ECOLOGICAL DROUGHT ACROSS THE UNITED STATES

Profound, widespread, and becoming more severe

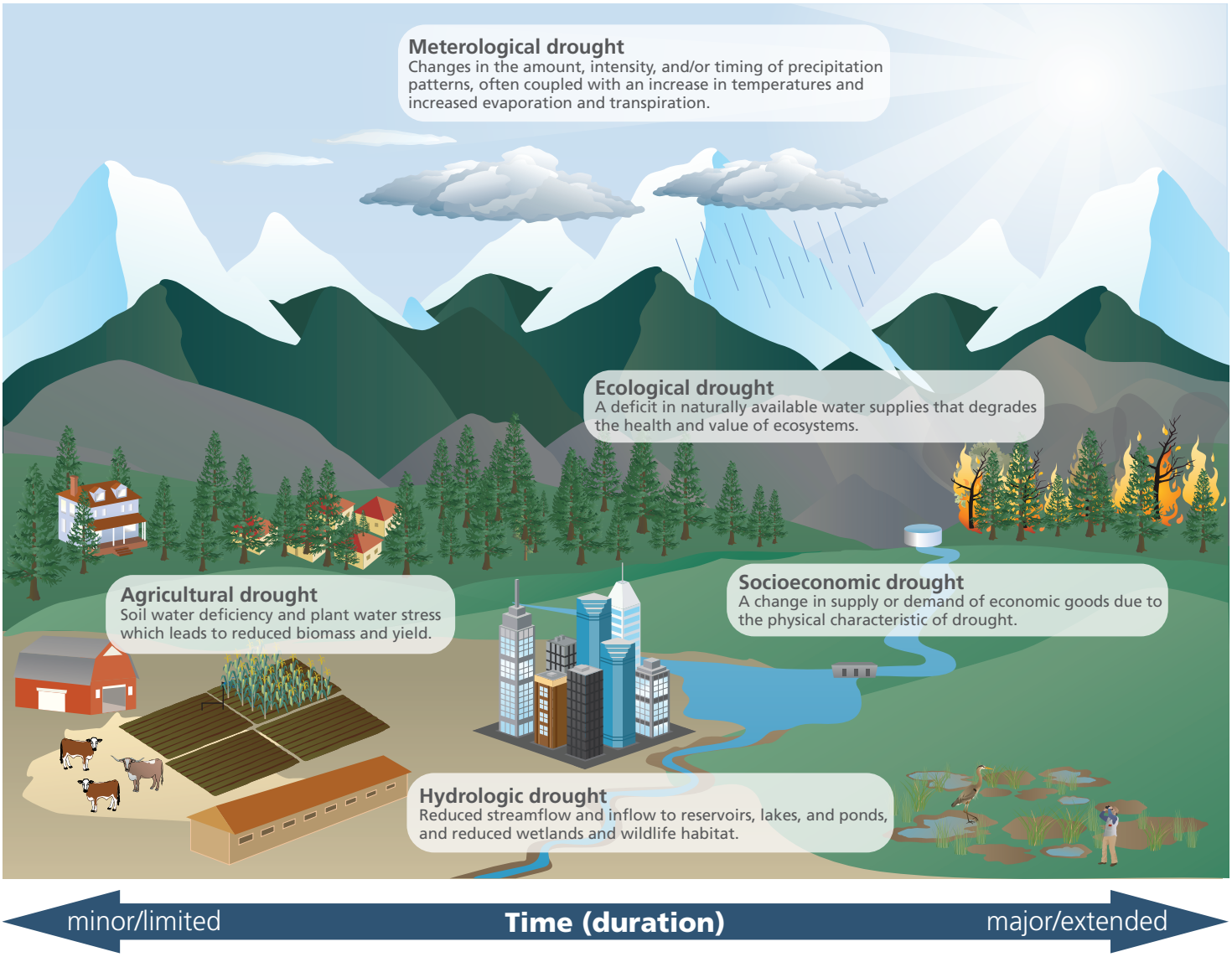
What is ecological drought?

Drought has been defined in numerous ways, often with an emphasis on its effects on food and water security. Existing definitions of drought (meteorological, agricultural, hydrological, and socioeconomic drought) do not fully address the impacts of drought on ecosystems, wildlife, and habitats.

Ecological Drought describes a deficit in naturally available water supplies that degrades the health and value of ecosystems. As global temperatures continue to rise, and climate becomes more variable, the intensity and frequency of ecological drought is expected to increase. Natural resource managers need information that will help them address the impacts of worsening ecological drought on natural systems and to anticipate the resulting impacts on human communities.

Both human and natural systems are experiencing the negative effects of ecological drought across the United States. From reduced water supplies and decreased streamflow, to forest diebacks and massive wildfires, the impacts of drought are broad. Without sufficient planning, the effects of drought over time can be difficult to manage. Every region is susceptible to drought, and widespread, prolonged drought can challenge even the most drought-resilient plants and animals.

Although many droughts occur naturally, the compounding effects of rapid global climate and land use change, along with the associated spread of non-native species that are both fire-promoting and drought-tolerant, can exacerbate harmful impacts on ecosystems and human communities. Consequently, historical patterns of temperature and precipitation may no longer serve as useful benchmarks for planning and decision making as hotter and drier conditions lead to ecological droughts. Land managers urgently require new scientific insights that take into account the compounding effects of drought and climate change, while identifying the ecosystems and wildlife most at risk from ecological drought.



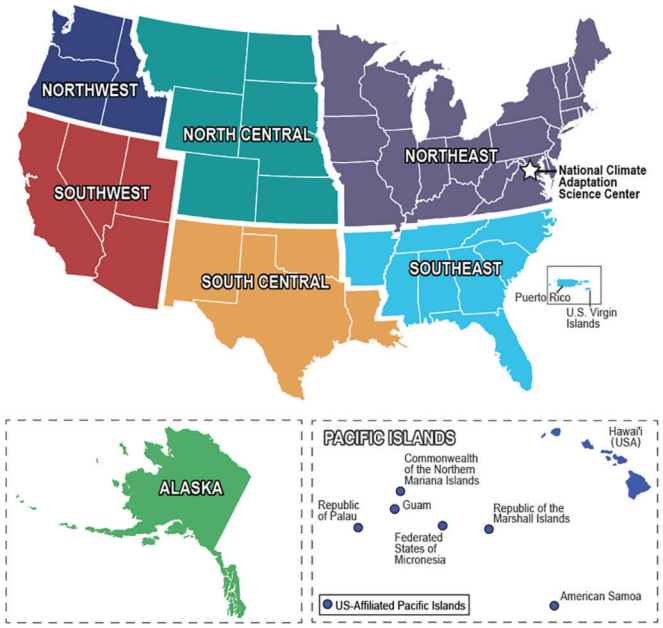
Conceptual diagram illustrating different forms of drought: meteorological, agricultural, hydrological, socioeconomic, and ecological. Adapted from U.S. Fish and Wildlife Service.

Regional workshops synthesized the impacts of ecological drought

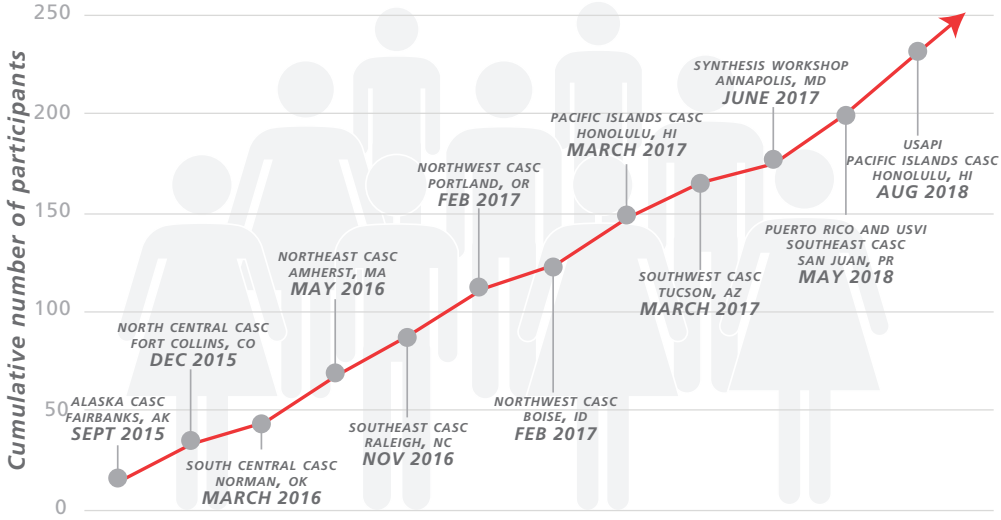
The Department of the Interior Climate Adaptation Science Centers, managed by the USGS National Climate Adaptation Science Center (NCASC), are focusing on ecological drought as an emerging research area. To help identify and communicate regional drought impacts, NCASC teamed up with the Integration & Application Network at the University of Maryland Center for Environmental Science.

The ecological drought synthesis project involved workshops at each of the eight regional CASCs. The eight CASCs provide a unique opportunity to compare the ecological effects of drought, related research activities, and management options at different regions, spatial scales, and biomes across the United States.

Additionally, it was recognized at these workshops that islands such as Puerto Rico, the U.S. Virgin Islands, and the U.S. Affiliated Pacific Islands experience unique challenges related to drought. To delve further into this topic, NCASC held two workshops on island drought - one in Puerto Rico and one in Hawai'i. The scope of these workshops was expanded since water demands are more interconnected in these freshwater-limited landscapes. Thus, island workshops included impacts to agriculture, water supply and distribution and other key sectors.



The location of the eight Climate Adaptation Science Centers (CASCs). Map provided by USGS National Climate Adaptation Science Center.



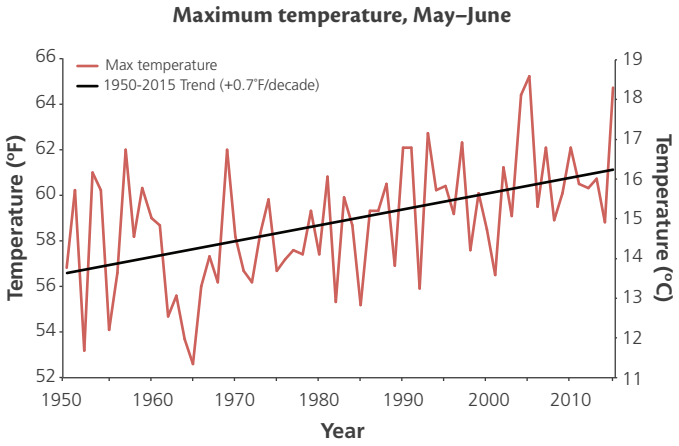
Cumulative number of participants at each of the eight regional CASC workshops, and group photos from each workshop.

Emerging drought themes across the United States

Across the U.S., ecological drought is ubiquitous, profound, and has become more severe. Droughts of the future will be hotter, longer-lasting, and more frequent than droughts of the past. Six types of ecological drought have emerged: Arctic drought, megadrought, snow drought, flash drought, urban drought, and island drought. Each of these drought manifestations has profound ecological consequences, which also affect the social and economic well-being of people in the regions where they occur.

Arctic drought

In Arctic regions like northern Alaska, temperatures are warming faster than the rest of the world, beginning an irreversible thaw of permafrost, decreasing snowpack, and retreating glaciers. These changes do not equate to more surface water availability, as thawed ground absorbs the water. As glaciers retreat and the ground thaws, iconic Arctic wildlife and ecosystems are threatened. Increased erosion and landslides shift loose exposed soils, increasing sediment input into streams. Increased stream sediment alters habitats for fish and other aquatic organisms. Drier vegetation causes more frequent wildfires, and warmer temperatures generate insect outbreaks that spread disease to wildlife. Humans are also affected by the thawing of the frozen landscape: infrastructure is threatened by subsidence as the thawed ground beneath roads and buildings shifts and compacts, and traditional native lifestyles are irrevocably changed with the loss of frozen ground and ice, causing migration and resettlement in extreme cases.



May–June maximum temperature in central Alaska. Researchers have found a strong correlation between warm June temperatures and large fire years. Data from NOAA Alaska Climate Division 3.

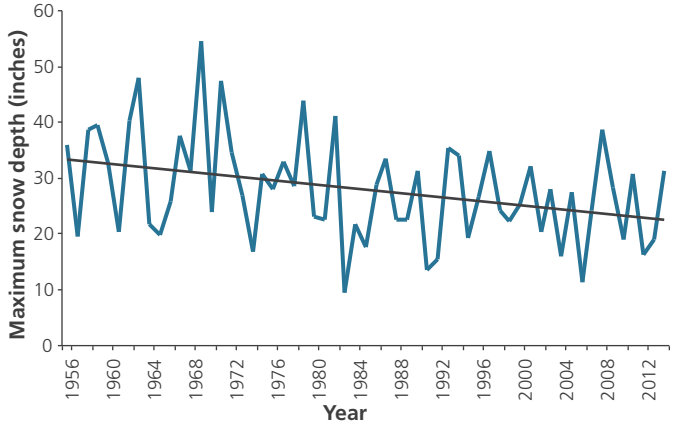
Megadrought

Megadroughts are slow-moving, pervasive droughts that span decades. Megadroughts require managers to think long-term about how to protect natural resources and supply communities with water. As climate and land use conditions change, the potential for these multi-decadal droughts is increasing. Megadroughts are unprecedented in the recent historical record. The closest example in the U.S. was the 1930's Dust Bowl drought, which lasted approximately eight years and impacted over 100 million acres of land. Although some plants and animals have adapted to living under sustained drought conditions, such as in the Southwest U.S., nearby urban areas and communities are growing – meaning water is in even higher demand, exacerbating periods of stress.

A dust storm approaching Stratford, Texas (April 18,1935). The dust bowl taught managers to manage for soil conservation; however, droughts of the future require new and innovative techniques. Source: NOAA.

Snow drought

Shifts in precipitation from snow to rain, combined with earlier spring snowmelt, can alter water availability and the timing of high flow periods. This can have important impacts on aquatic and riparian ecosystems. Therefore, it is important for natural resource managers to consider not only the amount of available water, but also its form and timing. The timing and length of the snow season impacts the life histories of plants and animals. Snow season length influences growing season length, which can lead to changes in species distributions, migratory bird species ranges, and habitat availability. Warming winter temperatures will reduce winter snowpack and cause earlier spring snowmelt, a longer growing season, and worse summer droughts.



Maximum snow depth observed at Hubbard Brook Experimental Forest (New Hampshire) from 1955-2015. Data provided by John Campbell, United States Forest Service.

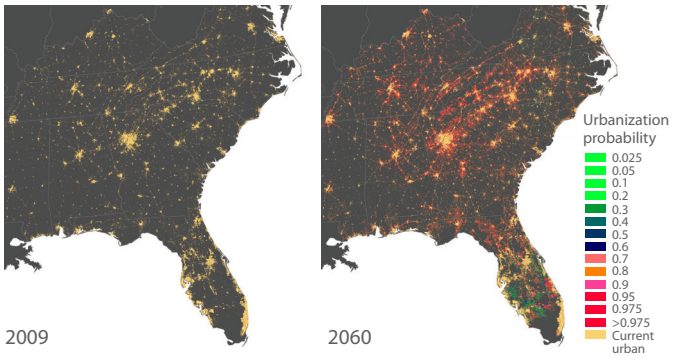
Flash drought

Flash drought occurs when drought conditions intensify over the course of weeks rather than months. This rapid onset of impacts can be caused by a lack of rain and/or a sudden rise in temperature. Soil loses water very quickly during flash droughts, harming agriculture, ecosystems, and water supplies. Sudden low water levels can cause water quantity and quality declines, negatively affecting fish and wildlife that depend on healthy aquatic environments. Because vegetation is under so much stress from lack of water during flash drought, it is more vulnerable to pests and disease. As dead wood accumulates, the risk of wildfire also increases. Areas that have been impacted by frequent wildfire are in turn at higher risk for flash floods, which can carry large amounts of loose sediment downstream and negatively affect human and ecological communities.

A corn field shows the effect of drought in Texas (2013). Rapid decreases in soil moisture during a flash drought have detrimental effects on water supplies, agriculture, and ecosystems. Photo by Bob Nichols, USDA.

Urban drought

Population growth in urban areas can create "thirsty cities." Increased population means increased water demand by the energy, agricultural, and urban sectors. This results in an increase in water competition between human use and ecological needs, and can lead to deficits in the amount of water needed to fulfill demands. Higher demand for a limited (and sometimes decreasing) supply of water can lead to a supply-demand mismatch. The resulting water scarcity creates challenging trade-offs between recreation, economic needs, and the overall health of people and communities. A host of negative health consequences rise in the midst of any drought, which can be particularly apparent when occurring in densely populated urban areas. As parched soils release particles to the air, the occurrence of respiratory illnesses increase. More frequent fires in drier, hotter drought conditions can create unhealthy or even hazardous air quality conditions and pose widespread risk to health and safety. As droughts shrink bodies of water, pest populations also increase, as do diseases such as West Nile Virus and bacterial infections.



Water resources in the Southeast United States have been abundant and sufficient to support heavily populated urban areas, rural communities, unique ecosystems, and economies. As the population continues to grow, it is imperative to understand how climate change and drought will further influence water availability. Urban land cover in 2009 (left) in the Southeast United States and projected urban land cover in 2060 (right). Scale indicates probability of urbanization. Source: Terando et al. 2014.

Island drought

Island environments experience unique drought conditions. Large-scale climate variability causes shifts in regional wind and storm patterns, reducing overall rainfall across many island territories. Natural freshwater storage is typically limited on islands, and even minor changes in precipitation have serious island-wide effects. Drought conditions threaten the delicate ecology of many islands. Reduced water availability threatens the unique, endemic species on islands compared to invasive flora and fauna that can better withstand drought. In Hawai'i, ungulate migration during droughts has proven particularly damaging to native species. Dry vegetation also increases the frequency and intensity of wildfires, causing extensive damage to native ecosystems.

*The Wiliwili tree (*Erythrina sandwicensis*) is drought tolerant, however, invasive pests, invasive grasses, and fire have threatened remnant dry forest populations. Source: Rosa Say / CC BY-NC-ND*

HOW OUR WORK IS DIFFERENT

- **Drought can change ecosystems, with implications for human communities**
- **But these ecological impacts of drought are not typically examined**
- **We are identifying how drought impacts ecosystems to support adaptation planning**

The overarching goal of the Ecological Drought initiative is to support the effective management of ecosystems and human communities in the context of drought. To meet this goal, we aim to:

1. Identify drought impacts across the country
2. Synthesize our knowledge of the ecological impacts of drought, so that we can get a complete picture of what we know and where the gaps are - which will help guide future research
3. Communicate this knowledge to resource managers and other stakeholders
4. Support decision-making by ensuring the resource managers have the information they need to prepare for and respond to drought.

For more information

To learn more about ecological drought across the country, and our efforts to synthesize its impacts, please visit *casc.usgs.gov/science/ecological-drought*. Here you can also access the newsletters that resulted from each of the eight regional workshops.

A special thanks to all of the participants in the regional ecological drought workshops for their support and continued contributions to the synthesis effort.

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Workshop participant photos: *University of Maryland Center for Environmental Science.*

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USGS science for a changing world

For more information on the Ecological Drought synthesis effort, and each of the eight regional Climate Adaptation Science Centers, visit casc.usgs.gov/science/ecological-drought