

Ecological Drought in the Southwest United States Confronting a hotter future

Southwest Climate Science Center Workshop
March 28-29, 2017
Tucson, Arizona

The Department of the Interior Climate Science Centers (CSCs) and their managing organization, the National Climate Change and Wildlife Science Center at the U.S. Geological Survey, have chosen the emerging climate science field of Ecological Drought as a research focus area. This workshop is part of a series of meetings at each of the nation's eight CSCs aimed at collating our existing knowledge of the ecological impacts, resistance, and recovery from drought. The eight CSCs provide a fantastic opportunity to compare the ecological effects of drought, related research activities, and management options at different regions, spatial scales, and biomes.

The arid Southwest faces an even hotter, drier future

Drought has long shaped the iconic landscapes of the Southwestern United States. However, the immediate threat of increasing temperatures are amplifying and accelerating the impacts of drought on humans and ecosystems. Ecological drought – the prolonged and widespread deficit in naturally available water for ecological processes—will drive ecosystems of the arid Southwest beyond natural thresholds, affecting ecosystem services, and triggering feedbacks in natural and human systems of the region.

Retaining the Southwest's awe-inspiring landscapes

The Southwest contains some of the most diverse and stunning landscapes in the country, ranging from the lowest to the highest points in the contiguous U.S. These landscapes include dramatic coastlines, deserts dotted with columnar cacti, deep 'slot' canyons, the world's tallest forests, and craggy, snowy peaks. These landscapes support the plants and animals that define the region, provide recreation and inspiration, and have fostered a long history of human livelihoods and ecological diversity. As the climate warms, and longer, hotter droughts emerge, threats to these iconic landscapes are rising. With science-informed land and water management, we will increase our capacity to adapt to these changes.



National Park Service

Ensuring a water resilient Southwest

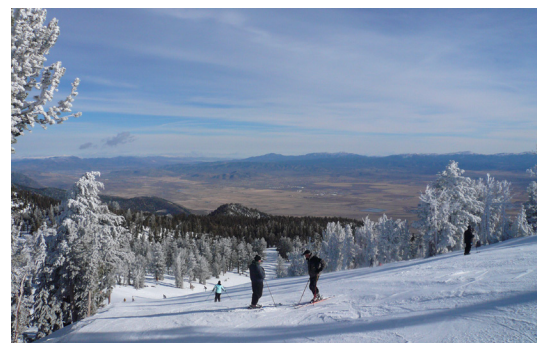
Water is the lifeblood of the Southwest. Ecosystems of the Southwest have evolved under a climate regime that includes droughts lasting years, decades, and even longer. Unique adaptations to drought have given rise to an amazing variety of plant and animal communities. In recent decades, warming temperatures have exacerbated water the demands of natural ecosystems and growing human populations. As we learn about the consequences of a hotter and drier future, we will need to take action to improve the ability of human communities' and ecosystems' ability to adapt to these increasingly rapid changes.



J.N. Stuart

Maintaining public lands to provide unique opportunities and experiences for people from around the world

Natural and cultural resources provide a high quality of life for residents and unique experiences for visitors alike, which provides a boon to the Southwest's economy. Abundant open spaces support wildlife watching, hunting, fishing, boating, skiing, hiking and camping. These recreational opportunities and supporting businesses contribute billions of dollars to the region each year. As a result of hotter, drier conditions, the Southwest stands to lose unique natural resources. Innovative and integrated approaches for preparing and coping are urgently needed to maintain the Southwest's economy and way of life in the face of drought.



Lawrence's Lenses

Hotter drought has arrived in the Southwest United States

Landscapes of the Southwest have been shaped by drought. However, landscapes of the Southwest are approaching a new standard of more frequent and severe droughts. Species are under major threat not only from severe and sustained droughts, but also the immediate threat of increasing temperatures that are amplifying and accelerating the impacts of drought.

Increasing water demands in a region of limited water supplies

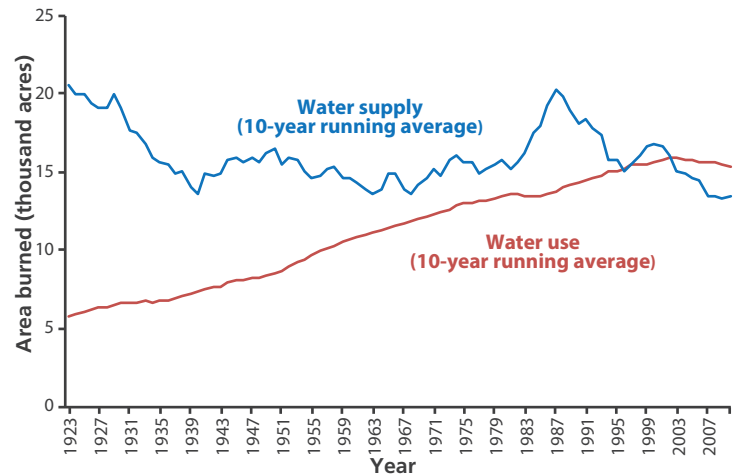
Population growth and increasing development in the Southwest—the fastest in the US—are putting ever-increasing demand on the limited water supplies. From river systems sustaining plant and fish, to rangelands and forests, each of these systems require water to sustain themselves and the people who depend on the them. The over-allocation of water supplies for human use across the region rarely accounts for the needs of natural ecosystems. Hotter drought exacerbates this situation. Land and water managers and decision makers need to work together to better incorporate the water requirements of both ecosystems and humans in their planning as the climate continues to warm and dry.

We risk losing our iconic landscapes

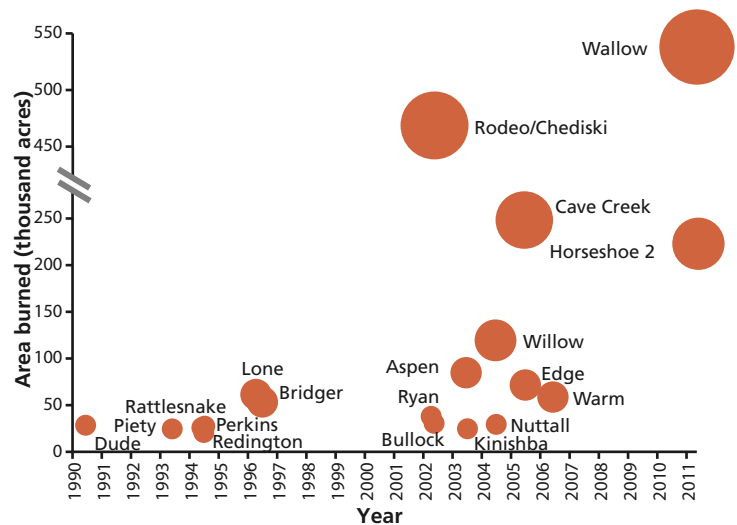
Although the Southwest region is where drought impacts are often unmistakable, novel features of the region's recent drought are unprecedented in our history, with massive wildfires, formidable bark beetle outbreaks, widespread forest dieback, and record-low snowpack and reservoir levels. Drought and resulting dryness increase the likelihood of wildfire, often resulting in the loss of native vegetation. When the precipitation finally arrives, the increasing force of these storms can lead to severe erosion on wildfire-scalded mountain landscapes, reducing water quality and overwhelming existing water infrastructure. These pressures represent significant risk of permanent changes in plant and animal communities, and the prevalence of such transformations are likely to increase in coming decades. The region's iconic landscapes and the human populations need adaptation strategies that help reduce the risk of catastrophic losses.

Nature's benefits are at risk

Intact ecosystems provide a multitude of cultural, economic, and recreational benefits for people in the Southwest US. The cascading effects of drought put these benefits at risk on the region's private and extensive public lands. In particular, rural economies and community livelihoods will be increasingly impacted by degradation and desertification of rangelands and agricultural areas. Human health is already suffering from the increased frequency and intensity of large dust storms that negatively affect air quality and reduce highway safety. Drought-induced reductions in water availability and quality increases the cost of providing clean water for drinking, fishing, and swimming. Winter skiing and outdoor recreational tourism are at risk from decreased snowpack, resulting from earlier onset of springtime temperatures and exacerbated by rainfall and dust-on-snow events.



Colorado River Basin historical water supply and use. Data from U.S. Department of the Interior Bureau of Reclamation.



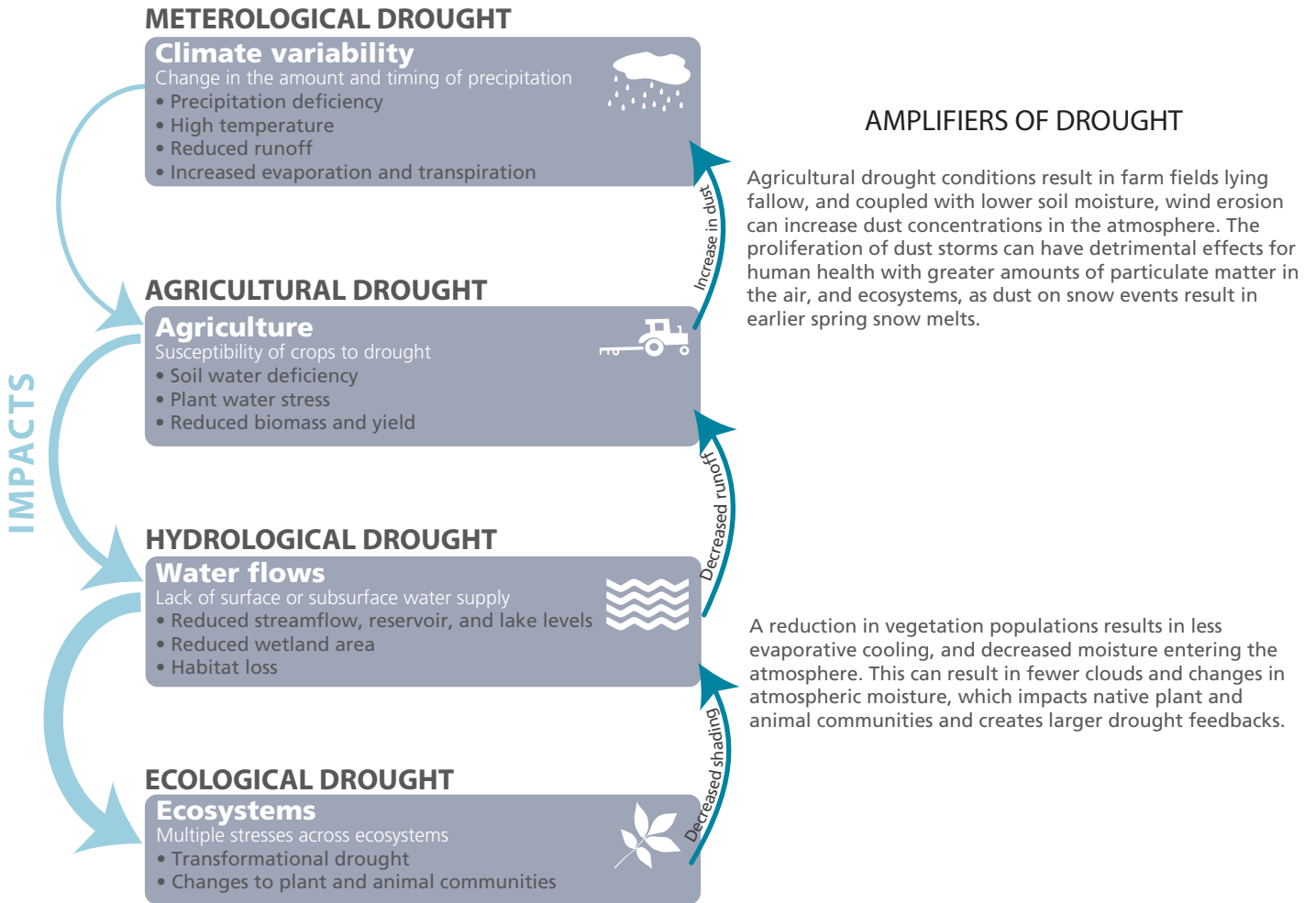
Largest Arizona wildfires, 1990-2012. Labels indicate fire name. Adapted from A. Youberg, AZGS; data SW Climate Assessment (SWCC Historic data).



Dust on snow events decrease albedo, and result in earlier spring snow melts Photo: C.B. Enquist.

Compounding impacts and amplifiers of drought

All droughts originate from a deficiency of precipitation (meteorological drought), but other types of drought and impacts cascade from natural climate variability. Long periods without rainfall can alter the delicate balance of human and natural ecosystems, further amplifying the impacts of all drought types. Although drought occurs naturally in the Southwest United States, the compounding effects of climate change exacerbate the impacts, wreaking havoc for ecosystems and their human counterparts. The term ecological drought encompasses and emphasizes these environmental consequences, including losses in plant growth, increases in fire and insect outbreaks, local species extinctions, as well as altered rates of carbon, nutrient, and water cycling.



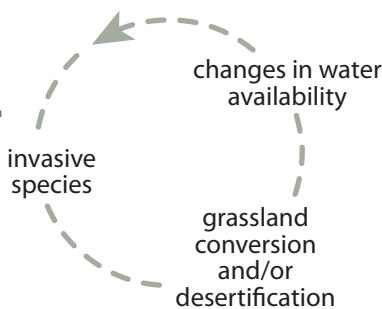
COMPOUNDING IMPACTS OF ECOLOGICAL DROUGHT

In grasslands, shrublands, and deserts, increased dominance by invasive species promotes conversion of vegetation, wildfire risk, and desertification. These changes in landcover can negatively affect water availability and aquatic resources: loss of shading for snow cover, increased evaporation, reduced infiltration for groundwater, warmer stream temperatures for cold water fish, lowered stream flows early in the growing season, and less water in reservoirs and lakes.

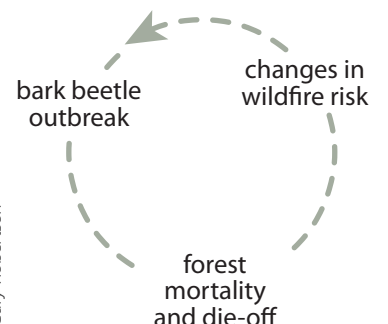
Dry vegetation serves as fuel and can lead to the proliferation of larger, more severe wildfires. Drought-stressed forests are susceptible to bark beetle outbreaks and subsequent widespread dieback, which can initially amplify the risk of fire. Many forested areas are not regenerating, resulting in diminished carbon stocks and degraded wildlife habitat.



U.S. Bureau of Land Management



Gary Robertson



Preparing for future droughts

Drought is nothing new in the American Southwest, but rising temperatures are increasing the vulnerability of the region's fish, wildlife, natural features, water resources, and human populations to severe drought. The region has been in the grip of persistent drought for nearly two decades, and for much of this period, drought severity has been amplified by record-high temperatures. Drought-related events of the past few years may offer glimpses of the 21st century and beyond, as rising temperatures interact with natural climate variability in the Southwest and elsewhere. Such "transformational drought" impacts in the region are unprecedented, with massive wildfires, extensive forest mortality, and record-low snowpack and reservoir levels. Of particular concern is the emergence of novel ecosystems in the aftermath of severe drought-related disturbances. Researchers and resource managers alike will need to think beyond conventional boundaries, anticipate surprises, and prepare for unfamiliar conditions, events, and outcomes. This can be done most effectively with intensive engagement, dialogue, and collaboration among researchers and stakeholders. What's being learned in the current drought can inform development of potential scenarios for future drought impacts, and develop effective plans for adaptation. A major priority for the Southwest Climate Science Center is to draw on lessons and experience from the recent past to anticipate and prepare for the droughts of the future.

– Steve Jackson, Director, Southwest Climate Science Center



Fires result in the loss of vegetation and exposure of soil to erosion, and increased water runoff may lead to flooding and damage to critical natural and cultural resources. Photo: USDA.



Participants at the Southwest Climate Science Center workshop held in Tucson, Arizona in March, 2017.

Workshop participants

Genevieve Johnson, *U.S. Bureau of Reclamation.*

Julian Reyes, *U.S. Department of Agriculture.*

Matthew Grabau, *U.S. Forest Service.*

John Bradford, Adrian Das, Carolyn Enquist, Stephen Jackson, *U.S. Geological Survey.*

Shelley Crausbay, *University of California at Santa Barbara.*

Scott Bonar, Donald Falk, Daniel Ferguson, Jonathan Overpeck,

Christine Schirmer, Connie Woodhouse, *University of Arizona.*

James Thorne, *University of California Davis.*

Science communication, layout, and design:

Simon Costanzo, William Dennison, Brienne Walsh, *University of Maryland Center for Environmental Science.*

Cover photo:

Photo by JR P / CCBY-NC-ND

For more information regarding ongoing research and activities
at the Southwest Climate Science Center,
visit swcsc.arizona.edu

