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Catchment controls on water temperature and the development of simple metrics to inform riparian zone management

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Water temperature is a key water quality parameter and is critical to aquatic life Therefore, rising temperatures due to climate and environmental change will have major consequences for river biota. As such, it is important to understand the environmental controls of the thermal regime of rivers.

The Loughborough University TEmperature Network (LUTEN) consists of a distributed network of 25 sites along 40 km of two rivers in the English Peak District, from their source to confluence. As a result, the network covers a range of hydrological, sedimentary, geomorphic and land-use conditions. At each site, air and water temperature have been recorded at a 15-minute resolution for over 4 years.

Water temperature is spatially patchy and temporally variable in the monitored rivers. For example, the annual temperature range at Beresford Dale is over 18˚C, whereas 8 km downstream it is less than 8˚C. This heterogeneity leads to some sites being more vulnerable to future warming than others. The sensitivity of sites to climate was quantified by comparing the parameters of logistic regression models, constructed at each site, that relate water temperature to air temperature. These analyses, coupled with catchment modelling suggest that reaches that are surface-water dominated with minimal shade and relatively low water volumes are most susceptible to warming. Such reaches tended to occur at intermediate distances from rivers source in the monitored catchments.

Reaches that were groundwater dominated had relatively stable thermal regimes, which were relatively unaffected by inter-annual changes in climatic conditions. Such areas could provide important thermal refuge to many organisms, which is supported by monitoring of the invertebrate community in the catchment. The phenology (i.e. timing of life events) of some species remained consistent between years in a river reach with a stable thermal regime, but changed markedly in other areas of the river. Consequently, areas of thermal refuge could be important in the context of future climate change, potentially maintaining populations of animals excluded from other parts of the river during hot summer months.

International management strategies to mitigate rising temperatures tend to focus on the protection, enhancement or creation of riparian shade. Simple metrics derived from catchment landscape models, the heat capacity of water, and modelled solar radiation receipt, suggest that approximately 1 km of deep riparian shading is necessary to offset a 1˚C rise in temperature in the monitored catchments. A similar value is likely to be obtained for similar sized rivers at similar latitudes. Trees would take 20 years to attain sufficient height to shade the necessary solar angles.

However, 1 km of deep riparian shade will have substantial impacts on the hydrological and geomorphological functioning of the river, beyond simply altering the thermal regime. Consequently, successful management of rising water temperature in rivers will require catchment scale consideration, as part of an integrated management plan.