

Ecological Drought in the Northwest United States

Challenges and opportunities for management of diverse landscapes

Northwest Climate Science Center Workshop
February 7, 2017
Portland, OR

February 9, 2017
Boise, ID

The Department of the Interior Climate Science Centers (CSCs) and their managing organization, the National Climate Change and Wildlife Science Center at the U.S. Geological Survey, have chosen the emerging climate science field of Ecological Drought as a research focus area. This workshop is part of a series of meetings at each of the nation's eight CSCs aimed at collating our existing knowledge of the ecological impacts, resistance, and recovery from drought. The eight CSCs provide a fantastic opportunity to compare the ecological effects of drought, related research activities, and management options at different regions, spatial scales, and biomes.

Ecological drought presents challenges and opportunities in the Northwest

Ecological drought is a deficit in water supplies that causes impacts to the ecosystems and human communities that depend on them. Within the Northwest United States, resource managers are challenged with conserving diverse landscapes, including those that are dependent on seasonal water supplies (e.g., the Olympic Rainforest), as well as some of the driest regions in the country (e.g. the Great Basin Desert). As climate change influences temperature, precipitation, and circulation patterns within the region, drought conditions may become more prevalent across the region, further stressing the ability of managers to conserve or restore these unique ecosystems. However, there are also many opportunities for the Northwest to lead the way with cutting-edge drought research and resource management.

Diverse landscapes and topography contribute to a unique climate

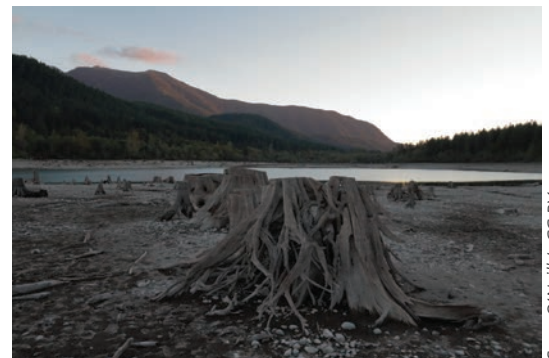
The Northwest United States conjures visions of rainy weather, verdant temperate forests with ferns and mosses, and beautiful rocky shorelines. Although this image is accurate for coastal Oregon and Washington, a series of mountain ranges longitudinally divide this region, restricting maritime moisture from penetrating inland. The result is very arid conditions and landscapes in eastern Oregon and Washington, Idaho and western Montana. The complex topography of mountain ranges, river valleys, steppes and plains interact with weather patterns to create ecosystems that range from rainforests to deserts. Ecosystem management must span this geographic and ecotype spectrum as well.

Climate change is changing drought in the Northwest

Climate change is already bringing about changes in the form and timing of precipitation, duration of snow pack, timing of spring thaw, and amount of soil moisture. These changes are in turn affecting the frequency, size, and severity of forest disturbances like wildfires, insect outbreaks, and floods— all of which have been increasing and are projected to increase further in the Northwest. Because current drought management strategies will likely be inadequate for addressing these more severe droughts, new approaches are essential. Unprecedented dry conditions along the Olympic Peninsula have resulted in forest fires occurring in places where they have never been recorded before. To the east, rangeland fires have increased, exacerbated by the invasion of cheatgrass (*Bromus tectorum*), an annual grass species that thrives in sagebrush habitats. More frequent, bigger, hotter fires lead to increased soil erosion, pest introduction, and flooding due to greater runoff. In order to mitigate these changes, innovations in drought management must consider the diversity of the region.



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Oregon Dept. of Forestry

Managing for wetter, warmer winters and drier, hotter summers

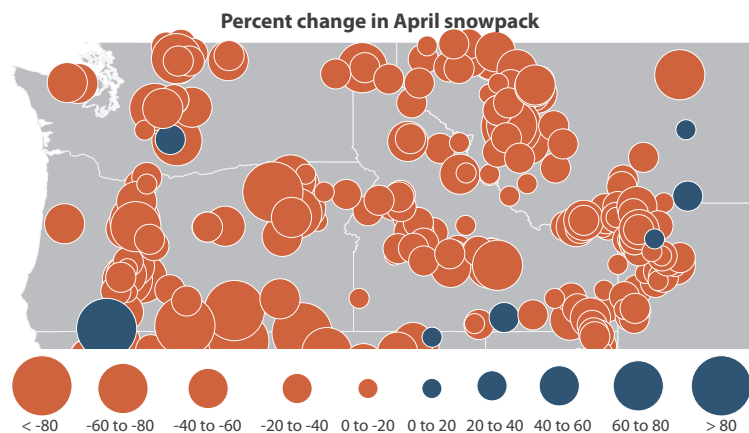
The Northwest is acutely vulnerable to changes in average wind speeds that are uniquely manifested in this region of the country. Precipitation is largely derived from the moist maritime air masses that blow from the west and encounter the various north-south mountain ranges. Rising air is cooled and moisture condenses to form clouds and ultimately rain or snow. The weakening of the winds that blow this moist air into the region has resulted in drier conditions. Future projections suggest this will be a continued trend, affecting rainfall patterns across the region. Annual precipitation has historically been variable and will continue to be in the future, however with increasing temperatures, more precipitation will fall as rain in the winter and early spring.

Changes in streamflows impact aquatic ecosystems

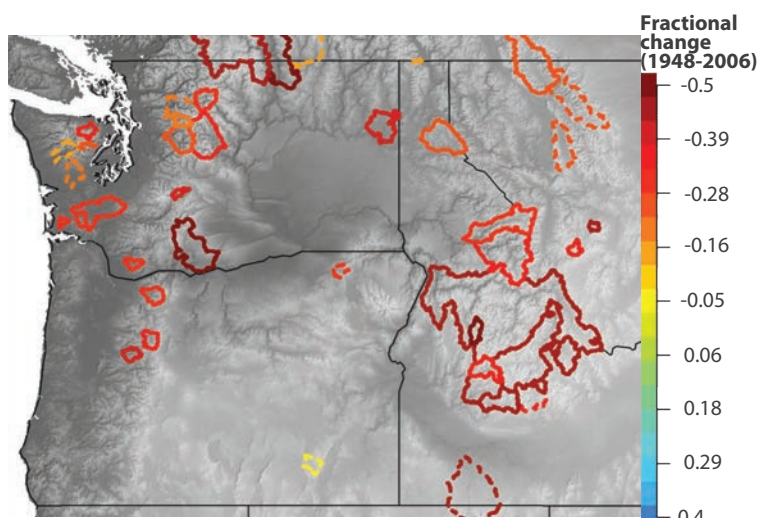
Aquatic species in the Northwest depend on seasonally available freshwater streams and cool water, and many are extremely sensitive to ecological drought. Warming winter temperatures will reduce mountain snowpack, resulting in changes to streamflow in snowmelt dominated basins. Changes in streamflow are associated with shifts in aquatic habitat, water temperature, nutrient availability, and sediment levels. With increasing temperatures and increasing precipitation variability, low water levels could occur earlier in spring and summer months, causing earlier droughts that persist longer into the growing season. The timing of spring runoff is important for fish species, including steelhead, trout, and salmon, that depend on streamflows to migrate to the ocean. This mismatch in timing of flows could have severe ecological, cultural, and economic implications for the region.

Drought amplifies stressors across Northwest landscapes

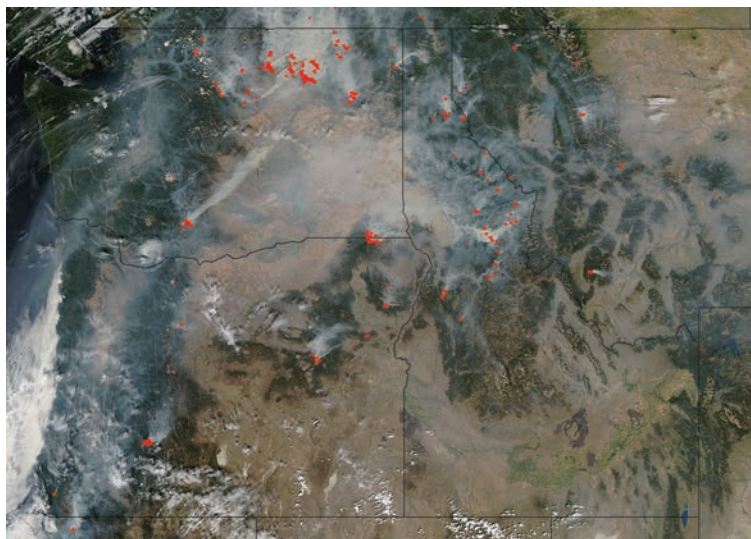
Wildfires are a natural part of most Northwest forest ecosystems, and warmer and drier conditions have increased the number and extent of forest fires and rangeland fires. Trends in wildfire and climate in the western U.S. from 1970 to 2002 show that both the frequency of large wildfires and fire season length have increased substantially after 1985. These changes were closely linked with advances in the timing of spring snowmelt and increases in spring and summer air temperatures. Increasing wildfires and insect and tree disease outbreaks lead to long-term shifts in forest types and species. Water deficits increase tree stress and mortality, vulnerability to insects, and fuel flammability. Higher temperatures and drought stress are contributing to outbreaks of mountain pine beetles. Rangeland fires increase the susceptibility of soils to erosion, especially during periods of drought. Large dust storms have become more frequent, especially following fires. In addition, the ash from fires or dust can coat snow, increasing sunlight absorption and accelerating snowmelt.



Trends in April snowpack in the Western United States, 1955–2016. Snow pack is measured in terms of snow water equivalent. Blue circles represent increased snowpack; red circles represent a decrease. Adapted from Mote and Sharp, 2016.



Trends in stream flow change within watersheds from 1948 to 2006. All watersheds have seen a negative change over the observed years. Dashed boundaries denote non-significant trends. Adapted from Luce et al. 2013, data from Hydro-Climatic Data Network streamflow gauges.



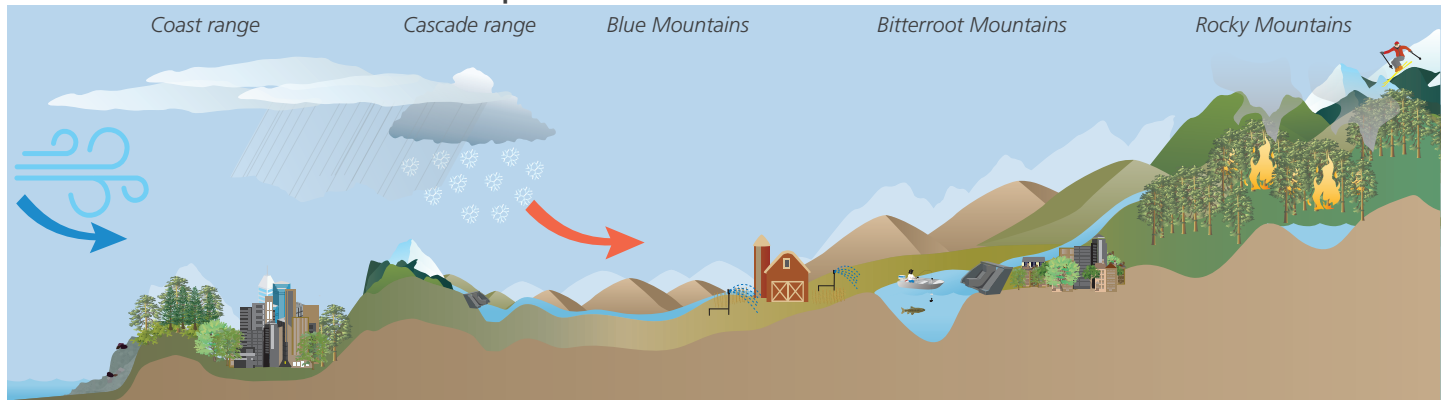
Red hotspots and gray smoke mark fires burning in the Pacific Northwest in late August 2015. Years in which fires are common over an entire region are associated with climate conditions like those expected under climate change. 2015 was a year of very low snow pack and higher than average temperatures. Image from MODIS/NASA.

Managing for drought on a diverse landscape

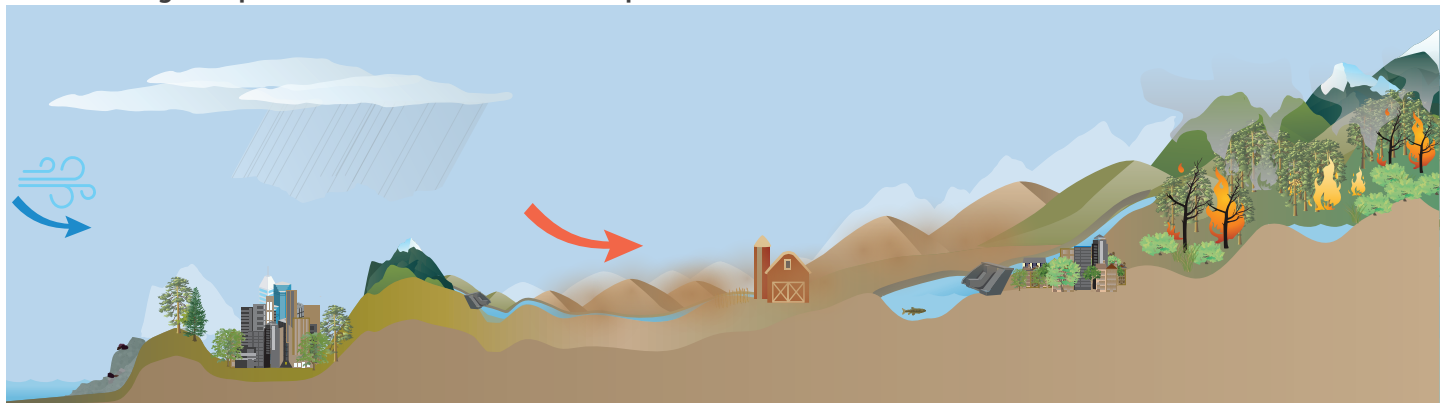
The threat of ecological drought in the Northwest United States has the potential to result in major ecological, social, and economic impacts. The diverse ecosystems of the Northwest are shaped by unique topography and weather patterns, and each landscape is threatened by ecological drought on a local and regional level. Effective management can limit the impacts of drought, reduce wildfire risk, protect native species, and sustain the delivery of goods and services that support ecosystems and people.

The varied topography and diversity of landscapes present within the Northwest contribute to the region's rich diversity. A complex topography interacts with weather patterns to create ecosystems that range from coastal rainforests to deserts. Warm, moisture laden air  travels from the Pacific Ocean and moves inland as it arrives at the Pacific Northwest. Large mountain ranges (Coast Range, Cascade Range, Blue Mountains, Bitterroot Mountains) act as a rain trap and rain barrier. On the western slopes of the Cascades, rainfall is high. Meanwhile, on the eastern slopes, precipitation  is much lower and decreases as you travel further east. Warm, dry air  on the leeward (dry) side of the mountains sinks and warms the valleys below, resulting in grasslands and desert landscapes.

Current status of Northwestern landscapes



Future drought impacts on Northwestern landscapes



Climate impacts



The weakening of winds that blow moist maritime air masses inland will impact rainfall patterns across the region, resulting in drier conditions.



A shift in precipitation from snow to rain.

Hydrological impacts



Reduction in snow pack reduces water available during spring freshet and to downstream ecosystems.

Social impacts



Changes in precipitation will have detrimental effects on economically important recreational opportunities: a lack of snow can shorten ski season and reduce water availability for summer water-dependent recreation such as rafting and fishing.

Ecosystem impacts



Timing, and amount of freshwater available can impact migration patterns of important aquatic species, such as salmon, coho, and trout.



Wildfire frequency and size will increase as forests experience a departure from historic regimes.



Landscapes will transition from forest to non-forest catalyzed by climate driven increases in wildfires and insect outbreaks.

Agricultural impacts



The construction of dams and reservoirs has modified streamflows and reduced ecologically available water downstream for aquifer recharge.



Loss of snowpack, increased temperatures, and the resulting increase in water demand threaten to create transformational drought for growers across the region.

Working together to manage multiple uses of water

The plentiful, high-quality water resources of the Northwestern U.S. have generated extraordinary environmental, biological, and cultural diversity, as well as economic prosperity for residents of the region. The Northwest is well-known for ample rainfall, snow-packed mountains, cool salmon- and trout-laden streams, and large hydroelectricity-producing rivers. Climate change, however, threatens these iconic Northwest features as projected rising temperatures and changes in precipitation patterns combine to create novel conditions across the region. Increasing air temperatures, diminishing snowpack, and reduced summer soil moisture are all expected to increase the frequency and severity of droughts across the western U.S.

Natural and cultural resource managers in the Northwest are very concerned about shrinking water supplies and associated extreme drought and fire conditions. In response to these concerns, the Northwest Climate Science Center (NW CSC) is working with managers and scientists to evaluate drought adaptation actions, such as re-introducing beavers in drier areas of Oregon, evaluating the buffering capacity of different types of refugia, attempting “fish rescue” as a means to assist wild fish during their migration through fragmented habitats, or assessing different patterns of strategic tree removal to increase snow-water storage in mountain ranges of the region. We are also facilitating conversations, such as the ones that took place during our ecological drought workshops in Portland, OR and Boise, ID, to ensure the science we support is usable and accessible to resource management agencies. As drought becomes more common and severe in the region, the NW CSC is poised to help scientists, managers, tribal leaders, and policy makers take creative and effective actions for preserving the Northwest’s natural and cultural heritage.

– Gustavo Bisbal and Nicole DeCrappeo, Northwest Climate Science Center



Flickr user cmh2315



U.S. Bureau of Land Management

In the Northwest United States, limited water resources support both natural and human systems. Coho Salmon (top) rely on seasonal water supplies for spawning, while hydropower dams (bottom) supply a large percentage of power within the region.



Participants at the Northwest Climate Science Center workshop held in Portland, Oregon (top) and Boise, Idaho (bottom) in February, 2017.

For more information regarding ongoing research and activities at the Northwest Climate Science Center, visit nwclimatescience.org

Workshop participants

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