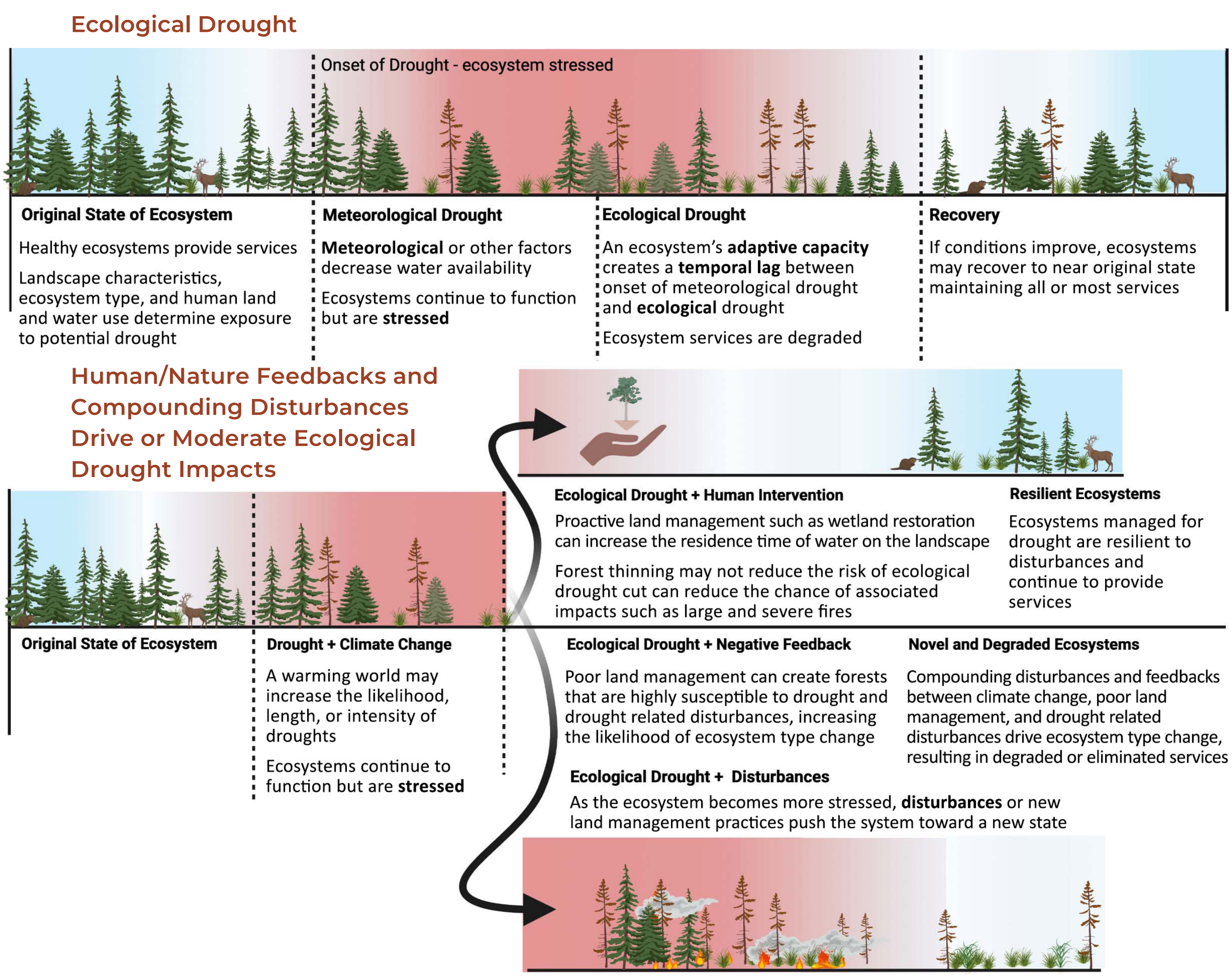
WESTERN WATER ASSESSMENT
A NOAA RISA TEAM
CIRES
University of Colorado **Boulder**

Ecological Drought in the Intermountain West

Understanding A New Type of Drought

Understood as a temporary deficit in the water needed to meet a community's needs, drought has historically been defined from a meteorological or hydrologic perspective. The timing, location, and intensity of droughts were driven by largely predictable atmospheric patterns and surface-atmospheric feedback. Today, climate change, shifting land-use patterns, and growing human water consumption are increasingly controlling water availability and leading to novel forms of drought. Among these new forms of drought is ecological drought. ***Ecological drought*** occurs when ***water availability drops below an ecosystem's needs, increasing a system's susceptibility to compounding disturbances potentially leading to shifts in ecosystem type or health, changes in the services it provides, and cascading impacts to human systems.***[1] Ecological drought can be hard to identify as it often lags reductions in precipitation, changes in land use, or increases in temperature. **Across the Intermountain West, ecological drought increasingly threatens the productivity and health of forests, rangeland, and many spring fed ecosystems**.

Building off foundational papers, [1,2] this factsheet summarizes how ecological drought differs from other forms of drought, illustrates the many pathways to ecological drought, and highlights key mitigation strategies for reducing its impact in the Intermountain West. The figure below illustrates how ecological drought lags reductions in water while interacting with compounding disturbances and human feedback.

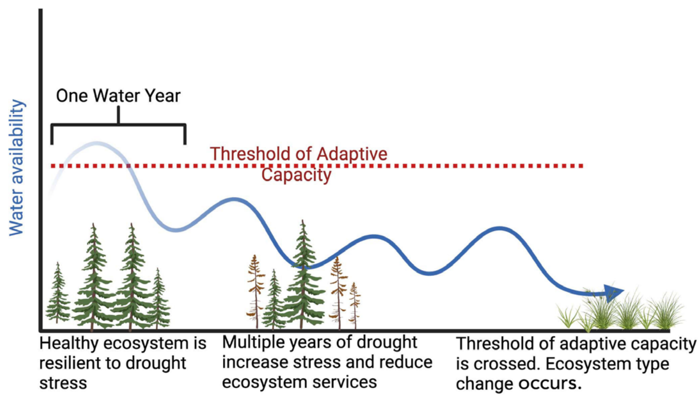


Pathways to Ecological Drought

Ecological drought occurs through multiple and often overlapping pathways. These can be entirely natural or human induced or modified. Many pathways to ecological drought are becoming amplified in severity or frequency due to shifts in climate, changes in land use, and increasing water demands. The pathways below highlight common drivers of ecological drought in the Intermountain West.

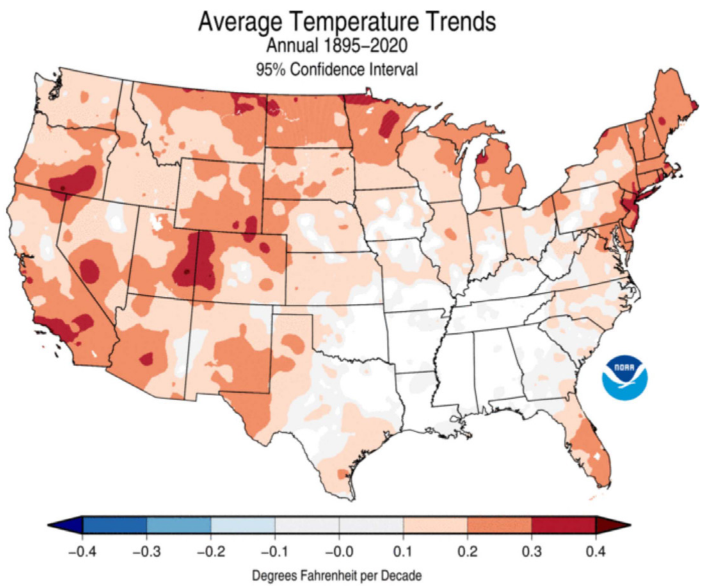
Decreased Precipitation

Ecological drought often begins with meteorological or hydrologic drought. Reduction in the amount of precipitation may lead to decreases in soil moisture, lower snow accumulation, or reduction in groundwater recharge. Initially ecosystems may continue to function. However, if low moisture availability continues throughout or across growing seasons, ecosystems may be pushed beyond their adaptive capacity, resulting in reduced health and function.

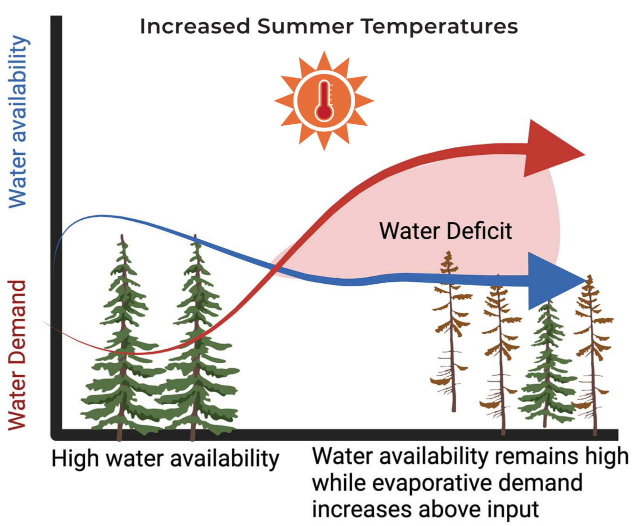


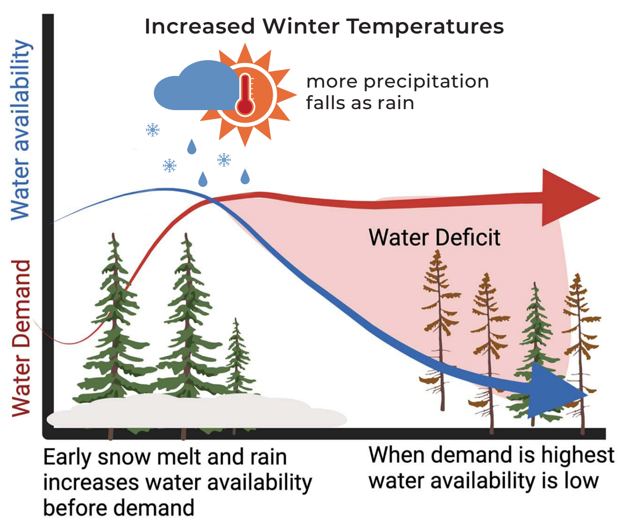
Increased Temperature

Average annual temperatures warmed as much as 4 degrees Fahrenheit between 1896 and 2020 for parts of Western Colorado, Eastern Utah, and Southeastern Wyoming.[3] While projections of future warming vary in magnitude and timing, climate models consistently suggest continued warming. Such increases in temperature will have multiple and compounding effects on water availability. **Increasing winter and spring temperatures** are already lengthening the snow-free season by reducing snowpack and shifting spring melt dates. A longer snow-free season increases overall evapotranspiration and reduces late-summer stream flows, potentially pushing systems into drought conditions even if total precipitation inputs remain the same. Similarly, **increased summer temperatures** can lead to increases in evaporative demand, leading to drought conditions even in relatively wet or good snowpack years.



Average temperature trends in the continental US between 1895 and 2020. Map from NOAA's National Center for Environmental Information.



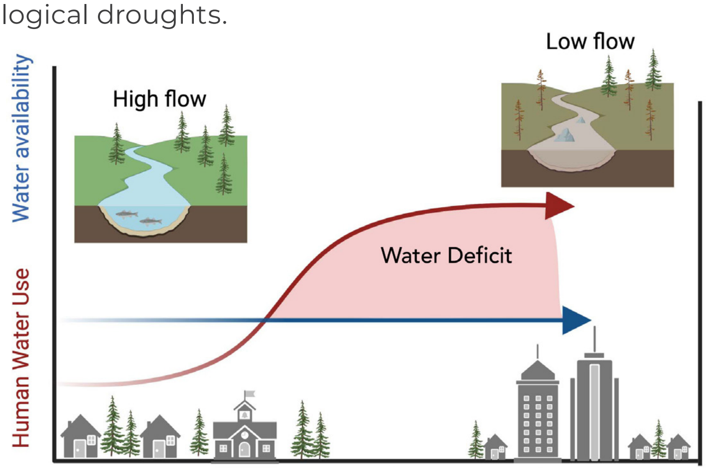


Changing Climate

While recent drought in the western US has been more frequent and severe than those of the last century, paleoclimate data suggest that prolonged and severe droughts have occurred multiple times across the region. Additionally, global climate models provide little consensus as to how greenhouse gases and a warmer climate will impact precipitation totals in the region. However, despite this uncertainty, observed increases in temperature across the region align with multiple global climate models, are the result of increased emissions, and will continue to increase as atmospheric greenhouse gas concentrations continue to rise. This warming, regardless of changes in precipitation totals or timing, will exacerbate already dry conditions as illustrated in the section above and likely lead to increases in the severity and spatial extent of ecological droughts.

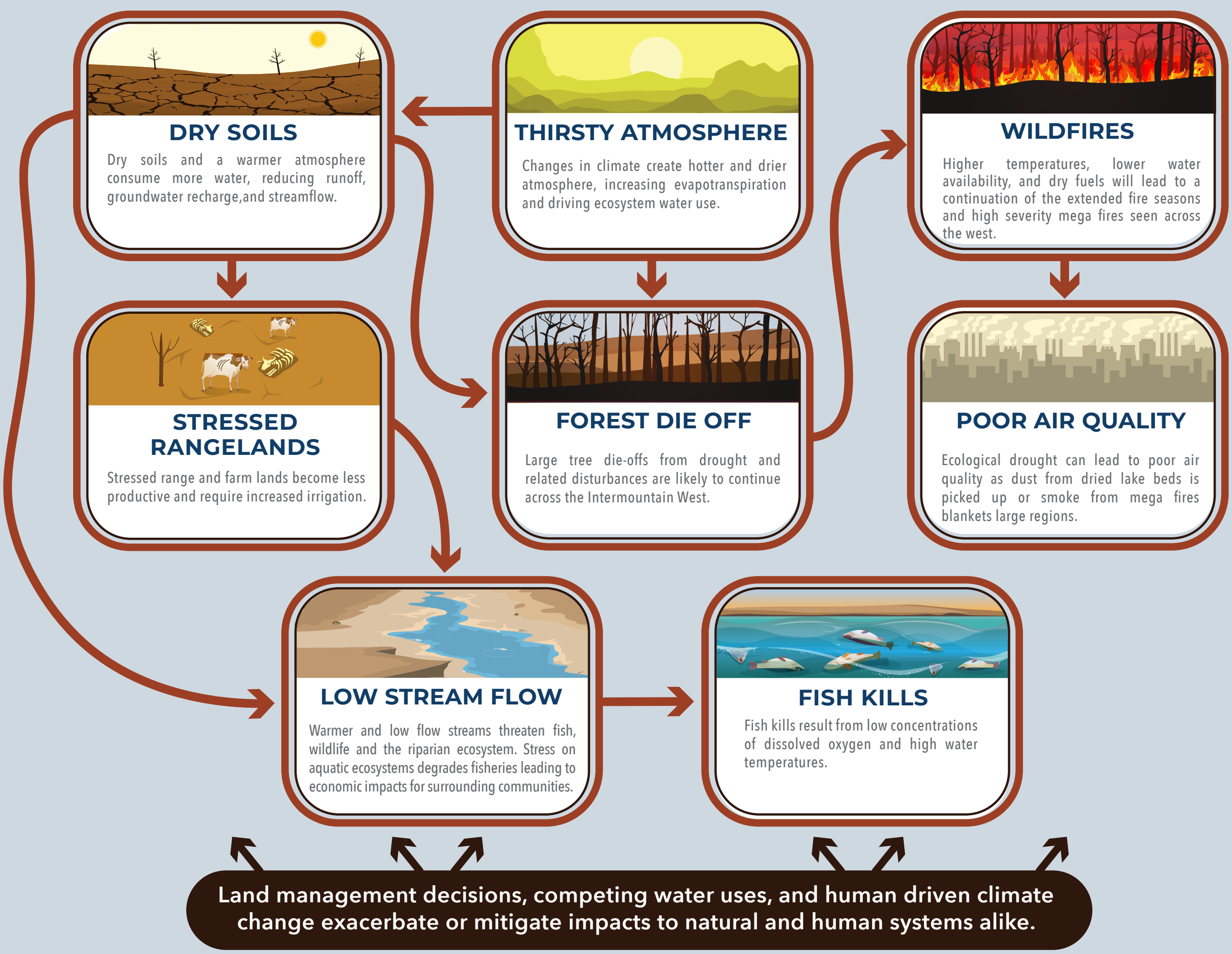
Role of Humans

As human water use grows, extractions have the potential to push stressed systems beyond their threshold of adaptive capacity. Groundwater extraction may be particularly detrimental to ecosystems that rely on springs for their water supply. Spring fed ecosystems, such as the hanging gardens of Utah, are hotspots of diversity as they provide a crucial source of water for both flora and fauna.



Rapid development and increased water demand reduces ecologically available water even if inputs remain the same

Impacts of Ecological Drought in the Intermountain West



Preparing for and Mitigating the Impacts of Ecological Drought

Actively Manage Forest

Reducing tree density ecosystems to return to natural disturbance intervals. It will also reduce high severity fire risk while minimizing transpiration demands. Prioritizing the planting and conservation of drought tolerant species will increase forest resilience to future climate conditions as well.

Photo to the right: Sam Beebe, Ecotrust, Creative Commons.

Reintroduce Beavers

Beavers are nature's engineers, building wetlands that provide refugia during fires and that keep water on the landscape later into the summer.

Photo to the right: Adobe Stock.

Photo below: Two Ponds National Wildlife Refuge, Jefferson County, Colorado. Photo: Seth Beres / USFWS.

Grazing Rotation

Reducing overgrazing and removing invasive species will help stressed ecosystems to maintain rangeland productivity under a changing climate.

Rethink and Rebuild Water Diversion Systems

In some instances, water diversion systems may need to be modified to minimize impacts on groundwater-dependent ecosystems.

Reconnect Floodplains and Side Channels

Rebuilding wetlands will improve aquatic ecosystem function, storing water on the landscape and improving groundwater recharge.

Increase Water Conservation

Using water-smart technologies and community education, water consumption can be minimized, increasing the resilience of communities, and mitigating the multi-year impacts of increased temperatures and low water availability.

References

1. Crausbay, S. D. et al., 2017. Defining Ecological Drought for the Twenty-First Century. Bulletin of the American Meteorological Society 98, 2543–2550.

2. Crausbay, S. D. et al., 2020. Unfamiliar Territory: Emerging Themes for Ecological Drought Research and Management. One Earth 3, 337–353.

3. NCEI, 2021. Temperature, Precipitation, and Drought. National Centers for Environmental Information, National Trends, https://www.ncdc.noaa.gov/temp-and-precip/us-trends/tavg/ann.

Fact sheet written by Ethan Burns. Figures created in BioRender.

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The Western Water Assessment is a university-based applied research program that addresses societal vulnerabilities to climate variability and climate change, particularly those related to water resources. Our mission is to conduct innovative research in partnership with decision makers in the Rocky Mountain West, helping them make the best use of science to manage for climate impacts.