United States Department of Agriculture

Drought Impacts in the Northern Region

A synopsis of presentations and work group sessions from the

Region 1 Drought Workshop

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Northern Plains Climate Hub
U.S. DEPARTMENT OF AGRICULTURE
Crown Managers Partnership
Montana DNRC
SNAPP
Roundtable on the Crown of the Continent
Alberta Environment and Parks
Wildlife Conservation Society

Drought Impacts
in the Northern Region

Drought is a natural and recurring attribute of climate in the Northern Rockies. In the past century, this region had significant periods of drought in 1917-1919, the late 1920s to early 1940s (the Dust Bowl droughts), the 1950s, the late 1980s to early 1990s, and the early 2000s (Whitlock et al. 2017; reference maps).

The economic, social, and environmental costs of drought can be significant. According to the National Climatic Data Center's Billion Dollar U.S. Weather Disasters, economic losses from drought account for roughly 24 percent of all losses from major weather events, including floods, hurricanes, and severe storms. Vulnerability to drought will likely increase in the future with a warming climate.

To promote stronger drought resilience on federal lands, the National Drought Resilience Partnership was initiated in 2016. As a part of this effort, the U.S. Forest Service conducted a series of focused workshops across the country to build the capacity to address the impact of short- and long-term drought on forest and rangeland resources, thus informing land management, restoration, and climate change adaptation.

In March 2017, a three-day drought resilience workshop was conducted in Choteau, Montana. The workshop was co-hosted with the ***Crown Managers Partnership*** and developed in collaboration with ***Science for Nature and People Partnership, Montana Department of Natural Resource Conservation, USDA Northern Plains Climate Hub, Alberta Environment and Parks, Wildlife Conservation Strategy,*** and the ***Crown Roundtable.***

The workshop included over 120 participants from 16 different agencies, 2 tribes, 34 non-governmental organizations, and 6 industry groups. Topics covered in the workshop included drought and climate trends, and drought impacts on forest, range, agricultural, riparian and aquatic systems.

This fact sheet summarizes key messages from presentations and small work group recommendations.

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Definitions of drought include:

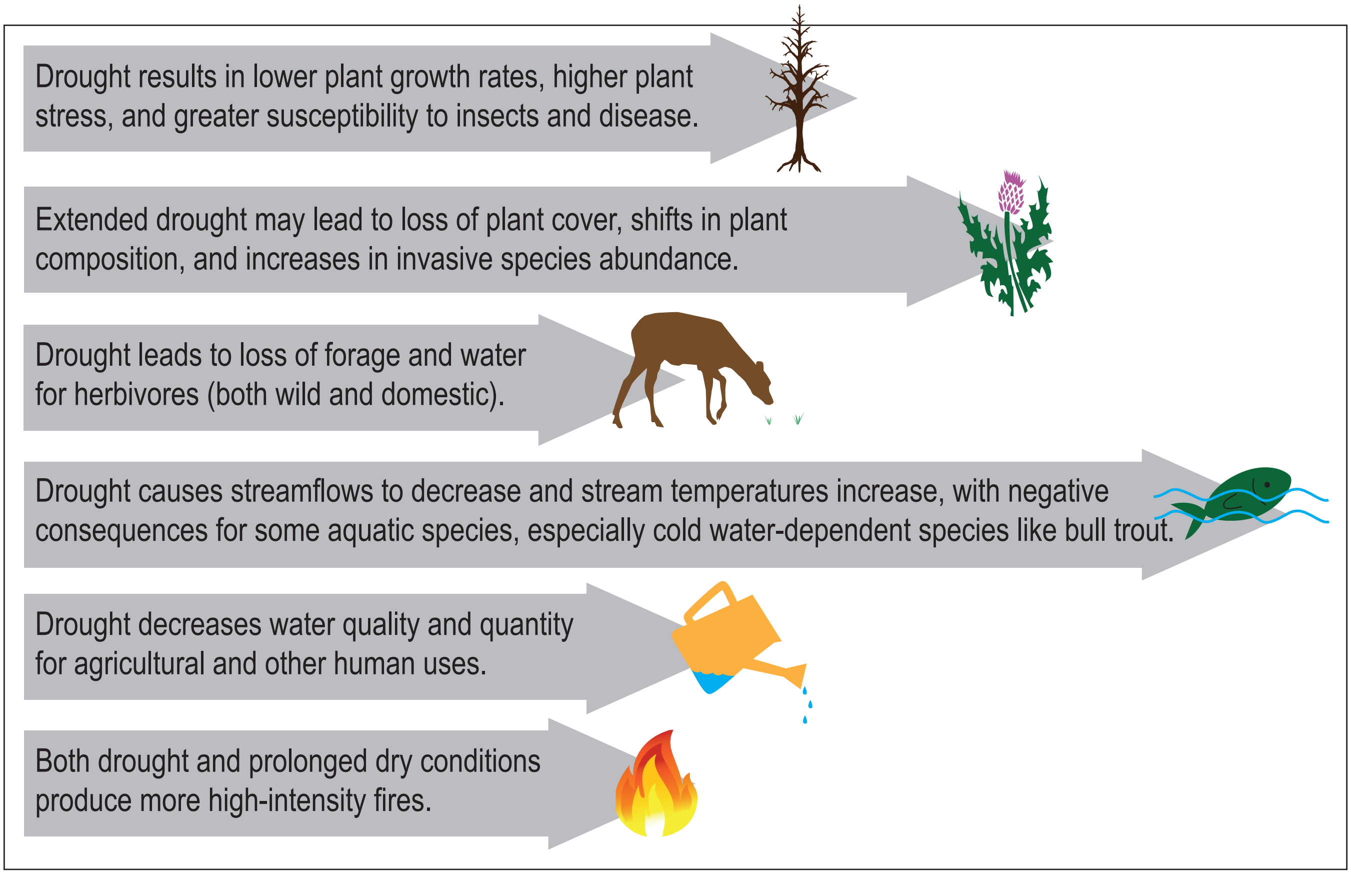
- ***Meteorological*** – degree of dryness over a defined period of time. Most types of drought relate to meteorological conditions due to lack of precipitation or excess evapotranspiration (Vose et al. 2016);
- ***Hydrological*** – precipitation deficits and their effect on the hydrologic system, (e.g., lakes, and stream volume, and flow reductions);
- ***Agricultural*** – links meteorological drought with agricultural impacts (e.g., reduced commodity production, crop failures); and
- ***Socio-economical*** – human needs (e.g., electrical power production, recreation, wildlife) exceeds supply due to weather/ climate-related water shortfall (Vose et al. 2016; Wilhite and Glantz 1985).

Ecological drought is a water deficiency that drives ecosystems beyond thresholds of vulnerability and causes impacts to the services they provide to people, such as carbon sequestration and available drinking water (Crausbay et al. 2017).

Humans also contribute to or alleviate drought by modifying hydrological processes (e.g., through land use change, irrigation, and dam building) (Van Loon et al. 2016).

Key Impacts of Drought in the Northern Region

Figure 1 - Drought impacts both resources and services provided by national forests and grasslands in the northern Rocky Mountains.



Future Drought in the Northern Region

Temperatures in the Northern Rockies, including mean monthly minimum and maximum temperatures, have increased by 0.5-3 degrees Fahrenheit between 1895 and 2012, while precipitation has remained relatively constant. By mid-century, temperatures are projected to increase by another 2-8 degrees Fahrenheit (Joyce et al. 2017, Whitlock et al. 2017).

Projections for future precipitation suggest a slight increase; however precipitation projections, in general, have greater uncertainty than those for temperature.

Many global climate models project increases in precipitation for the winter and spring, but decreases in the summer (Joyce et al. 2017, Whitlock et al. 2017), and summer temperature increases may be greater than those for other seasons (Joyce et al. 2017). Thus, evapotranspiration is likely to increase and soil moisture availability decrease during the summer in the future.

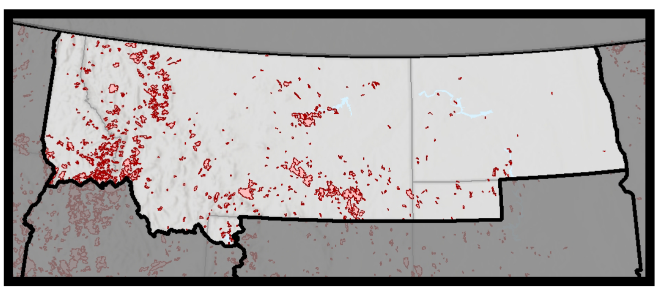
Figure 2 - The OSC Drought Gallery has interactive maps showing historic versus 2080 temperature and precipitation maps; time series maps for drought patterns; moisture deficit and surplus maps; and other resources. (Click to visit the gallery.)

Forest Ecosystems

Drought in the Northern Rockies affects forest ecosystems both directly and indirectly. Drought often leads to reductions in tree growth and increased mortality, particularly when coupled with high temperatures (Allen et al. 2010). For example, Douglas-fir growth in the Northern Rockies (and throughout its range) is negatively correlated with water deficit (Restaino et al. 2016).

Drought affects forest ecosystems indirectly through impacts on disturbance processes such as fire and insect outbreaks. Drought weakens tree defenses, making them more susceptible to insects and pathogens (Weed et al. 2013). Drought is also positively associated with area burned in the western U.S. (Littell et al. 2016).

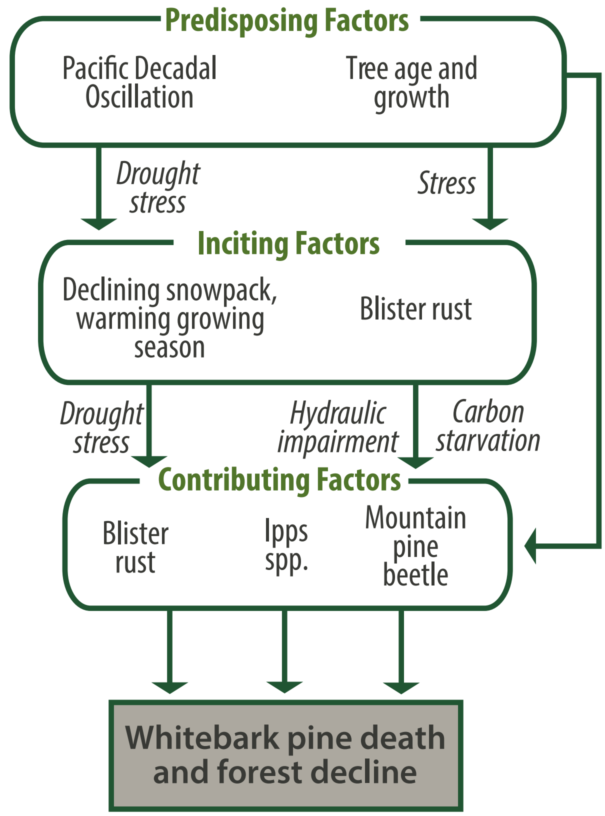
Figure 3 - Areas burned by wildfire 2000-2015, including all wildfires with areas of 1000 acres or greater. *(Data source: Eidenshink, J., Schwind, B., Brewer, K., Zhu, Z., Quayle, B., & Howard, S. (2007). A project for monitoring trends in burn severity. Fire Ecology 3 (1): 3-21. Fire Ecology Special Issue Vol, 3, 4. https://www.mtbs.gov/sites/default/files/inline-files/Eidenshink-final.pdf)*



Past management and forest conditions can affect the impacts of present-day droughts in forested ecosystems. Fire suppression in dry forest types of the Northern Rockies has led to increased forest density, and high forest density exacerbates moisture stress during drought (Clark et al. 2016). High forest density, when combined with drought, can also lead to increased incidence of high-severity fire (Clark et al. 2016; Littell et al. 2016).

Interactions among stressors, including drought, fire, and insects, have the potential to accelerate tree mortality (see Figure 4).

Figure 4 - Example of how stressors interact to accelerate tree mortality.



- ***Pacific Decadal Oscillation*** is a recurring pattern of ocean-atmosphere climate variability centered over the mid-latitude Pacific basin.
- ***Hydrologic impairment*** refers to the negative effects that blister rust has on hydraulic processes in white pine (xylem can lose connectivity).
- ***Carbon starvation*** occurs when plants close their stomata to avoid water loss, resulting in a negative carbon balance.

Forest Ecosystems Management Response Options

» ***Plan for uncertainty*** (e.g., use scenario planning).

» ***Implement adaptive management*** (i.e., learn as you go, monitor, make changes with new knowledge).

» ***Promote tree size and age diversity*** at the stand and landscape-levels to increase resilience to insect outbreaks, fire, and drought.

» Prioritize management strategies that ***enhance natural disturbance regimes, but without promoting*** *invasive species* (e.g., use prescribed fire and manage fire for resource benefit).

» ***Promote drought-tolerant species*** (e.g., in thinning prescriptions and planting).

» ***Use prescribed fire*** to reduce stand densities, increase landscape heterogeneity, and increase resilience to drought.

» ***Conduct thinning*** in overstocked forests to increase individual tree health and make trees more resilient to drought and more resistant to insect outbreaks.

» Increase resilience of sensitive species, such as whitebark pine, by ***protecting them from high-severity fire*** (e.g., through prescribed fire and removal of competing species such as subalpine fir and Engelmann spruce).

» ***Increase resources to implement landscape treatments;*** look for cost-sharing opportunities with other agencies and organizations.

Rangelands and Agricultural Systems

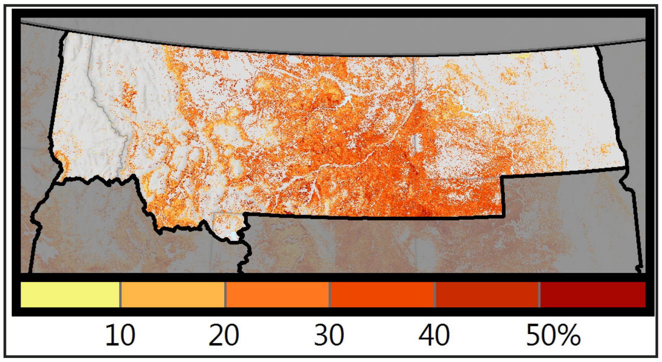
Rangeland productivity is directly linked to soil moisture; there is a strong linear relationship between mean annual precipitation and aboveground net primary productivity for most rangelands (Sala et al. 1988).

Reduced productivity from drought can result in increased plant mortality, reduced plant cover, increased bare ground, and increased soil erosion (Finch et al. 2016). Reduced productivity also decreases crop production, forage value, and livestock carrying capacity.

Impacts of drought are also affected by ecosystem condition. For example, ecosystems with healthy soil have high water infiltration and retention, and thus greater resilience to drought. Presence of invasive species and altered fire regimes can limit the ability of native vegetation to withstand drought (Finch et al. 2016).

Figure 5 - Variability (standard deviation) in rangeland productivity, as a proportion of the mean, based on data from 2000-2016. (Click for interactive version.)

(Data source: Reeves, Matthew C. 2017. MODIS-based annual production estimates from 2000-2015 for rangelands in USFS grazing allotments in Region 5. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2017-0004.)



Drought may also increase fires in some rangelands if sufficient fuels are present. However, drought can limit fuel production and thus lower fire risk in some systems (Littell et al. 2016).

Past droughts and their impacts can provide examples of what may occur under future drought conditions. For example, a drought near Miles City, Montana caused substantial mortality of pine, juniper, cottonwood, and shrubs, and grass cover declined by up to 79 percent (Ellison and Woolfolk 1937).

The authors also documented recovery from the drought and noted relatively quick regeneration of needle-and-thread grass and Sandburg bluegrass. Silver sagebrush was able to regenerate by sprouting, but regeneration of big sagebrush was poor.

Rangelands and Agricultural Systems Management Response Options

» ***Promote healthy soil and biodiversity***—both above and below ground—to increase drought resilience (e.g., increase organic matter to increase soil water holding capacity).

- » ***Use early detection/rapid response for invasive species***; conduct more research on eradication methods for invasives species such as cheatgrass.
- » ***Use best management practices*** (BMP) to help mitigate effects of drought and speed recovery.
- » ***Evaluate and adjust herd composition and numbers*** so stocking rates match forage production; increase flexibility in stocking rates.
- » ***Provide rest or defer grazing*** on lands in an unhealthy condition.
- » ***Brand and build a culture for water efficiency*** (e.g., through education and extension); reward farmers for more efficient use of water.
- » ***Develop new markets for water-efficient crop varieties.***
- » ***Promote the economic benefit of changes*** in rangeland management practices for producers.
- » ***Modernize conveyance and distribution of water*** (e.g., use automated headgates and maintain needed flows more accurately).

Riparian and Aquatic Ecosystems

Drought directly affects the amount of available water for riparian areas, wetlands, and streams. Increased temperatures, reduced streamflow, and slower water velocities result in increased stream temperatures (Vose et al. 2016). Dissolved oxygen is lower in warm water, and lower water volumes limit aquatic organisms to smaller habitat volumes, leading to increased competitive interactions with other organisms (Vose et al. 2016). Thus, droughts can stress fish and other aquatic organisms.

Bull trout (courtesy of ClarkFork.org)

For coldwater species in the Northern Rockies (such as westslope cutthroat trout and bull trout) warmer stream temperatures can limit habitat extent and fragment populations, while high temperatures that cross species thresholds can be lethal (Vose et al. 2016).

In contrast, many invasive species are competitive in warmer waters and can take advantage of drought conditions to the detriment of native species.

Fire and vegetation change associated with drought can also degrade aquatic habitat by increasing erosion and sedimentation in streams.

Riparian and Aquatic Systems Management Response Options

- » ***Reconnect floodplains and side channels,*** and maintain and restore functioning riparian corridors (e.g., by re-establishing riparian vegetation).
- » ***Increase instream flows through change in water rights and incentives*** (e.g., reduce water allotments when water supply is low and provide rewards to users for reducing consumption).
- » ***Reintroduce North American beaver*** where appropriate to increase water storage.
- » ***Remove barriers to fish movement*** where appropriate and for bull trout in particular (e.g., by modifying infrastructure to increase habitat connectivity).
- » ***Maintain the function of the transportation system without damaging riparian and aquatic ecosystems*** (e.g., develop engineered solutions for necessary roads in floodplains and develop partnerships with

the department of transportation, counties, and different agencies to mitigate negative impacts of the transportation system).

» ***Conduct riparian and stream restoration*** in places that are likely to be refugia in the future with drought and climate change (e.g., high elevation streams and locations with cold water upwelling).

Gravel bed river valleys, such as the Flathead River Valley shown here, provide habitat for a variety of species. Maintaining or restoring the hydrologic function of these rivers will likely help improve habitat and species resilience under drought conditions. (Photo courtesy of Harvey Locke.)

» ***Deploy more integrated and comprehensive monitoring networks*** to detect change; use data to deliver information to decision-making tools (models and forecasting).

» ***Restore structure and function of gravel bed river valleys and their floodplains.***

Next Steps

The information developed in the regional drought workshops will be used to develop a Forest Service General Technical Report (anticipated in 2018) that synthesizes the most important issues related to drought's effects on natural resources. Building on information generated from a previously-published drought science synthesis (Vose et al. 2016) and drought workshops, this publication will describe specific planning and management options in each Region, providing the necessary documentation for on-the-ground action.

The Forest Service is also working with partners to develop a drought indicator for forested ecosystems. This indicator will provide early warning of drought impacts and help to prioritize management treatments such as thinning.

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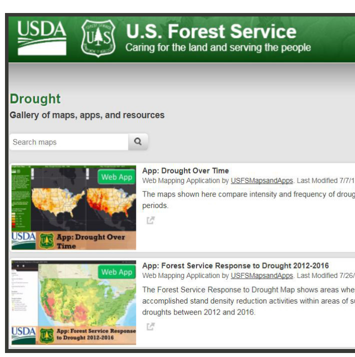

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Cover photo - Crystal Mountains, Montana (Forest Service)