

California's dry season is turning into a permanent state of being

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Drought across the Western U.S. has forced California to ration water to farms. Hydroelectric dams barely work. The smallest spark—from a lawnmower or even a flat tire—can explode into a wildfire.

While this region has always had dry summers, they're supposed to follow a pattern that leads to relief with the arrival of the annual rainy season in November. But a break is no longer guaranteed.

In fact, there are now both short- and long-term factors drying out the Western U.S. Under the influence of fast-warming temperatures, as documented in detail by this week's report from the U.N.-backed Intergovernmental Panel on Climate Change, the region may be entering a drier state. Drought season might be giving way to a drought era.

Here are three forces desiccating the region.

A second consecutive La Nina looms

The Climate Prediction Center just issued a forecast water managers in the Western U.S. didn't want to hear. The latest report, released Thursday, puts the odds in favor of a second straight year of La Nina conditions in the Pacific Ocean.

La Nina tends to steer the storm track north of California, leaving most of the state and the Southwest parched. Last year's La Nina is one of the reasons for the current drought. If the forecast had instead called for El Nino, the odds would have favored a wetter than average winter for California and the Southwest—something the region badly needs.

"If we want to see improvement of the drought across the West, the last thing you want to see is a back-to-back La Nina," said Tom Di Liberto, a meteorologist with the National Oceanic and Atmospheric Administration. While it doesn't always lead to a dry winter, it stacks the deck in favor of one.

La Nina is driven by a vast pool of unusually cool water near the equator in the eastern Pacific, just as El Nino is driven by warmer water in the

same place. The consequences of La Nina aren't all bad, since additional storms sent into the Pacific Northwest and Western Canada will help subdue devastating wildfires there.

The effects in Northern California are harder to predict. "California has the highest variability in precipitation anywhere in the U.S." said Jeanine Jones, interstate resources manager for the California Department of Water Resources. "We cannot say what next year is going to be like."

If the coming winter brings little rain and snow, the results will be troubling. California has already suffered through two dry years, leaving the soil so parched that what little snow fell in the Sierra Nevada Mountains last winter either evaporated into the air this spring or sunk straight into the dirt, leaving little runoff for rivers and reservoirs. Even with average winter rain and snowfall, runoff would remain low just because the land is so dry.

"If you have a string of dry years, that sets you up for low runoff efficiency in the next year," Jones said. "It is going to take above average precipitation to get average runoff."

How warmer air creates parched ground

While La Nina can influence rainfall patterns over the course of a year, longer-range effects are also in play. One is hard to avoid because of climate change: hotter air.

Hot air holds more moisture, so the warming atmosphere is sucking up more water from plants and soil day after day, said Park Williams, a climate scientist at the University of California, Los Angeles. Williams studied tree-ring data stretching back 1,200 years and found four periods when the Western U.S. was gripped by "megadrought," a dry period of unusual severity lasting decades. Only the most recent one, at the end of

the 1500s, had soil moisture levels as low as California has experienced in the first two decades of the current century.

That means the impact from warmer air might already be registering in the soil. "The normal really is changing to a drier state, and that trend is becoming clear," Williams said.

If annual precipitation increased substantially, this could compensate for the daily drying. But Williams said most climate models don't predict more rain. To make matters worse, his tree-ring study showed that the 20th century was actually an unusually wet period.

Our expectations of "normal" rainfall, in other words, have always been a little skewed. "Modern society really developed in the Western U.S. in the 1900s—that's when all the infrastructure was built—and we're experiencing conditions it wasn't built to handle," Williams said. "In the 1900s, society was able to really evolve in a period of ignorant bliss."

In the short-run, meanwhile, the drier earth can amplify heat waves like the recent record-breakers in the U.S. and Canada. "Droughts lead to drier grounds, which lead to higher temperatures. It's a vicious cycle," Di Liberto said.

The Hadley Cell brings dry air from above

Think of the Hadley Cell as two constantly spinning wheels in the atmosphere, moving in opposite directions. Moist, hot air rises near the equator, then drops most of its moisture as rain before flowing towards the two poles. One current runs north, the other runs south. These currents descend back toward the surface drier than at the start of the cycle.

In the Northern Hemisphere, the current ends up close to the southern

border of California, Arizona and New Mexico.

Scientists have speculated for years that climate change would expand the Hadley Cell, pushing its drier edge in each hemisphere closer to the poles. This week's IPCC report found that's happening, although only in the Southern Hemisphere could they blame the effect on global warming with confidence. (In the Northern Hemisphere, the change so far lies within a range that could be explained by natural variability.)

As it expands, California and much of the Western U.S. will fall more clearly in the bulls-eye of the cell's drier air. Richard Seager, senior research scientist at Columbia University's Lamont-Doherty Earth Observatory, wrote about the effect in 2007, citing it as one of several factors that would lead to a drier climate in the West. Seager said there will be years when natural cycles like El Nino—with its wetter winters in California—will counteract some of the longer-term forces like the expansion of the Hadley Cell. But the overall trend is toward a more arid future.

"There are better cases and worse cases, but there aren't any models saying that water availability in the Southwest will get better with [climate change](#)," he said. "It's a case of less bad or more bad."

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