WASHINGTON STATE DEPARTMENT OF
NATURAL RESOURCES

Assessment of Climate Change-Related Risks to DNR's Mission, Responsibilities and Operations, 2014-2016 Summary of Results

Climate change poses significant threats to the natural resources that are central to DNR's mission and responsibilities. To address these threats, DNR conducted an assessment of climate change-related risks to its mission, responsibilities and operations across most of its major programs. This memo provides a summary of the climate change-related risks identified through DNR's climate risk assessment.

OBSERVED AND PROJECTED CLIMATE IMPACTS

Washington State is already experiencing impacts from a changing climate. The Pacific Northwest warmed about +1.3°F during the past century (1895-2011).[1] Globally, atmospheric levels of greenhouse gases have risen to levels unprecedented over at least the last 800,000 years and this has contributed to long-term warming, a lengthening of the frost-free season, rising sea levels, increased ocean acidity, decreased glacial area and snowpack and earlier peak streamflows in many rivers.[2] Globally, 2014, 2015 and 2016 each set successive records for warmest average annual temperature. The high temperatures in 2015 contributed to Washington's record drought and the state's worst fire season in recorded history.

Current trends in climate change impacts and ocean conditions are expected to continue or accelerate as a result of continued greenhouse gas emissions. According to the University of Washington Climate Impacts Group,[3] projected climate-related changes prior to mid-century (2050) are largely inevitable, driven by the warming that is already "in the pipeline" due to past emissions of greenhouse gases. The following are projected changes in key Pacific Northwest climate and ocean variables.

- *Higher average annual temperature:* Warming of +4.3°F (range: +2.0 to +6.7°F) for a low greenhouse gas scenario or +5.8°F (range: +3.1 to +8.5°F) for a high greenhouse gas scenario by the 2050s, compared to 1950-1999.
- *More frequent heavy precipitation:* 13% more days (±7%) with more than one inch of rain by the 2050s for a high greenhouse gas scenario, relative to 1971-2000.
- *Less spring snow:* 38-46% lower April 1 snowpack in Washington State by the 2040s for a low and a medium greenhouse gas scenario, relative to 1916-2006.

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[1] Kunkel, K. E. et al., 2013. Monitoring and understanding trends in extreme storms: State of knowledge. Bulletin of the American Meteorological Society, 94(4), 499-514. Available from: https://dspace.mit.edu/openaccess-disseminate/1721.1/81287.

[2] Snover, et al. 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.

[3] *Ibid*.

- *Higher sea levels:* +1-19 inches higher sea levels by 2050, and +4-56 inches higher sea levels by 2100 for low to high greenhouse gas scenarios, relative to 2000. Local (relative) sea level rise will vary by location across the Puget Sound and along the outer coast.
- *Increasing ocean acidity:* +38-41% for a low greenhouse gas scenario and +100-109% for a high greenhouse gas scenario by 2100, relative to 1986-2005.[4]

ASSESSMENT PROCESS

Between 2014 and 2016, DNR leadership and staff worked with nine climate and natural resource experts from UW, WSU and NOAA to conduct an assessment of climate risks to major resource divisions and programs at DNR including Forest Resources, Forest Health and Wildfire; Aquatic Resources; Agriculture, Rangeland and Water; Washington Geological Survey; and Natural Heritage and Natural Areas programs. To evaluate climate risks, we considered the *likelihood* that climate change could affect DNR's mission, responsibilities or operations, and if it did, the *significance* of the consequences. Activities that were more likely to be affected by climate change or would have significant consequences to our mission or responsibilities if they did occur, were rated as higher risk.

CLIMATE RISKS

Forest Management, Forest Health, and Wildfire Suppression

Climate change is projected to continue to increase temperatures, lengthen the warm dry season, and increase the intensity of heavy rain events. These changes are projected to cause more winter rain, reduce snowpack, reduce soil moisture, increase the frequency and severity of wildfire, and increase the frequency of landslides. Some harmful insect populations and diseases are expected to increase due to climate change, and others are not.

Key Climate Risks to DNR

- **Forest Resources:** Timber production may be negatively affected by increased disturbance and prolonged moisture stress in some locations. Increased disturbance will likely affect critical habitats for forest dependent species and may challenge the existing strategies that support species recovery. Increased landslide risk may result from heavier rainfall and more rain in winter, potentially threatening public safety, damaging public resources such as fish and water, and causing the loss of productive timber lands. Seed diversity and supply may be insufficient to support reforestation needs. The financial viability of dry forests in eastern Washington is expected to become more challenging due to reduced productivity. Reforestation of some dry forest areas may no longer be ecologically viable due to low moisture levels.
- **Forest Roads:** Stream crossing design on non-fish bearing streams may be affected by projected increases in peak flows and sediment transport, and the frequency of road damage could increase due to additional landslides. (Stream crossings over fish-bearing streams on DNR-managed lands have already been upgraded to support fish passage and increased flows.)
- **Forest Health:** Forest health treatment needs exceed the pace and scale possible with current resources. Tree mortality will likely increase due to interactions between reduced soil moisture, pests, and pathogens, especially in eastern Washington.
- **Wildfire:** Large fires are projected to become more frequent and the fire season is likely to start earlier and last longer, requiring increased resources over a longer period. Increased wildfire

[4] *Ibid.*

activity is expected to increase the risk to wildland firefighters, communities, infrastructure and natural resources across the state.

Aquatic Resources

In the marine environment, climate change is projected to raise sea levels, increase sea surface temperature, and exacerbate periodic coastal flooding from storm surge, 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, and increase winter flows.

Key Climate Risks and Opportunities for DNR

- **Relative sea level rise** varies across the Puget Sound and along the Washington coast. Existing data and related sea level rise forecasts may not provide sufficient spatial or temporal resolution to make parcel-scale land use management decisions.
- **Existing Use Authorizations** (lease contracts) don't allow DNR to change requirements to accommodate increasing risk from sea level rise and other climate impacts. Fixed items such as docks, wharves, and nearshore buildings may be especially at risk from sea level rise and increased wave and storm surge reach on marine coasts; or from higher peak stream flows on the banks of rivers and streams.
- **Erosion and lateral channel migration** is projected to increase due to higher peak flows. High risk items are primarily structures that could be damaged by flooding, high energy flows, erosion, or channel migration.
- **Geoduck** survival, reproduction, and recruitment may be negatively affected by ocean acidification and other changing ocean conditions. If the frequency and duration of harmful algal blooms increases throughout Puget Sound, the geoduck fishery may experience more closures due to biotoxins. However, more information is needed to quantify potential impacts.
- **Aquatic Reserves and eelgrass beds** are biodiversity hotspots, but are vulnerable to loss due to sea level rise, ocean acidification, and other climate impacts. More information is needed to determine potential impacts.
- **Blue Carbon** (aquatic-based carbon sequestration) is an opportunity because vegetated coastal ecosystems and deeper basins may sequester significant amounts of CO_2. However, sediment disturbance may release significant amounts of CO_2 into the atmosphere. More research and supporting data is needed to determine how to consider and manage blue carbon in the marine environment.

Agriculture, Grazing land and Water

Reduced snowpack and higher rates of evaporation could cause increased water right curtailments for junior water right holders that would affect irrigated agriculture. Changes in precipitation patterns and extended dry periods could affect dryland agriculture and rangeland. Increased wildfires could cause vegetation losses to agriculture and grazing land and could destroy cattle fencing that is costly to replace. However, warmer temperatures and water reductions outside the state could make Washington agricultural lands more valuable for some crops, especially wine grapes, where sufficient water is available.

Key Climate Risks to DNR

- **Water reductions**: Low-elevation mixed rain-snow basins are at greatest risk of curtailment, especially in late summer. In eastern Washington, rain fed agriculture has greater risk due to uncertainty regarding projected precipitation amounts and patterns. DNR relies heavily on groundwater in some basins where it is projected to become increasingly scarce, making the search for substitute sources or water conservation efforts more urgent.

- **Wildfire damage**: Range fires can burn cattle fencing that is not cost effective to replace and can make grazing land unusable until forage regenerates. High severity fires can incinerate much of the vegetation, including the natural seedbank required for revegetation. Loss of vegetation can lead to floods, landslides and debris flows during precipitation events, harming public safety and water quality in streams.
- **At-risk Species and Shrub Steppe Habitat**: Eastern Washington harbors many rare and imperiled species including seven Threatened and Endangered species and at least 40 species closely associated with shrub-steppe habitat. These species tend to be vulnerable to climate change impacts and have the potential to reduce trust revenues by restricting uses of DNR-managed lands. Management to protect some species already restricts water usage in some areas. Grazing lands often overlap with shrub steppe and in some cases are degraded by overgrazing, which can harm forage quality, ecosystem health and key habitat areas for multiple years. Increased fire and invasive cheatgrass are also projected to further degrade shrub steppe habitat.
- **Crop and Livestock Production**: Through the 2030s, most crops in Washington are projected to increase yields due to warmer temperatures and CO_2 fertilization effect, assuming sufficient water remains available. Of crops studied to-date, only corn is projected to decrease yield. Irrigation water volume is projected to remain within historical ranges; however, some basins may experience increased frequency of low water years (e.g. Yakima's water short years are projected to increase from 14% historically to 31% by the 2040s).

Washington Geological Survey

Less snow and more rain in winter combined with more intense heavy downpours (extreme storms or "atmospheric rivers") may increase landslide occurrence. Sea level rise could contribute to higher inundation levels during a tsunami.

Geologic Hazards Most Affected by Climate Change

- **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.
- **Tsunami inundation**, which would increase due to sea level rise and could be exacerbated by other climate-influenced dynamics.
- **Flood inundation** for coastal and riverine systems**,** which would be exacerbated by sea level rise, coastal erosion, more intense heavy rains, declining snowpack, and changes in landslide risk and sediment transport.

Natural Heritage and Natural Areas Programs

Warmer temperatures may cause shifts in species distributions, changes in high elevation ecology, altered hydrologic regimes and reduced summer soil moisture and summer streamflow. Increased wildfire frequency and extent could result in the loss of priority species and ecosystems in protected areas. Non-native, invasive species could benefit from changes in climate and associated increases in disturbance, allowing them to outcompete native species (both rare and common), alter ecosystem processes, and negatively impact intact, functioning ecosystems. In coastal and marine ecosystems, priority features and natural areas could be affected by sea level rise, ocean acidification, reduced freshwater inputs in summer, and altered water chemistry.

Key Climate Risks for Terrestrial and Freshwater Systems

- **Shifts in species ranges** are generally projected to cause northward and/or upslope shifts in species distributions, but will ultimately vary by species. These shifts may result in range contractions or expansions for some species within the state, and also to new species moving into the state from neighboring areas.
- **Reduced snowpack** is projected to cause changes in high elevation ecology, altered hydrologic regimes and reduced summer soil moisture and summer streamflow. Alpine, subalpine, riverine and riparian ecosystems and obligates are most at risk.
- **Increased wildfire** frequency and extent could result in the consumption and loss of priority species and ecosystems in protected areas affected by fire.
- **Increased presence and abundance of non-native, invasive species.** Non-native, invasive species can be better adapted to the new climate conditions than the native species that are adapted to the historic climatic conditions. As a result, non-native, invasive species may thrive at the expense of native species in some cases.
- **Dis-assembly of ecological communities.** Changes in phenology (i.e., the timing of biological events), altered species interactions, and non-uniform responses by individual species to climate impacts may lead to the emergence of novel ecological communities.
- **Precipitation changes,** including drier summers and wetter winters, reduced snowpack, and more intense heavy rains. This could lead to species range contractions or extirpation in some locations and expansion in others.

Key Climate Risks for Coastal and Marine Ecosystems

- **Sea level rise** is projected to eliminate some coastal wetlands and other nearshore habitats, alter their composition or shift them landward.
- **Ocean acidification** is expected to reduce the potential persistence of key ecosystem components, especially shell-forming organisms such as oysters, clams, mussels, pteropods, and phyto- and zooplankton, and species that depend on them.
- **Reduced freshwater inputs during summer** could raise salinity in estuaries and reduce the potential persistence of key ecosystem components.
- **Increased winter precipitation and extreme storms** could lead to increased freshwater inputs and altered water chemistry (e.g., decreased salinity) as well as increased river flooding, which could lead to increased sediment inputs.

EXPERT COUNCIL ON CLIMATE & ENVIRONMENTAL CHANGE

- **Amy Snover** (Co-Chair): University of Washington. Director, UW Climate Impacts Group; Assistant Dean for Applied Research, College of the Environment; University Director of the Northwest Climate Science Center; Affiliate Associate Professor, School of Marine and Environmental Affairs.
- **Jerry Franklin** (Co-Chair): University of Washington. Professor of Ecosystem Analysis, School of Environmental and Forest Sciences, College of the Environment.
- **Jon Bakker**: University of Washington. David R. M. Scott Associate Professor, School of Environmental and Forest Sciences, College of the Environment.
- **Tim Beechie**: NOAA Fisheries. Supervisory Research Fish Biologist, Northwest Fisheries Science Center; Leader, Ecosystem Processes Research Team, Watershed Program.
- **Terrie Klinger**: University of Washington. Director, School of Marine and Environmental Affairs; Co-Director, Washington Ocean Acidification Center; Stan and Alta Barer Endowed Professor in Sustainability Science in Honor of Dr. Edward L. Miles.
- **Meade Krosby**: University of Washington. Senior Research Scientist, Climate Impacts Group; University Deputy Director, Northwest Climate Science Center.
- **Chad Kruger**: Washington State University. Director, Center for Sustaining Agriculture & Natural Resources; Director, Northwestern Washington Research & Extension Center; Director, Puyallup Research & Extension Center.
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- **Jonathan Yoder**: Washington State University. Professor, School of Economic Sciences; Director, State of Washington Water Research Center.

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