CLIMAS
Southwest Climate Outlook
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THE UNIVERSITY OF ARIZONA®

Average winter rains in Arizona could bring drought relief

When the most recent water year ended in September, the state of Arizona was in much better shape than it had been in the previous year. Perhaps surprisingly, a round of normal winter rain and snow could be enough to pull much of the state out of drought, at least in the short term. This represents a dramatic improvement over last year, when there was virtually no chance of the drought ending from winter season precipitation.

This assessment follows from the average state value of -3.3 on the Palmer Drought Severity Index (PDSI). As Figure 1 indicates, six of the seven climate divisions in the state improved compared to the water year ending September 30, 2002. In southeastern Arizona (climate division 7 on Figure 2), conditions remained dire in some places, particularly in Cochise and Graham counties.

In general, 6 to 10 inches of precipitation in the six months from October through March would be enough to pull the state out of drought. The statewide average for the same six-month period is 6.2 inches. Although 46 of the past 108 winter seasons (42 percent) have produced a statewide average of 6 inches or more, only nine winters have yielded statewide precipitation averages of 10 inches or greater.

So the likelihood of a statewide reprieve depends on the precipitation falling in the right place as well as the right time. The approximate amount of rain required by each climate division to escape drought conditions and the probability of this occurring are shown in Table 1, which is based on the Palmer Hydrological Drought Index (PHDI) rather than the PDSI. Both indexes use the same two-layer soil model to assess water balance, but the PHDI is slightly more conservative (1).

Even with the PHDI, the six-month prognosis (October–March) was yielding about a 1-in-5 to almost 1-in-2 chance that drought conditions could end by April in four of the seven climate divisions (Table 1), with odds greater than 1-in-10 for the remaining divisions. Admittedly, these are not great odds, but they are markedly better for most divisions than the three-month prognosis (October-November), as the table indicates. What's more, the three-month prognosis for November–January improved for every region except climate division 6, which had been temporarily freed of the clutches of drought by official standards as of September, at least in the shorter term prognosis.

These probabilities—and the determination of whether a division is in a drought, for that

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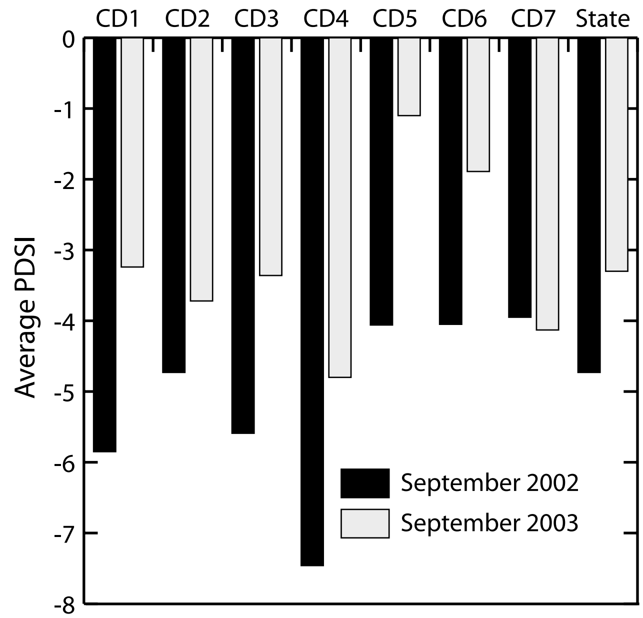

Figure 1. Palmer Drought Severity Index by Arizona Climate Division, September 2002 vs. September 2003.

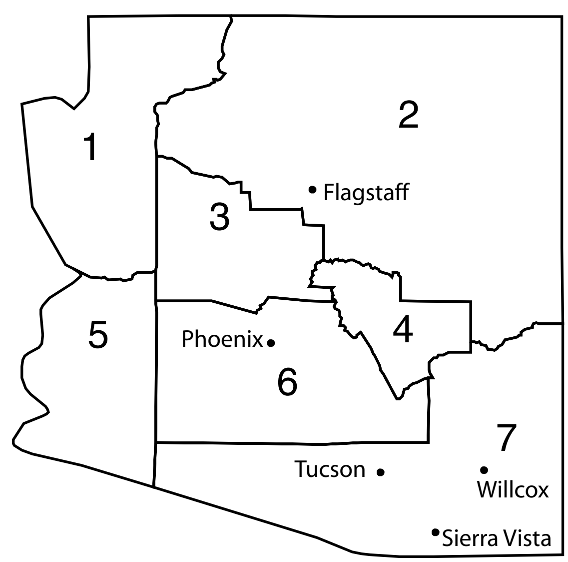

Figure 2. Map of Arizona Climate Divisions.

Winter Rains, continued

matter—are based on average precipitation in that division during the most recent three completed decades, in this case 1971–2000. Following this line of reasoning, Winslow could be in a drought year with 75 mm of rainfall (about 3.1 inches), while Yuma would be enjoying above-average annual rainfall with the same amount.

It's important to note that the probabilities do not consider whether the Southwest climate has moved into a drier climate pattern in general. Some suspect the Pacific Decadal Oscillation (PDO) moved in 1998 into a potentially 20- to 30-year cool phase that would tend to bring drier conditions to Arizona (2), particularly in a swath along the Colorado River from the Grand Canyon through about the Petrified Forest, and in the southeastern part of the state, particularly around Casa Grande and Tucson (3).

Even worse, if a PDO cool phase is coupled with a warm phase of the Atlantic Multidecadal Oscillation (AMO), as some fear, this could result in a double-whammy that could increase the likelihood of a long-term drought in the Southwest (4). The AMO is a pattern of slowly varying sea-surface temperature and associated atmospheric circulation in the North Atlantic Ocean. Recently, researchers have determined that this pattern has effects on precipitation in the continental United States, including the southern Rocky Mountains. For example, an AMO warm phase between 1940–1960 coincided with the 1950s Southwest-Southern Plains drought (5).

The PDO is still fluctuating, and at this point it's unclear whether it will quickly return to a cool phase. Also, the science involving the AMO circulation pattern is still in the relatively early stages.

So there's still hope that drought conditions could end by spring, at least for this year. Last year's winter precipitation helped. By the end of September, water year precipitation values were within about a third of an inch of normal in all divisions, and had even topped normal values in climate divisions 1 and 5, albeit it ever so slightly.

Some February and March storms drizzled rain around the state, a welcome relief from an unusually warm and incredibly dry January. Temperature plays a smaller but sometimes decisive role in drought through its effect on evaporation rates. Despite January's unseasonably warm temperatures, the temperature departure for the water year as a whole was less dramatic than in the previous year. Statewide, average temperature was about 2 degrees Fahrenheit above the 1895–2003 mean for the water year that ended in September, compared to about 2.5 degrees Fahrenheit above the mean for the previous year.

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Table 1. The columns show the precipitation required to end the current drought in the time period indicated and the odds of receiving the required amount by Arizona climate division. (See Figure 2 for location of divisions.) The odds are based on the percentage of times the division received the requisite amount of precipitation during periods of similar time frames between 1971—2000.

	October-March		October-December		November-January	
Climate Division	Precipitation required to end drought (inches)	Odds of receiving precipitation required to end drought (%)	Precipitation required to end drought (inches)	Odds of receiving precipitation required to end drought (%)	Precipitation required to end drought (inches)	Odds of receiving precipitation required to end drought (%)
1	4 to 8	15 to 18	3 to 6	7.5 to 9	3 to 6	18 to 24
2	8 to 12	15 to 18	6 to 9	6 to 7.5	3 to 6	12 to 18
3	8 to 12	18 to 47	6 to 9	7.5 to 9	3 to 6	24 to 30
4	12 to 16	18 to 47	9 to 12	6 to 7.5	9 to 12	6 to 13
5	Trace to 4	18 to 47	Not in drought		Not in drought	
6	4 to 8	18 to 47	Not in drought		Trace to 3	36 to 85
7	8 to 12	12 to 15	6 to 9	3 to 4.5	3 to 6	12 to 18

Winter Rains, continued

As for the all-important precipitation, one storm centered around February 13 and concentrated around central Arizona dropped about three inches in the Phoenix area, and another storm system spread across Arizona starting around February 25 (6). The latter lingered in some areas, including Winslow, Phoenix, and Tucson, through the first few days of March (6). Mid-March brought more rains to much of the state (7).

By March 25, Arizona's snowpack was near its long-term average in many basins (8). As snow melted, streamflow improved and reservoir levels rose. White-water tour operators welcomed an "ideal" season on the Upper Salt River, after facing a raft-free season the previous year. (9) Storage in six Salt River Project lakes had reached an average of 43percent capacity, compared to 35 percent at that time during the previous year (10). Unlike the Verde and Salt rivers, Colorado River runoff did not approach normal levels, but the basin was expected to yield about two-thirds of its usual runoff compared to little over one-tenth the previous year (11).

If the Colorado River basin were to receive 100 percent of normal snowpack this year, streamflow still would lag behind at about 80 percent of normal, predicted U.S. Bureau of Reclamation hydrologist Chris Cutler (10). Dry soils absorb more moisture before releasing some of it as runoff, which is why it takes longer to rebound from hydrological drought than meteorological drought.

The spring fire season made it clear that last year's winter precipitation had not cleared the hurdles set by the entrenched drought. At the same time, it did succeed in moving the hurdle down a notch or two for the coming winter. A November 12 storm that dropped another half an inch to inch of rain across much of the state (7) lent a hopeful sign that the improvement might continue in the current water year that began October 1.

However, even in the somewhat improbable event that some or all of the state goes back to normal conditions in the coming water year, there would be no guarantee that it wouldn't revert back into drought in the near future. As researchers pointed out during a national drought workshop held in Tucson last week, occasional years of normal or even above-average precipitation can occur even during decades-long entrenched droughts found in historic records, and in prehistoric records developed from tree rings.

But it's a sure bet that, even then, the people suffering through the drought appreciated a year or two of reprieve.

— Melanie Lenart, CLIMAS Research Associate and Andrew Ellis, Arizona State Climatologist

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