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# Scientists map stress on freshwater species in European lakes and rivers

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Birk, S., et al. (2020) Impacts of multiple stressors on freshwater biota across spatial scales and ecosystems. *Nature Ecology & Evolution*, 4(8): 1060–1068.

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**Many European freshwater bodies are unlikely to meet the 2027 targets of the Water Framework Directive.** This Europe-wide study assesses multiple types of freshwater stressor (physical, biological or chemical constraints on an ecosystem) to quantify the frequency, interactions and impacts of these on freshwater plants and animals. By mapping stressors' effects on scales — starting from single lake or river to an entire basin — such assessment can inform ecosystem management decisions.

In previous years, freshwater bodies have predominantly been affected by intense, well-known stressors from localised and stationary sources, such as organic and nutrient pollution. As these are now increasingly under control, other freshwater stressors are emerging to impact European rivers and lakes, giving rise to new ecological responses. As more than one stressor is usually present, this study seeks to quantify the impact of pairs of stressors on a single biological indicator, such as fish or bottom-dwelling invertebrates, under real-world conditions. The researchers note that two stressors acting together can have three main types of effect: only one of the two has a noticeable ecological effect (dominant); the two stressors act independently, with the joint effect being the sum of both (additive); or one stressor weakens or strengthens the effects of the other (interactive).

The researchers used data from 33 mesocosm experiments (outdoor experimental systems that examine the natural environment under controlled conditions), 14 river basins and 22 cross-basin studies across Europe to identify stressors across six categories — nutrient, hydrological, morphological[1], thermal, toxic, or other chemical stress — and paired these into relevant combinations. Overall, 12 paired-stressor combinations were investigated (for example, pairing nutrient and morphological stressors for rivers, as these were shown to be most frequent for such ecosystems). The researchers then investigated these stressor pairs across four categories of biological response variable — biodiversity, biomass/abundance, functional traits, and behaviour — and a variety of organism groups (including phytoplankton, benthic flora and invertebrates, and fish).

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# Scientists map stress on freshwater species in European lakes and rivers (continued)

This resulted in 174 combinations of paired-stressor effects on a biological response variable; a statistical model, based on known ecological responses to stressor interactions, was then applied to the data. From these models, the frequencies of cases with each type of stressor effect — additive, dominant, interactive — were grouped into either rivers or lakes, or by spatial scale.

The analysis showed that, for lakes, the single stressor of nutrient enrichment (eutrophication) is still common and dominant; while for rivers, stressor interactions are more important, demanding more complex and informed management decisions. These results reinforce the traditional focus of lake restoration and management on nutrient stress, whilst highlighting that river management requires more bespoke stewardship solutions.

The researchers conclude that the differing lake and river responses to stress are not rooted in the distinctions between the specific stressors or organism groups studied and suggest that this may be due to the inhabiting organisms being exposed to varying types and intensities of stressor. Freshwater ecosystems are sinks that collect anthropogenic stressors, but the far longer shorelines of rivers multiply the effects of human activities such as land and water use, resulting in higher exposure to hydrological and morphological stressors. The frequency of additive and interactive effects did not depend on scale for lakes, but increased with scale for rivers. Toxic substances can also act more directly in small rivers to have a bigger impact, as lower amounts are needed to reach toxic concentrations. Indeed, of the 58 cases in which toxic substances were a stressor, 57 of these were in rivers.

Understanding the influence of multiple stressors on Europe's waterways and bodies can help inform actions to ameliorate these detrimental impacts on freshwater ecosystems. Ahead of the Water Framework Directive evaluation in 2027, this information could be used by EU Member States to inform their decisions on how best to manage their river systems.

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1. The study of the size, shape, and structure of animals, plants, and microorganisms and of the relationships of their constituent parts.