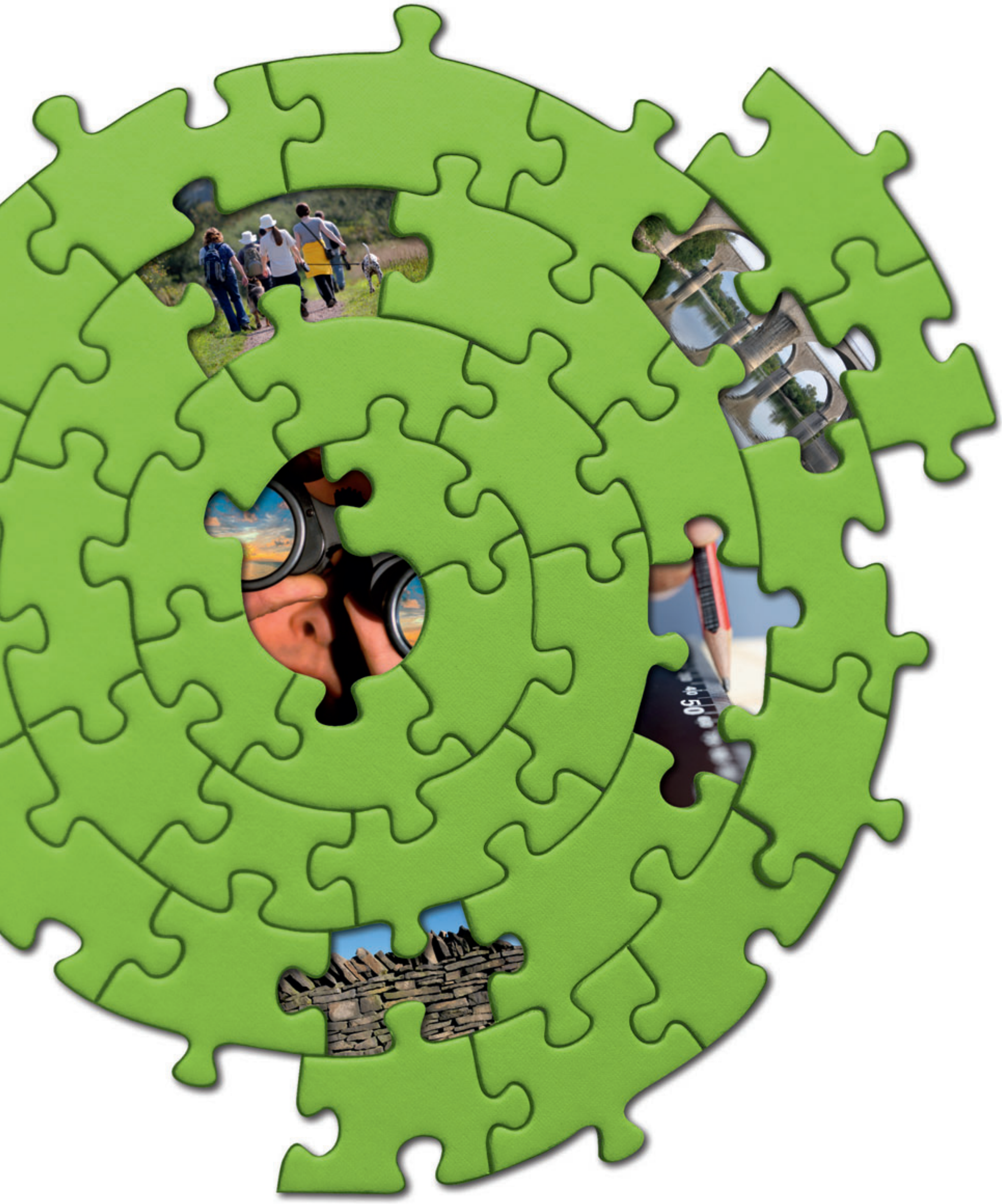
INNOVATION IN INTERDISCIPLINARY METHODS - **THE RELU EXPERIENCE**



NOVEMBER 2011

RURAL ECONOMY AND LAND USE DATA SUPPORT SERVICE

The Rural Economy and Land Use (Relu) Programme has been not only an important research programme in its own right, producing significant results and impact, but a large-scale experiment in how to do science. Interdisciplinarity was fundamental and this posed particular challenges, both in the design and implementation of projects, and in managing and integrating data.

The researchers have risen to these challenges in novel ways, experimenting creatively with their methodology. Also the setting up of the Relu Data Support Service to allow interdisciplinary data management and archiving has provided an important model for future programmes.

Thus, during the course of the Relu programme we have been able to develop and learn about the mechanics of data integration and create a legacy, not only of substantive findings, but of methods that can be applied in future research.

Jeremy Phillipson, Rural Economy and Land Use Programme

First published November 2011

Editor: Veerle Van den Eynden

Published by:
Relu Data Support Service
UK Data Archive
University of Essex
Wivenhoe Park
Colchester, CO4 3SQ

ISBN: 1-904059-84-8

Designed and printed by
Print Essex at the University of Essex

CONTENTS


REACHING OUT ACROSS RESEARCH DISCIPLINES,
ENGAGING STAKEHOLDERS, GAINING KNOWLEDGE,
STUDYING COMPLEX REALITIES.

INTRODUCTION

FROM THE START OF THE RURAL ECONOMY AND LAND USE (RELU) PROGRAMME, INTERDISCIPLINARITY WAS SEEN AS A KEY PRIORITY FOR THE FUNDING RESEARCH COUNCILS AND AN ESSENTIAL APPROACH FOR THE STRATEGIC RESEARCH THE PROGRAMME WOULD UNDERTAKE.

Studying the complex and pressing problems Relu aimed to address - the social, economic, environmental and technological challenges facing rural areas in Britain - needs an interdisciplinary approach to consider all angles[1]. The research focused on sustainable food chains, the management of animal and plant diseases, adaptation to environmental change, and integrated land and water management.

Equal importance was placed on researchers working closely with and engaging stakeholders, to ensure research was grounded in the realities of the countryside; and for the research findings and outcomes to be policy-relevant and applicable to rural areas and the people who live there.

The Programme required that in all research projects it funded, social and natural scientists would work together to investigate the chosen topic. The research teams themselves decided and developed which interdisciplinary approaches and methods they would employ.

The Relu Programme was funded by the Economic and Social Research Council (ESRC), Biotechnology and Biological Sciences Research Council (BBSRC) and Natural Environment Research Council (NERC), the Scottish Government and the Department for Environment, Food and Rural Affairs (Defra).

WHY INTERDISCIPLINARITY? THE RESEARCHERS' VIEW

"Scientific understanding of plants and insects and their interaction was essential to the expertise of our project, but it was also necessary to draw on the knowledge of political scientists of regulatory processes and the way in which their design and implementation is affected by stakeholders, including private governance initiatives by retailers."
Wyn Grant, Warwick University, The role of regulation in developing biological alternatives to pesticides

"The issue of 'quality' within food chains cannot be interpreted solely from natural or from social science perspectives. Identifying the linkages and networked practices that join the ecological quality of grassland to the feeding patterns of stock animals; the nutritional properties of grasses to the perceived taste and metabolic capacities of meat; the societal imaginaries of high landscape value farming with the economic realities of upland husbandry; all required an interdisciplinary practice and a lively process of knowledge creation through which socio-natural entities were defined and explored."
Henry Buller, University of Exeter, Realising the links between quality food production and biodiversity protection

"Ecologists think of communities in different ways to sociologists. To an ecologist a community is an assemblage of populations of different species, interacting with one another within a shared environment. Species interact by competition (lose/lose), predation (win/lose) and mutualism (win/win), governed by environmental circumstance. To a sociologist, a community is a group of diverse people living within a defined geographical area. Individuals interact along similar lines as species (competition, predation, mutualism), but are governed by mutually agreed rules, shared interests and shared beliefs. Ecologists and sociologists then need to link their different understanding of ecological and sociological communities."
Jeremy Franks, Newcastle University, Collaborative conservation in agri-environment schemes

"The challenge was to capture the knowledge of local managers and utilise this in a model of deer distribution to generate predictions that fitted the observed data."
Justin Irvine, James Hutton Institute, Collaborative deer management

[1] Lowe, P. and Phillipson, J. (2006), Reflexive Interdisciplinary Research: The Making of a Research Programme on the Rural Economy and Land Use. *Journal of Agricultural Economics, 57: 165–184*. doi: 10.1111/j.1477-9552.2006.00045.x

Between 2004 and 2012, Relu funded a total of 94 projects. The projects engaged around 4,000 stakeholders and the programme forged close networks with key individuals and organisations. Relu brought together researchers from 40 distinct disciplines from across the social, environmental and biological sciences, ranging from anthropology to water engineering and sociology, with the largest numbers coming from ecology, economics, human geography, environmental modelling, sociology, hydrology and crop sciences. Relu teams all included natural and social scientists and merged qualitative and quantitative disciplines.

There is now a unique opportunity to analyse and reflect on the variety of innovative interdisciplinary methods and approaches to data integration that emerged. Specific types of approaches and methods can be distinguished, with many projects applying a combination of many such approaches.

The research data from Relu projects have been archived at the UK Data Archive and the Centre for Ecology and Hydrology's Environmental Information Data Centre and are available for future research. Research outputs and publications are held in the ESRC research catalogue. Data and outputs can be explored and accessed via the Relu knowledge portal.[2]

[2] Relu knowledge portal: relu.data-archive.ac.uk

COMMON UNDERSTANDING

INTEGRATING DISCIPLINARY RESEARCH PERSPECTIVES AND METHODS

MANY PROJECTS IMPLEMENTED A COLLABORATIVE APPROACH AMONG RESEARCHERS AND STAKEHOLDERS TO CREATE A MUTUAL UNDERSTANDING OF THE ISSUES STUDIED AND OF EACH OTHER'S METHODS AND LINES OF THOUGHT.

This was frequently realised through discussion, reflection, shared evaluation of findings and joint publications. Researchers developed common frameworks for the research and jointly designed and adapted methods. Some researchers took this even further and engaged in cross-disciplinary activities, swapping roles during data gathering or carrying out fieldwork together. This led to more holistic assessments of problems, systems and technologies, and more rounded framing and interpretation of core concepts.

CASE **STUDY**

THE TRADING ZONE OF MICROBIOLOGY AND POLITICS

More sustainable means of plant protection are needed that enable food security whilst also protecting the environment.

Although chemical pesticides have often attracted controversy, viable biological alternatives have been slow to come onto the market. Commercial take-up has been relatively limited, in part because of the limited availability of suitable products. One reason for this is that the regulatory process was designed to cope with synthetic products and had difficulty in adjusting to the difficult requirements for registering biopesticides.

Scientific understanding of plants and insects, and their interaction with and possible impacts on beneficial insects, was essential to the expertise of this project. It was also necessary to draw on political scientists' knowledge of regulatory processes and the way in which their design and implementation is affected by stakeholders, including private governance initiatives by retailers.

The microbiologists and political scientists engaged in the project needed to have an understanding of each other's discipline to facilitate interdisciplinary working. The two literatures were written in very different ways, with political science literature being more discursive than the tersely written life sciences literature. Each discipline had its own particular terminology. It was therefore necessary to establish a 'trading zone' to facilitate understanding of each discipline's methodologies.

Each group of natural and social scientists read selected articles from the other discipline relevant to the project and then reported back to the next team meeting on their understanding and interpretation of the article and what they thought its significant points were. This helped to clear up any misunderstandings about terminology and also permitted a fuller understanding of the substantive goals and methodological procedures of each discipline. It helped to create a shared interdisciplinary space in which both disciplines felt comfortable.

It facilitated considerably the greatest practical challenge of all: writing coherently and accessibly together, particularly for the book the project produced. It helped the team reach out successfully to diverse audiences of stakeholders and academics.

The role of regulation in developing biological alternatives to pesticides
Wyn Grant, Warwick University

CASE **STUDY**

SWAPPING ROLES AND MUCH MORE

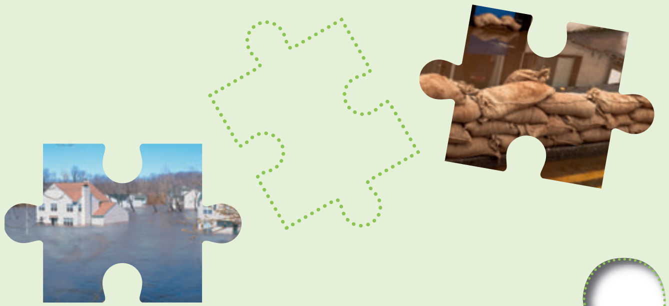
The researchers set out to provide data and methods to support decisions by organisations with responsibility for the management of floodplains as they seek to balance competing demands such as food production, nature conservation and flood risk management. Such organisations include government agencies, regional drainage organisations, farmers and their associations, and conservation bodies.

The project required continual integration of social, economic, ecological and engineering perspectives, with the management of flooding as the core focus. The team developed analytical methods that combined biophysical and ecological assessments, hydrological modelling, appraisal of engineering options, and economic valuation of outcomes. Interdisciplinary integration was advanced by close and shared working amongst researchers. They swapped roles during data collection and analysis, did team field visits and jointly prepared and delivered presentations and publications to report findings.

Using eight floodplain sites in England, they carried out detailed monitoring of floodplain water levels to construct a hydrological model that predicted water table levels based on rainfall and site conditions. Linked to this, the tolerances of different types of agricultural crops and ‘natural’ vegetation species to seasonal flooding and water table height were derived based on science literature and site observations. This informed the analysis of land use scenarios which prioritise different outcomes, such as food, nature conservation or flood control. The project developed a framework of 14 indicators of ecosystem services such as food production, carbon storage, flood storage, biodiversity and recreation; which clearly identifies the potential synergies and trade-offs amongst different benefits as land use changes.

Together with the Relu project on farming and biodiversity, a novel stakeholder mapping tool was developed to assess the range of interests and influences in floodplains. This demonstrates how stakeholder interests tend to focus on particular ecosystem services and how the interactions amongst stakeholder interests might be managed so as to realise more value from floodplains.

Integrated management of floodplains
Joe Morris, Cranfield University



STAKEHOLDER ENGAGEMENT

STAKEHOLDER EXPERTISE INFLUENCING THE RESEARCH PROCESS

INTERDISCIPLINARY WORKING ENABLED CLOSER ENGAGEMENT WITH STAKEHOLDERS IN THE RESEARCH AND INCORPORATION OF THEIR EXPERTISE.

Stakeholders were involved in data collection, ground truthing research findings, modifying and validating models and scrutinising findings. through their interdisciplinary teams the researchers developed new methods of participatory research. ecologists said that being able to work more closely with stakeholders was one of the main benefits of working with social scientists[3].

CASE **STUDY**

STAKEHOLDERS GROUND TRUTH ECOLOGICAL MODELS

Most kinds of natural resources are best managed collaboratively. In a free-for-all, a resource is likely to be over-exploited with each user attempting to extract his or her maximum benefit in the short term. But simply knowing that collaboration is a good idea does not guarantee that it can be achieved.

Red deer management is an excellent case study to investigate collaboration because deer provide both societal benefits and costs: wild deer are not owned by anybody but as they move around, they cross boundaries and provoke potential conflicts between neighbouring owners who have differing management goals.

Researchers have developed many models to predict wildlife use of habitats. These are often of little value for local management because their predictions do not match observations, largely because they do not take account of the local management actions. For models to be credible tools to develop collaborative solutions for wildlife management, they need to bring together scientific knowledge with the wealth of insights held by those who manage these resources.

The challenge was to capture the knowledge of local managers and use this in a model of deer distribution to then create predictions that fitted the observed data. The credibility of the deer distribution predictions in the eyes of managers would be enhanced, making it a useful tool to explore potential conflicts between neighbours or between local practice and national policy objectives.

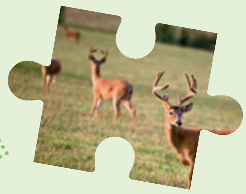
The team developed a participatory approach to integrate deer managers' local knowledge with scientific understandings and ecological spatial data in a simple Geographic Information System (GIS).

Managers' knowledge on deer habitat use in relation to shelter and forage, together with local information on paths, fences and habitat changes was used to change the way in which the GIS developed deer distribution predictions. The results fitted very well with observed data and were much better than predictions from a model based only on the existing scientific data. They clearly showed the value of using local knowledge.

This approach allows knowledge from different sources and at different spatial scales to be combined to give realistic predictions of deer distribution. Such participatory interdisciplinary approaches to wildlife-habitat models can improve communication and consensus across ownership boundaries where different management objectives exist and can therefore remove key obstacles to collaborative natural resource management.

The team also explored the perspectives of researchers and stakeholders on the successes and challenges of this way of working. Perceived benefits of a participatory interdisciplinary approach included improved social networking, social and technical learning and academic achievements. Challenges included the time and cost of intensive engagement, the building of relationships within the constraints of the research project, meeting diverse expectations and the difficulties of integrating different forms of knowledge.

Collaborative deer management
Justin Irvine, James Hutton Institute



[3] Lowe, P., Whitman, G. and Phillipson, J. (2009), Ecology and the social sciences. Journal of Applied Ecology, 46: 297–305. doi: 10.1111/j.1365-2664.2009.01621.x

CASE **STUDY**

PARTICIPATORY MODELLING TO SUPPORT CATCHMENT MANAGEMENT

Reductions in water pollution have so far been achieved mainly through regulation and investment in waste water treatment, but the underlying water quality problem in much of the UK is diffuse pollution derived from current and past land use, plus atmospheric deposition.

The project focused on how to improve the ecological quality of rivers and lakes and worked in two case study catchments: Tamar and Thurne. A key proposition has been that stakeholders with differing understandings and values must weigh up catchment management options. This requires a shared knowledge base and common understanding of processes of water quality degradation.

The team developed a participatory modelling approach and built an Extended Export Coefficient Model in which they incorporated local knowledge. Stakeholders were involved in developing the model and in testing and applying it, through a series of workshops and evening meetings. Stakeholder analysis and 'circuit riding' through face-to-face meetings and telephone conversations by a social scientist, first built interest and trust in the process. Continuity of engagement of key representatives of varied stakeholder groups was achieved through the series of meetings. These followed an adaptive planning and management cycle of visioning, catchment and pollution characterisation, pollution source and pathway modelling, scenario development and implementation planning.

Graphical modelling of catchment processes was used to clarify expectations and create a shared understanding. In the words of a leading Thurne farmer: "After living and farming in the area for so many years this diagram has brought home to me for the first time the importance of the pumps in the Thurne catchment and that otherwise surface inflows are relatively insignificant. It does provide a good means to capture local understanding of the catchment."

Whilst the mathematics of the modelling depends on expert knowledge, key assumptions, sources of uncertainty and limitations were all scrutinised by stakeholders. The local knowledge of stakeholders, in particular farmers, was essential to ground truth data like agricultural census data. This knowledge also allowed the inclusion of the impact of farmer adoption of management practices, best suited to local conditions, into the model.

Using farmers' knowledge for otherwise unknown parameters, and ground truthing data and outputs with farmers - who had previously been disengaged - built trust and demonstrated social learning. This built ownership of the process and a commitment to collective action. Stakeholder testing also helped the design of user-friendly interfaces for running scenarios and showing outputs.

Expertise from the social sciences helped design and facilitate the processes of data collection and engagement. Advanced statistical methods were used to account for model uncertainties but the model's credibility and its probabilistic predictions were improved by the modeller explaining these in lay terms, and being open towards interpretation and suggestions by stakeholders. In the words of a Tamar farmer: "How on earth could you have come up with a single number as a result anyway?"

In the iterative and participatory planning process the model was the essential tool that enabled participants to frame the scale and severity of selected water quality problems. Management scenarios were explored in real time, stimulating dynamic and engaged debate. Management options were then costed and a collective assessment made of governance and implementation arrangements.

The lessons from this experience were combined with wider interdisciplinary assessments of international examples of catchment management programmes that integrate the best science with effective communication tools and decentralised and collaborative modes of governance. This provides guidance for catchment management in the UK and other areas of intensive agriculture and dense rural settlement.

Catchment management for protection of water resources
Laurence Smith, School of Oriental and African Studies

CASE **STUDY**

COMPETENCY GROUPS - AN EXPERIMENTAL METHOD FOR COLLABORATIVE ENVIRONMENTAL RESEARCH

This project sought to understand how and why flood risk management, and the forecasting technologies on which it relies, become matters of public controversy.

It combined the ethnographic techniques of science and technology studies with hydraulic modelling and experimented with a new method of bringing the knowledge of local people with experience of flooding to bear on the modelling of flood risk - competency groups. This method was trialled in two localities in which flood risk management was already in dispute - Ryedale in Yorkshire and the Uck catchment in Sussex.

The competency group approach is designed to 'slow down reasoning' in the event of a knowledge controversy, enabling those affected by flood to interrogate the expert knowledge claims and practices that inform existing flood management policies and to try out alternative ways of understanding and mitigating local flooding problems. It centred on bi-monthly meetings over a 12-month period in which hands-on computer modelling became the key practice, supplemented by field visits, the production and analysis of video and photographic materials and other collaborative research activities.

The groups combined the different experiences and skills of the natural and social scientists in the project team (university members) with those of volunteer residents affected by flooding (local members) by working closely with various materials and artefacts that embody expert knowledge claims – flood maps and computer models. This way of working also emphasises the importance of producing new materials and artefacts to help the group's own knowledge; and propositions 'travel' and therefore make a difference to public debate and policy-making.

The approach requires a sustained commitment from all to negotiate the different modes of reasoning of fellow participants and to appreciate the different kinds of expertise brought to the collaborative production of knowledge. The project produced a web-resource to help others in trying out competency groups.

Understanding environmental knowledge controversies: the case of flood risk management
Sarah Whatmore, University of Oxford

CASE **STUDY**

MODELLING ENVIRONMENTAL FACTORS FOR THE COMMUNITY

Algal blooms are excellent indicators of declining water quality. Their presence indicates that there are excessive nutrients in the water body. In Loweswater, the occurrence of regular potentially toxic blooms of blue-green algae and their impact on visitors and locals, made it important for scientists and local people to try to understand more about the sources of those nutrients. Then locals could begin to address potential causes and take on the management of their catchment area.

The algal problem at Loweswater clearly required studying linkages between humans and the land and also between land and water. This meant scientists from different disciplines had to step outside of their disciplinary boundaries and focus on how the specific systems that they specialise in are connected to, and interact with, other systems.

Scientists, local residents and agencies worked together to form a new organisation, the Loweswater Care Project, through which scientists could draw on the benefits gained from being closely engaged with catchment stakeholders from institutions and the community. This maximised the use of information, expertise and data available to the modellers and drew on the knowledge and experience of stakeholders to identify the important factors which needed to be included in the modelling. Residents' memories of land use changes, changes in agricultural practice, environmental changes and the ways in which relations within the community and the composition of the community of Loweswater have changed in time contributed substantially to inform the research priorities.

The team developed a series of three simple linked models, with outputs from one model leading into the other. The models linked land management processes and land cover to catchment hydrology and nutrient flow and further to algal populations in the lake. Modellers felt an unusual responsibility to make the model relevant to Loweswater Care Project participants, because of the close connections forged, especially with those involved in farming the land.

Modelling incorporated information from farmers on farm management and soil data, septic tanks data collected by a local resident, rainfall data collected by residents in the catchment area, alongside information collected by scientists and the Environment Agency.

The modelling demonstrated to the Loweswater Care Project how land cover and land use in the catchment impact on algal populations and showed various scenarios of change of algal populations in response to changes in land cover and use.

Testing a community approach to catchment management
Claire Waterton, Lancaster University

QUANTIFYING

WEIGHING UP AND MEASURING DIFFERENT DISCIPLINARY ANGLES

SEVERAL PROJECTS TOOK ON THE CHALLENGE OF MEASURING AND QUANTIFYING INTERDISCIPLINARITY THROUGH STRUCTURED METHODS.

In some projects experts from different disciplines and key stakeholders scored and ranked the relevance of research findings, topics and factors to study. In others they put a value on the social and natural factors contributing to a particular problem. By engaging experts from a wide range of disciplines and stakeholders with differing interests and concerns, researchers aimed to weigh up and numerically define the different disciplinary angles of the problems studied, whilst at the same time avoiding disciplinary bias.

CASE **STUDY**

EXPERT WEIGHING OF RISK FACTORS

The project studied microbial pollution risks of watercourses from livestock farming. Joint reasoning and learning about this environmental protection issue from different analytical and interpretive starting points was a fundamental aspect of the research process. Co-production of data, interpretations and outputs resulted in the development of a practical learning tool to mitigate microbial risks at both the farm and field levels. It also informed a process of citizen science for the public scrutiny of these risks.

Making sense of the underpinning drivers of pollution risks depends on a wide assessment of the various physical, social and economic characteristics of farms that can contribute to run-off and result in water pollution.

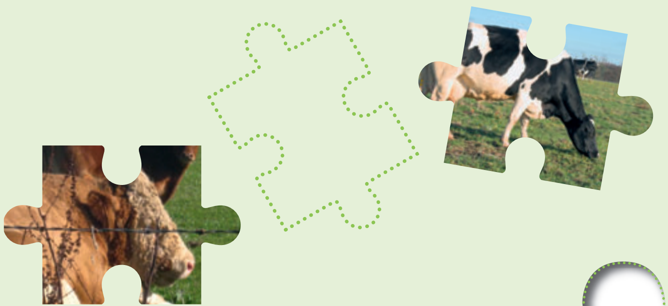
The team integrated the monitoring of watercourses for potential pathogens with determining *E. coli* mobilisation from faecal material; and desk-based identification of diffuse microbial pollution mitigation measures with interviewing farmers about their attitudes and practices towards livestock management. Farm maps were used during interviews to represent the character of, and reasoning behind, management actions.

Expert elicitation was used to prioritise and assign weighting to key social and natural risk factors that exist across farm systems. Such risk factors are categorised into four components: infrastructure characteristics of farms; *E. coli* burden; the run-off potential of farm land; and farmers approaches and attitudes towards manure, land and animal management.

The results were translated into a risk assessment tool - nick-named the ‘kite’ tool to reflect the four components that interact to influence risk - that can be used to graphically represent cumulative risks posed by any farm enterprise, so that decisive interventions can be put in place.

Risk also depends on a deeper and unresolved set of uncertainties regarding what might constitute appropriate levels of intervention, and where responsibilities for action and investment lie. The project investigated the scientific and political basis for action against these microbial risks through a citizens’ jury, which reinforced the case for strong state support of microbial risk management, but also added weight to the case for cross-industry subsidies of mitigative action.

Sustainable and safe recycling of livestock waste
David Chadwick, Rothamsted Research, North Wyke



CASE **STUDY**

BEST-WORST SCALING OF INTERVENTIONS FOR INFECTIOUS DISEASES

The researchers applied an established market research tool - best-worst scaling - to elicit and analyse perceptions of the effectiveness and practicality of interventions to manage *E. coli* O157 risk in farming and rural settings.

Candidate interventions were proposed by project team members based on findings from key stakeholder interviews. This generated 99 interventions to manage *E. coli* O157 risk. Experts from a broad cross-section of academic disciplines - public health sector, environmental microbiology, epidemiology, veterinary sciences and land management – as well as many farmers in the study regions, then commented on the relative effectiveness of the proposed interventions through best-worst scaling. This allowed each expert to give a differing perspective on the marking of the most effective process.

Best-worst scaling is a choice-based technique whereby respondents make repeated choices between sets of options. In this project, experts in a first instance assessed twelve options sets that each contained five interventions, indicating the most and least effective measures to reduce *E. coli* O157 in each set. This round reduced the number of interventions to the 30 interventions considered to be most effective. The process was then repeated with livestock farmers, who chose what they perceived to be the most and least practically implementable interventions in the field. Experts and farmers therefore combined their opinions on an equal footing to generate a list of interventions that were considered to be both effective and practical to implement.

A selection of the top 30 interventions was modelled using quantitative microbiological risk assessment to determine their potential to reduce *E. coli* O157 exposure to humans.

This technique has the potential to be applied to assess interventions associated with other infectious diseases.

Reducing E. coli risk in rural communities
Norval Strachan, University of Aberdeen

CASE **STUDY**

SUSTAINABLE APPRAISAL FRAMEWORK

Future policies are likely to encourage more land use under energy crops - principally willow, grown as short rotation coppice, and the tall grass Miscanthus. These crops will make an important contribution to the UK's commitment to reducing CO_2 emissions and are grown under low input agriculture.

However, they are quite different from the arable crops that we are used to and it is not clear how planning decisions based on climate, soil and water should be balanced against impacts on the landscape, social acceptance, biodiversity and rural economy. The problem is that these wider implications of land use change have not been investigated, and there has been no attempt to identify the full extent of the broad range of potential impacts, or more usefully, to highlight scenarios for land use change which can minimise negative impacts and accentuate positive impacts.

The dominant environmental governance goal over the last two decades has been the achievement of sustainable development. Such a goal is normally conceptualised in terms of social, economic and environmental 'pillars', and recognises the need for humanity to co-exist with nature. As such, an investigation of the implications of spatial change needs to combine evidence of impacts on the natural environment within a socio-economic and political setting that provides the context for sustainable land management decisions.

To combine the social and natural sciences, sustainability appraisal was used to incorporate social, economic and environmental criteria and data in a single framework. This uses a workshop approach that enables participants to question natural scientists, social scientists and economists to improve knowledge and understanding (the analytic component); thus facilitating more informed deliberation (the deliberative component) over the key sustainability criteria to include.

Sustainability appraisal is adapted from spatial planning. It relies on examining the sustainability implications of policy options in order to determine the best ones to take forward. Implications are determined by testing the options against social, economic and environmental sustainability objectives measured through the use of indicators.

In this project, the team agreed on scenarios to be tested (equivalent to policy options) with a broad range of stakeholders including growers, government agencies, energy companies, non-governmental organisations, union members, etc. The same broad stakeholder engagement was used to develop the sustainability appraisal framework and to interpret the results.

Impacts of increasing land use under energy crops
Angela Karp, Rothamsted Research

CASE STUDY

CHOICE EXPERIMENT TO VALUE CHANGES IN UPLAND LANDSCAPES

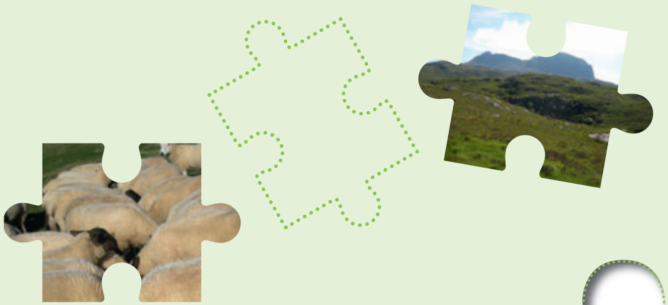
Recent work in the economics literature stemming from behavioural psychology suggests that the act of experiencing a ‘good’ impacts on preference. That means that, for a given individual, their forecast or memories of utility (relative satisfaction) are likely to differ from those stated at the moment of experience. But in the past this theory has only been tested using happiness-based measures of utility, and not for environmental goods.

This project applied the choice experiment technique to valuate changes in upland landscapes in the UK in order to identify whether experience, at that moment or in memory, impacts on the value associated with changes in ecosystem services under different management regimes. Four treatments were employed using the same sample to measure decision utility (off-site), experienced utility (on-site), and remembered utility at two different time intervals (off-site).

On-site treatment generates very different estimates of preferences than any of the off-site treatments. Whilst measurement of experienced utility is fraught with difficulties, the approach taken allowed the identification of experiential impacts on utility.

It was found that the act of experiencing an environmental good altered how individuals made decisions about environmental resources. They changed their views on the cost to the environment, with more emphasis placed on environmental goods. This result may have implications for the future use of experienced utility as a basis for the valuation of public goods.

The sustainability of hill farming
Nick Hanley and Dugald Tinch, University of Stirling



MODELLING

CREATING REPRESENTATIONS OF COMPLEX REALITIES

PROJECTS ALSO APPLIED INTERDISCIPLINARITY AT THE DATA LEVEL, BY MODELLING SOCIAL, ECONOMIC, ECOLOGICAL, ENVIRONMENTAL AND HYDROLOGICAL FACTORS FROM INPUT DATA REPRESENTING DIFFERENT FACTORS OR PERSPECTIVES TO A PROBLEM.

In some instances this was done by modelling a combination of social and environmental data, either using linear or tabular modelling, or spatial modelling in a geographical information system. Other projects incorporated local knowledge – qualitative or quantitative – as input data into models. Local or stakeholder knowledge was often used to fine-tune models and make them better fit the reality.

CASE **STUDY**

MODELLING THE IMPACTS OF THE WATER FRAMEWORK DIRECTIVE

This project brings together hydrology and economics to examine the physical impacts of the EU Water Framework Directive upon rivers and how the changes in land use needed to achieve a reduction in pollutants in water are likely to impact upon already fragile farming communities.

The project developed a methodology for integrated modelling of the relationship between rural land use (and consequent farm incomes) and water quality (including diffuse and point sources of nutrients, pesticides and faecal matter and consequent ecological status). This methodology combines econometric statistical and linear programming analysis of a large cross-section and time series panel database of farm activity with hydrological models linking land use with consequent water quality.

The model is being used to provide policy guidance on strategies for implementing the Water Framework Directive within the context of ongoing Common Agricultural Policy reforms. Particular attention is given to the impact on land use, farm incomes and the rural economy of alternate policy options.

The project is also assessing economic values for the social benefits that may be generated by implementation of the Water Framework Directive and testing the transferability of these benefits assessments.

The project shows the impact of Water Framework Directive policy changes that aim to reduce diffuse pollution on farm activities, farm income and water quality. A hydrological model at catchment level simulates how pollutants from fertilisers or pesticides leach into water and how this affects aquatic biology. An econometric shows land use changes, farm activities and incomes for farms in water catchment areas, as a result of policy changes that aim to reduce diffuse pollution by reducing inorganic fertiliser application, livestock rates or conversion from arable to ungrazed grassland.

These models can be used to predict land use changes in response to shifts in environmental, policy, or market forces; and to assess how such changes in agricultural land use are likely to affect levels of diffuse pollution to rivers.

Modelling the impacts of the Water Framework Directive
Ian Bateman, University of East Anglia

CASE STUDY

SIMULATING THE PRESENT FROM THE PAST

The threat to biodiversity and rural landscapes from tree disease epidemics is greater today than ever before.

Expanding international trade in plants, together with increased passenger movements, has led to the entry of various invasive pathogens into the UK in recent years. Many of these have the capacity to kill native trees in very large numbers. Tree disease management is complicated by scientific uncertainty, the presence of large numbers of stakeholders, the difficulty of establishing clear lines of institutional responsibility and a clash of public and private interests over who should pay.

However, tree disease epidemics are not new and policymakers have various historical precedents on which they can draw in seeking to avoid past mistakes and lengthen institutional memory. In the UK, the Dutch Elm Disease epidemic of the 1970 killed over 30 million trees. For scientists and public alike, it is probably one of the most dramatic domestic environmental events in their lifetimes. This project has sought to integrate historical analysis into the heart of the current biosecurity debate by comparing the Dutch Elm Disease epidemic with the Sudden Oak Death outbreak that is currently unfolding in the UK.

For Dutch Elm Disease to be a rich source of interdisciplinary and policy-relevant knowledge to understand present day threats like Sudden Oak Death, there needs to be an integrated understanding of the biological and socio-economic aspects of these different disease problems.

This was achieved through a linked historical and contemporary analysis that began with a biophysical and socio-economic reconstruction of the Dutch Elm outbreak. Modelling work, directly informed by insights from archival research and interviews with key actors involved in the attempted management of the outbreak at the time, was undertaken to simulate the origins, spread and eventual trajectory of the disease. This allowed the researchers to identify key events and phases of the outbreak, drawing on an interdisciplinary understanding of the interaction between the biology, epidemiology and economics of the epidemic.

Further work explored the sensitivity of the outbreak to different courses of action. Different disciplines were brought together in order to arrive at a full understanding of the way in which interacting biological and institutional factors shaped the course of the disease and its outcomes.

This fresh analysis of Dutch Elm Disease sheds important light on the current Sudden Oak Death outbreak and explains what policymakers are encountering in their attempts to contain it. Despite biological differences between the two disease systems, the research demonstrates the difficulties in both cases of early detection and the speed with which outbreaks become uncontainable once established in the wider environment. But it also points to an enduring lack of public awareness of the underlying drivers of disease risk and need for a broader debate amongst stakeholders of the conflicts between freer trade in horticultural products and effective biosecurity.

Lessons from Dutch Elm Disease in assessing the threat from Sudden Oak Death
Clive Potter, Imperial College London

CASE **STUDY**

MODELLING AND MEASURING RURAL INEQUALITY

Achieving sustainable rural development depends on the distribution of social, economic and environmental goods and services that are needed to maintain and reinforce the vitality of rural areas.

Inequality in such goods and services has important implications for individuals or groups of people experiencing it, but also for society as a whole. In urban areas, poor environments are associated frequently with deprivation and social exclusion, but the relationship between environment and deprivation in rural areas is less well understood.

Research that can inform evidence-based rural policy-making requires readily accessible data, from both social and natural scientific disciplines, about the distribution and inequality of social, economic and environmental conditions. The researchers quantified and measured such inequalities throughout rural England by developing a high resolution spatial dataset containing: the natural and constructed physical components of rural areas; the qualities and character of places and people in the countryside; information about living and working there; and the political and economic context. After identifying those areas where inequalities were greatest they investigated how rural residents experience the kinds of inequalities identified and which inequalities they perceive as inequitable.

One of the challenges was the apparent incompatibility of spatial data collected by different academic disciplines, due to the differing scale and nature of data collection and the phenomena studied. This requires a critical understanding of data form and distribution.

Social data typically correspond to administrative or political areas, which are often subject to temporal change and not related to the landscape. Environmental data such as land cover or biodiversity correspond to ecological zones and are frequently organised as grids. For farmed areas, the farmers to whom socio-economic data are attached are located spatially at points that may be some distance from their land holdings, the areas associated with environmental data. Also underlying distributions pose challenges, like irregular distributions of land cover, land use or settlement, or continuous distributions for air pollution. Variation also depends on how data are collected and organised. The combined expertise of researchers with different disciplinary backgrounds was essential in getting to grips with such challenges.

The team selected as its basic spatial unit the Lower Super Output Areas. These are areas with consistent population size (average 1,500 residents) but highly variable in size, designed for the collection and publication of small area statistics for the 2001 Census of Population in the UK. They mapped onto those areas a range of data related to economic activity, income and wealth, health and well-being, and ecology, land and the environment.

Social and environmental inequalities in rural areas
Meg Huby, University of York

VISUALISATION

VISUAL SCENARIOS OF FACTORS AND INFLUENCES CONTRIBUTING TO CHANGE

PROJECTS HAVE USED MODELLING METHODS TO DEVELOP VISUAL SCENARIOS SHOWING HOW DIFFERENT FACTORS OR INFLUENCES CAN CONTRIBUTE TO CHANGE.

This enables stakeholders and researchers from different disciplines to study the consequences or future options of particular scenarios, proposed changes or interventions. Such techniques particularly help to make scenarios more accessible for stakeholders to understand and evaluate and gives them a degree of realism that could not otherwise be achieved.

CASE **STUDY**

MODELLING WITH VISUALISED SCENARIOS AND COGNITIVE MAPS

To manage the countryside sustainably in future, one needs to understand how it is likely to change and why. Some of the biggest changes are likely to happen in upland areas, and may compromise the many important benefits they provide to society, such as clean water, carbon storage and the protection of internationally important species of plants and animals.

This project combined knowledge from local stakeholders, policymakers and scientists to identify the current needs and aspirations of those who live, work and play in three upland areas: Peak District National Park, Nidderdale Area of Outstanding Natural Beauty, and several catchments in Galloway.

By combining interviews, surveys and computer modelling, scenarios were developed that can be used as a starting point to discuss the opportunities and threats that climate change may bring and find viable options for future upland land management and sustainable rural livelihoods.

The team's approach to interdisciplinary working was diverse. Co-researchers trained colleagues in their disciplinary methods. Joint researcher-stakeholder site visits enabled the exchange and integration of knowledge. Stakeholders scrutinised information and policy briefs developed by research from published literature. Conceptual models of system structure and function developed from researchers' expertise, local knowledge and research literature formed the basis for the development of computational models used to explore scenarios.

An integrated computational model was developed from different disciplinary models: an economic agent-based model of land manager's behaviour; a hydrological soil erosion model of the effects of land management behaviour on soil properties and erosion; a habitat succession model of the effects of land management on plant species composition and succession; and a land use choice model of land managers' activities on individual parcels of land.

This integrated model was then linked to a carbon model estimating carbon fluxes and was run across the three project areas. For each area a range of scenarios were considered, including finding optimal carbon management. The optimal carbon management scenario was used to examine the viability of carbon offsetting using peat restoration within the English Peak District and used to project scenarios forward to 2030 given climate change.

Model outputs were integrated with qualitative outputs to develop scenarios for upland futures. These scenarios were visualised and developed into short films to elicit stakeholder feedback on adaption options for changes of the uplands.

The decision to use video as a medium to integrate local and scientific knowledge, was in itself based on stakeholder feedback. Documentary and animated participatory video was created to communicate project findings and adaption options online and via social media. At the same time, an interactive map-based website now allows people to share videos, photos and thoughts about what the uplands mean to them. A song and music video are currently being created to communicate the message "More than just a bog: carbon trap, sponge, history classroom".

Sustainable Uplands: learning to manage future change Klaus Hubacek, University of Leeds and Mark Reed, University of Aberdeen


REACHING OUT ACROSS RESEARCH DISCIPLINES,
ENGAGING STAKEHOLDERS, GAINING KNOWLEDGE,
STUDYING COMPLEX REALITIES.

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