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Story and simulation approaches to appraise possible programmes of measures for a sub basin in Scotland.

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Abstract:

This paper reports on the outcomes of a study that sought to develop innovative methods to involve stakeholders' views in the design and implementation of the Water Framework Directive (WFD) programme of measures. The project recognised that we needed to adopt an integrated approach when studying coupled human-environment systems, such as sub basin catchments. For this reason, the project considered in what ways a bio-physical transport process model (CAMEL) could be linked with an agent based social simulation model (FEARLUS) to illustrate the feedbacks between biophysical, social and economic processes in the sub basin catchment. The evolutionary nature of ABSS means it is well

placed to tackle the adaptive management approach that is required in the ongoing River Basin Management Planning cycles.

CAMEL (Chemicals from Agricultural Management and Erosion Losses) is a distributed continuous simulation model to simulate daily transport of water, sediment and phosphorus (P) at the catchment scale. It is a process-oriented mass-balance model using both analytical and numerical approaches. CAMEL simulates both surface and subsurface processes explicitly and therefore is suitable for catchment-scale applications. The distributed, process-oriented structure of CAMEL enables the model to be used for identifying critical source areas of sediment and P at the catchment-scale. FEARLUS, using the Swarm agent-based modelling system, explicitly represents, in simplified form, the behavioural heterogeneity, feedback processes, and multi-level spatial and institutional structures present in the real world of land use change. It has been applied to the same upland agricultural Scottish catchment as CAMEL.

Taking the perspective of policy makers, the particular pressing issue is the need to identify the desirable features that we considered important for testing catchment-related policy measures, and which are not necessarily being taken into account in many approaches to catchment management. These criteria can be summarised as: integrated; spatially explicit (for both bio-physical and social processes); mirroring human behaviour (both collective and individual processes); applicable to statutory and voluntary measures (including non-monetary sanctions and rewards); cognisant of uncertainty; and amenable to involving the multiple forms of stakeholder understandings. These criteria were developed through a combination of desk based analysis of existing case studies of integrative and deliberative processes and ongoing dialogue with policy makers in Scotland.

The project has used the linked models described above with a 'story and stimulation' framework. This involved developing outline scenarios for both baseline climate and economic conditions that were used to frame various ways that potential policy options (different bundles of measures) could be implemented. The linked models simulations were run to test the policy scenarios, with the climate scenario information used to vary the bio-physical input data for CAMEL and FEARLUS; and the economic scenario information used to vary the socio-economic input data for FEARLUS.

The methodology will be further explained in the paper, but the key aspect to emphasize is the way the two models interact. The decisions made by agents within FEARLUS directly affect water quality (through pollutants leaving the land and entering surface and ground waters), creating the first link with CAMEL; and then water quality as measured by the government agent at the downstream monitoring point can affect future agents' decisions by means of the government agent's implementation of policy measures. The methodological development and review relied on ongoing and in-depth deliberations within the project team, comprising of hydrological modelers, agent based modelers and socio-economic scientists.

The paper will explain how and in what ways stakeholder involvement can contribute to this process, drawing on case studies and empirical findings from the project team's going research. It will also reflect on the challenges faced in social learning within the multi-disciplinary team itself. In conclusion, the paper reflects on how such processes can improve opportunities for deliberation between stakeholders (including scientists) and situates these findings within debates about new forms of 'sustainability science' (Kates *et al.*, 2001) including the appropriate kinds of data, skills and tools required for ongoing WFD implementation.