5.3 Changes in Ecosystem Health & Vegetation Disturbance: Wildfire, Tree Health, and Non-Native Invasive Species

Washington State Parks manages diverse habitats across the state – from rainforest on the Olympic Peninsula and prairie-lowland forests in the Puget Trough[28], to dry pine-mixed conifer forests and shrub-steppe in eastern Washington (WSPRC 2016). Natural forest areas are central to the experience that Washington State parks provide visitors. These areas also provide essential habitat for native species, including federally designated threatened and endangered species. Maintaining and restoring a wide diversity of habitat is an important component of the agency's stewardship responsibilities.

Observed Changes: Fire Risk, Tree Health and Non-Native Invasive Species| Observed changes in ecosystem health and vegetation disturbance are discussed in Box 1 in Section 4.

Impacts on Parks: Current Ecosystem Health and Vegetation Disturbance | Washington State Parks are significantly impacted by wildfire, insect and disease outbreaks, and non-native invasive species. Wildfire is a major threat in eastern Washington, although fires have also occurred in western Washington (e.g., Beacon Rock and Fort Ebey state park).

Wildfires have forced temporary park closures and have directly damaged park infrastructure. For example, Washington's record breaking 2015 fire season resulted in a five-week closure of Alta Lake State Park and damaged large swaths of forested park land (Figure 15). Required repairs to the site included replacement of power lines and facilities. Staff also noted that burn bans can lead to campsite reservation cancellations, and lost revenue. Similarly, cancellations occur when fires compromise air quality. The ability to quickly evacuate campgrounds in the event of a fire is always a concern in high fire risk areas (e.g., 25-Mile Creek in Lake Chelan). Eastern Region staff have also had to deal with significant post-fire flooding and debris management

Figure 15. Fire damage at Alta Lake State Park, 2015. Image source: John Hendrick; KXLY4 News

[28] The Puget Trough ecoregion is a stretch of land between the Olympics and Willapa Hills (to the west) and the Cascade range (to the east). The ecoregion stretches the length of Washington State, and does not exceed 1,000 ft. in elevation. The region includes coastal lowlands, coastal islands, and low-elevation foothills.

issues in areas affected by wildfire. State Parks is currently partnering with the School of Environmental and Forest Sciences (SEFS) at the University of Washington to assess wildfire fuel and fire hazards, as well as develop strategies to reduce these issues on State Parks lands (Box 3).

Parks staff in all regions are actively engaged in forest thinning and fire prevention to reduce fire risks to parks. These activities also extend to addressing tree health issues related to insects and disease. Disease or insect damage to park trees creates tree-fall hazard risks for visitors and structures, and can impact operations via the need to mitigate these risks. In the last seven years, the Northwest Region has closed multiple campgrounds because of tree health concerns. For example, the campground and group camp site at South Whidbey State Park were closed in 2015 and in 2016 due to aging old-growth and concerns that falling limbs or trees pose a risk to campers. Concerns over tree health and a resulting increase in tree-fall hazard led Parks to close the campground at Rockport State Park in 2013 and convert the park to day-use only. Staff noted a feedback loop among fire, insects, and disease, where insect/disease damage often results in high stress conditions in trees or leads to tree mortality, resulting in drier fuels and greater risk of wildfire intensity and spread. These feedback loops pose challenges for State Parks in both developed landscapes (e.g., protecting staff, public, and infrastructure), and in undeveloped areas of the park system (e.g., safeguarding recreational trails, preserving user experience and habitats).

In addition to tree health issues, Parks is significantly affected by invasive species and noxious weeds. For example, English ivy and Scotch broom are rampant in several western Washington parks. Poison hemlock is also an issue on Whidbey Island.

Parks currently conducts surveys to identify a subset of the known or suspected non-native invasive species across the park system. Where these species are identified in high-value habitats, regardless of their legal status, efforts are made to map these populations, develop treatment approaches, and suppress them as time and resources allow. Resources are never sufficient and most efforts commonly focus on noxious weeds, which are most commonly found in developed areas of the park system and areas that are disturbed by human or natural events. This is especially the case following wildfire, where noxious and/or non-native species always increase their footprint in the wake of a fire. Parks visitors and adjacent landowners expect that Parks will identify, remove, and prevent the spread of noxious weed species. Additionally, Parks has a legal responsibility, enforced by the Washington State Noxious Weed Control Board, to remove noxious weeds from their property. Eradicating existing invasions and preventing future spread is a resource intensive process requiring funding, staff time, equipment, and continued monitoring.

Box 3. Identifying Fire Risk to Prioritize Treatments to Reduce Fuels and Fire Hazard in Eastern WA State Parks

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The 2014 through 2016 Washington state fire seasons had a combined 1,687,503 acres burn in large wildfires, with 2015 being the largest wildfire season in state history with more than 1 million acres burned (DNR 2017). The state had not experienced an area burned of this magnitude since early in the 20th century. The majority of these fires occurred in eastern Washington, where conditions typically remain hot and dry for much of the late spring through the end of September, although western Washington is not immune to fire risk. While the general public often views these fires as issues for private timber lands and national forests, state lands, including parks, are also involved in this growing threat.

Fire exclusion since the late 1800s and early 1900s (Cohen and Miller 1978) has caused a shift in fire regimes that has increased the availability of fuels. Lack of fire has led to overly dense, flammable forests, and woody debris, organic duff, and plant litter to accumulate on the forest floor (Agee 1993, Ogle and DuMond 1997), creating unprecedented amounts of fuels that can prompt longer, more intense fires than these environments have experienced in recent history. Population across the state is expected to continue to grow, as will the associated wildland-urban interfaces (WUIs). For example, current population estimates show Spokane County increasing from approximately 489,000 residents in 2015 to 592,000 residents in 2040, a 20% increase over a 25-year period (WA OFM 2012). This assessment centers around two of eastern Washington's largest state parks in the Spokane area: Riverside and Mt. Spokane. Both parks currently have large accumulations of woody debris and very dense tree stands.

University of Washington's Wildland Fire Sciences Laboratory (WFSL) developed models to determine the amount of fuels and associated fire risks for the two state parks. This assessment was designed to help Parks staff "rank" the fire risks across each park, so that fuel treatments are prioritized for park areas with the highest wildfire risk.

Initial results of fuel and forest condition indicate the fire risks are moderate to high in several areas across both parks. Both parks have many fire-related vulnerabilities that contribute to higher risks. Riverside is an urban park, and its proximity to WUIs and wildlife habitat make these areas a higher priority for protection from mixed and high-severity fire damage than other areas with similar fire hazard. Mt. Spokane's steep slopes, high elevation, and minimal number of entrance and egress points from the park make areas bordering the park's two main roads particularly important to lower fuel hazard on.

Due to the increasing population of the Greater Spokane Area, we recommend treating fuels in park areas with these additional associated "weights" listed above. We recommend reducing tree density per stand and raising the average crown height per stand to reduce surface fire and potential crown fires. Additional outreach to neighboring landowners (both residential and commercial) is recommended to educate park neighbors of fire dangers and land treatments that they can implement on their properties.

Projected Changes: Fire Risk, Forest Health, and Non-Native Invasive Species | Warming temperatures, declining summer precipitation, and declining snowpack will stress trees and vegetation in ways that are expected to increase disturbance events such as drought, fire, and insect and disease damage**.** Projected changes in ecosystem health and vegetation disturbance are discussed in greater detail in Box 2 in Section 4.

Workshop Concerns About Changes in Fire Risk, Tree Health and Non-Native Invasive Species| Changes in vegetation are a serious concern for Washington State Parks. Through a series of regional workshops, staff highlighted the implications of increased fire risk, increased susceptibility of stressed trees to insect and disease damage, and the spread of non-native invasive species and noxious weeds for State Parks.

Figure 16. State Parks staff respond to a fire in Conconully State Park in summer 2015. Photo credit: *Washington State Parks.*

Wildfire. The majority of Park regions ranked an increased risk of wildfire as a high consequence issue. Wildfires can result in more campsite cancellations, more frequent park closures, costly repairs to damaged infrastructure, reduced air quality due to smoke, increased establishment of non-native invasive species, loss of unique landscapes and habitats, and diversion of staff and resources to deal with issues related to on-going fires, which can affect the ability to complete previously planned work. Post-fire tree damage can create safety hazards for park visitors and require removal from areas in proximity to campgrounds, trails, and other areas accessed by the public. Even in the absence of fires, an increase in high fire risk conditions would require more frequent or prolonged burn bans at parks, affecting visitor experiences. Extensive thinning to reduce fire risk may also affect visitor experiences and reduce visits to affected sites. The net result is a higher potential for lower revenue, lower visitor satisfaction, and increased operating expenses in areas affected by more wildfire (Figure 16).

Staff rated the ability to adapt to an increased risk of forest fires as moderate to hard. While Parks is already engaged in efforts to reduce wildfire risk, adapting to an increased risk of fire will require more proactive forest fuel reduction management. Without additional funding, there would be increased strain on staff time and financial resources.

Insects & Disease. Changes in tree health due to an increase in insects and disease would exacerbate existing challenges with forest health issues in many parks. Main concerns relate to the potential for more tree fall impacts on park operations. Tree hazards could lead to more campsite and picnic area closures or more extensive clearing of infected trees, which may reduce visitor satisfaction. Consequences include increased public safety concerns, fewer park visits, lower revenue, and higher operating expenses at affected sites. Staff considered these issues to be of high consequence.

The ability of Parks to adapt to changes in insects and diseases varied from easy to hard. Parks' strategy to address insect and disease issues includes thinning and forest health evaluations aimed at 1) reducing the spread and susceptibility of forested habitats, and 2) identifying trees which may present public safety concerns in the future. Increased tree susceptibility to these non-native agents will require expanding existing management programs, a process that could build upon structures and staff already in place. More resources are needed to expand staff training to recognize symptoms of stressed and infected trees, however. Staff also noted that it can be difficult to identify trees that pose a fall risk; even trees that appear healthy (especially coniferous trees) can "fall over at a moment's notice." As climatic changes increase stressors on treed landscapes, forest management practices will need to be increasingly proactive (i.e., removing susceptible trees before they are infested or become diseased), as the agency will be unable to treat and spray entire forests to prevent infestation or disease. These management shifts will likely require increased staff involvement (e.g., staff effort and staff training to identify signs of tree stress), which may be challenging given current staff limitations.

Non-Native Invasive Species. The potential for expansion of non-native invasive species (including noxious weeds) in a changing climate could reduce the ecological integrity of native vegetative communities on park properties. This shift could affect visitor experiences and the stewardship mission of State Parks. Staff noted that rising summer temperatures and extended drought periods will likely stress hard pine species in Washington, especially at the lower, drier edges of their ranges, thus weakening them and predisposing them to high risk of successful beetle attacks. Additionally, more non-native weeds would require expanding management efforts to identify, remove, treat, and prevent further invasion of these unwelcome "visitors". Absent additional resources, enhancing these efforts would put additional strain on limited staff time and resources.

Staff rated the ability to adapt to more non-native invasive species and noxious weeds as moderate to hard. While Parks has significant experience managing weeds, controlling expansion of non-native invasive species may prove challenging due to finite financial resources and staff time. Increasing herbicide use would be expensive and may be undesirable to park visitors, who have voiced disapproval over past use of herbicides to combat noxious weeds.

5.4 Sea Level Rise and Related Impacts

Washington State Parks has dozens of parks located along the Washington coastline. Many of these parks are among the more heavily used parks in the State Park system. As a result, sea level rise was identified as a major concern for the Northwest Region, Southwest Region, and the Planning and Stewardship programs.

Observed Changes in Sea Level | As discussed in Section 4, sea level is rising in most coastal areas of Washington State and Puget Sound, with the notable exception of Neah Bay.

Impacts on Parks: Current Climate | Coastal erosion and flooding related to storm surge, wave action, and King Tides[29] are already common problems in coastal parks. Bluff erosion has been a persistent issue at South Whidbey State Park; portions of a coastal trail have been lost and stairs providing beach access require regular repair. Staff are working to limit shoreline erosion near historic buildings at Manchester State Park, and erosion at Dash Point State Park has led to bluff sloughing. Significant sloughing events have also occurred at Blake Island, Kopachuck, and Sequim Bay state parks. These events have limited or blocked access to beaches and trails, which negatively affects visitation rates at these parks. On the outer coast, Cape Disappointment has lost over 260 acres to erosion over the past 40 years (Kaminsky et al. 2003, Kaminsky et al. 2010). Westport Light State Park has also experienced significant losses from beach erosion near the South Jetty for more than 25 years.

Coastal flooding has also created challenges for Parks staff. Inundation of coastal parks can disrupt facility operations, reduce access to parks or park amenities (if low-lying roads are inundated), damage low-lying facilities, and lead to campsite closures. In the Northwest Region, the beach and cabins at Cama Beach State Park are frequently inundated during annual King Tides (Figure 17). Staff often have to clear out driftwood deposited by the flooding and repair cabins (e.g., dry out cabins, replace damaged wiring).

King Tides also frequently flood the lower day use area and boat launch at Camano Island State Park, Spencer Spit State Park, Bay View State Park, and the campground at Fort Casey Historical State Park.

[29] King Tides are higher-than-usual-tides which only occur a few times per year. In Washington, King Tides typically occur during winter.

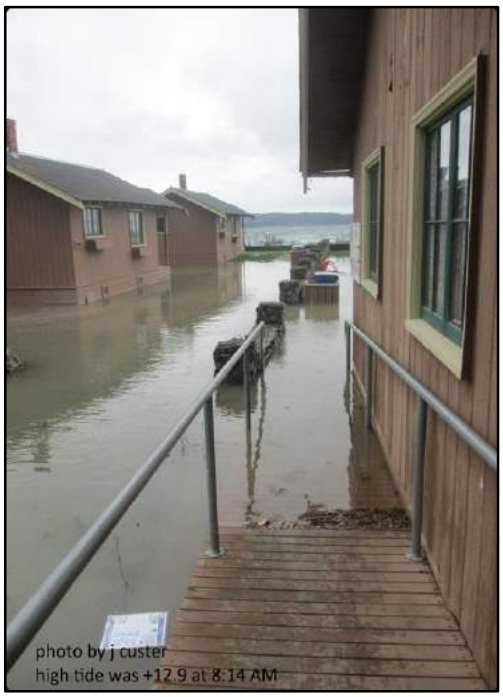


Figure 17. King Tide flooding at Cama Beach State Park, December 17, 2012. *Image source: J. Custer, http://www.camabeachfoundation.org/king-tides.html*

Other parks with historical structures and archaeological sites currently at risk of damage from coastal flooding, storm surge, or erosion include Kitsap Memorial, Potlatch, Belfair, and Fort Worden state park.

Projected Sea Level Rise | Detailed discussion of projected sea level rise for Washington State is available in Section 4.

Workshop Concerns About Sea Level Rise | Parks staff ranked most of the impacts associated with sea level rise as *hard to adapt to* and *high consequence* issues. A key concern is the number of coastal parks potentially affected by sea level rise impacts and the associated cost of dealing with those impacts.

As sea level rises, greater reach of tides and storm surge, increased erosion, and permanent inundation of low-lying areas is expected to increasingly disrupt or limit access to park beaches and facilities. For example, low-lying parking lots may become unusable for longer periods of time with more frequent coastal flooding. These issues can also damage parks infrastructure, including buildings, roads, septic systems, campgrounds, docks, and beach stairs. Reduced access and potential park closures will negatively impact visitation rates and visitor experiences, while also increasing operating costs to repair damage. Saltwater intrusion in groundwater supplies could also affect services at coastal parks, expanding the issue beyond current saltwater intrusion problems at Blake Island State Park.

Another issue raised by Stewardship staff is the potential that increased erosion will reveal more archaeological deposits on park properties. Once exposed, these sites become more vulnerable to vandalism. Agency responsibilities for protecting archaeological sites will increase in this scenario. Staff noted the potential need to expand off-site artifact storage as a result. Sea level rise will also likely have implications for coastal restoration projects.

Adapting to these projected changes will be expensive. Managing erosion issues is an on-going and costly challenge for State Parks with few permanent solutions. Relocating low-lying facilities and campsites to higher areas will only be possible if suitable areas exist within a park. State Parks may also receive pushback from the public on relocating campsites further from the shoreline. Moving facilities becomes even more challenging when historical facilities are involved. Historical sites are areas of significance for State Parks and popular attractions; moving the facilities disrupts the historical setting of those sites, changes visitor experiences with the sites, and can potentially damage the structures. State Parks does not currently have any guidance to help staff determine if, when, and how to adapt historic sites to the impacts of sea level rise.

Adapting facility water supplies affected by saltwater intrusion would also be difficult. Depending on location, the ability to hook into alternative uncontaminated water sources may be limited. This may require limiting operations or closing facilities where issues cannot be resolved. Belfair State Park and parks along Hood Canal are more likely to experience these challenges relative to other Southwest Region parks.

While adapting to sea level rise will be costly, sea level rise impacts and the order in which to address those impacts will vary by location depending on what is affected by sea level rise, visitor levels, unique or historical features of a park, and other factors, as illustrated in the following examples from the Southwest Region's "deep dive" discussion (for more information see Appendix A) based on the Surging Seas Risk Zone Map:

- *Manchester State Park.* With four feet of sea level rise (either permanent inundation or with the combination of lower amounts of sea level rise and storm surge), road access to structures within the Manchester State Park are inundated. However, campsites and major facilities are not directly affected. The facilities that did fall within the inundation area are not unique or of historic significance, and therefore would be lower priority for adapting.
- *Blake Island State Park.* Sea level rise would increase erosion rates and inundate coastal areas of the park. Of particular importance is potential inundation of the marina area and the day-use area with heavy day-use activity. Blake Island State Park is considered a unique area, and therefore the potential inundation of popular day-use areas was considered a high concern.

While the sea level inundation maps are useful for showing areas that are likely to be permanently inundated or affected by higher surge, the maps are unable to capture the dynamic effects of coastal erosion and bluff sloughing. Additional site-by-site evaluation of sea level rise impacts is recommended (see Section 6; Conclusions).

5.5 Other Climate Change Impacts on State Parks: Increasing Temperatures

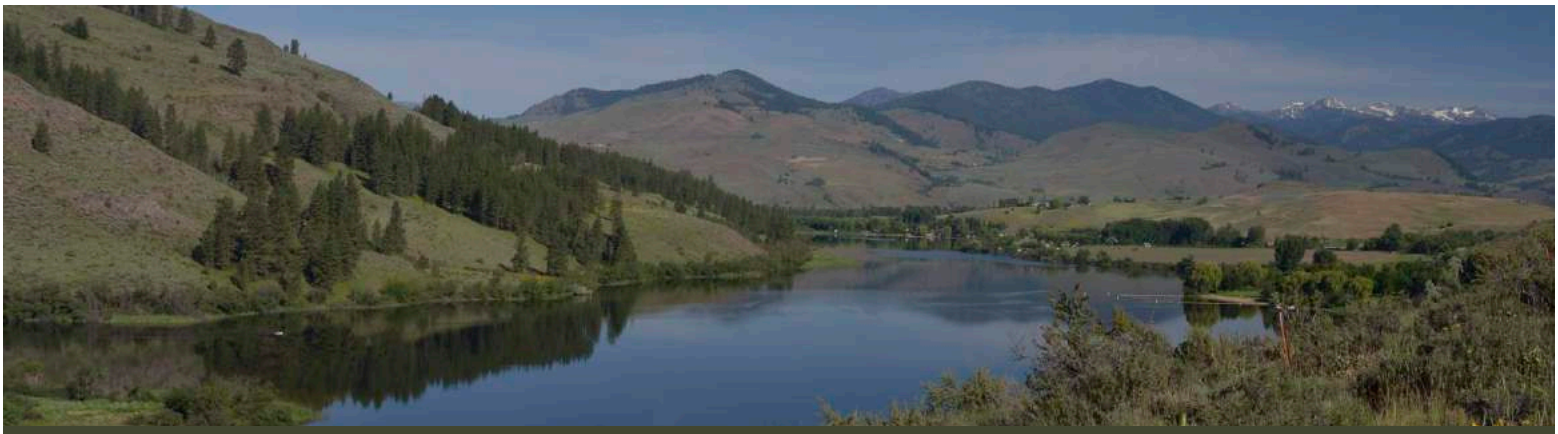
Other climate change impacts discussed by staff included those more directly associated with increasing temperatures. In general, impacts related to temperature were considered easier to adapt to, although results varied by region and impact. Potential issues noted by staff in multiple regions and programs included the following:

Changes in Park Visits. Warmer fall and spring temperatures could lead to more park visitors in the shoulder seasons (spring, fall). Warming temperatures may also shift regional patterns of park visits. For example, warming may increase the number of people traveling from eastern Washington (where people may consider it too hot) to visit parks west of the Cascades. More extreme heat events would also likely drive more people to visit parks with water features, straining parking facilities in more popular locations and increase general wear-and-tear on facilities. The number and frequency of heat-related medical responses at parks is also expected to increase. If the park visitation rates increase it will likely mean more revenue, which helps deal with some of these impacts.

Changes in Water Quality. Algal blooms in lakes are a concern because of the potential consequence to human health prior to detection. Warmer temperatures during summer can increase algal bloom issues in lakes. If specific algal thresholds are reached, State Parks is required to close recreational access to the affected lakes. Southwest Region staff noted that Anderson Lake State Park currently experiences algal blooms. Staff also thought that Deep Lake in Nolte State Park could experience algal bloom issues in the future with continued warming.

Similarly, warmer summer water temperatures can increase the potential for *Vibrio* outbreaks in coastal areas, lakes, rivers, and streams, particularly in the southern Hood Canal region. *Vibrio* outbreaks may require shutting down swimming or shellfish harvest areas. However, staff noted that they have not seen any reductions in park use where those closures occur, so the impact is easy to adapt to.

More on these and other impacts discussed in this section are included in the workshop summaries in Appendix A.



6 Conclusions and Next Steps

As a preliminary assessment, this report represents an initial step towards preparing the Washington State Parks system to address climate change impacts. However, this assessment is just the beginning of a continuing process to integrate climate change considerations into planning, decision-making, and activities at all levels of State Parks management.

This assessment reveals that many parks are already experiencing climate-related concerns, including flood damage to campsites and infrastructure, wildfires that close or threaten parks, reduced snowpack that curtails winter activities, and sea level rise that inundates coastal parks and infrastructure. The assessment also describes how these and other climate-related impacts are expected to be exacerbated by continuing climate change trends. While the assessment identified examples where Parks staff considered climate change in planning and decision-making, staff also emphasized the need for a more proactive and intentional approach to addressing climate change impacts.

To develop a proactive approach to addressing climate change impacts, the authors of this assessment recommend the following next steps.

Engage Staff to Address Climate Risks | This assessment provides a foundation for developing and implementing responses to climate change impacts. Some responses are appropriate at the agency-wide level and some will be specific to a region or individual park. In most cases, engaging staff to develop responses will enhance the effectiveness of responses and increase support for their implementation.

While this assessment describes a wide range of expected climate change impacts, there are a common set of impacts that affect most parks. These include changes in precipitation and hydrology, changes in snowpack and changes in ecosystem health and vegetation disturbance. Sea level rise and related impacts are also a common impact at most coastal parks. There may be a common set of responses that would be applicable across parks experiencing similar climate change impacts.

The assessment also reveals that each region, and in some cases each park, is likely to experience climate change impacts uniquely depending on how the impacts manifest in relation to the specific geographical setting and park features (see Appendix A). Thus, while there are commonalities in impacts and responses, implementation should be tailored to the specific impacts and park setting. At the

specific park level, additional assessment may be required for planning, siting infrastructure and other activities.

Due to the large number of Park properties and the wide range of climate change impacts, prioritizing response efforts may be needed. This assessment provides ratings for the expected consequences of climate change impacts and the ability to adjust to them. Focusing on the high and moderate consequence impacts, and secondarily on the impacts rated easy or moderately difficult to adjust to may provide an initial framework for prioritizing efforts.

Fill information gaps | In most cases, this report provides sufficient information to develop responses to climate impacts, especially at the agency-wide and regional scale. However, at the specific park scale, additional precision may be warranted for infrastructure siting and other activities. When determining if additional information is necessary, it is useful to clarify the degree of precision that is needed. In many cases, understanding the trends and the potential magnitude range of the impacts is sufficient to develop responses.

This assessment identified a number of topics where more specific information could aid in planning and decision making. These information gaps could inform priorities for future research, ideally within the context of an adaptation management framework. The primary information gaps identified in this assessment are:

- *Site-specific examination of sea level rise impacts at priority parks.* While the sea level maps included in Appendix D are useful for showing areas that are likely to be permanently inundated or affected by higher surge, the maps are unable to capture the dynamic effects of coastal erosion and bluff sloughing. These sediment processes play a significant role in determining how sea level rise will affect the shorelines by changing the shape of a coastline over time and altering sediment movement in the nearshore. Therefore, interpretation of how sea level rise will affect coastal parks should consider the dynamic effects of coastal erosion and bluff sloughing, in addition to the storm surge zones and permanently inundated areas.

- *Higher resolution modeling of projected changes in the snowline.* Projected changes in snow water equivalent (Section 5.2 and Appendix C) were developed using the macroscale Variable Infiltration Capacity (VIC) hydrologic model (Liang et al. 1994). VIC is a large-scale hydrologic model with limited ability to provide fine-scale projections in small and medium sized catchments. As a result, VIC is unable to generate projections for shifts in the snowline across Washington State, which require localized, high resolution projections. Projected changes in snowline elevation are extremely important for the Winter Recreation Program, as they would help inform Sno-Parks prioritization at various elevations and may result in moving Sno-Park access points (e.g., parking lots) to higher elevations. The Distributed Hydrology Soil Vegetation Model (DHSVM; Wigmosta et al. 1994) is a high-resolution (e.g., 100 m for watersheds to 10^4 km^2 for multi-year simulations) hydrologic model. The ability of DHSVM to generate projections at high spatial resolutions makes it an ideal choice for developing projected shifts in the snowline. Vulnerability of individual Sno-Parks across the state should thus be re-assessed as these data gaps are filled.

Build partnerships | Washington State Parks is not alone in confronting climate change impacts. Many state agencies have begun addressing climate change, including Washington Department of Fish and Wildlife, Washington Department of Natural Resources, Washington Department of Transportation, and many others. Many tribes have also conducted climate vulnerability assessments and developed adaptation plans. Many agencies and tribes are addressing climate change impacts that are similar to those identified in this assessment or may have developed responses that could be applicable to parks. As the Washington State Parks and Recreation Commission takes the next steps to develop responses to climate change impacts, these entities could provide valuable guidance, insights and experience to support the efforts.