorer health and are less able to regulate their body temperature during periods or extreme health. Economic constraints can also place low-income households at disproportionate risk to extreme heat events due to lack of air condition or failure to use air-conditioning to cut down on associated energy costs.
Regional Importance of Vulnerabilities: Across the region.
Variation in importance across the Region: Across the region.
### Appendix C: Detailed Description of EPA Region 10 Existing Actions

The tables below include detailed information on existing actions in Region 10. It is organized by Office and includes the following columns:

- **Vulnerability**: This identifies the vulnerability associated with each action. Many actions have multiple vulnerabilities.
- **Relevant Agency Direction**: This includes the EPA strategy from which the action is derived. For example, many of the actions come from the Region 10 Strategic Alignment Plan while other actions come from the Puget Sound Action Agenda or EPA National Water Program Strategy.
- **Relevant EPA Goal**: This identifies the EPA National or Regional Goal associated with the action. These goals were included in the vulnerability assessment.
- **R10 Lead/Partners**: This column includes the EPA person responsible for the action and the partners EPA is working with to accomplish the actions.
- **Linked to Tribes, Sustainability, and EJ**: This column indicates whether the action can be linked to EPA Region 10 tribes, related to sustainability, or environmental justice. These areas are very important to EPA Region 10 and we wanted to evaluate which actions could be identified with these three areas.

#### Office of Air, Waste, and Toxics

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Relevant Agency Direction</th>
<th>Relevant EPA Goal</th>
<th>R10 Lead/Partners</th>
<th>Tribes</th>
<th>Sustainability</th>
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<td>Air Toxics</td>
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<tr>
<td>Promoting methods to reduce evaporative loss (due to increasing temperatures) of volatile toxics released thereby reducing toxic emissions from fuel storage, transfer, and handling facilities including tankfarms and transfer terminals:</td>
<td>Increase in average summertime temperatures and extreme temperature events resulting in increased concentration of air toxics from anthropogenic sources;</td>
<td>R10 Strategic Alignment Plan</td>
<td>Goal (1.2) Promote Sustainable Energy</td>
<td>R10 Leads: Don Dossett UM Dan Brown DERA grants/ WCC Partners: U.S. Dept. of Energy/ States/ Tribes</td>
<td>• DERA grants for Tribal fishing boats</td>
<td>• DERA grants</td>
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2020 and 2025 and the actions that will be pursued to meet these goals.
- Continue to work to promote the use of alternative fuels and support
the TOTE liquefied natural gas demonstration projects under the North
American Emission Control Area.
- Continue to promote the SmartWay Transportation project and award
Diesel Emissions Reduction Act (DERA) grants to yield emission reductions
and fuel savings in FY14.

### Indoor Air Training

Develop and host training for professionals (housing, medical, schools) on
making indoor environments healthier for the most vulnerable. This is a
particularly important Climate Change Adaptation activity because of
increasing mold problems following floods as well as increasing indoor
levels of ambient pollutants due to wildfires, inversions with peak
pollutant levels, and increased use of back-up power generators due to
extreme weather events.

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### Tribal Waste Management Programs

Work with federally recognized tribes in Washington, Alaska, Oregon and
Idaho to address landfills and unconfined open dumps which are impacted
by climate change and help develop appropriate responses to these
threats.

RCRA Tribal Team – 2013 ongoing work and beyond
Continue to update 2011 Indian Health Service Indian Lands Open Dumps
Inventory. In 2011 the EPA RCRA Tribal Team, RCRA Program Unit, Office
of Air Waste and Toxics, completed an inventory of all open dumps in
Washington, Oregon, Idaho and Alaska and posted this information on the

<table>
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<tr>
<th>Increased precipitation and floods</th>
<th>R10 Strategic Alignment Plan</th>
<th>R10 Strategic Alignment Plan Goal 4.4 – See Existing Actions column to left</th>
<th>R10 Leads: Lisa McArthur UM Fran Stefan-Tribal SW Program Mgr Partners: Alaska Native Villages; rural</th>
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Partner with Tribal communities, Tribal Consortia such as the Tribal Solid Waste Advisory Network, the EPA Tribal Trust and Assistance Unit and the Alaska Department of Environmental Conservation (ADEC) to develop appropriate responses to address the needs of tribal communities which are threatened by climate change impacts to their landfills and unconfined open dumps. Actions include:

- Convening teleconferences with partners to ascertain the state of knowledge about climate impacts to tribal landfills and unconfined open dumps in Washington, Oregon, Idaho and Alaska and strategies to address these impacts.
- Providing on-site technical assistance to interested tribal communities to help them to address climate change impacts to landfills and open dumps on their lands.

**Materials Management and Pollution Prevention Program**

Climate change is expected to continue to adversely impact the cost of raw materials. Materials management enables the use of the highest and intensities, and increasing frequency of floods may increase the exposure to and risk associated with hazardous chemicals (i.e. contained at RCRA sites.

Thawing permafrost and sea ice changes lead to damaged roads, runways, water and sewer systems, and other infrastructure including solid waste landfills and RCRA containment sites.

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<td>national Indian Health Service Operations and Maintenance Database (OMDS). This database includes information on all open dumps on Tribal lands, including Alaska.</td>
<td>intensities, and increasing frequency of floods may increase the exposure to and risk associated with hazardous chemicals (i.e. contained at RCRA sites.</td>
<td>communities</td>
<td>Goal 4.6 – Sustainable Materials</td>
<td>Kris Colt UM</td>
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Best substitutes for materials that may become scarce or too costly.

Facilitate Climate Change Adaptation by:
- Helping the public and regulated community adapt to the production and use of new materials, processes, and products that support the transition to sustainable materials management processes and away from: a) the use of more costly and limited natural resource based materials, and b) disposal-based systems with high uncontrolled emission and waste product management impacts. Materials Management Adaptation work includes:
  - Promoting More Sustainable Practices in Materials Management (SMM) and in Our Own Cleanup Work through: a) the recruitment and retaining participants for the Federal Green Challenge (helping our federal partners to reduce their GHG emissions through work on energy, transportation, waste and water), and b) recruiting for the Food Recovery Challenge in support of the EPA’s Sustainable Materials Management (SMM) Program which seeks to reduce the environmental impact of a material throughout its entire life cycle - including how it is extracted, manufactured, distributed, used, recycled, and disposed (See Appendix E – Supporting Documentation).
  - Continuing to work with state and local governments through the West Coast Climate and Materials Management Forum (WCMMF) in their transition to materials management.

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<th>EJ</th>
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</thead>
<tbody>
<tr>
<td>released from non-sustainable materials mgmt. practices.</td>
<td>Plan WCMMF</td>
<td>Mgmt</td>
<td>Federal Green Challenge: Melissa Winters Food Recovery Challenge &amp; WCMMF: Ashley Zanolli Partners: R9; state and local governments</td>
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### Water infrastructure

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</thead>
<tbody>
<tr>
<td>Melting permafrost</td>
<td>R10 strategic alignment plan; sustainability</td>
<td>Building Strong State &amp; Tribal Partnerships, EJ, Protecting America’s Waters</td>
<td>R10 Lead: OWW-Dennis Wagner Partner: State of Alaska</td>
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</tbody>
</table>

Work with the State of Alaska in the R&D of alternative technologies with providing first time service to unserved homes in a more sustainable way compared to a traditional piped system. The State has provided $1M for this effort. The most promising proposals for pilot system development will be identified in 2013. Systems approved for field installation and testing will be identified in 2014. Field testing is expected to begin in 2015 and be concluded by 2016.

### Freshwater fisheries

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<tr>
<th>Vulnerability</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Increased temperatures.</td>
<td>R10 strategic alignment plan; Goals 1 and 2 and Regional Goal 7</td>
<td>R10 Leads: OEA-Bruce Duncan OWW-Laurie Mann ORD-WED</td>
<td>•</td>
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</table>

Continue with pilot program for including Climate Change in an ongoing TMDL. EPA Region 10 and ORD Corvallis are working with the Washington Department of Ecology, the Lummi Nation and the Nooksack Tribe to identify the best way to integrate available climate change data into Ecology’s TMDL for temperature stress on salmon in the South Fork Nooksack River, Washington. This will provide a case study of both process and climate change science as a basis to support increased temperatures.
future Tribal Consultation, Co-Management, Policy and Regulation Development as needed. Examining the way temperature can be improved in the Nooksack watershed in order to support salmon restoration is a high priority for the Nooksack and Lummi Tribes. The climate change pilot will identify available science for the watershed, and document technical issues in a parallel effort to the ongoing TMDL.

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<thead>
<tr>
<th>Vulnerability</th>
<th>Relevant Agency Direction</th>
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</thead>
<tbody>
<tr>
<td>Training and Outreach</td>
<td>OW Climate Strategy</td>
<td>Goals 1 and 2.</td>
<td>R10 Lead: Paula VanHaagen</td>
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<tr>
<td>Maintain current participation in the National Water Program Climate Change Workgroup, including identifying a single point of contact for the Regional water program.</td>
<td>OW Climate Strategy; R10 strategic alignment plan;</td>
<td>Goals 1 and 2.</td>
<td>R10 Lead: Paula VanHaagen</td>
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<tr>
<td>Help to develop and implement the Office of Water Climate Change Adaptation Implementation Plan (due to the Council on Environmental Quality in Fall 2013) and to coordinate between the National Water Program 2012 Strategy and the EPA Regional Adaptation Implementation Plans</td>
<td>OW Climate Strategy; R10 strategic alignment plan;</td>
<td>Goals 1 and 2.</td>
<td>R10 Lead: Paula VanHaagen</td>
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<tr>
<td>After the Fall completion of the Office of Water Climate Change Adaptation Implementation Plan, provide training for water program staff on the challenges that climate change poses for water programs, and familiarize them with the National Water Program Climate Strategy and Regional Climate Adaptation Plans through a variety of means such as “all hands” meetings, webinars, seminars, and dissemination of the plans</td>
<td>OW Climate Strategy; R10 strategic alignment plan;</td>
<td>Goals 1 and 2.</td>
<td>R10 Lead: Mike Cox</td>
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<tr>
<td>Support national program efforts to inform and educate water program managers in the public and private sectors on climate change and water issues through a variety of means such as identifying key stakeholders and expanding professional networks, improving educational outreach efforts on National and Regional climate change websites and in other media, and disseminating clear</td>
<td>OW Climate Strategy; R10 strategic alignment plan;</td>
<td>Goals 1 and 2.</td>
<td>R10 Lead: Mike Cox</td>
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<td>and credible messaging on climate change science and impacts</td>
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<tr>
<td>In program meetings with States and Tribes in 2013, include discussion of ongoing Agency and Region climate change adaptation planning, the new National Water Program climate change strategy, and climate change activities related to State water programs as appropriate</td>
<td>OW Climate Strategy</td>
<td>Goals 1 and 2 and Regional Goal 7</td>
<td>R10 Lead: Mike Cox</td>
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<tr>
<td>Coordinate with the regional offices of other Federal agencies on climate change adaptation matters and participate, where appropriate, with related interagency cooperative and collaborative efforts to address climate change challenges on a regional scale</td>
<td>OW Climate Strategy</td>
<td>Goals 1 and 2.</td>
<td>R10 Lead: Mike Cox</td>
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<tr>
<td>Work with municipal and private water utilities to promote their use of the new Climate Ready Resilience and Awareness (CREAT) Version 2.0 to recognize and respond to climate change risks, and with National Estuary Program partners to promote the use of the new Climate Ready Estuaries Vulnerability Assessment Handbook to develop local climate resilience plans</td>
<td>OW Climate Strategy; National Water Program Strategy</td>
<td>Goals 1 and 2 and sustainability.</td>
<td>R10 Lead: Paula vanHaagen</td>
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<tr>
<td>Work with States, Tribes, municipalities, non-profit organizations and businesses to promote the Water Sense Program in the region</td>
<td>OW Climate Strategy; National Water Program Strategy</td>
<td>Goals 1 and 2 and sustainability.</td>
<td>R10 Lead: Bevin Horn</td>
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<tr>
<td>Support the national Water Program in revising the State Revolving Loan Funds “Green” paper and the Annual Review Guidance for on-site reviews to incorporate climate change, including a new “Climate Change” checklist. The Green paper will provide information on best practices and tools to help state SRF programs support climate change activities. The guidance and checklist would identify opportunities for States to develop priorities and make investments that respond to the climate change risks in that State</td>
<td>OW Climate Strategy</td>
<td>Goals 1 and 2 and sustainability.</td>
<td>R10 Lead: Paula vanHaagen</td>
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## Office of Ecosystems, Tribal, and Public Affairs

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<tr>
<th>Vulnerability</th>
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<th>Relevant EPA Goal</th>
<th>R10 Lead/Partners</th>
<th>Tribes</th>
<th>Sustainability</th>
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<tr>
<td><strong>NEPA</strong></td>
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<tr>
<td>Through NEPA review comments, seek to protect waters of the United States and promote management of sustainable surface water resources.</td>
<td>Decreasing precipitation days and increasing drought intensity</td>
<td>National Water Program Strategy&lt;sup&gt;118&lt;/sup&gt;</td>
<td>Goal 2.</td>
<td>R10 Lead: NEPA Review staff Partners: Lead federal agency (HUD, DOT, STB)</td>
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<tr>
<td>Encourage green infrastructure and low-impact development to protect water quality and make watersheds more resilient</td>
<td>Increasing risk of floods</td>
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<tr>
<td>Through NEPA review, ensure consideration of climate change on federal projects that may be at risk due to inundation, flooding, or salt water intrusion</td>
<td>Changes in abundance and geographical distributions of plant species and habitats for aquatic and terrestrial wildlife</td>
<td>National Water Program Strategy&lt;sup&gt;119&lt;/sup&gt;</td>
<td>Goal 2.</td>
<td>R10 Lead: NEPA Review Staff Partners: Lead federal agency (BLM, USFS FERC, USBR, DOT, STB)</td>
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<tr>
<td>Work with federal partners through the NEPA process to identify, protect, and maintain a network of healthy watersheds and supportive habitat corridor networks</td>
<td>Changes in abundance and for aquatic and terrestrial wildlife</td>
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<tr>
<td>Work with federal partners through the NEPA process to incorporate climate resilience into watershed restoration and</td>
<td>Changes in abundance and</td>
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<tbody>
<tr>
<td>Floodplain management</td>
<td>Work with partners to protect and enhance buffers to rivers, streams, lakes, wetlands, and coastal resources as a means of building resiliency</td>
<td>Geographical distributions of plant species and habitats for aquatic and terrestrial wildlife</td>
<td>Program Strategy</td>
<td>Partners: Lead federal agency (Forest Service, BLM, Park Service, USFWS)</td>
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<tr>
<td>Work with federal partners through the NEPA process to incorporate climate change adaptation into forest restoration plans</td>
<td>Encourage appropriate use of prescribed burning/thinning to reduce risk of uncharacteristic wildfire. Where appropriate, encourage managing for species best adapted to future climate</td>
<td>Increased frequency or intensity of wildfires</td>
<td>R10 Strategic Alignment.</td>
<td>Goal 1.</td>
<td>R10 Lead: NEPA Review Staff</td>
<td></td>
</tr>
<tr>
<td>ETPA will include ocean acidification language in NEPA review comment letters as appropriate.</td>
<td>Refine template language in letters and example NEPA analyses that include ocean acidification information</td>
<td>Increase in ocean temperatures, with potential for changes in ocean chemistry and increased ocean acidification</td>
<td>R10 Strategic Alignment.</td>
<td>Goal 2.</td>
<td>R10 Lead: NEPA Review Staff</td>
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<tr>
<td>Wetlands</td>
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<tr>
<td>Wetlands and Climate Change Research Meeting focused on new approaches and tools to better understand, manage, and conserve wetlands in a changing climate.</td>
<td>Loss of wetland ecosystems and services</td>
<td>U.S. EPA Climate Adaptation Plan</td>
<td>Goal 2.</td>
<td>R10 ARU Lead: Linda Storm</td>
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</table>
| Incorporate climate change considerations into the CWA 404 regulatory program as they relate to permit reviews and compensatory mitigation  
  - Consider the effects of climate change, as appropriate, when making significant degradation determinations in the CWA Section 404 wetlands permitting and enforcement program  
  - Evaluate, in conjunction with the U.S. Army Corps of Engineers, how wetland and stream compensation projects could be selected, designed, and sited to aid in reducing the effects of climate change | Loss of wetland ecosystems and services | National Water Program Strategy | Goal 2. | R10 Lead: Linda Storm  
Partners: USACE |
| As resources allow, improve baseline information on wetland extent, condition and performance to inform effective adaptation to climate change  
  - Expand wetland mapping by supporting wetland mapping coalitions and training on use of the new federal Wetland Mapping Standard.  
  - Produce a statistically valid ecological condition assessment of the nation’s wetlands | Loss of wetland ecosystems and services | National Water Program Strategy | Goal 2. | R10 Lead: Maryann Thiesing  
Partners: ORD, USFWS, UW Wetlands Adaptation Group |
| FY13 and FY14 Region 10 Wetland Program Development Grants RFP integrates climate adaptation by considering how the design and installation of demonstration projects would take relevant | | | | | |

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<tr>
<td>potential impacts from climate change into account when considering long-term viability</td>
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<tr>
<td><strong>Ocean Programs</strong></td>
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<tr>
<td>Participate in interagency development and implementation of federal strategies through the National Ocean Council (NOC) and the National Ocean Policy Implementation Plan</td>
<td>Increase in ocean temperatures, with potential for changes in ocean chemistry and increased ocean acidification</td>
<td>National Water Program Strategy</td>
<td>Goal 2.</td>
<td>R10 Lead: Sediment Management Staff Partners: NOC</td>
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<tr>
<td><strong>Tribes</strong></td>
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<tr>
<td>Build the capacity of Tribes to develop adaptation actions (plans) and to engage in the collaboration with local, state and federal agencies.</td>
<td>All (mitigation)</td>
<td>Regional Tribal Operations Committee</td>
<td>Goal 1.</td>
<td>R10 Lead: Michelle Davis-TTAU;</td>
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</tr>
<tr>
<td>EPA R10 Tribal Trust and Assistance Program will provide GAP funding as appropriate to support Tribes who have climate change in their GAP workplans to learn how to research climate change impacts upon their environment, natural resources, infrastructure to be used for development of a planning mechanism for adaptation and mitigation.</td>
<td>All</td>
<td>RTOC</td>
<td>Goal 1.</td>
<td>R10 Lead: TTAU; AIEO/OITA Partners: R10 Tribal Governments</td>
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<tr>
<td>Through the GAP program, Tribes may be able to do baseline environmental assessments that will add to documentation of the impact on climate change on Tribal communities and their ecosystems and support their adaptation planning.</td>
<td>All</td>
<td>National Tribal Science Council</td>
<td>Goal 1.</td>
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<tr>
<td>Share information to support climate change educational outreach and adaptation activities within Tribal communities</td>
<td>All</td>
<td>National Tribal Science Council</td>
<td>Goal 1.</td>
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</table>


Tribal Program staff will regularly submit articles on climate change to Tribal newsletters. Coordinate with other programs and their Tribal specialists on climate change info and resources to include in the EPA Tribal newsletter.

Continue to offer quarterly calls to Alaskan Tribes with Institute for Tribal Environmental Professionals on tribal climate change adaptation models and resources.

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<tr>
<td>Tribal Program staff will regularly submit articles on climate change to Tribal newsletters.</td>
<td>All</td>
<td>2010 Tribal Leader’s Summit Action Plan</td>
<td>Goal 1.</td>
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<tr>
<td>Coordinate with other programs and their Tribal specialists on climate change info and resources to include in the EPA Tribal newsletter.</td>
<td>All</td>
<td>2010 Tribal Leader’s Summit Action Plan</td>
<td>Goal 1.</td>
<td>R10 Lead: Michelle Davis Partners: ITEP</td>
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<tr>
<td>Continue to offer quarterly calls to Alaskan Tribes with Institute for Tribal Environmental Professionals on tribal climate change adaptation models and resources.</td>
<td>All</td>
<td>2010 Tribal Leader’s Summit Action Plan</td>
<td>Goal 1.</td>
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**Puget Sound Program**

Address Climate change in Puget Sound Grants, consistent with the Puget Sound Action Agenda. Grant activities include: Conduct an erosion survey to evaluate sea level rise threat in San Juan County; b) Map habitat and infrastructure vulnerability in Puget Sound and restoration potential for reducing vulnerability; c) Several Tribes and counties will incorporate climate change in their plans and/or analyses. Puget Sound Grant partners include: Puget Sound Partnership, Friends of the San Juan’s, The Nature Conservancy, Snohomish County, Washington Dept. of Ecology, Samish Indian Nation, Swinomish Tribe, Nooksack Tribe, Suquamish Tribe, Port Gamble Indian Commission.

Puget Sound Partnership is working to control source pollution.
- No Discharge Zone Evaluation and Petition. Draft petition to EPA by September 2013
- Pollution Control Action Team to respond quickly when areas are identified where water quality problems threaten shellfish areas. The first effort will be in Drayton

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<th>Tribes</th>
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</thead>
<tbody>
<tr>
<td>Address Climate change in Puget Sound Grants, consistent with the Puget Sound Action Agenda.</td>
<td>Sea Level Rise/erosion</td>
<td>Puget Sound Action Agenda</td>
<td>Goal 2.</td>
<td>R10 Lead: ETPA/Puget Sound: Angela Bonifaci; See partner list under description</td>
<td></td>
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</tr>
<tr>
<td>Puget Sound Partnership is working to control source pollution.</td>
<td>Increasing heavy precipitation events. Increased pollutant loads in runoff and the velocity of runoff will scour and erode</td>
<td>Puget Sound Action Agenda</td>
<td>Goal 2.</td>
<td>R10 Lead: EPA Team Partner: Puget Sound Partnership, Washington</td>
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<tr>
<th>Vulnerability</th>
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<th>Relevant EPA Goal</th>
<th>R10 Lead/Partners</th>
<th>Linked to</th>
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<tbody>
<tr>
<td>Harbor and Portage Bay.</td>
<td>Creek beds.</td>
<td>Climate Ready Estuaries</td>
<td>Goal 2.</td>
<td>EPA Climate Change Division</td>
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<tr>
<td>• Pollution Identification and Correction Programs to identify and correct nonpoint source pollution sources.</td>
<td></td>
<td>National Water Program Strategy</td>
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</tr>
<tr>
<td>The Puget Sound Partnership has developed climate change indicators which will allow them to track climate-driven changes and identify vulnerabilities or ecological thresholds</td>
<td>Increase in ocean temperatures, with potential for changes in ocean chemistry and increased ocean acidification</td>
<td>Climate Ready Estuaries</td>
<td>Goal 2.</td>
<td>R10 Lead: Michael Rylko</td>
</tr>
<tr>
<td></td>
<td></td>
<td>National Water Program Strategy</td>
<td></td>
<td>Partners: OCPD, National Estuary Programs, EPA Climate Change Division</td>
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<tr>
<td>Puget Sound Grants process integrates climate adaptation concepts by considering how the design and installation of projects would take relevant potential impacts from climate change into account</td>
<td>All</td>
<td>U.S. EPA Climate Adaptation Plan/ FY 2011-2015 EPA Strategic Plan</td>
<td>Goal 2.</td>
<td>R10 Lead: Puget Sound Grants Team</td>
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<tr>
<td>A four part effort, comprising climate statistics, GIS visualization and analysis, data delivery platform development, and engagement with policy and management entities, will underlie the proposed development and delivery of information about the projected time of emergence of various elements of a changing climate in the Puget Sound Basin.</td>
<td>All</td>
<td>Puget Sound NEP.</td>
<td>Goal 2.</td>
<td>R10 Lead: Jon Schweiss.</td>
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<td></td>
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<td>Partners: UW</td>
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<tr>
<td><strong>Children’s health and vulnerable populations</strong></td>
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<tr>
<td>Through work on children’s health, develop and host training for professionals in the housing, health and educational fields on making indoor environments healthier for the most vulnerable populations</td>
<td>Changes in precipitation, extreme temperatures, more frequent wildfires, and severe weather events will impact outdoor air quality and indoor air quality since ambient air is entrained indoors</td>
<td>Goal 1 and Regional Goal 7</td>
<td>R10 Lead: Margo Young</td>
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<tr>
<td>Provide technical assistance and training to affected communities on risks associated with poor outdoor air quality</td>
<td>Goal 1 and Regional Goals 6 and 7</td>
<td>R10 Lead: Margo Young, Erin Mader</td>
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<td>• Work with Tribal Air Program</td>
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<td>Partners: EPA Tribal Air Program, ANCH</td>
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<td>• Convene Rural Alaska Children’s Environmental Initiative</td>
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<tr>
<td>Outreach/risk communication to vulnerable and economically deprived communities.</td>
<td>Decreasing precipitation days and increasing drought intensity Increasing risk of floods</td>
<td>U.S.EPA Climate Adaptation Plan</td>
<td>Regional Goals 6 and 7</td>
<td>R10 Lead: Sheryl Stohs</td>
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<td></td>
<td></td>
<td></td>
<td>Partners: Beyond Toxics, Eugene; Verde of Portland; DRCC of Seattle</td>
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</tbody>
</table>
Regional Clean Air Act Grants are provided to Tribes to build capacity and knowledge and assess and address air quality concerns. Many grant-funded programs aim to prevent the presence of and exposure to indoor air pollution, for example, through supporting clean burning practices for wood stoves and adequate and effective ventilation in homes and public buildings. Ambient pollutants are also targeted, for example, from idling vehicles, diesel generators, outdoor burning, agricultural burning, wood stoves, and wildfires. Many of these factors will worsen with climate change, making tribal capacity building in these areas critical.

Region 10’s Children’s Environmental Health and Tribal Air Program co-lead the Rural Alaska Children’s Environmental Health Initiative and its two active workgroups, the Alaska Healthy Homes and the Alaska Healthy Schools Workgroups. These groups were established in December 2010 and work together regularly to protect children from harmful environmental exposures in rural Alaska, including factors related to climate change.

The Tribal Air Program has an IPA position in the Anchorage office serving as the Alaska Tribal Air Liaison. She provides direct assistance to Alaska Tribes and GAP grantees to do air quality work, including climate change related topics.

As appropriate, communicate with the public about hazards posed by climate change and EPA response/remedies to events exacerbated by climate change (storm events, flood, drought).

As appropriate, raise public awareness about climate change and actions being taken by the EPA to address climate change.

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Relevant Agency Direction</th>
<th>Relevant EPA Goal</th>
<th>R10 Lead/Partners</th>
<th>Tribes</th>
<th>Sustainability</th>
<th>EJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor air quality</td>
<td>R10 Strategic Alignment Plan.</td>
<td>Regional Goals 6 and 7.</td>
<td>R10 Lead: Erin Mader Partners: Tribes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>R10 Strategic Alignment Plan.</td>
<td>Goals 6 and 7.</td>
<td>R10 Lead: Erin Mader Partners: Tribes</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Air quality</td>
<td>R10 Strategic Alignment Plan.</td>
<td>Goals 6 and 7.</td>
<td>R10 Lead: Michelle Davis Partners: Tribes</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>All</td>
<td>U.S.EPA Climate Adaptation Plan</td>
<td>Goal 3.</td>
<td>R10 Lead: Public Affairs Unit</td>
<td></td>
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<tr>
<td>All</td>
<td>U.S.EPA Climate Adaptation Plan</td>
<td>Goal 3.</td>
<td>R10 Lead: Public Affairs Unit</td>
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</tbody>
</table>
Vulnerability and Resilience of Puget Sound Estuaries to Climate Change. Vulnerability assessments will allow decision makers to understand known risks, key uncertainties and the level of vulnerability their habitats and communities face from future storms and elevated sea levels (Cooper et al. 2008).

<table>
<thead>
<tr>
<th>Puget Sound Projects</th>
<th>Vulnerability</th>
<th>Relevant Agency Direction</th>
<th>Relevant EPA Goal</th>
<th>R10 Lead/Partners</th>
<th>Tribes</th>
<th>Sustainability</th>
<th>EJ</th>
</tr>
</thead>
</table>
| Puget Sound Action Plan. | In the Puget Sound basin these include increased winter precipitation, higher river flooding, lower summer low flows (Hamlet and Lettenmaier 2007), sea level rise (Mote et al. 2008), and uncertain effects on wind storms, sediment recruitment, and larger scale wind and ocean currents. | Puget Sound Action Plan. Objective 3. Vulnerability analysis | Goal 2. | R10 Lead: Michael Rylko
Partners: The Nature Conservancy in collaboration with USGS and UW CIG |

The Puget Sound Partnership plans to launch a tree planting/canopy cover campaign in FY13

| Goal 2. | R10 Lead: Partner: Puget Sound Partnership |

In FY13, Snohomish County’s Department of Public Works will address the threats of climate change and increased population growth with a focus on addressing altered basin hydrology.

| Goal 2. | R10 Lead: Partner: Snohomish County’s Department of Public Works |

The Washington State Department of Ecology will continue to

| Goal 2. | R10 Lead: Ben |
### Tribal Related projects in Puget Sound

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Relevant Agency Direction</th>
<th>Relevant EPA Goal</th>
<th>R10 Lead/Partners</th>
<th>Tribes</th>
<th>Sustain-ability</th>
<th>EJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>work on a Puget Sound Circulation and Dissolved Oxygen Model (v2.0) in order to determine climate change effects on Puget Sound water quality.</td>
<td>temperature.</td>
<td>NEP.</td>
<td>Cope Partner: WA Ecology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>King County will produce modeled flow and water quality conditions in the rivers and streams of WRIA 9 for idealized fully forested conditions, and anticipated 2040 conditions considering population growth and climate change</td>
<td>Sea level rise.</td>
<td>Puget Sound NEP.</td>
<td>Goal 2</td>
<td>R10 Lead: Michael Rylko Partner: King County.</td>
<td></td>
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</tr>
</tbody>
</table>

**The Samish Indian Nation will continue its climate change monitoring of Fidalgo Bay waters in FY13 providing continuous temperature data for trend analysis**

Increasing ocean temperature. Puget Sound NEP. Goal 2 and Regional Goal 7. R10 Lead: Lisa Chang Partner: Samish Indian Nation

**The Swinomish Tribe will hold its annual workshop on climate change issues in the Skagit, with a written report to follow**

All. Puget Sound NEP. Goal 2 and Regional Goal 7. R10 lead: Lisa Chang Partner: Swinomish Tribe

**The Nooksack Tribe will attend climate change conferences, meeting, and presentations, and review technical reports to evaluate the magnitude of expected local changes. This information will be considered in the salmon recovery plan implementation for WRIA 1**

All. Puget Sound NEP. Goal 2 and Regional Goal 7. R10 lead: Lisa Chang Partner: Nooksack Tribe

**The Suquamish Tribe will continue to monitor the work of the Climate Change Study Group, review climate change related studies and documents, and attend related meetings in order to build tribal capacity with respect to climate change**

All. Puget Sound NEP. Goal 2 and Regional Goal 7. R10 lead: Lisa Chang Partner: Suquamish Tribe
The Port Gamble Indian Commission of the Port Gamble Reserve plans to participate in climate change and ocean acidification programs in order to inform the development of a climate change program in FY13.

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Relevant Agency Direction</th>
<th>Relevant EPA Goal</th>
<th>R10 Lead/Partners</th>
<th>Tribes</th>
<th>Sustainability</th>
<th>EJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean acidification</td>
<td>Puget Sound NEP.</td>
<td>Goal 2 and Regional Goal 7.</td>
<td>R10 lead: Lisa Change Partner: Port Gamble Indian Commission</td>
<td></td>
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</tr>
</tbody>
</table>
### Inreach Project – Meet with each unit within OEA (including our Manchester Environmental Laboratory Director) and determine where climate science can be used in our work for programs:

**E.g.,** EJ related apps and heat stress/vegetation; riparian setbacks and hyporheic flow models; TMDL models; Any modeling involving temperature or flow terms.

<table>
<thead>
<tr>
<th>Vulnerability</th>
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<th>Relevant EPA Goal</th>
<th>R10 Lead/ Partners</th>
<th>Tribes</th>
<th>Sustainability</th>
<th>EJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>R10 Strategic Alignment plan</td>
<td>R10 Lead: Mike Cox; Partners: POCs in Offices</td>
<td>•</td>
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</table>

### Regional Outreach/Training – Continue to brief offices on vulnerabilities and tee up discussions where climate science can be used in decisions.

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Relevant Agency Direction</th>
<th>Relevant EPA Goal</th>
<th>R10 Lead/ Partners</th>
<th>Tribes</th>
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<tbody>
<tr>
<td>All</td>
<td>R10 Strategic Alignment plan</td>
<td>R10 Lead: Mike Cox; Partners: POC in offices</td>
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</table>

### Coordination with other federal agencies by participating on Climate Change Cooperative

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Relevant Agency Direction</th>
<th>Relevant EPA Goal</th>
<th>R10 Lead/ Partners</th>
<th>Tribes</th>
<th>Sustainability</th>
<th>EJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>R10 Strategic Alignment plan</td>
<td>R10 Lead: Mike Cox; Partners: Other federal agencies</td>
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</tbody>
</table>

### Support Pacific NW Landscape Conservation Cooperative – Steering Committee – OEA Director, Sci TEK subcommittee – CC Science Advisor

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Relevant Agency Direction</th>
<th>Relevant EPA Goal</th>
<th>R10 Lead/ Partners</th>
<th>Tribes</th>
<th>Sustainability</th>
<th>EJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>All coastal &amp; marine-related</td>
<td>R10 Strategic Alignment plan</td>
<td>R10 Leads: Joyce Kelly an; Mike Cox; Partners: NPLCC participants.</td>
<td>•</td>
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</table>

### Participate on the National Tribal Science Council, and support actions related to climate change and tribes

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Relevant Agency Direction</th>
<th>Relevant EPA Goal</th>
<th>R10 Lead/ Partners</th>
<th>Tribes</th>
<th>Sustainability</th>
<th>EJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>National Tribal Science Council</td>
<td>Goal 1.</td>
<td>R10 Lead: Lon Kissinger; Partners: RTOC</td>
<td>•</td>
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</tr>
</tbody>
</table>
### Office of Compliance and Enforcement

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Relevant Agency Direction</th>
<th>Relevant EPA Goal</th>
<th>R10 Lead/Partners</th>
<th>Tribes</th>
<th>Sustainability</th>
<th>EJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change may have more impact on overburdened communities as these communities, due to various concerns, adapt less well than other communities. OCE is using an Environmental Justice Screening tool to identify regulated facilities located in these overburdened communities. This tool was nationally developed to screen for communities with environmental justice concerns for implementation in various EPA programs.</td>
<td>All</td>
<td>R10 Strategic Alignment plan</td>
<td>Goal 5</td>
<td>R10 Lead: Anne Dalrymple Partners: Running Grass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuing enforcement in small programs that have climate change influence such as the Clean Air Act Mobile Source Enforcement Program. In this program, OCE is implementing and taking enforcement actions against illegal imports of non-compliant engines and tampering devices that produce elevated levels of greenhouse gas emissions (Oxides of Nitrogen and Carbon Dioxide). Also OCE is pursuing enforcement against industries releasing Ozone Depleting Substances into the atmosphere until full transition of enforcement to the Region 5 ODS Center.</td>
<td>Increasing summer temperatures.</td>
<td>R10 Strategic Alignment plan</td>
<td>Goal 5</td>
<td>R10 Lead: Air Compliance Team Partners:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permitting Class I Underground Injection Control (UIC) Wells in the North Slope of Alaska. The permafrost in the North Slope of Alaska has been identified as a vulnerable resource. In substitution for retention ponds used to store oil and gas industry’s drilling wastes, the UIC program continues to permit several Class I wells for underground injection of those wastes. This reduces the need to establish waste retention ponds on the increasingly vulnerable permafrost.</td>
<td>Permafrost thawing.</td>
<td>R10 Strategic Alignment plan</td>
<td>Goal 5</td>
<td>R10 Lead: UIC Compliance Team Partners:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuing to support the Regional Support Corps by deploying staff for varying emergency response efforts (e.g. Hurricane Katrina).</td>
<td>All</td>
<td>R10 Strategic Alignment plan</td>
<td>Goal 5 and Operation and Facilities.</td>
<td>R10 Lead: Wendy Adams Partners: Ann Williamson</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vulnerability</td>
<td>Relevant Agency Direction</td>
<td>Relevant EPA Goal</td>
<td>R10 Lead/Partners</td>
<td>Tribes</td>
<td>Sustainability</td>
<td>EJ</td>
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</tr>
<tr>
<td>RCRA enforcement is evaluating land-based units which have received hazardous waste and determining the extent to which precipitation and evaporation levels must be considered in protective management standards and closure requirements. In these instances, changes in precipitation and evaporation rates could likely change the required compliance actions.</td>
<td>Increased precipitation.</td>
<td>R10 Strategic Alignment plan</td>
<td>Goal 5</td>
<td>R10 Lead: RCRA Compliance Team Partners:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuing to look for opportunities to encompass green infrastructure as part of settlement agreements. An example of this is the City of Seattle, Washington and King County, Washington CSO settlement agreements. These settlements allow for the City of Seattle and King County to substitute green infrastructure projects for gray infrastructure projects (e.g. green roofs, permeable pavements, urban gardens).</td>
<td>All</td>
<td>R10 Strategic Alignment plan</td>
<td>Goal 5</td>
<td>R10 Lead: Depends on the case. Partners:</td>
<td>•</td>
<td></td>
</tr>
</tbody>
</table>
Appendix D: Comparison of Vulnerabilities and EPA Region 10 Existing Actions

Appendix D compares the vulnerabilities identified in Section 2 and Appendix B with the existing actions identified in Section 3 and Appendix C. This comparison provides valuable information as EPA Region 10 evaluates how to best proceed to integrate climate change into the programs.

**Goal 1: Taking Action on Climate Change and Improving Air Quality**

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Action(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in tropospheric ozone pollution may occur in certain areas due to increased average summertime temperature</td>
<td>No specific existing actions.</td>
</tr>
<tr>
<td>Increase in air toxics from anthropogenic sources is uncertain due to variability in effects of temperature increase on individual air toxics.</td>
<td>Work with the West Coast Collaborative to reduce evaporative losses of air toxics from fossil fuels.</td>
</tr>
<tr>
<td>Increase in particulate matter levels is occurring now and is very likely to increase due to increased frequency or intensity of wildfires due to increased summertime temperatures, prolonged droughts, and decreased soil moisture.</td>
<td>No specific existing actions.</td>
</tr>
<tr>
<td>Indoor air quality is very likely to be impacted, especially in Alaska, due to changes in precipitation, extreme temperatures, more frequent wildfires, and severe weather events.</td>
<td>Develop and host training for professionals (housing, medical, schools) on making indoor environments healthier for the most vulnerable. Assistant Tribes to build capacity and knowledge and assess and address air quality concerns including those related to climate change through the Regional Clean Air Act Grants.</td>
</tr>
<tr>
<td>Stratospheric ozone layer is likely to be impacted in Alaska due to climate change effects</td>
<td>No specific existing actions.</td>
</tr>
<tr>
<td>Increased rate and deposition of sulfates, nitrates, and mercury is uncertain due to changes in precipitation patterns.</td>
<td>No specific existing actions.</td>
</tr>
</tbody>
</table>

**Goal 2: Protecting America’s Water**

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Action(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinking water, wastewater, stormwater, and agricultural infrastructure is likely to be impacted by increased heavy precipitation, more frequent flood events, storm surge, coastal erosion, and drought.</td>
<td>Work with the State of Alaska to identify alternative technologies for providing first time service to unserved homes in a more sustainable way compared to a traditional piped system. Work with the Water Sense program to encourage water efficiency in homes, landscaping and commercial buildings with a focus on new homes. Continue implementing the Sustainable Energy</td>
</tr>
<tr>
<td>Vulnerability</td>
<td>Action(s)</td>
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<td>------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Impacts to freshwater fisheries is occurring now and likely to increase due to</td>
<td>Continue with pilot program examining how to integrate climate change in an ongoing TMDL by examining how temperature can be improved in the Nooksack watershed in order to support salmon restoration.</td>
</tr>
<tr>
<td>earlier stream runoff and scouring of streambeds due to earlier snow melt,</td>
<td></td>
</tr>
<tr>
<td>decreased summer stream flows and increased stream temperatures, and longer</td>
<td></td>
</tr>
<tr>
<td>periods of low stream flow.</td>
<td></td>
</tr>
<tr>
<td>Estuarine watersheds, aquatic ecosystems, and wetlands are very likely to be</td>
<td>Coordinate a <em>Wetlands and Climate Change Research Meeting</em> focused on new approaches and tools to better understand, manage, and conserve wetlands in a changing climate.</td>
</tr>
<tr>
<td>impacted by sea-level rise, sea surface temperature and increasing heavy</td>
<td>Incorporate climate change considerations into the CWA 404 regulatory program as they relate to permit reviews and compensatory mitigation.</td>
</tr>
<tr>
<td>precipitation events during the winter months, and decreasing precipitation</td>
<td>As resources allow, improve baseline information on wetland extent, condition and performance to inform effective adaptation to climate change.</td>
</tr>
<tr>
<td>days and increasing drought intensity during the summer months.</td>
<td>Integrate climate adaptation in the FFY13/14 Region 10 Wetland Program Development Grants RFP.</td>
</tr>
<tr>
<td>Forest ecosystems will likely be impacted by warming temperatures and more</td>
<td>Through the NEPA review process ensure consideration of climate change in review of all federal projects and incorporate climate change adaptation into land management planning and other projects as appropriate.</td>
</tr>
<tr>
<td>frequent and intense drought conditions.</td>
<td></td>
</tr>
<tr>
<td>Loss of sea ice is occurring now and will very likely increase in Alaska due</td>
<td>No specific existing actions.</td>
</tr>
<tr>
<td>to warming air and water temperatures.</td>
<td></td>
</tr>
<tr>
<td>Ocean acidification is occurring now and is very likely to increase due to</td>
<td>Include ocean acidification language in NEPA review comment letters as appropriate and develop template language in letters and example NEPA analyses that include ocean acidification information.</td>
</tr>
<tr>
<td>increasing concentrations of CO₂ in the atmosphere.</td>
<td>Participate in interagency development and implementation of federal strategies through the National Ocean Council (NOC) and the National Ocean Policy Implementation Plan.</td>
</tr>
<tr>
<td>Change in vegetation is likely in eastern Washington and Oregon and Idaho</td>
<td>Through the NEPA review process ensure consideration of climate change in review of all federal projects and incorporate climate change adaptation into land management planning and other projects as appropriate.</td>
</tr>
<tr>
<td>due to pest outbreaks, invasive species, increased fire, shifts in species</td>
<td></td>
</tr>
<tr>
<td>ranges and increased erosion, drier soils, and depletion of water.</td>
<td></td>
</tr>
<tr>
<td>Puget Sound: Many of these projects address multiple vulnerabilities.</td>
<td>Support Tribal projects on climate change in Puget Sound through the National Estuary Program. A listing of those projects is included in Appendix C.</td>
</tr>
</tbody>
</table>
### Goal 3: Cleaning Up Communities and Advancing Sustainable Development

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Action(s)</th>
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</thead>
<tbody>
<tr>
<td>Remedial, removal, brownfield, corrective action or permitted sites may be impacted due to flooding, sea level risk, storm surges, extreme events, and landslides.</td>
<td>No specific existing actions.</td>
</tr>
<tr>
<td>Increase in work for Alaska’s Tribal and emergency response programs is occurring now and likely to increase due to thawing permafrost and changes in sea ice that leads to damage of roads, runways, water and sewer systems, and other infrastructure.</td>
<td>Work with federally recognized tribes in Region 10 to address landfills and unconfined open dumps which are impacted by climate change and help develop appropriate responses to these threats.</td>
</tr>
<tr>
<td>EPA Region 10, Tribal and state partners will have increasing workloads in many aspects of site and waste management as well as work related to the formation and implementation of sustainable development and materials management programs, partnerships and initiatives.</td>
<td>Work with our partners through the West Coast Climate and Materials Management Forum and our pollution prevention technical assistance providers and grants to assist in the transition to sustainable materials management processes and source reduction.</td>
</tr>
<tr>
<td>Availability of raw materials and the cost of mining and refining raw materials, producing products, transporting products, and disposing products may increase due to impacts of climate change.</td>
<td>Recruiting and retaining participants for the Federal Green Challenge and for the Food Recovery Challenge in support of the EPA’s Sustainable Materials Management (SMM) Program.</td>
</tr>
</tbody>
</table>
Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution

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<thead>
<tr>
<th>Vulnerability</th>
<th>Action(s)</th>
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</thead>
<tbody>
<tr>
<td>Increased exposure and risk to hazardous chemicals is likely due to increasing extreme temperatures and heavy precipitation events, changes in storm intensities, and increasing frequency of floods.</td>
<td>Incorporating green remediation in corrective action decision-making and raising issues nationally regarding the potential impacts of climate change on alternative landfill covers.</td>
</tr>
</tbody>
</table>

Goal 5: Enforcing Environmental Laws

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Action(s)</th>
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</thead>
<tbody>
<tr>
<td>Non-compliance at regulated entities may increase due to extreme weather events and changing weather patterns.</td>
<td>Continue to use an Environmental Justice Screening tool to identify regulated facilities located in overburdened communities. Continue to look for opportunities to encompass green infrastructure as part of settlement agreements.</td>
</tr>
<tr>
<td>Shift in regional enforcement priorities due to changes in compliance (both increased compliance and non-compliance in different sectors) and increased number of inquiries from industry about maintaining compliance due to extreme weather events and changing weather patterns.</td>
<td>Continue enforcement in small programs that have climate change influence such as the Clean Air Act Mobile Source Enforcement Program. RCRA enforcement is evaluating land-based units which have received hazardous waste and determining the extent to which precipitation and evaporation levels must be considered in protective management standards and closure requirements.</td>
</tr>
<tr>
<td>Increased permitting of Class VI Underground Injection Control (UIC) wells for Carbon Dioxide sequestration and Class V UIC wells for stormwater management.</td>
<td>No specific existing actions.</td>
</tr>
<tr>
<td>An increase in regulated industrial activities in Alaska may result as the melting of sea ice opens new areas for activities.</td>
<td>No specific existing actions.</td>
</tr>
<tr>
<td>An increase in non-compliance at facilities with Underground Storage Tanks (UST) holding ethanol-blended fuels.</td>
<td>No specific existing actions.</td>
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</tbody>
</table>

Facilities and Operations

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Action(s)</th>
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</thead>
<tbody>
<tr>
<td>Drinking water may be limited and an increase in demand for air conditioning is possible due to increasing drought frequency and intensity.</td>
<td>No specific existing actions.</td>
</tr>
<tr>
<td>Operations of Region 10 facilities may be impacted by increasing risk of floods and increasing intensity of storms.</td>
<td>Continuing to support the Regional Support Corps by deploying staff for varying emergency response efforts</td>
</tr>
</tbody>
</table>

Tribal and Vulnerable Populations
<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Action(s)</th>
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</thead>
<tbody>
<tr>
<td>Vulnerable population such as children, the elderly, poor, and the infirm may be at increased health risk due to increased temperatures, failing infrastructure, and extreme weather events.</td>
<td>Support the Rural Alaska Children’s Health Initiative which works to protect children from harmful environmental exposures in rural Alaska, including factors related to climate change. Through work on children’s health, develop and host training for professionals in the housing, health and educational fields on making indoor environments healthier for the most vulnerable populations. Provide technical assistance and training to affected communities on risks associated with poor outdoor air quality (e.g., work with Tribal Air Program and convene Rural Alaska Children’s Environmental Initiative). Outreach/risk communication to vulnerable and economically deprived communities.</td>
</tr>
<tr>
<td>Food security for native Alaskans and Tribal people in the Pacific Northwest who live a subsistence lifestyle may be at risk due to warming associated with climate change.</td>
<td>Support Tribes to develop adaptation actions (plans), to document that impact from climate change and to engage in the collaboration with local, state and federal agencies working on broad based adaptation plans. Provide GAP funding as appropriate to Tribes with climate change in their GAP workplans to do baseline environmental assessments and support adaptation planning.</td>
</tr>
<tr>
<td>Increased erosion of shorelines is likely to increase risk to coastal native villages due to increased intensity of coastal storms and rising sea levels.</td>
<td>No specific existing actions.</td>
</tr>
<tr>
<td>Decreased access to clean drinking water is very likely due to loss of permafrost.</td>
<td>No specific existing actions.</td>
</tr>
<tr>
<td>Reduced availability of fish and shellfish resources is occurring now and is likely to increase due to changing water conditions.</td>
<td>No specific existing actions.</td>
</tr>
<tr>
<td>Training and Outreach which will address all vulnerabilities.</td>
<td>Raise awareness by providing educational outreach, training, and webinars to Tribes and work with the Institute for Tribal Environmental Professionals on tribal climate change adaptation models and resources.</td>
</tr>
<tr>
<td>Training and Outreach (supports all the goals)</td>
<td></td>
</tr>
<tr>
<td>Vulnerability</td>
<td>Action(s)</td>
</tr>
<tr>
<td>General training and outreach that supports all the goals and programs</td>
<td>Provide outreach/trainings to increase awareness of climate science to regional staff, and work with</td>
</tr>
</tbody>
</table>
| | staff to incorporate climate science into their work programs.
| | Communicate with the public about hazards posed by climate change and actions being taken by the EPA to address climate change.
| | Coordinate with other federal agencies by participating on Climate Change Cooperative and supporting the Regional Landscape Conservation Cooperatives. |
Appendix E: EPA Region 10 Approach for Measuring Success

Several key steps to developing the Region 10 approach to meeting our Strategic Alignment Plan, measuring our progress, and adapting as we go are discussed below. In Region 10 we have identified a point of contact (POCs) for each of our offices to assist with developing the Implementation Plan and they will have a critical role in collecting measures from their offices.

Collate the measures and reporting requirements for the existing actions.
Section 3 identifies existing actions that Region 10 has underway. Many actions are part of the Region 10 Strategic Alignment Plan and SMART (Specific, Measurable, Attainable, Relevant and Time-sensitive) and some may have measures associated with them. These available measures will be collated. For all other actions, we will seek clarification through our POC network on the status of development of SMART measures and how to prioritize completion of the SMART process.

Consider developing Logic Model as the underlying framework for Measures.
Under a Logic Model, the ultimate goal is to measure changes, commonly called outcomes, which often are changes in behavior. In the figure below shared nationally by the Office of Water, goals of awareness are followed by the desired behavior that climate science is incorporated into federal policies and programs. Measures of outcomes also benefit from determining a baseline condition as well as benchmarks for success. Both of these will be considered in implementing the Region 10 approach.

The Logic Model example below is based on the following considerations:
- Diagram/Text illustrating the relationships among program elements
- Identifies key activities, “players”, and expected results
- Identifies program span of control and external influences
- Span of control: Region 10 only has direct influence over key activities & outputs

The model is developed keeping in mind that:
- To meet ultimate goals, Region 10 will seek to change the attitudes, knowledge, and behavior of others (outcomes).
- The challenge of the measurement approach is to balance output vs outcome measurement.
- In order to obtain Buy-In we will clearly define the purpose of the measurement effort to staff (how will the information be used) and minimize staff time needed to report the measures.
- We will need to address Measurement “apprehension”: Programs recognize progress toward outcomes is important, but hesitate to be held “accountable” for things outside their direct control.

Consider existing climate vulnerabilities in refining/selecting Measures.
For climate change adaptation, successful adaptation would be measured against conditions we do not expect to face for several decades. However, some conditions are occurring now and actions in response to these conditions are ones where meaningful measures of outcomes could be generated. In Region 10, particularly Alaska, we are seeing accelerated changes that are documented in our vulnerability analysis. And, in Puget Sound, ocean acidification is already affecting larval cultures of oyster growers.

Include other considerations in refining/selecting Metrics:
How many measures are too many?
How “measureable” are the metrics (precision of language, access & availability of data)?
Output (short term) vs. Outcome (longer term) Focus
Challenges to Analysis:
   How will reporting and analysis take place (process)
How information can/will be presented to meet the needs of key stakeholders (utility)
Retaining the flexibility to modify the measurement framework as the program “learns” vs. need to retain core metrics for comparability.

Learn from other regions and the national program.
The key areas Region 10 will look for concerning measures are specific benchmarks/commitments, ease of reporting, matching with national and regional reporting requirements, ability to adapt/adjust measures in the future, how closely measures relate to outcomes, and how other efforts have developed measures based on immediacy of vulnerabilities (for example, how hurricane Sandy and other recent extreme events have shaped measures developed for the east coast).

How to track and report progress
• Consider an annual Highlights of Progress document that is excerpted from the existing Region 10 reporting requirements and provided in a useful format common to other regions and national programs
• Consider how our strategic action contacts would report internally on adaptive management phase, with guidance provided from the Climate Change Science Advisor
• Region 10 Strategic Alignment could include an adaptive management phase at the Goal level in Highlights of Progress.
• The Climate Change Science Advisor will use the Evaluation and state of management phase to:
  o Inform any needed changes to the Region 10 Climate Change Adaptation Strategy.
  o Identify appropriate performance measures for measuring the effectiveness of the Strategy.

Document regional program awareness and use of climate science even as we develop measures.
Even without a logic model structure in place for climate change adaptation actions, in Region 10 we are seeing awareness of the availability and use of climate science increasing, and can begin to document this trend. An example is awareness and use of climate science and tools in our Office of Water and Watersheds TMDL program. For approximately the past two years, we have been conducting an ongoing pilot project where we have been incorporating climate science into an ongoing temperature TMDL. As follow-on to this process, the TMDL unit in March 2013, held an internal demonstration of where to find downscaled 7Q10 flow data projections under climate change scenario models on an interactive website. Similarly, our regional wetlands program led (co-sponsored with our Region 10 Science Steering Council) a workshop on new tools to assess the impact of climate change on wetlands.

Office of Water, Logic model example:
### Vision

**Area 3 Coastal and Ocean:** Ocean and coastal environment protected against climate change and against unintended adverse consequences of responses to climate change.

### Goal

- Support collaborations creating and sharing of information and best practices
- Develop partnerships that assist effective adaptation action for coastal and ocean environments
- Ensure that mitigation and adaptation measures are environmentally sound
- Adjust EPA programs to incorporate shifting environmental conditions and other emerging threats

### EPA Role

- Foster partnerships, collaborations, and information sharing
- Provide technical assistance
- Promote best practices for climate-readiness planning
- Develop climate-readiness guidance for federal programs, agencies, and authorities
- Develop environmental safety criteria for offshore renewables and CCS

### Primary Audiences

- EPA’s NWP and NEP programs
- U.S. National Ocean Council
- Regional ocean organizations
- State and local watershed organizations
- Coastal communities and planners
- Coastal infrastructure owners and operators

### Audience Awareness

- Understand strategies for incorporating adaptation into federal policies & programs
- Aware of adaptation options
- Aware of relevant partners & opportunities to collaborate/share information
- Mindful of the potential hazards that offshore renewables and CCS may pose to coastal and ocean resources

### Audience Behavior

- Integrate adaptation considerations into policies & programs at the federal level
- Incorporate climate change & adaptation considerations into regional, state & local programs & plans
- Engage in collaborative partnerships that ensure information-sharing and prevent duplication of efforts
- Adjust offshore renewables and CCS permitting criteria to consider adverse effects to ocean & coastal resources

### Conditions

- Climate-change-induced risks to coastal and ocean ecosystems and infrastructure are minimized
- Coastal and ocean environments continue to provide current levels of ecosystem services and socioeconomic benefits
- Coastal and ocean infrastructure and ecosystems are protected against adverse effects of climate change adaptation and mitigation efforts

### EPA Sphere of Direct Influence

- Examples of additional influences on primary audiences:
  - Shoreline development and real estate trends
  - Weather, tidal, and climate conditions
  - Technological advances (particularly CCS, renewables, and IT)
  - Offshore navigational dredging
  - Renewable portfolio standards
  - Competing planning considerations
  - Emerging climate threats
Subcommittee Meeting - Jefferson County Conservation Futures
DRAFT Agenda
4:30 PM – 6:00 PM       Monday, June 8, 2015
Jefferson County Public Health Pacific Room
615 Sheridan St. Port Townsend, WA 98368

4:30 – 4:35   Welcome and Introductions
4:35 – 4:40   Observer Comments

Old Business

4:40 – 5:50   New Business

General discussion on Conservation Futures Program and process.
Identify next steps on proposing changes for 2016 funding cycle to full committee.
Next meeting

5:50 – 6:00   Guest Observer Comments

6:00          Adjourn

Subcommittee Members: Phil Andrus, District 2; Lige Christian, District 3; Rob Harbour, Interest – Working Lands; Richard Jahnke, Interest – Coastal Areas