

As groundwater depletes, arid American West is moving east

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Depletion of groundwater will be more disruptive to vegetation, streams and rivers in the eastern US than in the arid Southwest, where deep groundwater already is largely disconnected from surface waters, illustrated here by the Colorado River meandering through red sandstone in northern Arizona. Credit: Daniel Stolte

Even under modest climate warming scenarios, the continental United States faces a significant loss of groundwater—about 119 million cubic meters, or roughly enough to fill Lake Powell four times or one quarter of Lake Erie, a first-of-its-kind study has shown.

The results, published today in *Nature Communications*, show that as [warming](#) temperatures shift the balance between water supply and demand, shallow [groundwater](#) storage can buffer plant [water stress](#)—but only where shallow groundwater connections are present, and not indefinitely. As warming persists, that storage can be depleted—at the expense of vital connections between surface water, such as rivers, streams and [water reservoirs](#) underground.

"Even with a 1.5 degrees Celsius warming case, we're likely to lose a lot of groundwater," said Reed Maxwell, professor of hydrology at the Colorado School of Mines, who co-authored the paper with Laura Condon of the University of Arizona and Adam Atchley of Los Alamos National Laboratory. "The East Coast could start looking like the West Coast from a water standpoint. That's going to be a real challenge."

Most global circulation models don't take into account the lateral movement of water in the subsurface. Typically, they only include limited up-and-down movement, such as rain percolating from vegetation into the soil and roots pulling up water from the ground. In addition, these models tend to limit their scope to mere meters above or below ground.

This new study goes beyond that to simulate how water moves in the subsurface and connects with the land surface.

"We asked what would the response look like if we included the entire complexity of subsurface water movement in a large-scale simulation, and we think this is the first time this has been done," said Condon, lead

author of the paper and assistant professor of hydrology and atmospheric sciences at the University of Arizona.

The calculations revealed a direct response of shallow groundwater storage to warming that demonstrates the strong and early effect that even low to moderate warming may have on groundwater storage and evapotranspiration.

In the western U.S., changes in groundwater storage may remain masked for a long time, the study revealed, because the groundwater there is already deep, and dropping levels would not have as great an effect on surface waters. Additionally, the region's vegetation is already largely water limited and adapted to being disconnected from deep groundwater sources.

However, the eastern U.S. will be much more sensitive to a lowering of the water table. Groundwater and [surface water](#) are more closely linked, and depleting the groundwater will be more disruptive to vegetation, streams and rivers. Many of the systems that have been put in place in the western U.S. for handling and managing water shortage are lacking in the eastern part of the country, as well.

The study revealed that regions in the eastern U.S. may reach a tipping point sooner rather than later, when vegetation starts to lose access to shallow groundwater as storage is depleted with warming.

"Initially, plants might not be experiencing stress because they still have existing shallow groundwater available, but as we continue to have warmer conditions, they can compensate less and less, and changes are more dramatic each year," Condon said. "In other words, shallow groundwater is buffering the response to warming, but when it's depleted, it can't do that anymore."

The study's simulations were set up to keep precipitation patterns the same and only increase atmospheric temperatures according to projections ranging from 1.5 to 4 degrees Celsius. Even with a modest 1.5 degrees Celsius of warming, 119 million cubic meters of storage were lost from groundwater—or four times the volume of Lake Powell, the largest reservoir in the Upper Colorado basin. At 4 degrees Celsius, groundwater losses were projected at 324 million cubic meters—roughly 10 times the volume of Lake Powell or enough to fill nearly three-quarters of Lake Erie.

"We are facing a crisis in global groundwater storage," Condon said. "Huge groundwater reservoirs are drying up at an alarming rate, and that's a problem because they nourish major growing regions around the world."

The research paper, "Evapotranspiration depletes groundwater under warming over the contiguous United States," is published in the open-access journal *Nature Communications*.

More information: Laura E. Condon et al. Evapotranspiration depletes groundwater under warming over the contiguous United States, *Nature Communications* (2020). [DOI: 10.1038/s41467-020-14688-0](https://doi.org/10.1038/s41467-020-14688-0)

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