Researchers shed light on river resiliency to flooding

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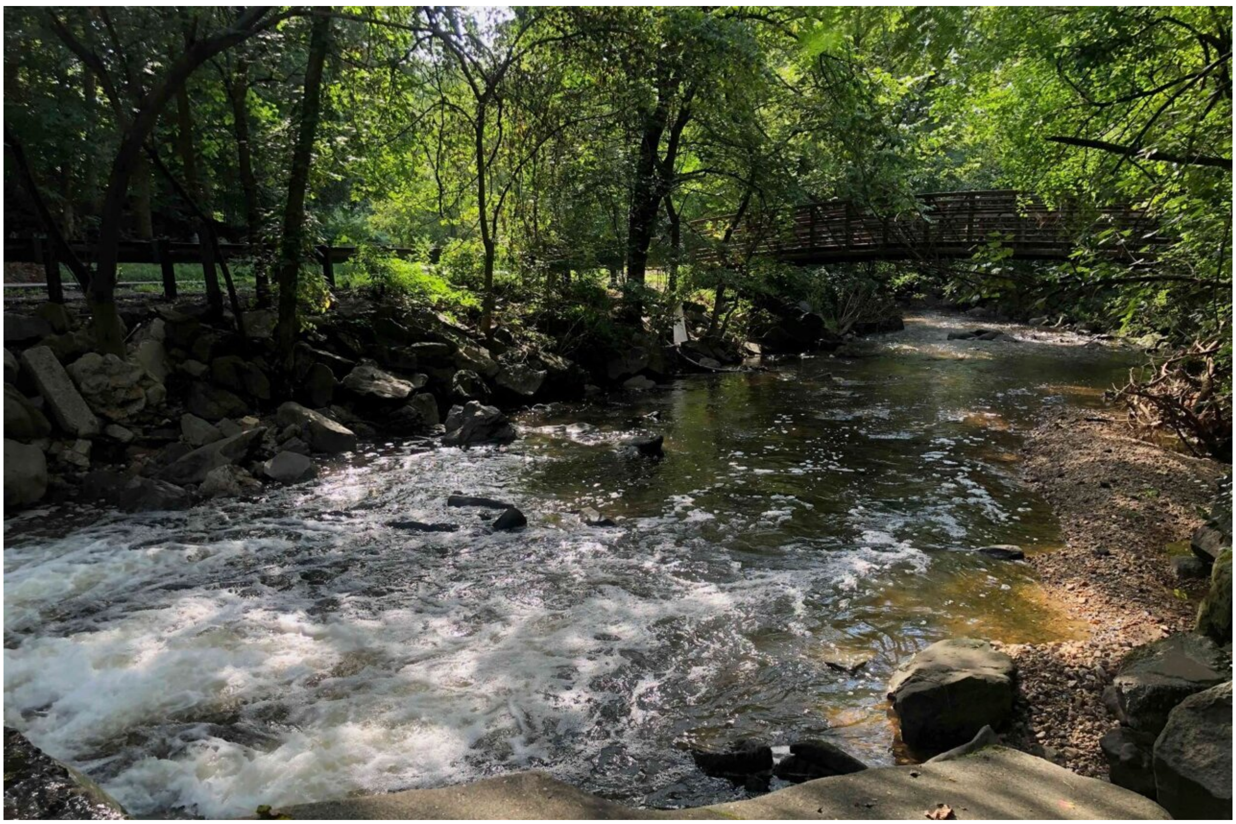

The researchers estimated the recovery time of river productivity in Sligo Creek in Maryland, about 30 miles southwest of Baltimore, to be about 12 days, which is greater than the median recovery time of 7.3 days across all sites in the study and more typical of narrower rivers. Credit: Heili Lowman, University of Nevada, Reno.

Researchers at the University of Nevada, Reno have completed one of the most extensive river resilience studies, examining how river ecosystems recover following floods. They developed a novel modeling approach that used data from oxygen sensors placed in rivers to estimate daily growth in aquatic plants and algae. The researchers then modeled the algal and plant biomass in 143 rivers across the contiguous U.S. to quantify what magnitude of flooding disturbs the biomass and how long the rivers take to recover from floods.

Increased understanding of rivers' resiliency is important to maintaining healthy rivers, as human actions can affect flood regimes and change the conditions in rivers for other aquatic life that may rely on algae and plants as a food source.

Assistant Professor Joanna Blaszczak and Postdoctoral Scholar Heili Lowman, both in the University's College of Agriculture, Biotechnology & Natural Resources and Global Water Center led the research, which was published in two separate journal articles.

The preliminary work, led by Blaszczak and published in *Ecology Letters* last June, first studied six rivers and laid the groundwork and methodology for the second study, which Blaszczak hired Lowman to conduct, examining the 143 rivers. The results of that research were published January 24 in the *Proceedings of the National Academy of Sciences.*

The research is unique because it estimates changes in biomass in rivers more frequently than ever before without needing to directly sample rivers. This is done by using both data from oxygen sensors placed in the rivers by the U.S. Geological Survey and a population model of algal and plant biomass—similar to a human population model that models change in the number of people over time, but instead modeling the change in the amount of algae and plants.

The oxygen sensors began collecting data in 2007, and the most recent Nevada-led study of 143 rivers includes some data that are for nine years running, among the longest such records on file for rivers across the globe.

"Previously, you would have to go to a river and scrub rocks to measure the algae, and do that several times for an extended period of time in order to estimate changes in biomass growth and loss," Blaszczak said. "This is very time consuming, so the data have been extremely limited relative to how extensive our sensor networks are."

Blaszczak said that with the oxygen sensors that take data as frequently as every five minutes, the team found that they could use statistical models to extract the amount of photosynthesis that occurs daily and estimate daily changes in the amount of biomass in a river over time.

"The dissolved oxygen sensors show the peak during the day, and the low during the night, and from those patterns, you can estimate how much new algae and other biomass grew that day," she said. "With the sensors measuring data continuously in hundreds of rivers for years now, we can get a much bigger, clearer picture. The data is there, and we can use it to model the size of flood needed to disturb the biomass in a river, as well as the rate at which a river recovers from flood disturbances, which can help us manage rivers more effectively."

Getting started

In the first study, Blaszczak used two years of data from oxygen sensors placed in six rivers. She found that she could successfully use this data to model the flood threshold specific to a river that disturbed the underlying biomass, and that generally, the magnitude of flood necessary to disturb biomass and reduce ecosystem productivity was lower than the disturbance flow threshold necessary to mobilize river bed sediment, a metric of disturbance commonly used by those studying rivers.

In other words, instead of estimating the disturbance of the river by the movement of the rocks on the river bed, this study used the biology—the changes in algae and plant growth—to quantify disturbance to the river and found that the biological disturbance threshold was lower.

"The amount of biomass is important for water quality and a food source for everything that lives in a river," Blaszczak explained, "so it is more important than rock movement, in terms how a river ecosystem is affected by a disturbance."

Blaszczak, a freshwater ecologist, began this work with Robert O. Hall Jr. of the Flathead Lake Biological Station at the University of Montana and enlisted the help of her colleague Assistant Professor Robert Shriver, a plant ecologist, for both research projects to complete the biomass growth modeling. Blaszczak, Shriver, and Lowman all conduct research as part of the College's Department of Natural Resources & Environmental Science, as well as the College's Experiment Station research unit. The College's faculty often take interdisciplinary approaches to meet research challenges, Blaszczak said.

Expanding out to a continental scale

Blaszczak wanted to delve further by applying this approach to more rivers over a longer period of time to shed light on how various factors may be influencing both a river's thresholds for flood disturbance and its resilience to floods. Thus, she recruited Lowman to embark on the second, more extensive study. Lowman's research examined landscape and river characteristics that affected the rivers' resiliency to floods.

"We've never had such great insight into the resilience of rivers, and because of the amount of data and our modeling, we now understand the natural variation in resilience, and that the widest rivers without dams upstream recover the most quickly," Lowman said.

The fact that wide rivers without dams recover more quickly than wide rivers with dams upstream was not immediately obvious, she said, and is one example of how rivers can be affected and/or managed by our actions. Most of the rivers Lowman researched had three to four years of data, with some having as much as nine years, and a handful having less than a year.

"Having three to four years' worth of data is way more than we've ever been able to use before," Lowman said. "And, we used rivers of various sizes with various climates and land characteristics."

Besides wider rivers without dams being more resilient, Lowman said those rivers that had more frequent floods also tended to recover more quickly.

"It could be that they have had a long history of frequent flooding, so their algae and plant communities have developed the ability to adapt to more frequent disturbance," she said.

Overall, Lowman said the new model results are consistent with other previous approaches. But, she said that some sites took much longer, a month or more, to recover from floods than other sites, regardless of river size.

"It might be the composition of the algal and plant communities, the structure of the river bed, or other factors," she said. "The thresholds and recovery times are very likely partially dependent on the slope, the grain size of the sediment, and possibly other factors that aren't as well documented. Those are some next steps for future research."

More information: Joanna R. Blaszczak et al, Models of underlying autotrophic biomass dynamics fit to daily river ecosystem productivity estimates improve understanding of ecosystem disturbance and resilience, *Ecology Letters* (2023). DOI: 10.1111/ele.14269

Heili E. Lowman et al, Macroscale controls determine the recovery of river ecosystem productivity following flood disturbances, *Proceedings of the National Academy of Sciences* (2024). DOI: 10.1073/pnas.2307065121

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