Study finds timing of drought is more damaging to invertebrates than severity

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Populations of some aquatic invertebrates, such as beetles, or the order Coleoptera, didn't change much over the more than three-decades-long study period (a sunburst diving beetle from Sycamore Creek is shown here). The researchers reported that some beetle populations were resistant to disturbances caused by flooding and drought. Credit: Brian Gill, University of Arizona

Populations of various species of aquatic insects and other invertebrates respond to flooding and waterway drying due to drought in different ways that can be anticipated, according to a new Penn State-led study that employed a novel method to assess the stability of stream ecosystems.

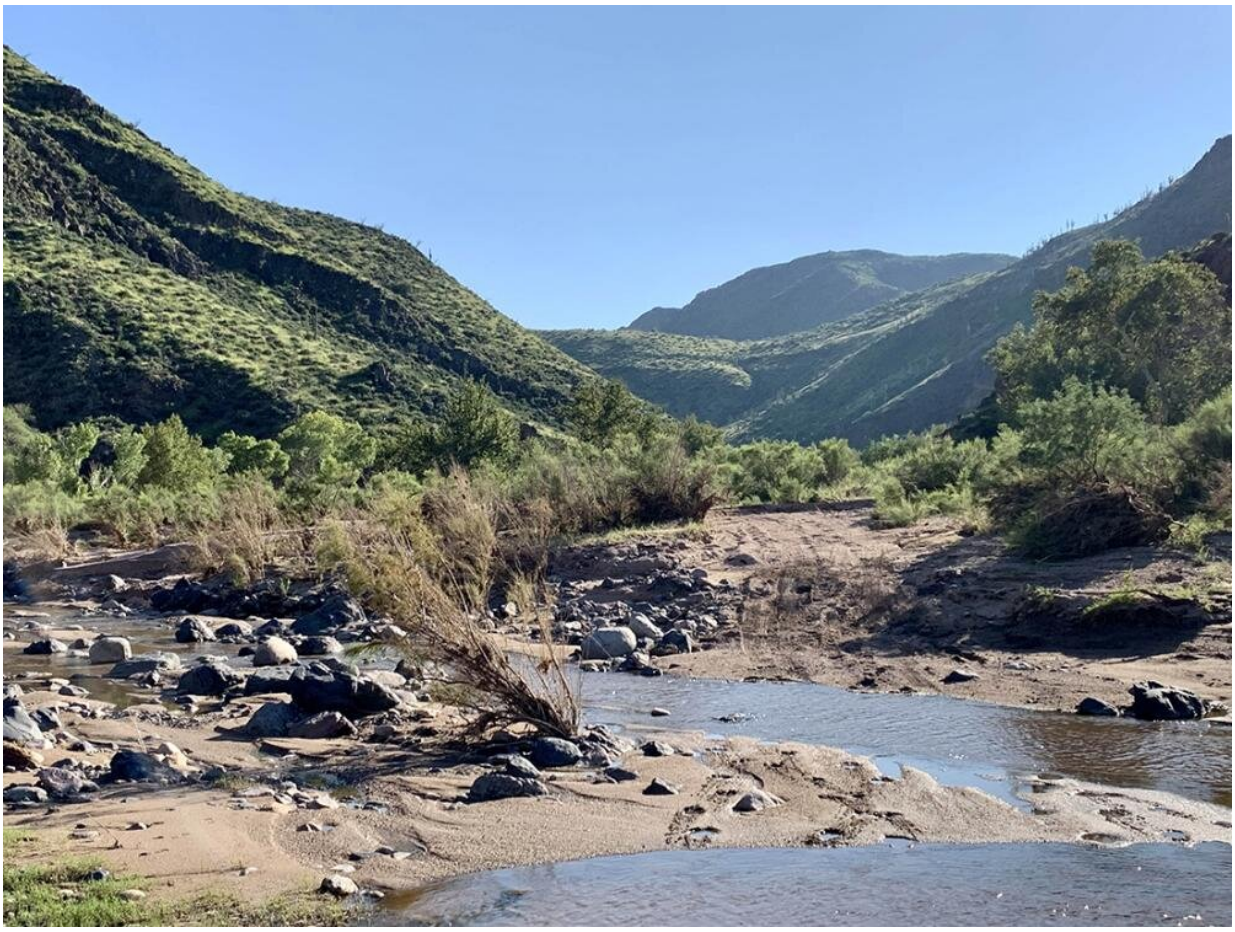
As the frequency and magnitude of floods and droughts increase due to climate change, a comprehensive understanding of the stability of stream ecosystems in response to these disturbances is needed, according to lead researcher Daniel Allen, assistant professor of aquatic ecology in Penn State's College of Agricultural Sciences.

He explained that the dimensional stability framework employed in this research is an innovative approach in which multiple stability metrics are analyzed, but it has been rarely used in long-term observational studies of natural ecosystems. In this study, researchers applied this framework to a long-term dataset of macroinvertebrates from an intermittent desert stream subject to frequent hydrologic disturbances.

They found widespread variation in stability over time among invertebrate populations and that widely varying monsoon disturbances were more important than more consistent winter disturbances in influencing individual population-stability metrics.

The research focused on Sycamore Creek in Arizona, one of the most

extensively studied desert streams in the world. It drains a mountainous watershed of 164 square miles, with a stream gage in the Sonoran Desert. The area has a semi-arid, hot climate. Most precipitation occurs during the winter (December to March) or monsoon (July to September) seasons. Sycamore Creek is prone to flash floods; however, some years the stream's flow is greatly diminished, even drying up.



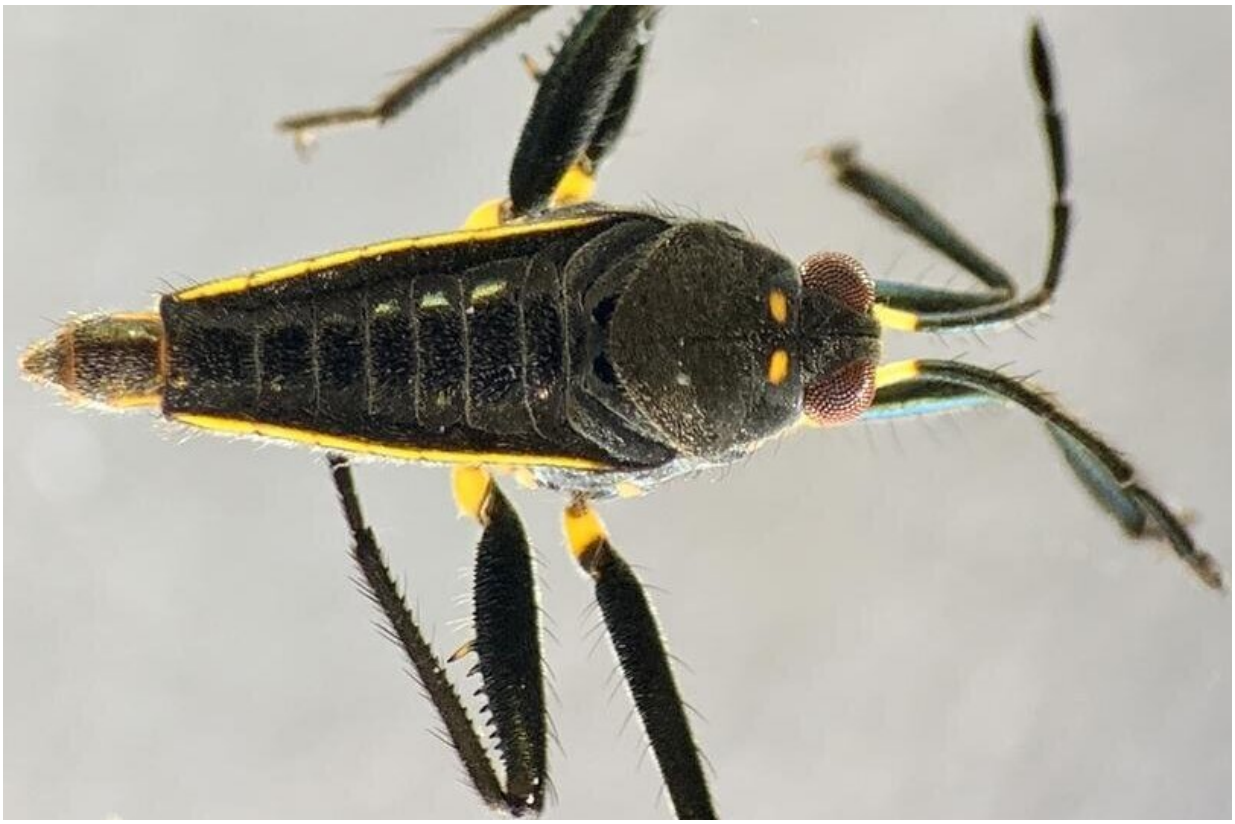
Benthic macroinvertebrates were sampled in Sycamore Creek over 35 years, from 1985 to 1999 and 2010 to 2019. Both sampling periods used the same location. Credit: Brian Gill, University of Arizona

Benthic macroinvertebrates were sampled in Sycamore Creek over 35 years, from 1985–1999 and 2010–2019. Both sampling periods used the same location. Samples were collected using a streambed sediment corer to about 4 inches depth at five locations throughout a gravel run more than 325 feet long. Samples were strained through a fine mesh net in the field, where organisms from 18 taxonomic groups were identified.

With Sycamore Creek, there's a long record of how these organisms respond to winter floods, which are predictable in the sense that the occur every winter, but they vary from year to year in magnitude, Allen noted. In some years, major floods occurred, while in other years weak floods occurred—allowing researchers to look at how the magnitude of those floods impacted the stability of the different invertebrate populations.

"But what is really interesting is that in addition to those winter floods, we also were able to analyze the impact on invertebrates of the other rainy season—the summer monsoon," said Allen, who is an affiliated researcher with Penn State's Institutes of Energy and the Environment. "And we found that the summer monsoon is more impactful than the winter floods."

In findings recently published in *Limnology and Oceanography Letters*, the researchers reported on the fate of aquatic invertebrates in Sycamore Creek based on the dimensional stability framework they utilized. Aquatic invertebrate species populations differed in stability metrics as follows:



Disturbance regimes are transforming rapidly due to climate change increasing the magnitude and frequency of floods and drought, according to the researchers, affecting aquatic invertebrates such as this water strider, from the genus Rhagovelia. Credit: Brian Gill, University of Arizona

Some taxonomic groups like Chironomidae (non-biting midges) are very resistant, meaning that the flood and drought doesn't reduce their abundance very much. Other taxa were very resilient, which means that populations get knocked down after a disturbance but regrow rapidly, like Fallceon (blue-winged olives in the family of mayflies called Baetidae) and Oligochaeta (aquatic worms).

Some populations simply didn't change much overtime and were invariant, like some Coleoptera (beetles). Finally, some taxa like

Hydropsychidae (net spinning caddisflies) and Tipuloidea (crane flies) were the best at recovering from a disturbance, meaning that they were typically able to regrow to pre-disturbance abundances.

"These species are responding to disturbances in different ways," Allen said. "Some are resistant to the disturbances. Some populations get knocked down really low, but then are able to recover very quickly afterwards. And then some do neither of those things, and those are the ones that are most prone to being wiped out and are at ecological risk."

Disturbance regimes are transforming rapidly due to climate change increasing the magnitude and frequency of floods and drought, Allen added. "So, we need to know how organisms are responding to disturbances and what the aquatic invertebrate community will look like in 20, 30 or 50 years."

More information: Daniel C. Allen et al, Taxonomic identity, biodiversity, and antecedent disturbances shape the dimensional stability of stream invertebrates, *Limnology and Oceanography Letters* (2023). DOI: 10.1002/lol2.10303

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