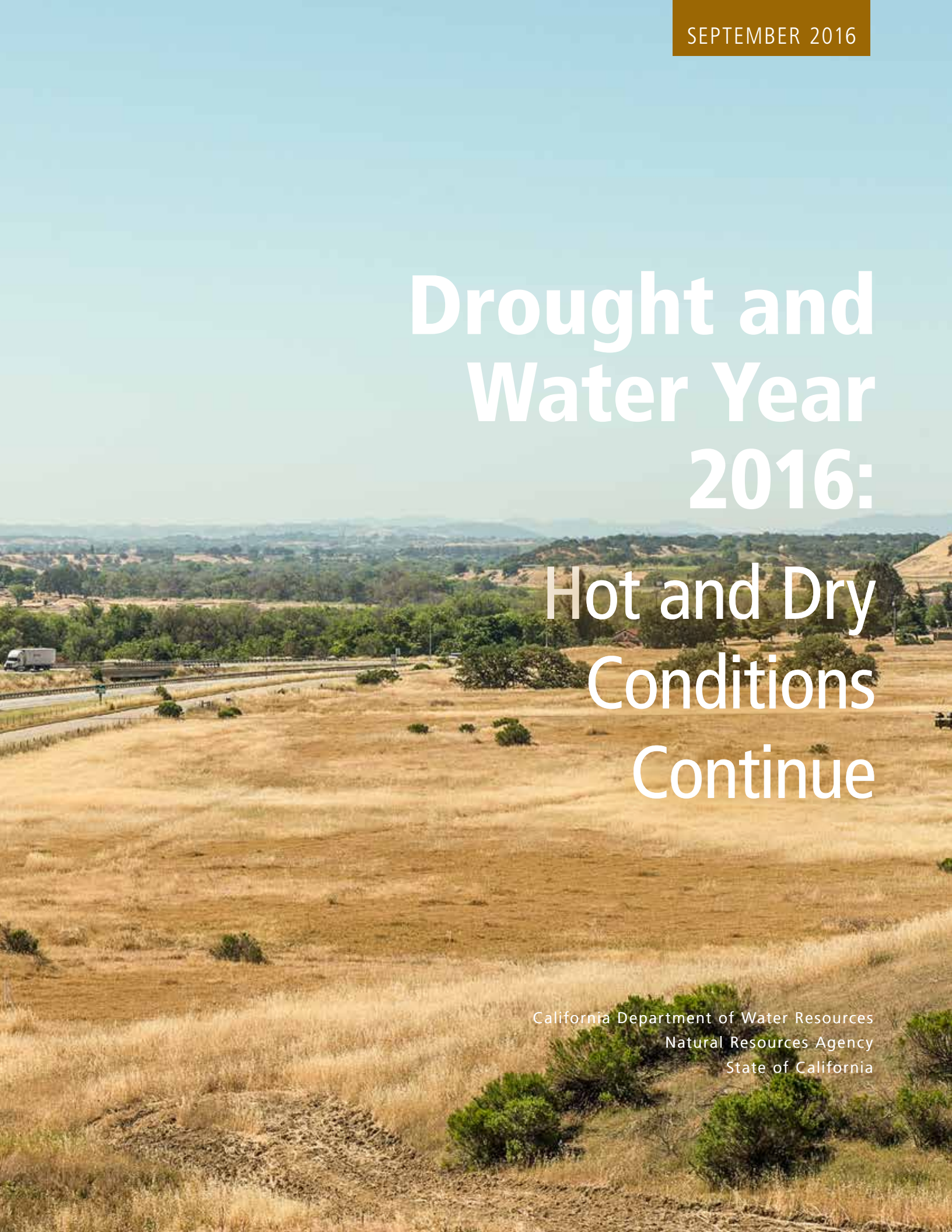
SEPTEMBER 2016

Drought and Water Year 2016:

Hot and Dry Conditions Continue



California Department of Water Resources
Natural Resources Agency
State of California

Tule elk graze on the bottom of the 2 million acre-foot state-federal San Luis Reservoir on August 24, 2016, when the reservoir was at 13 percent of its capacity. Low water levels exposed the upper intake structure for San Felipe Division of the Central Valley Project, which supplies water to Santa Clara Valley Water District and to San Benito County Water District. The intake has also been exposed in other drought years, such as 1991 and 2008. Low water levels in the reservoir in late summer lead to a problem known as "low point" for the San Felipe Division contractors, when reduced reservoir volume and warm temperatures contribute to growth of a thick layer of algae. The algae create drinking water taste and odor problems for urban water users, and clog drip irrigation systems for agricultural water users.

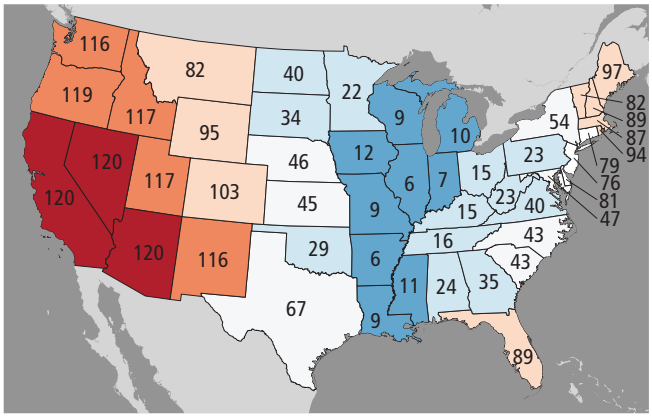
Record Warm and Dry Conditions Continue

Drought is a recurring feature of California's climate. Paleoclimate information, such as streamflow or precipitation reconstructions developed from tree-ring data, can provide a perspective on long-term climate variability. Reconstructed hydrologic records show that California has experienced droughts of much longer duration than those in our century-plus recorded historical period. There is, however, one drought within the historical period on a par with driest events in the paleo record, if the comparison is made using driest 10-year streamflow periods. The prolonged off-and-on dry conditions of the 1920s-30s were severe in terms of their hydrology, but they occurred at a time when the state's population was in the ballpark of 6 million and irrigated acreage was less than half of present levels.

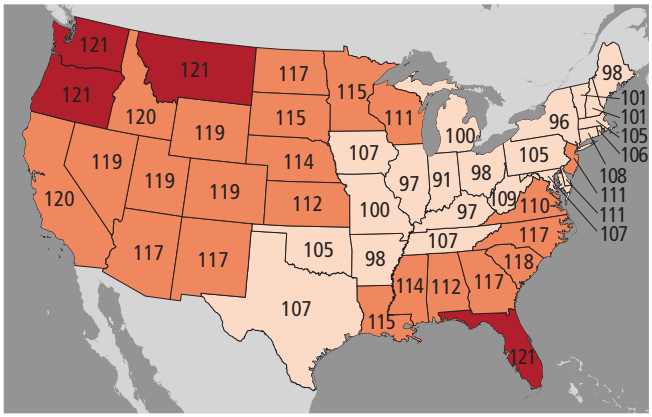
Our present drought is occurring at a time of record warmth in California. Broadly speaking, the period since 1950 has been warmer across the U.S. Southwest (including California and the Colorado River Basin) than in any comparable period in at least 600 years, according to the 2013 Southwest Climate Assessment. Increased warmth in the climate system has many implications – an increasing fraction of precipitation falling as rain instead of snow, diminished mountain snowpack, earlier snowmelt runoff, increased water demands for crops or urban landscaping or native vegetation. California tied a record for lowest April 1st statewide snow water equivalent in 2014, at 25 percent of average, breaking records dating back to 1950. That record was broken in 2015 when April 1st snow water equivalent was five percent of average.

Statewide Average Temperature Ranks

January - December 2014; Period: 1895-2014



January - December 2015; Period: 1895-2015



Data courtesy of NOAA/NCEI

Driest Four Consecutive Water Years in California Based on Statewide Precipitation

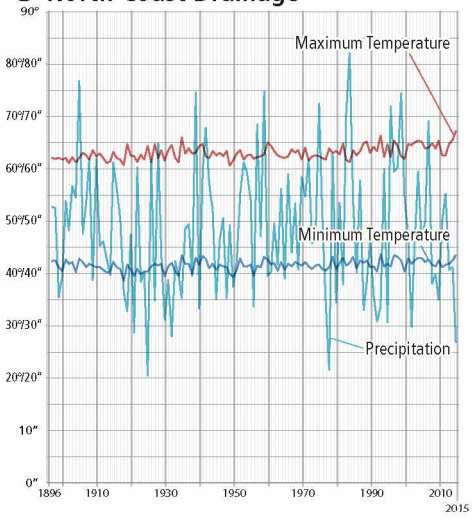
Drought impacts increase with the duration of dry conditions. All but two years of the last decade have been dry in California – our most recent prior drought of water years 2007-09 was followed by the current five years of drought (water years 2012-16), and four of those years set a record for the driest four consecutive water years. Extended dry conditions have also been occurring in the Colorado River Basin, where the period of 2000-2015 was the driest 16-year period in the historical record.

Year	4-Year Total, inches
2012-2015	62.2
1917-1920	63.1
1923-1926	63.3
1928-1931	64.5
1931-1934	65.1
1921-1924	65.7
1922-1925	65.9
1918-1921	66.8
1929-1932	67.3
1987-1990	67.3
1930-1933	68.0

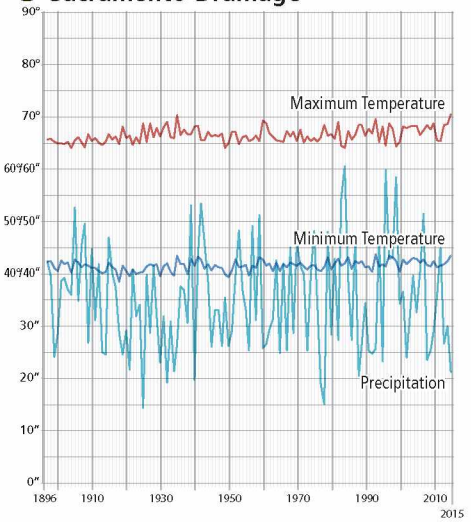
Data from Western Regional Climate Center

National Centers for Environmental Information Climate Division Data by Water Year, 1896 to 2015: Maximum and Minimum Temperature and Precipitation

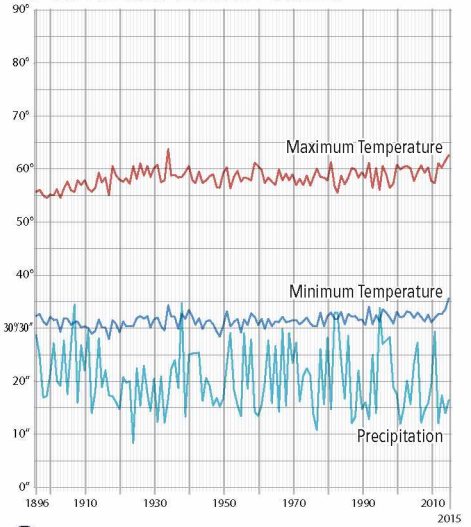
1 North Coast Drainage



2 Sacramento Drainage

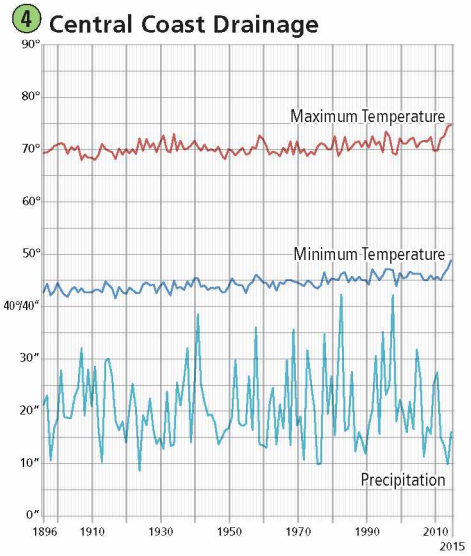


3 Northeast Interior Basins

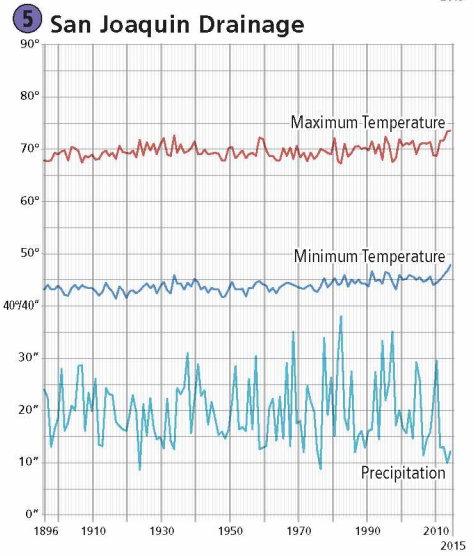


Temperatures have increased regionally across the state during the historical period. Baseline climate conditions are warmer now than they were during the severe drought periods of the 1920s-30s. Unfortunately we do not have sufficient snowpack data coverage from that time period to provide a comparison with the record low levels of the present drought.

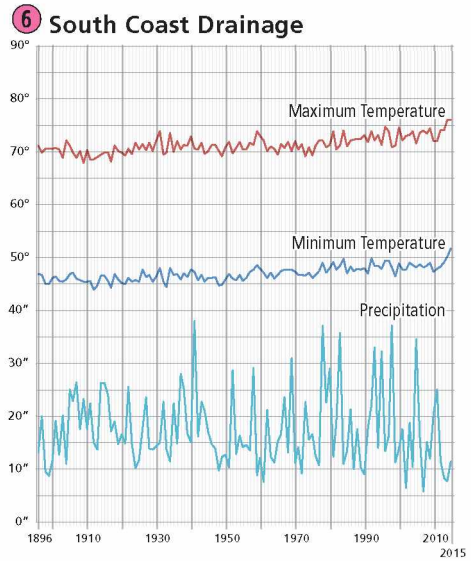
4 Central Coast Drainage



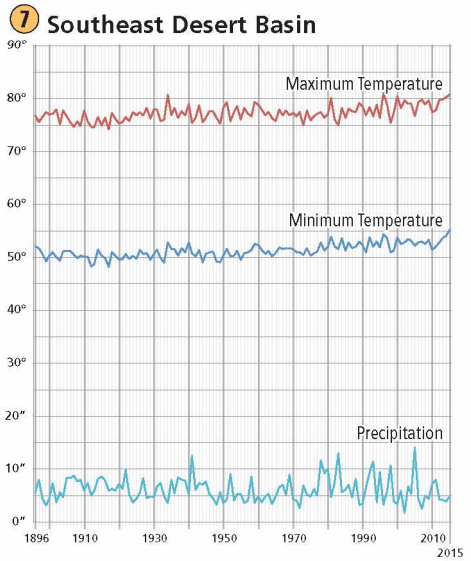
5 San Joaquin Drainage



6 South Coast Drainage



7 Southeast Desert Basin



The impacts of cumulative conditions – multiple dry years, low snowpack, warm temperatures – can be seen in spring runoff values for the major Central Valley watersheds that provide much of California's developed water supplies. Water year 2011 (a wet year) values are provided for comparison. Even though parts of Northern California experienced average to slightly above average precipitation in water year 2016, spring runoff was significantly below average due to factors such as replenishment of depleted soil moisture, increased uptake by vegetation, and less precipitation falling as snow. The April 1st statewide snow water equivalent was 85% percent of average in 2016, better than that of the two prior dismally low years, but not enough to achieve average runoff levels. The term "snow drought" is beginning to be used to describe these low snowpack conditions.

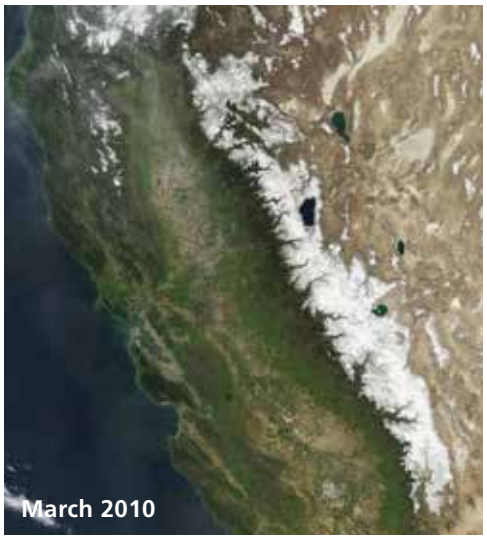
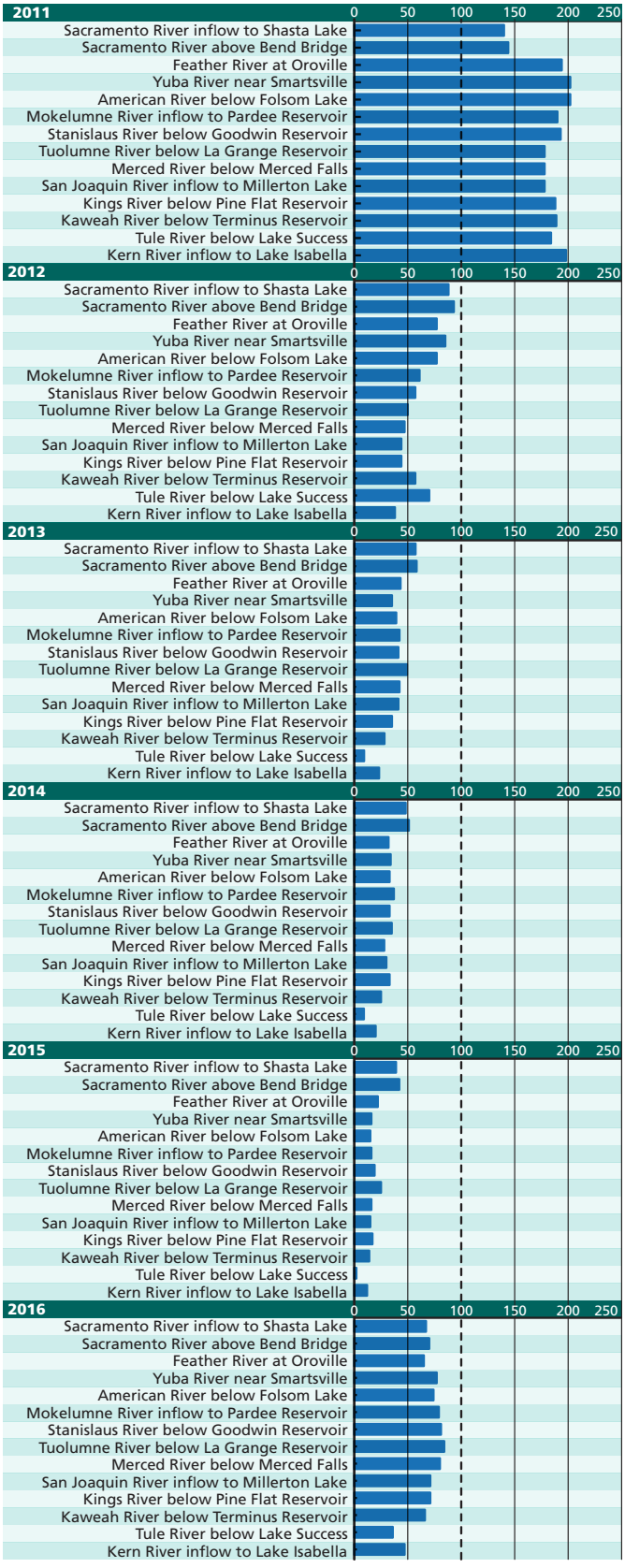


Photo: NASA satellite imagery

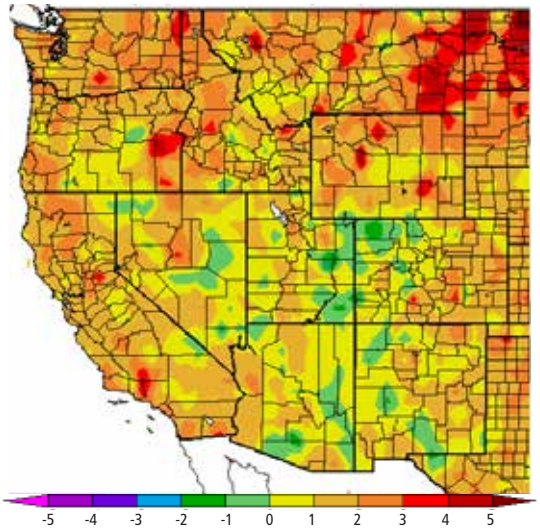
Water year 2011-2016 April-July runoff at forecast points on major Central Valley rivers, as percentage of average



Water year 2016 values are provisional

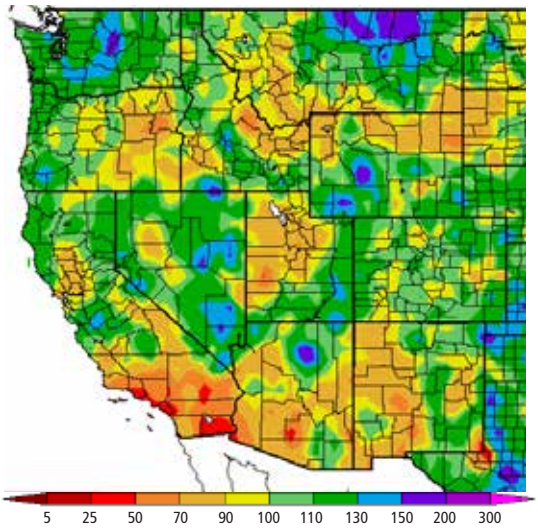
The cumulative warm and largely dry conditions persisting into water year 2016 affect water supplies for human uses and the environment. Water level declines in groundwater basins are continuing, with many wells breaking their prior record lows. Wildfire risk remains elevated, especially in Southern California, and widespread tree mortality has occurred in some Sierra Nevada watersheds. Emergency drought relief activities continue, including assistance for small communities and private well owners whose drinking water supplies are affected.

Average Temperature departure from Average (degF), 10/1/2015 - 9/15/2016



Generated 9/16/2016 at WRCC using provisional data. NOAA Climate Centers

Percent of Average Precipitation (%), 10/1/2015 - 9/15/2016



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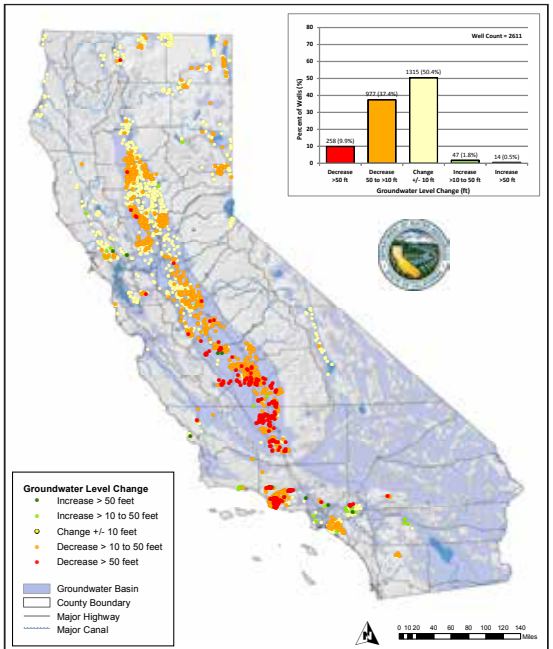
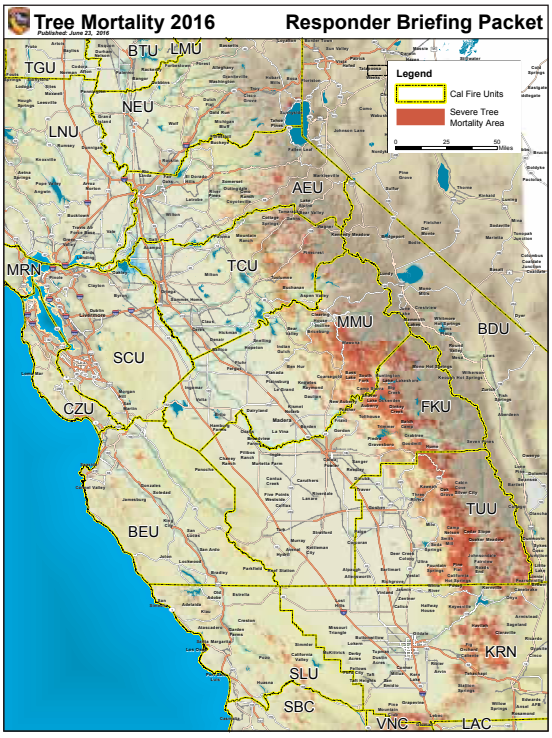
Groundwater Level Change* - Spring 2011 to Spring 2016



*Groundwater level change determined from water level measurements in wells. Map and chart based on available data from the DWR Water Data Library as of 7/5/2016. Document Name: DROUGHT_S1611-50_20160705 Updated: 7/7/2016. Data subject to change without notice.

Tree Mortality, 2016

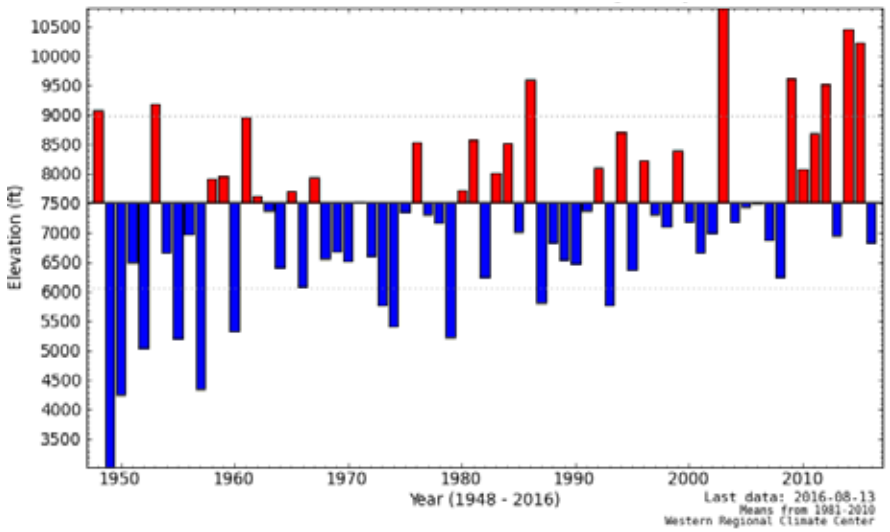


California's annual water supplies are dominated by a surprisingly small number of winter storms – the absence of several large storms or an intensification of several of them tips the balance between a dry year and a wet year. Operational weather models, which are run out to two weeks in the future, are relatively skillful in predicting these large storms out to about a week, although accurate quantitative estimates of precipitation at specific points remain a work in progress. There is currently very little scientific skill in predicting precipitation at sub-seasonal (a month or two) or seasonal (the winter wet season) timescales, and improving this prediction skill is a high priority for water management. The inability to correctly predict seasonal precipitation in water year 2016 during one of the strongest El Niño events of record illustrates how much work remains to be done in this area.

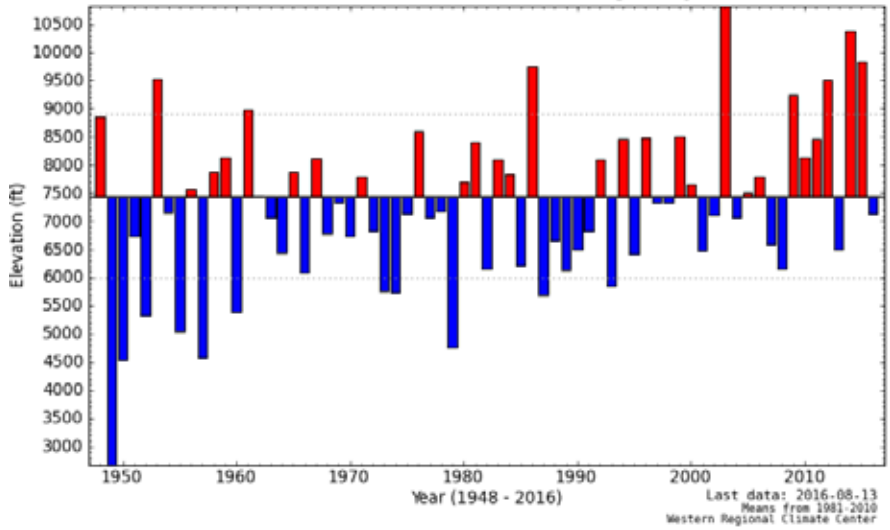
Skill in temperature predictions is higher than that for precipitation predictions, and climate models run over very long time periods show high agreement for a warmer future for California. Future droughts are likely to resemble what California has begun to experience with reduced snowpacks, more precipitation falling as rain, and diminished snowpack runoff. While it is not possible to accurately say whether water year 2017 will be wet or dry, we can expect that on average future droughts will become increasingly challenging due to the expected warmer temperatures.

Average freezing levels in January at two popular Sierra Nevada ski areas

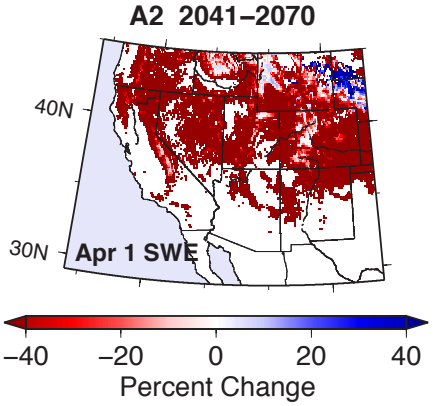
Squaw Valley



Mammoth Mountain



Predicted future change in April 1st snow water equivalent using a high (A2) greenhouse gas emissions scenario, from the Southwest Climate Assessment



Bias Corrected and Downscaled World Climate Research Programme's CMIP3 Climate Projections archive at http://gdo-dcp.ucllnl. org/downscaled_cmip3_projections/#Projections:%20 Complete%20 Archives

FALL 2016
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