Integrated models for sustainable catchment management

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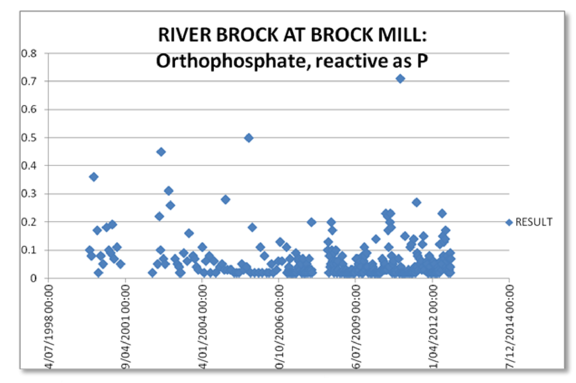
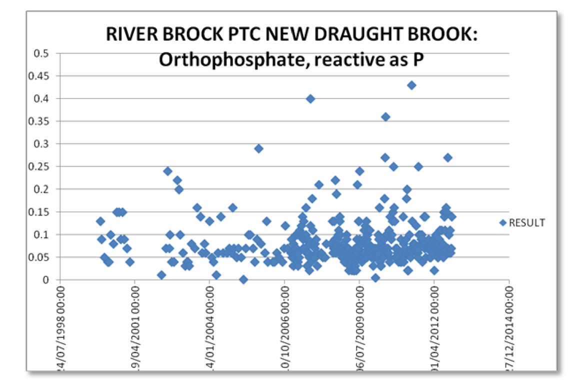
Water catchments support our livelihoods and well-being but they are under increasing pressure from pollution, land-use and climate change.

The European Water Framework (WFD) recognises the issues and requires EU member states to draw up comprehensive River Basin Management Plans (RBMP) by 2015.

These will comprise strategies to address **chemical**, **morphological** and **ecological** shortcomings in the districts' water bodies.

Pollutants originate from **diffuse** or **point** sources distributed across the catchment. Their signals vary both in space and time and due to adsorption and diffusion will attenuate considerably with distance from channel. Retardation rates will vary according to the solute, soil type, moisture content, temperature and other ambient conditions.





Computer models will be used to support management decisions detailed in the RBMP.

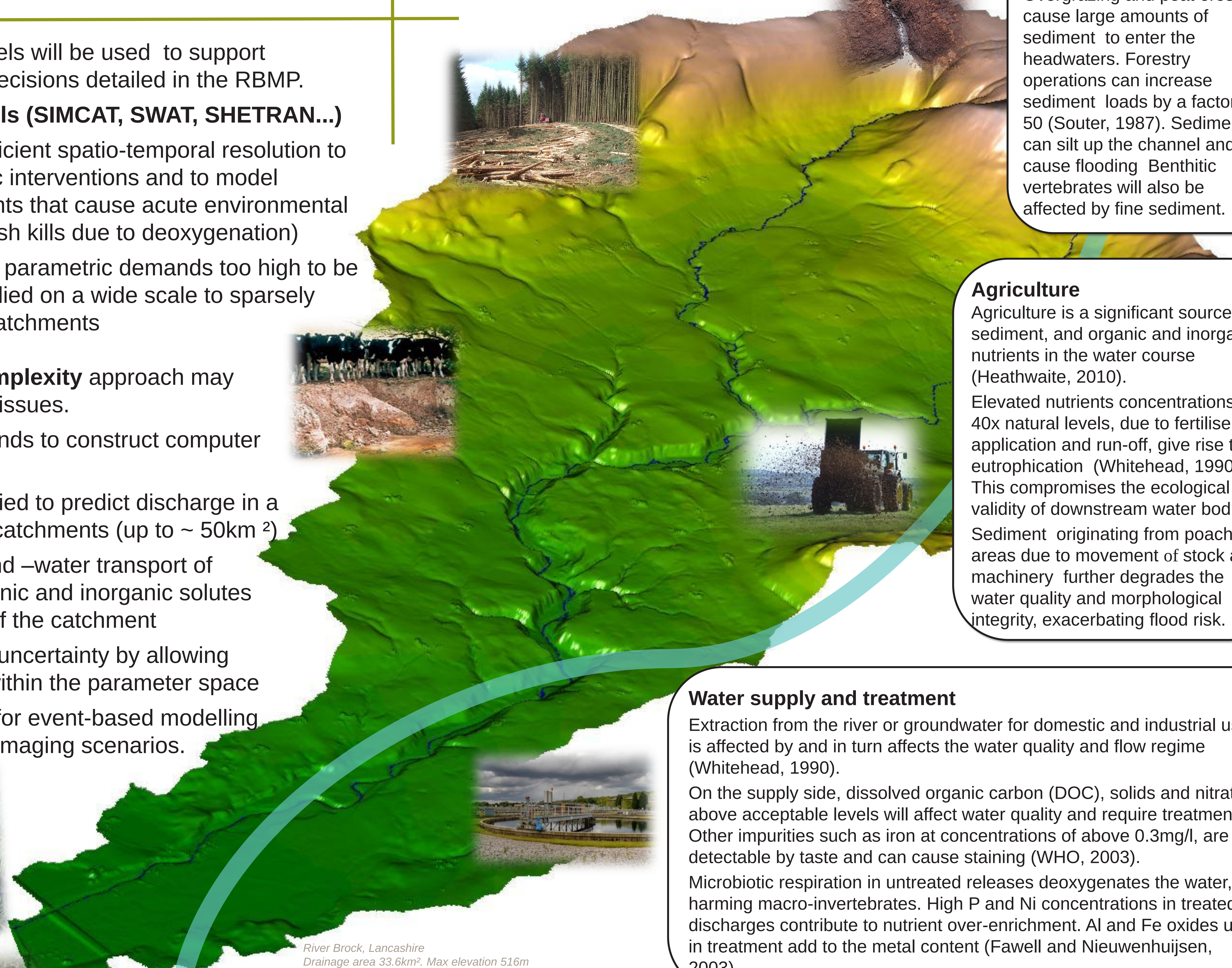
Existing models (SIMCAT, SWAT, SHETRAN...)

- ❑ Either: insufficient spatio-temporal resolution to support specific interventions and to model contingent events that cause acute environmental damage (e.g. fish kills due to deoxygenation)
- ❑ Or: data and parametric demands too high to be practicably applied on a wide scale to sparsely instrumented catchments

A **medium complexity** approach may address these issues.

My project intends to construct computer models that:

- ❑ Can be applied to predict discharge in a wide range of catchments (up to ~ 50km ²)
- ❑ Integrate land –water transport of sediment, organic and inorganic solutes from all parts of the catchment
- ❑ Incorporate uncertainty by allowing multiple runs within the parameter space
- ❑ Be suitable for event-based modelling of the most damaging scenarios.



River Brock, Lancashire
Drainage area 33.6km². Max elevation 516m
DEM: OS Digimap (2012). DRN: Environment Agency (2012)
Rendered with R and RGL (http://cran.r-project.org/web/packages/rgl/rgl.pdf)

Upland farming and forestry

Overgrazing and peat erosion cause large amounts of sediment to enter the headwaters. Forestry operations can increase sediment loads by a factor of 50 (Souter, 1987). Sediment can silt up the channel and cause flooding Benthitic vertebrates will also be affected by fine sediment.

Agriculture

Agriculture is a significant source of sediment, and organic and inorganic nutrients in the water course (Heathwaite, 2010).

Elevated nutrients concentrations4-40x natural levels, due to fertiliser application and run-off, give rise to eutrophication (Whitehead, 1990).. This compromises the ecological validity of downstream water bodies

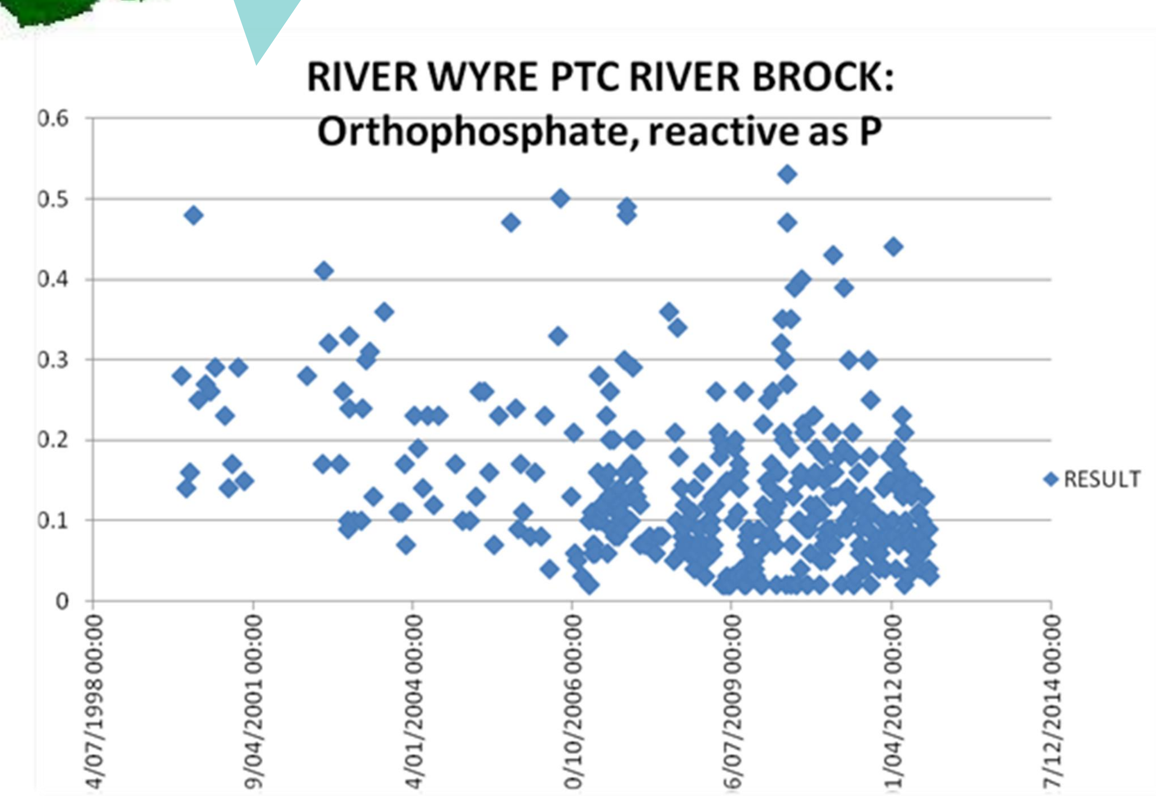
Sediment originating from poached areas due to movement of stock and machinery further degrades the water quality and morphological integrity, exacerbating flood risk.

Water supply and treatment

Extraction from the river or groundwater for domestic and industrial use is affected by and in turn affects the water quality and flow regime (Whitehead, 1990).

On the supply side, dissolved organic carbon (DOC), solids and nitrates above acceptable levels will affect water quality and require treatment. Other impurities such as iron at concentrations of above 0.3mg/l, are detectable by taste and can cause staining (WHO, 2003).

Microbiotic respiration in untreated releases deoxygenates the water, harming macro-invertebrates. High P and Ni concentrations in treated discharges contribute to nutrient over-enrichment. Al and Fe oxides used in treatment add to the metal content (Fawell and Nieuwenhuijsen, 2003).



Water chemistry data courtesy B. Hankin, JBA consulting (2013)

Discharge and composition of the river in its lowland, populated reaches will be the aggregated, lagged and attenuated response to upstream input signals. Modelling this response is a non-trivial task but it has extensive socio-economic and biological impacts. Continued research is vital for a greater understanding of .our ability to predict and intervene in catchment dynamics.

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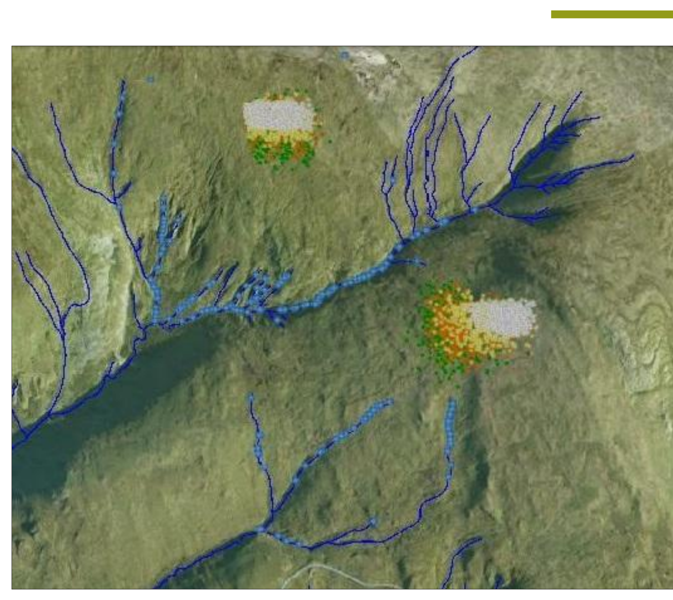
Modelling approach

Soil moisture and subsurface storage control timings (surface / subsurface velocities) and concentrations (channel flows). Apply a physically-based , semi-distributed model (Dynamic TOPMODEL, Beven and Freer, 2001) to predict these hydrological state variables. Utilises widely available topographic data and has minimal parametric demands..

Model will now be used to inform spatially distributed subsurface drainage rates and lateral transport velocities for "carrier" particles for solutes. Fluxes aggregated on reaching the channel and concentrations determined along their lengths. Sources can be persistent, periodic or ephemeral and represent point or spatially-extended features such as fields or storage tanks.



DEM and DRN for Gwy catchment, Wales: CEH. Downloaded 1/12 from http://www.gateway.ceh.ac.uk

Acknowledgments

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