Sediment Source Risks in Landscapes: From Field Scale Scoring to Bayesian Approaches

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Introduction: To protect endpoints within regions and watersheds, it is necessary to understand and manage soil–sediment and hydrodynamic processes at the field- and reach-scale, and to aggregate these processes to larger scales. To address such issues for the management of sediment impacts at the river basin scale, Apitz et al. [1] adapted the hierarchical patch dynamics paradigm (HPDP) approach, used to address multi-scale issues for invasive species management [2]. Calculation modules were developed that evaluate how interacting processes at the field and river reach scale affect field-scale sediment status and transport; these field and reach-scale factors were then aggregated and integrated in a Sediment Regional Risk Assessment (SRRA; Fig 1) model to evaluate regional-scale effects on aquatic endpoints [1]. This model was developed for the Environment Agency of England and Wales to support the development of sediment river basin management plans for European Water Framework Directive compliance. This multiple-scale, systematic, transparent, and adaptable model, a sediment-specific adaptation of the Regional Risk Assessment approach [2], ranks the risks and benefits of multiple sediment sources to a range of endpoints throughout a river basin in a spatially explicit manner. It evaluates the relative risks and benefits as a function of industry, land use, endpoint, habitat or region in a spatially explicit manner, either retrospectively (to evaluate sediment sources, risks, and benefits regionally) or prognostically (to evaluate the basin-scale risks and benefits of policy changes and targeted mitigation options).

Approach and Discussion: Although the field-scale source risk and sediment transport calculation modules were designed to apply land and river use and management data which should be available on a field and reach scale, the need for resource-limited agency employees to gather and aggregate field-scale data for an entire catchment has inhibited model uptake. Since the development of the SRRA model, there has been extensive development of the use of Bayesian networks for environmental management. Bayesian networks are graphical models that use probabilistic relationships among variables of interest, encoding dependencies among all variables, readily handling situations where some data entries are missing. These models are ideal for combining prior knowledge (which often comes in causal form) and data. Rather than requiring that data are integrated on a field-by field basis and then aggregated (Fig 1), then, probabilistic inputs about regional land use and management and expert knowledge can be integrated using Bayesian networks (Fig 2 illustrates a simplified logical flow).

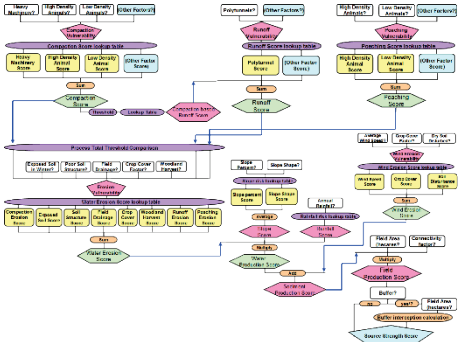

Fig 1.

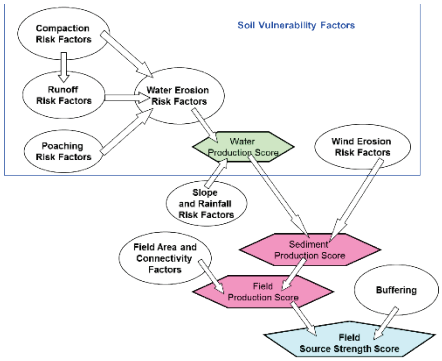

Fig 2.

In this paper, we will compare estimates of regional sediment source strengths or transport risks from a range of landscape uses, using both spreadsheet-enabled field-by-field calculations and Bayesian network models using the same data distributions. Whether these approaches differ in how they predict effects on downstream aquatic endpoints will also be addressed.

References: [1] Apitz et al (2010) *EA Report* 175p; [2] Landis (2005) *Regional Scale ERA Using the RRM* 320p.