

Who's paying attention to the drought on the Colorado Plateau?

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Daniel Ferguson, CLIMAS program manager, and Michael Crimmins, a climate science extension specialist for Arizona Cooperative Extension, visited staff members from the Hopi Department of Natural Resources (DNR) in May to discuss drought and climate change on the Colorado Plateau. During the day-and-a-half Ferguson and Crimmins were able to spend with the Hopi DNR, one theme continually emerged: who's monitoring the current drought on the Colorado Plateau?

Driving along Arizona Highway 264 toward the Hopi mesas in May 2009, our conversation kept circling back to the unusual thunderstorms that had been forming across the southern Colorado Plateau all week. These climatologically uncommon rains were a welcome relief from an otherwise dry 2009, but they certainly did not signal the end of the long-term drought plaguing the region. At the behest of Arnold Taylor, manager of the Hopi Department of Natural Resources (DNR), we were headed to Kykotsmovi, Ariz., to meet with staff members from the Hopi DNR to discuss drought and climate change on the Colorado Plateau and begin assessing the DNR's small weather monitoring network.

Prior to our visit, we were well aware that monitoring in this part of the Southwest was spotty at best, even though several federal agencies, including the National Weather Service (NWS), the US Geological Survey (USGS), and the US Department of Agriculture (USDA), and both the Hopi Nation and Navajo Nation have weather stations and stream gages across this part of the plateau. We also knew the ongoing drought was creating a variety of impacts, but our day-and-a-half visit with our Hopi colleagues made

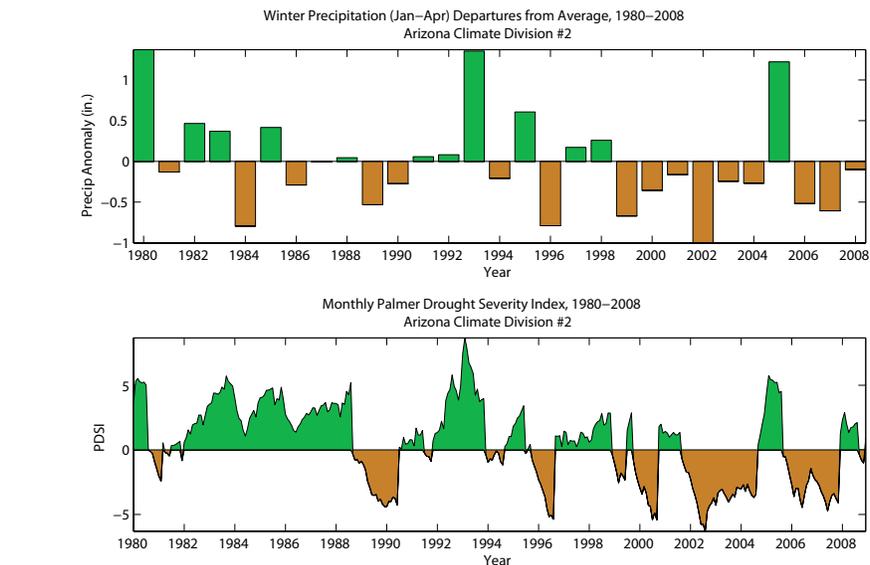


Figure 1. Precipitation and Palmer Drought Severity Index data from Arizona Climate Division 2, 1980–2008.

clear that natural resource managers and climate scientists alike were all facing the same fundamental question: Is anyone actually capturing the current drought on the Colorado Plateau?

Mr. Taylor had invited us to the Hopi Nation to brief his staff about current science, but perhaps more important, he wanted to make us aware of drought conditions on the reservation and Hopi efforts to monitor it.

The string of very dry years has Mr. Taylor concerned about present conditions as well as anticipated changes in climate that are expected to bring even more intense droughts. In the midst of this current drought, it is clear the somewhat ad hoc climate monitoring network across the region is having difficulties resolving and tracking these conditions.

Hopi people have been living on or near the mesas at the heart of the current Hopi reservation for more than a millennium. Located on the Colorado Plateau, in the Little Colorado River watershed, the Hopi landscape encompasses high mesas, deep canyons, and an arid climate.

As dryland farmers and ranchers, the Hopi have a long and deep cultural relationship with the climate of the Southwest. Drought is neither uncommon nor unexpected in Hopiland, but current drought conditions and recent science about a future warmer, dryer Southwest has decision makers across the desert Southwest, including Hopi resource managers like Mr. Taylor, asking a common question: how do we best proceed into a climatologically uncertain future?

One clear component of any answer to this question is effective monitoring of weather, climate, and drought impacts. Our Hopi hosts made clear throughout our visit that monitoring on the Hopi Nation and across the Colorado Plateau is inadequate for the climate adaptation task at hand. Recent work led by CLIMAS investigator Dr. Gregg Garfin and a team of researchers from The University of Arizona, Arizona State University, and Northern Arizona University, in partnership with the Navajo Nation, resulted in a detailed assessment of monitoring issues on the Navajo Nation

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that also indicated a large climate monitoring gap on the Colorado Plateau.

Drought on the southern Colorado Plateau: 15 years and counting

Both the Hopi Nation and Navajo Nation in northern Arizona have quietly been suffering through drought conditions for well over a decade. A quick look at coarse precipitation data for the northeastern quarter of Arizona (Climate division 2, covering all of Coconino, Apache, and Navajo counties) shows that winter precipitation from January through April has been below average 11 out of the last 15 years since 1994 (Figure 1). The years 1996 and 2002 stand out as exceptionally dry, with most of the other years just below the long-term average for winter precipitation. A plot of monthly Palmer Drought Severity Index (PDSI) values over the same period shows a clearer picture of the cumulative effect of the somewhat subtle string of below-average winters (Figure 1). A shift from very wet conditions

in the winter of 1993 to very dry in 1994 marked what several Hopi natural resource managers that we met consider the beginning of the current long-term drought. Below-average precipitation has kept PDSI values negative (indicating dry conditions) in a majority of months up through the present.

An unusually wet winter spanning December 2004 through February 2005 brought widespread, heavy snow to northern Arizona and temporary drought relief. Above-average temperatures and below-average precipitation later that spring quickly melted snow and brought back short-term drought conditions, as depicted in the deep drop in PDSI values (see Figure 1).

These climate data only hint at the actual drought conditions experienced on the ground by the Hopi and Navajo people. Resource managers on the Hopi Nation report wide-ranging drought impacts to rangeland and water resources, including poor forage quality and dry stock tanks.

During our visit to Kykotsmovi, we were presented with photographs and range reports related to extreme dust storms in April 2009. These storms buried rangelands on parts of the Hopi Nation as high winds moved loose soil from dunes and already degraded rangelands. Several inches of dust smothered vegetation across the plateau, leading to further impacts on range conditions. Such wind-driven sandstorms have plagued the Hopi Nation and Navajo Nation in recent years. Indeed, research by U.S. Geological Survey (USGS) scientist Dr. Margaret Hiza-

Redsteer has indicated recent drought conditions have supported a large increase in wind erosion and sand dune mobility across northeastern Arizona. In addition, as reported in the June 2008 issue of *High Country News*, Dr. Hiza Redsteer and University of Arizona Ph.D. candidate Casey Thornbrugh observed that higher spring temperatures in recent years have negatively impacted rangeland vegetation, leading to more wind erosion and movement of sand dunes.

The sensitivity of this landscape to complex interactions between temperature and precipitation variability and its ominous slide toward desertification argue for more responsive and place-based drought monitoring strategies. These could include a combination of volunteer climate observations, new remote sensing-based tools, and investment in new, high-quality official monitoring stations tied to national networks (e.g., NOAA Climate Reference Network).

Compounding dust storms and desertification, warming temperatures and the invasion of new weed species hamper the recovery of rangelands when more favorable rains return. In addition, in an area where livestock production is an important industry, the invasive weeds are changing the composition of existing forage; many of the encroaching species are of limited palatability or are even toxic to livestock, reinforcing the stress on ranching operations. During our visit, Priscilla Pavatea, director of the Hopi Range Management Office, reported the total number of cattle on Hopi lands has fallen 60 percent since 1994 due to decreasing forage production and quality.

A challenging geography for drought monitoring

These drought impacts are particularly surprising if you look at a current map of long-term precipitation deficits for



Figure 2. Rangeland across the Hopi Nation and Navajo Nation was heavily impacted by severe dust storms in April. Range conditions, already stressed by overgrazing and years of persistent drought, have been degrading rapidly in recent years.

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the region or even the current National Drought Monitor (see page 8). Precipitation totals have been slightly below-average over the past couple of years, but have not signaled a deep and persistent drought. Why is it that current drought monitoring programs at state and national levels seem to be overlooking this drought situation on the Hopi Nation and Navajo Nation?

Part of the problem is explained by examining how precipitation and temperature data, key variables in tracking drought conditions, are collected across this region. The recent work by Dr. Garfin and his colleagues to assess hydroclimatic monitoring needs for the Navajo Nation found only 20 active National Weather Service Cooperative Observer (NWS-COOP) sites collecting temperature and precipitation data across the Navajo and Hopi reservations. The land area of the two reservations covers nearly 30,000 square miles, roughly the size of South Carolina, which has more than 100 NWS-COOP sites.

The 20 NWS-COOP sites on the reservations are distributed relatively well across the Navajo and Hopi lands but cannot even begin to adequately characterize the complex climatic patterns across the region. Only a subset of them have reports timely enough to be integrated into weekly and monthly climate maps used by state and national drought monitoring officials.

Elevations vary from over 2,500 meters in the Chuska Mountains to less than 1,200 meters along the banks of the Colorado River, so the region is home to dramatically varying mean precipitation amounts and vegetation communities that range from conifer forest to desert scrub.

The characteristics of the precipitation that falls across this region also creates a challenging environment for climate and drought monitoring. Winter storms typically bring widespread light- to moderate-intensity rain and snow, providing relative

uniform coverage that can support the recharge of soil moisture and local water resources. Summer thunderstorms, on the other hand, can be very isolated, dropping large amounts of rain over small areas. This can create a patchwork of drought impacts during the summer that reflects where precipitation has or has not fallen. Only very dense rain gage networks—which the reservations lack—can capture the capricious patterns of precipitation during the summer in northern Arizona.

Furthermore, traditional precipitation-based drought metrics have missed some subtle but important interactions with other climate variables, adding to the drought monitoring hurdles in the region. Increasing temperatures over the period have been implicated in exacerbating some of the observed drought impacts by creating additional moisture stress on vegetation.

Monitoring drought and climate for the 21st century on the Colorado Plateau

On the morning of the second day of our visit to Kykotsmovi, we had the opportunity to visit two of the Hopi Water Resources Program's (WRP) weather monitoring stations with Jon Mason, the WRP Non-point Source Coordinator, and Shirley Piqosa and Avery Pavinyama, both WRP technicians.

Through the WRP, the Hopi DNR is able to gather some weather data across a handful of sites on the Hopi Nation. The small network the program is able to maintain, however, is insufficient for truly monitoring climate or drought, a fact that is abundantly clear to Mr. Taylor and the DNR staff. With extremely limited resources, the Hopi DNR, like many other natural resource management agencies throughout the region, is unable to gather enough quality data or analyze what they can collect in such a way that it is useful for decision making.

With a potential long-term drought already underway, and a strong signal

that the whole Southwest is warming, it seemed clear to all of us during our visit that it is going to take a sustained effort and a number of partnerships to begin addressing the monitoring gap that exists on the Colorado Plateau.

Our visit to Kykotsmovi presented us with a question: who is monitoring drought and climate on tribal nations on the Colorado Plateau? The answer, it turns out, is many of us in the climate science and natural resource management communities are monitoring the situation, but in an incoherent and uncoordinated way that does little to support management decisions across the region. With an ad hoc network of instruments from the Hopi Nation and Navajo Nation, the National Weather Service, the USGS, and a variety of other entities, a steady stream of information exists but much of it is ill-suited for answering fundamental questions about adapting to climate.

One obvious path forward is working toward better coordination and cooperation among the many stakeholders in the region. The Hopi and Navajo reservations represent a significant portion of the Colorado Plateau and Colorado River watershed. Given the scale of this area, tribal, federal, and state land and water resource managers all have an interest in better climate monitoring across the region. Neither the tribes themselves, nor any one agency, is well positioned to solely support monitoring and data analysis activities on the Plateau.

Short-term resource management decision making and long-term climate change adaptation planning both require a high-quality regional climate monitoring network. Building creative partnerships and working together to find resources and coordinate efforts currently offers the best hope of improving our collective understanding of what is happening now across the region and how to prepare for anticipated changes in climate in the future.

