SAFEGUARDING OUR LANDS, WATERS, AND COMMUNITIES:

FEBRUARY 2020

DNR'S PLAN FOR CLIMATE RESILIENCE

WASHINGTON STATE DEPT OF
NATURAL RESOURCES
HILARY S. FRANZ
COMMISSIONER OF PUBLIC LANDS

LETTER FROM THE COMMISSIONER OF PUBLIC LANDS

HILARY S. FRANZ
Commissioner of Public Lands

As Commissioner of Public Lands and the leader of the state Department of Natural Resources (DNR), it is my job to ensure that Washington's lands, waterways, shorelines, and communities thrive today and into the future. Climate change presents unprecedented threats to that responsibility.

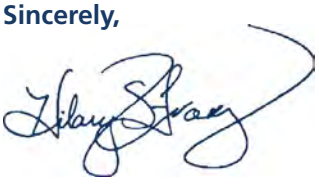
Across the state, we are seeing and feeling impacts related to a changing climate. Wildfire and smoke are threatening the health and welfare of people throughout the state. Orca and salmon runs are in decline. Communities are confronting coastal flooding, water shortages, and drought. As these impacts mount, already highly impacted communities and vulnerable populations will face increasing risks.

At DNR, our first step has been to identify and prioritize the ways in which climate change impacts our mission and responsibilities. For example, we know that our wildland firefighters are facing changes in wildfire behavior that have implications for wildfire preparation and response. Our forests confront the potential for increased damage from insects, pathogens, and drought, and our agricultural lands are facing decreasing water supplies and potential increases in weeds and invasive species. In addition, we are confronting the potential for increased damage to roads and other infrastructure from changes in precipitation, and the challenges of ocean acidification and sea level rise.

This report takes a critical look at what our agency is doing today to address and respond to climate change. It also sets forth DNR's priority responses for each program and at a statewide level to achieve climate resilience on our lands and for our beneficiaries and communities. For many responses, DNR can take action with our existing resources and authorities. Others will require support from the Legislature and need the expertise of our many partners across the state to achieve the goals. Finally, this plan provides options for supporting communities of Washington State to take critical steps to become more resilient.

This climate resilience plan illustrates the enduring commitment we have as an agency to work alongside partners, scientists, lawmakers, tribes, beneficiaries, communities, and others to achieve climate resilience across our state.

Sincerely,



HILARY S. FRANZ
Commissioner of Public Lands

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I. A CALL TO ACTION

The summer of 2015 was a climate change wake-up call for Washington state. That year, the state experienced its worst wildfire season in recent history, burning more than 1 million acres and more than doubling the previous fire record set the previous year. Wildfires destroyed more than 500 structures[1] and severely burned four firefighters, killing three. Wildfire smoke blanketed the state, causing significant air quality concerns for nearly five weeks.[2] Washington also experienced its hottest year on record in 2015[3], leading to water shortages, as much as $733 million in agricultural losses[4], and the death of hundreds of thousands of salmon and other fish.[5] Seattle, Tacoma, and Everett were forced to institute water conservation measures, and a number of drinking water systems in smaller communities nearly failed.[6] Extreme marine water temperatures were associated with a record-setting harmful algal bloom from California to Alaska that resulted in high levels of shellfish toxins and closed salmon, shellfish, and Dungeness crab fisheries along the entire Northwest coast.[7]

These impacts did not begin—and did not end—in 2015. Temperature and climate-related impacts have increased for decades and are projected to continue on this trajectory.[8] Globally, nine of the 10 hottest years on record all occurred since 2005[9], and the last five years were the hottest (2015-2019).[10] The years 2010-2019 were the hottest decade on record, and every decade since the 1960s has been hotter than the one before.[11] The primary cause of this warming

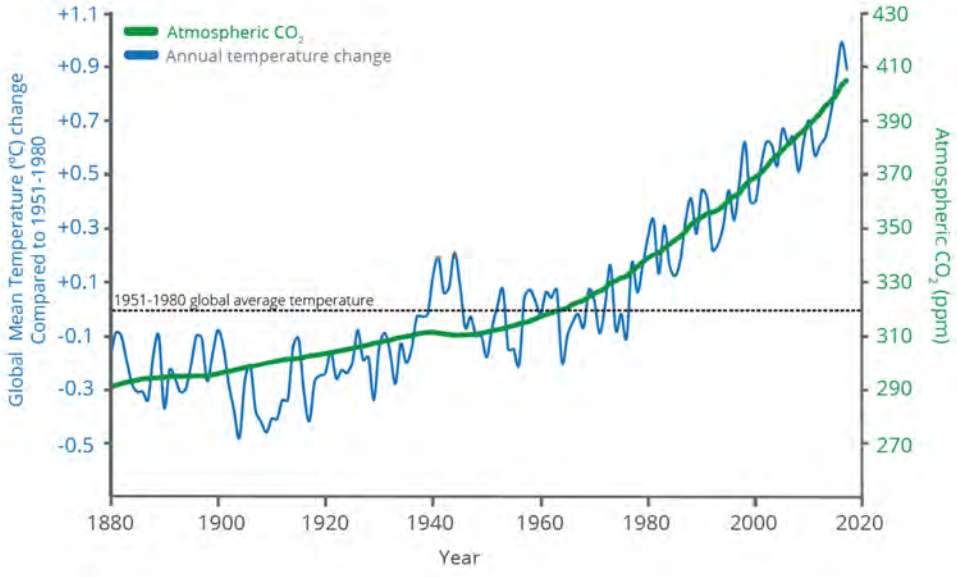
"Although the projected impacts of climate change can seem dire, our future doesn't have to be."

–Hilary S. Franz, Commissioner of Public Lands

GLOBAL TEMP AND CO_2 PPM

Since the industrial revolution, atmospheric concentrations of CO_2 and global temperatures have increased significantly. Atmospheric CO_2 increased from about 290 ppm in 1880 to over 410 ppm today, as shown by the green line. Over the same period, global temperatures increased approximately 1°C (1.8°F)—the blue line shows global annual temperature compared to the average global temperature for the period 1951-1980.

Source: Snover, et al. 2019. "*No Time to Waste. The Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C and Implications for Washington State.*"



[1] Northwest Area Coordination Center. 2019. *Significant Incident Summary Spreadsheet for GACC Incidents*. [GACC = Geographic Area Coordination Center]. Incidents involving 100+ acres or an IMT Type of 1 or 2.
[2] United States Department of Agriculture. 2016. *Narrative Timeline of the Pacific Northwest 2015 Fire Season*.
[3] https://statesummaries.ncics.org/chapter/wa/
[4] McLain, et al. 2017. *2015 Drought and Agriculture*. Washington State Department of Agriculture.
[5] Washington Department of Fish and Wildlife. 2016. *Drought Response 2015*.
[6] Washington State Department of Ecology. 2016. *2015 Drought Response: Summary Report*.
[7] May, et al. 2018: Northwest. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. U.S. Global Change Research Program.
[8] Snover, et al. 2019. "*No Time to Waste. The Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C and Implications for Washington State.*"
[9] NOAA. 2019. *State of the Climate: Global Climate Report for December 2018*. https://www.ncdc.noaa.gov/sotc/global/201812. Accessed October 2, 2019.
[10] https://www.nasa.gov/press-release/nasa-noaa-analyses-reveal-2019-second-warmest-year-on-record. Accessed January 15, 2020.
[11] https://www.nasa.gov/press-release/nasa-noaa-analyses-reveal-2019-second-warmest-year-on-record. Accessed January 15, 2020.

trend—increasing atmospheric carbon dioxide (CO_2) and other greenhouse gases—continues to rise, from about 280 parts per million (ppm) of CO_2 in 1750 (pre-industrial) to more than 410 ppm in 2019 (a 50 percent increase).[12]

Ocean acidification—a consequence of elevated atmospheric CO_2 levels—is also affecting marine ecosystems. Average global surface ocean waters have increased in acidity an estimated 30 percent relative to pre-industrial times[13], compromising the growth, reproduction and survival of nearly a third of Washington's nearshore species, including oysters, clams, scallops, mussels, crabs, and calcifying plankton.[14,15] Sea level is rising at most locations around Puget Sound and has already risen more than nine inches near Seattle since 1899.[16] Sea level rise is leading to increased risk of flood inundation in many parts of Puget Sound and the outer coast.

Climate scientists describe 2015 as a preview of our future.[17] By mid to late century, the unusually warm temperatures that contributed to record-setting impacts will be the norm.[18] By the 2050s, average annual temperatures are projected to increase more than 4.5°F and April 1st snowpack is projected to decline more than 35 percent (relative to 1970-1999).[19] With the current global greenhouse gas trajectory pointing upward, temperatures are projected to continue rising and local impacts are expected to become more frequent and severe.[20]

Although the projected impacts of climate change can seem dire, our future doesn't have to be. We have choices that can prevent the worst impacts of climate change. These choices include reducing CO_2 and other greenhouse gas emissions that cause climate change, removing CO_2 and other greenhouse gases from the atmosphere, and making our communities and natural resources more resilient to the climate-influenced changes that are projected to come. ■

▲ Photo credit: Department of Ecology

[12] NOAA Monthly Average Mauna Loa CO_2 for December 2019 = 411.76 ppm. https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html. Accessed January 23, 2020.
[13] Raven, et al. 2005. *Ocean Acidification due to Increasing Atmospheric Carbon Dioxide*.
[14] Alin, et al. 2016. In: *PSEMP Marine Waters Workgroup. 2016. Puget Sound marine waters: 2015 overview*. www.psp.wa.gov/PSEMP/PSmarinewatersoverview.php.
[15] Washington State Blue Ribbon Panel on Ocean Acidification. 2012. *Ocean Acidification: From Knowledge to Action: Washington State's Strategic Response*.
[16] Mauger, et al. 2015. *State of Knowledge: Climate Change in Puget Sound*. Tide gauge data: https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=9447130. Note that lands near NOAA's Seattle tide gauge have subsided approximately 3.5 inches since 1900 (Miller et al. 2018).
[17] May, et al. 2018: Northwest. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. U.S. Global Change Research Program.
[18] May, et al. 2018: Northwest. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. U.S. Global Change Research Program.
[19] Snover, et al. 2013. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report*.
[20] Snover, et al. 2019. *No Time to Waste. The Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C and Implications for Washington State*.

II. DNR'S ROLE IN ADVANCING CLIMATE RESILIENCE

The purpose of this plan is to advance climate resilience within DNR, throughout the natural resource sectors in which we work, and among our partners throughout the state, including tribes, cities, counties, stakeholders, and other state agencies.

In this plan, DNR defines climate resilience as:

Being prepared for, and adapting to, current and future climate-related changes.

This definition of climate resilience is applicable to the lands and waters DNR manages, the functioning of DNR as an agency, and for our partners. For our lands and waters, achieving resilience means that we increase the health and integrity of our natural systems and enhance their ability to absorb and recover from disturbance. For the agency and for our partners, achieving resilience means planning for change and projected impacts in order to maintain basic functions, minimize harm, respond effectively when impacts occur, and quickly recover to resume services following disturbances. Advancing climate resilience also means reducing atmospheric greenhouse gas concentrations (through reduced emissions and carbon sequestration) to prevent further escalation of climate change impacts.

PRINCIPLES

There are two central principles to this plan, each of which is offered as overarching guidance for DNR's work to increase climate resilience.

- **Principle #1: Climate resilience requires us to be proactive rather than reactive.** Preparation is crucial, and sooner is better than later. We must plan for the growing frequency and magnitude of climate-influenced threats, be ready to respond when they occur, and have a strategy for post-event recovery. When a flood, wildfire, or other climate-influenced event occurs, we must be prepared to respond with future climate conditions in mind. Once destroyed, returning roads or structures back to the same high-risk places in the same vulnerable ways invites repeat disasters. For agencies, municipalities, and communities, resilience is often influenced by the degree of planning and preparation that allows our social, political, and administrative systems to respond effectively. Climate resilience requires us to prepare, act, respond, and recover with current and future climate conditions in mind.

- **Principle #2: Climate resilience requires us to expand partnerships and collaboration.** Climate change is the ultimate cross-boundary challenge. Wildfire, flooding, drought, and other climate impacts demand we reach outside our organizational boundaries and silos to share information, coordinate resources, and ensure that the resilience-building efforts of one sector or community do not compromise the resilience of another, especially communities facing disproportionate exposure or vulnerability to climate hazards. This will require culture change as we establish shared goals for resilience that stretch beyond what individual organizations or jurisdictions typically do and what they can accomplish alone.

STATEWIDE CONTEXT

The breadth and scale of projected climate impacts require a comprehensive response that goes beyond what currently exists in Washington state. Currently, responses to climate risks are predominantly organized at a jurisdictional or sectoral level. Many tribes, counties, and cities have developed climate

EXAMPLES OF RESILIENCE EFFORTS IN WASHINGTON STATE

- **Washington State Integrated Climate Response Strategy.** In 2012, Washington State Department of Ecology published Washington's first statewide climate change response strategy. Produced in collaboration with DNR and other agencies, the strategy articulates priority responses for seven key sectors: human health; ecosystems, species, and habitats; oceans and coastlines; water resources; agriculture; forests; and infrastructure and the built environment.[21]
- **Natural Disaster and Resiliency Activities Work Group (SB5106).** In 2019, the Legislature directed the Office of the Insurance Commissioner (OIC) to create a work group to study and make recommendations on natural disaster mitigation and resilience, including whether the state should create an ongoing disaster resiliency program. A final report is due December 1, 2020.
- **Landscape Collaboratives.** The Cascades to Coast Landscape Collaborative and the Cascadia Partner Forum's Cascadia Climate Adaptation Strategy are developing information, visions, and resources to achieve a network of resilient, healthy, and connected ecosystems and working landscapes capable of providing a full suite of ecosystem services.
- **Local and Tribal Government Resilience Plans.** Tribes, cities, counties, agencies, and others have created climate-related plans across Washington state and across the U.S. Listings of current climate adaptation plans are available at https://www.adaptationclearinghouse.org/ and https://tribalclimateguide.uoregon.edu/adaptation-plans.
- **U.S. Forest Service Climate Change Vulnerability Assessments.** The U.S. Forest Service has conducted and published vulnerability assessments for multiple regions in Washington: the Olympic Mountains, East and West Cascades, Blue Mountains, and Southwest Washington. See http://www.adaptationpartners.org.

adaptation plans, a few have implemented specific actions to build their resilience,[22] and some state agencies have organized multi-agency or broader responses to specific issues such as drought, wildfire, and coastal hazards.[23] However, the scale of climate change impacts goes beyond jurisdictional, agency, and sectoral boundaries. Multi-sector impacts are already occurring, such as post-wildfire landslides and floods, or human mortality and sickness from heat

and smoke driven by drought-related wildfire.[24] In many cases, low income, vulnerable, and historically disadvantaged communities experience the brunt of these impacts.[25] Although there are many plans and projects addressing climate resilience in Washington, the scale of the challenge is large, and the scale of the response must be commensurate in order to build resilience to increasing climate threats.

DNR is not the first entity to develop a climate resilience plan in Washington. Around the state, many are working to prepare their communities and their natural resources for the changes that are expected over the coming decades. Tribes, government agencies, counties, cities, local organizations, and others have developed plans and initiated projects to enhance resilience to increasing climate-related threats such as wildfire, drought, and flooding. This plan is intended to identify ways in which DNR's actions can complement and support these efforts around the state.

DNR'S MISSION

Manage, sustain, and protect the health and productivity of Washington's lands and waters to meet the needs of present and future generations.

DNR'S VISION

Our actions ensure a future where Washington's lands, waters, and communities thrive.

DNR PROGRAMS INCLUDE:

- **Wildfire**
- **State Uplands**
  - Forested Trust Land Management
  - Uplands Leasing (agriculture, grazing, commercial, and water management)
  - Natural Heritage & Natural Areas Programs
- **Forest Health and Resiliency**
  - Urban and Community Forestry
- **Forest Practices**
  - Adaptive Management Program
  - Small Forest Landowner Office
- **Aquatic Resources**
- **Washington Geological Survey**
- **Recreation**

APPROACH

DNR operations connect to all parts of the state and every natural resource sector. Every DNR program is sensitive to climate change in one way or another. Therefore DNR is committed to enhancing climate resilience within all parts of the agency and across all sectors of our state's natural resources.

DNR manages 5.6 million acres of state lands including forests, farms, rangeland, aquatic lands, conservation areas, urban and commercial properties, recreation sites, and clean energy facilities such as wind and solar farms. The agency supports the state's largest on-call fire response team with responsibility for wildfire prevention and suppression on more than 13 million acres of private and public lands. It manages statewide biodiversity information through the Natural Heritage Program, administers Forest Practices Rules on non-federal lands, and provides urban forestry and forest health assistance throughout the state. It is also home to the Washington Geological Survey, which develops information to help communities prepare for geologic hazards such as earthquakes, tsunamis, and landslides.

This *Plan for Climate Resilience* addresses climate-related risks and responses for each DNR program, the agency overall, and for the natural resource sectors in which we work. To develop the plan, we

[21] See 2009 State Agency Climate Leadership Act, Senate Bill 5560, codified in RCW 43.21M.010-040.
[22] Stults, et al. 2017. *Looking under the hood of local adaptation plans: shedding light on the actions prioritized to build local resilience to climate change*; and Woodruff, et al. 2016. *Numerous strategies but limited implementation guidance in US local adaptation plans*.
[23] For example, Ecology's Water Supply Availability Committee, DNR's *Washington State Wildland Fire Protection 10-Year Strategic Plan*, and the Coastal Hazards Resilience Network.
[24] See for example "Workshop on Correlated Extremes" convened at Columbia University May 29-31, 2019, including links to presentations and posters: http://extremeweather.columbia.edu/workshop-on-correlated-extremes/. Accessed October 2, 2019.
[25] Mohnot, et al. 2019. *Making equity real in climate adaptation and community resilience policies and programs: a guidebook*.

began by assessing climate-related risks to each program's mission and responsibilities. By evaluating the likelihood of a climate-related impact and the consequences if that impact occurred, each program prioritized climate-related risks. Programs then developed responses to priority risks by considering how they could continue to fulfill their mission and responsibilities under changing climate conditions. They began by identifying actions they could take with existing resources and authorities, and if necessary, then considered additional resources or authorities that would be needed to meet the challenge. To inform sector-wide climate needs and opportunities, DNR staff conducted interviews with over 70 experts from around the state that represented a range of expertise in specific sectors and in climate resilience for a variety of jurisdictions. The results of this work are summarized in this plan. Each chapter on resource-specific climate resilience challenges and opportunities is organized into four sections:

1. **DNR's role.** This provides a description of the mission, responsibilities, and operations of each DNR program.
2. **How climate change affects DNR's responsibilities.** This includes a summary of the key risks climate change poses to each program's ability to achieve its mission and responsibilities.
3. **DNR's priority responses.** This summarizes high-priority responses essential to meeting each program's mission and responsibilities.
4. **Sector-wide needs and opportunities.** This summarizes high-priority opportunities to support climate resilient preparation, coordination, investment, and implementation among DNR and its partners.

DNR can implement many of the response actions identified in this plan independently within its existing authorities and resources. Other program-specific responses will require legislative support or coordination with external partners, such as through community engagement or tribal consultation. Each sector-wide section includes specific partner-oriented recommendations for funding, incentives, investments, policies, and other opportunities that relate to DNR's mission and responsibilities, but that may be most appropriately led by a combination of agencies, organizations, or governments. In addition, Statewide Systems-Level Needs and Opportunities

(Section VII) describes responses that would enhance climate resilience across all state agencies as well as for our partners and the state overall, but will likely require legislative action to initiate. The breadth and increasing magnitude of climate risks compels a united effort across agencies, municipalities, tribes, and others. DNR cannot do it alone.

DNR recognizes that reducing greenhouse gas emissions and atmospheric greenhouse gas concentrations is an integral component of climate resilience and is essential to limiting statewide climate-related impacts. We are working to reduce our carbon footprint in our transportation, facilities, and other aspects of our operations. We are promoting clean

energy facilities on DNR-managed lands and we are working to advance carbon sequestration in our lands, waters, and geologic formations. While this plan addresses some aspects of greenhouse gas mitigation, it is not intended as a comprehensive climate mitigation action plan.

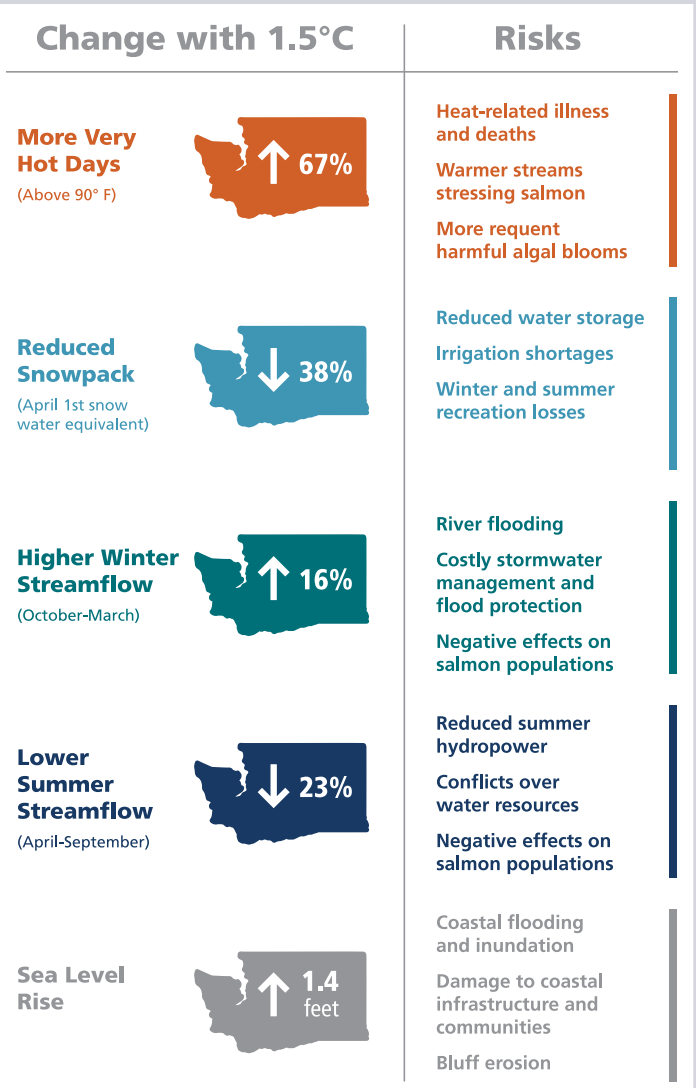
DNR also recognizes that climate-related changes are not uniformly negative. Some changes are beneficial and some create opportunities. For example, climate change is expanding the range of crops that can be grown on some of Washington's agricultural lands and is creating demand for higher value renewable energy leases that increase revenue for DNR's trust beneficiaries and others. In addition, higher atmospheric CO_2 concentrations can enhance forest productivity in some cases, which can benefit timber goals but can also harm some types of habitat. While there are ways that climate change can benefit some resources, the goal of this Plan is to prepare DNR for the risks climate change poses to its ability to fulfill its mission and responsibilities. These risks can be significant, and it is DNR's duty as a steward of the state's natural resources to prepare for them.

Although this *Plan for Climate Resilience* is the first of its kind for DNR, the concepts in it are not new to the agency. As natural resource stewards and trust managers, achieving DNR's mission and responsibilities has always required long-term stewardship, adjusting

PROJECTED CHANGE BY 2030-2052 DUE TO 1.5°C (2.7°F) OF WARMING RELATIVE TO LATE 20TH-CENTURY

Projected changes in hot days relative to 1976-2005; changes in sea level rise relative to 1991-2010; all others relative to 1970-1999.

Source: Snover, et al. 2019. *No Time to Waste. The Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C and Implications for Washington State.*



to changing conditions, and forward-thinking action. What is new is the range and pace of the climate-related changes we are experiencing, the scale of projected changes going forward, and the increasing chance of certain climatic extremes. This Plan is designed to address these changing conditions and ensure that DNR continues to fulfill its mission and responsibilities into the future.

SUMMARY OF CLIMATE SCIENCE

To identify climate-related risks to DNR's mission and responsibilities, we began with climate syntheses produced by University of Washington (UW) Climate Impacts Group. These were augmented by additional sources of peer-reviewed climate science. Key climate science and impacts data referenced in this report include:

- **Greenhouse gases:** Global atmospheric CO_2 concentrations were less than 300 parts per million (ppm) for at least 800,000 years prior to 1950.[26] Since then, they have risen to over 410 ppm.[27]
- **Temperature:** Average annual Northwest temperatures have increased 1.5°F compared to the first half of the last century (1901-1960).[28] By mid-century in Washington state, average annual temperature is projected to increase 4.3°F to 5.8°F (relative to 1950-1999) for a low and high greenhouse gas scenario; much higher warming is possible after mid-century.[29]
- **Precipitation:** Projected change in average annual precipitation in Washington during this century is small relative to natural variability; however, larger seasonal changes are projected. The warm season dry period is expected to be drier, and the cold season wet period is expected to be wetter and exhibit heavier downpours. By mid-century, some models project up to 30 percent decline in summer precipitation (relative to 1950-1999). Conversely, days with more than one inch of rain—a definition of extreme precipitation—are projected to occur 6 to 20 percent more often by mid-century (relative to 1971-2000) for a high greenhouse gas scenario.[30]
- **Snowpack and glaciers:** Spring snowpack in Washington declined by about 30 percent on average from 1955 to 2016.[31] Glacier area in the North Cascades decreased 56 percent between 1900 and 2009.[32] Warmer temperatures will cause more winter precipitation to fall as rain rather than snow. Statewide average spring snowpack is projected to decline by 38 to 46 percent by mid-century and 56 to 70 percent by the 2080s (relative to 1970-1999) for a low and moderate greenhouse gas scenario, respectively. Wetter winters, more winter precipitation as rain, and drier summers are projected to increase the risk of fall and wintertime

▲ Photo credit: Washington Department of Agriculture

▲ Photo credit: Department of Ecology

flooding, shift the timing of peak spring streamflow earlier in the year in rivers with significant snowmelt today, and decrease summer streamflows and natural summer water availability.[33]

- **Sea level rise:** Sea level is rising at most locations in or near Puget Sound. Rates vary, however, as local vertical land movement, weather patterns, and ocean currents can amplify or mask regional trends in sea level.[34] Seattle experienced 9.7 inches of sea level rise between 1899 and 2018.[35] By the end of the century, sea level is projected to rise 1.6 to 2.0 feet for Washington's coast (relative to 1991-2009) for a low and high greenhouse gas scenario, respectively.[36] Local rates of relative sea level rise will vary along the coast with differences in vertical land movement.

- **Ocean acidity:** Average global surface ocean waters have increased in acidity an estimated 30 percent relative to pre-industrial times.[37] By end of century, Washington's coastal waters are projected to acidify 38 to 109 percent relative to 1986-2005. These changes result from a combination of natural processes (mixing, circulation, biology) and elevated atmospheric greenhouse gas concentrations.[38]

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[26] Snover, et al. 2019. *No Time to Waste. The Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C and Implications for Washington State*.
[27] NOAA. Monthly Average Mauna Loa CO_2. December 2019 = 411.76 ppm. https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html. Accessed January 23, 2020.
[28] Knutson, T., et al. 2017. Detection and attribution of climate change. *Climate Science Special Report: Fourth National Climate Assessment, Volume I*.
[29] Snover, et al. 2013. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report*.
[30] Kunkel, K. E., et al., 2013: *Part 6. Climate of the Northwest U.S.*, NOAA Technical Report NESDIS 142-6.
[31] Mote, et al., 2008. *Has spring snowpack declined in the Washington Cascades?*
[32] Mauger, et al. 2015. *State of Knowledge: Climate Change in Puget Sound*.
[33] Roop, et al. 2020. *Shifting Snowlines and Shorelines: The Intergovernmental Panel on Climate Change's Special Report on the Ocean and Cryosphere and Implications for Washington State*.
[34] Mauger, et al. 2015. *State of Knowledge: Climate Change in Puget Sound*.
[35] Roop, et al. 2020. *Shifting Snowlines and Shorelines: The Intergovernmental Panel on Climate Change's Special Report on the Ocean and Cryosphere and Implications for Washington State*. Tide gauge data: https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=9447130. Note that lands near NOAA's Seattle tide gauge have subsided approximately 3.5 inches since 1900 (Miller et al. 2018).
[36] Miller, et al. 2018. *Projected Sea Level Rise for Washington State—A 2018 Assessment*.
[37] Raven, et al. 2005. *Ocean Acidification due to Increasing Atmospheric Carbon Dioxide*.
[38] Mauger, et al. 2015. *State of Knowledge: Climate Change in Puget Sound*.

SUMMARY OF CLIMATE RISKS AND RESILIENCE RESPONSES

The following table summarizes key climate risks identified for DNR programs, as well as DNR's priority responses for each sector category, including program-specific responses and agency-wide responses. These risks and responses are detailed in Section VI of this plan. ■

SUMMARY OF DNR PROGRAM-SPECIFIC CLIMATE RISKS AND RESILIENCE RESPONSES

SECTOR	RISKS	DNR RESPONSES
Wildfire	Accelerating wildfire risks; increasing area burned of uncharacteristic fire; changing fire risk in western Washington; increasing costs to manage wildfire; growing wildland-urban interface; wildland fire response systems are stretched; lack of consistent, integrated response to support post-fire recovery.	**1.** Reduce human-caused wildfire ignitions and address increasing wildfire risk in the wildland urban interface (WUI). **2.** Enhance and sustain a wildfire workforce to support increased fire response.
Forest management	Increased wildfire potential; potential increased damage from insects and pathogens; potential seed and reforestation challenges; possible increases in conditions that trigger landslides and debris flows; potential changes in forest productivity; potential forest road damage; potential impacts to at-risk species.	**Forested trust land management** **1.** Develop climate-resilient seed management and reforestation approaches. **2.** Promote climate-suitable strategies for at-risk species. **3.** Prepare for increased variability in harvest opportunities under changing climate conditions. **4.** Design and maintain forest roads to be resilient under current and projected climate conditions. **Forest health and resiliency** **5.** Support implementation of DNR's *20-Year Forest Health Strategic Plan*, the *Wildland Fire Protection 10-Year Strategic Plan* and the *Forest Action Plan*.

SUMMARY OF DNR PROGRAM-SPECIFIC CLIMATE RISKS AND RESILIENCE RESPONSES (*cont'd*)

SECTOR	RISKS	DNR RESPONSES
Forest management *(cont'd)*	*See previous page.*	**6.** Address forest health and increased wildfire risk on eastern Washington forestlands. **7.** Develop post-wildfire recover and restoration strategies. **8.** Enhance watershed health and forest drought mitigation. **9.** Increase DNR's small forest landowner forest health assistance capacity. **Forest practices** **10.** Enhance monitoring to assess standards for culverts and bridges. **11.** Assess reforestation requirements. **12.** Assess implications of climate change on potentially unstable slopes. **13.** Assess implications of climate change on Forest Practices Adaptive Management studies. **Small forest landowner office** **14.** Enhance retention of working forest land held by small forest landowners. **Urban and community forestry** **15.** Provide assistance in municipalities to support urban forest management that is climate informed and includes fire-adapted community strategies.
Agriculture, grazing, and leased trust upland management	Water reductions; wildfire damage; weeds, invasive species, insects, and disease; at-risk species and shrub-steppe habitat; increasing precipitation intensity and soil erosion.	**1.** Address climate change risks to roads and infrastructure. **2.** Reduce risk of financial loss from disturbances such as wildfire, drought, and flooding. **3.** Reduce risk of water curtailments on DNR-managed lands. **4.** Advance clean energy and carbon sequestration on DNR-managed lands.

SUMMARY OF DNR PROGRAM-SPECIFIC CLIMATE RISKS AND RESILIENCE RESPONSES (*cont'd*)		
SECTOR	**RISKS**	**DNR RESPONSES**
Special callout: urban, commercial, and industrial lands	Coastal flooding; wildfire damage; flooding, landslides, debris flows, erosion, and lateral channel migration from higher peak flows.	**1.** Address climate change risks to roads and infrastructure. **2.** Strengthen resilience to infrastructure damage through encouraging climate-informed design. **3.** Reduce GHG emissions from transportation by exploring responsible development in transit-oriented locations. **4.** Advance clean energy on DNR-managed lands.
Ecosystem conservation, natural areas, and natural heritage programs	Shifts in species distributions and abundances; reduced snowpack; increased wildfire; increased presence and abundance of non-native, invasive species; dis-assembly of ecological communities; sea level rise; ocean acidification; increase sedimentation.	**1.** Assess vulnerability and enhance monitoring of Natural Areas. **2.** Incorporate climate change considerations into Natural Areas site prioritization, selection, and design. **3.** Fund and implement statewide inventory of rare species and ecosystems.
Aquatic resources and coastal management	Damage due to coastal flooding and sea level rise; harm to aquatic species due to ocean acidification; declining salmon and orca populations; threats to shellfish and wild stock geoduck survival, reproduction, and recruitment; threats to aquatic reserves, eelgrass beds, and kelp forests; damage due to higher peak river flows, erosion, and lateral channel migration.	**1.** Identify areas of high vulnerability to lessee activities and establish strategies for resilience. **2.** Develop strategies to protect and restore aquatic habitats that provide refuge for sensitive species and also support resilience from climate-related impacts. **3.** Accelerate salmon and orca recovery efforts. **4.** Anticipate and prepare for increases in derelict vessels and structures on state-owned aquatic lands. **5.** Update guiding documents to support appropriate responses to changing climate conditions.

SUMMARY OF DNR PROGRAM-SPECIFIC CLIMATE RISKS AND RESILIENCE RESPONSES (*cont'd*)

SECTOR	RISKS	DNR RESPONSES
Washington Geological Survey	Landslides; flood inundation; tsunami inundation.	**1.** Accelerate assessment of water and groundwater resources. **2.** Improve landslide modeling and inventory mapping. **3.** Improve tsunami modeling methods to accommodate rising sea levels, changing erosion patterns, and other climate-influenced impacts. **4.** Integrate climate change impacts into development of data, analysis, and risk models.
Recreation	Damage to recreation facilities due to wildfire, flood, sea level rise, and heavy precipitation; increased risk of human injury or need for evacuation due to increasing extreme climate-related events and falling trees or limbs; potential increase in Washington state population.	**1.** Prepare for potential evacuation or rescue from recreation sites due to extreme climate-related events. **2.** Increase management of trees in campgrounds, at trailheads, and on trails. **3.** Strengthen resilience to infrastructure damage through climate-informed design of recreation infrastructure. **4.** Increase the availability of high-quality recreation to all.

III. TRIBAL NATIONS AND CLIMATE RESILIENCE

Tribes have been stewarding their ancestral homelands since time immemorial. However, over the approximately 200 years since European-American settlement, ecosystems have become degraded such that these areas currently provide only a fraction of their historical services. Tribes in Washington state are now facing a wide array of climate change impacts on the resources and processes that are fundamental to tribal cultures, economies, health, and ways of life.[39] Changes in stream temperature and water quantity are affecting salmon throughout the state. Rising ocean temperature and ocean acidification are impacting coastal fisheries and shifting species ranges from historic areas. Storm surges, high volume precipitation events, and sea level rise are threatening tribal cultural sites, villages, and infrastructure. Declining forest health and changes in wildfire activity are altering the timing and abundance of tribally-important plants, animals, roots, berries, and other first foods. As ecosystems and first foods shift in distribution, timing, and abundance, tribes face the challenge of maintaining access to culturally important resources. Limited funding compounds these challenges as tribes seek to fund necessary investments in resilience implementation, on top of the existing needs for habitat restoration and tribal services.

Tribes are responding to these threats with climate resilience plans and actions aimed at reducing risks and protecting tribal culture, resources, and sovereignty. More than half of the tribes in Washington have completed, or are in the process of developing, climate adaptation plans. Regional organizations such as the Affiliated Tribes of Northwest Indians (ATNI), Northwest Indian Fisheries Commission, Columbia River Intertribal Fish Commission, and the PNW Tribal Climate Change Network support tribes by providing climate change information, training, strategy, and advocacy. The ATNI climate change program now hosts an annual Tribes and First Nations Climate Summit. The leadership, expertise, and local and indigenous knowledges of tribal members and tribal staff, together with these collaborations and resources, are enabling tribes to make advancements in climate impacts assessment, adaptation planning, and implementation to increase climate resilience.

DNR continuously strives to maintain good relationships and expand partnership opportunities with tribes. DNR programs such as forest practices regulation, state lands leasing and forest management, and state aquatic land leasing and management provide a platform for partnership and collaboration with tribes on climate resilience. DNR recognizes that tribes bring valuable science, leadership, expertise, and local and indigenous knowledges that can better inform DNR's management of resources in the state. DNR also hears the call from tribes for increased funding for climate resilience planning and implementation, and enhanced partnerships with governments, non-profit organizations, researchers, businesses, and others throughout the region.

DNR is committed to honoring tribal sovereignty, maintaining respect for treaty rights, engaging in government-to-government consultations with tribes, and collaborating with tribes to build the resilience of lands, waters, and communities around the state. The response options listed in this plan represent the starting point for DNR's work on climate resilience. DNR commits to consultation with tribes on next steps, regular and consistent communication with all tribes as implementation steps are developed and evolve, and regular communication with the ATNI Climate Change Program and other tribal forums on climate change and climate resilience. ■

[39] Jantarasami, et al. 2018: Tribes and Indigenous Peoples. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*.

IV. EQUITY, ENVIRONMENTAL JUSTICE, AND CLIMATE RESILIENCE

▲ Photo credit: Governer's Interagency Council on Health Disparities Environmental Justice Task Force 2019

Climate change will affect all of us in Washington state, but not in the same ways or to the same degree. Some populations face disproportionate impacts. These highly impacted communities[40] include those already suffering from economic, social, and health disparities such as low-income communities, indigenous people, people of color, and immigrant communities. As climate impacts mount, already highly impacted communities and vulnerable populations will face increasing risks.[41]

In addition, some responses to climate change have the potential to exacerbate inequality. For example, a 2019 study of FEMA investments to increase resilience by buying out properties in flood hazard zones on the East Coast shows that funding is flowing to more affluent counties, instead of focusing on areas with low-income homeowners and residents with the highest needs for financial assistance.[42] Reports and interviews from the intentional power blackouts in California in October 2019, which were intended to help prevent wildfires during periods of high winds and low humidity, indicated that the loss of power had particularly acute impacts on lower-income rural communities.[43] Green infrastructure projects, which are meant to help urban areas handle storms that bring a higher volume of rainfall, can result in increased property values which can in turn elevate the risk of displacing existing residents.[44]

As a public agency with broad responsibilities that affect the

health of lands, waters, and communities around the state, DNR has an obligation to consider equity and environmental justice in the execution of its duties, including planning for and enhancing resilience. A first step is for DNR to better understand the disproportionate impacts of climate change and resilience strategies on specific communities across Washington state. In the 2019 session, the Washington Legislature took an initial step by allocating funding for a task force to explore the use of the Department of Health Environmental Health Disparities mapping tool to guide the work of state agencies. DNR is one of 27 task force members helping to advance this work. But more information is needed to fully understand which communities are most vulnerable to climate impacts and to understand the depth and breadth of inequities as a result of societal conditions.

With improved understanding of where communities are facing disproportionate impacts, DNR will create strategies to address them. Some initial strategies are included in this plan. For example, DNR's Urban and Community Forestry Program has an objective to seek new funding opportunities to support communities in using urban forestry and green infrastructure as a tool for reducing inequity. DNR will enhance engagement with limited English proficiency communities as a step toward addressing increasing wildfire risk in the wildland urban interface. And the agency will develop drought mitigation strategies that explicitly address areas with disproportionate environmental health risks. As DNR implements these actions, we will continue to seek additional opportunities to address disproportionate impacts.

DNR also recognizes that building resilience to climate impacts will mean working with and empowering local partners. In order for resilience efforts to be successful, communities must have the opportunity to define success locally and to leverage networks and trusted partners, particularly when there is a

[40] RCW 19.405.020 defines "Highly impacted community" as "…a community designated by the department of health based on cumulative impact analyses in RCW 19.405.140 or a community located in census tracts that are fully or partially on "Indian country" as defined in 18 U.S.C. Sec. 1151."

[41] UW Climate Impacts Group, UW Department of Environmental and Occupational Health Sciences, Front and Centered and Urban@UW. 2018. *An Unfair Share: Exploring the disproportionate risks from climate change facing Washington state communities*.

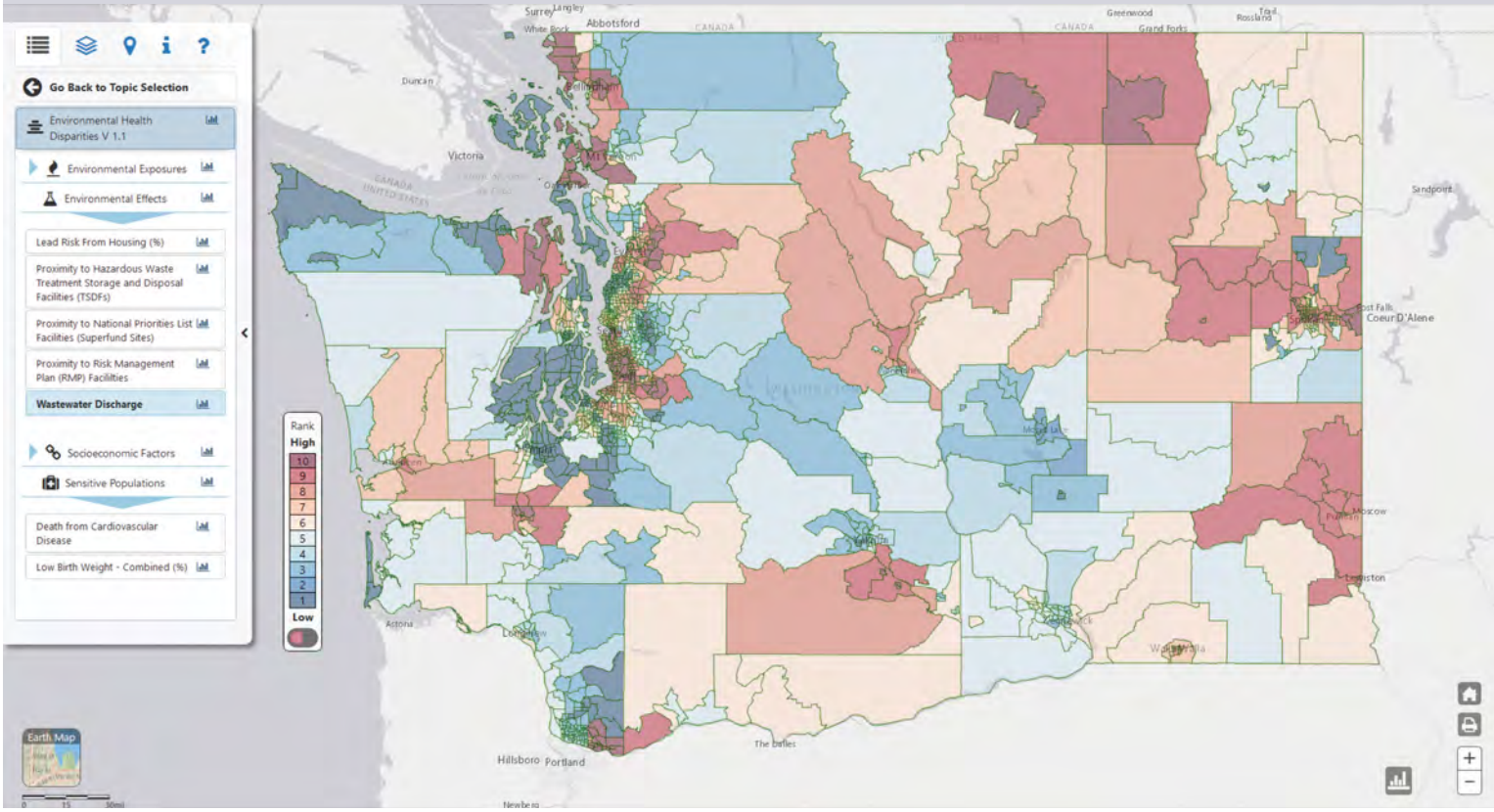
[42] Mach, et al. 2019. *Managed retreat through voluntary buyouts of flood-prone properties*.

[43] Chabria, et al. 2019. "PG&E power outages bring darkness, stress and debt to California's poor and elderly." Los Angeles Times.

[44] Bick, C. 2019. "South Seattle residents want greener neighborhoods—without more gentrification." Crosscut.

VIEW OF THE WASHINGTON STATE DEPARTMENT OF HEALTH'S WASHINGTON TRACKING NETWORK INFORMATION BY LOCATION TOOL

Available at https://fortress.wa.gov/doh/wtnibl/WTNIBL/

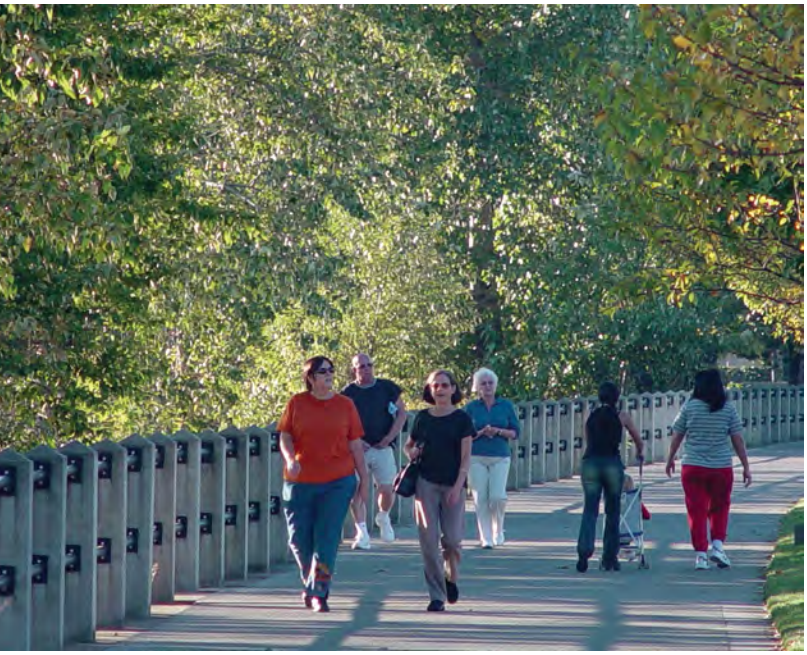


history of environmental health hazards, racial or ethnic discrimination, or economic challenges. DNR's development of the *Washington State Wildland Fire Protection 10-Year Strategic Plan* began the process of engaging frontline communities in identifying risks and developing strategies through workshops that included outreach to Latinx community organizations and community leaders in efforts to increase language accessibility, such as the Washington State Coalition for Language Access (WASCLA), the Latino Community Fund, La Casa Hogar, and other community-based groups in Wenatchee and Yakima. DNR and the Wildland Fire Advisory Committee also worked with WASCLA in developing a plan to better protect limited English proficiency communities during wildfire as called for in HB2561 from the 2017 legislative session.

Working with local partners also means helping to ensure that local community-based organizations are able to access the resources needed to effectively facilitate community leadership and engagement. Too often, engagement by larger entities or agencies leans on local organizations to leverage trusted networks, connect with community leaders, and reach out to members of the community without an acknowledgment from those agencies of the true expense associated with these activities, or the full value of the assets that these community organizations bring. DNR recognizes the need for resources for community organizations, and the need to broaden understanding of the essential role that local organizations play in building the trust and social capital needed for effectively enhancing resilience.

Our work to fully integrate equity and environmental justice principles into climate resilience must be an ongoing and sustained effort that leverages established best practices.[45] This plan serves as an invitation for collaboration in this critical pursuit. In the near-term, DNR commits to the following next steps:

- Convene an Equity and Environmental Justice Advisory Committee. DNR will form an Equity and Environmental Justice Advisory Committee in 2020 to help the agency develop its approach to these issues, and to guide efforts to address them.



- Identify highly impacted communities. DNR will conduct a preliminary review to identify highly impacted communities that are at the intersection of DNR's authorities and responsibilities and the agency's climate response actions.
- Create an Environmental Justice and Equity Strategy. In collaboration with the Equity and Environmental Justice Advisory Committee and other partners, DNR will create an Environmental Justice and Equity Strategy for the agency, which will help guide implementation of plans such as this *Plan for Climate Resilience*, the *Wildland Fire Protection 10-Year Strategic Plan*, and others. This strategy will also advance DNR's internal work to foster diversity, equity, and inclusion within the agency.
- Collaborate to assess our progress. DNR will engage with the Equity and Environmental Justice Advisory Committee and other organizations and partners to help the agency assess progress toward the goals and strategies we establish in our Environmental Justice and Equity Strategy. Accountability is a critical part of any strategy, and it will be important for the communities that DNR identifies in its review of frontline communities connected to DNR actions and resilience strategies to be involved in helping DNR to assess progress. ■

[45] See for example: Urban Sustainability Directors Network, May 2017. Guide to Equitable, Community-Driven Climate Preparedness Planning.

V. REVERSING GREENHOUSE GAS TRENDS

The climate resilience efforts outlined in this plan are essential in the short- to mid-term for DNR to continue fulfilling its mission and responsibilities. Improving resilience alone, however, will not secure our long-term future. We cannot stop climate change by being more resilient. Climate mitigation—stopping carbon pollution and reducing atmospheric greenhouse gas concentrations—is the only way to prevent ever-escalating temperatures and increasingly dangerous and uncertain outcomes. With this in mind, DNR is working in two main areas—reducing carbon emissions and sequestering carbon already in the atmosphere—to go beyond adaptation and reverse the trends in greenhouse gas levels.

REDUCING CARBON EMISSIONS

1 WASHINGTON STATE EMISSIONS

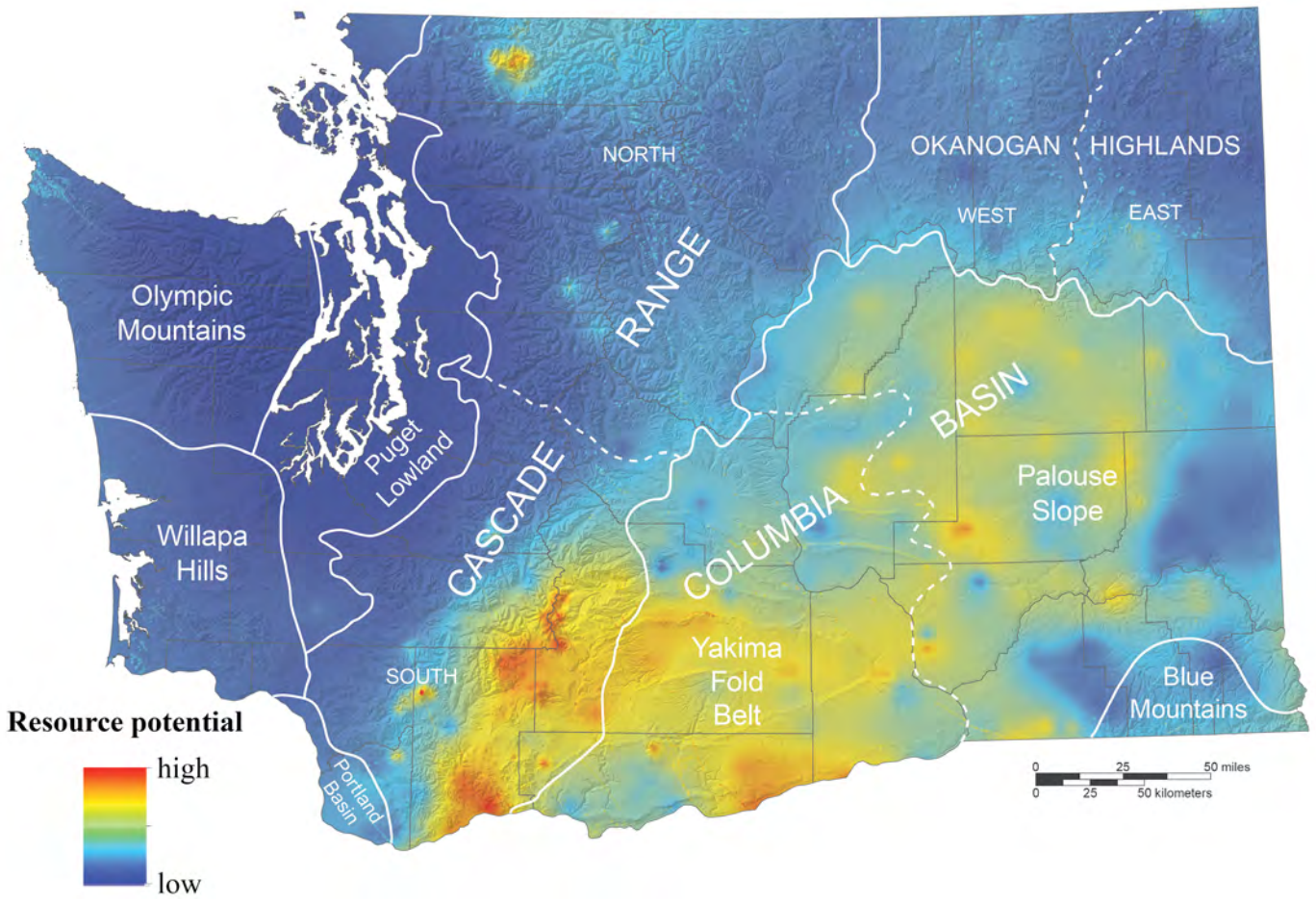
In 2017, the most recent year for which data are available, Washington's greenhouse gas (GHG) emissions totaled 97.5 million metric tons of carbon dioxide equivalent (CO_2e). Transportation was the leading source of GHG emissions (44.6 percent of the total), followed by residential/commercial/industrial heating (23.7 percent), and electricity (16.7 percent). Between 2016 and 2017, GHG emissions in Washington were nearly flat, and 2017 totals remain 7.6 million metric tons CO_2e above Washington's 1990 baseline.[46] These figures do not include emissions from wildfires.

PARIS CLIMATE AGREEMENT: NO TIME TO WASTE

In 2015, 195 countries endorsed the Paris Climate Agreement, committing to limit global temperature rise to "well below 2°C" (3.6°F) and "pursuing efforts to limit the temperature increase to 1.5°C" (2.7°F) above pre-industrial levels. In 2019, UW Climate Impacts Group published "No Time to Waste,"[47] which summarizes the Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C and the related consequences for Washington state. Key findings from these reports include:

- If current rates of warming continue, global warming could reach 1.5°C as soon as 2030.
- Even if countries around the world limit their near-term emissions to the amounts pledged under the Paris Agreement, global warming is expected to surpass 1.5°C.
- In order to seek to return to warming of 1.5°C at a later date, society would have to implement both existing and new practices and technologies to remove CO_2 from the atmosphere.
- Every degree of additional warming matters. Climate-related risks are higher for global warming of 1.5°C than at present, and even higher at 2°C warming.

STATEWIDE GEOTHERMAL ENERGY POTENTIAL PRODUCED BY THE WASHINGTON GEOLOGICAL SURVEY



A. Reducing Washington State Emissions: Renewable Energy

DNR is actively working to increase renewable energy in Washington, in service to the state's commitment to 100 percent renewable energy by 2045. DNR is currently leasing state trust lands for wind and solar power production and is exploring the power potential of geothermal energy. DNR currently manages leases that involve more than 100 wind turbines, producing over 200 megawatts (MW) of clean electric power. During 2019, DNR entered into its first two leases for solar power installations, totaling approximately 100 MW. DNR has established a renewable energy office, hired a renewable energy manager, and set a goal of 500 MW of new solar power under lease by December 2023. In addition to their emissions reduction advantages, renewable energy leases represent a new revenue stream for trust beneficiaries and can provide economic benefits for rural communities. DNR is proceeding carefully to ensure that renewable energy development does not negatively affect cultural resources, prime agricultural land, critical wildlife habitat, or rare plant communities.

Biofuels are a less carbon-intensive source of energy than fossil fuels because some of the carbon emitted when they are combusted is offset by the carbon that is sequestered as they

[46] Washington Department of Ecology: https://ecology.wa.gov/Air-Climate/Climate-change/Greenhouse-gases/2017-greenhouse-gas-data. Accessed November 25, 2019.

[47] Snover, et al. 2019. "*No Time to Waste. The Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C and Implications for Washington State.*"

▲ Photo credit: Forterra

WASHINGTON STATE GREENHOUSE GAS EMISSIONS (IN MILLION METRIC TONS CO_2e PER YEAR) ▼

Source: Washington Department of Ecology. 2018. *Washington State Greenhouse Gas Emissions Inventory: 1990-2015*. Department of Ecology, Lacey, WA. Publication 18-02-043.

1990	2000	2005	2012	2013	2014	2015
90	108.6	96	91.8	93.9	94.1	97.4

are grown. DNR periodically conducts public auctions to sell the rights to harvest forest residual biomass—the limbs and small pieces of wood left on a site after its timber is harvested—as a source of biofuel. Forest biomass marketed by DNR does not include wood from old growth forests, wood that is protected as a habitat component by policy or rule, or any type of chemically-treated wood. DNR is working to support increased use of forest biomass as an alternative to fossil fuels.

B. Reducing Washington State Emissions: Development and Construction

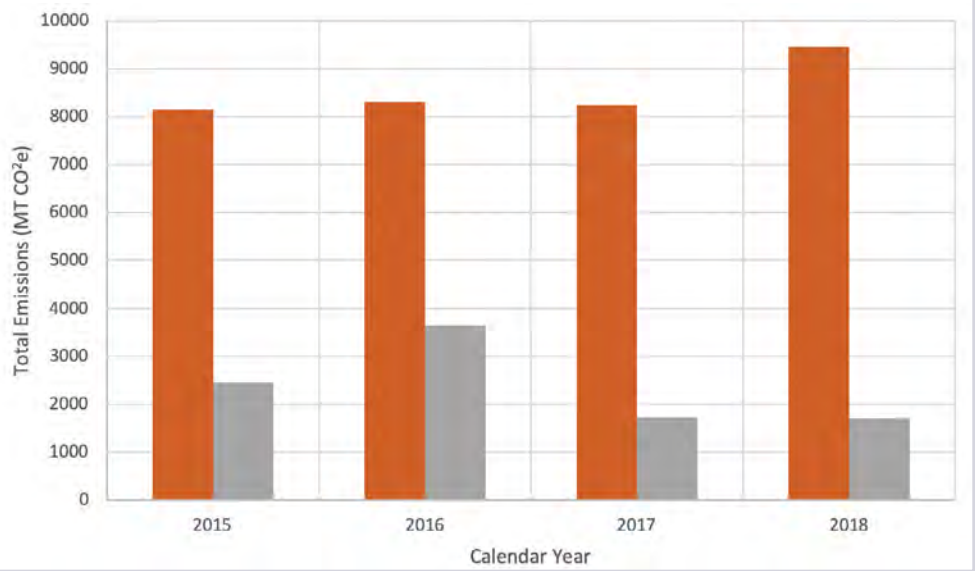
With the state's population projected to grow by 1.5 million over the next two decades,[48] DNR is focused on several interconnected emissions reduction areas related to the rapid growth of housing and infrastructure that a larger population requires. These areas include:

- Avoiding conversion of working forests and agricultural lands that sequester carbon in their vegetation and soils, including work toward a goal of one million acres of land conserved by 2040, and locally supply fiber and food without incurring GHG emissions associated with transportation from out-of-state locations.
- Supporting high standards for energy efficiency and sustainability of materials used in construction and renovation, through certification programs such as Leadership in Energy and Environmental Design (LEED).
- Promoting the use of sustainably sourced advanced forest-based building materials such as cross-laminated timber and wood-carbon composites that have lower levels of embodied carbon (i.e., CO_2 emitted to extract, manufacture, and transport the material) than traditional building materials such as steel and concrete.

DNR'S GREENHOUSE GAS EMISSIONS (IN METRIC TONS CO_2e PER YEAR)

- Total Fleet GHG Emissions (MT CO_2e)
- Total Building Energy Use GHG Emissions (MT CO_2e)

While total DNR agency emissions for three of the past four years have remained above 10,000 MT CO_2e, per FTE annual emissions have dropped from approximately 7.5 MT CO_2e to approximately 5.5 MT CO_2e, reflecting improvements in fleet and facilities management.



- Supporting affordable urban housing and transit-oriented communities that allow people to live in closer proximity to work and reduce emissions associated with commuting and reliance upon automobiles.

C. Reducing Washington State Emissions: Wildfires and Forest Health

The intensity, size, and number of wildland fires are increasing in Washington. "Fires in 2014 and 2015 burned approximately 425,300 and 1,064,100 acres and cost state and federal agencies nearly $182 million and $345 million in firefighting expenses, respectively."[49] In 2015, wildfires were Washington's second-leading source of GHG emissions, emitting 24.0 million metric tons of CO_2e, surpassed only by the transportation sector. When added to 2015's 97.4 million metric tons of anthropogenic emissions, wildfires represented 19.8 percent of Washington's total GHG emissions.

Wildfire trends are fueled and compounded by the declining health of many Washington forests, particularly in eastern Washington. Densely packed and moisture-stressed forests have become less resistant to wildfires and insects and disease outbreaks. Combined with record-setting summer droughts, forest fires in eastern Washington often burn with uncharacteristic severity and duration, in part because of dense and continuous fuel accumulations.[50]

In response to these trends, DNR is implementing two significant plans: the *Washington State Wildland Fire Protection 10-year Strategic Plan* and the *20-year Forest Health Strategic Plan*. Both plans are early in their implementation; DNR and its partners will need significant financial and collaborative support to see these plans through to completion.

2 DNR EMISSIONS

Approximately 80 percent of DNR's GHG emissions are from its fleet—the vehicles, aircraft, and boats the agency operates to get its work done. DNR is working to reduce its emissions from fleet and facilities as well as from work-related communications and travel. DNR is actively participating in Executive Order 18-01 on State Efficiency and Environmental Performance (SEEP). SEEP provides an encouraging emissions reduction implementation environment and shared learnings forum.

A. Reducing DNR Emissions: Fleet and Facilities

DNR has made significant gains in fleet management. Thirty-five percent of DNR's sedans are now fully electric, and the remainder are hybrids. DNR is continuing to build out a network of electric vehicle charging stations statewide and

[48] https://www.ofm.wa.gov/sites/default/files/public/dataresearch/pop/stfc/stfc_2019_presentation.pdf. Accessed December 16, 2019.
[49] Washington State Department of Natural Resources. 2019. *Washington State Wildland Fire Protection 10-year Strategic Plan*.
[50] Washington State Department of Natural Resources. 2017. *20-Year Forest Health Strategic Plan*.

currently has EV chargers at over 50 percent of agency-owned facilities. DNR is actively monitoring rapidly evolving electric vehicle technology with an eye toward the off-road capable pickups, SUVs and heavy equipment that comprise the majority of DNR's fleet. All-electric options for these types of vehicles are on the horizon. When these vehicles become available, DNR will integrate them into the fleet. Also, DNR must consider the sources of electricity that it purchases, where possible. The benefit of converting DNR's fleet to all-electric vehicles is reduced if the electricity fueling the vehicles is generated through fossil fuels combustion.

DNR is also acting upon opportunities to reduce the amount of energy needed to power agency buildings. DNR has augmented two of its smaller buildings with solar power and is now routinely evaluating solar where this can be accomplished as part of overall project goals. At the same time that DNR is striving to reduce its facilities energy footprint, the agency must address a substantial backlog of basic facilities needs required to ensure employee health and safety and maintain agency operations. Additional funding is needed to accomplish both of these goals in an integrated and efficient manner.

B. Reducing DNR Emissions: Communications and Travel

DNR is reducing work-related travel by making increased use of conference calls, video conferences, and webinars to conduct agency business, all of which reduce vehicle miles driven. Reflecting on projections that by 2050 airline travel will consume 12 to 27 percent of the global carbon budget for 1.5°C,[51] DNR will conduct an evaluation by the end of 2020 aimed at eliminating non-critical business air travel by DNR employees. DNR has also revised policies and procedures with the aim of reducing employee commuting. Employees are supported to telework when compatible with job requirements.

CARBON SEQUESTRATION

Carbon sequestration means removing carbon from the atmosphere and storing it in terrestrial or aquatic systems and in harvested wood products. DNR is exploring five main opportunities for carbon sequestration:

- Trees and forested ecosystems. Carbon can be stored in trees, vegetation, and soils in natural and working forests, urban forests, and other systems. Avoiding conversion of forested lands also contributes to carbon sequestration.
- Harvested wood products. Carbon can be stored in wood products such as lumber, panels, paper, and other products.
- Soils, grasslands, and agricultural systems. Carbon can be stored in soils and vegetation above and below ground on farms, rangelands, and other natural and working lands.
- Aquatic systems and marine vegetation (aka "blue carbon"). Carbon can be stored in freshwater,

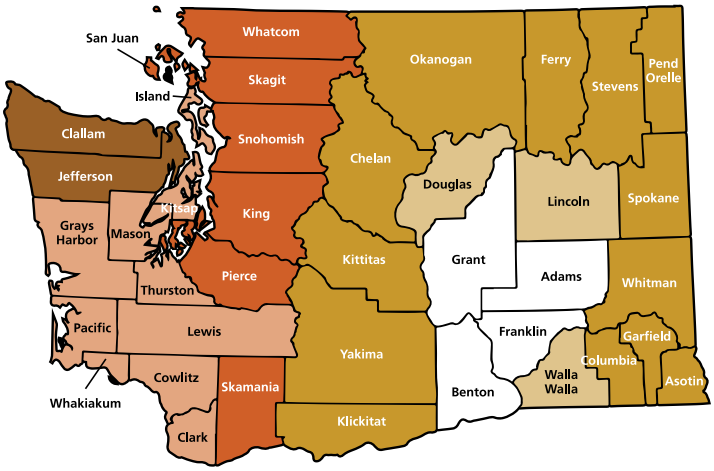
CARBON SEQUESTRATION IN LIVE TREES BY COUNTY ▸

Aboveground Live Tree Carbon (megagrams/hectare)

- 0
- 0.1-40
- 40.1-80
- 80.1-120
- 120.1-160
- >160

Carbon stocks in the map represent only the carbon stored in live trees, not including the roots. While not represented here, other significant pools of carbon include carbon in forest soils, dead trees, downed woody debris, and harvested wood products.

Source: Palmer, Marin; Kuegler, Olaf; Christensen, Glenn, tech. eds. 2019. Washington's forest resources, 2007–2016: 10-year Forest Inventory and Analysis report. Gen. Tech. Rep. PNW-GTR-976. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 79 p.



coastal, and marine ecosystems, including sea grasses, coastal wetlands, and aquatic bedlands.

- Geological formations. Carbon can be captured, injected, and stored in subsurface rock layers, especially basalt.

DNR's role as manager of 5.6 million acres of terrestrial and aquatic lands conveys significant potential for sequestering carbon in terrestrial and marine environments and in harvested wood products. Carbon sequestration has the additional advantage that it can be monetized as a new revenue stream through carbon markets. To advance carbon sequestration efforts, DNR contracted with U.S. Forest Service to conduct a forest ecosystem carbon inventory for the entire state. With legislative support, DNR is working to conduct carbon inventories of harvested wood products, sawmill energy use, wildfire, and land management, and has convened a Carbon Sequestration Advisory Group to guide this work. DNR is also working with the University of Washington School of Environmental and Forest Sciences on a legislatively mandated study[52] to assess and improve retention of working forestlands held by small forest landowners. In aquatic systems, DNR is working with partners to enhance understanding of carbon dynamics and identify opportunities to increase carbon sequestration in the marine, brackish, and freshwater environments. In addition, DNR's Washington Geological Survey is partnering on a regional initiative to identify suitable geologic storage reservoirs for carbon capture, utilization, and storage.

DNR will continue to advance carbon sequestration opportunities in all areas of its operations.

LOOKING FORWARD

DNR is fully committed to both climate mitigation and to climate resilience. Going forward, we intend to fulfill our mission and responsibilities in a manner that reduces the agency's GHG emissions and reduces GHG concentrations in the atmosphere.

Although DNR is making significant progress in reducing GHG emissions from its agency operations, progress has been largely opportunistic and is not yet targeted toward the emissions reduction outcomes stipulated in state law. DNR intends to submit a request to the 2021 Legislature for resources needed to develop an emissions reduction plan that ensures DNR will meet legislatively directed emissions reduction outcomes while continuing to achieve its mission and responsibilities. ■

[51] Pidcock, R., and S. Yeo. 2016. Analysis: aviation could consume a quarter of 1.5C carbon budget by 2050. CarbonBrief August 8, 2016 (extrapolating from data in International Civil Aviation Organization. 2016. On board: a sustainable future.)

[52] See ESSB 5330: https://app.leg.wa.gov/billsummary?BillNumber=5330&Year=2019&Initiative=false. Accessed January 28, 2020.

VI. RESOURCE-SPECIFIC CLIMATE RESILIENCE CHALLENGES AND OPPORTUNITIES

WILDFIRE MANAGEMENT

1 DNR'S ROLE

DNR maintains the state's largest on-call wildland fire department. Trained personnel include permanent and seasonal firefighters and DNR staff who perform other work within the agency and can be redeployed for fire duty when needed. DNR is responsible for suppressing wildfires on 13 million acres of forestlands and provides significant support and resource coordination on large wildland fires on other non-forested lands across Washington state, regionally, nationally, and internationally with Canada when necessary.

DNR PROGRAMS COVERED IN THIS SECTION

- Wildfire

The federal government is responsible for the approximately 12 million acres of federally-owned forested and non-forested land. By mutual agreement, DNR and certain tribes may "offset" response functions of their respective organizations. Local fire districts provide primary initial attack suppression response throughout the state. In addition, DNR has contributed significant response expertise to other major events, such as landslides and floods.

2 HOW CLIMATE CHANGE AFFECTS DNR'S RESPONSIBILITIES

Climate change and other factors are changing wildfire risk in Washington and are require shifts in our response. The primary climate-related risks to DNR's mission and responsibilities are:

- Climate change is accelerating wildfire risks throughout Washington. Projections indicate that the annual area burned will quadruple in Washington's forests by the 2040s and will double in non-forested areas such as the Columbia Basin and Palouse Prairie.[53] Climatic conditions conducive to very large fires—those over 12,355 acres—are also expected to triple in the interior western U.S. by mid-century (2041-2070).[54] Meanwhile, our fire seasons are getting longer. The U.S. Forest Service reported that in 2015, fire seasons were averaging 78 days longer than in 1970.[55] Warmer, drier summers and longer dry periods with climate change could cause the fire season to start earlier and last longer in the future.[56]
- Increasing area burned of uncharacteristic fire. Eastern Washington has seen an increase in annual area burned by wildfire in recent decades, relative to the twentieth century, owing to a combination of a warmer climate and nearly a century of fuel buildup from fire exclusion and other forest management practices. The average size of wildfires and proportion of high-severity fire is increasing. The amount of uncharacteristic fire will likely continue to increase absent changes to forest management.
- Changing fire risk in western Washington. As summers warm and conditions become drier, forested areas of western Washington face the potential for more wildfire. Although large patches of stand-replacing wildfire are characteristic of this

[53] Littell, J.S. et al., 2010. *Forest ecosystems, disturbance, and climatic change in Washington State, USA.*
[54] Barbero, et al. 2015. *Climate change presents increased potential for very large fires in the contiguous United States.*
[55] U.S. Forest Service. 2015. *The rising cost of wildfire operations: effects on the Forest Service's non-fire work.*
[56] Westerling. 2016. *Increasing western US forest wildfire activity: sensitivity to changes in the timing of spring.*

region, increases in area burned pose risks to the natural resources and communities that DNR has a responsibility to protect. While measures to reduce wildland fire risk are well understood in fire-adapted forests, such as those found on the eastern slopes of the Cascade Mountains, adaptation responses are less understood for forests on the western slopes of the Cascades.[57] To address the changing wildfire risk for forests that historically experience stand-replacing wildfire, resilience responses should emphasize community preparedness, evacuation planning, structure hardening, aggressive wildfire detection and suppression, appropriate and effective fire management, and post-fire adaptation actions.

- Increasing costs to manage wildfire. Recent large wildfires and severe fire seasons are resulting in exorbitant costs. The cost to manage large wildfires in Washington averaged nearly $37 million per year between 2008 and 2012. Between 2013 and 2018, the average annual expense quadrupled to $153 million.

- Growing wildland-urban interface. More people are moving to areas adjacent to wildlands, resulting in more communities, homes, and values at risk. Washington state has over 7,400 square miles of wildland-urban interface—a land area almost the size of New Jersey. Approximately 1.4 million homes have been built in this area, each with an average lot size of 0.9 acre. The potential for continued development of the wildland-urban interface is significant; approximately 71 percent of Washington state's private forestland within 0.3 miles of public forestland has yet to be developed.[58]

- Wildland fire response systems are stretched. While multiple agencies coordinate remarkably well to suppress wildland fires once they start, there is widespread acknowledgment that better communication and improved cross-jurisdictional coordination are needed to achieve a truly unified approach to fire response. Both volunteer and permanent firefighting forces also struggle to recruit and maintain a pipeline of qualified, well-trained responders. Effective response systems will need to address firefighter safety, training, and retention as fires grow in frequency and severity. In addition, thousands of acres of Washington state are outside of a formal fire protection district, challenging neighboring jurisdictions and further taxing the wildland fire response system.

- Currently, Washington lacks a consistent, integrated response to support post-fire recovery. Often referred to as the "second disaster," floods, hazard trees, and debris flows pose a threat to communities for approximately five years following a fire. Community recovery, including rebuilding the social and built environments, can often take longer. Resources to address the impacts of wildland fire are often not coordinated between agencies and difficult for communities to navigate.

In addition, data show that approximately 70 percent of wildfire ignitions statewide are caused by human activities, while approximately 30 percent are caused by lightning. Debris burning and campfires are the two most common human-caused sources of fire.[59] Human-caused fires are more likely to occur in proximity to communities and people, while lightning-caused fires are in remote areas.

The data and the trends outlined above suggest that DNR must be prepared to fight fires on the west and east sides of the state. Projections of future area burned suggest that the fire seasons of 2014, 2015, and 2018 are not anomalies, but are an indication of what to expect as the climate warms. DNR must

be prepared for seasons like these. We must support firefighting resources for an extended period each year and be prepared to fight fires on the west and east sides of the state. To do so, DNR and other state wildland fire responders will require sufficient and reliable resources to reduce the risk of wildfire starts and damage, and to prepare for, detect and fight wildfires when they occur. In addition, increased resources will be needed to support recovery of communities and landscapes following wildfires.

3 DNR'S PRIORITY RESPONSES

DNR has already started responding to changing climate conditions by modifying its operations in a variety of ways, including:

- Developing and implementing the statewide *Wildland Fire Protection 10-Year Strategic Plan*, which calls for new approaches to address changes in wildland fire across the state.[60]
- Developing and implementing DNR's *20-Year Forest Health Strategic Plan*, which calls for restoring landscapes at a pace and scale that increases the resilience of forest ecosystems in a changing climate.[61]
- Integrating climate change considerations into Washington's updated *Forest Action Plan*, which guides efforts to conserve, protect, and enhance trees and forests across the state.
- Altering start and end dates for fiscal agreements with local fire departments to address earlier starts and longer fire seasons.
- Increasing state funding for wildfire prevention and preparedness such as public education, firefighter training, and advanced detection systems. Seeking a new and stable funding source to support enhanced preparation and response.
- Acquiring additional firefighting equipment (e.g., aviation, trucks, etc.).

In addition, based on increased understanding of the risks climate change poses to our mission and responsibilities, DNR is pursuing the following strategic opportunities:

1. **Reduce human-caused wildfire ignitions and address increasing wildfire risk in the wildland-urban interface (WUI).**

   Population growth in wildfire-prone areas, combined with climatic and fuel conditions increasingly conducive to large fires, is expected to result in more human-ignited fires, greater fire complexity and severity, and larger human exposure to wildland fire. Although DNR is primarily responsible for suppressing wildland fires, its resources are likely to be increasingly diverted to protect homes and infrastructure, thereby interfering with its ability to suppress wildland

[57] Halofsky, et al. 2018. *The nature of the beast: examining climate adaptation options in forests with stand-replacing fire regimes.*
[58] Washington State Department of Natural Resources. 2019. *Washington State Wildland Fire Protection 10-Year Strategic Plan.*
[59] DNR analysis based on data from: Short, Karen C. 2015. *Spatial wildfire occurrence data for the United States, 1992-2013.*
[60] Washington State Department of Natural Resources. 2019. *Washington State Wildland Fire Protection 10-Year Strategic Plan.*
[61] Washington State Department of Natural Resources. 2017. *20-Year Forest Health Strategic Plan .*

fires. Wildfire and public safety risk is projected to increase for residents and communities in the WUI. In addition, more human-caused fires will require more investigations and cost recovery activities. To address these risks, DNR's priority responses include:

- Address under-protected lands by exploring opportunities to consolidate or regionalize fire services in eastern Washington, supporting the establishment of Rangeland Fire Protection Associations (RFPAs) and annexation/creation of new fire districts as options.
- Clarify DNR's authority to respond to wildland fires when they are not a threat to forestland and state mobilization has not been approved.
- Establish a wildfire risk mitigation program and conduct risk mitigation planning, in coordination with DNR's Forest Health and Resiliency Division.
- Add year-round fire prevention staff; apply insights from social science to develop engagement strategies in high-risk areas that foster behavior change; increase involvement with fire-adapted communities and establish a coordinator position to facilitate community assistance programs; and enhance engagement with limited English proficiency communities.
- Facilitate adoption of land-use plans, regulations, and codes that reduce wildland fire risk in the WUI.

2. Enhance and sustain a wildfire workforce to support increased fire response.

Warming conditions are projected to increase the length of fire seasons and the occurrence of large wildfires. These impacts will significantly challenge DNR's current suppression capacity. During periods of high fire activity or extensive resource demands from large fires, new and emerging wildfires may be inadequately staffed, compromising the program's initial attack mission and safety of personnel and the public. Increasing fire risk across the western U.S. will increase strain on regional firefighting resources, making it less likely DNR can obtain reinforcements from other states during times of need. DNR's current staffing model is likely insufficient to scale up to meet expected resource needs. In addition, seasonal suppression staff will be difficult to recruit and retain through longer seasons. As more partners and staff become involved, increased training capacity will be necessary to support a professional, capable suppression organization. To address these risks, DNR's priority responses include:

- Increase permanent wildland fire workforce to complement and supplement the existing volunteer-based model. Create 30 permanent firefighter positions that will conduct forest health activities when not engaged in wildland fire suppression activities.
- Enhance seasonal capacity; establish two additional hand crews; encourage development and basing of private vendor hand crews and engines; and strengthen partnerships with Department of Corrections and other state agencies that can provide trained fire personnel.
- Improve retention of entry level firefighters.
- Support interagency initiatives to provide succession planning for Incident Management Teams and overhead positions identified as "critical shortage" positions.
- Standardize training, qualifications, and certifications across local and state agencies and response organizations.
- Assess the full costs of wildland fire in Washington to better inform resource allocation decisions.

FOREST MANAGEMENT

1 DNR'S ROLE

Washington state contains more than 22 million acres of forested lands, including highly productive moist forests west of the Cascade crest and dry forests in eastern Washington. DNR plays a broad and vital role in Washington's forest management. DNR manages state-owned forest lands for timber, conservation, and other public values; monitors and manages forest health statewide; administers Forest Practices Rules on non-federal, non-tribal lands; and provides support for small forest landowners and urban and community forests.

On state-owned forested trust lands, DNR manages 2 million acres of timber-generating lands and conservation lands, with approximately 67 percent of trust forest land in western Washington and 33 percent in eastern Washington. DNR's operations include harvesting and replanting forests and constructing and managing forest roads. DNR's forestry operations create a balance of sustainable revenue generation and healthy forested habitats while protecting public safety and resources. Revenues from DNR's timber management support public schools, universities and colleges, state capitol buildings, prisons, state institutions, local services in many counties, and the state general fund. In fiscal year 2018, DNR's forestry operations and related product sales generated $215.9 million in revenue; approximately 95 percent of this revenue was generated on westside forests and 5 percent was generated on eastside forests.[62]

DNR PROGRAMS COVERED IN THIS SECTION

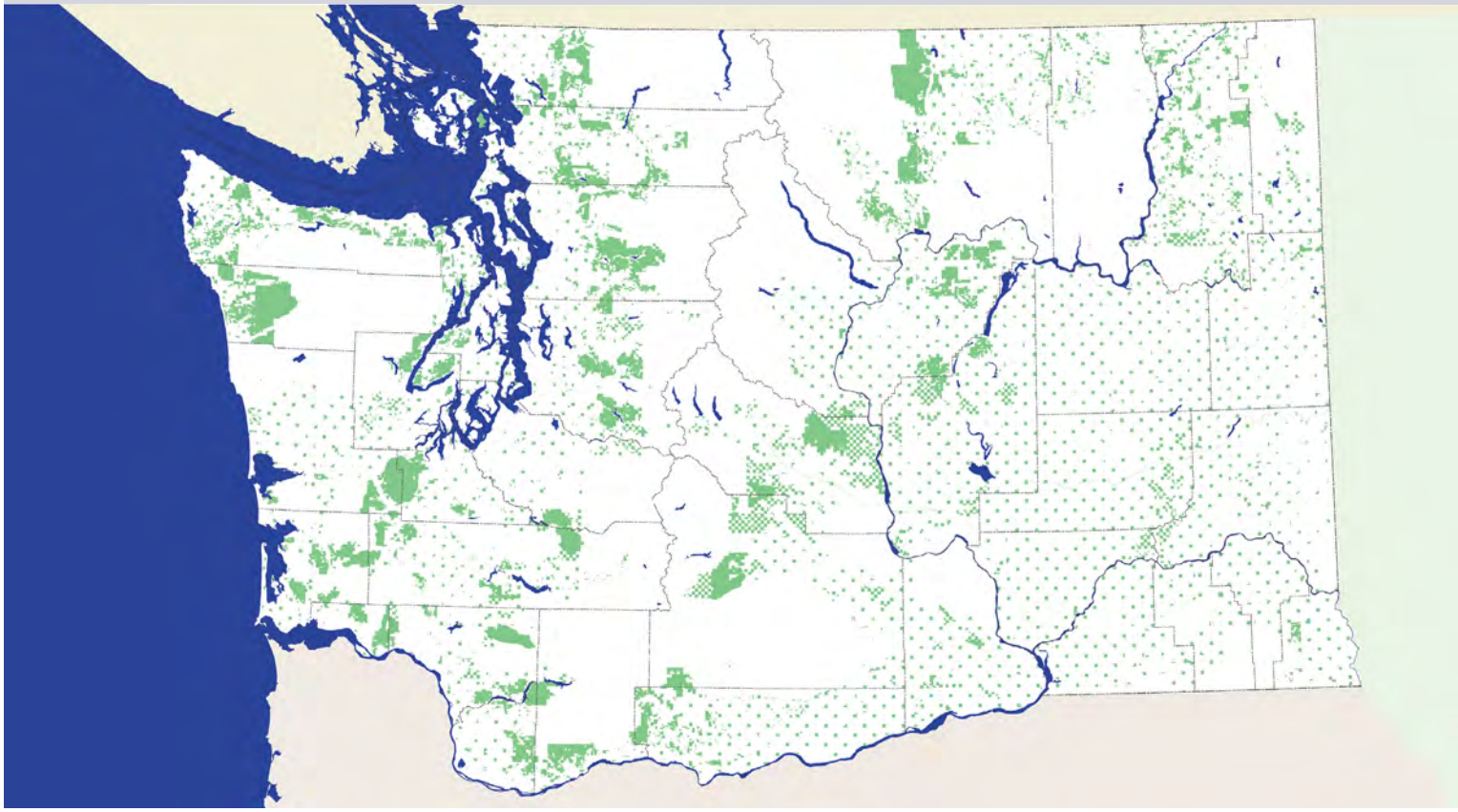
- Forested Trust Land Management
- Forest Health and Resiliency
- Forest Practices
- Small Forest Landowner Office
- Urban and Community Forestry

[62] Washington State Department of Natural Resources. 2018. *2018 Annual Report.*

STATE TRUST LANDS

State trust lands and other DNR-managed uplands

DNR manages 5.6 million acres of state lands including forests, farms, rangeland, aquatic lands, conservation areas, urban and commercial properties, recreation sites, and clean energy facilities such as wind and solar farms. The map below shows the 3 million acres of uplands.



On all forestland ownerships, DNR's Forest Health and Resiliency programs work to improve the health of Washington's forests. This work ranges from helping public and private landowners care for their forests to leading the state's efforts to reduce uncharacteristically severe wildfires. Guiding this work is the state's *Forest Action Plan* and DNR's *20-Year Forest Health Strategic Plan*, which provides a landscape-scale framework for investments to improve forest productivity and resilience and help forests adapt to projected climatic changes. Through the agency's forest health programs, DNR also conducts annual assessments of tree damage and mortality due to insects and pathogens and provides technical assistance to landowners, which includes forest restoration across federal jurisdictions using authorities such as those outlined in the Cooperative Forestry Act and Farm Bill, such as Good Neighbor Authority agreements.[63]

Since 1974, the state has regulated forestry practices on non-federal public and private forest lands through the Forest Practices Act. The Act is designed to protect Washington's public resources (fish, water, wildlife, and capital improvements of the state) and public safety coincident with maintaining a viable forest products industry. Forest Practices Rules are adopted by the Forest Practices Board, which is an independent state agency chaired by the Commissioner of Public Lands or designee. DNR implements the state Forest Practices Rules, including timber harvest and road construction. Adjustments to the rules and accompanying guidance are made by the Forest Practices Board and managed through the Forest Practices Adaptive Management Program, which provides science-based recommendations and technical information.

DNR's Small Forest Landowner and Stewardship programs provide family forest owners with assistance to improve forest health, reduce vegetative fuels, support revenue generation, enhance fish and wildlife habitat, and increase recreation opportunities. DNR's Urban and Community Forestry Program provides technical, educational, and financial assistance

REVENUE (IN THOUSANDS) FROM TIMBER SALES, NURSERY, AND OTHER PRODUCT SALES, 2009-2018

Source: DNR Annual Reports, 2009-2018, available at https://www.dnr.wa.gov/about/fiscal-reports/dnr-annual-reports

2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
$161,675	$229,537	$219,051	$199,773	$187,602	$186,021	$197,872	$208,106	$191,370	$215,929

to Washington's cities and towns, counties, tribal governments, and others to create self-sustaining urban and community forestry programs that preserve, plant, and manage forests and trees for stormwater mitigation, public health benefits, and quality of life.

2 HOW CLIMATE CHANGE AFFECTS DNR'S RESPONSIBILITIES

The primary climate-related risks to DNR's forest sector responsibilities include:

- Increased wildfire potential across the state. As the climate warms and summers become drier, fire risk and area burned is projected to increase on both the east and west sides of the state.[64] Warmer, drier summers and longer dry periods could cause the fire season to start earlier and last longer.[65] Future increases in fire extent could reduce timber yield, conflict with conservation goals, and lead to the potential for larger and more frequent salvage harvests. More wildfire may also increase demand for seedlings and other reforestation resources.
- Potential increased damage from insects and pathogens. Climate change is projected to reduce soil moisture in many parts of the state due to warming temperatures and less summer rain.[66] A reduction in available soil moisture can increase tree stress and result in greater vulnerability to other disturbances such as insects and pathogens.[67] Especially in eastern Washington, the interaction between reduced soil moisture, insects, and/or pathogens will likely lead to greater tree mortality. Even in western Washington, reduced soil moisture during dry summers appears correlated with instances of local mortality of tree species such as western redcedar, western hemlock, and grand fir. Some insect and pathogen populations are highly sensitive to temperature and humidity, extremely mobile, and may increase reproduction under changing climate conditions.[68] Exotic insects or pathogens could also emerge on the landscape, analogous to recent outbreaks of chestnut blight or white pine blister rust.
- Potential seed and reforestation challenges. Seed diversity and supply may become insufficient to support reforestation needs following increased wildfire and other disturbances. Changes in seedling genotypes and species may be necessary due to changes in viable tree growth ranges. Reforestation of some dry forest areas may no longer be ecologically viable due to declining site moisture and increasing summer temperatures. Larger patches of high-severity fire may also reduce the potential for natural regeneration.
- Potential increases in conditions that trigger landslides and debris flows. In areas with potentially unstable slopes, increased landslide and debris flow risk is expected in fall, winter, and spring due to continued declines in snowpack and projected increases in the frequency and intensity of heavy rain events,[69] as well as post-fire changes in soil

[63] See: https://www.dnr.wa.gov/GNA. Accessed January 14, 2020.
[64] Littell, et al. 2010. *Forest ecosystems, disturbance, and climatic change in Washington State, USA.*
[65] Westerling. 2016. *Increasing western US forest wildfire activity: sensitivity to changes in the timing of spring.*
[66] Snover, et al. 2013. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers.*
[67] Littell, et al. 2010. *Forest ecosystems, disturbance, and climatic change in Washington State, USA.*
[68] Bentz, et al. 2010. *Climate change and bark beetles of the western United States and Canada: direct and indirect effects.*
[69] Mauger, et al. 2015. *State of Knowledge: Climate Change in Puget Sound.*

absorbance. Where landslide risk increases, threats include harm to public safety, degradation of fish and wildlife habitat and water resources, and damage to productive timber lands.

- Potential changes in forest productivity. As climate change causes warmer and drier growing conditions, some forests in the state will become increasingly moisture-limited and less productive (especially in the drier forests of eastern Washington and some drier locations in western Washington). In combination with increased risk from wildfire, insects, pathogens, landslides, and reforestation challenges, these reductions in forest productivity would result in an overall decline in woody biomass, and therefore timber. In contrast, other locations that are currently limited more by cold temperatures than moisture may see increases in forest productivity as temperatures warm and extend the growing season.[70]
- Potential forest road damage. The frequency of forest road damage could increase due to projected increases in the frequency and intensity of heavy rain events, more winter precipitation as rain rather than snow, increases in peak flows and sediment transport, and more landslides.
- Potential impacts to at-risk species. Increased disturbance may affect critical habitats for forest- and riparian-dependent species and may challenge the existing strategies that support species recovery.

3 DNR'S PRIORITY RESPONSES

DNR is pursuing the following strategic opportunities across our programmatic areas, including Forested Trust Land Management, Forest Health and Resiliency, Forest Practices, Small Forest Landowner Office, and Urban and Community Forestry.

A. Forested Trust Land Management

1. Develop climate-resilient seed management and reforestation approaches.

Changes in temperature and precipitation will make previously defined climatic zones less relevant and may affect survival and vigor of seedlings planted based on those zones. In addition, projected increases in forest disturbance are expected to increase the quantity of seeds needed for reforestation. Although DNR's seed inventory is currently

designed to ensure a dependable seed supply through high and low cone crops and occasional spikes in demand, climate change could elevate demand due to increased reforestation needs. To address these risks, DNR's priority responses include:

- Identify seed sources, genotypes, and species that have high potential for success over the full growing rotation.
- Plant operational trials to evaluate a range of seed sources over a variety of environments, with the goal of identifying those seed sources that may be most appropriate for planting in future climates.
- Increase seed storage capacity to accommodate potentially expanded reforestation needs.
- Ensure ongoing diversity of seeds and species collected, stored, and managed by DNR.
- Continue regional cooperative research efforts to better understand natural regeneration following wildfire.

2. Promote climate-suitable strategies for at-risk species.

Under DNR's 1997 multi-species State Trust Lands Habitat Conservation Plan, DNR manages forested habitat for more than 12 at-risk or listed species under the Endangered Species Act, including the northern spotted owl and marbled murrelet. Many at-risk species have specific habitat requirements that could be threatened by changing climate conditions. For example, warmer temperatures, increased drought potential and a lengthening of warm, dry periods are projected to increase wildfire risk. Increases in area burned could negatively impact northern spotted owl habitat, sometimes requiring replacement of habitat in alternate locations. Similarly, marbled murrelet habitat could also be negatively impacted by wildfire. While the wind-driven wildfires that shape western Washington forests are rare, the resulting large patches of severely burned forest are a natural and defining characteristic of wildfire in many western Washington forests.[71] Western Washington's moist forests have been resilient to stand-replacing disturbances in the past, meaning with sufficient time these forests have eventually returned to the complement of tree structures and species currently associated with mature and old-growth forests. However, future resilience to such disturbances becomes less certain as the climate changes. Retaining and promoting older forest conditions through fire suppression and other management decisions could help resist eventual change because older trees are better able to persist through unfavorable conditions created by disturbances than young trees and seedlings. Older trees tend to be more fire and drought tolerant, and they may provide seed sources for regeneration following a disturbance event. Given both the ecology of westside forests and wildfire risk, continued wildfire suppression is an important climate-resistance strategy, carrying relatively fewer of the negative ecological consequences compared to fire suppression in drier eastside forests.[72] In addition to minimizing fire in western Washington forests, other DNR priority responses include:

- Thin low-quality or non-habitat areas for northern spotted owls to accelerate the development of older forest-structures, where consistent with other objectives.
- Conduct research on and monitoring of the stand conditions that will support northern spotted owls and remain resilient in a changing climate, in collaboration with tribal governments and federal, state, local and academic partners.

[70] Halofsky, et al. 2018. *Climate change, wildfire, and vegetation shifts in a high-inertia forest landscape: Western Washington, USA.*; and Littell, et al. 2010. *Forest ecosystems, disturbance, and climatic change in Washington State, USA.*

[71] Halofsky, et al. 2018. *The nature of the beast: examining climate adaptation options in forests with stand-replacing fire regimes*; Spies, et al. 2018. *Old growth, disturbance, forest succession, and management in the area of the Northwest Forest Plan.*; and Donato et al. 2020. *Corralling a black swan: natural range of variation in a forest landscape driven by rare, extreme events.*

[72] Halofsky, et al. 2018. *The nature of the beast: examining climate adaptation options in forests with stand-replacing fire regimes.*

- Reduce risk of fire ignitions during high-risk periods by employing burn bans and other steps.
- In eastern Washington, enhance resilience to fire and drought around northern spotted owl areas through stand protection measures such as thinning and fuel breaks.

3. Prepare for increased variability in harvest opportunities under changing climate conditions.

Extreme climate events such as prolonged rainstorms, floods, wildfires, wind storms, and disease and insect infestations can alternately reduce and increase timber harvest opportunities. Some of these extreme events, particularly floods, wildfires, and insect infestations, are expected to be more frequent with climate change. These impacts can slow or stop harvest activities and cause spikes in DNR staff workloads related to unplanned salvage harvests and management of recently disturbed stands (e.g., to prevent floods or debris flow in post-fire sites). These events can reduce operational windows for timber harvest, impact prices for timber, and challenge DNR's capacity to respond. Any revenue reductions based on lower prices for logs or higher costs for harvest (which can be correlated to uncertainty) reduce revenue for trust beneficiaries as well as operational funds for the agency. To address these risks, DNR's priority responses include:

- Increase cross-training for DNR forestry staff to ensure adequate capacity to handle spikes in workload, especially to address salvage harvest following extreme events.
- Modify clause options in timber sales contracts to address the potential for increasing weather-related delays or impacts.

4. Design and maintain forest roads to be resilient under current and projected climate conditions.

Current tools and guidance used by DNR's road design engineers rely on historical streamflow data to design forest roads and size culverts. However, increases in winter precipitation, more winter precipitation as rain rather than snow, heavier rainfall, and earlier snowmelt are all expected to result in higher peak stream flows[73] and elevate the risk of culvert or bridge failures on forest roads which could harm public resources and threaten public safety. To address these risks, DNR's priority responses include:

- Develop a climate-informed culvert evaluation model that builds on the Washington State Department of Fish and Wildlife (WDFW)/UW Climate Impacts Group approach to climate-informed culvert and water crossing structure design.
- Identify climate-related culvert risk by evaluating the hydraulic capacity of all non-fish bearing stream crossings using existing spatial analysis tools. For high-risk culverts, follow with field evaluations and redesigns when needed.

B. Forest Health and Resiliency

5. Support implementation of DNR's *20-Year Forest Health Strategic Plan*, the *Wildland Fire Protection 10-Year Strategic Plan* and the *Forest Action Plan*.

Much of the forestland in central and eastern Washington is uncharacteristically overstocked and moisture-stressed. Decades of fire exclusion and past management practices have put these forests at higher risk of damage by pathogens, insects, and wildfire, a state that reduces ecosystem resilience in the face of climate change. Combined with extended warm and dry periods, wildfires can burn larger areas, for longer durations, and with greater severity. Tree mortality rates associated with bark beetles and other insects and pathogens have also increased substantially over large areas.[74] A significant portion of eastern Washington forestland requires active management or disturbance to create forest structures more resilient against insects, pathogens, and wildfires.[75] DNR's *20-Year Forest Health Strategic Plan* and the statewide *Forest Action Plan* are designed to address these risks and increase resilience across all forest ownerships. To advance these efforts, priority responses include:

- Establish dedicated funding for forest health and wildfire and strengthen existing federal funding to leverage implementation (such as the Collaborative Forest Landscape Restoration Program, Joint Chiefs, and other hazardous fuels funds through USDA, FEMA, etc.).
- Improve coordination with conservation districts, fire districts, and partner organizations to implement forest health treatments and projects in priority planning areas to increase forest resilience.
- Fully utilize Cooperative Forestry Act and Farm Bill tools, such as the Good Neighbor Authority, to assist with increasing pace and scale of forest and watershed restoration on federal lands, thereby improving forest health across entire multi-jurisdictional landscapes.
- Increase use of prescribed fire and mechanical fuels treatments, targeting high-risk wildland-urban interface areas and associated access roads and highways.
- Facilitate broader use of prescribed fire by implementing activities outlined in 2019 legislation (HB1784) and through approaches such as amending smoke management policies and supporting enhanced community outreach.
- Explore options for safely and proactively managing natural fires where applicable to support forest health goals.
- Support Firewise USA®, Washington Fire Adapted Communities Learning Network, and other community-level organizations to build capacity to implement defensible space and pre-fire planning.
- Integrate carbon sequestration policies and investments into forest health priorities and strategies where appropriate.
- Support the development and implementation of language access plans for Limited English Proficiency communities[76], working with partners and local emergency management organizations.

6. Address forest health and increased wildfire risk on eastern Washington forestlands.

Increasing temperatures, reduced soil moisture, and increasing wildfire and other disturbances

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[73] Snover, et al. 2013. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report.*
[74] Washington State Department of Natural Resources. 2017. *20-Year Forest Health Strategic Plan.*
[75] Haugo, et al. 2015. *A new approach to evaluate forest structure restoration needs across Oregon and Washington.*
[76] See RCW 38.52. Providing public notices of public health, safety, and welfare in a language other than English. Law enacted in 2017 (SSB 5046).

contribute to increased risks to forestlands in eastern Washington. As climate change exacerbates current fire and soil moisture trends, mortality risks will likely increase and the financial returns of many eastside forest areas are likely to further erode. To address these risks, DNR's priority responses include:

- Apply uneven-aged management with natural regeneration on economically marginal eastside lands to minimize regeneration expenses.
- Where ecologically appropriate, continue to promote more drought, disease and fire-resilient species by thinning less-resilient species and replanting with more-resilient species.
- Use funding mechanisms such as the Forest Health Revolving Fund to facilitate stand density and fuel reduction treatments that cannot be covered under the standard management fund model.

7. Develop post-wildfire recovery and restoration strategies.

Tree mortality at lower elevations and on dry sites is projected to increase due to warmer and drier conditions and more disturbances such as pathogens, insects, and high-severity wildfires. Post-disturbance concerns include loss of vegetation, greater runoff, and greater soil erosion and sediment transport to streams, rivers, and reservoirs. This can degrade drinking water supplies and cause flood damage to roads, buildings, and facilities. Short-term emergency response and long-term rehabilitation efforts may be needed to repair damage to the landscape and prevent future harm. To address these risks, DNR's priority responses include:

- Assess high-risk burned areas for evaluation of risks to public safety and adverse impacts to public resources, and include mitigation recommendations.
- Monitor to identify post-fire events where the fire was beneficial to forest health and resilience goals, versus where it negatively impacted values at risk. Follow with communications that interpret and explain the findings to enhance public understanding.
- Develop a statewide post-fire resilience and recovery plan through a joint effort of the Forest Health Advisory Committee and Wildland Fire Advisory Committee, to be complemented by subsequent localized plans developed at the community level with partners and stakeholders.
- Establish interagency state and private lands Burned Area Emergency Response (BAER) team(s) to assess non-federal lands post-fire.[77] Fund and implement post-fire forest restoration on state and private lands to improve ecological recovery and reduce sediment transport to streams.
- Develop tools to identify and prioritize post-fire recovery strategies and activities for areas with disproportionate environmental health risks.
- Explore opportunities to use post-fire landscapes to support goals within the *Wildland Fire Protection 10-Year Strategic Plan* and *20-Year Forest Health Strategic Plan* and contribution toward maintaining fire-adapted ecosystems.

8. Enhance watershed health and forest drought mitigation.

Projected declines in snowpack will affect the timing, quantity, and temperature of water in most basins. The risks associated with these changes include reduced moisture for vegetation during the growing season, increased tree stress and mortality, earlier peak flows, and lower, warmer base flows that can degrade water quality and harm salmon and other aquatic habitat.[78] To address these risks, DNR's priority responses include:

- Assess high-risk burned areas for evaluation of risks to public safety and adverse impacts to public resources, and include mitigation recommendations.
- Develop drought mitigation strategies at the landowner and landscape scales to reduce forest vulnerabilities. Coordinate with

partners including agencies, landowners, tribes, municipalities, and others to address drought mitigation.

- Establish a Washington Drought Resilience Partnership, in coordination with Department of Ecology and the Executive Water Emergency Committee, to foster long-term landscape scale drought resilience among state agencies and partners. Through the Partnership, develop a proactive and coordinated statewide response that addresses drought vulnerabilities to forests, watersheds, food production, water quantity and quality, and other values.
- Support drought mitigation through landowner assistance and coordinate with Department of Ecology on basin planning and restoration to increase natural water storage on the landscape.
- Address priority watershed drought vulnerabilities by developing plans and implementation strategies and coordinating with Department of Ecology's watershed planning efforts.
- Identify drought mitigation strategies for areas with disproportionate environmental health risks.

9. Increase DNR's small forest landowner forest health assistance capacity.

Requests for assistance by small forest landowners are growing due to increasing impacts and concerns related to wildfire, insect infestations, pathogens, and other climate-related changes. Needs include extending DNR's capacity to address invasive species on small forest land holdings, increasing support for community and landowner assistance programs, and providing adaptation strategies and other essential information to small forest landowners. To address these needs, DNR's priority responses include:

- Hire additional Landowner Assistance Foresters to provide consultation to small forest landowners.
- Train Landowner Assistance Foresters on relevant climate impacts and adaptation strategies; coordinate training with other extension forestry services such as WSU Extension and Washington Conservation Districts.
- Develop methods and materials to support climate resilience planning by small forest landowners.

C. Forest Practices

10. Enhance monitoring to assess standards for culverts and bridges.

The Forest Practices Rules for water-crossing structures rely on fish protection standards for hydraulic projects as stipulated under the Hydraulic Code (Chapter 77.55 RCW) administered by the Washington Department of Fish and Wildlife (WDFW). When WDFW determines there is a need to modify fish protection standards for culverts or bridges, DNR is committed to alerting the Forest Practices Board for the need to align Forest Practices Rules with revised fish protection standards as follows:

[77] See Strategy 8.3 of the *Washington State Wildland Fire Protection 10-Year Strategic Plan.*
[78] Snover et al. 2013. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report.*

- If changes are established through the rule-making process, DNR will incorporate those changes into the review of Forest Practices Applications.
- DNR will remain engaged with WDFW on the progress of these efforts through participation on the Fish Barrier Removal Board.

11. Assess reforestation requirements.

As climate conditions change, tree species and tree densities on the edge of the forest zone may change. This could create a gap between species preferences and stocking requirements in the reforestation rules (222-34 WAC) and ecological potential. To address this concern, DNR's priority responses include:

- Conduct a literature review, in conjunction with forest landowners (including DNR's state lands program), to determine any data gaps and create a pathway forward for determining any reforestation adjustments in those areas not likely to be commercial forests in the future.

12. Assess implications of climate change on potentially unstable slopes.

Forest Practices Rules associated with potentially unstable slopes are intended to protect water quality, habitat, and public safety by preventing forest practices-induced initiation or contributions to failure of potentially unstable slopes. The default protective management practice for potentially unstable slopes is avoidance. Accordingly, as part of the review process for forest practices applications, any harvest or road activity proposed on potentially unstable slopes identified in chapter 222-16 WAC, is reviewed through development of geologic information, on-the-ground field assessments, and licensed engineering geologists in accordance with Forest Practices Rules. Moreover, proposed forest practices considered under Class IV-Special rules require additional environmental review under State Environmental Policy Act (SEPA). Chapter 222-16 WAC was amended in 2016 to more clearly authorize the department to request needed information to better classify proposed actions on or around potentially unstable slopes. To address this topic, DNR's priority responses include:

- Continue supporting preliminary work at the Cooperative Management, Evaluation and Research Committee (CMER) to determine if the current definitions of potentially unstable slopes should be revised.
- Continue to support implementation of CMER's unstable slopes strategy for research and monitoring. These studies are in part a result of extreme climate events likely associated with climate change.
- Encourage forest landowners to conduct pre-application reviews of forest practices applications involving unstable slopes to ensure applications contain necessary information, are classified correctly, and can be effectively and efficiently reviewed.

13. Assess implications of climate change on Forest Practices Adaptive Management studies.

The Adaptive Management Program (222-12 WAC) provides science-based recommendations and technical information to assist the Board in determining if and when it is necessary or advisable to adjust rules and guidance for aquatic resources to achieve resource goals and objectives. To address this topic, DNR's priority responses include:

- Support design of CMER studies that include climate variability in aquatic resource work effectiveness and validation monitoring.

D. Small Forest Landowner Office

14. Enhance retention of working forest land held by small forest landowners.

As development pressure increases, working forests within the urban-rural interface will be relied on to provide cool, clean water and habitat and should be incentivized to remain in forest management. In addition, enhanced recognition is needed of the value of ecosystem services, including carbon sequestration, being provided by forests within the context of regional climate conditions and

landowner objectives. To address this topic, DNR's priority responses include:

- Expand existing programs that support retention of working forest land held by small forest landowners, including the Family Forest Fish Passage Program and the Forestry Riparian Easement Program, and create additional tools as may be suggested via a forthcoming assessment requested by the 2019 Legislature (ESSB 5330).

E. Urban and Community Forestry

15. Provide assistance in municipalities to support urban forest management that is climate informed and includes fire-adapted community strategies.

Extended warm, dry periods are projected to increase urban tree mortality, inhibit new tree establishment, and reduce canopy density and shade. These impacts are expected to increase the urban heat island effect, increase costs for heating and cooling, and create stressed trees that are more susceptible to insects, pathogens, and wildfire. Loss of trees is also likely to increase stormwater runoff and water pollution, and compromise human health and safety, especially within vulnerable communities.[79] Increased demands by communities for technical assistance will challenge DNR staff to respond. To address these risks, DNR's priority responses include:

- Modernize and implement the Evergreen Communities Act. Update legislation to support DNR's urban and community forestry programs with additional direction to focus work in areas where DNR's work can contribute significant gains for environmental justice, human health, and salmon recovery.
- Support development of local urban and community forest plans, with emphasis on risk abatement, tree planting in prioritized areas of low canopy density and with populations vulnerable to climate impacts, and access to carbon markets. Encourage site preparation adequate to address soil and water needs for urban trees, forests, and green stormwater infrastructure.
- Create an "urban forestry strike team" with qualified and licensed arborists to assist communities with post-storm or disaster assessment and response.
- Fund and implement the Urban Forestry Restoration Project and focus activities within prioritized communities/watersheds to mitigate risk and restore functioning natural areas.
- Develop urban and community education materials and engagement opportunities, and guide volunteer efforts to assist with climate informed natural area restoration and maintenance.
- Foster new funding opportunities to support use of urban forestry and green infrastructure as a critical therapeutic

[79] https://www.fs.usda.gov/ccrc/topics/urban-forests-and-climate-change. Accessed January 15, 2020.

tool for reducing inequity and improving community health and quality of life.

- Hire additional DNR urban forest specialists to provide technical assistance in priority watersheds and support increases in local capacity.
- Provide training and support to help municipal staff become Certified Arborists.

4 SECTOR-WIDE NEEDS AND OPPORTUNITIES

Approximately 90 percent of Washington's 22 million forested acres is managed by entities other than DNR. These landowners include private companies, family forest owners, tribes, conservation organizations, and federal, state, and local governments. The U.S. Forest Service is the largest forestland manager in the state with responsibility for approximately 37 percent of Washington's forested area.

Forest health at the landscape scale is a primary concern for forest managers. Healthy forests contribute to revenue and jobs in rural communities, clean air and water, wildlife habitat, recreational opportunities, carbon sequestration, as well as first foods and other cultural resources for tribes. For resource managers, a major challenge is the large scale of the landscape and the limited resources available to proactively manage the impacts of climate-driven changes.

Forest health and management needs differ among regions, especially when considering the relative abundance of dry forests in eastern Washington versus the predominantly moist forests of western Washington.

For many ecosystems in the drier forests of eastern Washington, fire is a natural and ecologically beneficial part of the landscape. However, decades of fire exclusion, past management practices, and land use change have contributed to a higher risk of damage by pathogens, insects, and uncharacteristic wildfire, resulting in reduced ecosystem resilience under a changing climate. An analysis by The Nature Conservancy and the U.S. Forest Service identified 2.7 million acres of eastern Washington forestland requiring some sort of active management or disturbance to create forest structures more resilient to insects, pathogens, and wildfires.[80] Ongoing research by DNR and University of Washington scientists are currently updating the estimate of restoration need.

One consequence of Euro-American landscape modification has been the increase in annual area burned in eastern Washington in recent decades relative to much of the twentieth century. However, while wildfire is increasing relative to the recent past (e.g., 1950-1980s), a longer view suggests eastern Washington is actually experiencing less wildfire than occurred on an annual basis historically (prior to Euro-American settlement).[81] For example, while large wildfires burned ~3.9 million acres in the Pacific Northwest from 1984 to 2015 (or 8 percent of the region), between 36.8 and 50.9 million acres would have been expected to burn in that many years historically.[82] This means the Pacific Northwest has experienced an order of magnitude less fire than would have likely occurred under natural processes and absent Euro-American presence. Not only has eastern Washington experienced less fire than the past, but the proportion of uncharacteristic high-severity fire has increased in forests that historically experienced low- and mixed-severity wildfire.[83] While achieving historical levels of fire may not be socially possible or desirable, the lower end of historical fire is likely a good measure of the amount of fire, or other treatments, necessary to maintain eastern Washington's forests in a resilient state. Ecologically, our wildfire problem isn't that we have too much fire, it's that we don't have enough of the right kind of wildfire (e.g., low- and mixed-severity fire in dry and moist forest types).

The scale of the forest restoration challenge requires use of all available tools, including mechanical thinning, prescribed fire, and managed natural fire where appropriate. To achieve healthy resilient forests and manage the growing wildfire challenge, we need "good" fires on the landscape that are generally less intense, have a greater mosaic of burn severities, reduce fuels, and improve the outcomes of future wildland fires.[84] However, DNR will continue to suppress fires that threaten communities or other values during unfavorable weather conditions. The National Cohesive Wildland Fire Management Strategy and the *Wildland Fire Protection 10-Year Strategic Plan* lay out a framework dealing with the paradox of fire: We need more good fire and less bad fire.

In contrast to eastern Washington, approximately 75 percent of the moist forests in western Washington

are characterized by infrequent and large patches of stand-replacing wildfire.[85] In these areas, the time between fire events can span centuries, and very large patches (2,500 – 250,000 acres) of stand-replacing fire are typical.[86] The types of wildfires that significantly shape these forests tend to be wind-driven; examples include the 1902 Yacolt Complex Fire that is estimated to have burned up to 1,000,000 acres, and the 1933 Tillamook Fire that burned 200,000 acres in 24 hours.

Western Washington forests are very productive, and because of the long duration between wildfires, they tend to have centuries to accrue biomass, making these forests naturally dense. Therefore, wildfire exclusion, which has contributed to many of the problems facing eastern Washington forests, has had a far less negative ecological impact in western Washington.[87] Given the ecology, characteristic wildfire disturbance, and high population densities, a focus on community preparedness, evacuation planning, structure hardening, aggressive wildfire detection, and appropriate and effective fire management will be increasingly important in much of western Washington. In drier areas of western Washington, such as the Olympic Rain Shadow (including the San Juan Islands) and Puget lowlands, wildfire was historically more frequent and tended to be more mixed severity in nature.[88] These lower-elevation areas may provide some opportunities to promote wildfire resilience through pre-fire forest management.

[80] Haugo, et al. 2015. *A new approach to evaluate forest structure restoration needs across Oregon and Washington, USA.*
[81] Haugo, et al. 2019. *The missing fire: quantifying human exclusion of wildfire in Pacific Northwest forests, USA.*
[82] Haugo, et al. 2019. *The missing fire: quantifying human exclusion of wildfire in Pacific Northwest forests, USA.*
[83] Haugo, et al. 2019. *The missing fire: quantifying human exclusion of wildfire in Pacific Northwest forests, USA.*
[84] Washington State Department of Natural Resources. 2019. *Washington State Wildland Fire Protection 10-Year Strategic Plan.*
[85] Estimates derived from Spies, et al. 2018. *Old growth, disturbance, forest succession, and management in the area of the Northwest Forest Plan.*
[86] Halofsky, et al. 2018. *The nature of the beast: examining climate adaptation options in forests withstand replacing fire regimes*; and Donato, et al. 2020. *Corralling a black swan: natural range of variation in a forest landscape driven by rare, extreme events.*
[87] Halofsky, et al. 2018. *The nature of the beast: examining climate adaptation options in forests withstand replacing fire regimes.*
[88] Spies, et al. 2018. *Old growth, disturbance, forest succession, and management in the area of the Northwest Forest Plan.*

From a forest health perspective in western Washington, there will likely be more opportunities to promote resilience to drought, rather than wildfire. Nearly two-thirds of western Washington forests are estimated to be young to mid-aged (5-80 years), homogenous, and dense due to past and current management.[89] This situation likely has no historical analog – i.e., the landscape was probably rarely, if ever, structured this way in its past. Thinning these forests to accelerate the development of older forest characteristics will increase resilience by reducing competition for resources as the growing season becomes both warmer and drier. For example, the dominant conifer species found in many low-elevation forests are Douglas fir and western hemlock. While Douglas fir is drought tolerant, western hemlock and other species such as Pacific silver fir are particularly affected by heat and drought and are more vulnerable to moisture stress. As temperatures rise and the dry season expands, drought-sensitive species will become increasingly at risk at lower and some mid-elevations, further suggesting a need to address drought resilience. While thinning to accelerate older forest conditions is an important climate adaptation strategy, regeneration harvests with retention in some of these younger forests would also foster the development of complex early seral conditions, which involve the structurally complex ecosystem of standing snags, down wood, shrubs, scattered live conifers, and broadleaf trees, among other characteristics. This condition rivals old growth forest in its biodiversity and habitat value and is currently the rarest condition on the landscape.[90] Both thinning and regeneration treatments also provide opportunities to promote greater species diversity within and/or across stands, especially increasing the proportion of broadleaf species which are resistant to the insects and pathogens affecting conifers.[91] Genetic diversity can also be increased by planting seedlings from climate adapted seed zones.

A related concern is post-wildfire forest restoration. As the number of annual acres burned trends upward, the need for climate-adapted species and seedlings will increase. The diversity of planting stock will need to be reconsidered to ensure it can support survival across current and future climates. Coordination is needed among nurseries, landowners, and those providing technical assistance to forest landowners to ensure the area to be reforested can support a forest stand into the future, the appropriate species are being planted, and sufficient supply is available.

PACIFIC COAST FOREST MEMORANDUM OF UNDERSTANDING

Leaders from British Columbia, Washington, Oregon, and California signed a Memorandum of Understanding (MOU) to support knowledge sharing across political boundaries. The leaders pledged to share and explore information regarding forest management under changing climate conditions, including:

1. Fuel management methods.
2. Climate-informed reforestation.
3. Accounting for changes in forest carbon.
4. Science and data collection regarding how forests are responding to changes in climatic conditions.
5. Utilization of harvested wood products.
6. Reducing conversion of forestland and promoting carbon-rich, climate-resilient forests.
7. Investments in natural and working lands that increase carbon sequestration, enhance forest resilience, encourage multi-benefit forest uses, and support natural resource dependent communities.

To make progress toward climate-resilient forests, forest managers, landowners, researchers, tribes, and others around the state would benefit from enhanced regional and cross-boundary cooperation. Many areas face similar concerns of increasing disturbance, closing mills, forest health challenges, inconsistent markets for wood products, limited social license for treatments, and other challenges. Numerous cooperative efforts exist such as DNR's Shared Stewardship agreements with USDA, forest collaboratives, and the Tribal Forest Protection Act. One example of cross-boundary cooperation which focuses on forests and climate is the Pacific Coast Forest Memorandum of Understanding (MOU). This agreement is facilitating information exchange on managing forests under climate change across British Columbia, Washington, Oregon, and California (see Pacific Coast Forest MOU box above).

Continued emphasis on cooperation is needed in relation to public engagement. Recent successes by other agencies and tribes illustrate an increased social license for prescribed burning with sufficient time and stakeholder engagement. Forest managers recognize that transforming forests to a resilient state will require a long-term commitment of resources and a public understanding that resilience will take decades to achieve and is an ongoing process that has to be

maintained. Public outreach on these topics has begun but continued engagement will be necessary.

Information sharing efforts should ensure involvement of small forest owners, who own nearly half of Washington's privately managed forests. As climate change increases the threats to forests and the complexity of forest management, these landowners will need increased technical support and resources. Forest management advice, carbon markets, and other support could help these landowners manage their forests and reduce the risk of disturbance or conversion to non-forest uses. Additional forest assistance experts are needed at DNR, conservation districts and WSU Extension to provide on-the-ground support as well as management advice that can translate scientific information into practical application for the non-industrial forest owner. Demand for these services outstrips current capacity.

Regional cooperation must also involve tribes. For tribes, forests support important first foods, provide habitat for plants and animals, and often sustain the headwaters for streams carrying salmon and other aquatic resources. Impacts from climate change on forests are changing the ability of forests to provide these critical resources, which are fundamental to tribal cultures and way of life and are protected by treaties. Tribes are actively engaged throughout the state in forest management to restore the health of forests on and off reservations, as well as forests on ceded and usual and accustomed lands through collaborative tools like the Tribal Forest Protection Act. As climate-driven changes continue to stress forests, federal, state, and local agencies have an opportunity and an obligation to partner with tribes to ensure protection and restoration of resources.

[89] Donato, et al. 2020. *Corralling a black swan: natural range of variation in a forest landscape driven by rare, extreme events.*
[90] Halofsky, et al. 2018. *The nature of the beast: examining climate adaptation options in forests withstand replacing fire regimes*; and Donato, et al. 2020. *Corralling a black swan: natural range of variation in a forest landscape driven by rare, extreme events.*
[91] Halofsky, et al. 2018. *The nature of the beast: examining climate adaptation options in forests withstand replacing fire regimes*

AGRICULTURE, GRAZING, AND LEASED TRUST UPLAND MANAGEMENT

1 DNR'S ROLE

On the state's 1.1 million acres of leased trust uplands, DNR's role is to manage agreements that allow agriculture, grazing, wind and solar installations, communication sites, commercial real estate, and other activities, while also providing for other public and ecological values. In Fiscal Year 2018, DNR generated $48 million from lease agreements for trust beneficiaries, such as public schools, universities, and public agencies.

DNR's leased trust upland management includes approximately 1,500 leases and permits for irrigated and dryland crops and grazing land; over 400 wireless telecommunication sites; approximately 20 wind and solar leases; more than 40 commercial ground leases including facilities such as retail, office buildings, and warehouses; more than 50 contracts and leases for the removal of subsurface products such as gold, basalt columns, gravel, and sand; and other uses such as recreation and habitat.

DNR also manages a large network of roads and rights-of-way that provide revenue and access to state trust lands and allow others to traverse state trust lands. In addition, DNR manages more than 300 state-owned surface water and groundwater rights and over 3,000 water claims.[92] The state's water rights increase trust revenue by supporting higher value irrigated agricultural lands and providing water for grazing animals.

In managing leased uplands, DNR operates primarily as a landlord. The agency does not grow crops or graze cattle itself, and, therefore, its primary concern is maintaining and enhancing the long-term productivity, sustainability, and value of the trust land as a revenue source from natural resource base production (e.g., soil, water, vegetation, and landholdings).

DNR PROGRAMS COVERED IN THIS SECTION

- Uplands Leasing Program: Agriculture, Grazing, Commercial, and Water Management

2 HOW CLIMATE CHANGE AFFECTS DNR'S RESPONSIBILITIES

Climate change is expected to affect many of DNR's agricultural, grazing, and other non-forested uplands leasing responsibilities. The primary climate-related risks to DNR's non-forested uplands management are:

- Water reductions. The value of DNR's irrigated agricultural lands is significantly influenced by the availability of water. Many mid-elevation mixed rain-snow basins are at high risk of surface water curtailment, especially in late summer. Historically DNR has rarely had water rights curtailed because most of its water rights are senior. However, junior surface water rights could

be more frequently curtailed in the future due to declining water availability in some basins. Long term, groundwater rights will be at risk in areas with declining aquifer levels and some groundwater rights that have connectivity to surface water could be curtailed. Dryland agriculture is also at risk due to warmer and drier conditions in the future.

- Wildfire damage. Range fires can destroy crops and rangeland vegetation and can damage or destroy livestock fencing that is costly to replace. High-severity fires can incinerate the natural seedbank required for revegetation. Loss of vegetation can lead to floods, landslides, and debris flows during high precipitation events, harming public safety and water quality in streams.
- Weeds, invasive species, insects, and disease. As temperatures rise, some weeds, invasive species, insects, and diseases are likely to increase in variety, incidence, and spatial extent.[93] If this occurs, land management costs are expected to increase.
- At-risk species and shrub-steppe habitat. Eastern Washington harbors 14 federally protected, threatened, or endangered plant and animal species and at least 40 species closely associated with shrub-steppe habitat.[94] These species tend to be vulnerable to climate change impacts and in some cases limit lease opportunities. Grazing lands often overlap with shrub-steppe habitat; increased fire and invasive cheatgrass are projected to further degrade shrub-steppe habitat.
- Increasing precipitation intensity and soil erosion. Heavy rainfall events are projected to become stronger and more frequent.[95] Heavier rainfall can cause flooding, soil erosion and other damage to crops, roads, cell towers, and other facilities.

3 DNR'S PRIORITY RESPONSES

DNR's management of non-forested uplands is designed to be flexible and adapt to changing conditions, whether from climate change, changing market conditions, or new societal concerns. DNR has already started responding to changing climate conditions by modifying its operations in a variety of ways, including:

- Enhancing water rights and flexibility. DNR is clarifying its water rights and positioning its water so it can be better managed in water-constrained areas and used in mechanisms such as water banking.
- Acquire future high-value land. DNR is identifying and acquiring lands that under future climate conditions could grow high-value crops and increase revenue for trust beneficiaries.
- Promoting wind and solar development. DNR is promoting development of clean energy facilities on state-owned lands while ensuring that it does not negatively affect cultural resources, prime agricultural land, critical wildlife habitat, or rare plant communities. Currently, there are approximately 20 wind and solar leases in operation or under development.

In addition, based on increased understanding of the risks climate change poses to our mission and responsibilities, DNR is pursuing the following strategic opportunities:

1. **Address climate change risks to roads and infrastructure.**

   Roads provide essential access to DNR-managed lands, including remote sites. More winter precipitation as rain rather than snow and more frequent and heavier rainfall events are projected to increase the frequency and severity of road washouts and infrastructure damage. In areas with

[92] Water rights are generally represented by three types of documents: claims, permits, and certificates. A *claim* is simply a claim to a water right for a water use which predates the water permitting system. Its validity can only be confirmed through judicial processes. A *permit* is the first step toward securing a perfected water right and requires a step-by-step application process, resulting in a permit issued by Ecology. When all the conditions of a water right permit are met and Ecology issues a *certificate*, the water right is said to be perfected. (Source: Washington State Department of Ecology. https://fortress.wa.gov/ecy/publications/documents/972022swr.pdf. Accessed January 28, 2020).

[93] Snover, et al. 2013. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report.*

[94] Azerrad, et al. 2011. *Management recommendations for Washington's priority habitats: managing shrub-steppe in developing landscapes.*

[95] Warner, et al. 2015: *Changes in winter atmospheric rivers along the North American west coast in CMIP5 climate models.*



recent fires, the risk of flooding, landslides, and debris flows is exacerbated. Damage to roads could make travel, emergency evacuation, and access to lease areas difficult if not impossible. Infrastructure such as mountain top communication sites are also vulnerable due to high winds, precipitation, and environmental extremes. Several of these sites are critical for county and state emergency service providers, making road access essential. Recreation sites and other uses could also be affected. Priority responses include:

- Develop road construction and maintenance specifications for non-forested uplands roads to reduce risk of damage due to heavy precipitation events and other climate-related impacts.
- Assess non-forested upland roads against updated specifications to determine where upgrades are necessary. Prioritize projects to update the most important and highest-risk sites first.
- Update lease agreements to incorporate road maintenance activities that reduce risks associated with heavy precipitation and other climate-related impacts.
- Move above-ground utilities below ground where feasible to reduce damage from windstorms and trees damaging infrastructure.
- Upgrade building and communication site infrastructure to reduce risk of damage or failure during heavy precipitation events. Prioritize sites that serve emergency service providers.
- Seek new funding source when FEMA funds are unavailable to support emergency road restoration following catastrophic events such as landslides and floods.

2. Reduce risk of financial loss from disturbances such as wildfire, drought, and flooding.

Increasing wildfire frequency, acres burned, drought, and flooding are likely to affect DNR lessees and permit holders by damaging crops, buildings, equipment, roads, bridges, soils, grazing land vegetation and fencing, communication towers, wind and solar installations, and other items. Invasive species have the potential to drive up management costs. In addition to harming lessees and permit holders, these impacts could also reduce revenues to trust beneficiaries. Priority responses include:

- Acquire lands with irrigation or have the potential to be irrigated.
- Enhance the stability and predictability of agricultural trust revenue under changing climate conditions by continuing to convert dryland parcels from a share crop revenue structure to cash rent.
- Support flexible crop rotations for lessees facing challenges related to irrigation curtailments and changing markets. This allows lessees the opportunity to grow alternate crops while protecting DNR's water rights from potential relinquishment.

REVENUE (IN THOUSANDS) FROM AGRICULTURE, COMMERCIAL, AND OTHER UPLAND LEASES, 2009-2018

Source: DNR Annual Reports, 2009-2018, available at https://www.dnr.wa.gov/about/fiscal-reports/dnr-annual-reports

2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
$32,076	$31,804	$32,031	$37,933	$41,620	$42,703	$40,290	$42,693	$44,325	$47,978

- Work with partners and lessees to standardize practices and advance incentives for protecting soil health.
- Collaborate with partners on cross-boundary management and treatment of invasive species.
- Collaborate with lessees to identify systems and infrastructure for water conservation to lessen the impacts of drought.

3. Reduce risk of water curtailments on DNR-managed lands.

Reduced water availability will likely result in curtailment of some DNR water rights in certain locations. This would affect the productivity of DNR's agricultural lessees and could reduce revenues to trust beneficiaries. Priority responses include:

- Support development of effective water markets. Explore water leasing opportunities and dry-year options contracts for DNR water rights available for short-term use.
- Work with lessees to shift water from low-value to high-value crops where feasible to increase revenues to trust beneficiaries.
- Purchase or lease water when feasible to support survival of perennial crops such as fruit during water-curtailed years.
- Work with lessees to adjust crop rotations as needed in response to drought or potential curtailments. Monitor drought forecasting and provide this information to lessees.
- Explore opportunities to increase water availability and use through mechanisms such as water storage and pump water storage for clean energy generation.

4. Advance clean energy and carbon sequestration on DNR-managed lands.

- Continue to seek appropriate opportunities for wind, solar, and other clean energy leasing on DNR-managed lands.
- Explore opportunities to enhance trust revenues through carbon sequestration and carbon markets.

4 SECTOR-WIDE NEEDS AND OPPORTUNITIES

Climate change affects agriculture in a range of ways. In addition to the impacts and responses described above (e.g., water reductions, drought, wildfire, disease, insects, weeds, and floods), there are a number of needs and opportunities to address climate change impacts in the agricultural sector that DNR cannot address on its own, but is committed to working with others to achieve.

Soil health is an important opportunity for enhancing agricultural resilience to changing environmental conditions. Improving agricultural soil health may involve planting cover crops over otherwise bare soil, retaining stubble after harvest, no-till methods, or other practices that help retain soil nutrients and reduce wind and water erosion. The results of these practices can include increased crop yields and soil water retention, habitat and forage for pollinators, improved resilience to weather extremes, greater soil carbon sequestration, and ultimately greater agricultural profitability. In Washington, the Soil Health Initiative is led by Washington State University, the Washington State Department of Agriculture, the Washington State Conservation Commission, and industry partners. They are working collaboratively with growers to develop locally-relevant soil health management strategies across the state's agricultural regions and varied cropping systems.

Agricultural research is also needed to support decision-making and adaptive responses under changing climate conditions. Washington grows a

diverse set of crops across unique climatic ranges and geographies. Climate change can increase risks to agricultural interests and, in some cases can create benefits such as expanded growing areas, longer growing seasons, and CO_2 fertilization. While progress has been made to understand the general impacts of climate change on agriculture, greater precision is needed to help predict how climate change will affect specific crop viability and quality, water availability, insects and disease, and opportunities for new and emerging crops in the state. The pace of change and the range of variability is increasing and is challenging producers to adapt quickly enough. For example, transitioning to a new crop mix requires not just a field-based planting decision, but also investments in harvesting equipment and vertical alignment with packing, processing, and distribution networks.

There is a need for improved coordination of research, technology development, and information dissemination to support climate resilience. This would build on and enhance existing structures such as WSU's research and extension programs, the Washington State Conservation Commission, the USDA Natural Resources Conservation Service, and the USDA Northwest Climate Hub. In addition, opportunities may exist for DNR lands and lessees to participate in research or identification of new threats. Improvements might take the form of regional coordinating bodies or agricultural resilience centers that link researchers, extension staff, growers, processers, marketers, investors, and others. These regional coordinating bodies could assist by guiding decision-relevant research or providing a hub for locally and regionally relevant information to guide agricultural decisions under changing climate conditions. The key components include leadership, coordination and resources that support research, technology, and information transfer and dissemination. Ultimately, the structure of this coordinating entity should be developed by those involved in the existing structures to ensure it supports their needs.

Water management is already a significant challenge for many producers, especially those with junior water rights in over-appropriated basins. As the availability of surface water declines, especially during the late summer growing season, increased flexibility of water use related to location, timing, and other factors could be beneficial. Water resource assessments and improved information on subsurface geology and groundwater could help fill gaps in knowledge about water supplies and inform science-based management of water resources.

Water markets and water trading have the potential to increase the value of water use under certain

SPOTLIGHT ON URBAN, COMMERCIAL, AND INDUSTRIAL LANDS

Across DNR's portfolio of managed lands, 3,700 acres are within Urban Growth Areas. These lands are managed for a range of purposes including commercial leases, communication sites, recreation, and agriculture. In particular, commercial real estate properties represent an important part of the diversified asset portfolio that DNR manages on behalf of state trust land beneficiaries. DNR manages eight properties with commercial buildings, including retail businesses, commercial office buildings, and commercial warehouses. DNR also manages 26 ground leases where DNR owns and leases the underlying land, but lessees own the improvements (buildings and other infrastructure) on those lands. The DNR Commercial Real Estate Program raises about $9 million in revenue every year for state trust land beneficiaries. DNR also manages and leases industrial properties inside and outside urban growth areas, such as wind farms, solar installations, communications sites, and other infrastructure.

Urban, commercial, and industrial properties face a range of unique risks from climate change:

- More extreme precipitation events and winter floods are expected to strain, and in some cases exceed, the capacity of stormwater infrastructure.[96]
- Urban coastal areas currently vulnerable to inundation will flood more frequently with sea level rise, and the coastal areas vulnerable to flooding will expand.[97]
- More frequent large wildfires and greater area burned can increase damage to wildland urban interface communities, damage energy transmission and distribution equipment, and increase transportation and electric service interruptions.[98]
- Flooding, landslides, and debris flows associated with heavy precipitation can damage transportation networks and other infrastructure.[99]
- Extreme precipitation events that bring substantial winter rainfall and major flooding west of the Cascades are expected to become more severe, leading to higher peak streamflows and flood risk.[100]

A number of the priority responses highlighted in this and other sections have particular relevance to urban, commercial, and industrial lands:

- Addressing climate change risks to roads and infrastructure including upgrading infrastructure to reduce risk of damage or failure during heavy precipitation events and other climate-related impacts.
- Strengthening resilience to infrastructure damage through climate-informed design including assessing climate-related risks to facilities, roads, and other infrastructure, determining whether infrastructure can remain in place, be hardened or must be relocated, and considering projected future climate conditions in site improvement and infrastructure design.
- Reducing GHG emissions from transportation by exploring responsible development opportunities in transit-oriented locations.
- Advancing clean energy on DNR-managed lands by continuing to seek appropriate opportunities for wind, solar, and other clean energy leasing.

circumstances. However, in some situations markets also have the potential to allocate water away from uses with high social or environmental value but low economic value. Any changes in flexibility of water availability will have to be managed in relation to other water uses such as domestic use, instream flows, return flows, and groundwater recharge.

Options for water management can be hampered by certain legal and regulatory structures that were established under more stable historical climate conditions. Uncertainty about future water availability, combined with regulatory uncertainty, causes fear of losing unperfected or certificated water rights.

Western water law provisions such as "use it or lose it" can impact water right holders' willingness to engage in water conservation practices, water banking, and water markets. As climate change increases the variability and unpredictability of precipitation and water availability, there will be a growing need for policy adaptation and regulatory flexibility to enable water conservation and movement of water to support a resilient agricultural sector.

[96] Mauger, et al. 2015. *State of Knowledge: Climate Change in Puget Sound*.
[97] Miller, et al. 2019. *Extreme Coastal Water Level in Washington State: Guidelines to Support Sea Level Rise Planning*.
[98] Snover, et al. 2013. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report*.
[99] Ibid.
[100] Mauger, et al. 2015. *State of Knowledge: Climate Change in Puget Sound*.

ECOSYSTEM CONSERVATION, NATURAL AREAS, AND NATURAL HERITAGE PROGRAMS

1 DNR'S ROLE

Washington is home to more than 3,100 vascular plant species, 140 mammals, and numerous species of freshwater and marine fish, birds, amphibians, reptiles, mosses, lichens, liverworts, fungi, and invertebrates. Some of these species occur nowhere else on Earth. For example, 86 plant species are unique to Washington state.[101] Washington also harbors more than 400 at-risk species, including 43 animal species and more than 360 plant species that are listed or considered Endangered, Threatened, or Sensitive under the federal Endangered Species Act, state criteria, or the Washington Natural Heritage Program. These include salmonids, orcas, northern spotted owls, marbled murrelets, lynx, and sage grouse.[102]

DNR's species and habitat conservation efforts are integrated throughout the agency's programs and operations. The Natural Heritage Program manages statewide biodiversity information and provides an objective basis for establishing priorities for designation of Natural Areas and other conservation actions. The Natural Heritage Program also connects conservation science with conservation action by collecting, maintaining, and distributing data on rare species and ecosystems, as well as providing a number of other services and products in support of conservation in Washington state.

DNR's Natural Areas Program provides stewardship across a suite of protected sites containing some of the best remaining examples of native Washington ecosystems and rare plant and animal communities in Washington. Today, the Natural Areas Program provides stewardship and protection across over 165,000 acres in 95 sites.

DNR PROGRAMS COVERED IN THIS SECTION

- Natural Heritage Program
- Natural Areas Program

2 HOW CLIMATE CHANGE AFFECTS DNR'S RESPONSIBILITIES

Both the Natural Areas Program and the Natural Heritage Program contribute to climate resilience for the state's plants, animals, and ecosystems through their work to inventory, protect, manage, and restore natural systems. However, climate change is expected to significantly affect the ability of the Natural Heritage Program and the Natural Areas Program to achieve their missions and responsibilities. The primary climate-related risks to these programs include:[103]

- Shifts in species distributions and abundances are expected in response to changes in climate and associated changes in habitats. These shifts may result in range contractions, extirpations, or expansions for some species within the state, as well as species previously not found in Washington moving in from neighboring areas.
- Reduced snowpack is projected to cause changes in mid- and high-elevation ecology, altered hydrologic regimes and reduced summer soil moisture and summer streamflow. Alpine, subalpine, riverine, and riparian ecosystems and obligates may be particularly sensitive to these changes.
- Increased wildfire frequency and extent is likely to result in population declines in affected areas and may facilitate ecosystem transformation in some sensitive landscapes.
- Increased presence and abundance of non-native, invasive species. Some non-native, invasive species may be better adapted to future climatic conditions than native species that are adapted to historical conditions. As a result, some non-native, invasive species may thrive at the expense of native species.
- Dis-assembly of ecological communities. Climate-induced changes in species distributions, phenologies (i.e., the timing of biological events), and interactions—each of which is expected to be non-uniform across individual species—may lead to the emergence of novel ecological communities.
- Sea level rise is projected to inundate some coastal wetlands and other nearshore habitats, altering their composition, shifting them inland, or eliminating them.
- Ocean acidification is expected to negatively affect the marine ecosystem, with especially severe impacts seen in shell-forming organisms (e.g., oysters, clams, mussels), as well as phytoplankton, zooplankton, and the species that depend on them.
- Increased sedimentation associated with heavy rainfall events and higher peak streamflows is likely to cause negative impacts to marine species such as kelps and eelgrass.

3 DNR'S PRIORITY RESPONSES

To address the risks that climate change poses to our mission and responsibilities, DNR is pursuing the following strategic opportunities:

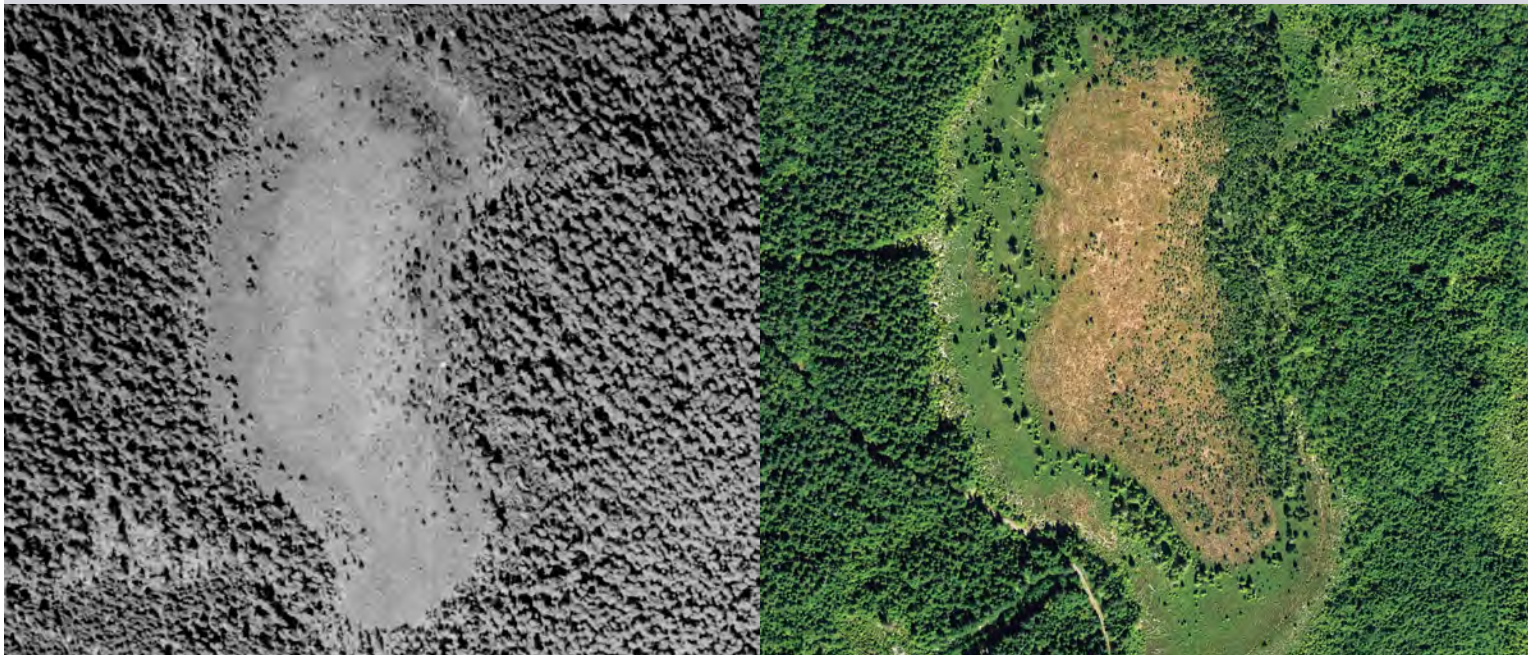
1. **Assess vulnerability and enhance monitoring of Natural Areas.**

   DNR's 95 Natural Areas include rare and high-quality ecosystems native to Washington state, populations of rare plant and animal species, significant geologic features, scenic attributes, and cultural heritage features. Climate change is expected to influence the function and persistence of these protected elements. While the elements for which Natural Areas were initially established are known, the majority of sites lack a comprehensive inventory of species and ecosystems upon which to assess changing conditions and potential loss within them. In addition, 47 Natural Areas lack a management plan. Without complete and current information on the communities and species found within Natural Areas, and a plan for the maintenance of these occurrences, there is an elevated risk of degradation or loss of species and ecosystems that occur within Natural Areas. This information is also necessary to assess the success of management investments. To address these risks, DNR's priority responses include:

[101] Washington State Department of Natural Resources. 2018. *State of Washington Natural Heritage Plan 2018.*
[102] Washington Department of Fish and Wildlife. 2019. *State Listed Species.*
[103] *State of Knowledge: Climate Change in Puget Sound;* May, et al. 2018: Northwest. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.*

CROWBERRY BOG, DNR'S NEWEST NATURAL AREA PRESERVE

An unusual type of raised bog that only forms under very narrow climatic conditions, Crowberry Bog is the only one of its kind known in the western United States. Because the bog's persistence is so closely tied to climate, it is an ideal place to conduct climate change research. One predicted outcome of climate change in bogs is increased tree growth. This appears to be occurring in many of Washington bogs, including Crowberry Bog. These photos show the increase in tree growth that occurred within Crowberry Bog and around its edge from 1939 to 2016.



- Develop, fund, and implement a monitoring protocol that leverages Ecological Integrity Assessments[104] for all DNR Natural Areas. Periodic monitoring with this protocol will help identify changes in ecosystem composition, provide guidance for restoration activities, and reduce the risk of species loss or ecosystem degradation.
- Fund and complete management plans for DNR Natural Areas to provide guidance for long-term management actions including consideration of potential climate change impacts.

2. Incorporate climate change considerations into Natural Areas site prioritization, selection, and design.

As climate change leads to temperature, hydrologic, and other shifts, some Natural Areas may no longer provide suitable habitat for the rare species and ecosystems for which the sites were originally established. Successful range migration of native species in response to changing conditions is likely to be limited due to habitat degradation in surrounding landscapes and minimal connectivity within the statewide system of Natural Areas (DNR and others). As human population and development increase, opportunities to address inadequacies in the system of Natural Areas will become increasingly rare and expensive. As these trends continue, the risk of species loss and ecosystem degradation increases. To address this risk, DNR's priority responses include:

- Complete Climate Change Vulnerability Index evaluations[105] for rare species and ecosystems to determine risk to protected elements.
- Evaluate existing Natural Areas for their potential to provide for the long-term persistence of protected elements, including immediate landscape context, location within the landscape, and connectivity to other potential habitat areas.
- For potential new Natural Areas, explicitly consider the potential impacts of climate change in site design. Site design could include drawing boundaries to enhance connectivity (e.g., along riparian areas) and abiotic diversity within a site.

- Incorporate redundancy and connectivity in prioritization of sites for protection. Consider precipitation and landscape gradients to support long-term protection of species and ecosystems under changing climate conditions.
- Increase collaboration with other conservation organizations, including federal and state agencies and non-profit land trusts to identify areas that may provide connectivity for rare species and rare and high-quality ecosystems.

3. Fund and implement statewide inventory of rare species and ecosystems.

Although there has been a concerted effort over the years to document the locations and status of Washington's species and ecosystems, our knowledge is far from complete. As a result, DNR is hampered in its ability to provide sufficient protection and Washington is at risk of losing components of the state's biodiversity as they are increasingly stressed by climatic and land-use changes. To address this risk, DNR's priority responses include:

- Provide core funding for Natural Heritage Program staff to plan and implement species and ecosystem inventory efforts.
- Conduct climate change vulnerability evaluations to inform prioritization of species and ecosystems for inventory.
- Explore opportunities to work with existing or develop new citizen scientist efforts to assist with species and ecosystem inventory.

[104] Ecological Integrity Assessments provide a succinct assessment of the current status of the composition, structure, processes, and connectivity of ecosystem type occurrences within Natural Areas.
[105] The Climate Change Vulnerability Index provides a rapid, cost-effective means of estimating a plant or species' relative vulnerability to climate change.

4 SECTOR-WIDE NEEDS AND OPPORTUNITIES

Managers of fish, wildlife, habitats, and ecosystems face a range of challenges associated with achieving conservation goals under changing climate conditions. An overarching challenge is the breadth of physical and biological changes occurring simultaneously. Climate change impacts are adding stressors to Washington's ecosystems and species through altered frequency and severity of ecosystem disturbances; degradation and loss of habitat; shifts in geographical ranges of some native plants and animals; changes in the timing of life history events for plants and animals; declines in species populations and loss of biodiversity; and spread of invasive species and disease.[106] These impacts are occurring in forested and arid landscapes as well as in rivers, lakes, coastal and marine ecosystems.

A related challenge is the relatively short time horizon of most conservation and resource planning processes. For example, a planning process that considers only the next 10 years might be inadequate for addressing gradual climate trends by dismissing small changes in the near-term and missing critical climate impacts projected over a longer time horizon. A more proactive approach is needed to assess longer-term trends and prepare for them in the near term. This includes identifying where plant and animal ranges might move in the future and connecting habitats to facilitate their movement.

Effectively promoting resilient habitats and species also requires working at large-landscape scales and across jurisdictional and institutional boundaries. It requires managing habitats strategically as a portfolio across a variety of ownerships, including DNR, WDFW, Washington State Parks, land trusts, tribes, and private landowners where possible. This requires coordination to facilitate ecosystem management across large landscapes that simultaneously addresses specific local objectives and broader conservation goals. Examples of these efforts in Washington include the Cascadia Partner Forum, the Cascades to Coast Landscape Collaborative, and the Arid Lands Initiative. Each of these is a collaborative, multi-organization effort to conserve species, habitats, and ecosystems across large landscapes and multiple ownerships in the face of climate change.

Although promising, existing landscape-scale conservation efforts are largely self-organized by committed individuals and lightly funded by private foundations. Their effectiveness is hampered by lack of statewide coordination, mandate, and authority for this work and the lack of committed investment by state and federal agencies. Effective conservation across large landscapes, especially under changing climate conditions, will require proactive investment to support coordination, science, planning, and implementation. A state-level mandate for such work could help to prioritize these efforts across agencies, and associated financial resources could provide the support needed to galvanize action. A state-level mandate could also support continuity of these efforts over time, and reduce the likelihood that they will be suspended or disrupted as administrations change.

Climate resilience will also require moving beyond planning and into implementation. Many climate adaptation plans have been created, but few on-the-ground projects have actually been implemented. In many cases, resource managers know what needs to be done, but resources are needed to support implementation of on-the-ground climate-adapted conservation actions. As the impacts of climate change accelerate, it will be increasingly important to develop early warning systems that identify downward trends in species abundance and ecosystem health. As species or systems decline, recovery options tend to shrink and costs tend to increase; early detection will allow for early action and prevent additional costs. There are a number of efforts to develop early warning systems for biodiversity and a number of existing platforms upon which to build. DNR's Natural Heritage Program currently tracks the abundance and status of the state's species and ecosystems, but it is not sufficiently funded to meet the demands of the increased pace of climate-related change. WDFW has also proposed a Climate Watch List for fish and wildlife, but it would also require funding to be effective.

The impact of climate change on ecosystems poses particular concerns for tribes. Plants and animals have sustained tribal communities for thousands of years—providing food, fuel, shelter, medicines, and materials for commerce—and they form the foundation for tribes' spiritual lives, sacred ceremonies, and community cohesion. Each tribe is unique, and climate change affects each tribe in specific ways. However, virtually every resource and activity that their treaties protect—fishing, gathering, and hunting—is impacted by the effects of climate change. Climate change impacts on tribally important species includes declining salmon and steelhead runs; migration of marine fish away from historical fishing grounds; declining shellfish populations, closing of shellfish harvest areas due to harmful algal blooms, and loss of traditional shellfish harvesting areas, forage fish spawning grounds, and important cultural sites to sea level rise or increased coastal erosion; declining populations and migration of wild game and birds out of traditional hunting grounds as they move farther north or to higher elevations; and loss of traditional hunting grounds, plant gathering areas, and sacred sites due to wildfire, landslides, or invasive species. In addition, climate change impacts include negative health outcomes from loss of nutrition from traditional foods, and loss of opportunities to engage in traditional cultural activities.[107]

Climate change is a significant threat to Washington's plants, animals, and ecosystems, but it is not the only concern. Increasing development in previously less-developed lands typically leads to habitat loss and fragmentation, increased invasive species, and pollution that can compromise the health and integrity of many species and habitats. During the last 10 years (2009-2019) the state's population grew by more than 870,000 people,[108] adding development pressure and other stressors to the state's already fragmented wildlands. Healthy species populations and functioning ecosystems can enhance resilience to changing climate conditions. Therefore, one of the most important actions to help increase the capacity of fish, wildlife, and plants to cope with climate change is to reduce the negative impacts of existing non-climate-related stressors such as pollution or habitat degradation.[109]

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[106] Washington State Department of Ecology. 2012. *Preparing for a Changing Climate: Washington State's Integrated Climate Response Strategy.*

[107] The paragraph is drawn from: Northwest Indian Fish Commission. 2016. *Climate Change and Our Natural Resources. A Report from the Treaty Tribes in Western Washingto*n.

[108] Washington State Office of Financial Management (OFM). Total Population and Percent Change. https://www.ofm.wa.gov/washington-data-research/statewide-data/washington-trends/population-changes/total-population-and-percent-change. Accessed October 18, 2019.

[109] National Fish, Wildlife and Plants Climate Adaptation Partnership. 2012. *National Fish, Wildlife and Plants Climate Adaptation Strategy.*

AQUATIC RESOURCES AND COASTAL MANAGEMENT

1 DNR'S ROLE

Washington state has more than 3,000 miles of marine shoreline,[110] approximately 70,000 miles of rivers,[111] and myriad lakes. These areas support fish and wildlife, industry, recreation, communities, and a wide variety of jobs. Our iconic salmon and orca depend on Puget Sound's aquatic ecosystem, and our fishing industry and others depend on access to the water. Many tribes and cultural communities depend on coastal and aquatic ecosystems for food and cultural resources.

DNR manages 2.6 million acres of state-owned aquatic land—mostly submerged lands that lie beneath navigable marine and fresh water—and associated aquatic resources attached to or embedded in the sediments. State-owned aquatic lands extend waterward three nautical miles from the coast and include the Strait of Juan de Fuca and marine waters to the Canadian border, Puget Sound, and beds and shores of navigable lakes and rivers, including the Columbia River to the Oregon border. In marine and estuarine waters, the state owns the land influenced by the tides unless the state has sold them.

DNR is mandated by the Legislature to "provide a balance of public benefits for all citizens of the state" by encouraging direct public use and access; fostering water-dependent uses; ensuring environmental protection; and utilizing renewable resources.[112] To implement this mandate, DNR promotes protection, restoration, and sustainable use of these lands and the resources embedded or attached to them. DNR's coastal and aquatics activities include aquatic leasing and licensing of uses on or over state-owned aquatic lands; habitat and ecosystem restoration; aquatic science, assessment, and monitoring regarding kelp, eelgrass, and other important aquatic resources attached to or embedded in state-owned aquatic lands; derelict vessel removal to prevent environmental damage and protect public health and safety; and managing state-owned resources such as razor clams and wild stock geoduck.

DNR PROGRAMS COVERED IN THIS SECTION

- Aquatic Resources

REVENUE (IN THOUSANDS) FROM AQUATIC LEASES, 2009-2018

Source: DNR Annual Reports, 2009-2018, available at https://www.dnr.wa.gov/about/fiscal-reports/dnr-annual-reports

2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
$20,166	$29,622	$37,061	$38,930	$23,672	$31,795	$30,475	$24,311	$37,379	$36,902

Uses on or over state-owned aquatic land require a use authorization from DNR, such as a lease, easement, right-of-entry, or waterway permit. Leases and easements typically contain improvements owned by the lessee. Revenue is generated from leasing submerged lands for marinas, aquaculture, marine terminals, and other uses, as well as from the sale of state-managed resources such as wild geoduck. In fiscal year 2018, DNR earned $36,902,000 from leases and the state wild stock geoduck fishery;[113] approximately 60 percent of that revenue came from wild stock geoduck sales. This revenue is allocated to the Aquatic Lands Enhancement Account (ALEA), which is used to manage and protect the health and sustainability of aquatic resources, and to fund projects that restore aquatic ecosystems and create public use and access to the waters of the state. Examples of projects supported by the ALEA program include creosote piling and bulkhead removal, restoring shorelines and estuary habitat, and developing waterfront for public use and access.

2 HOW CLIMATE CHANGE AFFECTS DNR'S RESPONSIBILITIES

In the marine environment, climate change is projected to raise sea levels, exacerbate periodic coastal flooding from storm surge, and increase sea surface temperatures, while increasing amounts of dissolved CO_2 in the ocean will cause ocean acidification. In the freshwater environment, climate change is projected to raise water temperatures, reduce summer low flows, increase winter streamflows, and shift peak streamflows earlier in the year.[114]

Climate change is expected to affect coastal, marine, and freshwater ecosystems. The primary climate-related risks to DNR's coastal and aquatic responsibilities are:

- Damage due to coastal flooding and sea level rise. Rising sea levels, compounded by storm surge, high tides and erosion, are projected to increase the frequency and magnitude of flood inundation and increase the risk of damage to coastal facilities, especially fixed structures such as docks and nearshore buildings. Waves and inundation could result in debris and toxic substances or contaminants entering the ecosystem and harming fish and other aquatic resources. Rising sea levels and damage to coastal facilities could also result in reduced public access to coastal lands and resources.
- Harm to aquatic species due to ocean acidification. Increasing ocean acidity is compromising the growth, reproduction, and survival of many nearshore species, including oysters, clams, scallops, mussels, crabs, and calcifying plankton.
- Declining salmon and orca populations. Over a dozen populations of salmon and steelhead in Washington state are currently listed as threatened or endangered. Washington's Southern Resident Killer Whale population (also known as orca) are also listed as endangered, and depend on Chinook salmon as their preferred food source. Warmer streams, ocean acidification, lower summer streamflows, higher winter streamflows, and earlier peak streamflows are projected to negatively affect salmon.[115]
- Threats to shellfish and wild stock geoduck survival, reproduction, and recruitment. Shellfish, including wild stock geoduck, may be negatively affected by ocean acidification and other changing ocean conditions such as lower dissolved oxygen

[110] Washington State Department of Ecology. 2012. *Preparing for a Changing Climate: Washington State's Integrated Climate Response Strategy.* Publication No. 12-01-004.
[111] https://www.rivers.gov/washington.php. Accessed October 3, 2019.
[112] RCW 79.105.030.
[113] Washington State Department of Natural Resources. 2018. *2018 Annual Report.*
[114] Snover, et al. 2013. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report.*
[115] Mauger, et al. 2015. *State of Knowledge: Climate Change in Puget Sound.*

and warming sea surface temperatures.[116] Ocean acidification may threaten multiple calcifying organisms such as oysters, clams, scallops, mussels, crabs, geoduck, abalone, and pteropods when the water becomes corrosive, possibly resulting in increased mortality and slower growth rates.[117] Blooms of the harmful dinoflagellate Alexandrium, the causative species of paralytic shellfish poisoning (PSP), could increase in geographic scale, frequency, and duration due to increases in sea surface temperature.[118] If the frequency and duration of harmful algal blooms increases throughout Puget Sound, shellfish harvest and geoduck fisheries may experience more frequent closures due to biotoxins.

- Threats to aquatic reserves, eelgrass beds, and kelp forests. These house important marine biodiversity, but are vulnerable to loss due to sea level rise, increasing temperatures, sedimentation, ocean acidification, and other climate change impacts.
- Damage due to higher peak river flows, erosion, and lateral channel migration. High-risk items are primarily structures that could be damaged by flooding, high energy flows, erosion, or channel migration.

3 DNR'S PRIORITY RESPONSES

DNR has already started responding to changing climate conditions and is reviewing its operations in a variety of ways, including:

- Promoting the resilience of aquatic lands by incorporating site-specific information to protect ecosystem process, structure, and function into aquatic leases, easements, and permits.
- Assessing how geoducks may be affected by a changing environment and researching if eelgrass beds help to suppress harmful algal blooms.
- Assessing the site-specific impacts of ocean acidification in the nearshore environment and quantifying the ability of eelgrass to ameliorate some of the negative impacts associated with ocean acidification.
- Participating in regional blue carbon work groups to assess carbon storage in Puget Sound aquatic environments. Identifying opportunities for protecting and recovering aquatic habitats for multiple benefits including carbon sequestration.

- Expanding monitoring and research in aquatic reserves and eelgrass beds. Developing and implementing monitoring protocols for citizen scientists that will detect climate-related changes in ecosystems and inform future management decisions.

In addition, based on an increased understanding of the risks climate change poses to our mission and responsibilities, DNR is pursuing the following strategic opportunities and taking the following actions:

1. **Identify areas of high vulnerability to lessee activities and establish strategies for resilience.**

   Rising sea levels and storm surge can result in inundation, erosion, and damage to structures that DNR authorizes on state-owned aquatic lands. These impacts risk compromising DNR's ability to provide public use and access, foster water-dependent uses, and ensure environmental protection. To address these risks, DNR's priority responses include:

   - Assess vulnerability of state-owned aquatic lands to sea level rise and storm surge, identify areas of high vulnerability, and identify the type of structures (e.g., docks or nearshore buildings) at highest risk in those areas.
   - When completed, work with lessees in areas of high vulnerability to develop plans for climate resilience, such as adapting existing and future facilities and structures to account for sea-level rise and increased storm events.

2. **Develop strategies to protect and restore aquatic habitats that provide refuge for sensitive species and also support resilience from climate-related impacts.**

   DNR's management of state-owned aquatic land strives to balance public benefits including ensuring environmental protection and utilizing renewable resources. Changing ocean and climate conditions, such as increased temperatures, ocean acidification, sea level rise, and changes to stream flow, threaten the future health of native aquatic habitats and species, and could dramatically alter food webs. Ocean acidification is affecting the early-stage formation of shells of some calcifying organisms (e.g., oysters). In addition, rising temperatures and ocean acidification may increase the threats of invasive species and increase the toxicity of some harmful algal species.[119] To address these risks, DNR's priority responses include:

   - Identify, protect, and restore aquatic habitats that are important for climate resilience, such as eelgrass, kelp, saltmarshes, and areas of climate change refugia.
   - Continue to research the ability of eelgrass and kelp to locally ameliorate ocean acidification in the nearshore environment.
   - Establish one or more reserves to maintain and enhance climate resilience related ecosystem services, such as removal of dissolved inorganic carbon from the surrounding waters, sequestering carbon and nitrogen, increasing local pH, or buffering uplands from storm damages.
   - Seek funding for DNR, other agencies and partners to identify and purchase uplands in anticipation of future landward migration of important habitats, especially adjacent to aquatic reserves and other protected areas. Develop a decision-support tool to identify important habitats for priority investment.
   - Monitor wildstock geoduck, oysters, and other shellfish populations. Identify adaptive management strategies to maintain their health and promote sustainable shellfish harvest and aquaculture practices.

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[116] Spencer, et al. 2019. *Pacific geoduck (Panopea generosa) resilience to natural pH variation.*
[117] Washington State Blue Ribbon Panel on Ocean Acidification (2012): *Ocean Acidification: From Knowledge to Action, Washington State's Strategic Response.*
[118] Moore, et al., 2015. *Present-day and future climate pathways affecting the harmful algal blooms species Alexandrium catenella in Puget Sound, WA, USA.*
[119] Sorte, et al. 2010. *Ocean warming increases threat of invasive species in a marine fouling community*; and Tatters, et al. 2013. *High CO_2 promotes the production of paralytic shellfish poisoning toxins by Alexandrium catenella from Southern California waters.*

3. Accelerate salmon and orca recovery efforts.

Many Pacific salmon populations could be harmed by warming stream temperatures, earlier and increasing winter peak flows, decreasing summer low flows, increasing marine sea surface temperatures, and ocean acidification.[120] Projections indicate that many rivers across the state will more frequently exceed thermal tolerances for adult salmon.[121] Decreasing summertime streamflows are projected to reduce the habitat, health, and survival of Pacific salmon. Flooding and high flows can increase egg and fry mortality, reduce return rates, and reduce the availability of slow-water habitat.[122] In addition, population growth in Washington state can also impact salmon through changes to land use, increased pollution, and other threats to salmon habitat.[123] Salmon are a vital food source for Puget Sound orcas.[124] Declining salmon populations have already negatively affected orcas and these problems are expected to continue until salmon populations rebound.[125] To address these risks, DNR's priority responses include:

- Utilize the full range of DNR programs from "tree to sea" to promote salmon, orca, and environmental stewardship by working across land uses (forestry, agriculture, and urban) and ownership classes (local, state, private, federal) and collaborating with key entities (tribes, state agencies, lead entities, regional fish enhancement groups, local government, and conservation districts). Focus on key watersheds where DNR programs can promote innovation and maximize impact. A pilot project has been initiated in the Snohomish watershed, likely to be followed by projects in additional watersheds in the near future.
- Explore opportunities to integrate protection, restoration, and enhancement of salmon habitat in existing DNR programs, such as aquatic lease management; derelict vessel removal; eelgrass restoration; creosote removal; invasive species removal; urban forestry; forest health projects; and landowner assistance, including Family Forest Fish Passage Program and the Forestry Riparian Easement program.

4. Anticipate and prepare for increases in derelict vessels and structures on state-owned aquatic lands.

DNR's experience administering the derelict vessel and large debris removal programs suggests that increases in heavy rainfall events, storm surge, sea level rise, and riverine peak flows, coupled with increasing popularity of recreational boating and population growth, is likely to increase the number of sinking or damaged vessels needing to be addressed. To address this risk, DNR's priority responses include:

- Accelerate derelict vessel and creosote/large debris removal programs.
- Conduct a derelict vessel waste stream recycling pilot project to improve the cost effectiveness of vessel removal.

5. Update guiding documents to support appropriate responses to changing climate conditions.

DNR's activities are guided by laws, codes, policy documents, strategic plans, and oversight or advisory groups. These provide legal or other

direction that may influence or restrict DNR's ability to respond to changing climate conditions. Updates to guiding documents provide opportunities to integrate climate considerations that support DNR's ability to continue meeting its mission and responsibilities under changing climate conditions. Aquatic Program-related guiding documents that are high priority for integrating climate considerations are:

- Aquatic land policies and procedures.
- Stewardship goals and measures: Ensure environmental stewardship goals and measures that are incorporated into use authorizations consider climate change.
- Contract language and lease templates: Incorporate climate change into contract language and templates for the use of state-owned aquatic land.
- Strategic Plan for Aquatic Resources: Incorporate climate change into DNR's Aquatic Resources Strategic Plan, considering the need for coordination with other regional and statewide efforts.
- Wildstock fishery management plan: Development of harvest plans should consider local and statewide climate impacts.
- Aquatic reserve management plans: Consider the potential impacts of climate change on reserve conservation targets and adapt management actions accordingly.

4 SECTOR-WIDE NEEDS AND OPPORTUNITIES

Coastal managers highlight a number of climate impacts of concern. For marine and nearshore ecosystems, the combined effects of increasing ocean temperature, ocean acidification, and other climate impacts are projected to alter the composition of biological communities, affecting organisms at the bottom of the food chain (e.g., phytoplankton and marine plants) and at the top (e.g., salmon and marine mammals).[126] These effects are being seen today; for example, the precipitous declines of Chinook salmon and Southern Resident Orca populations are blamed, in part, on the effects of these climate change impacts.[127]

Sea level rise and coastal erosion is also threatening nearshore and coastal ecosystems as well as coastal infrastructure. The area of some coastal habitats is projected to increase (e.g., tidal flats and salt marshes), while others are projected to decrease (e.g., estuarine beach, tidal swamp).[128] Coastal infrastructure such as homes, businesses, roads, ports, water delivery systems, and wastewater treatment plants are projected to be threatened by more frequent flood inundation, corrosion, and saltwater intrusion.[129] Together, the combined effects of climate-related impacts creates concerns for coastal resource managers and coastal communities and economies.

There are a number of efforts to address concerns in the marine environment. Investments in addressing ocean acidification include the Washington State Blue Ribbon Panel on Ocean Acidification and the University of Washington's Ocean Acidification Center. The Washington Coastal Marine Advisory Council

[120] Snover, et al. 2013. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report.*
[121] Mantua, et al. 2010. *Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State.*
[122] Mauger, et al. 2015. *State of Knowledge: Climate Change in Puget Sound.*
[123] Spromberg, et al. 2011. *Estimating future declines of wild coho salmon populations resulting from early spawner die-offs in urbanizing watersheds in the Pacific Northwest, USA.*
[124] Hanson, et al. 2010. *Species and stock identification of prey consumed by endangered southern resident killer whales in their summer range.*
[125] Southern Resident Orca Task Force. 2019. *Draft Year 2 Report and Recommendations.*
[126] Mauger, et al. 2015. *State of Knowledge: Climate Change in Puget Sound.*
[127] Southern Resident Orca Task Force. 2019. *Draft Year 2 Report and Recommendations.*
[128] Mauger, et al. 2015. *State of Knowledge: Climate Change in Puget Sound.*
[129] Ibid.

serves as a forum for ocean policy, planning, and management issues on the state's Pacific coast. The Puget Sound Partnership manages a collective effort to restore and protect Puget Sound through a common agenda and coordinated investments in priority actions. The Southern Resident Orca Task Force was convened to prepare recommendations to ensure a healthy and resilient ecosystem that supports a thriving Southern Resident Orca population, protected from extinction.[130] Salmon restoration investments are supporting on-the-ground habitat restoration work that is contributing to climate resilience.

Although Washington's efforts to address coastal and marine threats are encouraging, they also underscore the significant scale of the challenge. Decades of human disturbance have eroded the resilience of the marine ecosystem, and this is now being exacerbated by climate change and ocean acidification impacts. Significant investments and new strategies will be required to prevent further declines.

The built environment represents a significant barrier to coastal and nearshore restoration and a challenge unto itself. Sea level rise will require difficult policy decisions and costly investments regarding protection, accommodation, or relocation of coastal infrastructure while also supporting ecosystem and species needs. On the outer coast, a number of tribes are planning to move their communities to safer locations due to concerns over sea level rise or tsunami risk. Approximately 700 miles (more than 25 percent) of Puget Sound's shoreline is armored,[131] disrupting natural processes and creating barriers to upslope migration of nearshore habitats. Some of this armoring is likely to become ineffective as sea levels rise. Land ownership may also shift as the ordinary high tide boundary migrates upslope and current low-lying areas become permanently submerged.

Natural solutions to coastal armoring, sometimes known as "green infrastructure," "soft armoring," or "living shorelines" offer an alternative to hard armoring. Occasionally, natural solutions are used in combination with other approaches to optimize protection while supporting shoreline ecological functions. Although many of these techniques are well established and demonstrating success, they have not been widely promoted or implemented in Washington. Coastal managers highlight the need for pilot projects, assessment of costs and benefits comparing natural solutions with hard armoring, and further research to identify additional approaches that would be effective along Washington's coastlines. More information for coastal residents is also essential to help them make well-informed decisions.[132]

Some coastal communities in Washington are planning for sea level rise, but many are not. Currently, there is no statewide requirement to consider sea level rise in local plans. This means that coastal development can continue to occur, even when at risk from sea level rise and coastal flooding. The range of probable sea level rise projections for Washington's coastline was updated in 2018,[133] but communities and agencies find it difficult to incorporate these, or any other, projections into planning without additional encouragement and support from the state.

The State could advance statewide policy requirements or incentives to encourage local planning for sea level rise. To support these requirements or incentives, sea level rise projections need to be universally available with technical guidance that supports their use. This could include: (1) identifying an acceptable subset of sea level rise projections for use in planning, risk assessment, project design, and other applications; or, (2) guidelines for projection selection, validation, and use for these contexts. It will also be important to ensure strategies consider disproportionate impacts to residents with lower incomes and that meaningful engagement with these communities takes place to ensure needs are addressed and resources can be directed to these communities.

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[130] Southern Resident Orca Task Force. 2019. *Draft Year 2 Report and Recommendations.*
[131] Washington State Department of Ecology. 2019. http://ecologywa.blogspot.com/2019/08/new-app-shows-softer-side-of-puget-sound.html. Accessed October 20, 2019.
[132] For example: Examples of Puget Sound Soft Shore and Armor Alternative Projects: https://ecologywa.blogspot.com/2019/08/new-app-shows-softer-side-of-puget-sound.html. Accessed October 20, 2019.
[133] Miller, et al. 2018. *Projected Sea Level Rise for Washington State—A 2018 Assessment*.

LANDSLIDES, TSUNAMI, GROUNDWATER, AND THE WASHINGTON GEOLOGICAL SURVEY

1 DNR'S ROLE

DNR is home to the Washington Geological Survey (WGS), whose mission is to "collect, develop, use, distribute, and preserve geologic information to promote the safety, health, and welfare of the citizens of Washington, protect the environment, and support its economy." To achieve this mission, WGS evaluates geologic hazards such as landslides, tsunamis, earthquakes, volcanoes, and abandoned mines and produces hazard maps for use by planners, emergency managers, and others. It maps surface and subsurface geological features such as groundwater resources, aggregate, and mineral resources and geothermal opportunities. It regulates surface mining, oil and gas mining, and reclamation activities. It also provides technical support for environmental and forest protection including environmental cleanups and coastal management.

A central focus of WGS is to provide risk information and improve response and preparedness for geologic hazards such as earthquakes, tsunamis, volcanoes, landslides, and abandoned mines. Recent work by WGS includes tsunami inundation modeling and evacuation maps for high-risk coastal communities, assisting communities with tsunami vertical evacuation structure planning, and LiDAR-based mapping to assess landslide activity and susceptibility.

2 HOW CLIMATE CHANGE AFFECTS DNR'S RESPONSIBILITIES

Climate change is projected to exacerbate the risk of some natural and geologic hazards. The primary hazards affected by climate change are:

DNR PROGRAMS COVERED IN THIS SECTION

- Washington Geological Survey

- Landslides, which can be influenced by more intense heavy rainfall events, especially if preceding rain events create high soil moisture conditions. Coastal bluffs can also be affected by sea level rise and erosion. Areas burned by severe wildfire can also contribute to landslides in the years following fire.[134]
- Flood inundation for coastal and riverine systems, which is projected to increase due to sea level rise, coastal erosion, more winter precipitation as rain rather than snow, higher peak flows, and changes in sediment transport.[135]
- Tsunami inundation, which could increase due to sea level rise.

[134] Mauger, et al. 2015. *State of Knowledge: Climate Change in Puget Sound.*
[135] Ibid.

3 DNR'S PRIORITY RESPONSES

Washington Geological Survey has already started responding to changing climate conditions by modifying its operations in the following ways:

- Integrating climate change considerations (especially heavier rainfall events and wildfire effects) into landslide and debris flow analyses and mapping.
- Integrating sea level rise considerations into tsunami modeling and evacuation planning.

In addition, based on increased understanding of the risks climate change poses to its mission and responsibilities, Washington Geological Survey is pursuing the following strategic opportunities:

1. **Accelerate assessment of water and groundwater resources.**

   A legislatively established role of WGS is to investigate and report on the water supplies of the state.[136] This work complements the efforts of well-established programs within the Department of Ecology, USGS Water Science Center, and others. Changes in precipitation, snowmelt, drought, and water demand in Washington will all impact water availability. Increasing agricultural, domestic, and instream demand for water is already straining current supplies in some basins and there is not currently a detailed statewide inventory of surface and groundwater availability. Future changes in precipitation and snowpack could affect the availability of surface water and groundwater recharge in some areas, affecting food production, drinking water supplies, and industrial water use. To address these risks, WGS's priority responses include:

   - Collect and produce subsurface information related to water availability and resources and assess how climate change is likely to affect these resources, including saltwater intrusion.
   - Initiate studies of subsurface geology and improve water monitoring networks in sensitive or growing areas so that coordinating agencies such as the Department of Ecology, Department of Health, and the U.S. Geological Survey may determine availability.
   - Assess water conservation and water storage opportunities on DNR-managed lands, especially in water constrained basins.
   - Increase resources and staff capacity to support water resource assessments, and work with the Department of Ecology and U.S. Geological Survey to develop data, products, and analyses to support mutual goals.

2. **Improve landslide modeling and inventory mapping.**

   Landslides are the most frequently occurring geologic hazard in Washington. The combination of steep slopes, heavy precipitation, and unfavorable geology create the ideal conditions for deep, shallow, and coastal landslides. Increased heavy rainfall events can lead to an increase in landslide events. Increasing wildfires will remove vegetation that can segue into debris flows with just one heavy rainfall. Landslides are also triggered by erosion of coastal bluffs, which could increase with sea level rise. Landslide susceptibility modeling is critical for the safety of people living in areas at risk of landslides, wildfires, and debris flows. To address these risks, WGS's priority responses include:

   - Improve modeling capabilities for shallow landslides, landslide runout, and debris flows.
   - Enhance landslide susceptibility mapping with improved information for shallow landslides, landslide runout, and debris flow potential.
   - Increase the pace of landslide inventory mapping so that decision-makers can use this information in land-use designations.
   - Develop alternative remote-sensing methods for landslide monitoring to improve the efficiency and reduce the cost of landslide monitoring.
   - Participate on post-fire response teams to provide technical expertise.

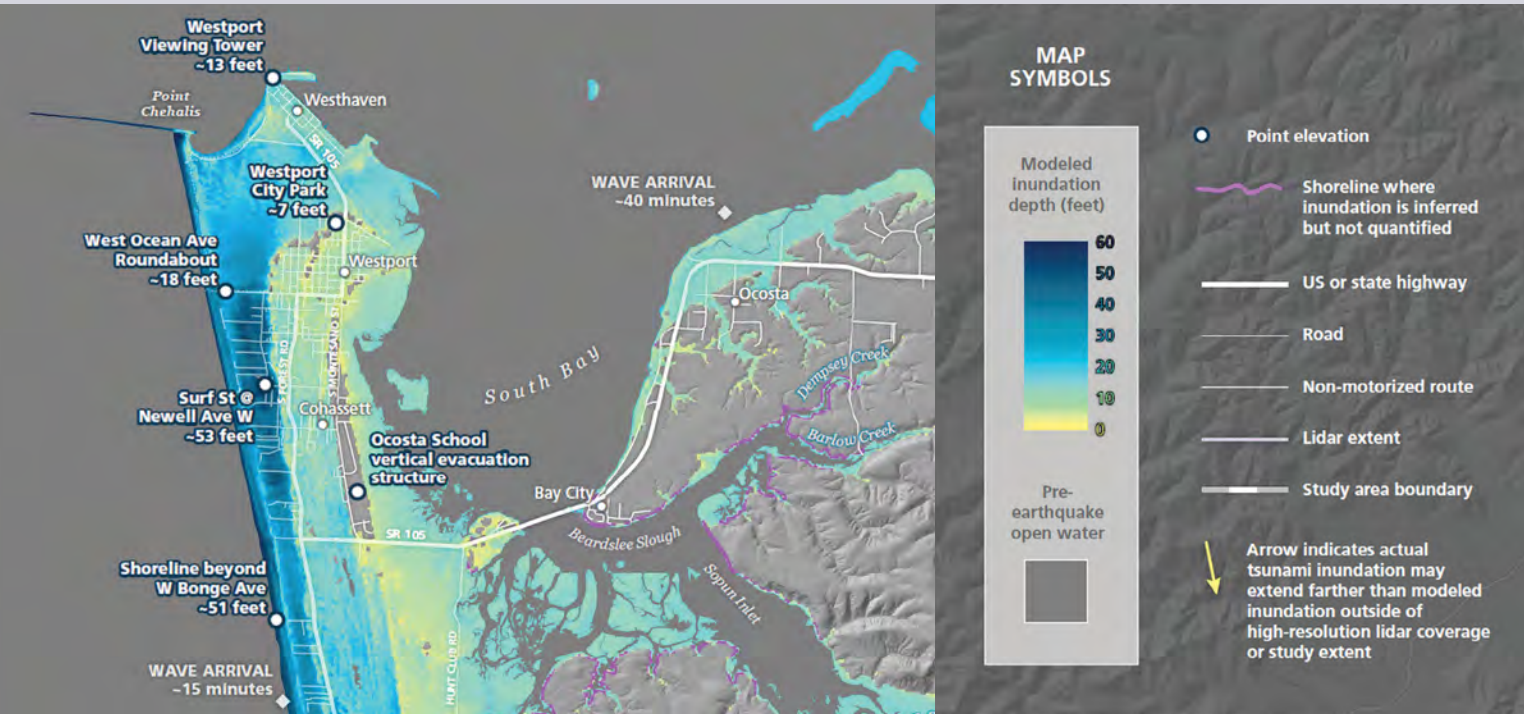
3. **Improve tsunami modeling methods to accommodate rising sea levels, changing erosion patterns, and other climate-influenced impacts.**

   The coast of Washington is at risk from tsunamis of both local and distant origin. A rise in sea

TSUNAMI INUNDATION MODEL IN WESTPORT, WA FOR A MAGNITUDE 9 CASCADIA SUBDUCTION ZONE EARTHQUAKE

This map shows modeled tsunami inundation (blue and green) using modern day sea level and best available LiDAR and bathymetry.

Source: Eungard et al. 2018.



level could significantly change the tsunami risk to coastal communities and increase inundation risk further inland. Tsunami hazard modeling, evacuation route planning, and vertical evacuation structure siting and design are all affected by sea level rise. Incorporating sea level rise projections into future tsunami hazard modeling will extend the useful life of evacuation plans and building designs. WGS's priority responses include:

- Develop faster modeling methods that can adapt to varied sea level inputs, followed by analysis to determine if evacuation routes and staging areas require alteration based on model results.
- Acquire improved bathymetry data and LiDAR quality to reduce model uncertainty.
- Develop improved guidance on tsunami hazard areas to be included in land-use planning decisions (critical areas ordinances) for building critical infrastructure in these hazardous areas. Work with Department of Commerce and local jurisdictions to develop this guidance.

4. **Integrate climate change impacts into development of data, analysis, and risk models.**

   WGS's data, analysis, and models provide essential information for planners, emergency managers, developers, and others. Because decisions using this information have long-term consequences for public safety, the effects of climate change should be clearly integrated. This information includes:

   - Shallow landslide forecast modeling.
   - Tsunami hazard modeling.
   - Incorporating sea level change data and projections into WGS's online Geologic Information Portal.[137]

[136] RCW 43.92.020.
[137] https://www.dnr.wa.gov/geologyportal.



RECREATION

1 DNR'S ROLE

DNR promotes and manages recreation opportunities across the state. These opportunities occur primarily on state trust lands, Natural Resource Conservation Areas, and state-managed aquatic lands. DNR's recreation goal is to provide recreation opportunities that co-exist with the agency's conservation objectives and with revenue generation for trust beneficiaries.

DNR's Recreation Program manages over 160 recreation sites, more than 70 campgrounds, and over 1,200 miles of trail statewide. The diverse range of outdoor experiences that can be found on DNR- managed lands include:

- Boating
- Camping
- Fishing
- Hiking
- Horseback riding
- Hunting
- Mountain biking
- Packstock use
- Target shooting
- Riding off-road vehicles
- Hang gliding and paragliding
- Rock climbing
- Geocaching
- Winter activities like snowshoeing, snowmobiling and cross-country skiing

2 HOW CLIMATE CHANGE AFFECTS DNR'S RESPONSIBILITIES

Risks to DNR's Recreation Program include:

- Damage to recreation facilities due to wildfire, flood, sea level rise, and heavy precipitation. Trails, campgrounds, roads, and other facilities are expected to be damaged more frequently due to increasingly extreme climate-related events.
- Increased risk of human injury or need for evacuation due to increasing extreme climate-related events and falling trees or limbs. As heavy rainfall, flooding, landslides, and wildfire become more frequent in the face of climate change, risk of unexpected conditions rises for outdoor recreationalists. A wildfire, flood, or landslide could close an exit trail or force an unanticipated route change; a heavy storm could increase the length of time of a trip. These events could also trap recreationalists and require emergency evacuations. Additionally, trees weakened by fire, insects, pathogens, or drought are at higher risk of falling or losing limbs, presenting a danger when in heavy use areas.
- Increase in Washington state population. Migration into the state is driving Washington's population growth, which is projected to continue rising another 20 percent by 2040 and surpass 9 million[138] (the state's population on April 1, 2019 was 7.5 million[139]). Migration is dominated by economic and social factors, but the state's relatively mild climate, even with warming conditions, could

enhance existing migration factors.[140] An increase in Washington's population leads to an increased demand for recreation facilities across the state as new residents look for opportunities to enjoy the outdoors.

1 DNR'S PRIORITY RESPONSES

1. **Prepare for potential evacuation or rescue from recreation sites due to extreme climate-related events.**

   Changing climate conditions are expected to increase the frequency and size of wildfires and floods, which can pose a public safety hazard to recreationalists and may require evacuations. For example, in Oregon the 2017 Eagle Creek fire in the Columbia River Gorge required the evacuation of more than 150 hikers. To address these risks, DNR's priority responses include:

   - Develop emergency management options and evacuation procedures during recreation planning efforts in risk-prone areas.
   - Enhance public outreach and signage at trailheads and campgrounds to include information regarding wildfire and storm safety.

2. **Increase management of trees in campgrounds, at trailheads, and on trails.**

   Human fatalities from trees or limbs have occurred in a number of state and local parks. Western hemlock and Pacific silver fir are particularly affected by heat and drought. To address these risks, DNR's priority responses include:

   - Regularly assess health of trees and large vegetation in and around areas of heavy use such as campgrounds and trails.
   - Consider climate-resilient vegetation in recreation planning efforts.

3. **Strengthen resilience to infrastructure damage through climate-informed design of recreation infrastructure.**

   Recreation trails and infrastructure face an increasing risk of damage due to wildfire, heavy rainfall, floods, erosion, washouts, sea level rise, or other climate-related impacts. To address these risks, DNR's priority responses include:

   - Assess climate-related risks to DNR's existing facilities, roads, trails, and other infrastructure. Determine whether infrastructure can remain in place, be hardened, or must be relocated. Develop plans for appropriate post-damage responses.
   - Consider projected future climate conditions in recreation planning and infrastructure design.

4. **Increase the availability of high-quality recreation to all.**

   As Washington's climate remains relatively mild and its population grows and becomes more diverse, demand for recreation opportunities across the state will increase. Additional facilities, locations, and greater diversity of recreation types is needed, as well as planning to increase resilience from climate change impacts, reduce impacts from increasing use, and avoid potential conflicts between user groups. To address these needs, DNR's priority responses include:

   - Develop a recreation strategic plan to guide investments.
   - Seek sustainable funding for maintenance of recreation trails and infrastructure.
   - Assess the recreational carrying capacity of popular landscapes and develop carrying capacity guidelines.
   - Explore with neighboring landowners the ability to improve connectivity over public and private lands.
   - Expand alternative transportation methods to trailheads, such as rideshare or transit. ■

[138] https://www.ofm.wa.gov/sites/default/files/public/dataresearch/pop/stfc/stfc_2019_presentation.pdf. Accessed December 16, 2019.
[139] https://www.ofm.wa.gov/washington-data-research/statewide-data/washington-trends/population-changes/total-population-and-percent-change. Accessed December 16, 2019.
[140] Saperstein, A. 2015. *Climate Change, Migration, and the Puget Sound Region: What We Know and How We Could Learn More.*

VII. INSTITUTIONAL AND SYSTEMS-LEVEL RESPONSES

> *We must continue to innovate and rethink what it means to be public land stewards, with a focus on preserving and protecting our wonderful legacy of productive and beautiful lands and waters."*
>
> **–Hilary S. Franz, Commissioner of Public Lands**

Until recently, nearly every law, policy, regulation, design standard, and activity protocol was established with the assumption that future climate conditions would mirror historical experience. Activities such as road design, coastal development, tree species choices, protected area acquisitions, and sizing facility heating and cooling equipment all assumed that relevant climate-related environmental conditions would generally remain within previously encountered ranges. This assumption is no longer accurate. The high tide mark is no longer stable, but a continually rising level that will not stop rising in 2030 or 2050 or 2100. Similarly, climatic seed zones and suitable habitat areas for plants and animals are projected to continue shifting as local temperatures continue to rise.

Climate change will continue to shift the range of important environmental conditions, suggesting a need to re-evaluate our current paradigm of stationarity and consider adapting to a paradigm that anticipates continually shifting environmental conditions.[141] Unfortunately, our laws, policies, regulations, design standards, and other guidance rarely accommodate dynamic or changing conditions. This requires a new management paradigm—for DNR and for every other agency at the local, state, and federal level.

DNR can take specific steps to move toward a climate-informed management paradigm, but in some cases the needs are greater than a single agency can achieve. This section describes agency-level responses DNR will take under its own authority, and then describes statewide responses that are beyond DNR's ability to implement alone. DNR will seek to coordinate with other agencies and our partners to achieve the needed changes.

DNR AGENCY-LEVEL RESPONSES

DNR's goal is to be a climate-resilient agency, which means being prepared for and adapting to climate-related changes. This is essential if we are to continue fulfilling DNR's mission and responsibilities.

To achieve this goal, climate resilience must be reinforced at the institutional level, in addition to the program-specific responses described above. This requires integrating climate considerations

seamlessly into all relevant aspects of agency guidance and decision-making, from strategic planning and capital investments to day-to-day operations. Climate resilience cannot be a separate add-on, but must be woven into the very fabric of the agency's guiding documents, leadership expectations, and culture. To successfully mainstream climate resilience, DNR commits to integrating climate considerations into key components of the agency, including:

- Authority structures
- Capacity development
- Knowledge
- Motivation and accountability

These components are "building blocks of climate resilience."[142] Below are opportunities that DNR will pursue, using each of these building blocks, to integrate climate resilience at an agency-wide level.

BUILDING BLOCKS OF CLIMATE RESILIENCE

Source: Snover, et al. 2018. *The Building Blocks of Climate Resilience.*

1 INCORPORATE CLIMATE RESILIENCE INTO AUTHORITY STRUCTURES

DNR's leadership and guiding documents such as laws, policies, and procedures must provide clear direction and consistent guidance regarding how climate resilience is incorporated into the agency's mission and operations. Staff must understand what is expected, why it is needed, and that it is supported by leadership throughout the agency. Specific steps include:

- Issue a Commissioner's executive order to provide clear and consistent direction to staff on incorporating climate change considerations in all relevant decisions, policies, procedures, and operations.
- Integrate consideration of changing climate-related environmental conditions, where relevant, into legal, policy, and guidance documents such as RCWs, WACs, board manuals, agency and program policies, procedures, and other guiding documents. Where present, remove erroneous assumptions regarding stationary climate or environmental conditions.
- Complete program-specific climate resilience strategies and implementation plans. Support implementation of resilience responses and conduct periodic updates to incorporate emerging information and changing conditions.
- Clarify DNR program leadership support for resilience actions and decisions in the context of competing goals through Leaders Intent memos, Standard Practice Memoranda, and other program-specific mechanisms.

2 ENHANCE CAPACITY TO ADDRESS CLIMATE RISKS AND RESILIENCE OPPORTUNITIES

Provide staff with technical capacity to effectively assess and implement responses that enhance climate resilience. Actions include:

- Embed climate resilience in applicable planning and analysis efforts; develop guidance for evaluating climate-related risks at project initiation, including

[141] Milly, et al. 2008. *Stationarity Is Dead: Whither Water Management?* Science.
[142] Snover, et al. 2018. *The Building Blocks of Climate Resilience.*

appropriate GHG scenario, time horizon, and level of acceptable risks;[143] develop guidance to incorporate climate resilience in each program activity.

- Embed climate resilience into annual budget development; establish a procedure for assembling budget proposals that includes consideration of GHG implications and future climate conditions; provide guidance and establish metrics and scoring for budgets that includes climate resilience.
- Update or develop decision support and analysis tools, models, systems, and approaches that appropriately incorporate future climate conditions and resilience goals.
- Allocate budget and staff to appropriately support resilience goals and provide multi-year commitments where possible to support continuity of efforts.
- Develop mechanisms for internal coordination regarding climate resilience such as an internal DNR Climate Resilience Implementation Team.
- Engage in forums for coordination with partners that incorporate climate resilience. Examples include the U.S. Climate Alliance, the Pacific Coast Forest MOU with California, Oregon, and British Columbia, and the Washington Interagency Climate Adaptation Network.
- Build climate change-related communications capacity, including trained and knowledgeable staff; a communications strategy that connects impacts, risks, and responses; use of social media; and specific resilience messages designed for specific programs, contexts, and communities.
- Periodically re-evaluate risks, capacity, and response effectiveness. Review and update this *Climate Resilience Plan* at three-year intervals to incorporate new knowledge and update climate risks and responses.

3 INCORPORATE CLIMATE RESILIENCE INTO KNOWLEDGE AND LEARNING STRUCTURES

To successfully address climate resilience at the operational level, many DNR staff members will require additional knowledge and training and the ability to apply climate change information to program operations. Actions to enhance staff knowledge and awareness of changing climate-related environmental conditions and resilience opportunities include:

- Provide access to climate science and other information, and clarify appropriate sources of information for specific purposes. Identify and acquire (or support development of) local and regional climate data necessary to make program-specific decisions. Identify science and data needed to inform decisions and detect trends in each DNR program and at the agency-wide level.
- Integrate climate impacts and resilience information into staff training and hiring processes. These include:
  - Adding a climate resilience module to the onboarding training program.
  - Adding climate resilience guidance to the DNR Employee Handbook.
  - Adding a climate change question to job applicant interview questions when applicable.
  - Developing program-specific modules that incorporate climate considerations into existing training programs.
- Establish climate mentors in each DNR program as program-based points of contact to support incorporation of climate-related topics. Provide training to designated climate mentors and incorporate this responsibility into mentors' job descriptions and Performance and Development Plans.
- Develop mechanisms to support continuous learning about topics relevant to program operations and emerging science on climate impacts and resilience opportunities.

4 INCORPORATE CLIMATE RESILIENCE INTO MOTIVATION AND ACCOUNTABILITY STRUCTURES

DNR's accountability structures clarify what is expected of staff and how decisions will be made regarding budgets, promotions, project initiation, and other components of the agency's operations. Climate resilience should be integrated into these structures. Specific steps include:

- Develop program-specific metrics for climate resilience. Develop monitoring and evaluation protocols and a reporting scorecard for each DNR program.
- Integrate climate resilience expectations where appropriate into job descriptions, work plans, staff Performance and Development Plans, and performance reviews, and clarify staff ability to act without additional permissions.
- Add consideration of climate change impacts to DNR's Core Competencies and incorporate climate resilience into DNR's measures of success.
- Foster an institutional culture that expects and supports consideration of changing climate-related environmental conditions and impacts.

[143] Consider adapting the EcoAdapt Climate Change Adaptation Certification Tool: https://www.cakex.org/sites/default/files/2018EcoAdapt%20CCAC%20Tool%20FINAL_SPREADS.pdf. Accessed November 25, 2019.

STATEWIDE SYSTEMS-LEVEL NEEDS AND OPPORTUNITIES

Achieving climate resilience within DNR requires a set of actions that are beyond the mandate of DNR to implement alone. In this section we identify actions needed by DNR to support informed, coordinated, and proactive responses to climate risks. These actions would also likely benefit the efforts of our partners, including tribes, cities, counties, stakeholders, and other state agencies. DNR will work with our partners, including the Legislature, to advance the following:

1 ESTABLISH AN INTERAGENCY CLIMATE RESILIENCE LEADERSHIP STRUCTURE

There are currently no active state-led efforts for state agencies to jointly develop resilience goals and priorities, coordinate investments, and effectively collaborate and implement across administrative authorities. Consequently, DNR and many other agencies are developing independent—and sometimes inconsistent—responses to climate risks or not responding to critical vulnerabilities. This creates the potential for duplication of efforts, missed opportunities, unfilled needs, conflicting actions, and mal-adaptation.

There are many models for designing an interagency climate resilience structure. California, Maryland, and Rhode Island provide examples that range from staffed offices within the Governor's office to executive multi-agency coordinating councils.[144]

Washington has examples of climate-related interagency coordination such as the State Efficiency and Environmental Performance (SEEP) office, which has dedicated staff and seeks to reduce greenhouse gas emissions and eliminate toxic materials from state agency operations (established by Executive Order 18-01). Washington has sector-specific interagency coordinating bodies such as the Coastal Hazards Resilience Network and the Water Supply Availability Committee. In addition, a voluntary Interagency Climate Adaptation Network (ICAN) was established by interested agency staff, and serves as an effective information-sharing group despite having no mandate or resources to operate. Washington is exploring broader opportunities for statewide governance and funding mechanisms for natural disaster resilience through the Natural Disaster and Resiliency Activities Work Group, led by the Office of the Insurance Commissioner and authorized by the 2019 Legislature under SB5106.

A successful interagency climate resilience structure would support outcomes such as increasing the effectiveness of investments, increasing public confidence in resilience implementation, enabling more nimble adaptive management, and increasing clarity and effectiveness for local jurisdictions. Although the configuration of an interagency climate resilience structure can take many forms, it should have some essential characteristics, including:

- A clear mandate that advances proactive statewide climate resilience across all agencies, all sectors and all communities.
- The authority to coordinate climate resilience priorities and activities across agencies at a high level.
- The ability to establish principles that guide climate resilience efforts across agencies, such as norms for the selection of climate model projections or how to appropriately include consideration of equity in strategies, investments and projects.
- Dedicated staff and resources to support the work.

2 PROVIDE STATE-SUPPORTED CLIMATE IMPACTS PROJECTIONS TO SUPPORT RISK ASSESSMENT, PLANNING, AND REGULATORY SYSTEMS

Washington is fortunate to have some of the most robust climate change impacts information in the country. With support from the Washington State Legislature, the UW Climate Impacts Group produced Washington's first statewide climate change impacts assessment in 2009.[145] The UW Climate Impacts Group published Climate Change Impacts and Adaptation State of Knowledge reports for the state in 2013[146] and for Puget Sound in 2015.[147] Numerous detailed climate and hydrologic projection datasets have been developed by Northwest research groups and federal agencies.[148] Projections for sea level rise and extreme coastal water levels for Washington state were published in 2018 and 2019 under the auspices of the Washington Coastal Resilience Project.[149] Hundreds of studies have quantified climate impacts

on Washington's human and natural systems; ongoing science at Washington's research universities and in state, federal and tribal agencies continually increases this body of knowledge.

Although extensive climate change information is available, many planners, resource managers, and others are unfamiliar with these resources and still face challenges accessing and applying information and data that can support local climate resilience planning and action. Much of the existing information about regional climate impacts is spread throughout numerous reports and websites. The availability of multiple independent climate projection datasets and lack of official guidance for their use increases uncertainty and confusion among planners and regulators over which climate projections are most appropriate to use. When multiple agencies are designing or evaluating a project, this can lead to conflicting assumptions about future conditions (e.g., sea level rise or peak river flows) that can slow project development and permitting, raise costs, or increase the risk of negative outcomes.

To support development of climate resilience, planners, regulators, and resource managers need universal access to current science-based climate impacts projections and additional guidance to support their use and increase consistency in planning and project design. There are three key components to achieving this:

- Ensure continued development and updating of scientifically robust regional and local projections of climate impacts. As noted above, Washington already has robust and locally-specific projections for many climate impacts, including sea level rise and peak river flows. These should be updated regularly to reflect ongoing scientific advances and updated global climate projections, and to provide information about subsequent consequences for local systems. In addition, support of social science and the human dimensions of climate impacts and adaptation should be expanded.
- Ensure universal availability of climate impacts assessments and projections. Washington should develop, maintain, and publicize centralized access to climate information. A single, well-publicized online portal could be developed to deliver Washington-specific climate impacts information and data. This would provide a consistent resource for climate data and would simplify updating projections when new information becomes available.
- Provide guidance on appropriate scenarios for local risk assessment, planning, and design. To improve consistency across independent efforts to build climate resilience, the state could (1) identify the subset of selected scientifically robust climate impact projections that would be acceptable for use in planning, risk assessment, design, etc., or (2) provide guidelines for scenario selection, validation, and use.

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[144] See California Integrated Climate Adaptation and Resiliency Program, Maryland Commission on Climate Change, and Rhode Island Executive Climate Change Coordinating Council.
[145] Climate Impacts Group. 2009. *The Washington Climate Change Impacts Assessment*.
[146] Snover, et al. 2013. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report*.
[147] Mauger, et al. 2015. *State of Knowledge: Climate Change in Puget Sound*.
[148] E.g., http://warm.atmos.washington.edu/2860/, https://climatetoolbox.org/tool/Future-Streamflows.
[149] See http://www.wacoastalnetwork.com/wcrp-documents.html. Miller, et al. 2018. *Projected Sea Level Rise for Washington State—A 2018 Assessment*; and Miller, et al. 2019. *Extreme Coastal Water Level in Washington State: Guidelines to Support Sea Level Rise Planning.*

3 ESTABLISH MECHANISMS FOR FUNDING AND FINANCING RESILIENCE INVESTMENTS

Climate change amplifies problems associated with existing areas of public and private investment that are under-resourced, such as aging water supply and drainage infrastructure, the mismatch between fuels management and fire suppression across our fire-prone landscapes, and the need to address infrastructure in floodplains that are at greater risk of flooding.

To succeed in addressing these needs and making investments sufficient to address infrastructure risks, restore natural systems, and build the social and economic capital of communities, the state will need to achieve multiple benefits with existing resources, realign existing public and private investments, and establish new opportunities and funding mechanisms.

In developing funding and financing mechanisms, the state should consider:

- Priorities for resilience investments. Factors to consider include opportunities for multiple benefits for communities, economies and ecosystems; immediate risks from climate change to health, safety, and livelihoods; long-term cost-effectiveness; and equity and environmental justice.
- Opportunities for innovative public financing. Jurisdictions are exploring a range of innovative public financing mechanisms to meet pressing infrastructure and resilience needs including public banks, infrastructure banks, and green bonds. The state should evaluate these or other opportunities for their potential to lower costs or risk for taxpayers, enable more capital to flow to critical infrastructure, and mitigate pressure on existing public revenue sources.
- Local community needs and equity. Investments in resilience run the risk of continuing or exacerbating existing inequities. In order to address this risk, funding and financing mechanisms should consider how to support local communities in defining success, prioritizing investments, and achieving equity.
- Incentives for climate-resilient investment by private industry. Public funding alone is unlikely to be sufficient to address climate risks across the state. The scale of investment needed means that the private sector must serve as a major source of the capital needed to shift our state toward more resilient infrastructure and communities. The state should identify incentives to align private capital behind statewide resilience goals.

4 SUPPORT AND FACILITATE COMMUNITY-LEVEL RESILIENCE PLANNING AND IMPLEMENTATION

Climate change can pose new and unfamiliar challenges for local communities and can exacerbate existing challenges, including water availability, flooding, excessive heat, wildfire, smoke, and impacts to revenue-producing natural resources. While some resources are available to help communities plan and implement responses to climate change, critical gaps exist. For example, local communities often lack easily accessible climate-related information needed for local decision-making. Funding is often insufficient to support local city- or county-level resilience planning.

DNR has a direct interest in empowering communities to plan for and achieve resilience. Virtually all of the agency's programs involve interaction and collaboration with local communities. DNR's aquatic lands division works closely with local governments during local shoreline master program updates to facilitate water-dependent uses on state-owned aquatic lands; the Washington Geological Survey provides local jurisdictions with information on geologic hazards; and DNR's trust land management generates funds for school construction and other local services in communities throughout the state. In addition, DNR is currently working to advance local resilience planning pilot projects.

Communities must be able to plan for resilience, and in doing so define what success means to the community. In addition, local resilience efforts should involve and empower those in the community who are most affected by climate-related changes or most affected by the proposed or existing actions taken in response to climate impacts.

Examples of how the state could support communities in preparing for projected climate impacts and achieving climate resilience include:

- Establish a grant or funding program to support local resilience planning processes.
- Ensure universal access to current science-based climate impacts projections suited for local use.
- Provide support for technical assistance such as research or facilitation.
- Support development of planning tools such as a menu of local policy options to help communities understand their range of possible actions.
- Provide tools to help communities identify populations with disproportionate impacts.
- Fund local community-based organizations to leverage their trusted networks and conduct outreach to engage members in the community, particularly limited English proficiency individuals or other populations that may face barriers to participation.

5 ENHANCE EDUCATION, OUTREACH, AND ENGAGEMENT ON RESILIENCE NEEDS AND OPPORTUNITIES

Public awareness of climate risks and response options will be necessary to engage communities in identifying and supporting resilience activities. Many agencies, including DNR, are independently developing and providing climate information to stakeholders and the public. However, this information is sometimes difficult to find, inconsistent across agencies, and occasionally not current. In addition, agency communications staff are rarely trained in best practices for climate communications.

A strategic and consistent statewide approach to developing climate communications capacity across state government and providing information would help improve the clarity, credibility, and accessibility of climate and resilience information from state agencies. DNR, other agencies, and the state overall would benefit from enhanced climate communications capacity and expertise, both to support agency staff and to support awareness among the public and stakeholders. This capacity would help DNR and other agencies play a leadership role in communicating about climate risks and resilience opportunities. When developing climate resilience messages, it will be important to ensure they are culturally specific, relevant, and draw on best practices and research from social science.

A model for climate education and engagement exists in the legislatively supported science learning initiative known as "ClimeTime."[150] This initiative provides curricula and funding to support climate science education to teachers and community-based organizations. A similar approach could be developed to support climate science education for state agency staff, sector-based stakeholder organizations, and the general public. ■

[150] https://www.climetime.org/.

VIII. NEAR-TERM IMPLEMENTATION STEPS

Achieving resilience within DNR's programs, across the agency, and among our partners will not occur overnight. Climate resilience will be a continuous effort as climate conditions continue to shift and impacts become more acute. However, there are many actions DNR can take in the near term to promote climate resilience and to position the agency and the state for more extensive action in the future. The following near-term implementation steps are intended to initiate key responses that will position DNR to proactively promote resilience across all aspects of our operations.

INITIATE RESPONSES THAT CAN BE IMPLEMENTED WITHIN DNR'S AUTHORITIES AND RESOURCES

DNR is committed to implementing the program-specific and agency-wide resilience responses identified in this plan. Many responses can be implemented within DNR's existing legal authorities and without additional resources. Some of these can be completed rapidly, while others will require assessment and development. Responses that can be implemented within existing authorities and resources will be initiated in 2020. Completion dates will vary depending on the complexity of the task. To facilitate task initiation:

- DNR leadership will develop and finalize climate resilience performance metrics for incorporation into program deliverables.
- The Commissioner of Public Lands will appoint an internal task force to guide implementation of program-specific and agency-wide responses.

SEEK LEGISLATIVE SUPPORT TO IMPLEMENT RESPONSES REQUIRING ADDITIONAL AUTHORITIES AND RESOURCES

Responses that cannot be completed within existing legal authorities and resources will be proposed in upcoming legislative sessions. Resilience-related requests for the 2020 legislative session include multiple items within DNR's legislative proposals, as well as additional critical near-term requests, both of which are summarized at dnr.wa.gov/climate-change. Key requests include:

- Dedicated funding for wildfire prevention and forest health (HB 2413)
- Urban and community forestry and updates to the Evergreen Communities Act (HB 2768)
- Small forest landowner assistance
- Urban Growth Area prescribed burning
- Utility wildfire prevention task force
- Derelict vessel prevention and removal (HB 2769).

DNR commits to incorporating climate change and resilience responses into future legislative requests.

SUPPORT IMPLEMENTATION OF STATEWIDE SYSTEMS-LEVEL CLIMATE RESILIENCE RESPONSES

Statewide systems-level responses include an interagency climate resilience leadership structure, state-supported climate impact projections, funding and financing mechanisms, community-level resilience planning, and an enhanced state-level climate communications capacity. These are items that DNR and other state agencies need to be successful, but no agency can implement on its own. Legislative support and engagement by a range of others will be needed to implement these responses. To initiate development of these systems-level climate resilience responses, the Legislature could establish a task force to assess needs and opportunities and prepare options for legislative consideration. DNR is committed to working with the Legislature and our partners to advance these activities. ■

APPX i.

ACKNOWLEDGMENTS

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APPX ii.

ACRONYMS

ALEA: Aquatic Lands Enhancement Account

ATNI: Affiliated Tribes of Northwest Indians

C: Centigrade

CIG: Climate Impacts Group

CMER: Cooperative Management, Evaluation and Research Committee

CO_2: Carbon dioxide

CO_2e: Carbon dioxide equivalent

DNR: Department of Natural Resources

ESSB: Engrossed Substitute Senate Bill

EV: Electric Vehicle

F: Fahrenheit

FEMA: Federal Emergency Management Agency

GHG: Greenhouse gas

HB: House Bill

ICAN: Interagency Climate Adaptation Network

IPCC: Intergovernmental Panel on Climate Change

LEED: Leadership in Energy and Environmental Design

MOU: Memorandum of Understanding

MW: Megawatt

NOAA: National Oceanic and Atmospheric Administration

PNW: Pacific Northwest

Ppm: Parts per million

RCP: Representative Concentration Pathway

RCW: Revised Code of Washington

SB: Senate Bill

SEEP: State Efficiency and Environmental Performance

SEPA: State Environmental Policy Act

SUV: Sport Utility Vehicle

USDA: United States Department of Agriculture

USGS: United States Geological Survey

UW: University of Washington

WAC: Washington Administrative Code

WASCLA: Washington State Coalition for Language Access

WDFW: Washington Department of Fish and Wildlife

WGS: Washington Geological Survey

WSU: Washington State University

WUI: Wildland Urban Interface

DEFINITIONS

APPX iii.

The following definitions are drawn from the most recent Assessment Report from the Intergovernmental Panel on Climate Change (IPCC).[151]

- **Adaptation:** The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.
- **Climate:** Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.
- **Climate change:** Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use.
- **Mitigation:** A human intervention to reduce the sources or enhance the sinks of greenhouse gases.
- **Projection:** A projection is a potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Unlike predictions, projections are conditional on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realized.
- **Representative Concentration Pathways (RCPs):** Scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases and aerosols and chemically active gases, as well as land use/land cover (Moss et al., 2008). The word representative signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term pathway emphasizes that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome. **Four RCPs produced from Integrated Assessment Models were selected from the published literature:**
  - **RCP2.6:** One pathway where radiative forcing peaks at approximately 3 W/m2 before 2100 and then declines (the corresponding ECP assuming constant emissions after 2100).
  - **RCP4.5 and RCP6.0:** Two intermediate stabilization pathways in which radiative forcing is stabilized at approximately 4.5 W/m2 and 6.0 W/m2 after 2100 (the corresponding ECPs assuming constant concentrations after 2150).
  - **RCP8.5:** One high pathway for which radiative forcing reaches >8.5 W/m2 by 2100 and continues to rise for some amount of time (the corresponding ECP assuming constant emissions after 2100 and constant concentrations after 2250).
- **Risk:** The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability or likelihood of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur.
- **Vulnerability:** The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

[151] Intergovernmental Panel on Climate Change (IPCC). 2014. *Annex II: Glossary*. In: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

APPX iv.

REFERENCES

A

Alin, S., C. Sabine, R. Feely, A. Sutton, S. Musielewicz, A. Devol, W. Ruef, J. Newton, and J. Mickett. 2016. In: *PSEMP Marine Waters Workgroup. 2016. Puget Sound marine waters: 2015 overview*. S.K. Moore, R. Wold, K. Stark, J. Bos, P. Williams, K. Dzinbal, C. Krembs, and J. Newton (Eds).

Azerrad, J.M., K.A. Divens, M.F. Livingston, M.S. Teske, H.L. Ferguson, and J.L. Davis. 2011. *Management recommendations for Washington's priority habitats: managing shrub-steppe in developing landscapes*. Washington Department of Fish and Wildlife, Olympia, Washington.

B

Barbero, Abatzoglou, Larkin, Kolden, and Stocks. *Climate change presents increased potential for very large fires in the contiguous United States*. International Journal of Wildland Fire. 2015. http://dx.doi.org/10.1071/WF15083.

Bentz B.J., J. Régnière, C.J. Fettig, E.M. Hansen, J.L. Hayes, J.A. Hicke, R.G. Kelsey, J.F. Negrón, S.J. Seybold. 2010. *Climate change and bark beetles of the western United States and Canada: direct and indirect effects*. BioScience. 2010 Sep 1;60(8):602-13.

Bick, C., July 30, 2019. "South Seattle residents want greener neighborhoods—without more gentrification." Crosscut. crosscut.com/2019/07/south-seattle-residents-want-greener-neighborhoods-without-more-gentrification. Accessed November 9, 2019.

C

Chabria, A., T. Luna. Oct 11, 2019. "PG&E power outages bring darkness, stress and debt to California's poor and elderly." Los Angeles Times. www.latimes.com/california/story/2019-10-11/pge-power-outage-darkness-stress-debt-vulnerable. Accessed November 9, 2019.

Checker, Melissa. 2011. *Wiped out by the 'Greenwave': Environmental Gentrification and the Paradoxical Politics of Urban Sustainability*. City & Society, 23:2, pp. 210-229, 2011.

Climate Impacts Group. 2009. *The Washington Climate Change Impacts Assessment*. M. McGuire Elsner, J. Littell, and L. Whitely Binder (eds). Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle, Washington.

D

Donato, D. C., J. Halofsky, M. J. Reilly. 2020. *Corralling a black swan: natural range of variation in a forest landscape driven by rare, extreme events*. Ecological Applications.

E

Eungard, D. W.; Forson, Corina; Walsh, T. J.; Gica, Edison; Arcas, Diego, 2018, Tsunami hazard maps of southwest Washington—Model results from a ~2,500-year Cascadia subduction zone earthquake scenario: Washington Geological Survey Map Series 2018-01, originally published March 2018, 6 sheets, scale 1:48,000, 11 p. text. http://www.dnr.wa.gov/publications/ger_ms2018-01_tsunami_hazard_southwest_washington.zip.

H

Halofsky, J.S., D.R. Conklin, D.C. Donato, J.E. Halofsky, J.B. Kim. 2018. *Climate change, wildfire, and vegetation shifts in a high-inertia forest landscape: Western Washington, USA*. PloS one. 2018 Dec 20;13(12):e0209490.

Halofsky, J.S., D.C. Donato, J.F. Franklin, J.E. Halofsky, D.L. Peterson, B.J. Harvey. 2018. *The nature of the beast: examining climate adaptation options in forests with stand-replacing fire regimes*. Ecosphere. 9(3): e02140.

Hanson, M., R.W. Baird, J.K. Ford, J. Hempelmann-Halos, D.M. Van Doornik, J.R. Candy, C.K. Emmons, G.S. Schorr, B. Gisborne, K.L. Ayres, et al. 2010. *Species and stock identification of prey consumed by endangered southern resident killer whales in their summer range*. Endang. Species Res. 11(1): 69-82.

Haugo, R., C. Zanger, T. DeMeo, C. Ringo, A. Shlisky, K. Blankenship, M. Simpson, K. Mellen-McLean, J. Kertis, M. Stern. 2015. *A new approach to evaluate forest structure restoration needs across Oregon and Washington, USA*. Forest Ecology and Management. 2015 Jan 1;335:37-50.

Haugo, R.D., B.S. Kellogg, C.A. Cansler, C.A. Kolden, K.B. Kemp, J.C. Robertson, K.L. Metlen, N.M. Vaillant, C.M. Restaino. 2019. *The missing fire: quantifying human exclusion of wildfire in Pacific Northwest forests, USA*. Ecosphere. 2019 Apr;10(4):e02702.

I

Intergovernmental Panel on Climate Change (IPCC). 2014: Annex II: Glossary [Mach, K.J., S. Planton, and C. von Stechow (eds.)]. In: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, pp. 117-130.

Intergovernmental Panel on Climate Change (IPCC). 2018: Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)].

International Civil Aviation Organization. 2016. *On board: a sustainable future*. Intl. Civil Aviation Org., Montreal, Quebec.

J

Jantarasami, L. C., R. Novak, R. Delgado, E. Marino, S. McNeeley, C. Narducci, J. Raymond-Yakoubian, L. Singletary, and K. Powys Whyte. 2018: Tribes and Indigenous Peoples. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D. R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 572-603. doi: 10.7930/NCA4.2018.CH15.

K

Knutson, T., et al. 2017. Detection and attribution of climate change. *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. Global Change Research Program, Washington, DC, USA, 114-132. http://dx.doi.org/10.7930/J01834ND.

L

Littell, J.S., E.E. Oneil, D. McKenzie, J. A. Hicke, J. A. Lutz, R. A. Norheim, M. M. Elsner. 2010. *Forest ecosystems, disturbance, and climatic change in Washington State, USA*. Climatic change. 2010 Sep 1;102(1-2):129-58.

M

Mach, K.J., C. M. Kraan, M. Hino, A. R. Siders, E.M. Johnston, and C. B. Field. 2019. *Managed retreat through voluntary buyouts of flood-prone properties*. Science Advances, 5(10), p.eaax8995.

Mantua N., I. Tohver, A. Hamlet. 2010. *Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State*. Climatic Change. DOI: 10.1007/s10584>010>9845>2.

Mauger, G.S., J.H. Casola, H.A. Morgan, R.L. Strauch, B. Jones, B. Curry, T.M. Busch Isaksen, L. Whitely Binder, M.B. Krosby, and A.K. Snover. 2015. *State of Knowledge: Climate Change in Puget Sound*. Report prepared for the Puget Sound Partnership and the National Oceanic and Atmospheric Administration. Climate Impacts Group, University of Washington, Seattle. doi:10.7915/CIG93777D.

May C., C. Luce, J. Casola, M. Chang, J. Cuhaciyan, M. Dalton, S. Lowe, G. Morishima, P. Mote, A. Petersen, G. Roesch-McNally, and E. York. 2018: Northwest. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lew¬is, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1036-1100. doi: 10.7930/NCA4.2018.CH24.

McLain, et al. *2015 Drought and Agriculture*. Washington State Department of Agriculture Olympia, Washington. 2017. AGR PUB 104-495 (N/2/17).

Miller, I.M., H. Morgan, G. Mauger, T. Newton, R. Weldon, D. Schmidt, M. Welch, E. Grossman. 2018. *Projected Sea Level Rise for Washington State-A 2018 Assessment*. A collaboration of Washington Sea Grant, University of Washington Climate Impacts Group, University of Oregon, University of Washington, and US Geological Survey. Prepared for the Washington Coastal Resilience Project.

Miller, I.M., Z. Yang, N. VanArendonk, E. Grossman, G.S. Mauger, H. Morgan. 2019. *Extreme Coastal Water Level in Washington State: Guidelines to Support Sea Level Rise Planning*. A collaboration of Washington Sea Grant, University of Washington Climate Impacts Group, Oregon State University, University of Washington, Pacific Northwest National Laboratory, and U.S. Geological Survey. Prepared for the Washington Coastal Resilience Project.

Milly, P.C.D., Julio Betancourt, Malin Falkenmark, Robert M. Hirsch, Zbigniew W. Kundzewicz, Dennis P. Lettenmaier, Ronald J. Stouffer. 2008. *Stationarity Is Dead: Whither Water Management?* Science. Feb 2008. 573-574.

Mohnot, S., J. Bishop, and A. Sanchez. 2019. *Making equity real in climate adaptation and community resilience policies and programs: a guidebook*. The Greenlining Institute.

Moore, S.K. et al., 2015. *Present-day and future climate pathways affecting the harmful algal blooms species Alexandrium catenella in Puget Sound, WA, USA*. Harmful Algae, 48, 1-11.

Mote et al. 2008. *Has spring snowpack declined in the Washington Cascades?*, Hydrol. Earth Syst. https://doi.org/10.5194/hess-12-193-2008, 2008.

N

National Fish, Wildlife and Plants Climate Adaptation Partnership. 2012. *National Fish, Wildlife and Plants Climate Adaptation Strategy*. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, National Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service. Washington, DC.

NOAA. 2019. *State of the Climate: Global Climate Report for December 2018*. NOAA National Centers for Environmental Information. Published online January 2019. https://www.ncdc.noaa.gov/sotc/global/201812. Accessed October 2, 2019.

NOAA. Monthly Average Mauna Loa CO_2. December 2019 = 411.76 ppm. https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html. Accessed January 23, 2020.

Northwest Area Coordination Center. *Significant Incident Summary Spreadsheet for GACC Incidents*. [GACC = Geographic Area Coordination Center]. Incidents involving 100+ acres or an IMT Type of 1 or 2. Report executed November 26, 2019.

Northwest Indian Fish Commission. 2016. *Climate Change and Our Natural Resources. A Report from the Treaty Tribes in Western Washington*.

Norton-Smith, Kathryn; Kathy Lynn, Karletta Chief, Karen Cozzetto, Jamie Donatuto, Margaret Hiza Redsteer, Linda E. Kruger, Julie Maldonado, Carson Viles, Kyle P. Whyte. 2016. *Climate change and indigenous peoples: a synthesis of current impacts and experiences*. Gen. Tech. Rep. PNW-GTR-944. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

R

Raven, J., K. Caldeira, H. Elderfield, O. Hoegh-Guldberg, P.S. Liss, U. Riebesell, J. Sheperd, C. Turley, and A. Watson. 2005. *Ocean Acidification due to Increasing Atmospheric Carbon Dioxide*. Royal Society Policy Document.

Roop, H.A., G.S. Mauger, H. Morgan, A.K. Snover, and M. Krosby. 2020. *Shifting Snowlines and Shorelines: The Intergovernmental Panel on Climate Change's Special Report on the Ocean and Cryosphere and Implications for Washington State*. Briefing paper prepared by the Climate Impacts Group, University of Washington, Seattle. DOI: doi.org/10.6069/KTVN-WY66.

S

Saperstein, A. 2015. *Climate Change, Migration, and the Puget Sound Region: What We Know and How We Could Learn More*. Report prepared for the University of Washington Climate Impacts Group. The Daniel J. Evans School of Public Policy and Governance, University of Washington, Seattle.

Short, Karen C. 2015. *Spatial wildfire occurrence data for the United States*, 1992-2013 [FPA_FOD_20150323]. 3rd Edition. Fort Collins, CO: Forest Service Research Data Archive.

Snover, A.K, G.S. Mauger, L.C. Whitely Binder, M. Krosby, and I. Tohver. 2013. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers*. State of Knowledge Report prepared for the Washington State Department of Ecology. Climate Impacts Group, University of Washington, Seattle.

Snover, A.K., H.A. Roop, and M. Krosby. 2018. *The Building Blocks of Climate Resilience*. UW Climate Impacts Group working paper.

Snover, A.K., C.L. Raymond, H.A. Roop, H. Morgan. 2019. *No Time to Waste. The Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C and Implications for Washington State*. Briefing paper prepared by the Climate Impacts Group, University of Washington, Seattle. Updated February 2019.

Sorte, C. J. B., S. L. Williams, and R. A. Zerebecki. 2010. *Ocean warming increases threat of invasive species in a marine fouling community*. Ecology 91:2198-2204.

Southern Resident Orca Task Force. 2019. *Draft Year 2 Report and Recommendations*. October 2019.

Spencer, L. et al. 2019. *Pacific geoduck (Panopea generosa) resilience to natural pH variation*. Comparative Biochemistry and Physiology Part D: Genomics and Proteomics. 30, 91-101.

Spies, T.A., P.F. Hessburg, C.N. Skinner, K.J. Puettmann, M.J. Reilly, R.J. Davis, J.A. Kertis, J.W. Long, D.C. Shaw. 2018. *Old growth, disturbance, forest succession, and management in the area of the Northwest Forest Plan*. In: T.A. Spies, P.A. Stine, R. Gravenmier, J.W. Long, M.J. Reilly, tech. coords. 2018. Synthesis of science to inform land management within the Northwest Forest Plan area. Gen. Tech. Rep. PNW-GTR-966. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station: 95-243. 2018;966:95-243.

Spromberg, J. A., N.L. Scholz. 2011. *Estimating future declines of wild coho salmon populations resulting from early spawner die-offs in urbanizing watersheds in the Pacific Northwest, USA*. Integrated Environmental Assessment and Management, 7(4), 648-656.

Stults, M. and S.C. Woodruff. 2017. *Looking under the hood of local adaptation plans: shedding light on the actions prioritized to build local resilience to climate change*. Mitig Adapt Strateg Glob Change. 22: 1249. https://doi.org/10.1007/s11027-016-9725-9.

T

Tatters A.O., L.J. Flewelling, F. Fu, A.A. Granholm, D.A. Hutchins. 2013. *High CO_2 promotes the production of paralytic shellfish poisoning toxins by Alexandrium catenella from Southern California waters*. Harmful Algae, 30, pp. 37-43.

U

U.S. Forest Service. 2015. *The rising cost of wildfire operations: effects on the Forest Service's non-fire work*. https://www.fs.usda.gov/sites/default/files/2015-Fire-Budget-Report.pdf. Accessed January 21, 2020.

United States Department of Agriculture. 2016. *Narrative Timeline of the Pacific Northwest 2015 Fire Season*.

Urban Sustainability Directors Network. 2017. *Guide to Equitable, Community-Driven Climate Preparedness Planning*. https://www.usdn.org/uploads/cms/documents/usdn_guide_to_equitable_community-driven_climate_preparedness-_high_res.pdf. January 5, 2020.

UW Climate Impacts Group, UW Department of Environmental and Occupational Health Sciences, Front and Centered and Urban@UW. 2018. *An Unfair Share: Exploring the disproportionate risks from climate change facing Washington state communities*. A report prepared for Seattle Foundation. University of Washington, Seattle.

V

Van de Waal, D. B., T. Eberlein, U. John, S. Wohlrab, and B. Rost. 2014. *Impact of elevated pCO_2 on paralytic shellfish poisoning toxin content and composition in Alexandrium tamarense*. Toxicon: official journal of the International Society on Toxinology 78, 58-67 (2014).

W

Warner, M. D., C. F. Mass, and E. P. Salathé. 2015: *Changes in winter atmospheric rivers along the North American west coast in CMIP5 climate models*. J. Hydrometeor., 16, 118-128, https://doi.org/10.1175/JHM-D-14-0080.1.

Washington Department of Fish and Wildlife. *Drought Response 2015*. October 2016. Contract 15-04107_C1600061.

Washington Department of Fish and Wildlife. 2019. *State Listed Species*. Revised June 2019. https://wdfw.wa.gov/sites/default/files/2019-06/threatened%20and%20endangered%20species%20list.pdf

Washington State Blue Ribbon Panel on Ocean Acidification. 2012. *Ocean Acidification: From Knowledge to Action, Washington State's Strategic Response*. H. Adelsman and L. Whitely Binder (eds). Washington Department of Ecology, Olympia, Washington. Publication no. 12-01-015.

Washington State Department of Ecology. 2012. *Preparing for a Changing Climate: Washington State's Integrated Climate Response Strategy*. Publication No. 12-01-004.

Washington State Department of Ecology. 2016. *2015 Drought Response: Summary Report*. Publication no. 16-11-001.

Washington State Department of Ecology. 2019. *Reducing greenhouse gas emissions in Washington State government*. Publ. 18-02-030. Wash. Dep. Ecol., Olympia.

Washington State Department of Natural Resources. 2017. *20-Year Forest Health Strategic Plan*. Washington State Department of Natural Resources.

Washington State Department of Natural Resources. 2018. *2018 Annual Report*.

Washington State Department of Natural Resources. 2018. *A Strategy to Restore Forest Health on State Lands in Eastern Washington*. https://www.dnr.wa.gov/publications/rp_fh_state_lands_fh_strategy_2018.pdf?3t9q005

Washington State Department of Natural Resources. 2018. *State of Washington Natural Heritage Plan 2018*. Olympia, WA.

Washington State Department of Natural Resources. 2019. *DNR State Lands Report to the Board of Natural Resources*. Slide Presentation. June 4, 2019. https://www.dnr.wa.gov/publications/em_bc_bnr_ssl_060719.pdf?ywvwnp. Accessed November 8, 2019.

Washington State Department of Natural Resources. 2019. *Final State Trust Lands Habitat Conservation Plan Amendment. Marbled Murrelet Long-term Conservation Strategy*. September 2019.

Washington State Department of Natural Resources. 2019. *Washington State Wildland Fire Protection 10-Year Strategic Plan: Solutions for a Prepared, Safe, Resilient Washington*. Washington State Department of Natural Resources.

Whitely Binder, L., H. Morgan, and D. Siemann. 2017. *Preparing Washington State Parks for Climate Impacts: A Climate Change Vulnerability Assessment for Washington State Parks*. A collaboration of the Washington State Parks and Recreation Commission and the University of Washington Climate Impacts Group. Seattle, WA. https://doi.org/10.7915/CIG6B27QV.

Woodruff, S., and M. Stults. *Numerous strategies but limited implementation guidance in US local adaptation plans*. Nature Clim Change 6, 796-802 (2016). https://doi.org/10.1038/nclimate3012.

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