FBA Conferences in Aquatic Biology

The Second *Freshwater Biology* Summit

Achieving Ecological Outcomes: Aquatic Ecological Responses to Catchment Management

12–15 April 2010
FBA Windermere, Cumbria, UK

Book of Abstracts

Oral papers

Posters

Opening Address

Miranda Kavanagh
Environment Agency

Biography

Miranda Kavanagh is Director of Evidence for the Environment Agency. She joined the Agency from the healthcare regulator, the Healthcare Commission, where she was Director of Communications and Patient and Public Engagement. Prior to that, Miranda was the Executive Director of the Centre for Corporate Governance at London Business School.

Previously in her career, Miranda has held senior posts in a number of blue chip companies including Pfizer, in investment banking and in consultancy across a 20 year period. She has also served as a non-executive director on the management board of the Department of Culture, Media and Sport. Miranda is a barrister by training.

Oral papers
(in programme order)

The influence of management activities and restoration on dissolved organic carbon concentrations in streams

E.H. STANLEY[1,*], I. BUFFAM[2], N.R. LOTTIG[3] AND S.M. POWERS[1]

[1] Center for Limnology, University of Wisconsin
[2] Department of Zoology and Center for Limnology, University of Wisconsin
[3] Trout Lake Station, University of Wisconsin
* Email: ehstanley@wisc.edu

1. Dissolved organic carbon (DOC) plays a central role in the dynamics of stream ecosystems, affecting rates of metabolism, the balance between autotrophy and heterotrophy, acidity, nutrient uptake, metals transport, and bioavailability of toxic compounds. Yet despite the importance of DOC to stream processes, stream restoration and management activities are rarely, if ever, motivated by the specific goal of modifying stream carbon regimes.

2. DOC from non-point sources by itself is unlikely to be the sole cause or best predictor of impairment in most streams and rivers. However, it may be part of a suite of changes that lead to compromised stream status.

3. Watershed and regional scale studies of C cycling provide insights for water quality management and restoration. First, land cover alone often explains substantial variability in dissolved organic carbon (DOC) concentrations. Wetland extent is a common variable in such models. Similarly, changes in land use/land cover within individual basins can result in changes in both DOC concentrations and quality.

4. DOC dynamics in heterogeneous landscapes and large-scale estimates of C budgets emphasize the role of hydrologic linkages among aquatic systems in affecting C cycling. Riverine fluxes of organic C may be strongly affected by processing and storage in upstream lakes and reservoirs, although much remains to be learned about how hydroscape configuration affects downstream ecosystems.

5. Peatland restoration projects have variable effects on stream water DOC, but also indicate that terrestrial and wetland organic C is a slow response variable. It may take several years before consequences of restoration activities become apparent or consistent over time.

6. Management activities can have consequences for stream DOC. Land use change and carbon cycling studies emphasize that stream DOC dynamics are driven most strongly by processes occurring at the basin scale. Thus, conventional engineering solutions of modifying channel form are unlikely to effect significant changes in DOC, and a multi-year time frame may be required to determine the consequences of restoration and management activities. Because it is part of a suite of changes that can lead to impairment, lessons about carbon may be transferable to other parameters that are more directly correlated with water quality status.

Nitrogen uptake and retention in fresh waters

S.K. HAMILTON[1] AND P.J. MULHOLLAND[2]

[1]Kellogg Biological Station, Michigan State University, USA
Email: hamilton@kbs.msu.edu
[2]Oak Ridge National Laboratory, Tennessee, USA
Email: mulhollandpj@ornl.gov

1. Much recent research has examined nitrogen (N) cycling in streams and rivers of the USA, motivated by intransigent problems of coastal-zone eutrophication linked to high nitrate delivery by rivers. Headwater streams have been studied in particular detail, including a large cross-site comparison called the Lotic Intersite Nitrogen Experiment (LINX) that employed stable isotope addition experiments to understand the fate of nitrate. This study synthesizes the LINX results as well as other studies of N processing in streams, rivers and wetlands.

2. Headwater streams are clearly important in changing the amount and form of N transported downstream in the river network, but LINX studies showed that direct denitrification of nitrate is only a minority of the proximate nitrate uptake, with the balance evidently due to biotic assimilation. The eventual fate of the assimilated nitrate remains unknown.

3. LINX studies showed that as nitrate loading increases, uptake processes in headwater streams approach saturation and an increasing proportion of the nitrate is transported downstream. Other studies show how in northern regions during winter and early spring, high discharges and lower biological activity may allow much larger fractions of nitrate loading to escape uptake than suggested by studies conducted at lower discharges.

4. Agricultural and urban land use in the LINX stream catchments affected stream nitrate uptake primarily through its relation to increased nitrate concentrations in stream water. In-stream primary production was correlated with higher nitrate uptake and was related to land use.

5. Wetlands and impoundments are important sites of N removal along landscape flow paths but they have received less attention than streams.

6. The efficacy of stream channel restoration for enhancing N uptake and retention remains unclear. Measures that slow the travel time of water and increase the ratio of benthic surface area to overlying water volume should enhance N processing, but this has proven difficult to demonstrate in practice. Some restoration projects may reduce N processing.

Phosphorus dynamics in catchments: from soils to streams to solutions, across scales

P.M. HAYGARTH

Centre for Sustainable Water Management, Lancaster Environment Centre, Lancaster University, UK.
Email: p.haygarth@lancaster.ac.uk

1. Phosphorus in catchments comes from industrial and sewage (point sources) as well as agricultural soils and septic tanks (nonpoint sources). The range of contributions from point and nonpoint vary considerably depending on location. The precise magnitude of nonpoint sources (the main focus of this paper) is particularly uncertain.

2. Phosphorus is a key nutrient for agricultural production, where inevitably some leaks to wider catchments. The challenge for us is in understanding the magnitude of the effects and the linkages across scales. The 'transfer continuum' source-mobilisation-delivery-impact framework, although relatively 'old fashioned', still provides a useful focus and start point.

3. Phosphorus cycling and residence dynamics can vary from long term (from tens to hundreds of years) to short term (a few minutes, often less). This makes understanding ecological 'cause and effect' linkages across scales particularly difficult.

4. If we were to 'turn off the supply' of phosphorus to agricultural soils today, the hysteresis of catchment recovery is likely to take many years to manifest in a favourable outcome in terms of ecological response. It is also possible, given the complexities and uncertainties involved, that we may not be able to see simple linear cause and effect response. Notwithstanding this, there is a popular perception and expectation amongst regulators and agencies that we can manage phosphorus problems (and thus catchment response) in a simple and reductionist manner. Clearly this is wholly unrealistic.

5. So what can we do? Firstly, we must adjust our expectations and communicate the complexity and uncertainty. Even though an ecological response signal may be elusive in the short term, we must proceed to manage agricultural and soil and phosphorus more sustainably, through a range of measures to minimise diffuse pollution. This is especially sensible given the pressures on food security and that supplies of phosphorus fertiliser are likely to run out within tens of years.

6. Accompanying the implementation of biophysical measures is the need for a more inclusive and community-owned approach to solutions. We must seed new community activities through demonstration catchments, build communication networks and raise national awareness and local ownership of the issues. There may well be a role for the arts in helping explore these ideas.

Catchments as simple dynamical systems: catchment characterisation, rainfall-runoff modelling, and doing hydrology backwards

J. KIRCHNER

Swiss Federal Research Institute WSL, Switzerland
Email: james.kirchner@wsl.ch

1. Catchment hydrology is controlled by processes and material properties that are complex, heterogeneous on all scales, and poorly characterized by direct measurement. This spatial heterogeneity and process complexity implies that any hydrologic model will necessarily entail substantial simplifications and generalizations. The essential question is which simplifications and generalizations are appropriate for the case at hand.

2. Many 'physically based' hydrologic models are grounded in an implicit up-scaling premise, which assumes that the small-scale physics in the subsurface will 'scale up' such that the behaviour at larger scales (e.g. hillslopes or catchments) will be described by the same governing equations (e.g. Darcy's Law, Richards' equation), with 'effective' parameters that somehow subsume the heterogeneity of the subsurface. There are reasons to believe that this upscaling premise may often be incorrect, and that the effective governing equations for these heterogeneous systems may be different in form (not just different in the parameters) from the equations that describe the small-scale physics.

3. Here I describe an approach for determining the constitutive equations that describe catchment behaviour at the small-catchment scale. This approach considers the catchment as a first-order

nonlinear dynamical system, and estimates its (nonlinear) governing equations at catchment scale, directly from field data. This approach assumes that discharge depends on the aggregate volume of water stored in the catchment, but makes no a priori assumption about the functional form of this storage−discharge relationship, instead determining it from rainfall-runoff data. This approach not only allows one to predict runoff from measurements of rainfall, but also allows one to do hydrology backwards: that is, to infer effective rainfall and evapotranspiration at whole-catchment scale, directly from runoff time-series data.

Land use, catchments and the ecological condition of rivers: supporting local management decisions

P.E. DAVIES[1,2], R.H. MAGIEROSKI[1] AND S. READ[3]

[1,*] School of Zoology, University of Tasmania, Hobart, Tasmania, Australia
[2] Freshwater Systems, Sandy Bay, Tasmania, Australia
[3] Forestry Tasmania, Hobart, Tasmania, Australia
* Corresponding author. Email: p.e.davies@utas.edu.au

1. Research over the last three decades can be used to identify tenets about the links between land use and stream ecosystem responses. These start with broad conclusions which recognise that the types of catchment land use dictate the suite of riverine ecological responses; that there is a range of ecosystem responses controlled by combinations of top-down and bottom-up intermediate drivers and responses to land use change; and that the intensity of land use and land management at least partially controls the intensity of response. It is also apparent that local hydrogeomorphological and bioregional contexts are important; that links between land use and stream ecological responses exhibit temporal and spatial scale dependence; and there can often be a hierarchy to responses, with adjacent higher and lower scales having strong influence. Connectivity is fundamental to driver-response relationships – through hydrology and materials transport − with riparian and floodplain areas as mediators. Combinations of hierarchical scale effects, stressor interactions, lags, connectivity changes and varying top-down and bottom-up control can result in thresholds in driver-response relationships.

2. How can managers working at local or regional scales make use of these concepts, especially when explicit ecosystem modelling tools are not sufficiently sophisticated or available? Generic tenets can have limited local utility and decision support needs 'calibration' to local contexts, conditions and scales. Managers often have limited resources, capacity and time to use models and decision support systems much beyond scenario evaluation for investment prioritisation. An ability to identify the type and scale of investment required and the sensitivity of river ecosystem responses to planned interventions within local contexts is particularly desirable.

3. We used multiple lines of evidence with data from catchments in Tasmania, Australia to infer dominant local land-use drivers and stream responses. We developed Bayesian Belief Networks (BBNs) to support management decisions based on a conceptual framework and the following lines of evidence:
   Data mining: We compiled a data set from 165 locations across 34 catchments on site-scale macroinvertebrate, algal and instream habitat, as well as derived bioassessment metrics. We coupled this with a range of spatial data, to evaluate land-use correlations with river ecosystem variables.
   Gradient studies: We have conducted two field surveys across a designed gradient of land use intensity where the dominant land uses were grazing and forestry. A range of intermediate and endpoint stream ecosystem responses were measured. The analysis has emphasised describing relationships between land use type and intensity, nutrient and sediment transport, reach scale stream metabolism, and site scale algal and macroinvertebrate status. We also attempted to differentiate catchment vs local scale influences on stream biological responses e.g. through riparian shading.
   Experiments: We conducted two multifactorial artificial stream experiments to evaluate stream biota and metabolic responses to combinations of high and low levels of fine benthic sediments, dissolved nutrients and shading. Results from the experiments were used to

develop neural networks that assigned nutrient and benthic sediment status to the local land-use gradient survey data to differentiate nutrient and benthic sediment status as the dominant intermediate drivers of land use effects.
Other information: Local scientific expert knowledge, relevant local data and published information was used to semi-quantitatively describe selected driver-responses and/or construct daughter-parent states and probabilities in the BBN's.

4. The Bayesian Belief Networks are being used to evaluate scenarios of land use change and riparian condition at catchment and smaller scales, and assist local and regional land use management.

Complexity and emergence in aquatic ecosystems: predictability of ecosystem responses

C.S.REYNOLDS AND J.A. ELLIOTT

Centre for Ecology and Hydrology, Lancaster LA1 4AP, UK
Email: csr@ceh.ac.uk

1. The paper explores the predictability of ecological conditions in aquatic systems and of their responses to catchment management schemes, in which the hydrological and material loads can be accurately and precisely quantified. Linkages between catchment hydrology and impacts on water quality are considered.

2. New approaches to modelling the complex biological behaviour of recipient systems are briefly reviewed. The case is made for simulating emergent outcomes on the basis of the adaptive strategies and dynamic behaviours of species attempting to meet their material demands within the supportive capacities furnished by local environments. This "bottom-up" approach is justified by the fact that ecosystems are the sum of their smallest components: their behaviour is the aggregate of the activities of individuals.

3. A framework model template founded upon the emergent properties of high-performing organisms is developed within the context of exergy fluxes and their deployment, and against axes representing the resource-carrying capacity versus the energy (photosynthetic and chemical) available to process it.

4. Some worked examples of simulated emergence in lakes are given, using the phytoplankton-community model, PROTECH, to demonstrate the acuity of predictions of the responses to quite subtle variations in biologically active solutes and suspensoids to simulated communities of the pelagic.

Why is achieving good ecological outcomes in rivers so difficult? Is it because of the fundamentally complex relationship between catchment characteristics and the responses of aquatic ecosystems?

G.P. HARRIS

Lancaster Environment Centre, Lancaster University, UK
Email: g.p.harris@lancaster.ac.uk

1. There is now considerable evidence from around the world to show that achieving good ecological outcomes in rivers from programmes of measures in catchments is quite difficult. The compliance problems with the regulatory goals of the EU Water Framework Directive are but one pertinent example. While most of the effort to achieve "good" ecological outcomes has, over the last couple of decades, been focussed on improving social and community engagement, in this paper I focus on the other side of the coin: the question of "is the knowledge base adequate"?

2. Following on from a series of Opinion papers published in *Freshwater Biology*, I further develop the thesis that catchments and receiving waters are truly complex systems in which there are fundamental limits to knowledge. Furthermore, I argue that the data and models we presently use for trying to understand highly complex interactions in space and time are mostly not fit for purpose. Our sampling and data analysis practices come with strong biases and inbuilt assumptions about the nature, and the values of, the world. So even with strong community engagement, our knowledge base is fundamentally flawed. “Good” outcomes are rarely achieved.

3. If we make a “complexity turn” then we can rethink our attitudes to uncertainty, causal thickets (multiple stressors) and cross-scale effects; and we can begin to develop new definitions of what constitutes a “good” ecological outcome. Dealing with inherent variability in data becomes less of a problem with controlling “noise” and more of a problem of understanding system dynamics. The presence of adaptive dynamics and self-organisation in complex systems means that uncertainties will always be large, knowledge will be partial and that such systems are fundamentally not computable.

4. I present evidence to show that small scale “noise” in ecosystems is an inherent property of non-equilibrium systems with predominant advection, reaction-diffusion dynamics. Flow paths in catchments and the dynamics of receiving waters are known to have fractal properties. Fractal dynamics indicate that multiple, cross-scale interactions are a characteristic of these systems. Furthermore the fact that catchments and receiving waters are embedded in regional and continental scale contexts and climates means that there will always be much Knightian uncertainty.

5. All is not lost however: there are some predictable ecological responses. There are fundamental, evolved constraints in the form of the basic molecular biology, physiology and stoichiometry of aquatic organisms. Also causal thickets can be unpicked if there are clear discontinuities in cross-scale interactions. Some things are predictable and applying ideas from hierarchy theory can be a useful approach.

6. Some of the properties of soils, catchments and river systems appear to be locally self-organised (as we might expect with complex systems populated by adaptive agents). When land use is changed these self-organised properties are destroyed. Restoration of river ecology has not included such properties in its reference frame. Aquatic organisms are known to respond to subtle aspects of environmental variance spectra and to cross-scale interactions: these are mostly ignored.

7. New technologies (in-situ sensor systems, web-based communications and on-line data bases) are already allowing us to develop much greater understanding of the true scales of pattern and process in catchments and rivers and give a much clearer picture of the most important scales and interactions. For the first time we are be able to determine the Nyquist frequencies of key processes and examine a much wider range of cross-scale interactions. New technologies may allow us to seek the fundamental order parameters for complex systems with changing spatial and temporal properties – a new way to think about what constitutes “good” ecological condition. This will improve predictive power but will never be a total panacea – uncertainty will still be present.

8. Yes, achieving good ecological outcomes in receiving waters will require strong community engagement, but it will also require much improved tools and techniques to guide action in situations where knowledge of pattern and process is, and always will be, partial. Directives which rely on strong predict-act frameworks will have to be replaced by more adaptive frameworks and more robust decision-making. We must develop new knowledge to suit reality not, as at present, try to make reality fit our philosophical biases.

9. Making the “complexity turn” is an acceptance that the world is more complex and uncertain (even more unknowable) than we thought. This extends to all aspects of environmental management: from data analysis and monitoring protocols, through models and prediction techniques, to social engagement and achieving outcomes. Because of long-standing beliefs and value-sets many individuals and institutions are not yet prepared to make that turn.

Scenario modelling and Bayesian Decision Networks to evaluate relationships between stressors and stream health

J.D. ALLAN

School of Natural Resources & Environment, University of Michigan, Ann Arbor, MI, USA
Email: dallan@umich.edu

1. Investigation of the influence of land use and associated human activities upon the health of waterways has grown into a major area of basic and applied research for aquatic ecologists and managers alike.

2. A large number of studies demonstrate the importance of nonpoint source runoff from catchments, and that impairment of aquatic communities is strongly associated with developed land uses.

3. Simultaneously, efficient methods for biological assessment of fresh waters have been developed and are widely used. Because aquatic ecosystems experience multiple stressors, however, assessment tools often are insufficient to diagnose cause of impairment.

4. This paper explores the use of Bayesian belief networks (BBNs) to establish causal links between stressors and response variables, and illustrates two approaches. The first application is an example based on empirical data, developed for a highly agricultural watershed. The second application is an example based on expert elicitation, developed as a general case of the effects of sedimentation on benthic invertebrates.

5. Such models may be used to develop a range of possible outcomes from a known set of conditions and, by working backwards through the model chain, to identify probable causes of impairment.

Eutrophication Control: how is status assessed and what can we learn about achieving ecological outcomes from long-term studies? Reflections on 30+ years of monitoring of the Norfolk Broads

G.L. PHILLIPS

Environment Agency, UK
Email: geoff.phillips@environment-agency.gov.uk

1. Eutrophication remains a significant problem in fresh waters. In England & Wales 42% of river and 63% of lakes monitored for phosphorus by the Environment Agency fail to achieve the Water Framework Directive (WFD) standards for Good status. Action to achieve a reduction in phosphorus loading and deliver ecological improvements is thus a priority for the 1st cycle of river basin planning.

2. To deliver ecological improvements requires an understanding of the impacts of phosphorus and models that can relate phosphorus concentrations to ecological conditions. To assess ecological status under the WFD Environment Agencies of the UK use a combination of biological indicators which are sensitive to nutrients, diatoms, macrophytes, and in lakes phytoplankton and chironomids. The majority of these methods are newly developed and require further testing and refinement, but together with an assessment of phosphorus concentrations they provide an overall assessment of the extent of eutrophication in the UK.

3. The effects of eutrophication in lakes are perhaps better quantified than in rivers. An increased biomass of phytoplankton is normally the primary response to nutrient enrichment, but in very shallow lakes submerged aquatic vegetation can be significantly reduced as a result of competition for light.

4. The Norfolk Broads, a very shallow lake system in Eastern England were recognised as eutrophic in the late 1970s and as a result tertiary treatment has been installed at the majority

of significant sewage treatment works discharging to the system. This has resulted in significant reductions in phytoplankton biomass in parts of the system, although changes have taken over 30 years to occur.

5. Some of the broads are not connected to the main river system. Diffuse nutrient inputs resulted in lower levels of phosphorus and in these systems fish manipulations have been used to aid restoration. Long term monitoring of the Trinity Broads has shown the power of “top-down” controls and revealed evidence of longer term cycles which need to be taken into consideration when assessing the outcome of other shorter term studies.

Thresholds of potential concern and the adaptive management of rivers in Kruger Park

K.H. ROGERS

Centre for Water in the Environment, University of the Witwatersrand, Johannesburg, South Africa
Email: kevin.rogers@wits.ac.za

1. What and who does it take to “achieve” an ecological “outcome” from a process of catchment management? It is far more than stating what outcome you expect from an action and certainly more than monitoring to see if the outcome emerges.

2. At least, we must ask what is the likelihood of getting an expected response from the action or actions? To most people, this question would have them seeking a statistical expression of certainty or probability, but in fact the answer lies in the very fundamentals of the scientific paradigm you invoke. If, for example, you recognise ecosystems as complex systems, with non-linear process interactions, feedback loops and multiple causality and outcomes, how do you express your expectation?

3. If the system does indeed behave as a complex system you probably need to question both your ability, and the need, to make a confident prediction. This would be especially so if the problem were one of site specific prediction of river response to alterations at the catchment level. Even if you did hazard a prediction, what and how would you monitor to be sure you had identified the actual ecological response and traced it back to the initial action/s? How do you separate the influence of historical conditions/events from those of your actions?

4. If you are dealing with a complex system how do you know when the response is “over” or “complete” and thus when to stop monitoring? When have you achieved your objective if you are dealing with a complex problem with no “stopping rules”?

5. An ecological outcome would not be sustained by a single management action and would require a “regime” of actions over time. How does one form and manage a partnership between science and “management” to sustain the regime in the face of the inevitable unexpected outcomes you will experience?

6. We are grappling with these issues in the Kruger National Park using a system of Strategic Adaptive Management and the concept of “thresholds of potential concern” to discover just how to “achieve” desired ecological outcomes within complex social-ecological systems.

Modelling everything everywhere: new approaches to decision making for water management under uncertainty

K. BEVEN

Lancaster Environment Centre, Lancaster University, Lancaster, UK
Email: k.beven@lancaster.ac.uk

1. There are increasing demands to predict the response of catchments to future change – whether due to climate, land management or urbanisation – for decision making and policy setting for effective prioritisation of investment (for example in the implementation of the Water Framework Directive). Such predictions are inevitably uncertain because of natural variability and different sources of epistemic uncertainty (inputs, process representations, effective parameter values, future boundary conditions etc). This makes the prediction of hydrological change difficult, of changes in water quality more difficult, and of change in ecological status more difficult still. As a result, policy setting and decision making should reflect the inherent uncertainties in both the prediction process. As part of a new NERC supported Knowledge Transfer project, the Catchment Change Network (CCN), academics and practitioners are being brought together to understand and manage uncertainty and risk in relation to future change in catchment systems. CCN is exploring the way in which the latest scientific methodologies can inform this process in three key Focus Areas: flood risk; water scarcity; and water quality, through the development of Guidelines for Good Practice.

2. Such Guidelines provide a useful framework for the discussion between scientist and practitioners of sources of uncertainty and the representation of different sources of uncertainty but also bring out really interesting scale issues, in both predicting the impacts of investment decisions and the assessment of the effectiveness of policy, which is necessarily implemented at local scales. In essence what is needed is models of everywhere, implemented in such a way that the local idiosyncracies of place are properly reflected in both prediction and assessment. Such models are increasingly computationally feasible and are already being implemented from global to national to large basin scales, but not in a way that allows readily for the quite different scales of action in different parts of the system. We need to find a way of incorporating information and understanding at both larger and smaller scales into predictions for individual places. This paper discusses the issues that arise in models of everywhere and how they will change the way in which predictions are made for management purposes.

Posters
(alphabetical order)

Too simple is too simple: predicting successful recolonisation of restored rivers by aquatic insects

M. ALP* AND C.T. ROBINSON

Department of Aquatic Ecology, Eawag, Duebendorf, Switzerland, and Institute of Integrative Biology, ETH, Zurich, Switzerland
*Email: maria.alp@eawag.ch

A widely used tool in river restoration is recreating hydromorphological heterogeneity under the assumption "build – and they come". As many studies now show, this approach may be too simple and insufficient to assure successful recolonization by aquatic biota. Colonisation of restored habitats by different taxa, especially aquatic insects with complex life histories, may be constrained by other important factors. We present the results of a field experiment which aimed to differentiate between the effects of substrate availability, flow conditions, as well as landscape context of replicated study reaches on oviposition of stream macroinvertebrates in relation to species-specific life histories.

Stream ecosystem response to UK moorland management

[1]K.L. ASPRAY*, S. RAMCHUNDER, S. BROWN, L.E. BROWN, J. HOLDEN AND M.E. LEDGER

[1]School of Geography, University of Leeds, UK
*Email: gykla@leeds.ac.uk

In many UK moorlands there is concern surrounding the environmental implications of management practices, such as rotational heather burning and artificial drainage. This, combined with climate change and anthropogenic acidification, has contributed to the degradation of soils and the release of organic particulates and dissolved nutrients/metals. Many moorlands are now being restored in an attempt to improve terrestrial biodiversity, preserve peatlands, and to improve water quality prior to abstraction for potable water supply. Yet despite the concept of integrated catchment management, stream ecosystem responses to peatland management and restoration have largely been ignored. This poster outlines our research, which aims to address this gap.

The effectiveness of a catchment-scale, ecosystem management approach to deliver water quality improvements on the National Trust Holnicote Estate, Exmoor

M. GLENDELL[1*], R.E. BRAZIER[1] AND M. WALSINGHAM[2]

[1]Department of Geography, University of Exeter, UK
[2] The National Trust, Heelis, Swindon, UK
[*]Email: Mg315@exeter.ac.uk

This research is part of a catchment-scale, multi-objective flood management project funded by Defra to examine the effectiveness of an ecosystem management approach to deliver water quality objectives. The determinants of interest include dissolved organic and total carbon, suspended sediment, total nitrogen, total phosphorus and aquatic invertebrates. Detailed characterisation of the sediment sources within the catchment will employ state-of-the-art fingerprinting techniques, in combination with high resolution monitoring within a nested framework, during year one. Mitigation measures will be deployed prior to continued monitoring in years two and three. Development of spatially-explicit models accounting for mitigation techniques will then be used to relate water quality to management interventions and mitigation strategies both before and after habitat change.

Managing phosphorus in lowland river catchments; a waste of time and money?

[1] D.M. HARPER*, K. WASIAK, P. WASIAK, P. WITHERS, H. JARVIE AND C. STOATE

[1] Department of Biology, University of Leicester, UK
*Email dmh@le.ac.uk

Phosphorus has been long recognised as a serious contaminant of aquatic systems because it has usually been the natural limiting factor on ecosystem production. Added phosphorus, from point and diffuse sources, causes increased plant biomass, initially of rooted aquatic plants and then algae (planktonic algae in lakes, benthic filamentous algae in rivers); the latter associated with major losses of biodiversity, with change in ecosystem structure and function. Extensive studies on lowland lentic ecosystems (lakes) has shown us the two 'stable states' that lake ecosystems exist in and the difficulties of switching back to the natural state, dominated by rooted plants, just by removing the sources of phosphorus input.

Lotic ecosystems have proven more difficult to understand in this way. Elevated phosphorus levels cause major changes, but not elimination, of submerged macrophytes, because light dominance by algae is more difficult to achieve. Light is not a controlling factor however in headwater streams and the natural ecosystem is heterotrophic. The study described here, funded by Defra, sought to measure the impact of phosphorus, from multiple sources, on ecosystem structure and function in lowland headwaters.

It is nigh-impossible to find headwater streams in the UK lowlands which are not already enriched by phosphorus, since no stream is far from agricultural fields (phosphorus from eroded soils) or human settlements (phosphorus from septic tank effluent). A gradient of a dozen stream sites showed that change occurred rapidly with increased concentration from the limits of detection of phosphorus; by the concentration of 100μg/L all measured parameters were highly eutrophic. The work supports the belief that riverine phosphorus standards should be no higher than 50μg/L, much lower in rivers of high conservation importance, for there to be any hope of a natural ecosystem. Is achieving such standards in the overcrowded lowlands of the United Kingdom possible?

The ecosystem approach and catchment management

[1] A. HOLT* AND B. SURRIDGE

[1] Animal and Plant Services Department, University of Sheffield, UK
*Email: a.holt@sheffield.ac.uk

The ecosystem approach offers a promising way of managing trade-offs between the range of ecosystem services provided across terrestrial and aquatic environments. However, at present there is little understanding of how it can be practically implemented for the benefit of both. We present a decision-making framework that is based on viewing environmental issues as operating within nested sub-catchment systems, that are also linked social-ecological systems. What is crucial to achieving sustainable and integrated catchment management is establishing suitable governance and institutional arrangements that facilitate collaborative working among individuals and organisations, promoting information sharing, learning and conflict resolution.

Integrated modelling of the response of aquatic ecosystems to land use and climate change in the Poyang lake region, China – Design of a forthcoming research project

S.C. JÄHNIG[1*], Q. CAI [2], N. FOHRER[3] AND B. SCHMALZ[3]

[1]Senckenberg, Research Institute and Natural History Museum, Frankfurt, Department of Limnology and Conservation, Germany
[2]Chinese Academy of Sciences, Wuhan, Institute of Hydrobiology: Center for Freshwater Ecology, China
[3]Christian-Albrechts-University, Kiel, Ecology Centre, Germany
[*]Email: Sonja.jaehnig@senckenberg.de

The poster presents the approach towards the development of an integrated modelling methodology to assess the impact of fast environmental changes on aquatic ecosystems in the example catchment of the Changjiang (6260 km²) in the Poyang lake area (China). Joint measurement and sampling campaigns will be the basis for integrating three different models: we aim to model a dynamic DPSI(R)-system, coupling the models SWAT (catchment processes), HEC-RAS (in-stream processes) and MAXENT/BIOMOD (biological responses). Major drivers (climate, land use, channel alteration) are model input data, while the main pressures on the ecosystem (water balance, nutrients, sedimentation) are defined and represented in the model algorithms of SWAT and HEC-RAS. Based on the multiple pressures, we aim to dynamically assess the changes of the state of habitat parameters (e.g. flow, depth, substrate) in the model output. Finally, the impact of the state on the aquatic ecosystems will be evaluated by analysing shift of distribution ranges and changes in biodiversity or ecosystem health indicators such as benthic invertebrates.

Effects of hydromorphological alterations on littoral macroinvertebrates – choosing the appropriate scale

T. JURCA* AND K. IRVINE

Department Of Zoology, School of Natural Sciences, Trinity College Dublin, Ireland
*Email: jurcat@tcd.ie

After nutrient enrichment, hydromorphological alterations (changes of physical features) are referred to as a major driver of deterioration in freshwater systems (Sondergaard & Jeppesen, 2007). Recent studies in rivers have shown that structuring of benthic macroinvertebrate assemblages could be controlled by factors that operate both on local and landscape scales. Similar studies in lake catchments are scarce. The aim of the research is exploration of the impact of local hydromorphological modifications on littoral macroinvertebrates. The work incorporates the effects of altered mesohabitats, lake riparian zone and catchment features. Our hypothesis is that the scale of approach is important when assessing the impact of hydromporphological pressures.

Reference:
Sondergaard, M. & Jeppesen, E. (2007) Anthropogenic impacts on lake and stream ecosystems, and approaches to restoration. *Journal of Applied Ecology,* **44,** 1089-1094.

Ecological effects of eutrophication and climatic variability on a large north-temperate lake: case study of Lake Peipsi (Estonia/Russia)

K. KANGUR*, K. ORRU, O. BUHVESTOVA, M. HALDNA, A. KANGUR, P. KANGUR AND R. LAUGASTE

Centre for Limnology, Estonian University of Life Sciences, Estonia.
*Email: kylli.kangur@emu.ee

As Lake Peipsi (3,555 km^2, mean depth 7.1 m) is situated on the border of the EU, state and regional, economical and political interests are affecting the water management planning. Transboundary conditions complicate the implementation of policies that might prevent or mitigate environmental damage in the Peipsi region. Warm weather together with low water level increase the effects of nutrient enrichment, i.e. will raise the intensity of cyanobacterial blooms and probability of fish kills in L. Peipsi. Furthermore, the cumulative effect of eutrophication and extreme weather events destabilise the ecosystem and threaten the long-term survival of clean and coldwater fish species.

Understanding and acting in Loweswater: a community approach to catchment management

S.C. MABERLY[1*], L. NORTON[1], J. TSOUVALIS[2], C. WATERTON[2], N. WATSON[2] AND I.J. WINFIELD[1]

[1]Centre for Ecology and Hydrology, UK
[2]Lancaster University, UK
[*]Email: scm@ceh.ac.uk

The socio-economic problems faced by the small community at Loweswater (English Lake District) and the environmental deterioration in the lake caused largely by nutrient enrichment, are intricately-linked to economic, political and environmental issues that are common in rural communities worldwide. This project has brought together freshwater, terrestrial and catchment management scientists, sociologists, geographers, regulatory agencies and the local people to experiment with new ways of managing the catchment in a sustainable way. The approaches taken, including the setting-up of a local forum and the use of local knowledge and expertise, and the initial results, are described in this poster.

Do agri-environment schemes protect and enhance freshwater ecosystems?

J.F. MURPHY[1*], J.I. JONES[1], C. DUERDOTH[1], A. HAWCZAK[1], J. PRETTY[1], J. BLACKBURN[1], P. SCARLETT[2], P. NADEN[2], S. ANTHONY[3], C. FAWCETT[3] AND J. SKATES[4]

[1]Queen Mary University of London River Communities Group, c/o FBA River Laboratory, Wareham, Dorset,UK
[2]Centre for Ecology and Hydrology, Wallingford, UK
[3]ADAS, Wolverhampton, UK
[4]Welsh Assembly Government, Cardiff, UK
[*]Email: j.f.murphy@qmul.ac.uk

Agri-environment schemes (AES) are designed to encourage farmers to protect and enhance the environment by paying them for provision of environmental services. However, there is as yet little convincing evidence available that the €2.5 billion paid each year has created a better rural environment. At the request of the Welsh Assembly Government, we have developed an extensive monitoring programme to provide robust evidence of whether streams and ponds are in better ecological condition when their catchments are within rather than outside of AES land. Such information is critical for the continued improvement of AES design and implementation.

Linking catchment characteristics, benthic invertebrate assemblages and ecological status of Slovenian small and medium sized rivers

M. PAVLIN*, G. URBANIČ, V. PETKOVSKA AND N. STUPNIKAR

Institute for Water of the Republic of Slovenia, Ljubljana, Slovenia.
*Email: maja.pavlin@izvrs.si

Knowing the linkages between catchment characteristics, biological communities and ecological status might help in the efficient management of water bodies in order to achieve good ecological status. In our investigation, data from 82 sampling sites were used including catchment and sub-catchment land use variables, other catchment characteristics (pressures and natural), benthic invertebrate assemblage data and ecological status variables based on biological (phytobenthos and benthic invertebrates) and physico-chemical elements (NO_3^- and BOD_5). Multivariate ordination techniques PCA and (partial) CCA were used. Saprobity and hydromorphological gradients were observed along the first two PCA and CCA axes using ecological status variables. Saprobity gradient was strongly correlated to intensive agricultural land use and urbanisation in the catchment and intensive agricultural land use in the sub-catchment, whereas correlation between hydromorphological gradient and each catchment variable was weak. Land use variables and pressures in the catchment explained 34% and 20% of the variance explained by ecological status variables, respectively. These findings suggest careful planning of intensive agricultural land use and urbanisation in order to achieve Water Framework Directive objectives.

Effectiveness of block ramps for upstream migration of fish

D. WEIBEL* AND A. PETER

Eawag, Swiss Federal Institute of Aquatic Science and Technology, Kastanienbaum, Switzerland
*Email: denise.weibel@eawag.ch

Swiss rivers and streams are highly fragmented and their longitudinal corridor is intercepted by artificial barriers. Fish migrate in different spatial and temporal scales in order to reach either reproductive, feeding, or sheltering habitat. In order to reestablish longitudinal connectivity, many artificial barriers were replaced by block ramps (fish ramps) during the last few years. We tested eight block ramps of varying slope and different constructional design to assess the success of upstream passage. Field experiments included the translocation of fish from the upstream site to the ramp-bottom. Individuals of eight fish species were either marked and recaptured or individually PIT-tagged. We then assessed passage success, whereas a PIT-tag detector additionally provided information on temporal migration pattern. We show that PIT-tag detection is a successful and even more accurate method than the common mark-recapture procedure. Further, temporal movement patterns are influenced by discharge condition. In general, successful ramp passage depends on fish body length and is highly species-selective. Therefore, swimming capabilities of local occurring species must be taken into account when engineering block ramps.

Eutrophication in marl lakes: Cunswick Tarn as a case study

E. WIIK

University College London, UK
Email: e.wiik@ucl.ac.uk

Cunswick Tarn is a small spring-fed lake in a limestone catchment. Its high pH and alkalinity have warranted marl lake classification, but at present flora typical of marl lakes is limited to one species and marl formation has ceased. Grazing and duck shooting at the site may have contributed to this change. Initial investigation of two sediment cores from opposite ends of the site show that the entire lake was a typical marl system in the past with a climax and hiatus as an intermediate stage. Further chemical and macrofossil analyses will ascertain the role that nutrients have played in the life history of Cunswick Tarn.