# Researchers reveal the extent to which rivers across the country are losing flow to aquifers

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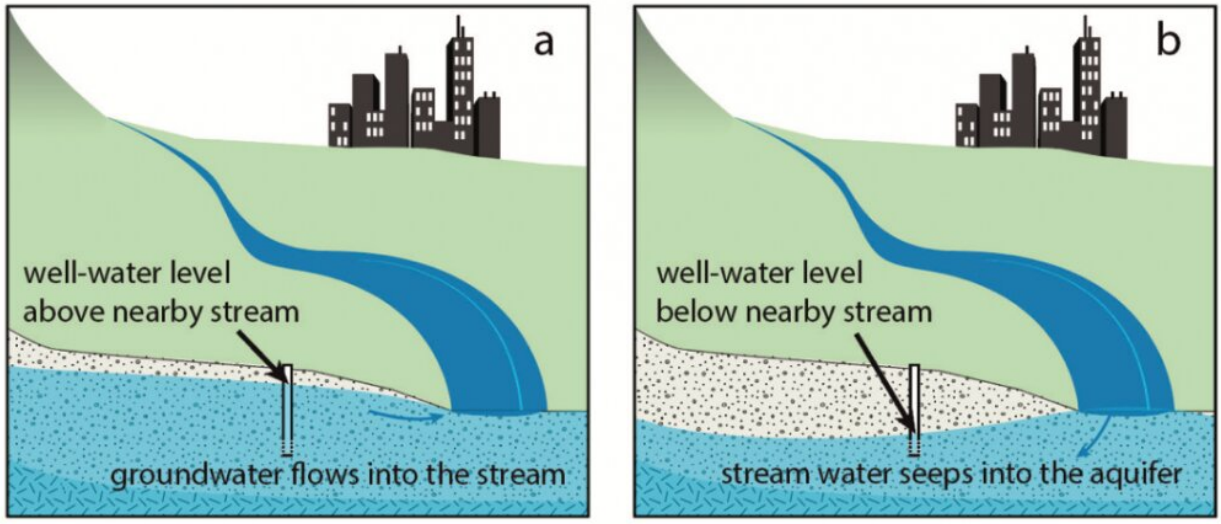



Waterways can gain water from the surrounding aquifer or leak water into the ground depending on the conditions. Credit: Jasechko et al

Water is an ephemeral thing. It can emerge from an isolated spring, as if by magic, to birth a babbling brook. It can also course through a mighty river, seeping into the soil until all that remains downstream is a shady arroyo, the nearby trees offering the only hint of where the water has gone.

The interplay between surface water and groundwater is often overlooked by those who use this vital resource due to the difficulty of

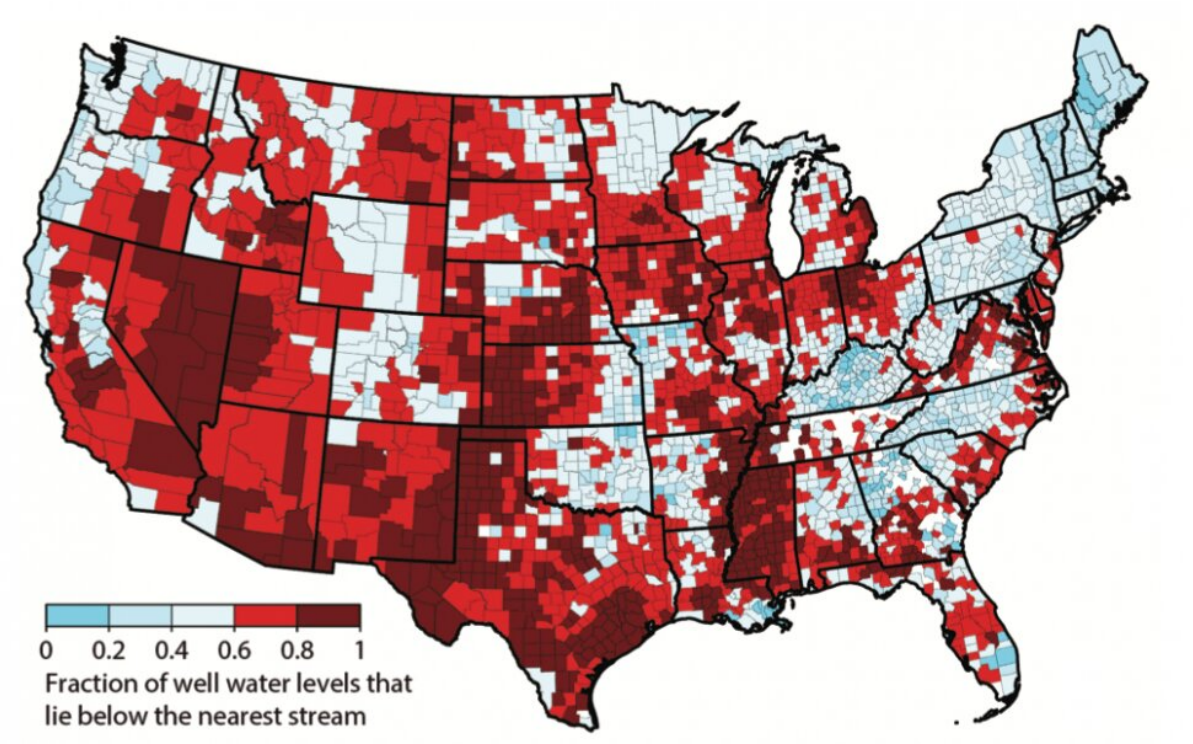
studying it. Assistant professors Scott Jasechko and Debra Perrone, of UC Santa Barbara, and their colleagues leveraged their enormous database of groundwater measurements to investigate the interaction between these related resources. Their results, published in *Nature*, indicate that many more rivers across the United States may be leaking water into the ground than previously realized.

In many places surface waters and groundwaters connect, while in others they're separated by impermeable rock layers. It depends on the underlying geology. But where they do intermingle, water can transition between flowing above and below ground.

"Gaining rivers" receive water from the surrounding groundwater, while "losing rivers" seep into the underlying aquifer. Scientists didn't have a good understanding of the prevalence of each of these conditions on a continental scale. Simply put, no one had previously stitched together so many measurements of groundwater, explained Jasechko, the study's co-lead author.

## Gaining and losing rivers

Typical groundwater studies include water level measurements from a few hundred to 1,000 wells. This study encompasses 4.2 million.




A map of well water levels with respect to the surface of the nearest river. Credit: Jasechko et al

Perrone and Jasechko devoted years to compiling data from 64 agencies across the U.S. and analyzing the results. "Compiling these data was a massive undertaking. We collected millions of datapoints and reviewed hundreds of papers over the course of six years," Perrone said.

The resulting database has precipitated a number of the team's subsequent studies. "We can use this extensive dataset in innovative ways to answer questions that we have not been able to address previously," she added.

For this paper, Jasechko, Perrone and their coauthors compared water levels in wells to the surface of the nearest stream. "We apply a simple

method to a large dataset," Jasechko said. "We identify wells with water levels that lie below the nearest stream, implying that these nearby streams could leak into the subsurface if it is sufficiently permeable."

The team found that nearly two-thirds of the wells had water levels below the nearest stream. This creates a gradient that can drive water from the river channel into the aquifer beneath.

"Our analysis shows that two out of three rivers in the U.S. are already losing water. It's very likely that this effect will worsen in the coming decades and some rivers may even disappear" said co-lead author Hansjörg Seybold at ETH Zurich.

"The phenomenon, set in motion decades ago, is now widespread across the U.S. There are far more streams draining into underlying aquifers than we had first assumed," Seybold continued. "Since rivers and streams are a vital water supply for agriculture and cities, the gravity of the situation came as a surprise."

This section of the Santa Ynez river leaks water into the surrounding aquifer. Credit: Debra Perrone

Rivers were particularly prone to losing water in arid regions, along flat topography and in areas with extensive groundwater pumping, they observed. A prime example of this would be flat agricultural land in semi-arid regions like California's Central Valley. "We are literally sucking the rivers dry," Seybold said.

Losing rivers can impact other water users, downstream communities and ecosystems that rely on surface flows. "Historically, we've often treated these two resources as separate resources," Perrone said. "Our work highlights the importance of considering groundwater and surface

water as a single resource where they are connected."

The researchers also found that losing rivers have been widespread in the U.S. for quite some time, present in many places at least as far back as the 1940s and '50s. And while many waterways naturally lose water, the issue can be exacerbated by human activity.

Humans have extracted water from the ground for thousands of years; in America they've been doing so for hundreds of years. The practice accelerated after World War II and has been rampant since the 1970s, accompanied by the undesirable and unintended consequences it entails.

"This isn't a new phenomenon," Jasechko said. "It's been with us for decades."

Water levels do fluctuate over years and decades, and unfortunately the researchers have only one data point for many of the wells in their sample. Other work by the team suggests that groundwater typically fluctuates by no more than a few meters over the course of a year. However, the water level for the many wells near losing rivers was more than two meters below the surface of the nearest stream, increasing the researchers' confidence that leaky rivers are likely widespread.

"We can only observe well water levels where wells exist," Jasechko acknowledged. "It's an obvious but important point. Our analysis is inherently biased to places where wells have been drilled, and therefore also to places where groundwater is pumped."

While the researchers don't see any straightforward way around this in the short-term, they hope their results can inform resource management and monitoring, perhaps informing policies that fund more monitoring wells in under-surveyed areas.

"Big studies like this get people thinking about broader water policy," Perrone said. "And for me, that is why continental scale analyses are important."

"My hope is that this study gets more people thinking about the interconnection of groundwater and surface water where these two resources are connected, and it also gets groundwater policy on the map," she continued. For so long this resource has been literally and metaphorically out of sight.

Perrone and Jasechko plan to expand this type of large-scale analysis to other parts of the globe and see how pumping and losing rivers impact groundwater-dependent ecosystems. Perrone also intends to connect their results back to her groundwater dashboard.

"Losing rivers aren't some hypothetical scenario," Jasechko stated. "They're here and now." They are in part the result of the past century of water use and misuse.

"If we have a better understanding of how widespread this phenomenon is, then we can influence future policy in positive ways," added Perrone. Because society is past the point where it can talk about prevention; we're now talking about response.

**More information:** Scott Jasechko et al, Widespread potential loss of streamflow into underlying aquifers across the USA, *Nature* (2021). DOI: 10.1038/s41586-021-03311-x

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