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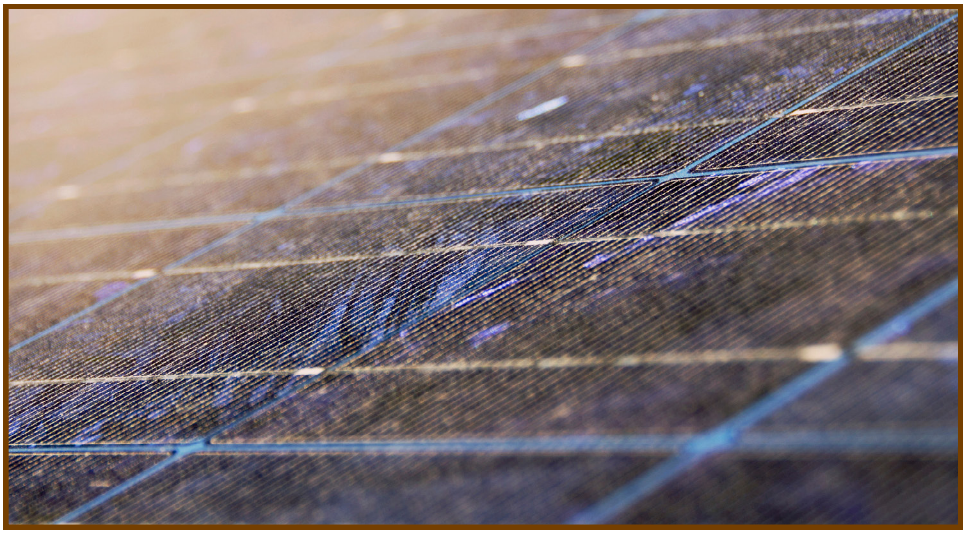

The Southwest's vast solar resources have the potential to supply a large fraction of the region's energy demand. This solar panel is part of one of many systems being tested at Tucson Electric Power's test yard in Tucson, Arizona. Credit: Thomas McDonald.

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In this issue...

CLIMAS Climate Assessment for the Southwest

Arizona Cooperative Extension — The University of Arizona • College of Agriculture and Life Sciences

Arizona

Office of the State Climatologist

NM State University

February Climate Summary

Drought: While slight improvements in short-term drought conditions occurred in parts of central Arizona, drought intensified in central New Mexico.

Temperature: Temperatures between January 22 and February 20 were within two degrees of average, except in eastern New Mexico, which was warmer than average.

Precipitation: Five winter storms blew through Arizona in the last 30 days, bringing above-average precipitation to many parts of the state. These storms, however, missed most of New Mexico.

ENSO: The current ENSO-neutral event is expected to remain through the spring.

Climate Forecasts: March–May forecasts call for above-average temperatures and below-average precipitation in all of Arizona and New Mexico.

The Bottom Line: Five storms in the last month helped cut winter precipitation deficits, particularly in the higher elevations of Arizona. However, when viewed with a longer-term lens, dry conditions still remain the norm. This is particularly true for New Mexico, because recent storms have missed most of the state. Since January 1, for example, precipitation has been less than 70 percent of average in many parts of New Mexico and drier in central regions. Arizona has received slightly higher totals. Even with recent rain and snow, drought conditions remain widespread and intense in both states. Nearly 83 percent of Arizona and 98 percent of New Mexico are classified with moderate or more severe drought. Temperatures since January 1 have been between 3 and 6 degrees F below average in most of the higher elevations of Arizona, New Mexico, Colorado, and Utah. This has helped keep snowpacks larger than they otherwise would be. Nonetheless, water contained in snowpacks, or SWE, is generally below average in the Southwest. Many monitoring stations in the Upper Colorado River Basin and Rio Grande headwaters report less than 80 percent of average SWE, fueling below-average spring streamflow forecasts for the region's two largest rivers. It is looking increasingly unlikely that reservoirs on these and other rivers in the Southwest will get a boost from above-average precipitation, particularly since forecasts are calling for increased chances for below-average rain in coming months. Thin snowpacks coupled with potentially warm temperatures and dry conditions have resource managers concerned for an elevated risk of wildfires in the spring.

A 470-year record of the Southwest monsoon

A recent study used tree rings to reconstruct 470 years of the monsoon for a region covering much of southeast Arizona and southwest New Mexico, where the monsoon is most vigorous in the U.S. The study, led by UA graduate student Daniel Griffin and CLIMAS investigator Connie Woodhouse, among other researchers, revealed that droughts in the last five centuries have been characterized not just by below-average winter precipitation, but also by failed summer rains. The monsoon fizzled during the 17th century drought, for example, leading to famine and, consequently, an uprising by Pueblo Indians against Spanish colonizers, according to some scholars. With the exception of the past decade, the absence of successive dry seasons helped stave off protracted droughts that have been more prevalent in past centuries. This suggests, the authors state, that the last century may not be ideal for characterizing monsoon precipitation.

While tree rings have provided accurate estimates of past climates, most of them have reflected winter precipitation. The study's results now provide the longest record of monsoon precipitation, which can help resource managers better plan for drought.

The article is published in the journal *Geophysical Research Letters*. Read the abstract and access the entire article (subscription required) at: www.onlinelibrary.wiley.com/doi/10.1002/grl.50184/abstract.

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This work is published by the Climate Assessment for the Southwest (CLIMAS) project, the University of Arizona Cooperative Extension, and the Arizona State Climate Office.

Southwest must make choices about future climate

By Melanie Lenart

This article is the second in a two-part series considering the findings of a new climate assessment for the Southwest, scheduled for release this spring. This article explores the climate choices facing the region.

During the hottest year in U.S. history, Hurricane Sandy managed to knock out power as far inland as central Ohio while burying swaths of New Jersey and other Atlantic Coast states in several feet of water for days. The 2012 storm gained strength in part from unusually warm seas, and its severity helped thrust climate change back into the national debate.

In the Southwest, residents were facing the opposite extreme. Severe drought triggered record-breaking wildfires in Arizona in 2011 and New Mexico in 2012. In both years, the area burned in U.S. wildfires topped 8 million acres, nearly double the annual average since 1983. The 2011 drought had Texans shipping cattle to Montana, while the 2012 drought decimated Midwestern corn and other crops.

The high cost of weather extremes—with hundreds of lives lost on top of Hurricane Sandy's $65 billion and the 2012 drought's $35 billion price tags—is something to keep in mind during discussions about the region's climate choices.

The choice is not whether to spend money to address climate changes or not, because taking no action will have its own costly repercussions, according to the authors of "Climate Choices for a Sustainable Southwest," a chapter in the soon-to-be-published book, *The Assessment of Climate Change in the Southwest United States*.

Rather, Southwest residents and decision makers will need to choose whether to merely react to disasters such as droughts, extreme storms and heat waves or to make choices that could help head off some of the more damaging effects of climate change. The likely effects are described in detail in other chapters of the book, a cutting-edge effort by 110 authors and 80 reviewers that is scheduled for release this spring.

The good news is that many of the steps to reduce emissions of the greenhouse gases linked to climate change can save money in the long run. What's more, some mitigation options could simultaneously make the region better able to cope with the coming changes.

Extreme Climate

Nobody blames climate change specifically for the hurricane or the drought. But there are hints that it played a role. Arctic warming may have influenced the collision of Hurricane Sandy with a winter storm, for example. And well-known laws of physics link warmer sea surface temperatures to stronger storms, while hotter air temperatures clearly dry out soils more quickly and thoroughly.

So, while scientists are still analyzing how much climate change affected these particular events, physical laws support the concept that higher temperatures can make droughts and storms more intense. As the Southwest assessment book details, a warming climate is expected to bring longer and more severe heat waves and hotter droughts that will dry soils and drain reservoirs more rapidly. The Southwest also could face more extreme rains.

Like the Atlantic, the Pacific Ocean spawns hurricanes, which can do damage far from the coast. Some of Arizona's worst floods resulted from heavy rains from remnants of hurricanes.

"Atmospheric rivers" can also strike this region (see the December 2011 Southwest Climate Outlook.) Scientists use this term to describe water-laden air traveling in long streams, often in the vicinity of the jet stream. These airstreams can carry up to 15 times more water than the Mississippi River, and they're associated with heavy flooding when they hit mountains or otherwise come down to earth.

On December 18, 2010, an atmospheric river descended on the Phoenix area, delivering 5 inches of rain in one day to an area that typically gets only 8 inches of rain in a year.

These airstreams are expected to become about a third more saturated on average by the middle of the century, mainly because warmer air has the capacity to hoist up more water vapor, noted Gregg Garfin, an assistant professor at the University of Arizona and lead editor of the Southwest assessment book. In fact, Garfin noted that scientists have already observed an extra 4 percent of water vapor in the air since the 1970s compared to earlier years. From warmer air alone, Arizona and New Mexico can expect more of their future daily rain to come in heavier doses.

At the scale of decades, though, hot, dry spells are expected to overwhelm the punctuated rains, changing the character of the land in Arizona and New Mexico toward greater aridity. During times of drought, which are expected to be hotter and more severe, the region can also expect more agricultural losses and raging wildfires.

Climate Choices

Just how hot temperatures get depends on many factors, most notably the amount of greenhouse gases wafting in the atmosphere. These gases trap heat, warming the air and causing the climate system to respond in its effort to dissipate that heat. By 2012, airborne levels of the greenhouse gas carbon dioxide had reached 394 ppm, about 40 percent higher than before the Industrial Revolution took hold in the 19th century.

Curtailing concentrations of greenhouse gases is often the goal of climate mitigation efforts. Mitigation can take many

continued on page 4

Southwest must make choices... continued

Solar energy systems have the potential to supply a large fraction of the Southwest's energy. Traditional photovoltaic arrays and new ones under research and development, like this photo holographic planar concentrator at Tucson Electric Power's test yard, are one of many options available to mitigate and adapt to climate changes. Credit: Thomas McDonald.

forms, from expanding the region's portfolio of renewable energy to strategically planting more shade trees to using more energy-efficient appliances. Whatever form it takes, Southwest assessment authors note, it's essential to do it. It's also crucial to take steps to adapt, or plan ways to make society and natural systems less vulnerable to impacts and more resilient to the coming changes.

"If we don't mitigate, we let the problem become so big that adaptation becomes impossibly hard," said Susanne Moser, a Stanford University researcher and one of the Climate Choices chapter's lead authors. "We just don't have the luxury of not doing both."

Generating electricity on a commercial scale using solar panels is not as cheap as using coal, but the authors suggest tapping the region's abundant solar resources would help keep the climate change more manageable while creating business opportunities.

"If it were easy enough to bring energy from the Southwest to the rest of the nation, we could supply everyone. It is of that magnitude," Moser said of solar energy.

Individual rooftop solar panels offer the advantage of keeping the residences below humming even during power outages. But Diana Liverman, another of the chapter's lead authors and co-director of the University of Arizona's Institute of the Environment, emphasized that large-scale commercial arrays are key to reducing greenhouse gases to a degree that might help keep global climate from warming beyond the 2°C (or 3.6°F) that experts suggest would be particularly dangerous.

To do its share to keep temperature from rising above 2°C, the United States would need to reduce greenhouse gas emissions to 50 to 80 percent below 1990 levels by 2050, the assessment notes, citing the U.S. National Academy of Sciences.

One way for the Southwest to meet this target would be for the region to retire all of its electricity plants powered by coal, Garfin suggested. Electricity plants are designed to last for many decades, so choices made today will continue to affect the region in 2050.

"A whole separate way of thinking about climate that people are now starting to focus on is 'It's about the infrastructure,'" Liverman said, noting this includes structures for electricity generation, coastal defenses, water treatment plants or large buildings. "Whether it's adaptation or mitigation, what really matters is the investments that we're making in infrastructure that will be with us for a while."

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Southwest must make choices... continued

Other Values of Mitigation

Reducing the use of coal for electricity generation could also help the region avoid an unsustainable increase in water demand—something seen as essential to help the Southwest remain attractive to investors and residents. Dry-cooled solar-powered electricity plants use far less water than coal plants, leaving more available to support crops, trees, wildlife and people.

Some mitigation options even save money, Liverman noted. Improving energy efficiency tops the list of cost-saving measures. Insulating homes better, adjusting thermostats and switching to lower-energy lighting, for instance, quickly translate into savings on energy costs.

Other forms of mitigation may cost money but provide benefits that go beyond economic. For instance, treatments to thin some of the smaller trees out of regional forests can make them less flammable, thus helping to keep the carbon they have siphoned from the air locked up in wood and soil instead of going up in smoke as greenhouse gases.

At the same time, these treatments would help save people and communities from the many costs associated with wildfires, including loss of lives as well as structures, money spent on suppression efforts, and health problems from polluted air.

Planting urban trees similarly offers a way to help the region adapt to higher temperatures and its impacts while mitigating climate change. Trees soak up carbon dioxide while cooling the urban environment, which, in turn, helps reduce the need for air conditioning.

Harvesting rainfall and reusing water can help Southwest residents grow trees. Liverman used her own home as an example, noting that she recycles water from her washing machine and shower to support trees that cool her home, saving her money and energy by reducing the need for air conditioning. Also, rainwater harvesting, which includes diverting stormwater off streets toward vegetation, can help reduce the severity of floods.

The climate choices facing the region may seem daunting, but the people of the Southwest have a record of taking on large-scale challenges that transform the environment, Liverman noted. She cited two examples to illustrate this: the protection of public land, and the large-scale construction of dams and canals to move water into drier regions.

“When Americans choose to act,” she added, “we can really make a difference.”

The Southwest assessment Summary for Decision Makers is available at: www.swcarr.arizona.edu

Links to fact sheets summarizing each chapter, a PDF version of the book, and an order form for a hard copy version will also be posted on the website in coming weeks.

Temperature (through 2/20/13)

Data Source: High Plains Regional Climate Center

Since the start of the 2013 water year on October 1, average temperatures in the southwest deserts of Arizona, on the Colorado Plateau of northern Arizona and New Mexico, and in southern New Mexico (*Figures 1a–b*) have been mostly near average. However, looking at the average hides the fact that temperatures have alternated from extremely cold to extremely warm, especially in December and January. In fact, this winter has seen both record cold and record warm temperatures across Arizona and New Mexico. The higher elevations along the Mogollon Rim and in west-central and northern New Mexico are generally a few degrees cooler than average, which is typical of El Niño-neutral events, like the one currently underway.

During the past 30 days, five cold fronts passed through the Southwest. Consequently, temperatures alternated between unusually warm conditions as a result of high-pressure conditions and cold and wet conditions associated with the fronts. The storms generally moved south down the California coast to the Los Angeles basin before veering northeast through Arizona and western New Mexico. The storms, however, missed eastern New Mexico, and temperatures there were 2–4 degrees F warmer than average (*Figures 1c–d*). The temperature pattern in the last 30 days was also spotty, with above-average and below-average temperatures in different areas. This largely reflects the location of precipitation, with cooler-than-average conditions occurring in areas hit by the storms.

Notes:

The water year begins on October 1 and ends on September 30 of the following year. As of October 1, 2012, we are in the 2013 water year. Water year is more commonly used in association with precipitation; water year temperature can be used to measure the temperatures associated with the hydrological activity during the water year.

Average refers to the arithmetic mean of annual data from 1981–2010. Departure from average temperature is calculated by subtracting current data from the average. The result can be positive or negative.

The continuous color maps (Figures 1a, 1b, 1c) are derived by taking measurements at individual meteorological stations and mathematically interpolating (estimating) values between known data points. The dots in Figure 1d show data values for individual stations. Interpolation procedures can cause aberrant values in data-sparse regions.

These are experimental products from the High Plains Regional Climate Center.

On the Web:

For these and other temperature maps, visit
http://www.hprcc.unl.edu/maps/current/

For information on temperature and precipitation trends, visit
http://www.cpc.ncep.noaa.gov/trndtext.shtml

Figure 1a. Water year 2013 (October 1 through February 20) average temperature.

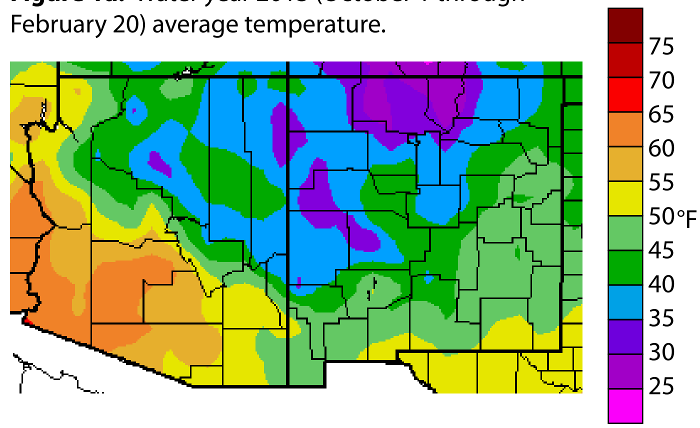


Figure 1b. Water year 2013 (October 1 through February 20) departure from average temperature.

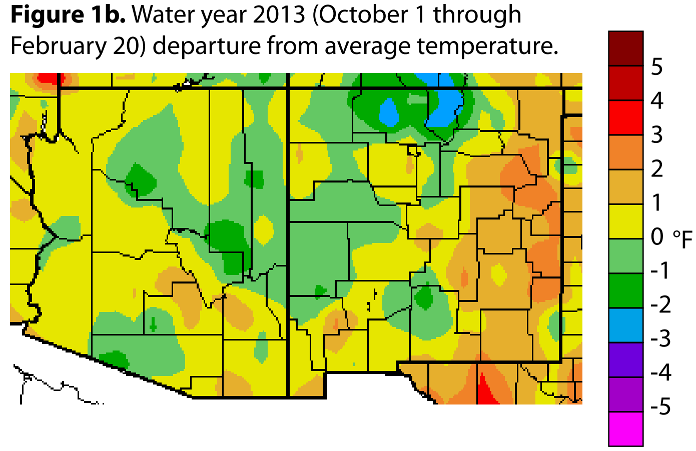


Figure 1c. Previous 30 days (January 22–February 20) departure from average temperature (interpolated).

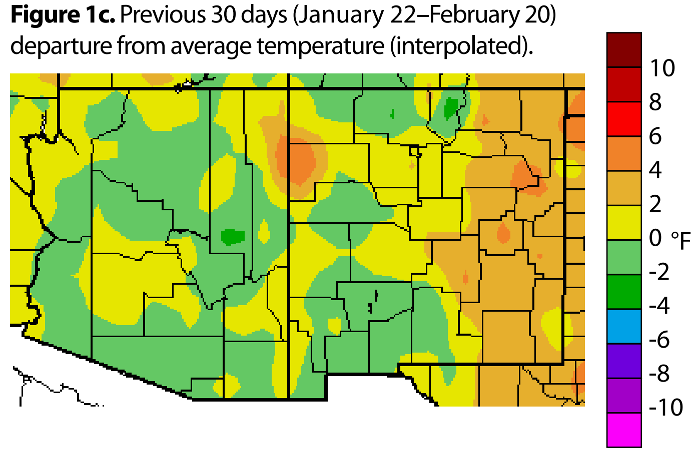
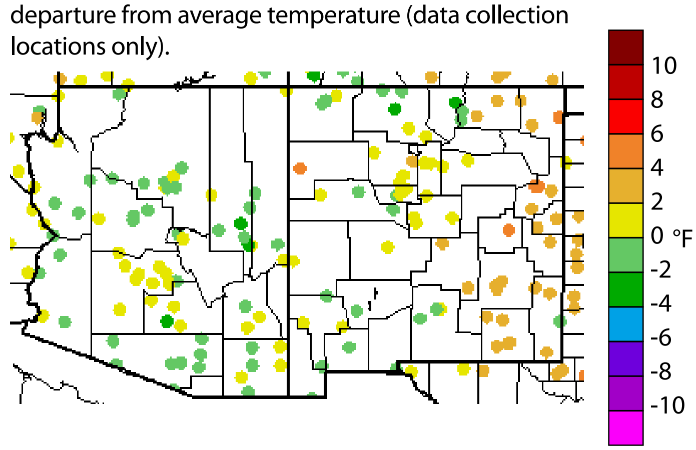


Figure 1d. Previous 30 days (January 22–February 20) departure from average temperature (data collection locations only).



Precipitation (through 2/20/13)

Data Source: High Plains Regional Climate Center

The Southwest generally has been dry since the water year began on October 1 (*Figures 2a–b*). In the early winter, few storm systems crossed the Southwest, and the region was much drier than average. When precipitation did fall, it tended to be in the higher elevations of the Mogollon Rim in central Arizona and along the lower Colorado River valley. Most of the early winter storms missed southern Arizona and New Mexico; since October 1, New Mexico has received less than 50 percent of average winter precipitation.

During the past 30 days, five winter storms moved through the Southwest, bringing much needed rain and snow to Arizona (*Figures 2c–d*). These storms, however, missed New Mexico, upholding a pattern that has persisted this winter. The first storm in late January brought moderate precipitation across most of Arizona that lasted more than 24 hours. It was followed by a warm storm that melted some of the snowpacks and actually raised the level of several central Arizona reservoirs. That storm was followed by a much colder event that brought snowfall to the mid and higher elevations. The two most recent storms, in mid-February, were very cold and snowfall was reported at low elevations in Arizona.

Figure 2a. Water year 2013 (October 1 through February 20) percent of average precipitation (interpolated).

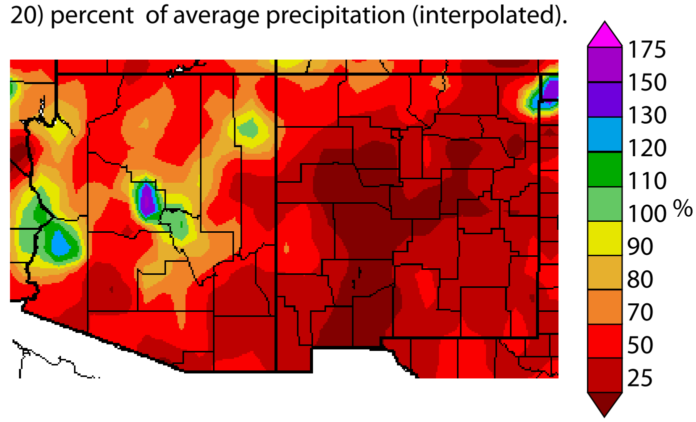


Figure 2b. Water year 2013 (October 1 through February 20) percent of average precipitation (data collection locations only).

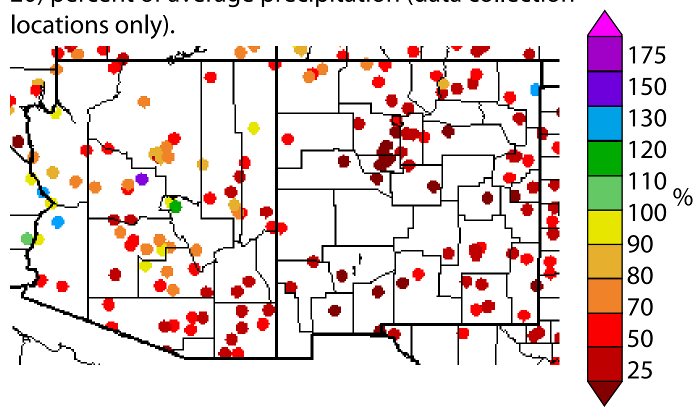


Figure 2c. Previous 30 days (January 22–February 20) percent of average precipitation (interpolated).

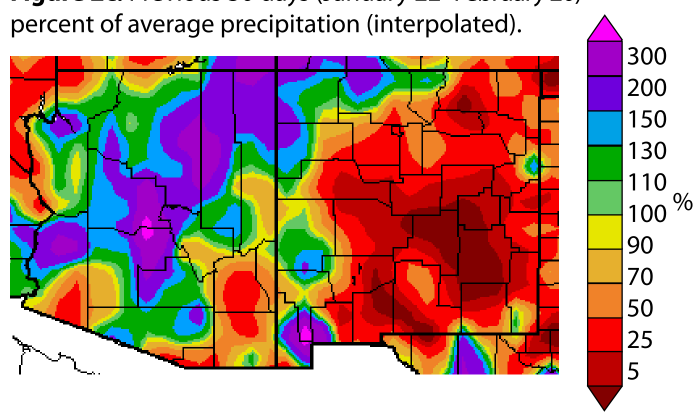
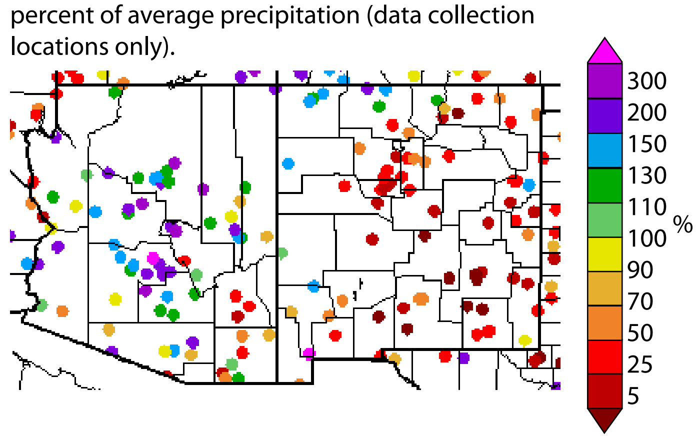


Figure 2d. Previous 30 days (January 22–February 20) percent of average precipitation (data collection locations only).



Notes:

The water year begins on October 1 and ends on September 30 of the following year. As of October 1, 2012, we are in the 2013 water year. The water year is a more hydrologically sound measure of climate and hydrological activity than is the standard calendar year.

Average refers to the arithmetic mean of annual data from 1981–2010. Percent of average precipitation is calculated by taking the ratio of current to average precipitation and multiplying by 100.

The continuous color maps (Figures 2a, 2c) are derived by taking measurements at individual meteorological stations and mathematically interpolating (estimating) values between known data points. Interpolation procedures can cause aberrant values in data-sparse regions.

The dots in Figures 2b and 2d show data values for individual meteorological stations.

On the Web:

For these and other precipitation maps, visit
http://www.hprcc.unl.edu/maps/current/

For National Climatic Data Center monthly precipitation and drought reports for Arizona, New Mexico, and the Southwest region, visit
http://lwf.ncdc.noaa.gov/oa/climate/research/2003/perspectives.html#monthly

U.S. Drought Monitor (data through 2/19/13)

Data Sources: U.S. Department of Agriculture, National Drought Mitigation Center, National Oceanic and Atmospheric Administration

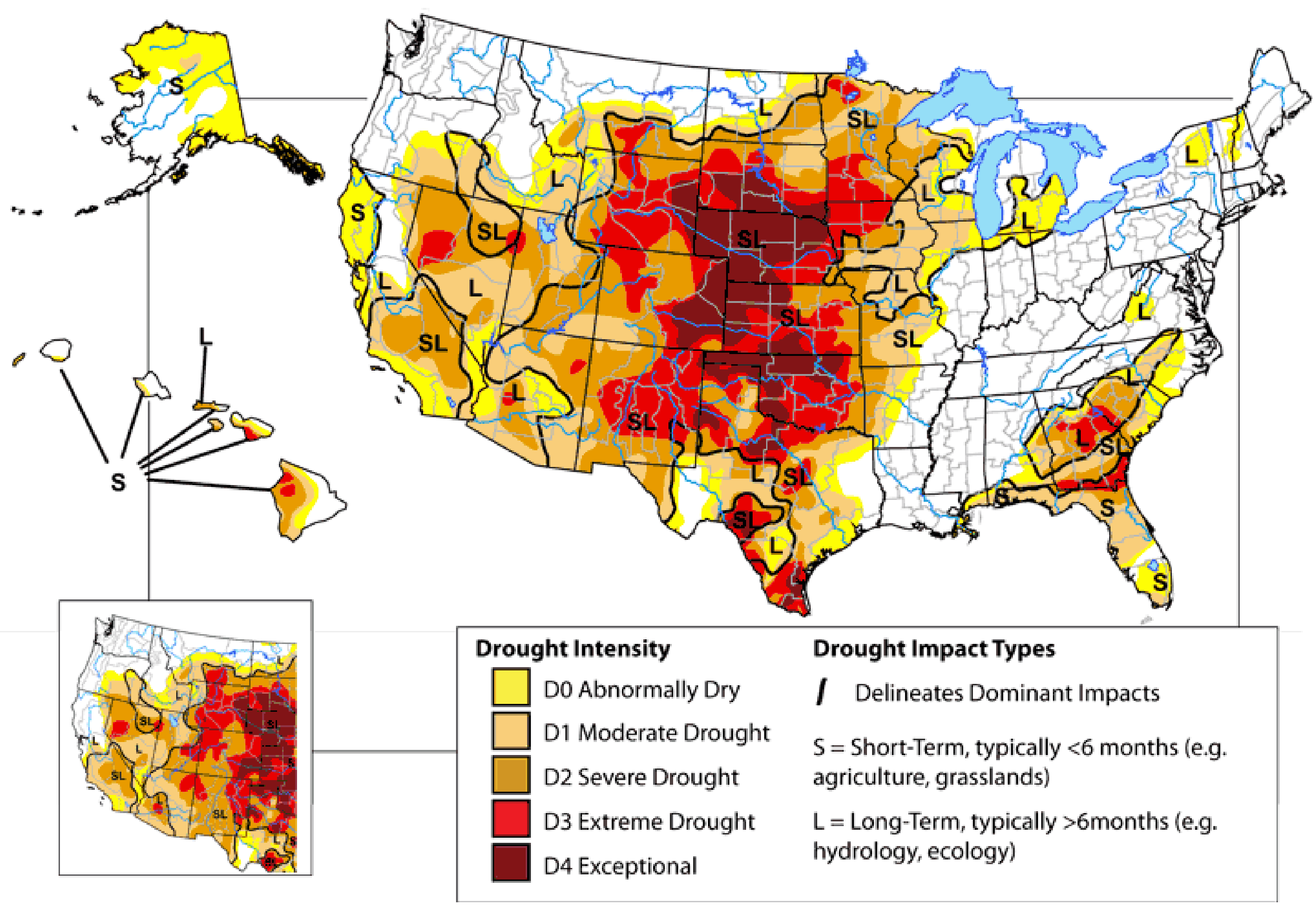
Winter storms have consistently wafted through the Pacific Northwest and northern Rockies this winter, helping these regions remain drought-free. The rest of the West has not fared as well; short and long-term drought conditions exist in most regions (*Figure 3*). The distinction between short- and long-term drought depends on how sensitive an environment or sector is to change. For example, it takes many months of below-average precipitation to dwindle the water supply in a large reservoir, whereas much shorter dry periods can cause grasses to wilt.

During the past 30 days, the extent and intensity of drought has remained relatively constant. A wet winter storm in late January brought some short-term relief to parts of Arizona, helping improve drought conditions in the central part of the state, but that storm did little to help other areas in the Southwest. Drought conditions intensified across Colorado and New Mexico where the area covered by extreme and exceptional drought expanded. Abnormally dry conditions along the coast of northern California also recently materialized. Overall, moderate drought covers 64 percent of the western U.S., a slight improvement from 68 percent in mid-January. The level of exceptional drought in the West, however, increased from 2.2 percent in mid-January to 3.5 percent in mid-February.

Notes:

The U.S. Drought Monitor is released weekly (every Thursday) and represents data collected through the previous Tuesday. The inset (lower left) shows the western United States from the previous month's map. The U.S. Drought Monitor maps are based on expert assessment of variables including (but not limited to) the Palmer Drought Severity Index, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts. It is a joint effort of several agencies.

Figure 3. Drought Monitor data through February 19, 2013 (full size), and January 15, 2013 (inset, lower left).



On the Web:

The best way to monitor drought trends is to pay a weekly visit to the U.S. Drought Monitor website: http://www.drought.gov/portal/server.pt/community/current_drought/208

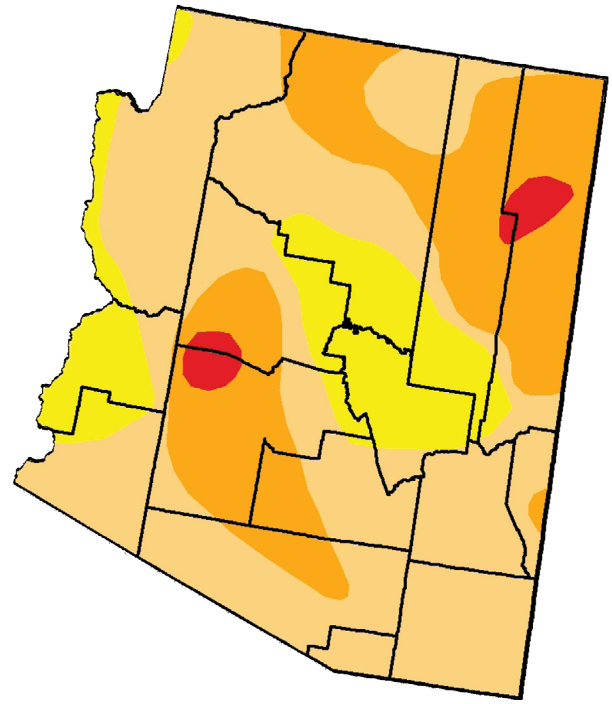
Arizona Drought Status

(data through 2/19/13)

Data Source: U.S. Drought Monitor

Several winter storms crossed Arizona in the past 30 days, including a powerful storm in late January that dropped more than an inch of precipitation on much of the state. Up to two inches were reported in several locations. This event, along with several other cold storms that brought snow to higher elevations across the region, helped improve some short-term drought. For example, conditions along the Colorado River valley and Mogollon Rim improved from moderate drought to abnormally dry, and areas of severe drought along the Utah border and in central Arizona improved one category to moderate drought. Even with these short-term improvements, moderate or more severe drought covers about 83 percent of the state (*Figures 4a–b*). This U.S. Drought Monitor update, however, does not account for the storm that brought snow and rain to much of the state beginning on February 20.

Figure 4a. Arizona drought map based on data through February 19.



Drought Intensity

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional

Figure 4b. Percent of Arizona designated with drought conditions based on data through February 19.

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	83.13	29.45	2.03	0.00
Last Week (02/12/2013 map)	0.00	100.00	87.66	29.45	2.03	0.00
3 Months Ago (11/20/2012 map)	0.00	100.00	98.66	34.10	5.67	0.00
Start of Calendar Year (01/01/2013 map)	0.00	100.00	97.91	37.78	8.68	0.00
Start of Water Year (09/25/2012 map)	0.00	100.00	100.00	31.93	5.67	0.00
One Year Ago (02/14/2012 map)	1.98	98.02	80.56	33.32	0.00	0.00

Notes:

The Arizona section of the U.S. Drought Monitor is released weekly (every Thursday) and represents data collected through the previous Tuesday. The maps are based on expert assessment of variables including (but not limited to) the Palmer Drought Severity Index, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts. It is a joint effort of several agencies.

On the Web:

For the most current drought status map, visit http://www.drought.unl.edu/dm/DM_state.htm?AZ,W

For monthly short-term and quarterly long-term Arizona drought status maps, visit http://www.azwater.gov/AzDWR/StatewidePlanning/Drought/DroughtStatus.htm

New Mexico Drought Status
(data through 2/19/13)

Data Source: New Mexico State Drought Monitoring Committee, U.S. Drought Monitor

Several storms drenched Arizona and lowered temperatures in the past 30 days but missed much of New Mexico. As a result, most of New Mexico received less than 70 percent of average precipitation in this period, and little to no precipitation fell across much of the eastern half of the state (see page 7). The lack of substantive rain and snow has added to the state's mounting winter precipitation deficits: since October 1, most of New Mexico has received less than 50 percent of average rain and snow. As a result, extreme drought conditions have expanded across the central part of the state, according to the February 19 update of the U.S. Drought Monitor (*Figures 5a–b*). Extreme or exceptional drought now covers 50 percent of New Mexico, up from 31 percent last month, and at least moderate drought covers about 98 percent of the state.

Figure 5a. New Mexico drought map based on data through February 19.

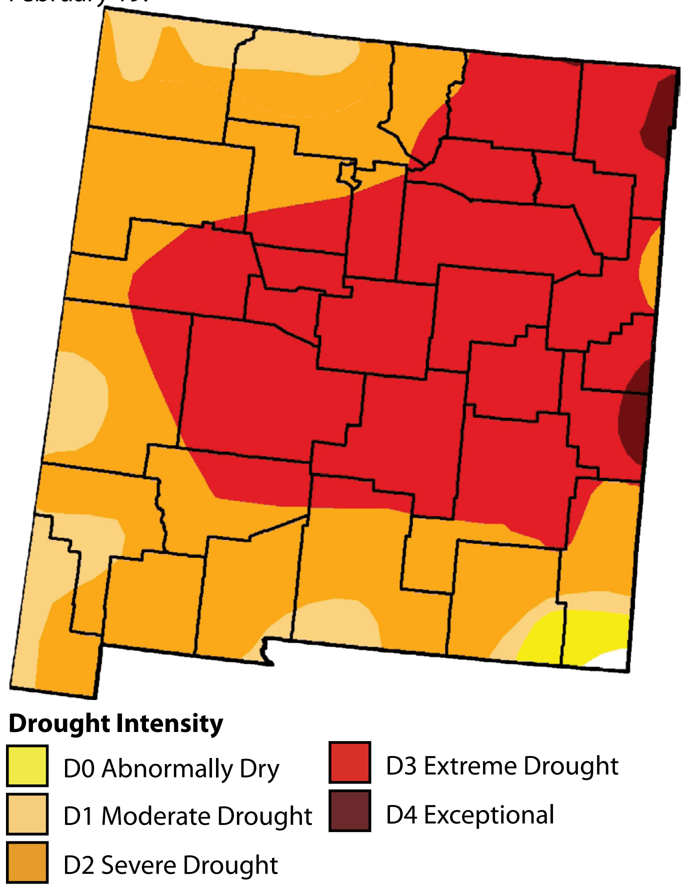


Figure 5b. Percent of New Mexico designated with drought conditions based on data through February 19.

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.20	99.80	98.45	89.85	49.59	1.22
Last Week (02/12/2013 map)	0.20	99.80	98.45	89.85	25.36	0.97
3 Months Ago (11/20/2012 map)	0.07	99.93	98.80	79.05	23.02	0.97
Start of Calendar Year (01/01/2013 map)	0.00	100.00	98.83	94.05	31.88	0.97
Start of Water Year (09/25/2012 map)	0.00	100.00	100.00	62.56	12.25	0.66
One Year Ago (02/14/2012 map)	11.69	88.31	81.50	59.57	24.79	8.13

Notes:

The New Mexico section of the U.S. Drought Monitor is released weekly (every Thursday) and represents data collected through the previous Tuesday. The maps are based on expert assessment of variables including (but not limited to) the Palmer Drought Severity Index, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts. It is a joint effort of several agencies.

This summary contains substantial contributions from the New Mexico Drought Working Group.

On the Web:

For the most current drought status map, visit http://www.drought.unl.edu/dm/DM_state.htm?NM,W

For the most current Drought Status Reports, visit http://www.nmdrought.state.nm.us/MonitoringWorkGroup/wk-monitoring.html

Arizona Reservoir Volumes
(through 1/31/13)

Data Source: National Water and Climate Center

Combined storage in Lakes Mead and Powell stood at 51.5 percent of capacity as of January 31, a decrease of 318,000 acre-feet from the previous month (*Figure 6*) and 9 percent lower than it was one year ago. Storage in all other Arizona reservoirs monitored by CLIMAS increased in January, which is typical for this time of year. However, combined Arizona reservoir storage remains lower than it was one year ago. Decreases in reservoir storage during 2012 primarily were due to a La Niña event, which helped push storms north of the Upper Colorado River Basin. In Arizona, snowpack measured at many sites are near or below average. In the Upper Colorado River Basin, snowpacks also are below average. Consequently, spring streamflow forecasts made on February 15 call for below-average runoff in all Arizona basins, except a couple emanating from the Chuska Mountains, which flow into the Navajo Nation.

In water-related news, a proposed plan to build 7,000 homes in Sierra Vista has caused a dispute over groundwater pumping and water rights near the San Pedro River (*The Wall Street Journal*, February 15). The U.S. Bureau of Land Management and some landowners and environmental groups argue that pumping will intercept water that is needed to sustain a stretch of the San Pedro.

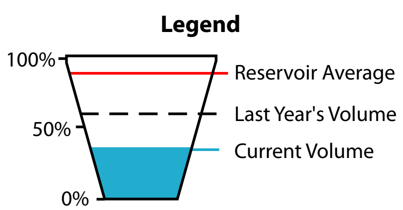
Notes:

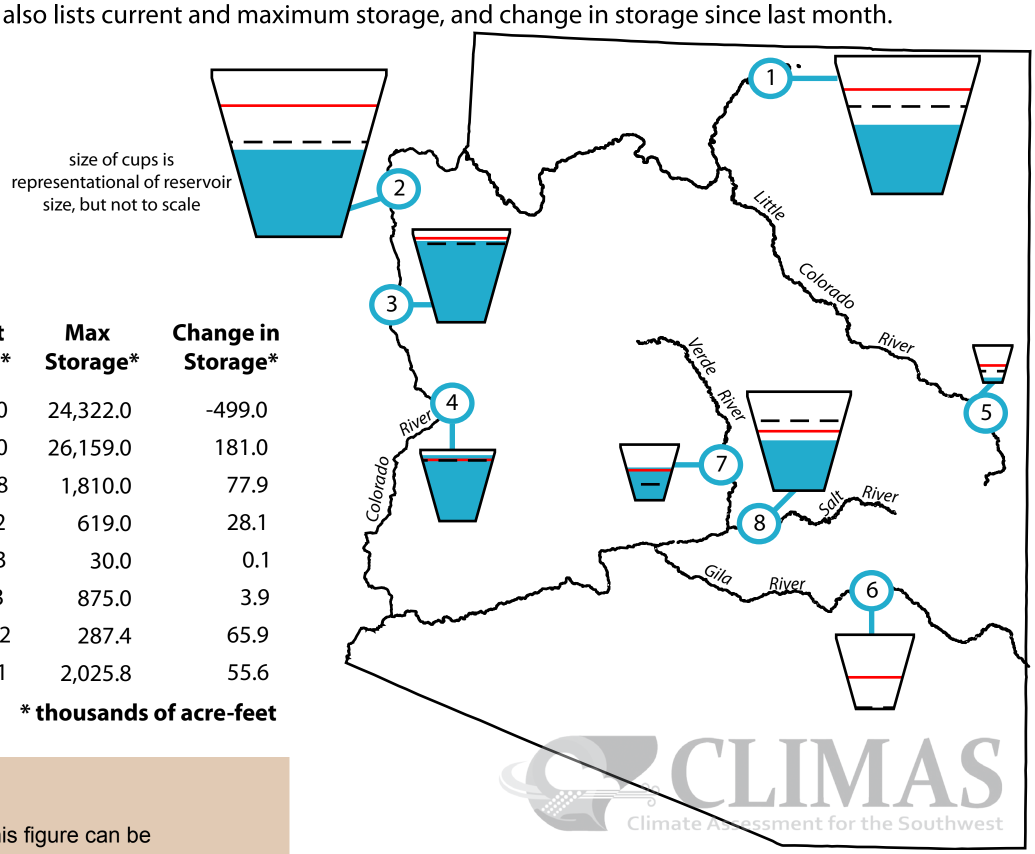
The map gives a representation of current storage for reservoirs in Arizona. Reservoir locations are numbered within the blue circles on the map, corresponding to the reservoirs listed in the table. The cup next to each reservoir shows the current storage (blue fill) as a percent of total capacity. Note that while the size of each cup varies with the size of the reservoir, these are representational and not to scale. Each cup also represents last year's storage (dotted line) and the 1971–2000 reservoir average (red line).

The table details more exactly the current capacity (listed as a percent of maximum storage). Current and maximum storage are given in thousands of acre-feet for each reservoir. One acre-foot is the volume of water sufficient to cover an acre of land to a depth of 1 foot (approximately 325,851 gallons). On average, 1 acre-foot of water is enough to meet the demands of 4 people for a year. The last column of the table list an increase or decrease in storage since last month. A line indicates no change.

These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS).

Figure 6. Arizona reservoir volumes for January as a percent of capacity. The map depicts the average volume and last year's storage for each reservoir. The table also lists current and maximum storage, and change in storage since last month.





Reservoir Name	Capacity	Current Storage*	Max Storage*	Change in Storage*
1. Lake Powell	50%	12,190.0	24,322.0	-499.0
2. Lake Mead	53%	13,828.0	26,159.0	181.0
3. Lake Mohave	91%	1,649.8	1,810.0	77.9
4. Lake Havasu	94%	580.2	619.0	28.1
5. Lyman	15%	4.3	30.0	0.1
6. San Carlos	1%	8.3	875.0	3.9
7. Verde River System	58%	167.2	287.4	65.9
8. Salt River System	54%	1,091.1	2,025.8	55.6

*** thousands of acre-feet**

On the Web:

Portions of the information provided in this figure can be accessed at the NRCS website:
http://www.wcc.nrcs.usda.gov/wsf/reservoir/resv_rpt.html

New Mexico Reservoir Volumes

(through 1/31/13)

Data Source: National Water and Climate Center

Combined water storage in New Mexico's reservoirs increased slightly compared to one month ago, primarily due to an increase in the level of Elephant Butte Reservoir (*Figure 7*). Reservoir storage often increases during this time of year. As of January 31, combined storage on the four reservoirs on the Pecos River was about 1.7 percent of capacity, which is well below average. Only Cochiti Reservoir and Lake Avalon had greater storage than they did one year ago. Reservoirs on the Rio Grande are extremely low as a result of well below-average runoff years in 2011 and 2012. Flows this spring also are likely to be below average. Snowpacks in the high elevations of New Mexico and southern Colorado, which generate much of the water for the Rio Grande, are generally 70–80 percent of average. Unless there is a shift in storm tracks in the next couple of months, there may be reduced water allocations for many water users this summer, according to the Natural Resources Conservation Service (NRCS). Ski areas also have been impacted by scant snow, and there are concerns that this summer's fire season could be active.

In water-related news, the state legislature has introduced multiple measures to deal with scarce water resources, including expediting water cases in district courts, averting in-state water wars between irrigation districts, and advancing regional water planning (*Santa Fe New Mexican*, February 12).

Notes:

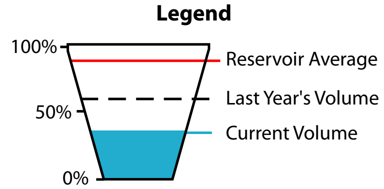
The map gives a representation of current storage for reservoirs in New Mexico. Reservoir locations are numbered within the blue circles on the map, corresponding to the reservoirs listed in the table. The cup next to each reservoir shows the current storage (blue fill) as a percent of total capacity. Note that while the size of each cup varies with the size of the reservoir, these are representational and not to scale. Each cup also represents last year's storage (dotted line) and the 1971–2000 reservoir average (red line).

The table details more exactly the current capacity (listed as a percent of maximum storage). Current and maximum storage are given in thousands of acre-feet for each reservoir. One acre-foot is the volume of water sufficient to cover an acre of land to a depth of 1 foot (approximately 325,851 gallons). On average, 1 acre-foot of water is enough to meet the demands of 4 people for a year. The last column of the table list an increase or decrease in storage since last month. A line indicates no change.

These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's

Figure 7. New Mexico reservoir volumes for January as a percent of capacity. The map depicts the average volume and last year's storage for each reservoir. The table also lists current and maximum storage, and change in storage since last month.

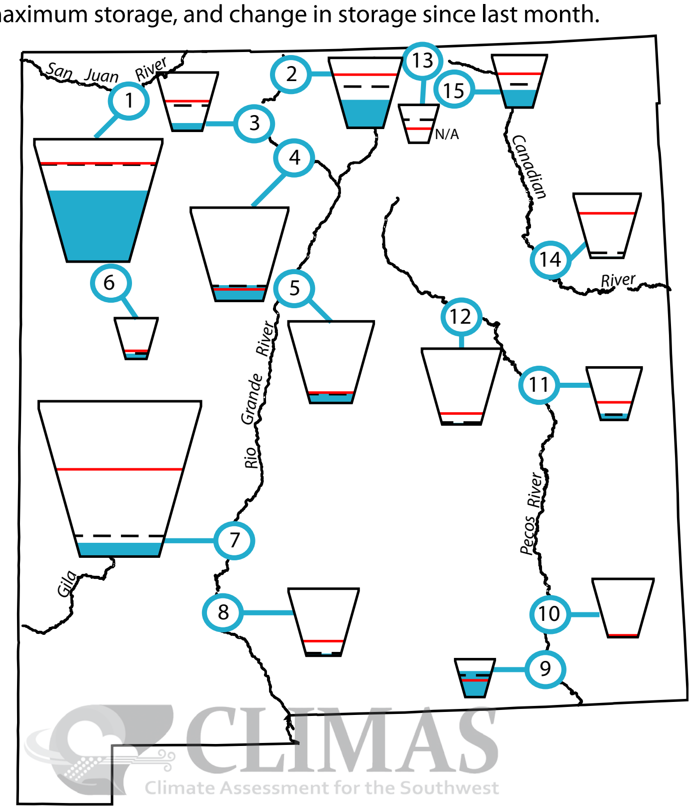
Legend



size of cups is representational of reservoir size, but not to scale

Reservoir Name	Capacity	Current Storage*	Max Storage*	Change in Storage*
1. Navajo	56%	974.3	1,696.0	- 9.0
2. Heron	38%	153.8	400.0	-12.1
3. El Vado	8%	14.4	190.3	4.4
4. Abiquiu	14%	161.7	1,192.8	5.8
5. Cochiti	11%	56.3	491.0	3.4
6. Bluewater	9%	3.3	38.5	-0.1
7. Elephant Butte	8%	183.1	2,195.0	21.0
8. Caballo	3%	8.4	332.0	0.9
9. Lake Avalon	73%	2.9	4.0	0.5
10. Brantley	1%	6.3	1,008.2	1.7
11. Sumner	12%	12.0	102.0	3.2
12. Santa Rosa	1%	4.8	438.3	0.0
13. Costilla	N/A	N/A	16.0	N/A
14. Conchas	1%	1.5	254.2	-0.5
15. Eagle Nest	37%	29.3	79.0	0.3

* thousands of acre-feet



N/A coresponds to reservoirs that did not report storage values this month

On the Web:

Portions of the information provided in this figure can be accessed at the NRCS website:
http://www.wcc.nrcs.usda.gov/wsf/reservoir/resv_rpt.html

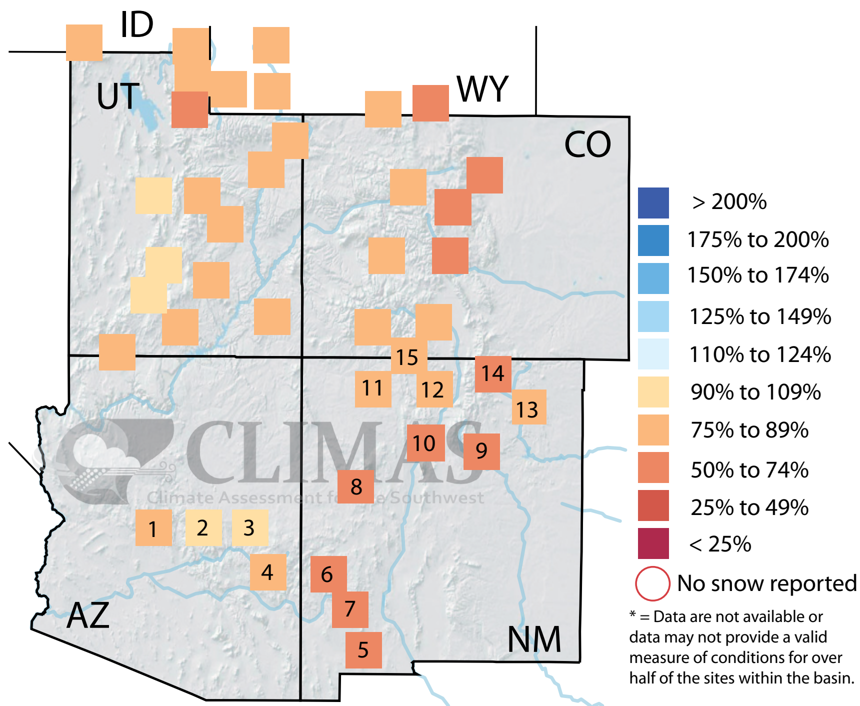
Southwest Snowpack

(updated 2/21/13)

Data Sources: National Water and Climate Center, Western Regional Climate Center

Precipitation in the last month has been above average for many parts of the higher elevations in Arizona, New Mexico, Colorado, and Utah (see page 7). While this recent snow helped boost the water contained in snowpack, or snow water equivalent (SWE), in some locations, the overall SWE picture is still grim. This is because precipitation since January 1 in most of the Southwest has been less than 90 percent of average, and less than 70 percent since start of the water year on October 1. Consequently, snow monitoring stations in the Upper Colorado River drainage basins in Colorado are generally reporting only 78 percent of average SWE for this time of year; SWE in the Animas and San Juan basins is about 85 percent of average (*Figure 8*). The headwaters of the Rio Grande in Colorado, which provides a large fraction of the water to New Mexico's largest river, is also below average, measuring about 79 percent of average SWE. This low value continues to be a major concern for water managers in this region because reservoirs, like Elephant Butte Reservoir, are low (see page 12). It seems unlikely that the Rio Grande will experience above-average spring flows, which is also the case for many other rivers in the Southwest (see page 17).

Figure 8. Average snow water equivalent (SWE) in percent of average for available monitoring sites as of February 21, 2013.



Arizona Basins
1 Verde River Basin
2 Central Mogollon Rim
3 Little Colorado - Southern Headwaters
4 Salt River Basin

New Mexico Basins
5 Mimbres River Basin
6 San Francisco River Basin
7 Gila River Basin
8 Zuni/Bluewater River Basin
9 Pecos River Basin
10 Jemez River Basin
11 San Miguel, Dolores, Animas, and San Juan River Basins
12 Rio Chama River Basin
13 Cimarron River Basin
14 Sangre de Cristo Mountain Range Basin
15 San Juan River Headwaters

Notes:

Snowpack telemetry (SNOTEL) sites are automated stations that measure snowpack depth, temperature, precipitation, soil moisture content, and soil saturation. A parameter called snow water equivalent (SWE) is calculated from this information. SWE refers to the depth of water that would result by melting the snowpack at the SNOTEL site and is important in estimating runoff and streamflow. It depends mainly on the density of the snow. Given two snow samples of the same depth, heavy, wet snow will yield a greater SWE than light, powdery snow.

This figure shows the SWE for selected river basins, based on SNOTEL sites in or near the basins, compared to the 1971–2000 average values. The number of SNOTEL sites varies by basin. Basins with more than one site are represented as an average of the sites. Individual sites do not always report data due to lack of snow or instrument error. CLIMAS generates this figure using daily SWE measurements made by the Natural Resources Conservation Service.

On the Web:

For color maps of SNOTEL basin snow water content, visit:
http://www.wrcc.dri.edu/snotelanom/basinswe.html

For NRCS source data, visit:
http://www.wcc.nrcs.usda.gov/snow/

For a list of river basin snow water content and precipitation, visit:
http://www.wrcc.dri.edu/snotelanom/snotelbasin

Temperature Outlook
(March–August 2013)

Data Source: NOAA-Climate Prediction Center (CPC)

The seasonal temperature outlooks issued by the NOAA-Climate Prediction Center (NOAA-CPC) in February call for increased chances that temperatures will be similar to the warmest 10 years in the 1981–2010 period for the three-month seasons spanning March through August (*Figures 9a–d*). If temperatures are above average for the March–May period, the magnitude of the anomaly is likely to be between 0.2 and 1.2 degrees F in Arizona and New Mexico; temperature anomalies increase from northwest Arizona towards southeast New Mexico. The NOAA-CPC indicates that recent decadal trends are predominantly leading to the above-average temperature forecasts. In addition, soil moisture conditions may influence temperatures in coming months. Dry conditions, which would cause soils to be dry, would maximize the probability for above-average temperatures in the spring.

Notes:

These outlooks predict the likelihood (chance) of above-average, average, and below-average temperature, but not the magnitude of such variation. The numbers on the maps do not refer to degrees of temperature.

The NOAA-CPC outlooks are a three-category forecast. As a starting point, the 1981–2010 climate record is divided into 3 categories, each with a 33.3 percent chance of occurring (i.e., equal chances, EC). The forecast indicates the likelihood of one of the extremes—above-average (A) or below-average (B)—with a corresponding adjustment to the other extreme category; the “average” category is preserved at 33.3 likelihood, unless the forecast is very strong.

Thus, using the NOAA-CPC temperature outlook, areas with light brown shading display a 33.3–39.9 percent chance of above-average, a 33.3 percent chance of average, and a 26.7–33.3 percent chance of below-average temperature. A shade darker brown indicates a 40.0–50.0 percent chance of above-average, a 33.3 percent chance of average, and a 16.7–26.6 percent chance of below-average temperature, and so on.

Equal Chances (EC) indicates areas where no forecast skill has been demonstrated or there is no clear climate signal; areas labeled EC suggest an equal likelihood of above-average, average, and below-average conditions, as a “default option” when forecast skill is poor.

Figure 9a. Long-lead national temperature forecast for March–May 2013.

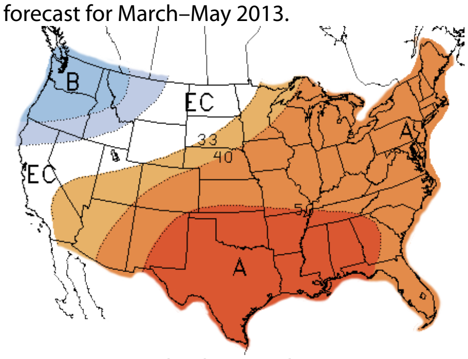
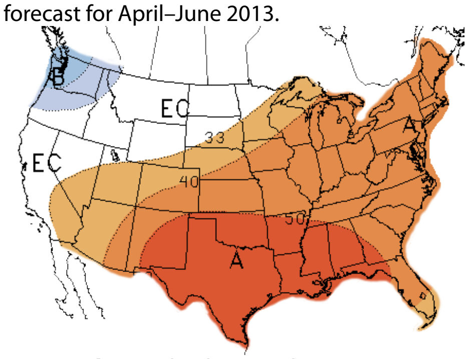


Figure 9b. Long-lead national temperature forecast for April–June 2013.



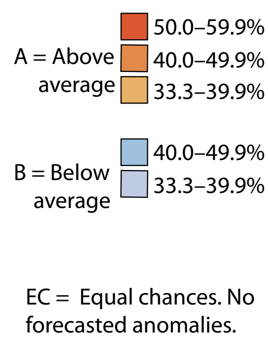


Figure 9c. Long-lead national temperature forecast for May–July 2013.

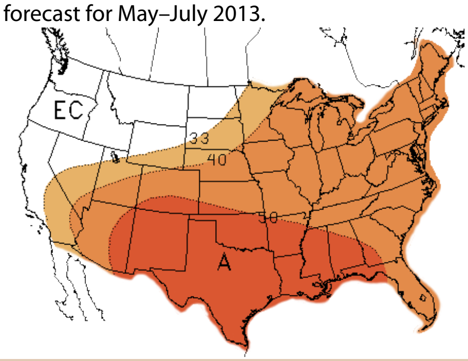
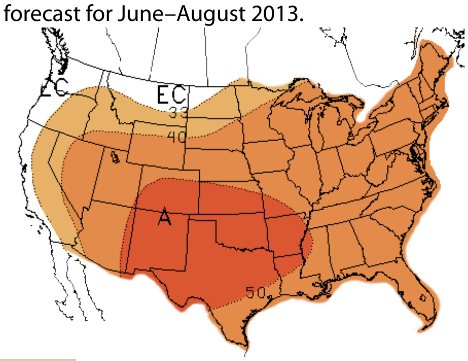


Figure 9d. Long-lead national temperature forecast for June–August 2013.



On the Web:

For more information on CPC forecasts, visit http://www.cpc.ncep.noaa.gov/products/predictions//multi_season/13_seasonal_outlooks/color/churchill.php

For seasonal temperature forecast downscaled to the local scale, visit http://www.weather.gov/climate/l3mto.php

For IRI forecasts, visit http://iri.columbia.edu/climate/forecast/net_asmt/

Precipitation Outlook
(March–August 2013)
Data Source: NOAA-Climate Prediction Center (CPC)

The seasonal precipitation outlooks issued by the NOAA-Climate Prediction Center (CPC) in February call for increased chances that precipitation during the March–May period will be below average across most of the Southwest (*Figure 10a*). All of Arizona and New Mexico have a 40 to 50 percent chance of being similar to the driest 10 years in the 1981–2010 record; probabilities for wetter-than-average conditions range from 17 to 27 percent, and near-average conditions have a likelihood of 33 percent. If below-average precipitation occurs in this period, there is a 50 percent chance that deficits will be between 0.2 and 0.4 inches. Forecasts call for equal chances of above-, below-, or near-average precipitation for the ensuing three-month seasons between April and August (*Figures 10b–d*). The April–June period, however, is historically dry. Most of Arizona and southwestern New Mexico, for example, receive less than 12 percent of their annual precipitation during these months.

Notes:

These outlooks predict the likelihood (chance) of above-average, average, and below-average precipitation, but not the magnitude of such variation. The numbers on the maps do not refer to inches of precipitation.

The NOAA-CPC outlooks are a 3-category forecast. As a starting point, the 1981–2010 climate record is divided into 3 categories, each with a 33.3 percent chance of occurring (i.e., equal chances, EC). The forecast indicates the likelihood of one of the extremes—above-average (A) or below-average (B)—with a corresponding adjustment to the other extreme category; the "average" category is preserved at 33.3 likelihood, unless the forecast is very strong.

Thus, using the NOAA-CPC precipitation outlook, areas with light green shading display a 33.3–39.9 percent chance of above-average, a 33.3 percent chance of average, and a 26.7–33.3 percent chance of below-average precipitation. A shade darker green indicates a 40.0–50.0 percent chance of above-average, a 33.3 percent chance of average, and a 16.7–26.6 percent chance of below-average precipitation, and so on.

Equal Chances (EC) indicates areas where no forecast skill has been demonstrated or there is no clear climate signal; areas labeled EC suggest an equal likelihood of above-average, average, and below-average conditions, as a "default option" when forecast skill is poor.

Figure 10a. Long-lead national precipitation forecast for March–May 2013.

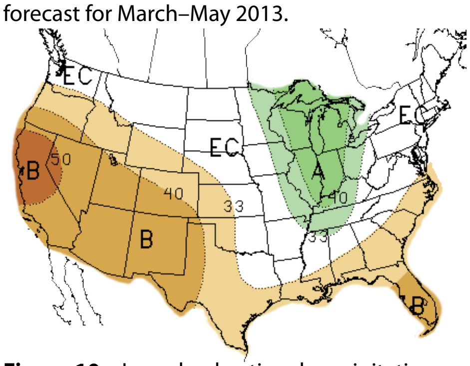
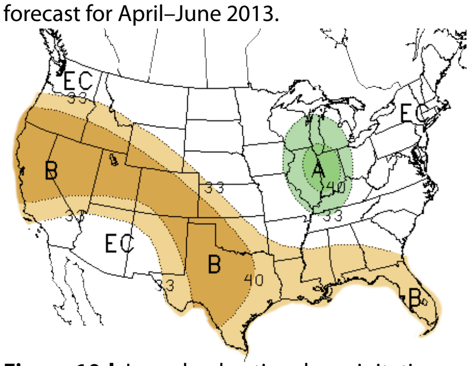


Figure 10b. Long-lead national precipitation forecast for April–June 2013.



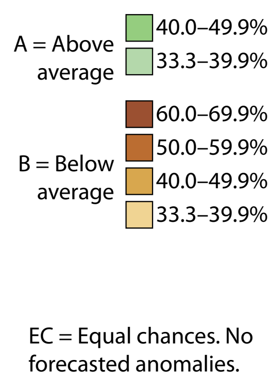


Figure 10c. Long-lead national precipitation forecast for May–July 2013.

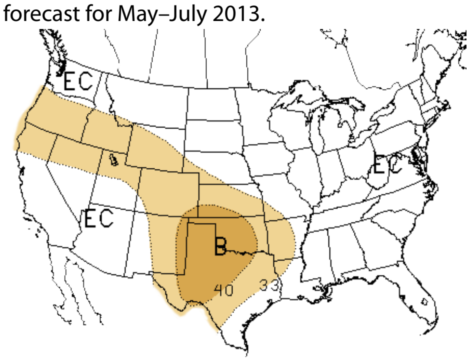
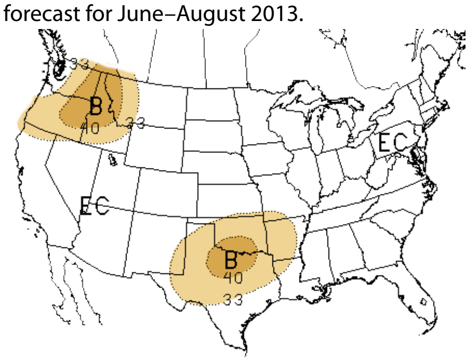


Figure 10d. Long-lead national precipitation forecast for June–August 2013.



On the Web:

For more information on CPC forecasts, visit http://www.cpc.ncep.noaa.gov/products/predictions//multi_season/13_seasonal_outlooks/color/churchill.php (note that this website has many graphics and may load slowly on your computer)

For IRI forecasts, visit http://iri.columbia.edu/climate/forecast/net_asmt/

Seasonal Drought Outlook

(through May 2013)

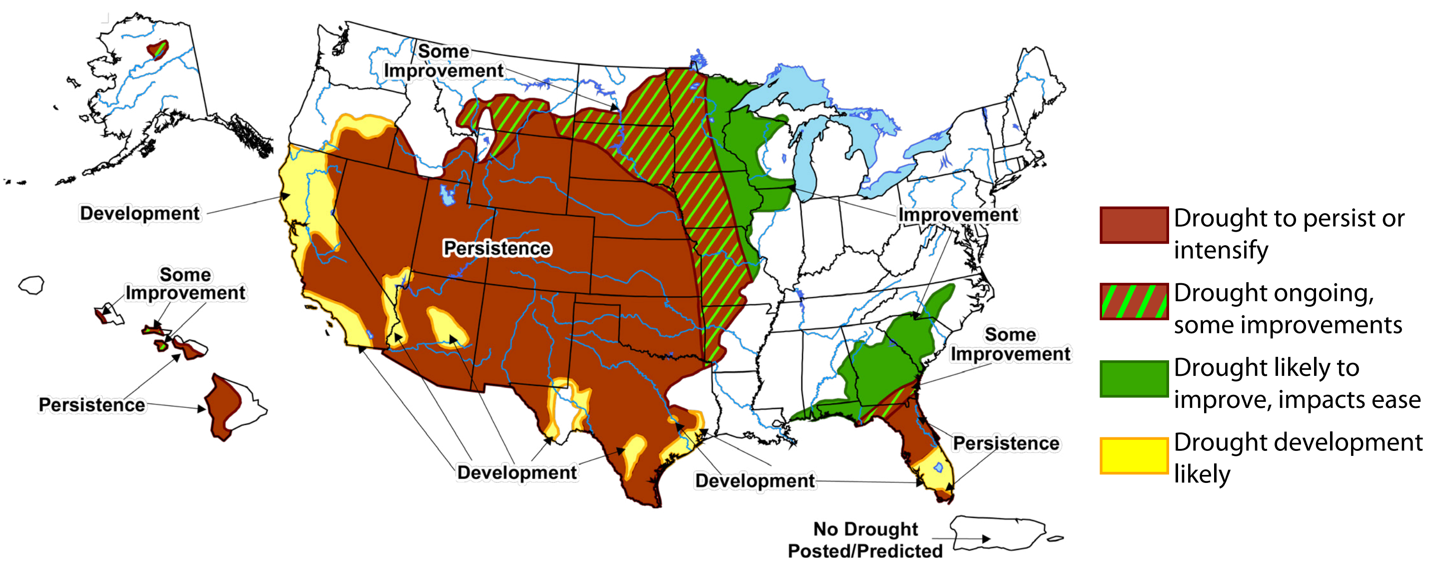
Data Source: NOAA–Climate Prediction Center (CPC)

Moderate or more severe drought covers about 83 and 98 percent of Arizona and New Mexico, respectively (see pages 9 and 10). In Arizona, there was some improvement in drought conditions in the last month, while dry conditions in New Mexico remained virtually unchanged. However, these drought statistics do not include the recent storm that brought cold and wet conditions to most of Arizona and many parts of New Mexico, including snow to the metropolitan cities of Phoenix, Tucson, and Albuquerque. In spite of the recent storm, the drought picture is unlikely to change in coming months. The Seasonal Drought Outlook, issued by the NOAA-Climate Prediction Center (NOAA-CPC) on February 21, calls for the persistence of drought across the Southwest through at least May (*Figure 11*). Isolated areas in northwest Arizona and southeast New Mexico that experienced improvements in drought conditions over the past several months are expected to slide back into more intense drought in coming months. The region normally experiences dry conditions after late March, which will create few opportunities, if any, to make up for precipitation deficits incurred during the winter until the monsoon season begin anew.

Notes:

The delineated areas in the Seasonal Drought Outlook are defined subjectively and are based on expert assessment of numerous indicators, including the official precipitation outlooks, various medium- and short-range forecasts, models such as the 6-10-day and 8-14-day forecasts, soil moisture tools, and climatology.

Figure 11. Seasonal drought outlook through May 2013 (released February 21).



On the Web:

For more information, visit http://www.drought.gov/portal/server.pt

For medium- and short-range forecasts, visit http://www.cpc.ncep.noaa.gov/products/forecasts/

For soil moisture tools, visit http://www.cpc.ncep.noaa.gov/soilmst/forecasts.shtml

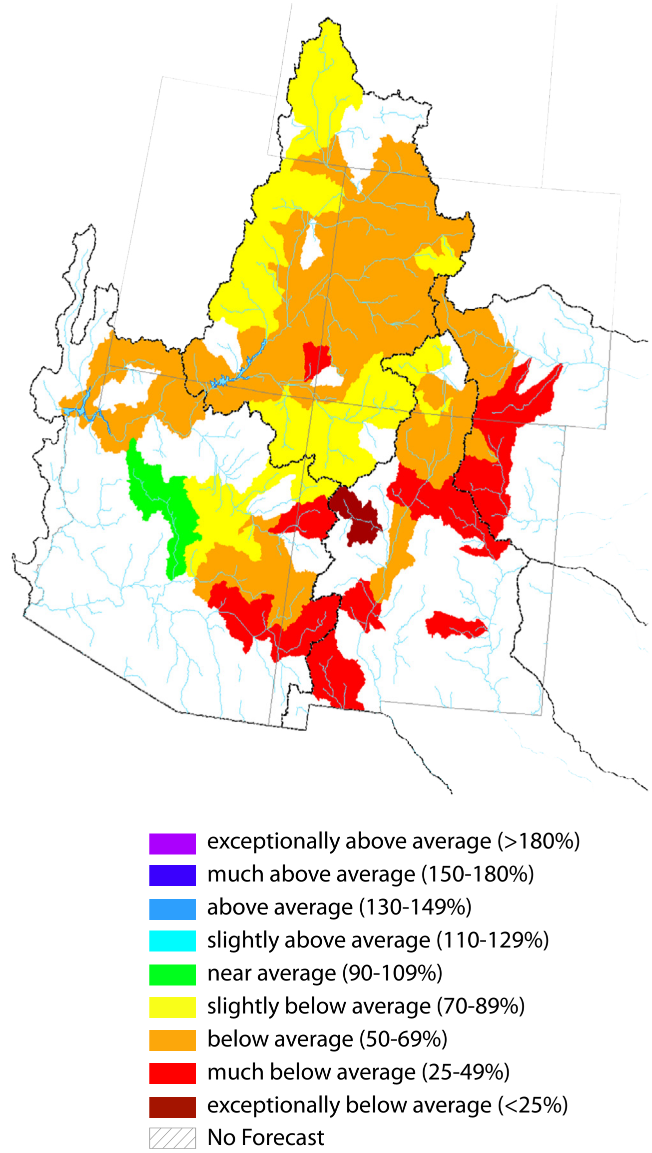
Streamflow Forecast
(for spring and summer)
Source: National Water and Climate Center

The spring–summer streamflow forecast for the Southwest, issued on February 1 by the Natural Resources Conservation Service (NRCS), calls for below-average flows in most river basins in Arizona and New Mexico (*Figure 12*). Based on the accumulated precipitation through February 1, there is only a 50 percent chance that the Salt River, measured near Roosevelt Lake, and the Gila River, measured at the inflow of San Carlos Reservoir, will exceed 63 and 44 percent of the February–May average, respectively. The 50 percent likelihood can be considered the best estimate. In these probabilistic forecasts, lower likelihoods are accompanied by a higher percent of average streamflows, and vice versa. For example, the Salt River has only a 30 percent chance of exceeding 84 percent of average flows.

For Lake Powell, there is only a 50 percent chance that spring inflow will exceed 52 percent of the 1971–2000 average for April–July, or about 3.75 million acre-feet. The forecast also indicates only a 10 percent chance that Lake Powell inflow will be more than 91 percent of average, providing an indicator that above-average flows are very unlikely. The Verde River is the only watershed in Arizona in which spring streamflows are likely to be above average.

Below-average precipitation has fallen this winter in the Rio Grande headwaters in southern Colorado. Consequently, there is a 50 percent chance that the March–July flow in the Rio Grande, measured at Otowi Bridge in New Mexico, will be 47 percent of average, the same as last month. If this occurs, irrigators in the Elephant Butte Irrigation District could experience another season with below-average allotments. As of February 1, Elephant Butte Reservoir contains only 8 percent of its full storage. Also, the projected inflow into the El Vado Reservoir, on the Rio Grande north of Otowi Bridge, is only 64 percent of average; El Vado contains only 8 percent of average storage.

Figure 12. Spring and summer streamflow forecast as of February 1 (percent of average).



Notes:

Water supply forecasts for the Southwest are coordinated between the National Water and Climate Center, part of the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS), and the Colorado Basin River Forecast Center (CBRFC), part of NOAA. The forecast information provided in Figure 12 is updated monthly by the NWCC. Unless otherwise specified, all streamflow forecasts are for streamflow volumes that would occur naturally without any upstream influences, such as reservoirs and diversions. The coordinated forecasts by NRCS and NOAA are only produced for Arizona and New Mexico between January and May,

The NRCS provides a range of forecasts expressed in terms of percent of average streamflow for various exceedance levels. The forecast presented here is for the 50-percent exceedance level, and is referred to as the most probable streamflow. This means there is at least a 50 percent chance that streamflow will occur at the percent of average shown in Figure 12. The CBRFC provides a range of streamflow forecasts in the Colorado Basin ranging from short-fused flood forecasts to longer-range water supply forecasts. The water supply forecasts are coordinated monthly with NWCC.

On the Web:

For state river basin streamflow probability charts, visit:
http://www.wcc.nrcs.usda.gov/cgibin/strm_cht.pl

For information on interpreting streamflow forecasts, visit:
http://www.wcc.nrcs.usda.gov/factpub/intrpret.html

For western U.S. water supply outlooks, visit:
http://www.wcc.nrcs.usda.gov/wsf/westwide.html
http://www.cbrfc.noaa.gov

El Niño Status and Forecast

Data Sources: NOAA-Climate Prediction Center (CPC), International Research Institute for Climate and Society (IRI)

Sea surface temperatures (SSTs) have been close to average across much of the eastern Pacific Ocean over the past 30 days, which is consistent with ongoing ENSO-neutral conditions. Atmospheric circulation patterns—reflected in the Southern Oscillation Index (SOI)—also have been close to average for this time of year, which is an additional indication of ENSO-neutral conditions (*Figure 13a*). Often, ENSO-neutral events bring more variable weather across the Southwest during the next several months.

ENSO forecasts issued jointly by the NOAA-Climate Prediction Center (NOAA-CPC) and International Research Institute for Climate and Society (IRI) indicate a strong likelihood that neutral conditions will remain through at least the upcoming spring season, and perhaps longer. The mid-February forecast indicates a 74 percent chance that neutral conditions will persist through the April–June period and a 26 percent chance that La Niña conditions will emerge; it is virtually certain that an El Niño event will not develop (*Figure 13b*).

While the chance of neutral conditions persisting through the summer and fall is about 54 percent and much greater than the development of either a La Niña or El Niño event, the NOAA-CPC notes that forecast confidence is low after the spring. Uncertainty for these time periods is typical for forecasts issued during the winter because models have difficulty identifying the initiation of La Niña or El Niño events. This is known as the "spring predictability barrier." ENSO forecasts will become more certain for the summer season during the next several months, and if a strong ENSO event rapidly materializes, it could lend some forecasting insight for the upcoming monsoon season.

Notes:

The first figure shows the standardized three month running average values of the Southern Oscillation Index (SOI) from January 1980 through January 2013. The SOI measures the atmospheric response to SST changes across the Pacific Ocean basin. The SOI is strongly associated with climate effects in the Southwest. Values greater than 0.5 represent La Niña conditions, which are frequently associated with dry winters and sometimes with wet summers. Values less than -0.5 represent El Niño conditions, which are often associated with wet winters.

The second figure shows the International Research Institute for Climate and Society (IRI) probabilistic El Niño-Southern Oscillation (ENSO) forecast for overlapping three-month seasons. The forecast expresses the probabilities (chances) of the occurrence of three ocean conditions in the ENSO-sensitive Niño 3.4 region, as follows: El Niño, defined as the warmest 25 percent of Niño 3.4 sea-surface temperatures (SSTs) during the three month period in question; La Niña conditions, coolest 25 percent of Niño 3.4 SSTs; and neutral conditions where SSTs fall within the remaining 50 percent of observations. The IRI probabilistic ENSO forecast is a subjective assessment of current model forecasts of Niño 3.4 SSTs that are made monthly. The forecast takes into account the indications of the individual forecast models (including expert knowledge of model skill), an average of the models, and other factors.

On the Web:

For a technical discussion of current El Niño conditions, visit http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/

For more information about El Niño and to access graphics similar to the figures on this page, visit http://iri.columbia.edu/climate/ENSO/

Figure 13a. The standardized values of the Southern Oscillation Index from January 1980–January 2013. La Niña/El Niño occurs when values are greater than 0.5 (blue) or less than -0.5 (red), respectively. Values between these thresholds are relatively neutral (green).

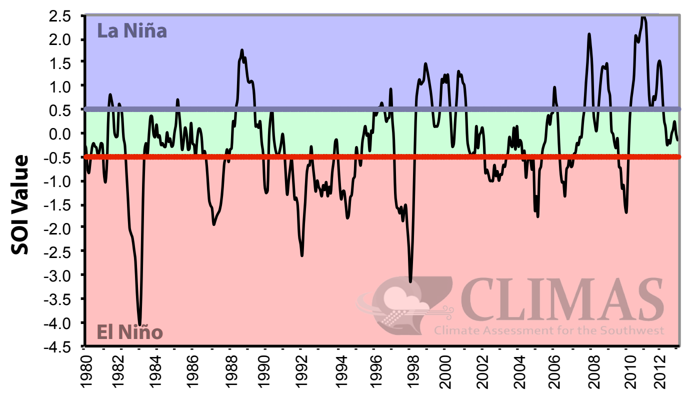


Figure 13b. IRI probabilistic ENSO forecast for the Niño 3.4 monitoring region (released February 21). Colored lines represent average historical probability of El Niño, La Niña, and neutral conditions.