

As winters warm, nutrient pollution threatens 40 percent of US

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Scientists are ringing alarm bells about a significant new threat to U.S. water quality: as winters warm due to climate change, they are unleashing large amounts of nutrient pollution into lakes, rivers, and

streams.

The first-of-its-kind national study finds that previously frozen [winter](#) nutrient pollution—unlocked by rising [winter temperatures](#) and rainfall—is putting [water quality](#) at risk in 40% of the contiguous U.S., including over 40 states.

Nutrient runoff into rivers and lakes—from phosphorus and nitrogen in fertilizers, manure, [animal feed](#), and more—has affected [water](#) quality for decades. However, most research on nutrient runoff in snowy climates has focused on the growing season. Historically, [cold temperatures](#) and a continuous snowpack froze nutrients like nitrogen and phosphorous in place until the watershed thawed in the spring, when plants could help absorb excess nutrients.

But winters are the fastest warming U.S. season, and the seasonal snowpack in much of the U.S. has become less stable. Increased rain-on-snow, snowmelt, and rainfall events now carry nutrients and soil into streams and rivers during winter when dormant vegetation cannot absorb them. As a result, winter runoff impacts on nutrient pollution has quickly progressed from rare or nonexistent to far worse than during other times of the year.

The study was published in *Environmental Research Letters* by a team of scientists from the University of Vermont, University of Colorado, University of Kansas, and University of Michigan.

"We are clearly seeing much larger amounts of cloudy water and sediment traveling through U.S. watersheds in winter," said Carol Adair, a University of Vermont researcher. The idea of winter nutrient pollution is new, because it's a relatively recent impact of [climate change](#) with the potential to cause significant problems for people and the environment—from [algae blooms](#) that make swimming dangerous to

'dead zones' that kill fish stocks."

Of particular concern are so-called "rain-on-snow" events, researchers say, which can cause large, economically and environmentally devastating floods. The team used geospatial datasets to explore the impacts of rain-on-snow events in U.S. regions with large pools of nitrogen and phosphorous.

The scientists found that rain-on-snow affects 53% of the contiguous U.S. and puts 50% of U.S. nitrogen and phosphorus pools at risk of export to groundwater and surface water. Where these factors converge, more than 40% of the contiguous U.S. is at risk of nutrient export and soil loss from rain-on-snow events.

Analyzing the Mississippi River floods of 2019, researchers found rain-on-snow events delivered a large pulse of nutrients and sediment into the river and Gulf of Mexico—at much greater levels than a similar growing season rainfall event would —contributing to the Gulf of Mexico's eighth largest dead zone on record. Dead zones occur when bacteria that thrive on excess nutrients remove too much oxygen from the water, causing massive die-offs of fish or other aquatic animals.

"We hope this study is a wake-up call for government agencies and researchers, because it reveals that 40% of the U.S. is producing winter pollution—but no one is tracking exactly how much, where it's going, or the impacts on water quality and ecosystems," said Adair, a researcher at UVM's Gund Institute for Environment, the Rubenstein School of Environment and Natural Resources, and Vermont EPSCoR. "That's a big problem that urgently needs addressing."

The study's findings are visualized in several maps showing projected winter [nutrient pollution](#) across over 40 U.S. states, including large swaths of the Northeast, the northern Midwest and central plains, the

Pacific Northwest, and the Sierra and Rocky Mountain ranges.

"Climate change impacts on winter are often overlooked," said co-author Aimee Classen, a Gund Affiliate from the University of Michigan. "If we care about our water quality, we can no longer ignore how climate change impacts winter precipitation."

Background

The research marks the first large-scale study of the impact of rain-on-snow on nutrient runoff and water quality. The findings are conservative and do not include the additional risks from snowmelt and winter rainfall events, nor the impact of winter runoff on downstream ecosystems and communities.

In addition to winters being the fastest warming season in the U.S., the longest cold snaps are becoming shorter, and the number of days with temperatures below 32°F is expected to continue to decline across the country, researchers say. Rain is also becoming more frequent than snow, a trend predicted to continue across the U.S.

The UVM research team included Carol Adair, Julia Perdrial, Andrew Schroth, and Dustin Kincaid, working with Erin Seybold (Vermont EPSCoR and University of Kansas), Ravindra Dwivedi (Vermont EPSCoR), Keith Musselman (University of Colorado), and Aimee Classen (University of Michigan).

The study is titled "Winter runoff events pose an unquantified continental scale risk of high wintertime nutrient export."

More information: Winter runoff events pose an unquantified continental scale risk of high wintertime nutrient export, *Environmental Research Letters* (2022). [DOI: 10.1088/1748-9326/ac8be5](https://doi.org/10.1088/1748-9326/ac8be5)

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