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The impact of climate change on hydroecological response in a chalk stream, the River Nar, Norfolk, England

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Freshwater biodiversity is a major determinant of ecosystem functionality and hence the provision of ecosystem services. Despite this, freshwater biodiversity is declining rapidly around the globe. Coupled with the impact of climate change, there are growing concerns about the long-term sustainability of our water resources.

Methods investigating hydroecological response (flow$\sim$ecology) have, typically, been qualitative in nature or quantitative with limited scope, whilst the effect of uncertainty (e.g. parameter, structural, emissions scenario) is rarely considered. To address this research gap, the author's proposed a coupled hydrological and hydroecological modelling framework in an earlier work. The framework was developed using an English chalk stream, the River Nar, a SSSI in Norfolk, south-east England, where the coupled model was run for a single scenario (SRES A1FI) and 30-year time slice (2041-2070). Building on this, here we consider both change in river health over time (from the 2030s to the end of century) as well as the implications for ecosystem functionality. To this end, we consider the same case study river, eliminating the need for model calibration, thereby allowing the focus to be on the outputs. Probabilistic climate projections from the UKCP09 Weather Generator serve as input to the coupled model; specifically, the high emissions scenario. The results focus on the 99-100% probability, consistent with the IPCC's definition of a virtually certain outcome.

The LIFE index served as the proxy for river health. Results showed that, from 2021 to the end-of- the century, inter-annual variation in hydroecological response becomes more heterogeneous. Over the IQR, this change is relatively gradually, with change at the tails indicating an almost complete loss of variability by the 2030s. The overall trend indicates an increased probability and magnitude of extreme responses, with less internal variability.

This level of change has major implications for the structure of the macroinvertebrate community, and hence on ecosystem functionality. A functional matrix revealed that all functional flow preferences are only met at intermediate flows (LIFE 6-8). Under more extreme conditions, they are effectively 'knocked out'. Despite the limited range of the functional feeding groups on the baseline, the River Nar has been able to adapt to extreme events due to inter-annual variation. In the future, this variation is greatly reduced, raising real concerns over the resilience of the river ecosystem. Further, increases in duration of hydro-hazards as reported in other studies could exacerbate threats to an increasingly vulnerable riverine ecosystem.

With manifest impacts of climate change in the river expected as early as the 2030s, the outlook for the River Nar is not promising. A large part of this low resilience may be attributed to the pressures on the river. The River Nar is not alone in this, overall, English chalk streams are in a poor state of health, largely for similar reasons. Therefore, our findings are likely to be more widely applicable to the 200+ chalk streams in England. However, this is not and should not be considered a foregone conclusion, as there remains the opportunity to intervene via improved river management.