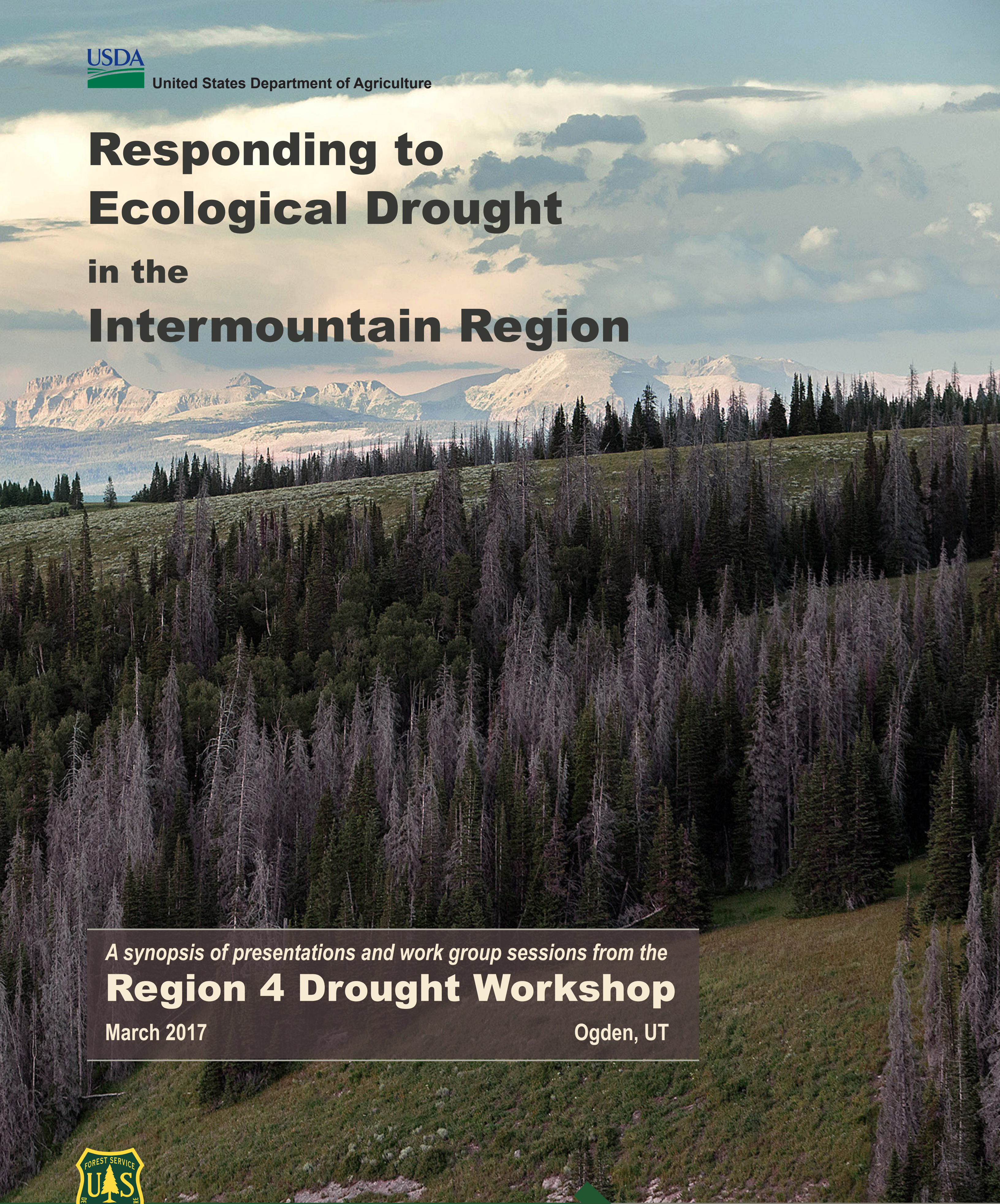


USDA United States Department of Agriculture

Responding to Ecological Drought in the Intermountain Region

A synopsis of presentations and work group sessions from the

Region 4 Drought Workshop

March 2017 Ogden, UT

Forest Service Washington Office September 2017 Office of Sustainability and Climate

USDA Southwest Climate Hub
U.S. DEPARTMENT OF AGRICULTURE

Responding to Ecological Drought

Intermountain Region

Background

The economic, social, and environmental costs of drought can be significant, and 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, the Forest Service Intermountain Region held a drought adaptation workshop to share state-of-science information on drought and climate effects in the region, and develop management response strategies. Scientists shared information about drought's effect on hydrology and aquatic ecosystems, forest vegetation, rangeland vegetation and soils, carbon storage, recreation, infrastructure, and water rights. Workshop participants prioritized vulnerabilities of each resource area relative to drought, and identified management strategies for adapting to projected drought conditions in the future.

Workshop participants included Forest Service regional office and national forest staff, the Great Basin and Southern Rockies Landscape Conservation Cooperatives, and the USDA Southwest Climate Hub. Many participants identified forest plan revisions and the need for improved management tools and practices as their primary motivation to participate.

Drought in the Intermountain Region

Scientific knowledge of drought dates back to 800 AD in the Intermountain Region. The longest drought lasted 71 consecutive years, and 28 droughts of 10 years or longer have occurred (Allen et al. 2013, DeRose et al. 2014, 2015). Records show that recent history (1940-present) has been far wetter than the rest of recorded history (DeRose et al. 2015).

© Olesya Chirkov/Bigstock

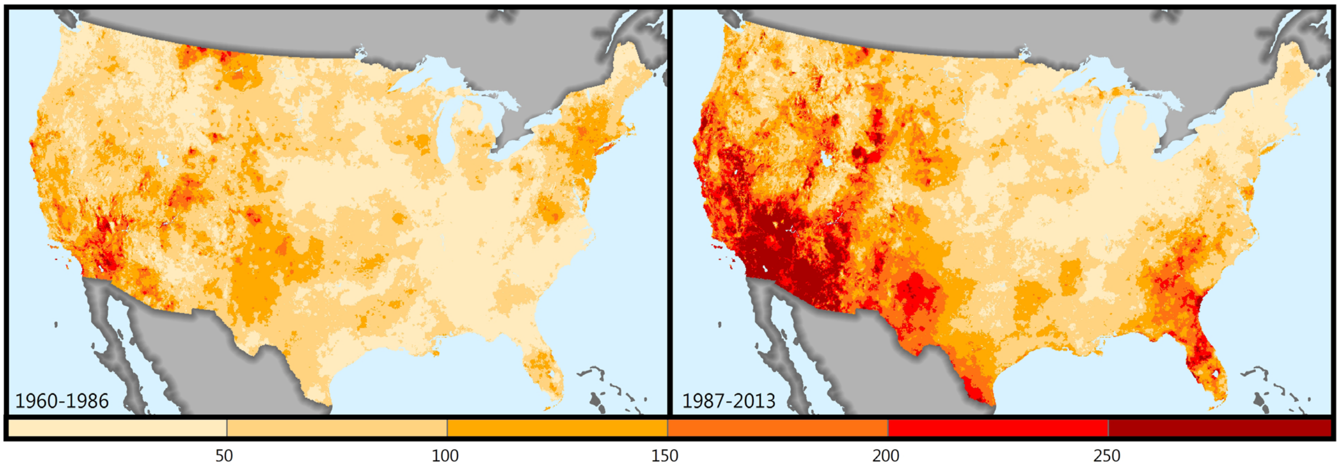
Definitions of drought include:

- ***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).

Figure 1 - The Cumulative Drought Severity Index maps compare intensity and frequency of drought over 2 27-year time periods. The map below shows droughts in many areas became more severe and frequent. (Click for an interactive version.)



Taking a finer look at recent times, 2000-2004 experienced record low precipitation in the western U.S. (Pielke et al. 2005). In 2015, drought was extreme in much of the West, particularly in California and Utah (Mote et al. 2016; Lin et al. 2017). In contrast, 2017 has experienced wet conditions, with almost no drought in the entire western U.S.

Precipitation is expected to decline somewhat in the future in the southwestern U.S., whereas the northwestern U.S. will likely experience increased precipitation. In addition, dry periods may be drier, and wet periods wetter.

It will be important to identify geographic areas with greater capacity to buffer against increased variability in meteorological drought effects, as well as areas that will become more vulnerable to such effects.

Figure 2 - The OSC Drought Gallery has interactive maps including historic versus 2080 temperature and precipitation, and other resources. (Click to visit the gallery.)

Key Impacts of Drought in the Intermountain West

Direct drought impacts:

- Reduced water availability
- Lower ecosystem primary productivity
- Slower tree growth
- Reduced forage for native and domestic animals
- Longer fire season

Indirect impacts:

- Increased wildfire
- Increased insect outbreaks
- Change in species distribution and abundance

Water Resources

The Intermountain Region is likely to experience a slight decline in precipitation overall, with much of the change coming in the timing and form (rain versus snow). Drier years are likely to be drier, with more consecutive dry days in some areas, whereas days of precipitation are expected to come with higher volumes. Monsoon precipitation in May and June is likely to decline (Cook and Seager 2013).

The effects of drought will not be evenly distributed across the landscape, as large aquifers below high mountains and rivers are likely to buffer the variability in meteorological drought effects (USGS 2000). Areas without large aquifers are likely to suffer more near-term effects of drought.

As temperatures increase with climate change, dry areas will most likely experience more heat, causing more evapotranspiration (Cook et al. 2014; Dai 2013).

Extremely low streamflow disconnects fish habitat as this dry stream segment on Whitehorse Creek on the Oregon/Nevada border demonstrates. (Photo courtesy of Jason Dunham, USGS)

Water Resources Management Response Strategies

» ***Incorporate drought planning*** in management considerations, decisions, and analysis.

» ***Develop or improve standards/guidelines, mitigation measures, and best management practices (BMPs)*** to protect both stream corridors and more isolated water features.

» ***Restore and maintain healthy stream, riparian, and aquatic ecosystems*** that will be more resilient to drought cycles.

» ***Improve existing or design new water diversion structures*** to divert only the water needed while retaining water in groundwater-dependent ecosystems. For example, do not divert flow beyond the allocation by using offsite livestock water troughs with float valves to fill and then return flow to the groundwater-dependent ecosystems.

» ***Consider diversions*** that divert water from below the groundwater-dependent ecosystems to reduce disturbances.

» ***Identify a target for a healthy riparian system*** and start managing for that target.

» ***Use exclosures and fences*** to protect very sensitive groundwater-dependent ecosystems.

Forest Vegetation

Forest vegetation is likely to experience less growth in water-limited systems at mid-elevation, whereas subalpine areas may increase growth as energy limitations are alleviated by longer growing seasons due to warming (Restaino et al. 2016).

Expected higher frequencies of extreme weather and warmer, drier growing seasons are likely to reduce productivity overall. Droughts will generally reduce the resistance of trees to some insect species, especially bark beetles (Koricheva et al. 1998, Mattson and Hack 1987, Sturrock et al. 2011).

Forest Vegetation Management Response Strategies

» ***Diversify species*** where site conditions allow.

» ***Use commercial and non-commercial thinning*** to reduce tree densities and to maximize species diversity.

» ***Use prescribed fire strategically*** to reduce stand densities and improve species composition.

» ***Modify local seed inventories*** to address increased drought.

» ***Focus thinning in fire-prone ecosystems*** within the wildland-urban interface (WUI).

» ***Utilize timber harvest*** (regeneration cuts) to create forested openings, allow for development of seral species and improve overall species composition.

Rangelands

Rangelands are vulnerable to drought, particularly with regard to soil health. Maintaining organic matter (carbon) in soils will be one of the most effective tools for improving resiliency, because reduced carbon in soils will reduce the chances of recovery after drought.

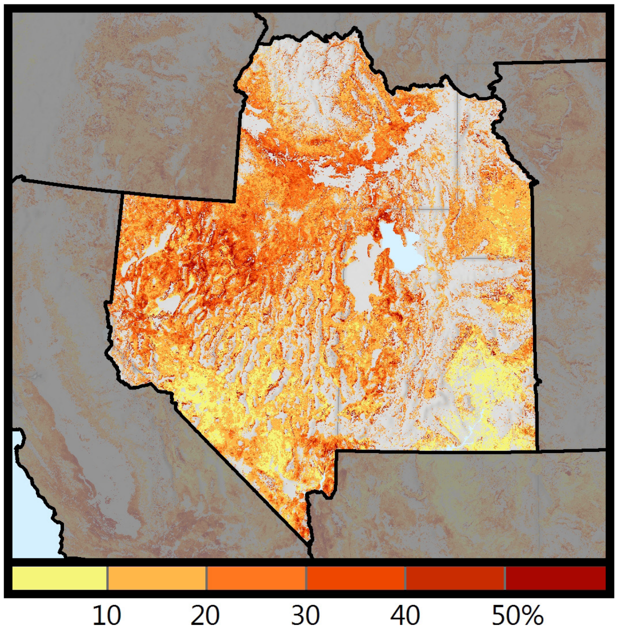
Cheatgrass, which is common in many rangelands, does not deposit carbon deep in the soil (Rau et al. 2011). Encouraging the growth and health of perennial species throughout the growing season can help reduce the competitive effects of cheatgrass.

Maintaining suitable cover of perennial species—especially herbs where appropriate—contributes to drought resilience (top photo). Cheatgrass does not contibute to soil carbon which reduces drought resilience (bottom photo).

The ability of drought monitoring (e.g. quantification of Palmer Drought Severity Index) to explain interannual variation in rangeland production varies by region and vegetation type, but is often limited (Ahmadi et al. 2011). Therefore, although indices currently express hydrologic and meteorological drought, more work is needed on how to evaluate and project vegetation response using drought indices. A more focused ecological drought index may have greater predictive value.

Carbon on the landscape depends heavily on maintaining vegetation regrowth. Post-disturbance conversion of forests to other dominant vegetation may reduce carbon storage on Forest Service lands both in the short term and long term (Kashian 2006). Retaining most current forest land in forest is a critical component of carbon management.

Figure 3 - Variability (standard deviation) in rangeland productivity, as a proportion of the mean, based on data from 2000-2016. (Click for an 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)



Rangeland Management Response Strategies

- ***Establish strong relationships with stakeholders*** based on understanding and trust, not just agreements.
- ***Establish shared values and shared ownership*** of drought impacts across partners and stakeholders.
- ***Establish an integrated monitoring plan*** that includes livestock management, drought, and climate.
- ***Build coalitions and flexibility*** into grazing management programs.
- ***Design permits*** based on drought considerations rather than historical ranch production.
- ***Consolidate monitoring data*** into a geospatial database across resources to aid knowledge preservation and for transitioning employees.

Recreation

Recreation, including hiking, camping, and other warm-weather activities, is likely to experience higher visitor use during shoulder seasons, as weather becomes warmer earlier in spring and stays warmer later in autumn (Albano et al. 2013, Fisichelli et al. 2015).

Wildlife viewing and hunting are likely to shift spatially as animals migrate in response to habitat and forage suitability. Warmer temperatures will also likely increase the number of days for hunting and viewing (Bowker et al. 2012).

Cold-weather activities, including skiing and snowmobiling, will be more challenging—especially at low to mid-elevations—as the duration of the snowpack decreases (Wobus 2017). See Figure 4 below.

Recreation Management Response Strategies

» ***Increase organizational flexibility*** to respond to changes in visitor behavior and demands as recreationists respond to changing weather patterns.

» Maintain strong and effective communication internally and externally to help ***facilitate adjustments to drought.***

» ***Engage in youth programs and citizen science*** to transform recreation visitations into data collection and monitoring. For example, develop mobile apps and/or enhanced reality games as digital tools for conservation education and data collection.

Infrastructure

Infrastructure (roads, bridges, culverts, trails, buildings, dams, and developed recreation sites) are exposed to risks in some areas, especially in steep terrain, erosive soils, and stream channels that flood and erode their banks (Gucinski et al. 2001, Murray and Ebi 2012).

Special attention should be given to areas that have failed before, where infrastructure is deteriorating, and locations with known risks to wildfire, landslides, and flooding.

Infrastructure Management Response Strategies

» ***Improve public engagement*** between the Forest Service, partners, and visitors.

» Approach forest plan revisions, NEPA, and project planning from the perspective of ***people as drivers,*** rather than a resource-oriented approach.

» Coordinate and engage with ***State action plans.***

» ***Communicate the value*** of projects to stakeholders.

» ***Increase the capacity*** to respond to public input.

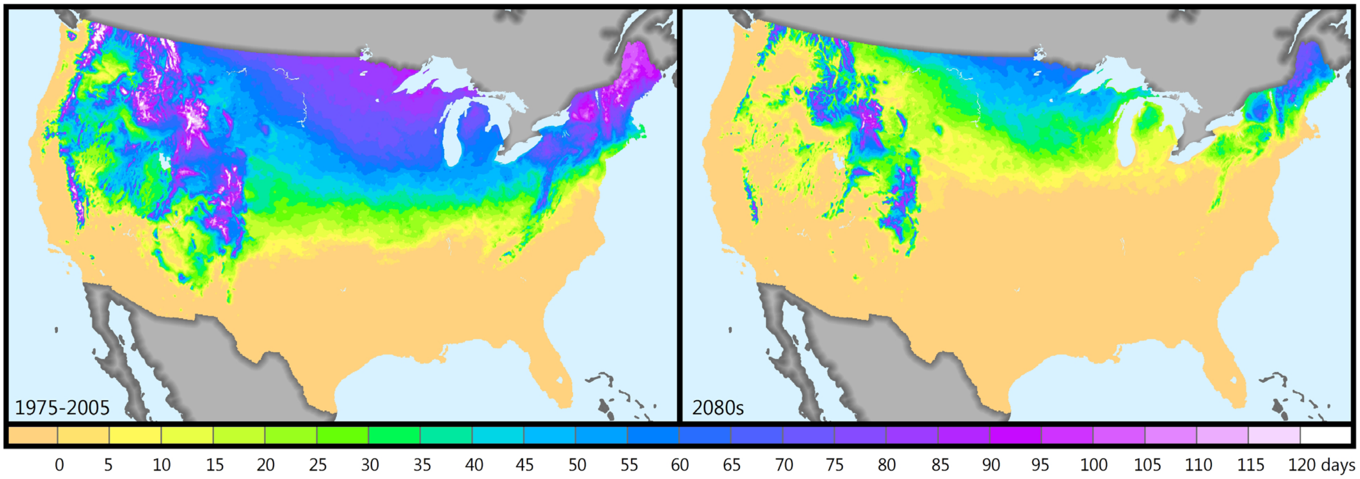


Figure 4 - Snow Residence Days comparison maps below show days with snow residing between 1975 and 2005 versus a projected map of 2080. (Click for an interactive version.)

References

Ahmadi, H.; Arzani, H.; Mahdavi, M.; Azarakhshi, M. 2011. Assessment of the Palmer drought severity index in arid and semi arid rangeland: (Case study: Qom province, Iran). Desert. 16: 77-86.

Albano, C.M.; Angelo, C.L.; Strauch, R.L. [et al.]. 2013. Potential effects of warming climate on visitor use in three Alaskan national parks. Park Science. 30: 37–44.

Allen, E.B.; Rittenour, T.M.; DeRose, R.J. [et al.]. 2013. A tree-ring based reconstruction of Logan River streamflow, northern Utah. Water Resources Research. 49: 8579–88.

De Rose, R.J.; Wang, S.Y.; Buckley, B.M. [et al.]. 2014. Tree-ring reconstruction of the level of Great Salt Lake, USA. The Holocene. 24: 805-813.

Bowker, J.W.; Askew, A.E.; Cordell, H.K. [et al.]. 2012. Outdoor recreation participation in the United States—projections to 2060: a technical document supporting the Forest Service 2010 RPA assessment. Gen. Tech. Rep. GTR-SRS-160. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 42 p.

Cook, B.I.; Seager, R. 2013: The response of the North American monsoon to increased greenhouse gas forcing. Journal of Geophysical Research, Atmospheres. 118: 1690–1699.

Cook, B.I.; Smerdon, J.E.; Seager, R.; Coats, S. 2014. Global warming and 21st century drying. Climate Dynamics. 43: 2607–2627.

Clark, J.S.; Iverson, L.; Woodall, C.W. [et al.]. 2016. The impacts of increasing drought on forest dynamics, structure, and biodiversity in the United States. Global Change Biology. 22: 2329–2352.

Crausbay, R. et al. 2017. Bulletin of the American Meteorological Society. Preliminary online version.

Dai, A. 2013. Increasing drought under global warming in observations and models. Nature Climate Change. 3: 52–58.

DeRose, R.J.; Bekker, M.F.; Wang, S.Y.; [et al.]. 2015. A millennium-length reconstruction of Bear River stream flow, Utah. Journal of Hydrology. 529: 524-534.

Gucinski, H.; Furniss, M.J.; Ziemer, R.R.; Brookes, M.H. 2001. Forest roads: a synthesis of scientific information. Gen. Tech. Rep. PNW- GTR-509. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Finch, D; Pendleton, R; Reeves, M; Ott, J; Kilkenny, F; et al. Rangeland Drought: Effects, Restoration, and Adaptation. Effects of Drought on Forests and Rangelands in the United States: A Comprehensive Science Synthesis. Forest Service GTR WO-93b, (Jan 2016) 155-194.

Fisichelli, N.A.; Schuurman, G.W.; Monahan, W.B.; Ziesler, P.S. 2015. Protected area tourism in a changing climate: will visitation at US national parks warm up or overheat? PLoS ONE 10: e0128226.

Kashian, D.M.; Romme, W.H.; Tinker, D.B. [et al.]. 2006. Carbon storage on landscapes with stand-replacing fires. BioScience 56: 598-606.

Koricheva, J., Larsson, S., & Haukioja, E. 1998. Insect performance on experimentally stressed woody plants: a meta-analysis. Annual Review of Entomology. 43: 195-216.

Lin, Y.H; Hipps, L.E.; Wang, S.Y.S.; Yoon, J.H. 2017. Empirical and modeling analyses of the circulation influences on California precipitation deficits. Atmospheric Science Letters. 18: 19–28.

Mattson, W.J.; Haack, R.A. 1987. The role of drought in outbreaks of plant-eating insects. BioScience. 27: 110-119.

Melillo, J.M.; Richmond, T.C.; Yohe, G.W., eds. 2014. US National Climate Assessment. Climate Change Impacts in the United States Climate Change Impacts in the United States: the third national climate assessment. U.S. Global Change Research Program.

Mote, P.W.; Rupp, D.E.; Li, S. [et al.]. 2016. Perspectives on the causes of exceptionally low 2015 snowpack in the western United States. Geophysical Research Letters. 43: 10,553-56.

Murray, V.; Ebi, K.L. 2012. IPCC special report on managing the risks of extreme events and disasters to advance climate change adaptation (SREX). Journal of Epidemiology and Community Health. 66: 759–760.

Pielke, R.A.Sr.; Doesken, N.; Bliss, O. [et al.]. 2005. Drought 2002 in Colorado: an unprecedented drought or a routine drought? Pure and Applied Geophysics. 162: 1455–79.

Rau, B.M.; Johnson, D.W.; Blank, R.R. [et al.]. 2011. Transition from sagebrush steppe to annual grass (Bromus tectorum): influence on belowground carbon and nitrogen. Rangeland Ecology & Management. 64:139-147.

Restaino, C.M.; Peterson, D.L.; Littell, J. 2016. Increased water deficit decreases Douglas fir growth throughout western US forests. Proceedings of the National Academy of Sciences of the United States of America. 113: 9557-9562.

Sturrock, R.N.; Frankel, S.J.; Brown, A.V. [et al.]. 2011. Climate change and forest diseases. Plant Pathology. 60: 133-149.

Vose, J.M.; Miniat, C.F.; Luce, C.H. 2016. Ecohydrological implications of drought. In: Vose, J.M.; Clark, J.S.; Luce, C.H.; Patel-Weynard, T., eds. Effects of drought on forests and rangelands in the United States: a comprehensive science synthesis. Gen. Tech. Rep. WO-93b. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. p. 231-251.

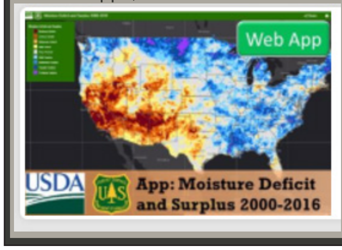
U.S. Geological Survey [USGS]. 2000. Groundwater atlas of the United States. (accessed July 5, 2017).

Wilhite, D.A. and Glantz, M.H. 1985. Understanding the drought phenomenon: The role of definitions. Water International 10(3):111–120.

Wobus, C.; Small, E.E.; Hosterman, H. [et al.]. 2017. Projected climate change impacts on skiing and snowmobiling: a case study of the United States. Global Environmental Change. 45: 1-14.

Office of Sustainability & Climate

Gallery of drought maps, apps,and resources



http://arcg.is/2uTALWW

Version: 9/12/17; 9:00 am

Cover photo - Unita Mountains (© Johnny Adolphson/Shutterstock.com)