Prediction of sediment delivery to watercourses from land

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Introduction

The accelerated erosion of soil in England and Wales has been an issue of some concern to researchers and policy makers alike for several years (Morgan, 1995; Robinson and Blackman, 1990). The impacts of accelerated soil loss include decreased fertility, a loss of viable agricultural land, sedimentation in reservoirs and rivers, decreased fish stocks and water quality (Butcher *et al.,* 1992; Theurer *et al.,* 1998). An understanding of sediment sources, movement and delivery is a crucial first step in the design and implementation of efficient management strategies (Higgitt and Lu, 2001; Walling *et al.,* 2001). This research was initiated to identify the risk of sediment delivery to rivers and streams in England and Wales by investigating the connectivity between erosion and watercourses.

Experimental method: erosion from arable, grassland and upland soils

Data on the rates and extent of erosion from land under upland, grassland and arable soils were derived from a series of objective and nationally-representative field monitoring programmes.

Erosion vulnerability and risk on arable soils was described using topsoil texture, which defines the stability of the soil, and gradient. Topsoil texture was determined from the proportions of sand, silt and clay within the uppermost soil horizon (McGrath and Loveland, 1992) and the presence of calcareous material, which confers greater aggregate stability to topsoils (Harrod, 1998). Coefficients of amounts of erosion from arable soils were then applied, using data from a study of 270 field sites.

For upland soils, erosion vulnerability was defined using soil hydrological status from HOST (Hydrology Of Soil Types; Boorman *et al.,* 1995) and slope (Morgan, 1995; McHugh, 2002). Quantitative data on erosion from upland soils was provided by a study of over 400 field sites.

The risk of erosion on grassland soils, which can suffer structural degradation following trampling by livestock or by untimely vehicle movements, can also be defined by hydrology and land management. Quantitative data on erosion from grassland soils were collected from 135 grassland field sites (Harrod, 1998).

Experimental method: Connectivity Index and Connectivity Ratio

The efficiency of sediment delivery from land to watercourses, which reflects the connectivity between the land surface and the river system, was characterised using a

Connectivity Index, which represents the relative efficiency of sediment transfer and Connectivity Ratio, which represents a quantitative measure of the efficiency of sediment transfer. Algorithms for estimating the connectivity index from existing datasets and a dataset providing national scale coverage of values of the Connectivity Index were derived. The Connectivity Index was then calibrated to provide values and national scale coverage of the Connectivity Ratio.

The key factors controlling the efficiency of sediment delivery to watercourses were identified as runoff potential, slope steepness, slope shape, drainage pattern, land use and sediment characteristics, each of which was parametrised using a variety of nationally-representative spatial data sets. Arc/Info GIS was then used to generate secondary data layers, to integrate different data layers and to up-scale data to the required spatial resolution of 1 km grid cells.

Experimental method: combining erosion risk and sediment connectivity using GIS

In the third and final phase of the research, ESRI's *ArcView GIS*© including the *Spatial Analyst*© extension software, was used to portray the erosion vulnerability and connectivity of land and watercourses in England and Wales. The quantitative assessments of soil loss were combined with the Connectivity Ratio to provide graphical illustrations of the sediment input to watercourses from arable, lowland grassland and upland soils.

Discussion

This project has progressed some way towards producing a robust, national-scale tool to identify areas of England and Wales at risk of sediment delivery to watercourses, and has also identified key areas where additional work, particularly the provision of additional data and the validation of indices, would be of benefit. Specifically, additional data on erosion are required to develop a fully robust and adaptable tool capable of identifying the risk of sediment delivery to water. Also, the basic framework for the characterisation of slope-channel connectivity established could be refined through further parameterisation of the controlling factors, improved calibration of the weighting factors and validation of the results obtained using erosion rate and catchment sediment yield data. In the longer-term, the limited understanding of sediment delivery processes and of the factors influencing the efficiency of slope-channel sediment transfer could be addressed.

Conclusion

The GIS maps of sediment delivery provide useful indications of where erosion and sediment control should focus. In addition, the research has considerably furthered our understanding and appreciation of erosion and sediment movement processes in a variety of landscapes in England and Wales, although further research is desirable in order to be able to produce a fully validated end product.

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