Impact of climate and land-use change on fine sediment transport and storage in UK catchments.

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Introduction

Increased sediment loads within river catchments have several detrimental environmental effects. To comply with the EU Water Framework Directive catchments should regulate sediment levels. Quantification of gaps between current and required sediment levels inform policy decisions. Modelling is used to predict changes in sediment concentrations in future climate and land-use scenarios and as a result of management options.

Overview of the research project

The overall aim of the project is to develop an improved model for simulating and predicting fine sediment transfers and budgets within UK catchments. This model will include the following components:

- **Channel bank erosion**
- **Floodplain inundation and sedimentation**
- **Within-channel hydrology**
- **With-catchment sediment routing**

The developed model should be computationally efficient and not require large amounts of data. Additionally the new approaches should have an improved capacity to deal with conditions beyond the calibration data set and a reduced reliance on local empirical relationships, making them better adapted for coupled model applications for estimation of the effects of climate and land-use change.

Data and test catchments

The models developed within this project will be tested on UK catchments (including the Hampshire Avon) using existing data sources as input variables.

Catchments for development of the bank erosion scheme (chosen from listed priority catchments of ECSFI) include: the Exe, Hampshire Avon, Yorkshire Ouse, Test and Itchen, Wye, Stour (Kent) and the Leicestershire Eye.

Methodology

An existing bank erosion index developed by ADAS (Collins et al, 2009) provides quantification of regional patterns of sediment flux at the catchment outlet contributed by bank erosion (see fig.1).

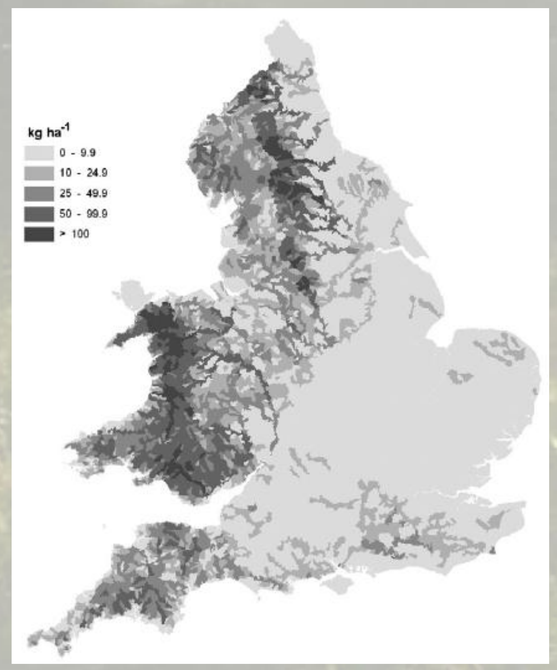

Figure 1: Bank erosion sediment input using national scale index.

In this project we aim to model channel bank erosion and within catchment sediment storage separately, in order to predict catchment sediment yield (i.e. erosion less storage).

To develop the bank erosion part of the model we shall analyse relationships between bank erosion and factors influencing rates of bank erosion such as channel sinuosity, valley slope, and restrictions due to valley floor width.

Estimation of bank erosion from GIS

Channel banks (from the catchment list) have been digitised in a GIS from historical maps and mastermap downloads. Erosion area between time periods was calculated using simple polygon overlay analysis as described by Gurnell *et al* (1994). This was converted into a volume of sediment using estimates of channel depth. Using these data we aim to test our new bank erosion model. A separate model will be used to represent sediment deposited between the point of erosion and the catchment outlet (i.e. deposition on floodplains).

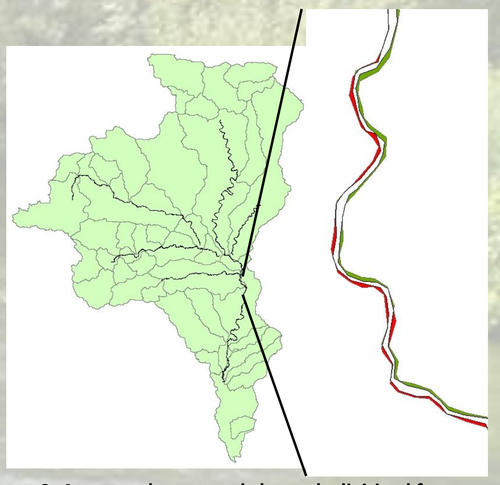

Figure 2: Avon catchment and channels digitised for analysis, a section of the Avon within WFD sub-catchment Avon8 representing the time period 1926-1985 (red=erosion, green=deposition).

Figure 3 illustrates the range of bank retreat rates as estimated from the GIS data. It is clear from both GIS data and previous ADAS work that a significant fraction of sediment eroded from banks is stored within the catchment before reaching the outlet.

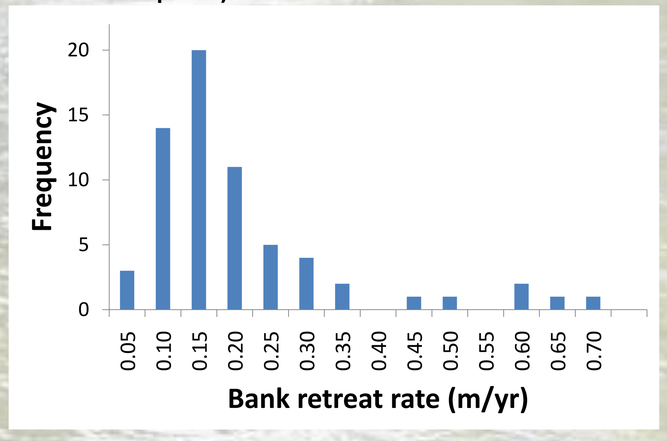

Figure 3: Range of bank retreat rates (m/yr) calculated from GIS data for all 65 WFD sub-catchments.

Relationship between sinuosity and bank erosion

Using models of channel migration over time (Howard and Knutson, 1984; Lancaster and Bras, 2002), relationships between channel sinuosity and bank erosion are being quantified. Model predictions of erosion rate and channel sinuosity show a strong correlation; peaks in sinuosity correspond to peaks in bank erosion (fig 4). We are using these models to develop simple tools for use in our catchment sediment budget model.

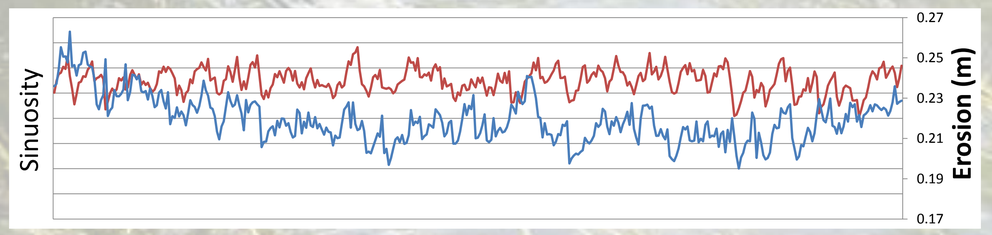

Figure 4: Relationship between channel sinuosity and erosion, from Howard and Knutson model output over 300 model iterations (time steps).

References:

•Collins, A.L., Anthony, S.G., Hawley, J. and Turner, T. (2009) The potential impact of projected change in farming by 2015 on the importance of the agricultural sector as a sediment source in England and Wales, *Catena* 79, 243-250.

•Gurnell, A.M. and Downward, S.R. (1994) Channel planform change on the river Dee meanders, 1876-1992, *Regulated Rivers: Research and Management* 9, 187-204.

•Howard, A.D. and Knutson, T.R. (1984) Sufficient conditions for River Meandering: A Simulation Approach, *Water Resources Research* 20 (11), 1659-1667.

•Lancaster, S.T. and Bras, R.L. (2002) A simple model of river meandering and its comparison to natural channels, *Hydrological Processes* 16, 1-26.