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Modelling the long-term impact of vegetation on river bank stability in small experimental systems

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It is accepted that climate change will impose modifications in forcing factors, such as changes in rainfall intensity and magnitude and periods of drought, across most river basins. However, the impact of such changes on the functioning of fluvial systems remains poorly understood. Estimates are difficult to verify, particular given the challenges presented by large time and space scales involved in monitoring and measuring change in processes and form. Physical modelling offers a solution to these problems through the use of scaled models to overcome these challenges across time and space scales of climate-landscape interactions.

One of the key issues for river channel stability in the face of changes in flow regime is cohesion or bank stability. Previous research has identified the strong links between sediment size or distribution and bank strength. However, both vegetation and other biota, are also expected to influence channel or bank stability and previous experimental research has showed the profound effect that surrogate vegetation like alfalfa can have on evolving channel patterns. Representing vegetation in these models does however add significant complexity to the scaling as the growing time (days to weeks) drastically constrains the timescales of the experiments. One way to overcome this time limitation is to use more readily implementable vegetation surrogates. Extracellular polymeric substances (EPS) have been shown to increase sediment cohesion when applied to submerged beds and as such present a possible methodology to represent vegetation processes in scaled experiments.

With the use of analogue small-scale bank erosion experiments, this research presents an investigation on the effect of both vegetation and EPS on the bank erosion processes. For this set of experiments, a small channel ran into a small block of sediment under a 45° angle. This 600 cm^2 block of sediment was either mixed with EPS or seeded with vegetation. Erosion of each block was analysed over time. The experiments ($\sim$200 runs) show the impact of vegetation age, vegetation density or EPS concentration on the rates and styles of bank erosion. Moreover, the results show how the variation amongst these settings can be used at high fidelity to represent trends, changes and thresholds in experimental conditions. Together these experiments show for the first time how EPS application can be used to represent vegetation in experimental analogue models and as such open up enhanced scaling and improved repeatability in riverine flume models.