



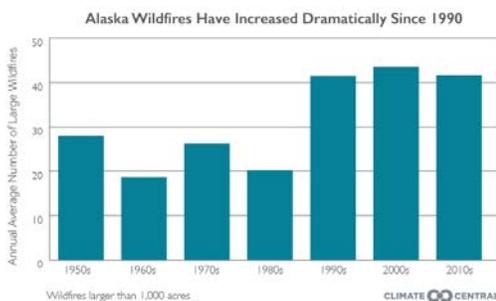
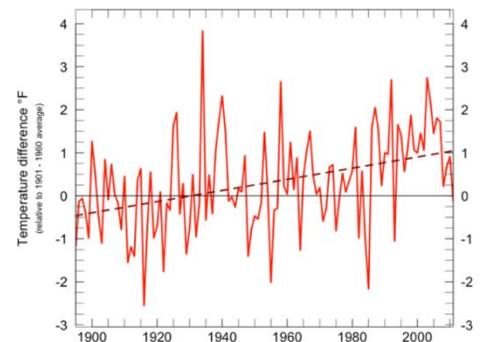
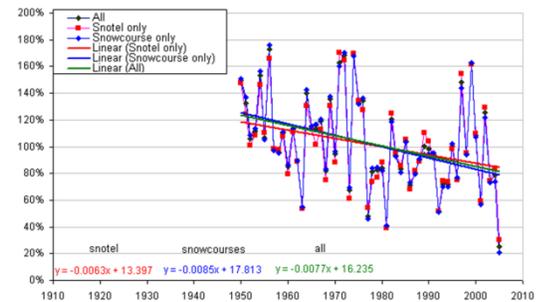
Drought Impacts on Forests and Rangelands in the Pacific Northwest and Alaskan Regions

Overview:

The Northwestern states of Oregon and Washington are known for abundant precipitation, especially near the coast where large conifers dominate the natural landscape. The overwhelming portion of this precipitation falls during the October-April wet season, but very little falls during May-September. High levels of precipitation reach into southeast Alaska, although here the dry season is less pronounced. Eastern Washington and Oregon, as well as Idaho, have much less precipitation, but snowmelt and subterranean flow support year-around urban, industrial, and agricultural water use.

Loss of snowpack from warmer temperatures is already occurring and is projected to continue to decline given the effects of climate change on warmer winters (higher rain:snow ratio) and hotter summers that will reduce soil moisture and streamflows throughout the Northwest, much like we experienced in 2015. Global climate model projections for precipitation are inconsistent, but most indicate slightly wetter winters and slightly drier summers, including higher winter peak flows and more floods caused by rain or rain-on-snow extreme events. Dominant modes of climatic variation (El Niño Southern Oscillation, Pacific Decadal Oscillation) can in some cases accentuate extremes of drought and flooding.

Climate change is expected to alter the timing and magnitude, water temperature, and streamflow volume of rivers and streams. Snow-dominant watersheds will likely have earlier and reduced spring peak flow, increased winter flow, and reduced late-summer flow, and rain-dominant watershed could have higher winter streamflows. Mixed rain-snow watersheds will become more rain-dominant.



Temperatures in the Pacific Northwest have been increasing in the last 80 years. As this trend continues, it will lead to lower soil moisture in summer, lower growth in some tree species, lower fuel moistures, and increased area burned by wildfire.

Like most northern latitude locations, Alaska has experienced larger temperature increases than the rest of the United States. Growth has declined in white spruce forests of interior Alaska because of drought stress, spruce beetles have caused extensive mortality in southern Alaska, and the number of large wildfires has recently increased.

Drought Impacts on Forests and Rangelands:

- **Drier soil conditions will persist later in the growing season (summer and fall)**, reducing growth in some tree species and reducing their resistance to insect outbreaks.
- **Higher temperature will increase fire hazard** by mid century, affecting nearly all forest, rangeland, and grassland ecosystems. Insect-induced tree mortality and other disturbances will contribute to fire hazard and fire severity on a local basis.
- **Large wildfire events will occur more frequently in coastal and interior forests and shrublands.** Regeneration of some tree species may be difficult where fires are widespread and very intense.
- **Droughts are predicted to accelerate the pace of invasion by some non-native plant species into rangelands and grasslands.** In rangelands, drought conditions as well as invasive annual weeds exacerbate the risk of fire, especially in areas dominated by native shrubs such as big sagebrush.
- **Drought in rangelands reduces forage and water available for livestock grazing and native ungulates.** Reduced vegetative cover can lead to wind and water erosion
- **Reduced water yield from forests and rangelands during extended drought will reduce domestic and agricultural water supplies.**
- **Invasive plant species, insect pests, and fungal pathogens will increase or become more severe and damaging.** Warmer temperatures will help some invasive plant species and insect pests expand into new areas; climate-related stress and disturbances in forest ecosystems can create more opportunities for non-native plants and insects to invade. Examples include expansion of (native) mountain pine beetles in lodgepole pine forests and cheatgrass invasion in sagebrush and other rangelands.
- **Cold-water fish species will face increased heat stress.** Anadromous salmon species support a vibrant commercial and recreational fishing in the Northwest. Thermally sensitive species such as bull trout will be extirpated in many locations.
- **Many water supplies are over-allocated, leading to conflicts among potential users and uses.**
- **Low diversity forest ecosystems are at greater risk.** Diverse systems are generally more resilient to disturbance with more options to respond to change, reducing risk and increasing adaptability.

Adaptation to Drought in Forests and Rangelands:

As soils become drier, available moisture for vegetation growth decreases and one can expect lower tree growth and higher mortality in the driest locations. This can alter ecosystem structure and function, reducing the goods and services coming from the land. Management options to deal with this additional stress include:

- Plant trees with genetic characteristics that confer tolerance to environmental stress now and in the future, considering both species and populations within species
- Manage forest stand density to ensure adequate soil water and other resources for the remaining trees.

Conclusions:

- Transition land managers from a reactive to an anticipatory mode to protect investments and defend against extreme weather events.
- Prepare for increased fire occurrence, especially where numbers of fires have historically been low (coastal coniferous forests).
- Invest in forest and shrubland fuels reduction, post-fire restoration efforts, and related research.
- Promote adaptation demonstrations, leveraging successful applications to advance climate change integration and adaptation in natural resource planning, particularly for owners and managers of livestock operations, woodlots, large forested areas, industrial lands, wildlife refuges, and watersheds.

To learn more about USDA Climate Hubs visit: <http://climatehubs.ocs.usda.gov/northwest>

To read the full report *Effects of Drought on Forests and Rangelands in the United States: A Comprehensive Science Synthesis* visit: <http://go.usa.gov/cEtd9>