

Interdisciplinary research: leading ecologists down the route to sustainability?

A special feature organised and edited by Alison Holt and Tom Webb

Introduction

Two headline events at the BES Annual Meeting in Oxford last year brought home to us the profound changes which are occurring in the Society as its centenary approaches. John Lawton's presidential address, *Ecology, Politics and Policy*¹ and Partha Dasgupta's BES Lecture *Nature and the Economy*² illustrated that British ecology is engaging to an unprecedented degree with wider societal issues, and that insights from other disciplines – such as economics – are increasingly seen as being vital to any attempt to address these concerns. In less tangible ways, too, the tone of this and other recent meetings has been orientated much more than was previously the case towards the applications of ecology, and the contributions it can make towards more sustainable development strategies.

More and more ecologists, in other words, are buying into Jane Lubchenco's call, some 10 years ago, for 'a new social contract for science'³. No doubt this has been prompted by the encouraging noises coming from society too, from the ubiquity of climate change in the news headlines, to Jeffrey Sachs's recent BBC Reith Lectures, an inspiring exposition of the interconnectedness of natural and social systems. At the same time, the Research Councils are dangling carrots, through programmes such as Rural Economy and Land Use Programme (RELU), and Living With Environmental Change (LWEC; see Box 1 for URLs), encouraging researchers from different backgrounds to join forces to address the big questions facing society – What's going to happen in the future? Where will the impacts be felt? What are the likely outcomes of different courses of action?

Quite significant amounts of money are being pumped into such schemes which, depending on your point of view, is either long-overdue manna from heaven or a gross imposition on your right to conduct blue-skies research. We suspect that most ecologists, being better equipped than most to see the effects of environmental degradation, will fall into the former camp. However, we've noticed considerable variation in the levels of enthusiasm with which ecologists respond to the word 'interdisciplinarity'; a review of this topic is therefore extremely timely.

We discuss the meaning of 'interdisciplinary research', and the challenges and rewards associated with tackling it, by presenting personal testimonies from leading UK interdisciplinary scientists with very different backgrounds. We also present the views of others just starting out on interdisciplinary research careers, as PhD students or recent post-docs. To gain a snapshot of what it's like to manage an interdisciplinary project, we've focussed on RELU, which aims to fund research that brings together the natural and social sciences to inform future policy and practice on sustainable rural development. This is the first initiative of its kind in the UK and has opened the door to scientists who want to work across disciplines to address particular environmental challenges, which makes it a barometer of whether these kinds of projects can be successful. The role of ecologists

Box 1. Links

BES Journals – www.britishecologicalsociety.org/articles/publications/journals
 bioSUSTAINABILITY – www.biosustainability.org
Conservation Biology – www.conbio.org
 DIVERSITAS – www.diversitas-international.org
Ecological Economics – www.ecoeco.org
Ecology and Society – www.ecologyandsociety.org
 Environment Department at York – www.york.ac.uk/environment
 Environmental Economics at Stirling – www.economics.stir.ac.uk/Research/research-interests.htm#environ
 ESRC (Economic and Social Research Council) – www.esrc.ac.uk
Journal of Environmental Management – www.elsevier.com/wps/find/journaldescription.cws_home/622871/description
 LWEC (Living With Environmental Change) – www.nerc.ac.uk/research/programmes/lwec/
 The Macaulay Institute – www.macaulay.ac.uk
 NERC (Natural Environment Research Council) – www.nerc.ac.uk
 QUEST (Quantifying and Understanding the Earth System) – quest.bris.ac.uk/index.html
 RAE (Research Assessment Exercise) – www.rae.ac.uk/
 Reith Lectures 2007 – www.bbc.co.uk/radio4/reith2007/
 RELU (Rural Economy and Land Use Programme) – www.relu.ac.uk
 SEERAD (The Scottish Executive Environment and Rural Affairs Department) – www.scotland.gov.uk
Society & Natural Resources – www.iasnr.org
 UKPopNet – www.ukpopnet.org

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within RELU is outlined in Box 3, and we've also canvassed the views of the principal investigators from all RELU projects in response to a series of questions concerning their personal experience of working within this framework. Across this broad range of views, from researchers at different stages in their careers and from different disciplinary backgrounds, we

ask: is interdisciplinarity the road to sustainable development, or just an expensive waste of time and effort?

What is interdisciplinarity?

It's well known that researchers in different disciplines have their own technical vocabularies, and even use the same



Box 2. Richard Aspinall, Chief Executive of the Macaulay Institute in Aberdeen.

I define interdisciplinary science as science that involves the synthesis and integration of expertise from more than one discipline at all stages of problem-solving, from establishing the research question onwards. It is also distinguished by the type of questions that are being asked. These are generally more complex than those being asked by any single discipline.

There is often confusion between the terms 'interdisciplinary' and 'multidisciplinary' science. The latter is where the expertise of multiple disciplines is brought together to provide a broader understanding of a problem but in which individual research questions fall within the expertise of single disciplines. Interdisciplinary science requires collaboration; multidisciplinary science needs cooperation. The questions that interdisciplinary science addresses are often fundamental to the challenges that humanity faces, where environmental processes like climate change intersect with human behaviours. Interdisciplinary science should therefore be both stimulating for the scientists involved and relevant to society.

My research in study of land use change, sustainable development, and global change requires an interdisciplinary approach and my collaborations span the social and natural sciences. My research links people, as individuals and via institutions, with environment and change, at a range of space, time, and organizational scales. The interdisciplinary science thus integrates universal laws, principles and relationships, with local geographical and historical contextual and contingent factors.

My disciplinary training is in geography. Both my undergraduate training and postgraduate experience in geography placed me in learning and research environments that presented a variety of ideas and epistemologies inherent to interdisciplinary work and that are central to training as a geographer. Fellow geography students graduated with degrees from science, social science and humanities faculties but the course structures ensured that we all were exposed to the full range of the discipline. Thus, although I largely focussed on physical geography, especially biogeography and geomorphology, as well as on GIScience and analytical methods, my training and education have foundations in a literature and practice that are thematically associated with a variety of other disciplines, especially others working on broad environmental issues (e.g. ecology, hydrology, climatology, landscape ecology, demographics, transportation, and landscape history). My training also provided a strong focus on fieldwork and interpretation of landscapes from social and natural science perspectives.

My employment and research reflect my interdisciplinary interests. I have worked in academic geography departments in the UK and USA, in an interdisciplinary research Institute (the Macaulay Land Use Research Institute), the Earth Sciences Department at Montana State University, and also spent two years in the Social, Behavioural, and Economic Sciences Directorate at the US National Science Foundation where I worked closely with social scientists from a variety of disciplines and in support of interdisciplinary research programmes. The interdisciplinary collaborations in this time have also been productive – in the last decade I have published research papers and book chapters with a total of 74 co-authors representing 30 different disciplines.

Some of the barriers to interdisciplinary science also provide the greatest intellectual stimulation. For example, it can take considerable time to develop the level of communication between disciplines that is necessary for true interdisciplinary work to progress. However, the discussion and debate (as well as the disagreements) that are needed provide insights into your own and other disciplines that are genuinely productive. By working in interdisciplinary teams on interdisciplinary projects I have been able to develop highly rewarding collaborations and friendships with colleagues from a wide variety of disciplines; this gives me considerable intellectual and professional satisfaction and is a very stimulating way to work and learn. I believe that my interdisciplinary experience was fundamental to my recent appointment as Chief Executive of the Macaulay Institute, a research organisation which addresses interdisciplinary research on land use, sustainable development, and environmental and global change.

word to mean different things, which makes interdisciplinary collaboration challenging. Just to add to the confusion, interdisciplinarity itself introduces a wealth of terminology. For instance, is what you are doing interdisciplinary, transdisciplinary, or multidisciplinary? Richard Aspinall, Chief Executive of the Macaulay Institute, untangles some of these issues in his account of an interdisciplinary career in Box 2 (see refs 4 and 5 for a more technical discussion). For our purposes, we consider interdisciplinary research to be any attempt to integrate theories and insights from different branches of knowledge. In particular, we concentrate in this feature on interactions between natural and social scientists (including economists), as these have been the most common form of collaboration within sustainability research. Of course, ecologists have often collaborated effectively with physical scientists and with other branches of the biological sciences. Although there are doubtless interesting stories of the challenges and rewards of such collaborations, we suspect that the communication barriers have been somewhat lower, due to the shared desire of all concerned to talk in quantitative terms. Certainly, the newer sources of funding available to ecologists seem to be particularly geared towards bridging the natural-social divide. We have also focussed on the situation in the UK, but of course interdisciplinary research has thrived elsewhere, for instance in continental Europe and in the US where the interdisciplinary 'Ecosystem Management' concept has been integrated into many natural resource management agencies. However, whilst some of the challenges and rewards that we outline will be specific to the UK, most will resonate with ecologists around the world.

Why do we need interdisciplinarity?

A common thread running through the contributions within this feature is that no single discipline will be sufficient to address the problems to which society is now demanding answers. For applied ecologists, it is no longer enough to live in a value-free bubble of 'scientific objectivity'. The most scientifically sound of management recommendations are unlikely to survive first contact with those responsible for determining policy – and certainly not with those destined to live with the outcome of that policy – if the social acceptability of different options has not been considered. Values – economic and more esoteric – are everywhere in applied ecology, and we neglect them at our peril. Interdisciplinarity is increasingly seen as a way to incorporate such values into the research process.

Challenges

Accepting that problems such as biodiversity loss and the sustainable management of natural resources are as

much social as they are ecological, the pressing need for interdisciplinary research becomes evident. However, there remain major challenges to be met to make this approach more widely attractive to the ecological research community, and to begin to provide answers to the questions posed by society.

The 'Jack of All Trades' Conundrum

It used to be easy to be interdisciplinary. The early Natural Philosophers of the Royal Society would move seamlessly from astronomy to zoology, making countless important discoveries along the way. In the 19th Century, the polymath was king – George Perkins Marsh's *Man and Nature*⁶, for instance, draws on an intimidatingly broad frame of reference in a remarkably modern investigation into the interdependency of natural and social systems. But gradually, as the sum of human knowledge increased, so the lot of the scientist became to learn more and more about less and less. Today – and be honest – how many *titles* of articles in the average new edition of *Nature* do you understand? Coleridge, who died in 1834, is said to be the last person to have read everything – or at least all that was worth reading (sometimes this honour is given to his near contemporary Goethe). Although this story is probably apocryphal, it was at least possible for a 19th Century scholar to master many fields – just look at Goethe's job description: 'poet, dramatist, novelist, theorist, humanist, scientist, painter, and polymath'!

Contrast this with the situation today, where the burgeoning volume of academic publication is highlighted by Kevin Gaston⁷ who has estimated that every day he receives at least 10 newly published papers relevant to his interests, and ISI now list around a million new papers on all topics every year. Clearly, if you need to read 10 papers a day to remain up to date in one discipline, the sheer volume of reading required to work effectively in an interdisciplinary context will be beyond most of us. Several of the RELU PIs we questioned highlighted this issue. For instance, it is 'important for interdisciplinary researchers not to dilute their specialisms', but can be 'difficult to innovate in one's own discipline and to contribute 'theory' whilst managing / taking part in a large interdisciplinary project'. As Richard Aspinall says (Box 2), the solution here is collaboration. Fortunately, finding collaborators from different disciplines does not seem to be a major obstacle for RELU researchers: although 10 of them agreed that this can be a challenge, they generally ranked it as of low importance (mean \pm s.d. rank = 4.13 ± 1.126 out of 5). There appear to be enough willing Jacks of single trades to have a go at mastering all.

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Box 3. Ecologists – Natural Interdisciplinary

Philip Lowe (philip.lowe@ncl.ac.uk), Director of RELU and **Jeremy Phillipson**, Assistant Director, at the Centre for Rural Economy, School of Agriculture, Food and Rural Development, University of Newcastle

Ecology is a portmanteau discipline – broad and outward looking. It has always been open to the borrowing of models and methods from other natural science disciplines, just as it has always been centrally concerned with the relations between human action and the environment. Through their training and outlook, therefore, ecologists tend to be well equipped for interdisciplinary collaboration.



Philip Lowe



Jeremy Phillipson

It is not surprising then to find that ecologists are the largest grouping of scientists in a major strategic research initiative on rural sustainability – the Rural Economy and Land Use (RELU) Programme. The Programme is a £25 million collaboration between the Economic and Social Research Council, the Natural Environment Research Council and the Biological and Biotechnological Sciences Research Council (with additional funding from Defra and the Scottish Executive). It is the most comprehensive interdisciplinary programme ever mounted by the research councils, and is demonstrating how the social and natural scientists can be harnessed effectively in sustainable development studies.

Over 40 disciplines are involved in RELU. The Programme is funding 29 big projects (£300 – 1000k each). One in five of the over 300 staff working on these projects are ecologists. Most of the projects – 21 in all – have an ecological dimension and in six of them ecologists are in the lead.

Examples include a project on the sustainability of hill farming, examining the interactions between economic and ecological factors on and across farms, led by Paul Armsworth at Sheffield. Justin Irvine at Macaulay, is leading a project on how collaboration between all those involved in deer management might be improved. William Sutherland at Cambridge is heading a team analysing the interactions between farm management and weed and bird populations to understand the great variability in arable farming practices and their implications for biodiversity. James Bullock at the Centre for Ecology and Hydrology, Dorset heads a project investigating how the effectiveness of agri-environment schemes might be improved through farmer training and targeting for the local availability of species and habitat types.

Every project funded must effectively combine natural and social sciences. The ecologists are working with a range of social science disciplines, most prominently with economists followed by human geographers, sociologists, political scientists, social anthropologists and psychologists. In all, ecologists in the programme are collaborating with 13 different social science disciplines. Unusual combinations with ecologists include a project where they are working with social policy specialists on the relationship between the geographical patterning of social and environmental inequalities; another where the mix includes a psychologist and a sociologist, working on the risk of, and possible responses to, zoonotic diseases on the recreational use of the countryside; and another, with geographers, a social anthropologist and a social policy specialist, working on the linkages between the organisation and practices of angling and the river environment.

What types of ecologists are attracted to this sort of interdisciplinarity? Over 20 different ecological specialisms – from biodiversity to restoration ecology – are represented in the RELU programme. The main ones are either methodological specialisms that are equipped for integrated working, such as modelling, mathematical ecology, population biology and landscape/spatial ecology; or applied specialisms oriented to the substance of the programme, such as conservation biology, entomology, plant ecology and agricultural systems. Five of the ecologists record a specialism in economics. Such hybrids would seem particularly well suited and much needed for social/natural science collaboration.

Interdisciplinary research is challenging for the scientific community. Getting to grips with the methodology, terminology and concepts of other disciplines is no easy task. Satisfying the assessment criteria and peer review processes of three research councils is arduous and demanding. Only one in 8 applications to RELU have been successful.

Fortunately leading scientists have been prepared to take up the challenge. They recognise that strategic programmes such as RELU will increasingly become the order of the day as society grapples with complex environmental problems.

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Funding

Only a proportion of interdisciplinary scientists are economists, but all are preoccupied by money. The lack of funding opportunities was highlighted as a major challenge by all 15 RELU investigators who responded to the question, often as the most significant one by those who ranked the 5 offered challenges (mean \pm s.d. rank = 1.55 ± 0.820). Our science funding framework does not yet encourage interdisciplinary research, particularly at the 'blue skies' level. If an ecologist submits a proposal to NERC that addresses pressing questions concerning environmental change and is truly interdisciplinary, it is not likely to get funded. Indeed, most (12 of 16) RELU investigators felt that their project would have stood at best only a 'reasonable' chance of being funded as a standard grant proposal; seven of these ticked the 'unlikely' or 'extremely unlikely' box. Such projects thus remain highly dependent for funding on thematic programmes such as RELU which, as one investigator pointed out, 'come attached to a strong 'steer' as to what topic areas projects can examine and what form research activities should take'. This highlights differences in the opinion of funding agencies such as NERC, which includes 'providing solutions to environmental problems' as a part of its mission, and the referees who review grant proposals, who on the whole are still promoting research ideas within mono-disciplinary realms, even in cases where working across disciplines clearly adds value to the proposed work. This is not surprising given that many scientists are unlikely to feel comfortable reviewing proposals containing elements with which they are not familiar, and using techniques for which they have no feel. It seems unlikely to change until many more interdisciplinary proposals have slipped through the net, or alternative funding sources appear. However, some at least of the RELU investigators felt some cause for optimism, with funding opportunities seen to be 'growing at last'.

Publishing – the three Ps

One of Peter Cook's comedic creations, hapless football manager Alan Latchley, outlined his management philosophy as 'Motivation, Motivation, Motivation – the three Ms'. Under pressure from RAE-minded heads of department, academics could be said to be working to a Latchley-esque strategy involving the three Ps: Publications, Publications, Publications. A constant challenge faced by interdisciplinary researchers – and, in our experience, a real disincentive for many ecologists – is thus to find a suitable, well-regarded outlet for this research. Eleven of fifteen RELU investigators identified the lack of high-impact outlets for publication of results as a major challenge; indeed, this ranked second behind lack of funding opportunities as the most significant challenge facing interdisciplinary

researchers. Sometimes, this might be due to the differing priorities of interdisciplinary projects: 'publishing does not take such a high priority as doing the project well'. So, even if a project reaches all of its goals, without sufficient publications '...this can be disastrous for an academic career'. Of course one can blame the 'narrow and conservative' strategies adopted by one's institution in preparation for the RAE, 'a major factor working against interdisciplinary work, despite rhetoric to the contrary', but that is the world in which we live. So, how to get that interdisciplinary research published?

A number of interdisciplinary journals specialise in publishing interdisciplinary environmental research: for example, *Ecology and Society*, *Society & Natural Resources*, *Journal of Environmental Management* and *Ecological Economics* (Box 1). We would encourage more ecologists to read these. However, as one RELU investigator stated, 'newer journals have not yet established reputations', and we suspect that many ecologists would fear that work published in such journals will disappear, and certainly will not reach the wide ecological audience they had hoped for. Slowly but surely alternatives are appearing, with more ecological journals encouraging interdisciplinary research papers in their aims and scope. This may not be widely adopted as there are problems selecting appropriate referees to review such work. Reviewers may often understand only part of the manuscript, but may feel compelled to comment on all of it. Editors, with limited space, are often looking for any excuse to reject a paper. So a negative comment from an ecologist on the economic content of a manuscript may be just the excuse that is needed for rejection. Either way this makes for frustrated authors.

Gary Meffe, Editor of *Conservation Biology*, is more encouraging. 'Absolutely!' is his response to the question of whether *Conservation Biology* is a suitable outlet for interdisciplinary research. 'By their very nature such papers are appropriate for and welcomed at this journal, and the field of conservation obviously will make its greatest advancements through such work. For example, the Society for Conservation Biology is actively developing and pushing for the integration of the social sciences (broadly defined) with the biological/ecological sciences because we recognize that our conservation problems are fundamentally human management problems and we cannot just stay within our traditional comfort zones. The real advancements in problem solving and scientific achievement are most likely to come from these broad, interdisciplinary efforts, rather than narrow, disciplinary papers. Plus, they are more challenging and generally more interesting papers!' Regarding the added challenges involved with reviewing interdisciplinary

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manuscripts, Meffe says 'the best we can do is attempt to get reviews from a broader range of experts within each of the fields represented, and listen to each one.' He also stresses the value of collaboration: 'We have found that, in general, biologists do not do social science very well, nor do social scientists do biology very well. Thus, there is a real need for actual interdisciplinary collaboration, where the best of several fields are truly integrated into outstanding, cutting-edge science.' We should not overlook the BES journals either. David Gibson, Editor of *Journal of Ecology*, stresses that all the BES journals can provide appropriate outlets for this kind of research, but that 'the key for authors... is to ensure that they are addressing important concepts and questions that include an 'eco' component' in order to publish in these ecological journals.

Training and Career development

With funding in short supply, and the frustrations of publishing, who wants to pursue this interdisciplinary path? Nine of fifteen RELU PIs identified a lack of suitably qualified researchers to employ as a challenge, ranking this third behind the funding and publication issues discussed above, so the work should be there for those with the correct training. Money has become available to offer studentships for interdisciplinary research, for example NERC/ESRC studentships, with many enthusiastic applicants. But for the successful, what can they hope for in terms of training? There may be particular difficulties with embarking on interdisciplinary research in establishments built on the mono-disciplinary epistemic model. In Box 4, three current and one past NERC/ESRC PhD student explain their motivations for embarking on interdisciplinary research, and their perceptions of its rewards and challenges.

Box 4.



Susannah Sallu is a NERC/ESRC PhD student at the School of Geography, University of Oxford

I have an undergraduate degree in Environmental Science and an MSc. in Environmental Technology. Although I have a natural science background, the modular nature of these courses allowed me to engage, although superficially, with the social sciences. I subsequently worked for three years in sustainable forest management, and biodiversity science and conservation in Europe and Africa. Throughout the process of my work in Africa, in particular, I increasingly came to recognise the importance of the need to incorporate social, economic, political and historical complexities into my quest to fully understand ecology. It frustrated me that this had

been neglected within the design of the projects and I felt uncomfortably positivist in my work there. These concerns stimulated my personal desire to broaden my training and knowledge, and ultimately motivated me to undertake an interdisciplinary PhD.

Conducting interdisciplinary research as a lone person is a major challenge but incredibly rewarding. It has allowed me to embrace complexity and thus, in my opinion understand the real world more accurately. I do feel, however, that it is difficult for university departments that are traditionally dichotomous (e.g. geography) or unidisciplinary (e.g. plant sciences) to provide interdisciplinary training to students. Interdisciplinary research institutes may be better placed to train interdisciplinary researchers. However, practically and theoretically I feel that I have learnt significantly more from my experience in-between disciplinary 'cliques', than if I had aligned myself with either one (human geography) or the other (physical geography), or within a unidisciplinary department, or a department with no dichotomy (i.e. an interdisciplinary institute). Being flexible to engage with either clique has opened doors and provided greater opportunity for novel thought. Critique from both sides has enabled me to strengthen my academic argument and make it more acceptable to them both.

I don't feel that there are any major disadvantages associated with undertaking an interdisciplinary PhD, but I do feel that it is important to retain some form of specialist knowledge or skill that identifies you and that you can apply. The academic job market is currently full of opportunities for interdisciplinarians and the non-academic work place values interdisciplinary skills. I hope to use my interdisciplinary skills, in the first instance, in a research career undertaking action-based and policy-relevant research, but am keen to leave the door open to future work in NGO or government sectors.

Box 4. cont'd



Claire Quinn is a post-doctoral fellow in participatory research for a RELU funded project (Managing Uncertainty in Dynamic Socio-Environmental Systems: An Application to UK Uplands) in the Sustainability Research Institute (SRI), School of Earth and Environment, University of Leeds.

When I started my interdisciplinary PhD in 2001 in the Environment Department in York, I had no idea that I was heading down a road less travelled. My university education began with a BSc in Ecology but I developed an interest in the ways to reach both environmental and socially desirable outcomes. My MRes in Ecology and Environmental Management, and research work in East Africa encouraged interdisciplinary approaches to understanding ecology, society and the interactions between them. Being awarded a NERC/ESRC joint studentship was the perfect opportunity to conduct research in socio-environmental systems, and I spent the next three years exploring the links between ecology, livelihoods and institutions for natural resource management in Tanzania. The support I received from my supervisors was excellent, both had expanded their research beyond disciplinary boundaries over the course of their careers. Unfortunately, there were few formal opportunities to learn how to do interdisciplinary research, instead my training focused on learning disciplines I was unfamiliar with and it was up to me (and my supervisors) to find the best way to conduct interdisciplinary research.

There are advantages to being an interdisciplinary researcher: you can draw on different perspectives to inform your research and you can understand the language in a range of fields. But there are some major disadvantages too. It is easy to be seen as a 'jack of all trades' and there are many who still believe that training should be in one discipline. There are fewer high ranking journals in which to publish interdisciplinary research. Funding opportunities are harder to come by with interdisciplinary proposals often judged on their contribution to new knowledge within the separate disciplines rather than their contribution to new knowledge across boundaries. Also, even with excellent joint Research Council funding sources like RELU and QUEST, interdisciplinary research funding is still viewed as a way to bring together people from different disciplines rather than provide opportunities for interdisciplinary people. Finally, and importantly, few universities are academically or administratively geared up to provide career progression and support for interdisciplinary people. The fact that I had to choose one discipline to graduate in for my PhD shows the inflexibility of university administration. All of this has serious implications for joint ESRC/NERC trained researchers.

I have been incredibly lucky so far. The departments that I trained in at York, and the department that I now work in at Leeds, both foster and support interdisciplinary research. I am now an interdisciplinary post-doctoral research fellow on an interdisciplinary project in an interdisciplinary department. However, I fear that there are not enough opportunities in academia for all the interdisciplinary researchers being created by the joint ESRC/NERC studentship programme. What the future holds for us is uncertain, without changes in universities and in funding the road less travelled may become a dead end.



Sam Staddon is a NERC/ESRC PhD student in the School of GeoSciences, University of Edinburgh

With a background in ecology and conservation but a desire to consider local people in the management of our natural resources, an interdisciplinary NERC/ESRC-funded PhD was the perfect option for me. My PhD investigates the monitoring of natural resources by local people and this allows me to work in an inherently interdisciplinary nature; keeping a foot firmly in the camps of both the natural and social sciences.

Interdisciplinary research opens many doors. All the disciplines you span are available to you in terms of theories and literature; you can delve into and take from whichever and whatever you please and this provides

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great intellectual freedom. This brings with it however a feeling of isolation, as whilst 'monodisciplinarians' stick together, as an 'interdisciplinarian' you feel that you are never probably truly accepted in any discipline.

No specific interdisciplinary training is provided at Edinburgh, instead your training is determined by the discipline of your supervisor (despite any interdisciplinarity that they may strive for).

Following the PhD I wish to conduct applied research and I believe that an interdisciplinary background will be helpful for this in my particular field. It has been pointed out that working in an interdisciplinary nature is easier during individual research endeavours than when working in an interdisciplinary research team however, as in teams individuals tend to stick to certain disciplinary strengths.



Helen Laycock is a NERC/ESRC PhD Student in the Environment Department, University of York

My first degree was in Biology, then I did a Master of Research in Ecology and Environmental Management. For my PhD, I didn't want to just continue doing what I had been doing, but instead wanted to increase my skills base further by taking on a project that involved interdisciplinary research. As a result, I have gained expertise in Ecological Economics, which I otherwise would not have had. It has been challenging but rewarding to build up my skills in this previously unfamiliar discipline and I feel that I am working in a developing and exciting field. One of the disadvantages though is that presenting at conferences can be tricky. I certainly

don't feel enough of an expert to present at a straight Economics conference, but some people attending Ecological conferences might struggle to understand the economics within the short time available. Another important issue is ensuring you have suitable supervisors on hand to help you with your research, either in the form of an expert in the interdisciplinary field you are working in, or several experts, one in each of the individual disciplines that make up that field. This is particularly crucial if, like me, you are new to one or more of the disciplines involved in your interdisciplinary research. In terms of interdisciplinary training, I have attended lectures for both undergraduate and postgraduate courses in Ecological Economics, and even given tutorials in this subject myself! I have also had plenty of general research methods training both within my department and provided centrally by the university. After I finish my PhD, I would like to work within a wildlife conservation organisation, either NGO or governmental, and hope that the extra skills I have gained from doing an interdisciplinary PhD will broaden the scope of jobs I can apply for.



Post-PhD, there may be difficulties for those wanting to take the academic route. As one RELU investigator puts it, there is 'no clear career path for post-docs' (although whether this is unique to interdisciplinary research is debatable!). It is true that interdisciplinary research may attract less recognition from one's peers than developing cutting-edge ecological theory (12 of 15 RELU PIs agreed here), although it is certainly intellectually as challenging. Taken together, these challenges may mean that interdisciplinary research is not seen as a risk worth taking, and may remain the luxury of the established academic (see Box 6).



Box 5. *Nick Hanley is Professor of Environmental Economics at the University of Stirling.*

Is the increasing focus on interdisciplinary work by UK Research Councils and other funding bodies such as the Leverhulme a good idea? Does interdisciplinary work make ecology more useful? Should universities invest resources in building up interdisciplinary units, and will this improve the scholarly qualities of academic output? Should we have more interdisciplinary journals, and less emphasis on single disciplines within the RAE? These are important questions which it is quite right for the BES to take an active interest in. In this short piece, I offer some thoughts about possible answers, based solely on my own personal experiences. How generalisable or useful these are I leave to the reader to guess. First, though, a little personal history is in order.

I studied economics for my first degree at the University of Stirling, from 1978 to 1982. I was very fortunate in that Stirling was one of very few universities in the UK at that time to offer a course in environmental economics, taught by Mick Common. Mick had met up with David Pearce at Southampton, and David's first (and still extremely useful) textbook on environmental economics had been published in 1976. I consumed this voraciously, partly because it was so well written, and partly because it was just so much more interesting than a lot of other economics that we were exposed to! I then wrote my 4th year dissertation on the economics of pollution control, before Mick suggested that I might be interested in a PhD in environmental economics. The problem was that it was then such a minority interest in the UK that there were not many places to study, and not many sources of funding. Agricultural economics, though, was very well funded, and so we came up with a PhD topic which took some issues in environmental economics, and applied them to the increasingly controversial subject of the interaction of farming with the countryside. I was fortunate to get PhD funding from what is now SEERAD, and was accepted by the Agricultural Economics Department at Newcastle University in 1983.

As Philip Lowe has pointed out, Faculties of Agriculture in the UK were early examples of interdisciplinary set-ups: ours contained ecologists, chemists and animal scientists as well as economists and farm managers. This was an excellent environment in which to foster the benefits of working between the disciplines in research – although less so in teaching back then. My PhD work did indeed involve interactions with ecologists studying the effects of farming methods on plant diversity, although by no stretch of the imagination could my PhD be called interdisciplinary.

However, interdisciplinary work became important in my first post as a lecturer, back at Stirling, by about the late 1980s. We had launched the MSc in Environmental Management, which combined economics, environmental science and environmental management. Then, in 1990, I got my first truly interdisciplinary research grant, working with Ian Moffatt to model alternative mechanisms for pollution control in the Forth Estuary, funded by ESRC. This was the precursor to a large number of interdisciplinary research projects, mainly funded by ESRC but also by agencies such as Scottish Natural Heritage and by Defra. Now we are involved with many ecologists, hydrologists and water quality scientists in our work, and previously I have worked with soil scientists, historians, paleo-ecologists and climatologists.

Enough personal history. I would now like to focus on three questions. First, what makes a good interdisciplinary project from my perspective? In general, I think we could all recognise poor quality interdisciplinary projects which either fail to integrate thinking and methods across the boundaries, or which are really multi-disciplinary projects with everyone "doing their own thing", or which are poorly structured in terms of who does what and when, or which simply contain bad disciplinary scholarship. Poor structure can come, for example, when the stages of delivery of different aspects of the project are badly thought-out, or get delayed: one project I was working on required some detailed water quality modelling of a catchment before the economists could set up their models; the water quality model got delayed for very good reasons, but this meant the economists ended up in a mad rush at the end of the project, and never did all that they wanted to do. Bad structure is really bad planning – another example being when it turns out halfway through a project that the time step the hydrologist wants to use is fundamentally different to that which the economist uses, or where the level of spatial analysis that the ecologist employs turns out to be incompatible with the spatial scale the economist used (e.g. the field versus the farm scale).

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Two of the best interdisciplinary projects I have been involved with have been a Leverhulme-funded project on drivers of biodiversity change over the last 400 years, which pulled together environmental historians, palaeoecologists and economists; and a RELU project on the interactions between farming and birds in the Peak District, which combines ecological and economic methods. Why did these “work” from an interdisciplinary perspective? First, because they each addressed a set of questions which no discipline could answer on its own. Second, because all team members “bought into” a common structural model, or procedural approach, at the outset of the project. This was vital for organising inputs and discussion, even if the model was only one aspect of the project’s work. Third, because team members put in a huge effort to communicate their different approaches and disciplinary perspectives to each other, so that problems of mis-perception could be explained away, and so that people could be clear about *why* the economists needed to know this piece of information, and what the hell they were going to do with it.

A second question concerns the career development of researchers. Will they have problems in publishing and advancement if they specialise in interdisciplinary projects? In my judgement, up until very recently the answer to this question has been “yes”: RAE panels and interview panels are much more likely to recognise “core” research within a discipline than collaborative, interdisciplinary work. Success in attracting funding helps, of course, but one suspects that this has a relatively low weight compared to peer-reviewed journal articles in the eyes of appointing or promotion committees. Only recently have career paths started to open up in the interdisciplinary field, and these are often paths typified by short term contracts and “project hopping”. Incidentally, interdisciplinary PhD programmes also seem high-risk strategies for the ambitious young would-be academic, no matter how wonderful we might think they are in principle.

Are some kinds of collaboration easier than others? In my experience, yes. Economists and ecologists share much in terms of statistical methods (even if our language differs) and theoretical concepts (e.g. constrained optimisation, strategic behaviour, competition). In contrast, economists and human geographers share much less, and often end up in ideological battles fought out in the battlefields of conference floors and research applications. Yet I have also had very fruitful collaborations with historians, whilst colleagues of mine have done good work with philosophers.

Finally, is interdisciplinarity required to make science “useful”? In particular, is it needed to make ecology useful? Most ecologists, I guess, would prefer the answer here to be “no”. But I suspect the correct answer is “increasingly often”. A straightforward ecological analysis can tell us what kind of habitat management is needed to secure the breeding success of corncrakes in the west of Ireland, or black grouse in the Highlands, but only by working jointly with social scientists can ecologists learn about how these management changes can be incentivised – in other words, how human behaviour can be best changed, and how these changes map into the parameters which ecologists are concerned with. And ecologists on their own would find it hard to predict the effects of climate change on flora and fauna in the English countryside, given that human reactions to climate change in terms of land use and land management matter as much as the direct response of species to changes in the weather. In fact, as environmental problems become more challenging and urgent world-wide, the need for good interdisciplinary research is likely to be increasing.

Rewards

Despite these challenges many ecologists are keen to work across disciplines. As Dave Raffaelli discusses in Box 6, it is intellectually challenging, it satisfies the moral obligation to conduct socially-relevant research, and it is the only realistic way of finding solutions to the environmental problems we face. Generally, the 17 RELU PIs we questioned provided an up-beat assessment of the interdisciplinary experience. All but one rated the overall experience of leading a RELU project as either positive or very positive, and most (11 of 14) felt that it had led them to alter their normal way of thinking about or conducting research. Although 12 of 16 investigators felt that

their project would not have stood a great chance of being funded through more traditional routes, 10 of 13 rated the scientific output as either excellent or world-leading, and most of them (11 of 16) felt that, in terms of quality, the RELU science was similar to ‘research-council’-type science (although clearly this depends on measures of quality). None of the 17 expressed a preference for the money distributed through RELU to be given instead to the individual research councils to supplement the funding available through ‘standard grants’: ‘there is a place for single science and multiple science... they have different and potentially



Box 6. *Dave Raffaelli is Head of the Environment Department at the University of York, established several years ago specifically to promote and deliver an interdisciplinary approach to teaching, training and research for environmental management. He also chairs bioSUSTAINABILITY, a core project within the international programme DIVERSITAS, is Vice-President of the BES and Director of UKPopNet.*

I am a natural scientist by training who, like many others, embarked on a career in ecology in order to indulge a passion for natural history. I never dreamt of working across the natural and social disciplines, immersing myself in entomology as an undergraduate and marine coastal ecology later on for my PhD, post docs and as a lecturer: a card-carrying mainstream ecologist for 25 years.

However, after working on the food web dynamics of an estuarine system in Aberdeenshire for 20 years, it became abundantly clear that the eutrophication issues which plagued this system (the Ythan) were unlikely to be resolved by ecology alone. Whilst ecology could help us understand the processes and impacts of nutrient enrichment within the Ythan catchment, the real drivers of eutrophication were clearly social, economic and political. I found myself totally unequipped to deal with the contention and conflict that arose when the Ythan catchment was proposed to become the first Nitrogen Vulnerable Zone in the UK, largely on the basis of our own research at Culterty Field Station.

It was clear to me then that what has now become known as the Ecosystem Approach was required for managing the Ythan, whereby people are acknowledged as part of, not apart from, the system. Furthermore, resolving an issue like the Ythan demanded an understanding of what motivates people to view and to use biodiversity in the way they do. It is this that took me into the realms of the social and economic sciences, a journey I am still enjoying and have never regretted embarking on, but which has thrown up some challenges which I thought worth airing here.

The benefits of the inter-disciplinary approach are many. First, I cannot see how biodiversity can be conserved or used sustainably through a mono-disciplinary approach. It is not enough to do the excellent ecology and then turn over the results to policy makers so that they can combine them with data from other disciplines, and then expect those policy makers to make sensible decisions. That will only lead to frustration on your part and to poor policies. Ecologists need to be actively engaged with that science-policy interface, which in turn means that they need to understand and appreciate the social context of their work, how it can be made relevant to wider society and what incentives will work in getting people to manage and use natural resources sustainably. This does not mean that one has to become an expert overnight in environmental economics, social anthropology or social policy. But you do need to engage with those disciplines, and this is not always easy. There will be challenges.

First, some of those in your own mono-discipline may think you're nuts. I have been accused of "going over to the dark side" by fellow ecologists. I have always believed that that's their problem, not mine.

Second, funding has not been easy to come by. Until the RELU initiative, it was hard to convince mono-disciplinary research councils (NERC and ESRC) and peer-reviewers of the worth of inter-disciplinary projects. Thankfully, that attitude is changing through the adoption of the *Living With Environmental Change* initiative by the UK research councils and agencies, but whilst the RAE and institutional recognition and promotion procedures continue to favour research income and publication in high impact (usually mono-disciplinary) journals, there will remain a disincentive for early career ecologists to take a chance on inter-disciplinary research. In my own case, this was not an issue because I was an established academic who could afford to take the risk. Others will be more risk averse.

Third, there is the challenge of understanding how other disciplines work and what their strengths and weakness are. This is not simply a lexical problem of language and jargon, although that can be very confusing in itself, almost like a physical barrier. The real challenge is learning how to approach problems in ways which one's scientific training with its dominant hypothetico-deductive model does not readily accommodate. Developing the pluralism needed to accommodate other ways of looking at and solving problems requires a critical examination of the strengths and weaknesses of scientific method

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and those methods used in the broader social sciences. Not everyone will be comfortable with this, perhaps feeling that by acknowledging the utility of other approaches and world views, the value of the scientific approach is somehow lessened. Nothing could be further from the truth: these different approaches are not mutually exclusive, but complementary and often synergistic.

The editors asked me how I have benefited from the interdisciplinary approach. The simple answer is: hugely. It's been hard work, challenging, and I have wondered from time to time what kind of researcher I have become. A better one, I hope. It's certainly been lots of fun.

complementary roles'. Concerns with the RELU model included the 'overwhelming influence of DEFRA on RELU panels' and other issues of 'poor quality project proposal evaluation'.

An important reward to be gained from interdisciplinary research is that it brings the researcher a step closer to policy. This step can be achieved through the close involvement with stakeholders at all stages of a project; 14 of 17 RELU PIs felt that involving stakeholders in planning and conducting a project was useful, particularly 'if we want the research to be relevant' and 'if the outputs are relevant to stakeholders'. A balance needs to be struck, of course, and one investigator complained that although 'stakeholder involvement is useful, stakeholder control is not'. Likewise, 'keeping stakeholders 'on board' is very time consuming and needs to be recognised as an important 'output''. As always, the usefulness 'depends on the people involved', and re-enforces the need to spend considerable time assembling a team which not only contains expertise across disciplines, but which also contains the will to put in the time and effort required to make interdisciplinary research a success.

Conclusions

There is growing political and social pressure to come up with ways of dealing with the unprecedented environmental changes that we face. Ecologists play a key role in understanding these threats and coming up with solutions, but it is now clear that we cannot do this without collaboration with other disciplines. The Living With Environmental Change (LWEC) programme (Box 1), backed by the UK's main funders of environmental research, recognises that there are 'complex and interconnected relationships between dynamic societies and changing environments', and is proof that interdisciplinary research is now firmly on the scientific and political agenda. However, even if RELU, LWEC and other funding bodies provide a solution to the current funding problem, serious attention needs to be paid to the other challenges we have outlined above, in order to make the best use of this investment.

The first step is to initiate a debate about possible solutions. Should interdisciplinary degrees be encouraged, steering students away from mono-disciplinary learning? Interdisciplinary departments and institutes may foster this kind of learning and create an environment for cross disciplinary collaboration at all levels. Perhaps there should be more incentives for those researching applied questions using interdisciplinary approaches, as the RAE in its current form certainly does not appear to encourage such work. Of course, not all ecologists will be convinced of the rewards of interdisciplinary research, and there are many challenges to overcome, but most would agree it is our responsibility to try.

Alison Holt & Tom Webb

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