THE MACAULAY LAND USE RESEARCH INSTITUTE

Annual Report 2010

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The Macaulay Land Use Research Institute

The Macaulay Land Use Research Institute is an international centre for scientific research and consultancy on the:

- Economic, social and environmental consequences of rural land uses
- Impacts of potential changes in policy, management, climate and pollution for the management of natural resources, and sustainable rural development

Our research provides new and impartial knowledge that contributes to environmental and rural development policy, both in Scotland and internationally and we are committed to ensuring that this knowledge is shared and effectively communicated to all interested parties.

We are internationally recognised as a leader in land use research and we transfer our skills and experience through collaborations within over 40 countries worldwide. A Times Higher Education survey recently ranked the Macaulay Land Use Research Institute as being the second most influential Scottish institution in the fields of environmental and ecological sciences, and ranked in the top 20 UK institutions in these fields.* These rankings are based on data from the Thomson Reuters Essential Science Indicators which covers journal articles published between January 2000 and February 2010.

The majority of our research is commissioned by the Scottish Government, but we also provide research and consultancy services to a wide range of organisations involved in natural resource management.

In addition to our core research programmes we provide research and consultancy services to a wide range of organisations. Although many of these are primarily involved in natural resource management we also provide specialist commercial analytical services for industrial sectors as diverse as oil and gas, and food. Our extensive state-of-the-art laboratory facilities test more than 50,000 samples a year and earn an additional £1 million annually from commercial analytical work.

Last year the Macaulay Land Use Research Institute competitively won over £5 million in new research contracts from projects totalling nearly £16 million.

The Institute's founder Dr T.B. Macaulay

*http://www.timeshighereducation.co.uk/story.asp?sectioncode=26&storycode=412625&c=1

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Chief Executive's Introduction

The Macaulay Land Use Research Institute is now in its 80th year. Founded in 1930 by Dr. T. B. Macaulay as the Macaulay Institute for Soil Research, and later expanded in 1987 through merger with the Hill Farming Research Organisation, the Institute's original mission was to support the development of agriculture and promote rural livelihoods in Scotland. I hope that you will agree that we have not only remained true to our roots but also have come a long way over those 80 years.

The need for science that supports our original mission is perhaps even stronger today. Global and regional population growth and environmental and economic changes have made achieving the productive use and management of land and water resources critical to meeting social, environmental and economic priorities. We must find ways of achieving high levels of production without compromising environmental quality. The work of the Institute remains dedicated to providing scientific insights that help us to meet these national and international priorities.

Over the period covered in this Annual Report, Institute staff have been actively involved in interdisciplinary research that informs policy and guides management decisions and options in areas as diverse as land use, climate change, river basin planning and water management, recreational use of Scotland's landscapes, renewable energy generation and planning, long-term changes in Scotland's soils, among other topics. This Report contains a series of examples of this inter-disciplinary research. These examples all reflect our broad-based inter-disciplinary approach which combines physical, biological, social and economic sciences. The research we carry out is directly relevant to contemporary social, economic and environmental issues and represents our concern to provide primary scientific evidence supporting the development of public policy and for the wider public good. Our research is relevant not only in Scotland, but also in the UK, EU and internationally.

Our commitment to communication of science and scientific understanding is another key element of our approach. We aim to get our research into the places where it can make a difference. This is shown clearly by both our education and outreach activities and the shifting balance of our publications. As in any leading scientific organisation peer-reviewed scientific articles remain a core requirement, but we also recognise that other activities are needed in terms of relationship building and personal communications with our many and diverse stakeholders.

In addition to carrying out research we are also responding to changes in the ways we work, in the ways we are funded, and in the ways that we engage with society. The Scottish Government remains our largest customer and partner but we are also active in contract research, consultancy and commercial work. Our funding reflects this range of activity – and the success of our staff in diversifying the income base of the Institute. As a result, and despite the general economic situation, the last several years have seen significant growth in our income. This has allowed us to make new investments. For example, we have invested in our world class laboratory facilities, including an increase in our Scanning Electron Microscope (SEM) capability. The new SEM has already been used for analysis of ash from Eyjafjallajökull in Iceland. We also continue to invest in our research stations and soils data as parts of the long-term foundation of the Institute.

From our relatively small beginnings 80 years ago, the Macaulay Land Use Research Institute is now a major international research and consultancy business with a staff of around 300. In the financial year covered by this Report, income was around £14.9 million with an overall surplus of £0.9 million. The competitive strength of the Institute is reflected in us recently winning £5 million worth of new research contract income. With a real year on year decline in our income from the Scottish Government this trend for increased external income through research, consultancy and commercial contracts will need to continue to increase into the future. A strong performance from our trading company Macaulay Scientific Consultancy Ltd is an important part of our future financial viability.

The Macaulay Land Use Research Institute is a quality brand. It is a business in good heart. We look forward to a successful future where our research continues to make a real and positive impact. I hope that you will enjoy reading this Annual Report.

Richard

Richard Aspinall
Chief Executive

Chairman's Introduction

This is a very exiting time for the Macaulay Land Use Research Institute. The imminent prospect of joining with the Scottish Crop Research Institute will lead to a new institute, the biggest of its kind in Europe and a force to be reckoned with throughout the world for research into food, land use and climate change; a real asset for Scotland and the UK where already there are other organisations expressing an interest in affiliating with it. That the Macaulay Land Use Research Institute is at the centre of this initiative is testament to the quality, reputation and relevance of the work carried out, and of the expertise of the staff, here at Craigiebuckler in Aberdeen.

The science undertaken seeks to answer many of the world's biggest questions, especially those around climate change. High class research is undertaken to consider the implications on our soil, water and biodiversity providing solutions on how society and industry can adapt to change. Change is not however singular. Technological progress, energy needs and societal considerations are all looked at in a truly interdisciplinary and multidisciplinary way that makes the Macaulay Land Use Research Institute unique. These solutions are not just theoretical; our research stations provide a platform to test and examine the implications of the research and ultimately to demonstrate solutions to a wider forum of stakeholders. Our scientists play a key role in providing the evidence used by Government to frame future policy and to understand the implications of it for its citizens and businesses. Finally the world class facilities in our laboratories provide analytical services to a wide range of commercial customers and the solutions based approach of many of our scientists makes them much sought after as consultants both nationally and internationally.

The Macaulay's scientists are at the heart of this work, but they would not be able to function effectively without the highly skilled and dedicated support staff who provide the essential infrastructure for them. Neither do our scientists work in a vacuum; the Macaulay Land Use Research Institute has an extensive network of collaboration and partnership, ensuring that we can harness the finest minds and organisations to help with our work, some of this involving Institute alumni now to be found dispersed throughout the world.

I have been both proud and privileged to be a part of the Macaulay Land Use Research Institute over the last seven years, the last five as Chairman of the Board of Governors. It has been stimulating and exhilarating to be involved in such a vibrant organisation and the commitment and support of the Board and senior staff have been essential to progress it to its current status. There are challenging times ahead but the formation of the new institute and the agenda being followed by the Institute are I believe in its best interests. I am convinced that the name and reputation of the Macaulay Land Use Research Institute will remain well known and respected for some time to come.

Michael Gibson
Chairman

Assessing and Enhancing Soil Quality

Colin Campbell

Our focus on Assessing and Enhancing Soil Quality requires us to clearly understand how each of the individual aspects of soil health respond to different pressures, and define useful thresholds beyond which soil function is impaired. Knowing how soil properties change between areas or over time is also essential for understanding the response of soils to these threats. Our research provides scientific evidence on the sustainable management of a range of soil / land-use combinations in Scotland.

The aims of our research are to:

- **Improve understanding of the role and function of soils in:**
  The development and maintenance of ecosystem resilience
  Contributing to sustainable rural landscapes
  Maintaining ecosystem health and services
- **Develop methods to detect and ameliorate threats to soil quality from climate change, pollution and changing land use**

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Context and Rationale

Soils perform a variety of functions that are essential for life on Earth. These include the production of food, fibre and forage, protecting our food chain, air and water by filtering, storing and transforming elements, regulating our climate through greenhouse gas exchange and providing habitats for biodiversity. Consequently, soils are central to the sustainability of landscapes, ecosystems, and the livelihoods of people and communities. To ensure the sustainability of soils, we need to understand what constitutes a healthy soil in terms of its functions and its resistance and resilience to pressures and stress. The balance of functions and the value of soil to society depend on its place in the landscape.

Soils in Scotland differ from those in the rest of the UK due to the different geological parent material, the cool wet climate, and different land use and vegetation. There is a greater proportion of soils with organic surface layers or peat. Even our agricultural mineral soils have elevated levels of organic matter. Some of our soil characteristics are common to other northern temperate and boreal areas of the planet and this, combined with our innovative science, mean our work has an international significance and relevance.

The functioning of soils is strongly influenced by the soil organic matter content. Sustainable management of soil thus requires process-based knowledge of the formation, loss and turnover of soil organic matter and of plant-soil interactions. Many of the ecosystem services provided by soils depend upon the functioning of the soil micro-biota which remains poorly understood and largely unexplored. Understanding how diversity and functioning will be affected by changes in land management and environmental conditions is important to predict responses to management and environmental change. Such work may provide important new biological indicators of soil status and allow us to monitor loss of biodiversity and determine the ecological status of our soils. The multifunctional aspects of soil mean it is valued in different ways by different interests. Knowledge of the societal value of soils (including their non-market benefits) is required to determine the long-term sustainability of soil management, and evaluate how policy instruments might be deployed to enhance the value of soil to society.

Our goals are therefore to improve basic understanding of the role and function of soils in the development and maintenance of ecosystem function and resilience, in contributing to sustainable rural landscapes, and in maintaining ecosystem health and services. We are developing methods and approaches to detect and ameliorate threats to soil from climate change, pollution and land use and management, and seek opportunities to use our knowledge to enhance soil's function and value.

Scientific activities

Scotland's soil resource – status and threats

In 2006, the report *'Scotland's soil resource – current state and threats'* (Figure 1) was produced for the Scottish Government by the Macaulay Land Use Research Institute and the University of Stirling (Towers et al., 2006). This remains one of the key documents guiding the Scottish Government's development of soil policy. The report provided a summary of the current status of our soils and the first qualitative assessment of the relative importance of a range of threats to soil quality in a specifically Scottish context. A key conclusion was the lack of trend data from which evidence of change in, and damage to, our soils might be determined.

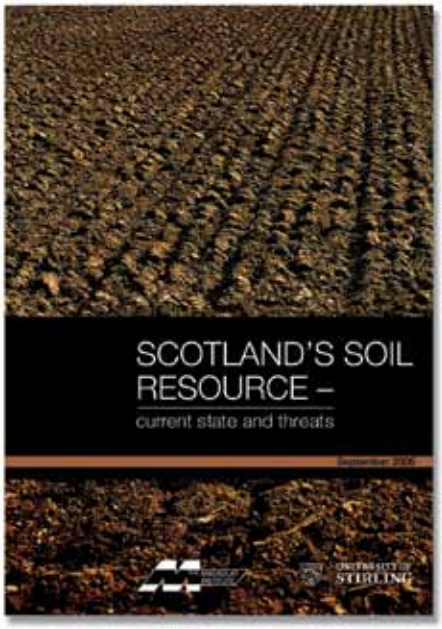

Figure 1 'Scotland's soil resource – current state and threats'

Our research is helping to address this gap (Lilly et al., 2008). In 2009, we completed the field resampling of a subset of the National Soil Inventory of Scotland (NSIS-1) sites. These sites, at 10km intervals across the country, were first sampled between 1978 and 1988; we revisited a subset of these at 20km intervals (NSIS-2) (Figure 2). In addition to collecting fresh bulk samples on the basis of profile morphology (as in NSIS-1), we also collected surface samples on a fixed depth basis by auger and cores to compare different sampling methodologies. Fresh soil samples are also being collected for testing new high throughput molecular biology technologies and gaps in data on key attributes such as bulk density are being addressed. NSIS-1 samples contained in the National Soils Archive at the Macaulay Land Use Research Institute are being re-analysed using updated analytical techniques to ensure like-with-like comparisons (Potts et al., 2009). We are also investigating the short range (4–32 metres) variability of key properties in the uppermost soil horizon (Figure 3).

Figure 2 Location of NSIS-2 resampling sites

Figure 3 An NSIS–2 resampling site showing the location of the central profile pit. Inset shows a typical podzolic soil under Scots pine showing classical sequence of horizons.

A key outcome of the Status of Scotland's Soils Report was the identification and description of the current information and data sets on soils in Scotland. These data sets are stored in a variety of media (database, GIS, paper documents) and links between them are often established using manual data processing. We are building a conceptual model of the information to design a more integrated database. The data collected during the NSIS-2 resampling and their NSIS-1 equivalents are ideal test data for the design of this new database which will underpin much of our new soil information system.

Valuation of soils

Compared to air and water, soil receives the least public attention despite its pervading role in our lives. In addition to its ecological functions (described above) the nature of soils shapes our landscapes and provides the basis for our built infrastructure and housing. Because we rarely 'consume' soil per se, the value of soil is often implicit in the value we place upon these goods and services (Glenk et al., in review). Consequently, the value of soil is more easily quantified if the value can be directly attributed to the properties and functioning of soil, e.g. in food production. It becomes more difficult to value soil when soil and its functioning are one out of many physical and biotic environmental elements that act together to produce the diverse end products we use, enjoy and consume e.g. above ground biodiversity or the provision of playing fields. At the Macaulay Land Use Research Institute, soil and social scientists have been working together and have developed a common language, understanding and framework, which enables the integration of their disciplinary views. We have examined the relationship between soil functions, a central concept in soil science, and the concept of ecosystem services (Figure 4).

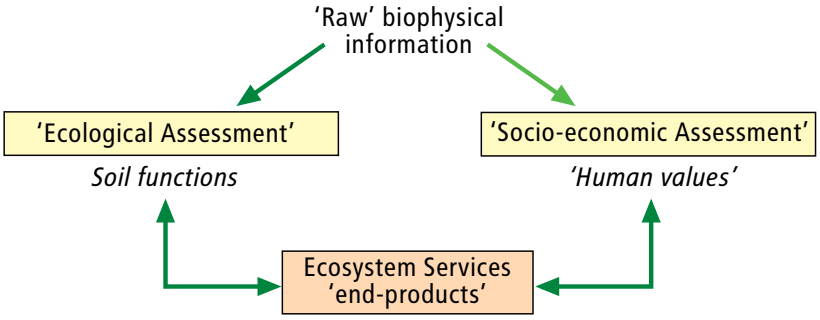

Figure 4 Framework for linking soil functions and human values to ecosystem services

Another direct link between soils and end products consumed by society is the release and storage of greenhouse gases from soils. In this case the link to human wellbeing is straightforward, although the science behind it is not. For example, it is uncertain if some practices to sequester carbon in soil would have a positive net effect due to increased releases of other greenhouse gases (Glenk et al., 2009). Consequently we made soil carbon sequestration the subject of a Scotland-wide survey among members of the public. In addition to assessing the amount respondents were willing to pay for a programme that reduces net emissions of greenhouse gases from Scotland, we accounted for the scientific uncertainty by allowing for the possibility that this programme may actually fail to deliver climate change mitigation benefits. While the influence of delivery uncertainty on preferences for mitigation is useful information for decision makers, it also implicitly places a value on the work of soil scientists who aim to reduce the uncertainty by improving their understanding of the biophysical relationships and soil processes related to mitigation practices.

Soils, carbon stocks and climate change

As the organic matter content of soils plays a crucial role in determining its intrinsic quality and ability to supply the ecosystem goods and services expected of it, knowledge of factors determining and regulating its occurrence become very significant.

Figure 5 The average depth of peat in Scotland is 2 metres

In a European, and indeed worldwide, context, the soils of Scotland contain above average levels of organic matter (Figure 5), and consequently carbon (C), making them significant in regulating climate change. The carbon stock is one which may potentially decrease, thus contributing to the nation's net carbon dioxide emissions, or may be encouraged to increase, thus contributing to the efforts to mitigate climate change. An added complexity is that the carbon

content of soil itself may be subject to the impacts of future climate change, with increased temperature accelerating organic matter decomposition and altered precipitation patterns promoting either reduced sequestration through drought or increased erosion through intense rainfall events.

Current efforts have focused on determining the C stock of soils in Scotland, particularly those in areas characterised by soils with an upper organic layer, the organo-mineral and peatland soils (Chapman et al., 2009). Using archived data on peat depths across Scotland and information from the Scottish soils information database, we have determined the peatland C stock to be 1,620 meta tonnes (Mt), which represents 53% of the Scottish total carbon store. We were able to use information collected during the NSIS-2 on peat bulk densities to improve on the accuracy of this estimate. Independent data collected during the previous NSIS-1 at points across the country provided validation of this value.

Since this peatland carbon stock value represents more than 100 times Scotland's current annual carbon dioxide (CO_2) emissions from energy generation, its integrity and preservation are critical. Negative impacts such as drainage, soil disturbance and cultivation, over-grazing, afforestation of deep peats and atmospheric pollution could all threaten this resource. Actively growing peatlands have the potential to sequester nearly 3% of current C emissions from the energy production sector in Scotland. Similar arguments apply to the organo-mineral and mineral soils, primarily under grassland. Therefore, to move towards more positive soil C management we should avoid the cultivation of semi-natural and permanent grassland soils to avoid C loss and a land use change from arable to grassland or semi-natural land would be beneficial in terms of C sequestration.

Measuring carbon dynamics in plant-soil-microbial systems

Soil and atmospheric carbon pools are dynamic, with exchanges between them mediated by the biological activities of plants and soil microbial communities (Paterson et al., 2007). Microbial decomposition of soil organic matter results in CO_2 emissions from soil that are ten times greater than those from human use of fossil fuels, but for ecosystems in equilibrium this loss of carbon is balanced by inputs to soil from plants (Millard et al., 2007). It is now recognised that land use and climate change each have the potential to alter the balance of these very large fluxes of carbon into and out of soil, either feeding-back to, or mitigating current trajectories of, increasing atmospheric CO_2 concentration.

In our research we have developed a suite of novel stable-isotope approaches for quantitative tracking of carbon fluxes in plant-soil-microbial systems: (i) continuous isotopic labelling of plants; (ii) stable-isotope probing of microbial biomarkers (Paterson et al., 2008); and (iii) isotopic partitioning of carbon sources contributing to soil CO_2 efflux (Midwood et al., 2007; Millard et al., 2008). The key advance from previous methods is that carbon fluxes into, through and out of soil can now be quantified, rather than simply described qualitatively. Using these approaches in combination, we have been able to demonstrate the tight coupling that exists between the deposition of organic carbon compounds from plants and the decomposition of soil organic matter that is mediated by soil microbial communities. These methods are being applied in important Scottish ecosystems such as peat bogs but also internationally in forest systems in New Zealand and Canada (Figure 6). Future research will focus on identifying the drivers and biological processes governing the net carbon balance of soils and on further developing and refining the methods for use in field-based studies.

Figure 6 Field application in Scotland of new system for detecting isotopic differences in CO_2 emissions to estimate relative contributions of plant and soil organic matter to C fluxes

Soil Biodiversity

Soils harbour the greatest concentration of biodiversity on the planet: a gram of soil may contain hundreds of metres of fungal hyphae, and tens of thousands of bacterial species (Figure 7) and it is this biodiversity that underpins the ecological functions of soil (Osler et al., 2007). One of the greatest constraints in researching this biodiversity is the small-scale heterogeneity of the organisms' resources (space and nutrients). The identification of spatial patterns in soil is therefore crucial to monitoring and understanding soil biodiversity and the Macaulay Land Use Research

Figure 7 Fungal fruiting body above ground. A gram of soil may contain hundreds of metres of fungal hyphae

Institute is actively involved and internationally renowned within this field. Our work focuses on organism detection and identification, their multifaceted functions and how diversity and function are affected by the activities of people.

Using cutting-edge molecular technologies (Figure 8), research questions encompass a wide range of organisms and ecosystems, examining their roles in organic matter turnover and nutrient cycling (Singh et al., 2008; Macdonald et al., 2008a, 2008b). Natural, high priority ecosystems such as peatlands and native Scots pine woodlands are actively investigated to determine their sustainability and potential threats. The conservation of soil biodiversity within these systems, in particular of internationally threatened fungal species, is a major research theme (Koljalg et al., 2005). The roles of soil biodiversity in the restoration of degraded soil systems, in particular peatland systems, are also central to our activities (Artz et al., 2007, 2009). The group is also active in research into the importance of soil biodiversity in maintaining the health of agricultural soils and in the role of soil microbes in climate change and future mitigation strategies. Research also focuses on method development (Ritz et al., 2009; Saari et al., 2007; Van der Linde 2008), with a view to anticipating future demands from end-users and policy makers.

Capturing the complexity of soil composition

Soils are often rightly described as complex systems due to their compositional complexity and high spatial variability at micro-environment, field, and landscape levels. Soils and the databases that encompass most of our knowledge are largely based on simple compositional descriptors such as pH and C which on their own offer limited insight into how different soils respond to management and environmental change. We aim to create a new paradigm by describing soil attributes with higher resolution methods that describe the physico-chemical and biological complexity in order to better predict how soils may respond to future change (Lumsden & Fraser, 2005).

Several methods that produce multivariate profiles of the : (i) mineralogical composition (quantitative X-ray diffraction, (XRD) Figure 9); (ii) organo-mineralogical composition (Fourier Transform Infra Red spectroscopy) and soil biomarkers (alkanes and alcohols) profiled by gas chromatography, (iii) mass spectrometry and DNA fingerprinting are being used to obtain more detailed descriptors of the soils of Scotland.

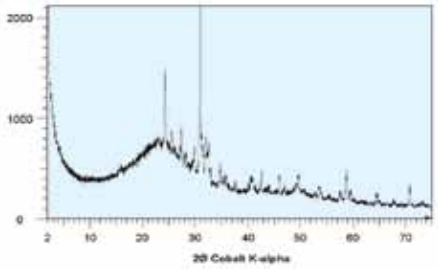

Figure 9 X-ray diffraction pattern of soil showing peaks that are used to identify different mineral components

1. *Rhizoscyphus ericae contiq* (2 isolates)	CAACGCCAACGGCCAACGAAGAGGCACCCTGAAYGATAT-CGACTACGTCGCG
2. *Meliniomyces variabilis contiq* (4 isolates)	CGCTCAGGATATTCAACGATGAGCTTATCTGGCCAACTGATTACAATGTTGTTC
3. *Phialocephala fortinii contig* (2 isolates)	CAACGGTAACGGTCAATACAGAGGCTACATCAATGGCAT-CGACTACGTTCCCC
4. *Lachnum spartinae* lac1	CGTTGCTGACGATCCAAAGCATTCCTCTCACCGTCAAGTTCAAC-ACG-AGCGA
5. *Myroconium species* lac1	CTCTCATGATCGCAAACGGAGAAAGTCCTTTTCCCACAGACTACAACGTGGTTC
6. *Sclerotinia sclerotiorum* lcc2	CACTCCAAGTATTCCGAAACGAATCCCTCTTCCCAACAGACTACAACGTCGTTC
7. *Sclerotinia minor* lcc2	CGCTCCAAGTATTCCGCAACGAATCAATCTTCCCAACAGACTACAACGTCGTTC
8. Botryotinia fuckeliana lcc2	CTCTCAAGATTTTCAACAACGAGACAATCTTCCCAACTGATTACAACGTTGTCG

Figure 8 Novel DNA sequences of the laccase genes of fungal species that colonise ericaceous shrubs (1–3) compared with the laccase (lac1 or lcc2) sequences of related plant pathogenic and other fungi (4–7) can aid the identification of unique (highlighted) coding regions useful for microarray probe design for specific species.

These approaches can be related to functional properties such as long term nutrient supply capacity (Andrist-Rangel et al., 2007) and soils capacity to bind and release pollutants (Lumsdon & Fraser, 2005) and nutrients (Shand et al., 2008).

These methods are being applied to soils from our National Soils Archive and a new soil DNA archive created during the re-sampling of the Nationals Soils Inventory (Figure 10).

Figure 10 Minus 80°C freezer being used to store soil DNA samples from NSIS–2

The soils database at the Macaulay Land Use Research Institute is being re-configured to accept these multi-variate datasets and explore the utility, discriminating ability and relationships to soil functions.

Even though some of these methods provide more information than conventional methods they are also capable of higher throughput and may therefore be very suitable for soil monitoring and field site characterisation where large numbers of samples are needed.

These methods have also been applied to environmental and criminal forensic investigations to solve issues such as the provenance of archaeological artefacts, crime scene evidence and source apportionment in environmental pollution incidents.

Dirt, Death, DNA and Detection

A trace of dirt on your shoe could link you to a footprint at a scene of crime, or a patch of muck on a spade could guide police investigators to a clandestine grave… These are just some examples of where our understanding of soil, provided by robust scientific research, has now led to the development and direct application of soil forensics in real life crime. Guiding police intelligence and providing evidence are the two main areas of the criminal justice system where soil forensics can play a key role.

Research at the Macaulay Land Use Research Institute has focused on understanding how we can use the multiple signatures of soil to help either find a likely location for an 'unknown' soil sample or associate or dis-associate soil on an object or person with a particular scene. From a search perspective we have developed prototype software-based comparison and geographic information system (GIS) tools, capable of comparing a forensic soil sample to a soil property database, providing map outputs which geospatially provenance such samples. From an evidential perspective, our understanding on variability in mineral, organic and soil DNA signatures and the impact of transfer and mixing on items such as footwear (Figure 11) and fabric has led to improved and more relevant methodological approaches (Macdonald et al., in press, Mayes et al., 2009).

We have also researched how the waxy surfaces of plants, which consist of complex mixtures of aliphatic compounds, are incorporated into the soil, leaving a complex organic signature. The mix of marker compounds persists in the soil for thousands of years. Soil DNA, (Figure 12 and Figure 13) as characterised by DNA fingerprinting, also provides a signature reflecting the vegetative and soil habitat suitable for soil organisms to survive. Research demonstrates that such novel biochemical and molecular analysis (organic) complement the mineralogical (inorganic) information.

Figure 11 Soil forensic sampling of footwear sample

Figure 12 DNA extracted from soil, cleaned and stained with a dye, fluoresces under UV light

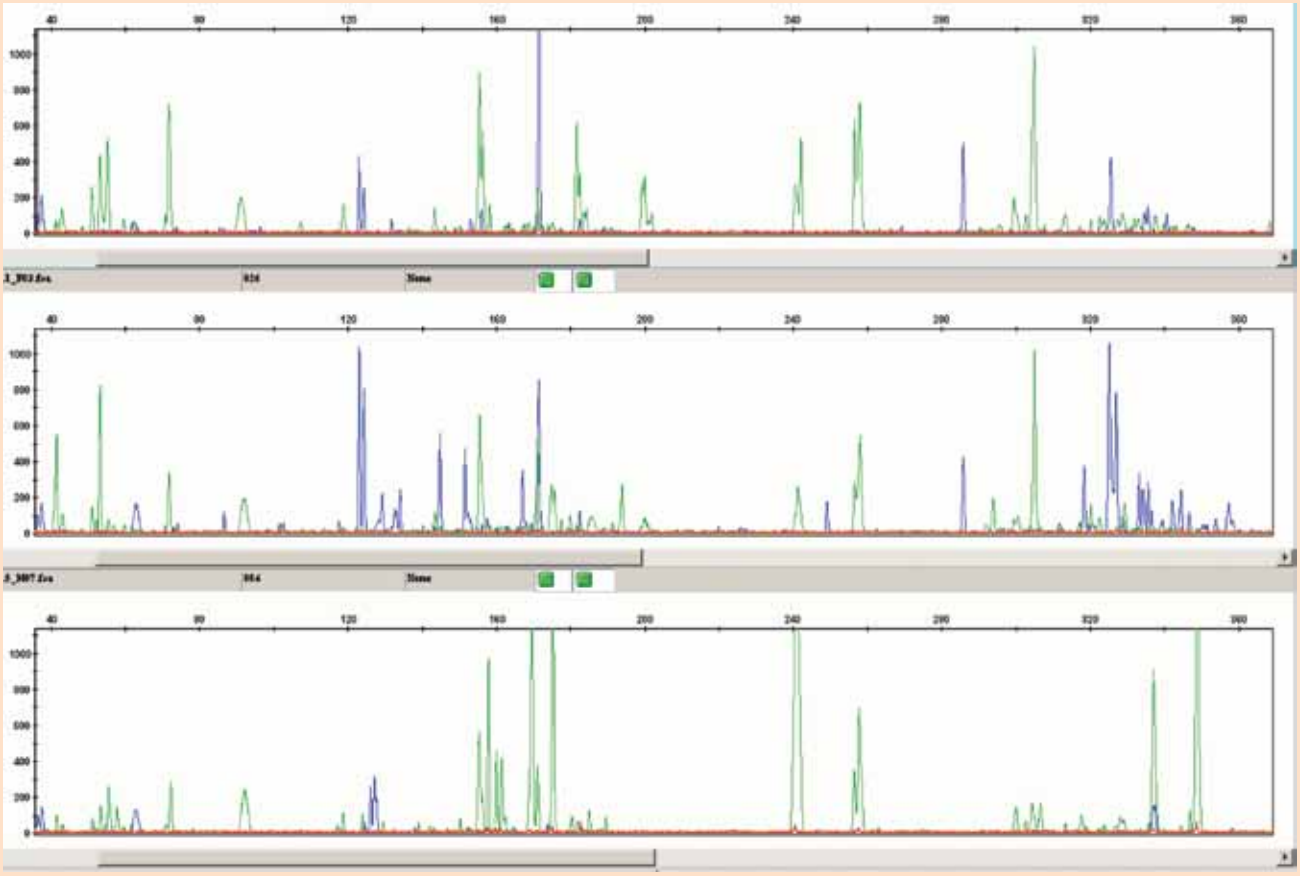

Figure 13 DNA fingerprints of three soils showing differences in fungal (blue) and bacterial (green) profiles measured using multiplex TRFLP (Singh et al., 2006)

Future directions and challenges

As the wider value of soils is recognised we are finding our expertise is increasingly useful in new areas such as human health and criminal and environmental soil forensics. While Scotland has generally fertile soils capable of producing high yields of excellent quality produce, there are many soils that are deficient in one or more micronutrient and this requires that we understand fully the implications of this for food quality and security. We have started new work on measuring and mapping soils in terms of trace elements status and linking this with other soil property data to datasets on human and animal health. As the inherent potential of soils to provide nutrients is dependent on our base geology we are developing ways to use our knowledge of the mineralogy of soils to predict micronutrient status.

However, convincing evidence for associations, both beneficial and non-beneficial, between soil and human health is scarce. In many instances, modelling approaches have been used to estimate exposures to soil contaminants and this often informs policy directives and other legislation. In the future, we aim to investigate suspected links between soil and human health further via collaborations with the medical and occupational health scientists. Our soils data provide a unique resource that can be used to map the distribution of disease incidence in relation to the distribution of soil factors. The methods we have developed for exploring soil biodiversity are also suitable for detecting bacterial pathogens of humans and we are also now testing their utility to detect several important human pathogens, and using our DNA archive of the soils of Scotland to examine the spatial patterns and associations of pathogens (e.g. enteric pathogens capable of surviving in the soil environment) with soil and land use.

The extensive data on soils held at the Macaulay Land Use Research Institute has value in epidemiological studies and there are unique opportunities for development in this area in relation to beneficial and detrimental effects of soil in the environment. We are currently exploring links between the occurrence of childhood asthma and local soil properties with colleagues at the University of Aberdeen Medical School.

In all our efforts to understand soil and its many important roles, participation from land managers, policy makers, and the public is centrally important. Such interactions help development of proactive management strategies and tools that enhance the natural, cultural and socio-economic value of soils. We have formed new partnerships with stakeholders in consultative groups so that we can co-construct the research required for the future.

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Managing Water Resources

Bob Ferrier

Our focus on Managing Water Resources is unique in the UK because it includes socio-economic research as well as the biophysical science of catchments. We address problems such as the way society uses water resources and the cost of changing current practices. Understanding the catchment means understanding the processes within and between ecosystems (upland, lowland and coastal).

The aims of our research are to:

- Improve understanding of the effects of land use and climate change on water quality and quantity, and ecological functioning
- Inform policy and provide evidence-based guidance for management and enhancement of water resources

Contributing Authors:
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Context and Rationale

Water catchments are the critical spatial unit at which to understand the link between processes within and between ecosystems (uplands, lowlands and coastal) and their inherent soil and biodiversity elements. Central to this linkage is the hydrological cycle, which connects the atmosphere, biosphere, and geosphere. Combined, these influence water quality, availability and quantity, and provide a feedback mechanism to regulate many ecosystem services.

The underpinning biogeochemical reactions, as well as the fate of nutrients, pollutants, and microbial contaminants, are strongly influenced by land management, human intervention and increasingly by climate change. These changes in turn have an impact on both the quality and ecology of surface, ground, and coastal waters.

There is an increasing raft of legislation directed at catchments and water policy (e.g. Water Framework, Bathing Waters, Habitats Directives and revaluation of the Nitrates Directive etc.) with further recent legislation such as the Climate Change Bill and the Marine Bill which have direct relevance to the water environment.

The Macaulay Land Use Research Institute's Catchment Management Programme provides knowledge, evidence, and advice for the improvement and maintenance of environmental quality in support of implementation of the Water Framework Directive (WFD) and other waters-based legislation in Scotland. It is also complementary to land-based initiatives such as the Scottish Rural Development Plan (SRDP), as every land use decision is also a waters decision.

Our research involves the development of innovative approaches to measuring, monitoring, manipulating and modelling biophysical and socio-economic processes arising from land and water management. The research contributes directly to the development of tools, to provide syntheses and information to assist decision-makers. This strengthens the evidence base on which sound policy and practical solutions for land and water management can be developed in global, national, regional and local contexts.

The programme is based on interdisciplinary interactions between scientists from different backgrounds to gain an understanding of physical, chemical, ecological and socio-economic systems. The strategic liaisons with socio-economic research in particular address the human dimensions of water quality and water resource use, building capacity and providing tangible solutions to applied problems.

Participation of regulators, end-users and other stakeholders is an important component of our development of principles for water resource management as part of wider sustainable development strategies.

Scientific Activities

UNDERSTANDING PROCESSES

Biogeochemistry

Analysis of long term data collected at multiple sites has allowed us to investigate the complex spatio-temporal responses of Dissolved Organic Carbon (DOC) to environmental change in different catchments. Annual mean DOC concentrations show both rising and decreasing trends (Figure 1). The most significant increases of 8% per year ($p<0.01$) occurred in a podzolic soil at Glensaugh (Angus), whereas a similar soil at Sourhope (Borders) had declining subsoil DOC 2% per year ($p<0.05$), (Stutter et al., 2009).

Our knowledge linking soil processes and catchment water flow paths to the nature of stream DOC is strengthened by our understanding of DOC compositions. End-member mixing analysis from Glensaugh has highlighted that subsoil flow paths contribute ~70% of stream flow. Subsoils may be highly influential on DOC quantity and quality entering streams, (Figure 2) and this may be especially important for stream ecosystems during critical summer periods of baseflow with consequences for water treatment for human consumption (Stutter et al., in press).

Transport processes

In order to predict how catchments will respond to future changes in land use and climate there is a need for a fundamental understanding of key physical processes that describe how water and pollutants are transported from the land to surface- and groundwater bodies, at relevant spatial and temporal scales. We have focussed on how natural hydrochemical and isotopic tracers in water can be used in conjunction with hydrometric data to help to understand flow pathways, mixing processes, and residence times of water in soils.

Dating of groundwater samples from the Lunan catchment, a lowland agricultural catchment, using disolved atmospheric trace gases (SF6 and CFC)

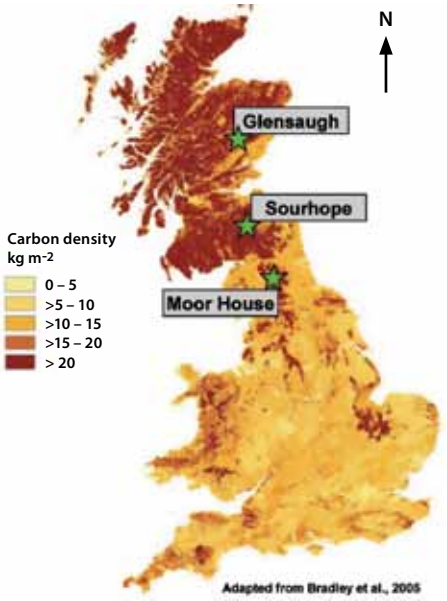

Figure 2 Locations of the three Environmental Change Network (ECN) study sites overlaid onto a base map of carbon density in UK surface soils

(Figure 3) suggests that groundwater in this catchment is a mix of ages but that some may be from 20–30years old (Dunn, 2009).

This has implications for short-term mitigation of N pollution through altered land management practices. In addition, the contribution of ground-

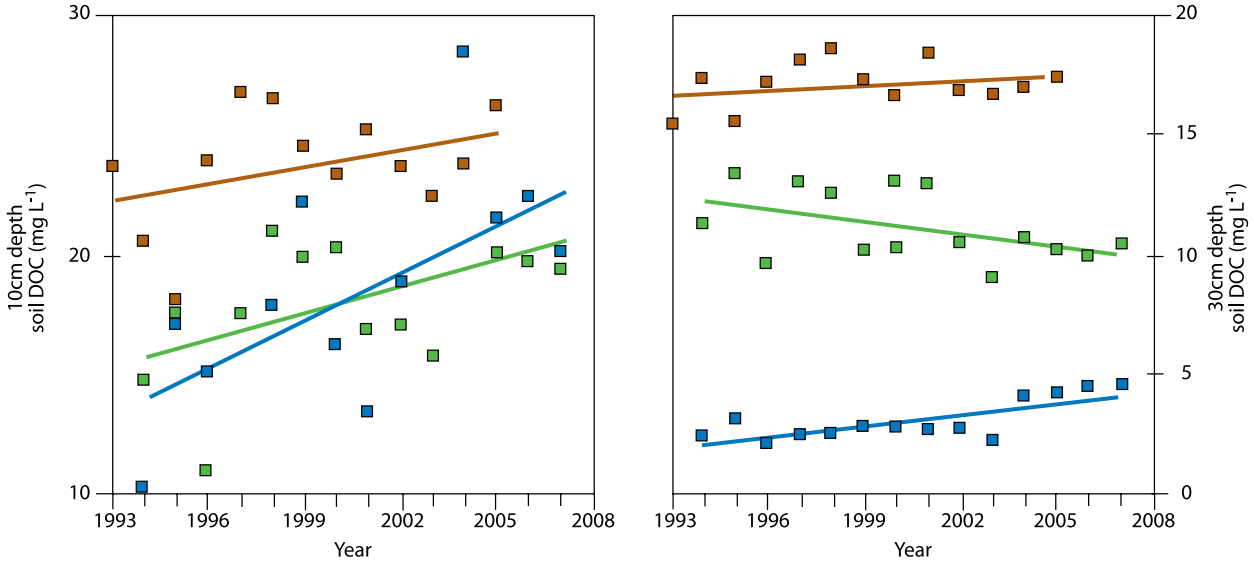

Figure 1 Annual mean DOC concentrations in soil solutions at selected UK Environmental Change Network sites: Glensaugh, Angus (Blue squares); Sourhope, Borders (Green); Moorhouse, N England (Brown)

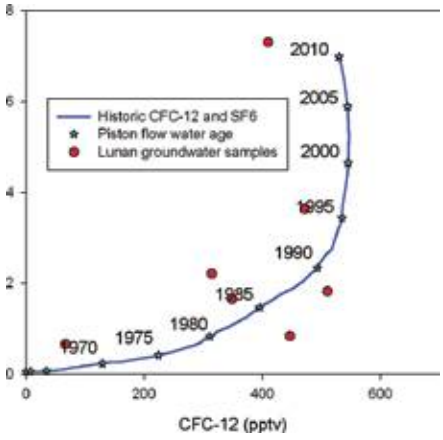

Figure 3 SF6 and CFC tracers in groundwaters

water to the river is also likely to affect the catchment scale response to changes in land management and climate change.

Ecological processes

In order to specify environmentally appropriate thresholds for ecosystem protection it is important to identify what are the most relevant ecological indicators for pollutants. Additionally, we need to identify which pollutants are most important in relation to ecological response. In order to address these issues, we have undertaken a number of studies on: i) the relationship of molecular community structure of biofilm composition to changing pesticide and trophic status, and ii) the relationships of macrophytes to nutrients, and invertebrate responses to changing water quality. In both cases our results showed that other factors (e.g. alkalinity, CO_2, geomorphology, site connectivity and site factors (flow, temperature)) dominate responses independent of trophic status (Vinten et al., 2007; Demars & Edwards, 2009; Demars & Tremolieres, 2009).

As an integrated part of our research we have developed skills and improved the methodology for undertaking Whole Stream Metabolism (WSM) measurements (whole ecosystem respiration and photosynthesis). In a recent manipulation experiment, treated waste water was redirected to a stream. The results showed that the treated effluent promoted heterotrophy (respiration increased by 50%), but not autotrophy (no change in gross primary production). Our results indicate that WSM can be used as a direct measure of ecosystem function (Demars and Friberg, 2008).

In a changing world it is critical to establish the effect of warming on stream ecosystem metabolism, particularly in relation to carbon balance. Stream metabolism assessment provides stream ecosystem respiration rate (ER) and gross primary productivity (GPP), from which the net ecosystem production (NEP) can be calculated (NEP=GPP-ER).

Thirteen groundwater fed streams located in Icelands' Hengill geothermal region were selected to evaluate the effect of temperature on carbon dynamics. Although the individual streams have similar hydrochemistry, they have a summer temperature range of 5–25°C. The analysis highlighted that NEP was negatively related to temperature (Figure 4). The implication of this is that as stream temperature increases due to climate changes, the CO_2 flux from rivers to the atmosphere will increase, creating a positive feedback loop that remains to be quantified.

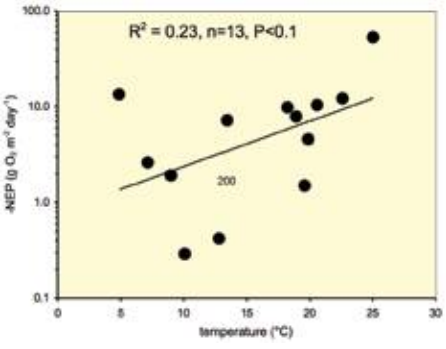

Figure 4 Response of the net ecosystem production to temperature

The impact of physical alteration of water courses can have major impacts on freshwater ecology. In order to address the consequences of these it is important to know: i) what key habitats within riverine systems are being used and exploited by different ecological elements and ii) whether future restoration gives rise to improved ecological function in terms of both process and habitat availability. To answer these questions, repeat surveys of the use of different in-stream habitats and their spatial connectedness has been conducted and analysed for returning Atlantic salmon (Figure 5).

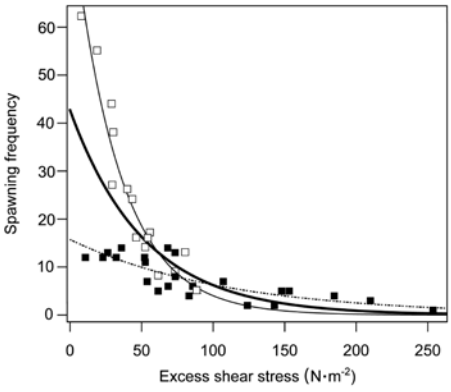

Figure 5 Regressions between spawning frequency and excess shear stress.
Open squares – downstream river section (R2 = 0.90, P < 0.001, n = 15); closed squares – upstream river section (R2 = 0.71, P < 0.001, n = 23); heavy black curve – overall regression for entire data set (R2 = 0.67, P < 0.001, n = 38); dashed curve for upstream section, thin black curve for downstream section. (Moir, H.J. et al. in press).

The results indicate that highly utilised sites are those with a low energy regime and there is a composite effect of distance from suitable holding habitat such as a large pool or distance from the main stem (Moir et al., in press).

PROTECTING WATER THROUGH MANAGING LAND

The Lunan Water in Angus, along with the Cessnock Water in Ayrshire, are the focus of a partnership approach between the Macaulay Land Use Research Institute, SEPA and SAC known as the Monitored Priority Catchments project. The project is working to demonstrate sustainable, cost-effective approaches to managing water that could be replicated in catchments facing similar issues.

Of primary importance is defining where and how nutrients are transported from land to water. Figure 6 shows desk estimates of sources for Phosphorus (P) values which will be established through the monitoring. The work indicates that it is not just agricultural sediment losses that are causing a problem. Phosphorus in septic tank and sewage treatment work effluent are also extremely important. Effluent from these sources is highly bioavailable and therefore could be a greater relative source of pollution. Work to date has shown that addressing such reactive sources is probably of equal importance to dealing with sources from agriculture. Preventing septic tank discharge into streams can make the difference in rural streams between meeting Good Ecological Status (GES), Figure 7 (green, post 2003) and failure red, pre 2004). Public awareness programmes educating rural residents about the impacts of septic systems are being well received. A short presentation on the Lunan MPC can be found at macaulay.ac.uk/water/presentation290409.pdf

NATIONAL RESOURCE ASSESSMENT

There are over 8,000 lochs in Scotland with an area greater than 1ha. Of these, less than 400 are monitored on a routine basis. Excessive nutrient inputs to surface waters can result in eutrophication, a process resulting in increased plant growth and impaired water quality. Phosphorus is the nutrient that is most likely to be limiting to plant growth in standing waters. Depending on their trophic status, or the amount of nutrients they contain, lochs can be classified as oligotrophic – when they have low nutrient levels, mesotrophic – when they have moderate levels or eutrophic – when they have high levels of nutrients. While there will be some amount of nutrients naturally entering a loch, human activity can increase the inputs of nutrients and migrate a loch towards an eutrophic or enriched state.

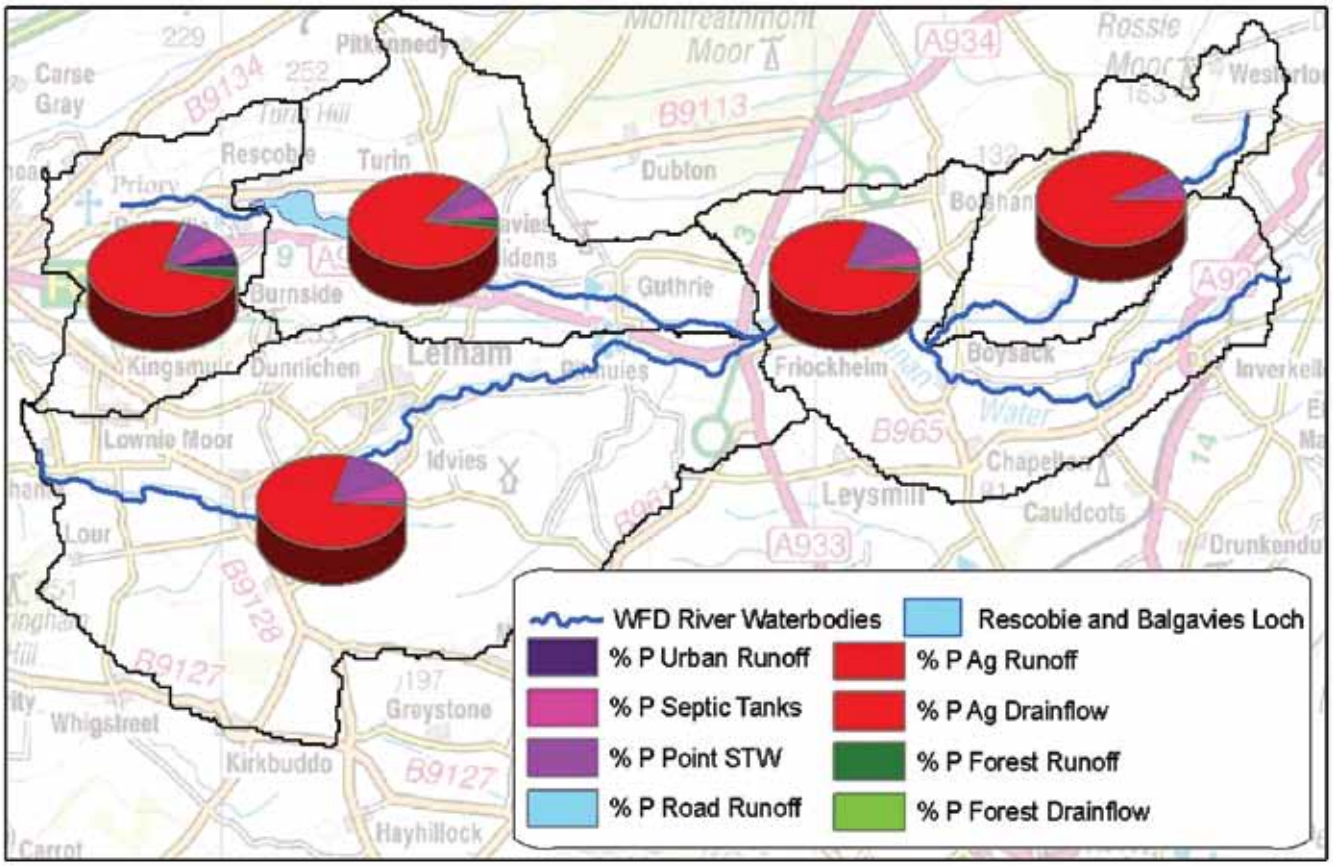

Figure 6 Modelled P source apportionment in the Lunan catchment (SEPA)

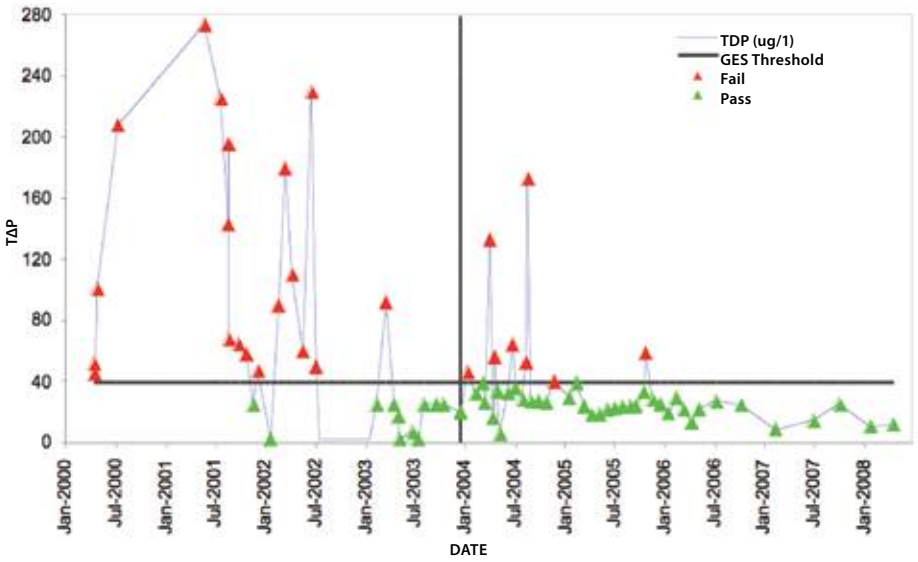

Figure 7 Phosphorus monitoring data relating to cessation of septic tank discharges to streams (SEPA)

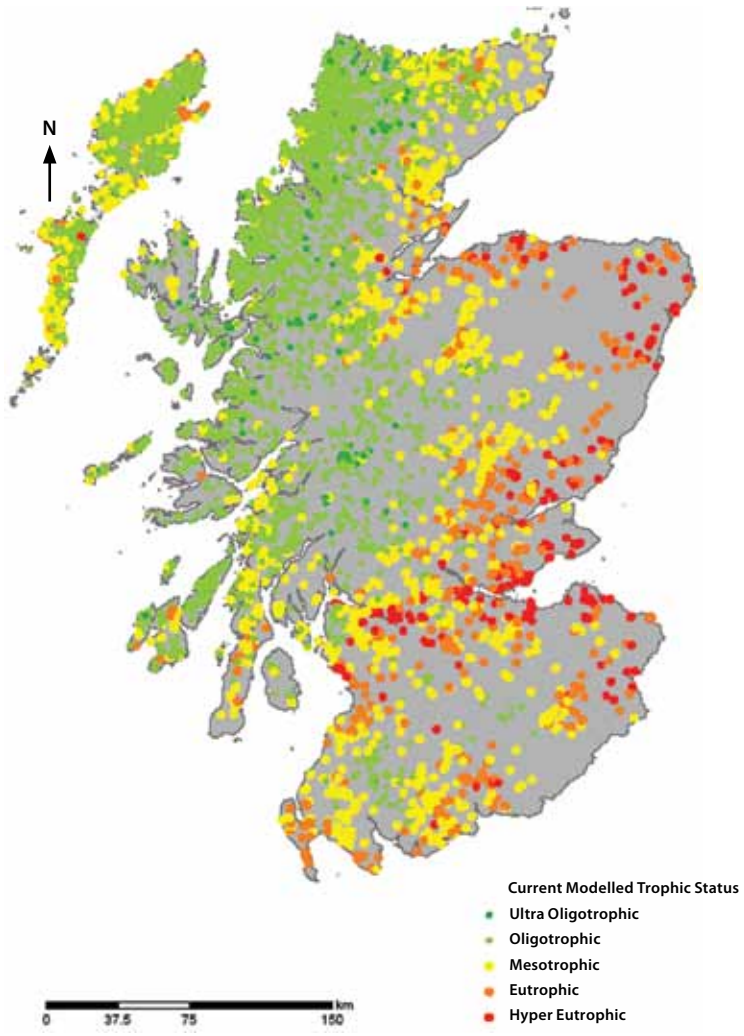

Figure 8 Modelled trophic status of standing waters in Scotland

Figure 8 shows the modelled trophic status for each of the more than 8,000 Scottish lochs based on modelled phosphorus concentrations. Concentrations were estimated using the OECD/PLUS system which simulates phosphorus concentrations as a function of land cover, human wastewater inputs and in-lake attenuation. It is clear from the map of modelled trophic status that there are strong regional patterns in loch water quality. Almost all lochs in the northwest part of the country and the Highlands are classified as oligotrohic. Many lochs in the Central Belt are classified as eutrophic as a result of high human inputs. Many lochs in the northeast of the country are also classified as eutrophic as a result of pressures from agriculture and large human populations (Futter et al., 2008 and 2009).

UNDERSTANDING COSTS AND VALUES

Water has a number of competing uses from which individuals and society derive value.

Society's allocation of water use between different uses can be informed by understanding these values explicitly or implicitly.

Efficient standard setting for water quality can be established in the light of understanding about relative values. Value can be judged using private and social cost data to inform when a standard is (dis)proportionate in terms of implicit costs and benefits. Standard-setting derogations ideally aim to reach socially optimal decisions through a combination of explicit cost and benefit curves, financial affordability tests, and integrated value mapping (which considers neo-classical welfare

economics, environmental ethics and social psychology). Work on P mitigation (often the water quality factor limiting achievement of Good Ecological Status) shows that there is scope to increase nutrient use efficiency, but that the social value of this mitigation may be low except in marginally eutrophic loch catchments (Vinten et al., 2008). The health benefit:mitigation cost ratio (based on willingness-to-pay) of preventing bathing water contamination from livestock has also been found to be low (Johnson et al., 2008). However, since single use estimates of value may be unreliable, choice experiment and benefit transfer methods for assessing multi-use valuation of loch and river water bodies are now underway. Moreover, focus group discussions with members of the general public have strongly indicated that procedural aspects were seen as essential to achieving good water management (Lago and Glenk, 2009).

MAKING PLANNING EFFECTIVE

Determination of ecosystem resilience and recovery, and scenarios of future change in aquatic environments have been incorporated into an interdisciplinary approach to elucidate "catchment futures". In particular, we have used model output as a tool for dialogue to scope adaptation strategies with catchment based stakeholders to deliver cost-effective water quality improvements and we have investigated how local scale Best Management Practices (BMP) such as farm ponds and other on the ground measures can successfully attenuate pollution burdens. At a larger spatial scale, the WFD River Basin Management Plan (RBMP) process exemplifies the shift to multi-scale governance, providing not only opportunities for wider stakeholder and public engagement but also challenges regarding representation and legitimacy. As part of this, we have been working with Area Advisory Groups (AAG) and the National Advisory Group (NAG) to investigate issues that facilitate or hinder the active involvement of stakeholders.

Similarly our work on floods has identified stakeholder preferences for natural rather than engineered solutions to management and the potential for conflict between different farm based and catchment based approaches (Kenyon, 2007). A new European Union funded project – Aquarius: Farmers as Water Managers – will address the technical, social, economic and legal constraints to enabling farmers to mitigate diffuse pollution whilst managing high and low flows. The ability to manage land adaptively, in ways that protect water quality and water resources, will be particularly important under increasing climate variability.

Effective institutional and governance arrangements are key elements for successful mitigation of water quality pressures. Our research is developing an interdisciplinary approach to understanding the causes and consequences of diffuse pollution and other pressures on water bodies and the role of planning and stakeholder engagement in helping to mitigate this pollution. This research is aimed at responding to theoretical and methodological challenges for multi-level natural resource management (NRM), such as: i) how to stimulate social learning through evaluation; ii) how to link stakeholder involvement with the achievement of social, economic and environmental objectives and iii) how to understand better the interlinked governance networks at different spatial and temporal scales. The outcomes of the research focus on improving implementation of plans through developing more effective institutions.

Working collaboratively with four Area and National Advisory Groups, we are evaluating the River Basin Management Planning (RBMP) process in Scotland. Initial findings suggest that there are tensions between inclusion, integration, efficacy and efficiency, reflecting different policy logics within the WFD, whereby adaptive management has been combined with prescriptive timelines and technical standards. These tensions include public versus private interests (inclusion); difficulties in combining regulatory, market and voluntary mechanisms (integration); and multiple definitions of success (efficacy) – achieving GES by 2015 is not stakeholders top priority – whilst working with limited resources (efficiency). These tensions work differently at various scales. Because locally salient issues often 'disappear' at a national level, it may be harder to achieve inclusion and integration by strategic planning, although it appears a more efficient process (Figure 9) (Blackstock, 2009).

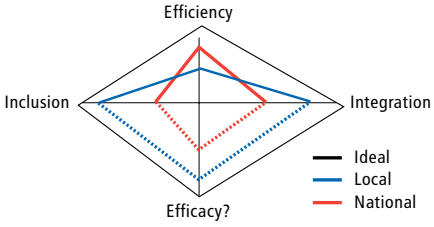

Figure 9 Tensions arising at different spatial scales within the RBMP process

This work has built on the completed analysis of inter-agency working for implementing the WFD (online guidelines available at macaulay.ac.uk/projects/203078_checklist.pdf).

Simultaneously, a framework for good practice has been developed based on an international literature review and analysis of eight UK Integrated Catchment Management (ICM) planning processes. This research illustrates how pre-existing issues and the wider context will influence how primary and supplementary principles for good practice processes are linked to outcomes, and the different judgements of what constitutes success (Marshall et al., in press).

INTERNATIONAL RELEVANCE

Our research extends well beyond Scotland, offering insights and knowledge into catchment management issues in other contexts in Southeast Asia, South America and Africa. For example, in many African countries the links between water resource management, the conservation of biological diversity, sustainable employment and working practices are poorly understood. The INTREPID project (funded through EU INCO-DEV programme) was specifically designed to address the interlinked challenges in the Mara basin, one of the most vulnerable and ecologically important river basins in sub-Saharan Africa (Urama and Davidson, 2008) (Figure 10). The land is a trans-boundary river basin hosting most of the endangered wildlife species and some of the poorest populations in the sub-region. The institutional, geo-political, socio-economic, biophysical and global drivers of sustainable natural resource management in Kenya and Tanzania also present different types of challenges to transboundary and international coordination in river basin management. INTREPID has helped develop policy initiatives amongst existing water resource management programmes to rational competing pressures (Urama et al., 2008). For further information see the INTREPID Policy Brief at macaulay.ac.uk/INTREPID/PolicyBrief.pdf (Figure 11).

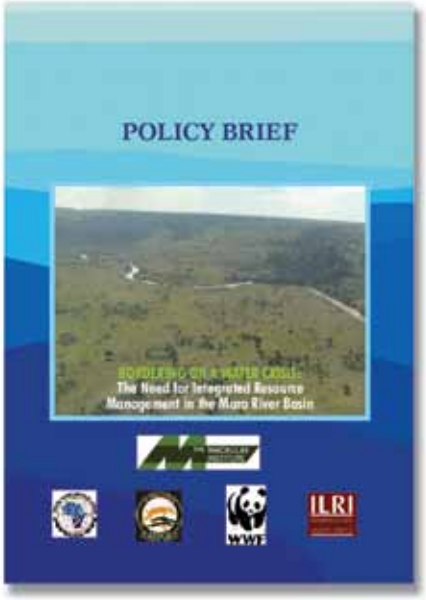

Figure 11 Bordering on a water crisis. Policy Brief for the Mara River Basin

Figure 10 Mara basin, one of the most vulnerable and ecologically important river basins in sub-Saharan Africa

In Brazil, future policy making in the Pantanal wetland has been enhanced in a collaborative project through Aberdeen Centre for Environmental Sustainability (ACES) funded by the Leverhulme Foundation. The project focuses on the prediction of the extent and nature of the seasonal flood wave which inundates the wetland. The dynamics of nutrient transport from rural and urban sources, and subsequent ecological stress is being identified through engagement with local landowners and stakeholders (aces.ac.uk/PantanalInternationalNetwork.htm).

Furthermore, staff from the Catchment Management and International Development Groups are taking the lead in shaping a new Scottish Government initiative called *Water Scotland*. *Water Scotland* is a network of more than thirty key organisations from across Scotland with expertise in the water sector. It will offer a gateway and one-stop shop to the wealth of experience and capability which Scotland has to offer in water for the international development banks and donor agencies. Further details on Water Scotland can be found at macaulay.ac.uk/aboutus/water_scotland.pdf

Future directions and challenges

Our work will continue to place emphasis on ecological functioning of catchments under pressure from anthropogenic emissions from diffuse pollution and engineering impacts on hydromorphology. We will concentrate on: the identification and functioning of catchment hot spots of pollutant generation; the potential pollutant attenuation and biodiversity reservoir roles of riparian areas, wetlands and other restoration options.

Key developments planned include:

- Improving our understanding of the role of different forms of phosphorus and suspended solids in impairing ecological function in relation to achieving Good Ecological Status (GES)
- Identifying functional indicators of GES in relation to diffuse pollution and hydromorphological pressures as multiple stressors
- Developing our capacity in microbial analysis to quantify risk to ground-waters and private water supplies from septic tanks and diffuse agricultural sources of organic pollution
- Using advanced probe technology for real time data monitoring, in collaboration with Biomathematics and Statistics Scotland (BioSS), to continue the development of advanced methods for the analysis of high resolution time series to determine the role of extreme event contributions to annual fluxes and the potential impact on ecology
- Evaluating potential conflicts between catchment management for power generation and the conservation of designated species.

Much of the work on practical measures is being delivered through the Monitored Priority Catchments Project. A rotation simulation model (LandsFACTS), will be applied in the Lunan catchment and the effects on diffuse pollution of changing land use capability resulting from climate change, as well as economic drivers, will be explored.

Integrated research will focus on whether Catchment Management Plans can be used as implementation measures, or work in parallel with RBMPs, and develop ways to minimise the disconnection between national and local scale activities. The adaptive nature of the plans will be assessed, both in light of concerns over climate change; and the need to respond to integration with other policies e.g. the forthcoming Floods Bill. The research evaluating RBMP is relevant to the forthcoming Bill, which proposes a three tier system of area flood risk management plans, local flood risk management plans and projects, which will all have to complement existing RBMP, and learn from their implementation.

We will continue to work closely with stakeholders to assess the biophysical and socio-economic opportunities and constraints for implementing General Binding Rules, and best management practices in catchments.

We totally depend on water as a central feature of our global heritage, so it is in the interest of all people with an interest in the water environment to work together to protect and preserve our waters and to ensure equity in all aspects of the water cycle and how we interact with it. The water cycle is the most important of all earth system processes supporting life on this planet. Its use by humans must acknowledge this fact. Our ever increasing demands place an enormous pressure on the freshwater environment and on water resources worldwide. With changing lifestyles, the rise in global population and the uncertainty of future climate change, we all need to look carefully at our attitude to water and the way it is used and managed.

From mountain top to sea and from hydrology to human behavior, understanding the bigger picture of how we manage our land and water together at a catchment scale is the route to successful and sustainable water management.

For further information on our approach to cathment management please view "Water Under Pressure", a short film available at macaulay.ac.uk/videos/wup

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Understanding Biodiversity

Pete Goddard

Our focus on Understanding Biodiversity requires a clear appreciation of how the major causes of environmental change impact our natural heritage, both now and in the future. Changes will be affected due to global environmental change or as a result of policy and economically-driven land-use change.

The aims of our research are to:

- **Improve understanding of biodiversity, especially the factors, processes, and drivers which influence interactions within and between populations, species, and ecosystems**
- **Investigate the extent to which biodiversity controls the function and resilience of ecosystems and the delivery of ecosystem services**

Contributing Authors:
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Context and Rationale

A range of ecological and related sciences provide the framework for understanding the biological limits to sustainable land use and the responses of natural systems to perturbations, including changes in land management and climate. Ecology is the science of interactions between living organisms and their biotic and abiotic environment and is key to our understanding of biodiversity, the types of living organisms in any system, their functioning and the services they provide.

We aim to:

- Understand the ecological processes that shape biodiversity and the functioning of natural and semi-natural habitats and landscapes
- Improve our understanding of interactions between ecological and human social processes
- Facilitate application of this understanding in sustainable land management, including conservation and enhancement of biodiversity
- Provide science-based predictions of the responses of key systems to alternative policies, policy driven land-management scenarios and other environmental changes

There are very few, if any, natural environments remaining in Scotland, or elsewhere in Europe, where anthropogenic influences have not profoundly shaped the communities now present (Figure 1). Such influences include the input of pollutants and the partitioning of land between the main rural uses of agriculture, forestry and recreation which affect biodiversity in the wider environment. The management of wild and domestic herbivores is also still one of the most important global and domestic drivers of vegetation and associated biodiversity change, as well as affecting the productivity of the herbivores themselves.

Many areas of land which have conservation protection are fragmented, and the importance of spatial and landscape ecological factors to the conservation of constituent species and their habitats varies with species characteristics, particularly their dispersal ability. These factors are particularly acute for environments which are strongly affected by global environ-mental change or as a result of policy and economically-driven land use change.

Our work is carried out in Scotland and internationally and we engage with a wide range of stakeholders to deliver focussed advice and support, for example in relation to land management decisions. Participation from land managers, policy makers and the public is centrally important in prioritising issues and assisting the development of proactive management strategies and tools that conserve and enhance the biodiversity and cultural and socio-economic value of our natural heritage. We present some examples of our work in a range of environments and at different scales; this provides a glimpse of how we are tackling major national and international challenges ranging from biodiversity conservation and management to carbon trade-offs as one increasingly important facet of ecosystem goods and services.

Figure 1 Commercial forestry activities

Scientific Activities

Biodiversity: carbon trade-offs in land use systems

Until recently, the impacts of agricultural change have been seen as a trade-off between productivity and biodiversity. Now there is growing recognition that agriculture and other land uses deliver a range of ecosystem goods and services and there is a need to balance production and conservation. The provision of ecosystem services may or may not be optimised alongside biodiversity. A study of biodiversity and ecosystem function in a crofting landscape is used to illustrate the potential trade-offs between biodiversity and carbon sequestration (Pakeman & Stockan, 2009).

Traditional hay-cropping is now a greatly restricted land use (Figure 2) only occurring in some areas. The fate of land previously used for hay includes silage making, conversion to pasture, abandonment and winter grazing. Biodiversity assessments of ground beetles, bees and vascular plants were made on these land use types during the summer of 2007 on the National Trust for Scotland's Balmacara Estate. On the same areas, three indicators of carbon dynamics were assessed; above-ground net primary production, litter decomposition rate (assessed as the rate of breakdown of standard litter) and litter quality (assessed as community-weighted leaf dry matter content which is inversely related to litter turnover) for hay and traditional meadows.

Almost all the potential transitions resulted in a drop in species richness, the largest losses being in vascular plant richness after abandonment and bee species richness after conversion to pasture or abandonment. Silage had a higher productivity than the meadows, and the pasture and abandoned sites had significantly poorer litter quality (higher leaf dry matter content) than the other land uses. There were no differences in the decomposition rate between sites which indicates that changing management from meadows to silage, pasture or abandonment may increase the amount of carbon entering the system.

However, there appears to be no win-win situation that maximises carbon sequestration and maximises biodiversity. All transitions resulted in a decrease in species richness in at least two of the groups, but the indicators of carbon dynamics suggest that three of the four transitions would be beneficial. Developing land use management for the benefit of biodiversity will become more complicated as other ecosystem goods and services are taken into account and the resulting trade-offs identified and made.

Drivers of biodiversity change, conservation and restoration

One of Scotland's foremost assets is the biodiversity of its natural and semi-natural systems. Changes in land use such as those described above, pollution and climate threaten the sustainability of key Scottish habitats and species (Figure 3), (Pakeman et al., 2009). The internationally important uplands of Scotland are home to some unique, but fragile habitats. Management of biodiversity requires a robust, predictive understanding of

Figure 2 Traditional hay meadow

actual and potential impacts of the main drivers of change, to inform the development of management options to conserve and enhance our natural heritage. Protecting and managing biodiversity in a changing environment requires:

- Knowledge of past and present impacts of different drivers on a range of key habitats
- Understanding of how these drivers affect ecosystem dynamics
- Prediction of potential future impacts to inform management and mitigation measures
- Knowledge of the impacts of habitat fragmentation on genetic, as well as species diversity, and how this affects habitat/species resilience and responses to further environmental change

By using experimental and modelling approaches at a range of spatial and temporal scales – from small experimental plots (Figure 4) to analysis of UK and world wide biodiversity patterns, and from single seasons through to 50-year changes – we aim to provide information to underpin conservation policy responses to natural and human-induced changes in our environment (Beale et al., 2009; Britton et al., 2009). Current research focuses particularly on woodlands, moorlands and montane habitats, examining how different drivers and their interactions affect habitat biodiversity and ecosystem function. For example, the drive to re-establish areas of native woodland across Scotland, which has fuelled the debate about the 'best' balance between moorland and woodland habitats as both are designated in the European Habitats Directive. Tree colonisation causes changes in vegetation and wildlife, but also changes in soil

Figure 3 Scottish primrose (*Primula scotica*) a Scottish endemic plant

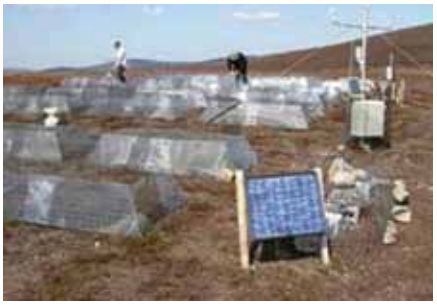


Figure 4 Experimental plots

chemistry, soil physical properties and below-ground biodiversity, although many of these changes have been poorly understood (Dawson et al., 2009; Mitchell et al., 2010).

We are also quantifying how key Scottish habitats have responded to human impacts in the recent past, informing our understanding and predictions of future change. Some upland habitats have undergone major changes in a relatively short time period, with important implications for species and habitat conservation. Pollution at current rates is causing nitrogen accumulation in plants and soils, which contributes to biodiversity loss, with lichens and mosses particularly affected (Britton et al., 2009; Britton & Fisher, 2010). Saturation of upland areas will result in harmful amounts of excess nitrogen leaking into our rivers, thereby reducing water quality for both wildlife and people. Through experimental work in mountain heath regions we also predict that a warming climate will lead to a further loss of important mountain lichen species and reduce the uniqueness of many different habitats.

Looking ahead, our understanding of the relative sensitivity of different Scottish ecosystems to predicted future environmental changes is crucial in relation to planning decisions. We continue to deliver advice and protocols for conservation and restoration of a range of different habitats and species, based on the results of our experimental, monitoring and modelling research in the context of environmental change.

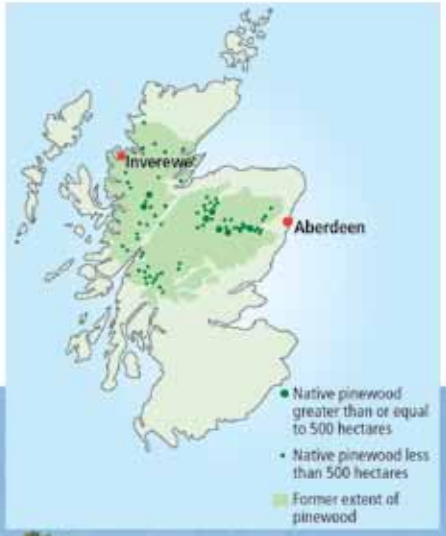
The biodiversity of Scots pinewoods

Naturally-occurring chemicals also have the potential to influence biodiversity. Native Caledonian pinewoods cover less than 1% of their former range in Scotland and are listed for protection under the EU Habitats Directive. The remaining woodland fragments present a major conservation issue. Like other coniferous trees, Scots pine (*Pinus sylvestris*) contains terpenoid secondary metabolites. Metabolite concentrations are strongly heritable, and known to be biologically active against many herbivores, pathogens and other organisms. Their concentration varies widely between individual trees within a population but how does this variation influence the biodiversity of associated species? The extent to which monoterpenes mediate interactions with their species and pinewood assemblages, including invertebrates and ground flora, has been investigated using experimental and inductive approaches (Iason, 2009). We have found evidence for avoidance of pine monoterpenes by species as diverse as slugs (which are important seedling herbivores) and Capercaillie (which

Our Caledonian Pinewoods

Scots pine *(Pinus sylvestris)* is Scotland's national tree

- Only 84 fragments of native pinewood left – some with only 30 trees
- Remnants cover less than 1% of former Caledonian forest
- Caledonian forest is protected under EU and UK legislation



Biodiversity of Scots pine

Scots pine is a 'foundation species' – it supports many other plants and animals

Red squirrel *(Sciurus vulgaris)* Formerly widespread – The UK's only native squirrel. Their decline is associated with the spread of North American grey squirrels. Scotland is now their main stronghold in mainland Britain. They are strongly associated with coniferous woods including Scots pine. They are adapted to feeding on pine cones. [photograph Stephen Willis]

Capercaillie *(Tetrao urogallus)* Iconic pinewood grouse. Declined in numbers to about 2000 in UK. Survival of chicks is very sensitive to weather in June. Closely associated with pine woods. Adults eat pine needles. [photograph Bozena Kalejta-Summers]

Pine hoverfly *(Blera fallax)* in Britain and declining pinewood specialist – found. Requires decaying rot-holes in pine stumps for egg laying. [photograph Ellen Rotheray]

Scottish wood ant *(Formica aquilonia)* Nationally scarce in Britain – found only in Scotland and one population in Northern Ireland. Favours native woodlands especially Scots pine and birch. Feeds in tree canopy mainly on aphids. [photograph Joan Beaton]

Creeping ladies tresses *(Goodyera repens)* The only British orchid with evergreen leaves. Found almost exclusively in Scots pine woods. UK distribution almost solely in Scotland – nationally scarce. Derives nutrients (Nitrogen and Phosphorus) from fungi associated with its roots. [photograph Jane Squirrell]

Twinflower *(Linnaea borealis)* Grows mainly in Scots pine woods. Considered nationally 'scarce'. Forms dense mats – often reproduces via stolons. [photograph Alison Hester]

Our research supports conservation of Scots pine and its associated species

Figure 5 Explaining the biodiversity of Scots pine

are rare and which browse extensively on pine needles). At the level of the whole pine ecological community, the species richness of soil mites, crown invertebrates and ground flora are all influenced by the monoterpene composition of the individual Scots pine. As a foundation species (Figure 5) and in the UK an iconic conservation issue, the chemical variation among Scots pine determines many of the pine's ecological interactions and associated biodiversity, and is a major influence on its extended phenotype. Conservation of the genetically-based phytochemical diversity of Scots pines would probably lead to greater community biodiversity. Because chemically and ecologically similar coniferous forests comprise the Boreal forest biome which covers approximately 11% of the land surface of the earth, the consequences of this research may be very far reaching.

According to genetic studies, Scots pine populations differ relatively little. However, few studies have considered variation in characteristics that determine whether the trees are adapted to their local environment. The nature and extent of variation between 21 populations of Scots pine in their growth and bud-burst characteristics as well as in the chemical profiles of the ecologically important monoterpenes are currently being compared. This work is in progress and is using the natural climatic variation between the west (warm and damp) and east (cold and dry) of Scotland at the National Trust for Scotland's Inverewe Gardens and at the site in Aberdeen, respectively (see map within Figure 5).

Learning about biological responses to anthropogenic environmental pollutants

Endocrine disrupting compounds (EDCs) are generated primarily, but not entirely, by human actions and manufacturing processes. They are present in a wide range of man-made compounds including detergents, plastics, tooth fillings, food can linings, electrical goods and soft furnishings but are also generated by the combustion of fossil fuels and by waste incinerators. They include multiple chemical classes but all have the capacity to interfere with the normal hormonal systems in animals of all groups, including both vertebrates and invertebrates. Accordingly, they have the capacity to disrupt normal physiological function, to compromise reproduction, reduce animal populations and reduce biodiversity and ecosystem sustainability.

Previously, environmental concentrations of these chemicals have not generally been considered to be a problem because environmental concentrations of individual chemicals are usually well below the concentrations known to cause physiological disruption. Initial observations showed that, relative to controls, sludge-exposed sheep exhibited minimal increases in tissue concentrations of EDCs, suggesting that physiological effects, following exposure, were highly unlikely. More recent results have shown that foetal tissue levels are generally, but not always, lower than in the ewe, with the pattern depending on the class of compound involved; since the foetus is considered to be the most sensitive stage of development, these observations suggested that physiological effects were even more unlikely (Rhind et al., 2009).

However, very recent observations by a number of collaborating groups have shown that the foetuses of sludge-exposed ewes exhibited: i) altered foetal testis structure, such that their sperm production as adults was likely to be compromised and ii) altered expression of multiple foetal ovarian genes of fundamental importance to normal function. Changes have also been reported in offspring behaviour and adult ewe bone structure (Rhind et al., 2010). Ongoing investigations suggest possible disruption of foetal and adult mammary structure and function and foetal thyroid and uterus structure. While these observations concern sheep, they have much wider implications for human health and ecosystem sustainability because they indicate that the combined actions of multiple environmental pollutants, each at very low (environmental) concentrations can severely perturb animal physiology, reproductive capacity and, potentially, the health and sustainability of populations.

Sustainable use of biodiversity – a national and international dimension

The sustainable use of biodiversity generates passionate views both in the scientific and conservation communities, and more widely across society. This is particularly so in Scotland, where a strong sporting heritage has led to large areas of the uplands being managed for shooting, stalking and fishing. Today, however, there is public perception that such management is at odds with conservation, animal welfare and recreational use of wilderness areas.

With such potential for controversy, it is essential that uses of wildlife resources are underpinned by a strong science base to help ensure that appropriate management decisions are taken (Perez-Espona et al., 2009; Gilbert, 2010; Harrison et al., 2010). The science base must also incorporate ecological relationships – such as the effects of parasites and predators on the population dynamics of harvested species. For example, mountain hare populations are under threat from habitat loss, climate change and over-exploitation (Newey et al., 2009). Our work on mountain hare population dynamics has shown that 50% of mountain hare populations are cyclic and show regular changes in density every 5–15 years, but the reasons for these fluctuations are unclear. Parasites and food supply can cause population cycles and we are working to provide a better understanding of the role of disease and nutrition (Townsend et al., 2009). We have shown that removing parasites in winter has no impact on survival or condition of mountain hares but improves female breeding success the following summer.

Natural and social scientists in the Macaulay Land Use Research Institute have an expanding portfolio of projects related to the sustainable use of wildlife as we recognise social dimensions of wildlife use and management (Irvine et al., 2009). Much of our work is based in Scotland and focuses on our most iconic species – red grouse, mountain hares, red deer (Figure 6) – and the role that their management systems play in delivering both biodiversity targets and rural sustainability. Our work on factors controlling the numbers of Scottish deer through long-term monitoring of body condition at larders, together with experimental studies of the effect of weather on grazing behaviour, has shown that the number of calves per hind decreases in rainy winters and that the number of calves per hind at the end of the winter is greater in the west of Scotland compared to east of the Great Glen. In many places in Scotland, reproduction rates of deer are found to decrease as numbers increase, indicating that many populations have exceeded the capacity of their available habitat.

Figure 6 Red deer stag

We also have some evidence that deer are moving to graze areas previously occupied by sheep. This may have impacts on vitally important habitats and we are investigating possible changes on biodiversity as a result of altered grazing impacts on heather. Increasingly, we are also working in the international arena – particularly in Africa and China – and our Scottish research is relevant to the global target of sustainable use.

Recent success with RCUK and European grants provides considerable added-value to Scottish Government funding. With global research agendas increasingly focusing on the Ecosystem Approach, our interdisciplinary research teams are well placed to make a major impact in this developing field.

Future directions and challenges

We have particular strengths and capacity in depth in areas such as understanding the functioning of species, habitats and ecosystems and the management of biodiversity change. The examples given here reflect research needs and aspirations outlined in a wide range of policy documents and large-scale research programmes such as Living With Environmental Change (LWEC). Our work will continue to provide an evidence-base for protection and enhancement of Scotland's natural heritage and underpin relevant strategic plans/policies that use biodiversity change as a monitor of progress. Our determination to engage with a wide range of stakeholders from inception (co-construction) of research activities to delivery of a wide range of end products is essential to ensure that we tackle contemporary issues in a socially-relevant way.

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Changing Landscapes

David Miller

Our focus on Changing Landscapes requires us to develop and apply innovative methodologies that integrate the social, economic and biophysical components of land use systems. We use concepts from the emerging field of socio-ecology, which synthesise ideas from political ecology, environmental ethics, ecological economics, and theoretical ecology, as well as research on common property institutions and indigenous knowledge and experience. Methodologies are based on a combination of modelling approaches and stakeholder involvement. A wide variety of modelling approaches are used including agent-based modelling, farming-systems modelling, biophysical modelling, and visualisation techniques.

The aims of our research are to:

- Understand how social, economic and biophysical processes interact to influence and drive landscape change
- Develop and test tools for evaluation of options for sustainable land management with particular relevance to policy-making

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Context and Rationale

The emerging area of sustainability science (Clark, 2007) synthesises ideas about the services, functions and capacities of multi-functional land uses, plus factors enabling resilience to undesirable change, economic, social and environmental interactions, and the ability of land systems to influence responses of socio-economic and environmental systems to change (Aspinall & Hill, 2007). Significant within this is the recognition that different elements of the landscape have their own dynamics, and are sensitive to different pressures and time periods over which change may take place (Aspinall, 2009). The work on landscape change develops and applies innovative methodologies that integrate the social, economic and biophysical components of land-use systems.

In Scotland, pressures for change include the need to meet future demands for housing, food and energy security, all linked to demographic change. These are all set in the context of the biophysical constraints and potential which are subject to change due to climate change. Our research outputs and outcomes are designed to contribute scientific understanding to public policy, and to inform the Scottish Government's strategic aims of sustainable economic growth in a greener, healthier, fairer, wealthier and smarter Scotland.

Our research aim is to understand how social, economic and biophysical processes interact to change urban and rural landscapes, and to provide insights into priorities for rural economic development, social justice and sustaining natural heritage. Methodologies developed to achieve this understanding are based on stakeholder involvement that identifies needs for evaluating sustainable land management relevant to policy-making.

The definition of landscape offered by the European Landscape Convention as 'an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors' (Council of Europe, 2003) is central to our research and its policy context. With this we also note that approaches to sustainability are best addressed through informed public participation. Our research in Changing Landscapes aims to make stakeholder engagement a central part of understanding landscape change and to the contribution of advice on adaptive responses to policy. It also underpins with our role as a Scottish centre for assessing scenarios of climate change with respect to the landscape and rural communities.

The programme of research has increasingly been informed by discussions with stakeholders about the planned Land Use Strategy for Scotland, and the two studies undertaken as part of the Scottish Government Rural Land Use Study (Miller et al., 2009; Slee et al., 2009). This provides an important context for the further development of the research on changing landscapes.

Scientific Activities

Land capability and scenarios of change

The development of integrated spatial frameworks which take account of the capability and function of land systems provides one means of relating the demand and supply of land to strategic decisions over land use. Agricultural land use, for example, contributes to the production of food, fuel and fibre, as well as offering cultural and environmental services.

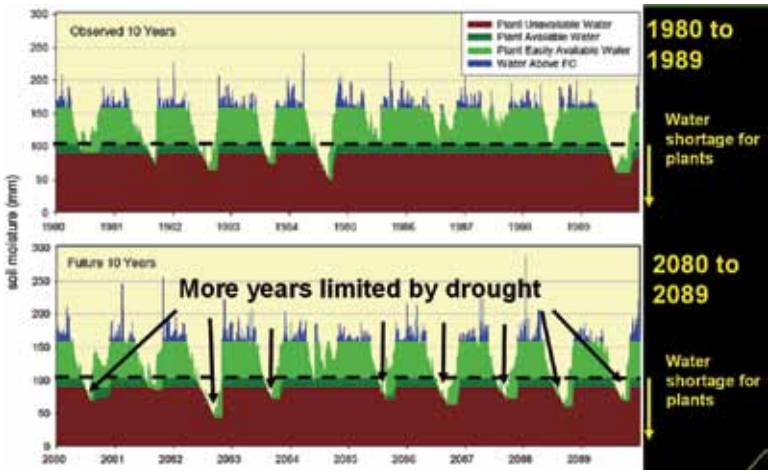

Figure 1 Changes in frequency of drought conditions in Scotland, with consequences for future farming practices

The development of methods for down-scaling outputs from regional climate models (RCM) has enabled the comparison of how well such models characterise conditions for the past. The results highlight that the use of data without downscaling can lead to erroneous conclusions on the nature of the challenges that may face land managers (e.g. Rivington et al., 2008).

Using down-scaled data has allowed us to present model outputs in a more readily understandable way. For example, Figure 1 shows changes in the frequency of years in which drought conditions might be experienced, leading to likely changes in farming practices.

At a farm-scale, case studies provide a better understanding of the trade-offs between multiple objectives that are made by managers. The Land Allocation Decision Support System (macaulay.ac.uk/LADSS/) is a spatial farm-scale systems model with loose-coupled components of cropping systems, livestock systems, resource scheduling and budgeting, and material/financial accounting. It is underpinned by a design which determines how best to employ complex computer-based tools and allows us to explore the spatial expression of trade-offs and their possible implications for other services provided by farmland.

Our work recognises that Decision Support is a much wider concept than the production of recommendations for specific courses of action. The key to success in Decision Support lies not in technological sophistication, but in the salience, credibility and legitimacy of the process within which it is used (Matthews et al., 2008). The LADSS toolkit provides the basis for integrated assessments of farm scale options, such as support of organic agriculture, as carried out within EU FP6 project Agri-GRID (macaulay.ac.uk/agrigrid/).

Other factors influencing change in agricultural areas include socio-economic targets or constraints for land use. By combining socio-economic understanding with the changing biophysical constraints represented by the Land Capability for Agriculture (LCA), scenarios of future agricultural land use can be developed. Working in the Lunan water-catchment (Angus) and the Tarland area (Aberdeenshire), a series of alternative land-use futures have been developed, using the LandSFACTS toolkit (macaulay.ac.uk/LandSFACTS/), supported by empirical evidence from analysis of current trends based upon the Integrated Administration Control System (IACS). Figure 2 shows three such scenarios for the Tarland basin.

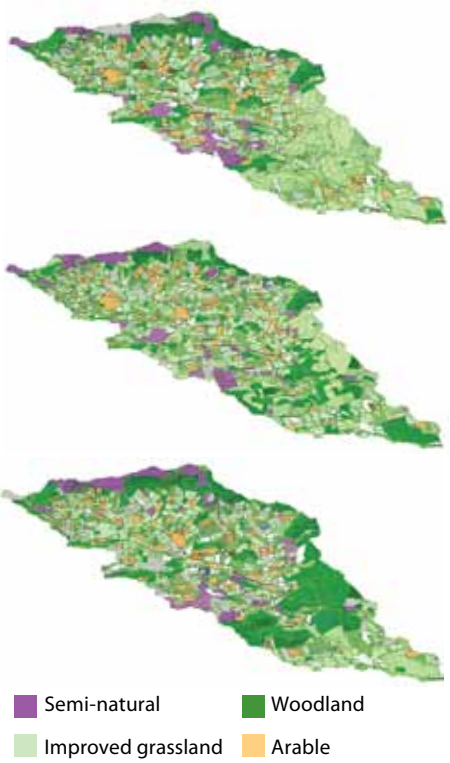

Figure 2 Scenarios of future land uses in the Tarland basin, eastern Scotland

Other approaches to modelling changes in land management exploit heuristics, such as Bayesian Belief Networks (BBNs). This approach has demonstrated that, with a limited amount of detail in the land manager's decision making process, land capabilities data and BBN's ability of inference, it is possible to explore effectively the impact of different personal circumstances on the land-use decision-making process (Aalders, 2008).

Land systems and adaptive responses to change

As land systems evolve over time, apparently stable systems can suffer surprising, catastrophic and irreversible changes. Analysis is being carried out which uses spatial databases of land ownership, use and management to assess the resilience of Scotland's farming system by looking at changes in patterns of rotations, the number and size of businesses and the diversity of enterprises. These GIS databases and associated maps support a wide range of policy-relevant assessments, particularly of alternative options for CAP and related payments. The outputs from this research, which draws on ideas from the Resilience Alliance provide essential support to Scottish Government in its deliberations on payments to land managers. Figure 3 shows the number of changes within individual land parcels between 2000 and 2004, based on the IACS data for Scotland as part of a test of resilience by studying trends in sustainability of Scotland's farming systems.

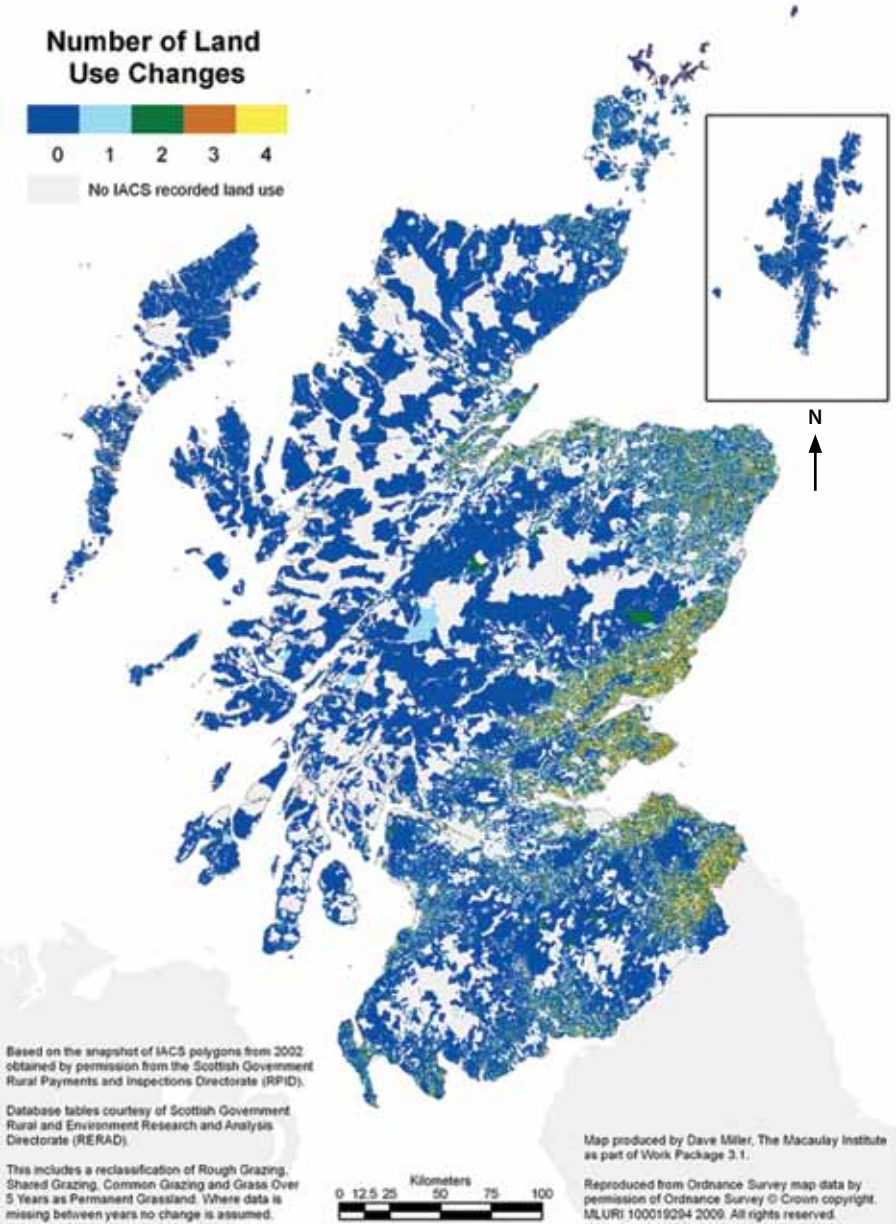

Figure 3 The number of changes within individual land parcels between 2000 and 2004

In a broader context of decision-making for sustainable land management, there is a requirement for tools which go beyond the use of ad hoc indicator sets, to include those which recognise the cross-scale and cross-sectoral flows of materials and money, and that take into account outcomes in terms of resource distributions and equity. Methods are being developed and applied which take a systemic approach to sustainability assessment, deriving system characterisations that are comparable between both the intensity and extent of resource use. One approach is in the use of social-metabolism methods, which have significant potential to improve the characterisation of social-ecological systems, identify issues, evaluate alternative future scenarios and support ongoing adaptive management. These are being tested in the RERAD research on Sustainable Farming Systems, and within an EC FP7 project on 'Synergies in Multiscale Inter-Linkages of Eco-Social Systems' (SMILE, tse.fi/EN/research/units/Pages/smile.aspx).

The involvement of stakeholders in the process of research is a central tenet of the work. The work is at the interface of science policy and science practice. A new initiative seeks to elicit mental models of sustainability using qualitative and visual methods. Different conceptualisations act as a barrier to communication and limit effective cooperation between researchers, stakeholders and policy makers. This is an element of the applied systems research which is focusing on the pre-analytical phase, with particular attention paid to agreeing the issues and scope of analysis, a frequently neglected and vital part of sustainability science.

With the University of Aberdeen, tools are being developed for social simulations which take advantage of semantic grid technology. These tools will enable large-scale social simulation experiments, involving tens of thousands of model runs, with metadata support backed up by automated reasoning. The ontologies used by these tools integrate provenance of social simulation with more traditional qualitative and quantitative methodologies in social science to explicitly represent evidence bases for policy-making.

Related research incorporates economic instruments, such as taxes ('sticks') or incentives ('carrots') aimed at reducing Greenhouse Gas (GHG) emissions and the impact that this may have on farmer livelihoods (Matthews and Bakam, 2007). This will then consider the challenge of implementing such schemes and issues such as transaction costs and the aggregate behaviour of land managers (see also Local Responses to Climate Change page 40). The agent-based modelling technology, therefore, offers a valuable set of tools for exploring future land uses (Matthews et al., 2007).

Social simulation of land use and change

Investigations of the complex dynamics of land-use change under stylised scenarios have considered the interplay of heuristic decision-making approaches and their impact on the landscape (Gotts & Polhill, 2009) (Figure 4). These have used cutting-edge agent-based modelling technology to simulate land-use change (Polhill et al., 2008), coupled with a species meta-community model, to analyse the effects of different government-funded land manager incentive schemes on biodiversity. The research has been undertaken in collaboration with a number of partners to take advantage of developments in qualitative methodology and computing science. As part of the EU CAVES project, a qualitative methodology has been developed for testing assumptions in model enhancements (Polhill et al., 2010).

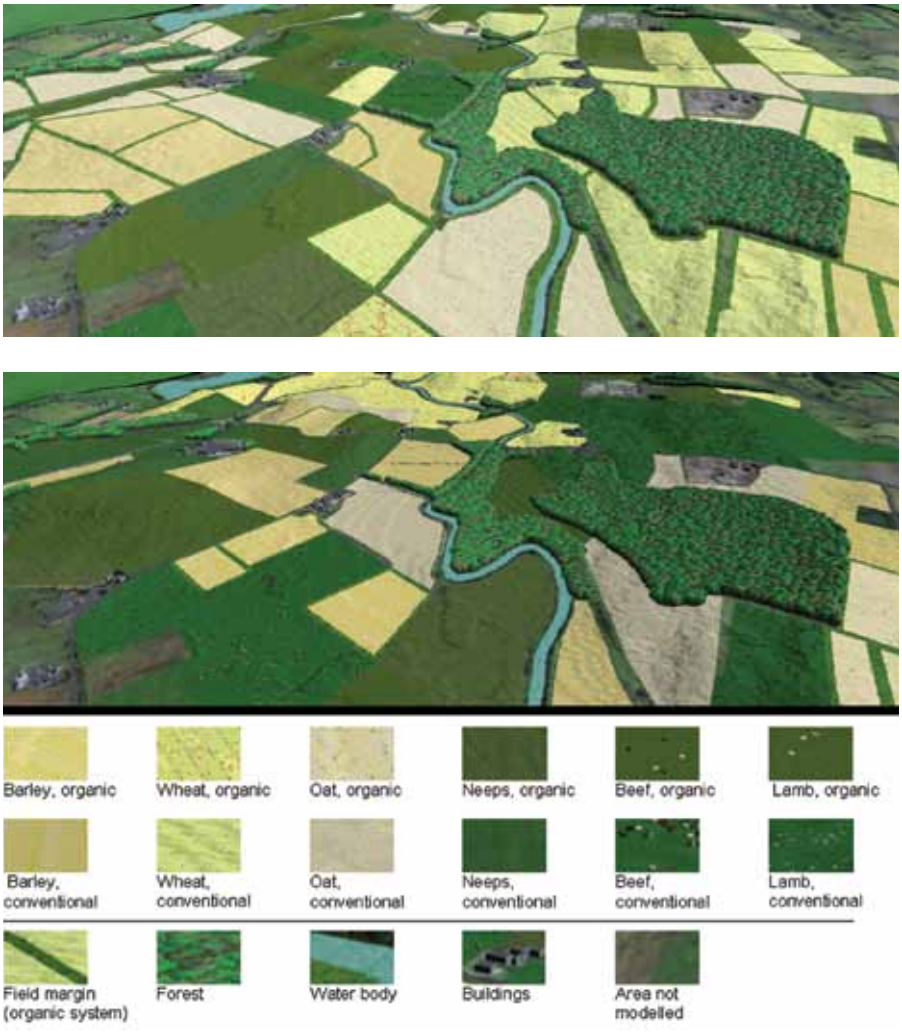

Figure 4 Scenarios of alternative outcomes of decision-making in a hypothetical landscape

Landscape values, experiences and preferences

Current land use and scenarios of change, however derived, can be evaluated in terms of their capacity for multiple land functions or ecosystem services (e.g. in a project developing a Model Ecosystem Framework). Amongst these services are those which are related to the visual landscape, including aesthetics and perceptions of function, requiring the development of scenarios of future land use to be expressed in three dimensions.

The visual quality of the landscape is an important factor in Scotland's economy, as well as the social and physical well-being of its population. Such qualities can be local in nature; that is, the visual quality of an area is not a simple product of the overall land-cover distribution, but the net impression of its appearance from many individual locations as one's perspective changes Ode & Miller (in press). Each perspective can provide a view onto a small subset of land-cover types, and provides a specific juxtaposition of these. For example, forested hillsides with grazed valley floors could appear to be blanket forest from some viewing angles. The development and testing of a framework for visual landscapes (the VisuLands Framework, developed in the EU VisuLands project) has shown how people's preferences are influenced by indicators of elements of landscape character, such as visual diversity and perceived naturalness (Ode et al., 2009). However, as the viewing position changes, actual landscape change and apparent landscape change can be significantly different, a fact which is difficult to monitor with existing map-based indicators.

Software tools have been developed to embed perspective view(s) of a landscape into land-cover maps, enabling the visual impact of landscape changes to be measured in a manner more akin to human experience (Sang et al., 2008). This has also led to the development of new theories of landscape perception that relate to the topology of the view, now being tested according to a framework which draws on the expertise of environmental psychology and landscape architecture, in collaboration with the Swedish University of Agricultural Sciences (Ode, Hagerhall & Sang, 2010).

The definition of landscape to which this science area follows recognises that values, experiences and preferences for current, and future, landscapes are wider than how people react to changes in the view. How do different individuals and groups value landscapes? How do such values relate to their socio-economic and cultural background and the specific practices through which they experience landscapes? A study of a range of walkers and mountain bikers has shown that particular mobilities, or ways of moving through landscapes, affect the ways in which those (and other) landscapes are valued. Modes of movement involve various aspects of identity, social dynamics, and sensory and emotional experience. Being a pedestrian, a cyclist, or a pedestrian with a pram or a dog all result in a change in the experience of landscapes and in turn the values attached to them (Brown et al., 2008). This underlines the limitations of carrying out landscape evaluations from a generalised and static position.

Capturing the multi-faceted nature of landscape experiences and values – especially visual, non-visual and mobile aspects – has demanded an innovative methodological approach. In support of this, new techniques of mobile and visual ethnography have been developed, specifically the 'ride-along' and headcam video. Different ways of combining them with established qualitative techniques (e.g. semi-structured interviews, participant observation) have been tested for collecting and analysing visual, aural and observational data. The results illustrate the importance of movement through the landscape in relation to people's experience.

To understand better the most important criteria of stakeholder perspectives and major factors influencing public attitudes to features in the landscape, a Q-method was developed, specifically on the place of woodlands and other nature landscape components in rural landscapes. The results suggest that people recognise the necessity of improving landscapes and conserving biodiversity, in the context of a multi-functional future for the countryside (Nijnik & Mather, 2008). The results of current research, addressing stakeholder evaluation of the status and prospects for biodiversity conservation in managed woodlands, indicate that occupation, education and work experience influence stakeholder attitudes and perceptions. They also recognise the scope for associated new employment opportunities, including consequences for tourism and recreation.

A complementary approach to analyse which ecological-economic values people place across inanimate natural components of landscapes is the CV

Method (contingent valuation technique of "willingness to pay"). The results (tested in the Ukraine) provide evidence that the value of landscapes (including monetary terms) is influenced by the presence of rocks, waterfalls, mountains and lakes, features associated with contributing to a sense of place, and that these natural landscape components are considered important by people (Nijnik et al., 2008). These results show comparability between public and stakeholder preferences, and demonstrate a consensus among stakeholder groups on the necessity of proper integration of woodlands with other land uses in rural landscapes in Scotland.

The importance of woodland has also been identified with respect to public preferences for urban greenspaces. In a study which used visualisation techniques to communicate different scenarios of the composition of urban greenspace, the results showed significant relationships between preference and factors such as access, the spatial arrangement of vegetation cover and the presence of people (Laing et al., 2009). The mapping of access to different types of greenspaces, with respect to demographic characteristics of the population, can then be used as an input to planning urban land use and the adequacy of the type and quality of provision of greenspaces (Figure 5).

This work is being combined with that on visual ethnography for the investigation of the contribution of greenspace to human health and well-being within a Scottish Government funded study, GreenHealth.

Mapping, monitoring and spatial planning

To enable the relationship of measured or modelled change with respect to potential impacts on future landscapes to be determined, assessments of biophysical and social resources are undertaken to provide baseline spatial data at a range of geographic scales. In rural areas, exploiting remotely-sensed data sources such as SPOT5, ETM+ and high resolution aerial imagery enables assessments of the extent of different types of land cover to be derived. In particular, the tools used have included neural networks for the classification of land cover, with interpretation of the associated reporting of uncertainty of classification success (Aitkenhead & Aalders, 2008). Similar tools have been deployed for the monitoring of gross change, such as that due to the Tsunami in south-east Asia in 2006 (Aitkenhead et al., 2007).

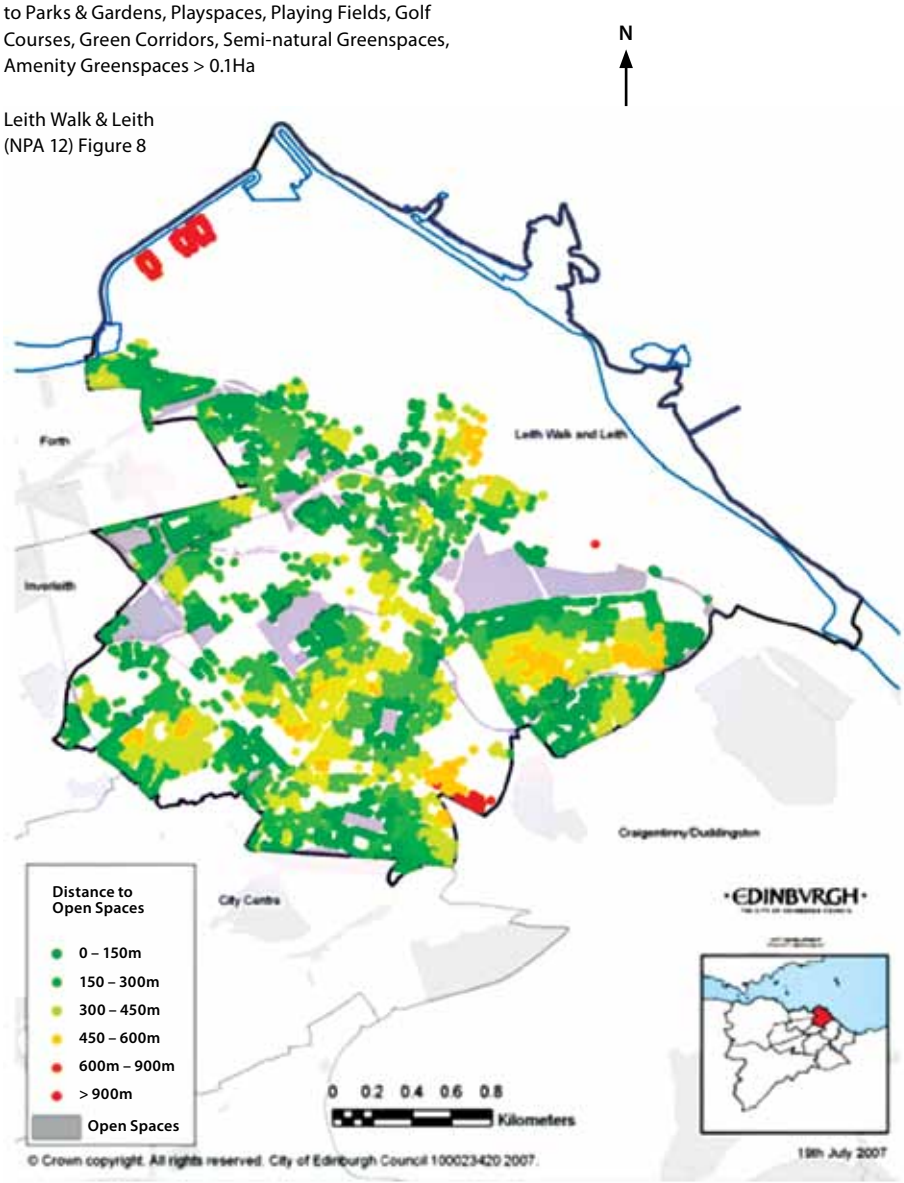

Figure 5 Accessibility of greenspaces in Edinburgh

In collaboration with BioSS, new tools, such as 'R', are linked to spatial data for the exploration of estimates of classification accuracy and statistical models used to explore alternative classification schemes (e.g. Poggio & Soille, 2009). These tools enable the maintenance of core datasets at the level of the region or case-study area. Their ongoing exploitation progressively provides coverage of substantial areas of Scotland.

Geographic databases provide inputs to the analysis of changes in the elements of the character of the landscape in Scotland, with features identified from the research into preferences and values and reported with respect to the national Landscape Character Assessment. Figure 6 shows the distribution of different types of woodland cover in Scotland and proportions of broadleaf and coniferous woodland with respect to landscape character units.

Such datasets are inputs to the planning of prospective land use at a national level, such as for renewable energy, using rule-based assessments, developed in association with stakeholders such as local authorities (e.g. Figure 7 overleaf).

The mapping and interpretation of land resources with respect to characteristics of landscapes can then be used to support a discourse about future use of Scotland's land.

Managing future landscapes for multiple demands

A key element of the European Landscape Convention, which reflects the aspirations of the Rio Summit and is now embedded in public policies in Scotland (e.g. PAN 85 on Community Engagement in Planning), is the engagement of all parts of society in the process of planning. Research in this topic has been carried out in close collaboration with public bodies, including the two Scottish National Parks. It comprises a number of different strands that

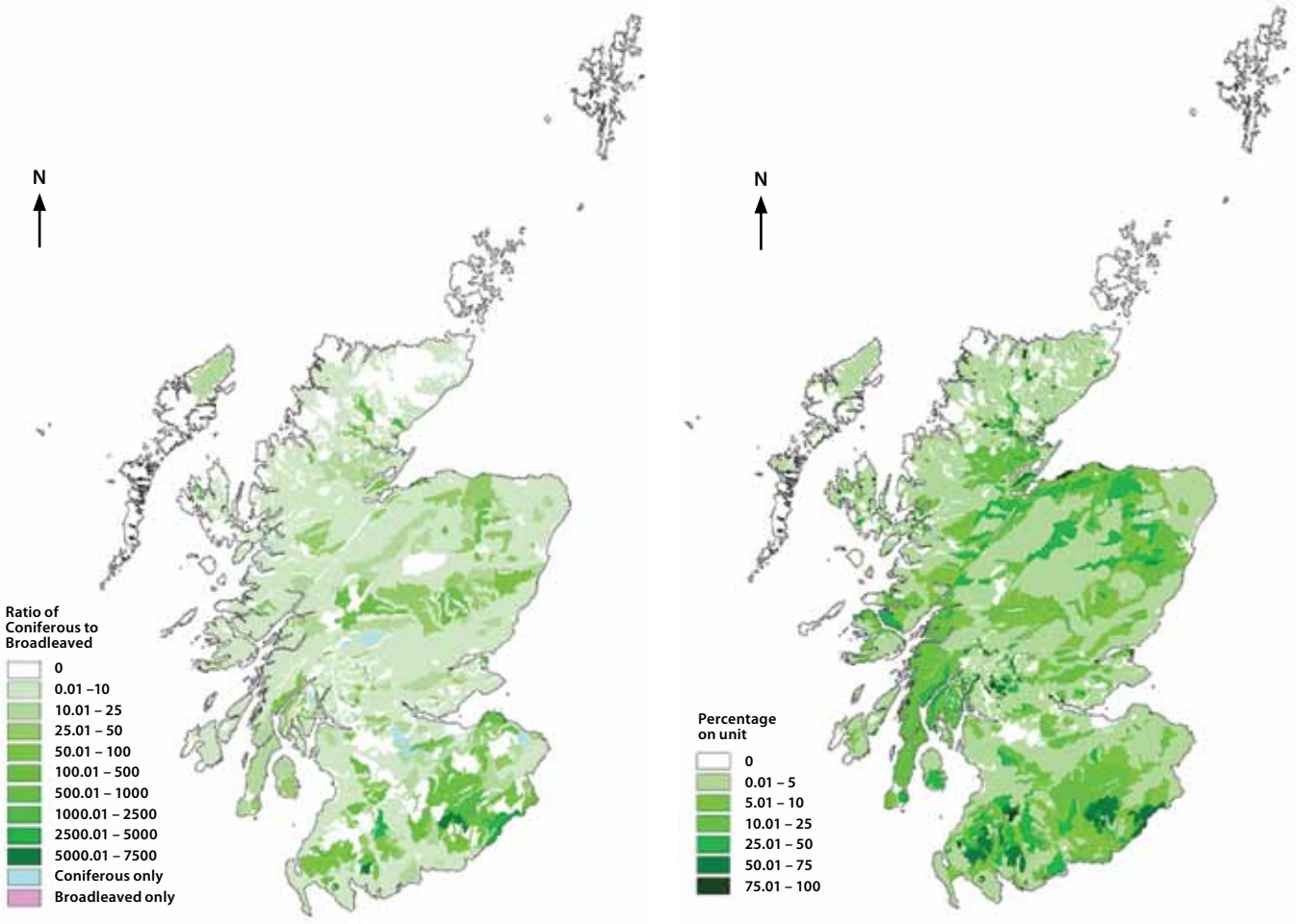

Figure 6 Distribution of woodland in Scotland with respect to landscape character units

together consider how best to manage our landscapes in ways that adapt to change and take account of multiple demands. In particular, the work has focused on how adaptive management and planning is practiced.

One piece of research is looking at how the Cairngorms National Park Plan was developed and is being implemented, with particular focus on the process of engaging diverse stakeholders. Findings suggest there is a hierarchy regarding which types of stakeholders are involved, these are difficulties in remaining both nationally and locally relevant, these are difficulties in enabling actions that balance environmental protection with economic and social development and different opinions about the role and governance of National Parks. This work uses the same methodology as work on River Basin Management Planning (see page 20 on Managing Water Resources), and their findings combine to support the literature on barriers to integrated spatial planning. Complementary work has looked at the role of indicators, especially for sustainable tourism, in supporting an adaptive management cycle.

Work by McCrum et al., (2009) has illustrated the importance of the 'neglected step' in indicator selection and development, whereby the values underlying choices are made transparent and discussed. This indicator work has also highlighted the importance of putting tourism in the wider rural context, something being explored further in research looking at the agri-tourism providers and consumers across Scotland (Flanigan et al., submitted). The planning and indicator research supports work on the application of sustainability appraisal tools in the Cairngorms National Park, within the EC-funded SMILE project. These research activities require collaboration with key stakeholders and their organisations, and in so doing are delivering improved policy and implementation.

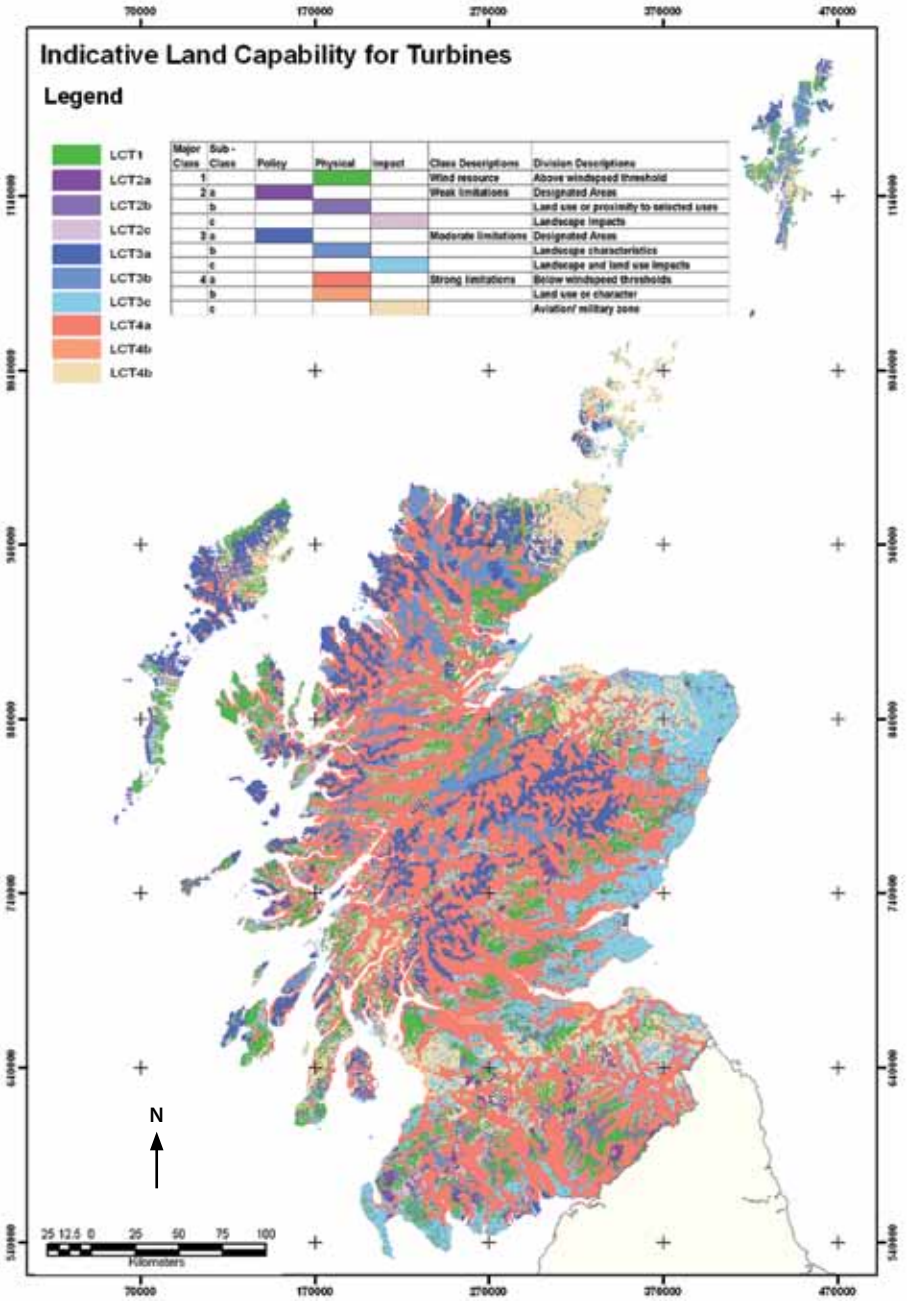

Figure 7 Classification of the potential for wind energy across Scotland

Figure 8 An audience discussing options for future land uses in the Virtual Landscape Theatre in Killin, Loch Lomond and The Trossachs National Park

In the Loch Lomond and The Trossachs National Park, a new five-year development plan is under preparation. In collaboration with the schools within and in the vicinity of the Park, and the Park Authority, a programme of events was specifically designed to obtain the views of young people in and around the Park. the Virtual Landscape Theatre (macaulay.ac.uk/landscapes) was used as a forum in which to elicit the aspirations and concerns of audiences, drawn from geography classes, to future options for land use, using computerised 3D models of the landscapes around the Park (Ball et al., 2008; Miller et al., 2009), and electronic voting facilities used for recording audience responses. Figure 8 shows an audience discussing options for future land uses in the Virtual Landscape Theatre.

Issues raised included perceived inconsistencies in public policy (e.g. forestry production and biodiversity objectives), conflicts between new development and landscape character, and between tourism services and community needs.

As part of a programme of knowledge exchange, dissemination events were held to communicate feedback on the protocols, tools and application to stakeholders with a remit to facilitate planning (e.g. Planning Aid Scotland), commercial companies and public bodies through the good practice workshop series run by Scottish Natural Heritage and the Scottish Government. (Figure 9 overleaf).

Figure 9 Feedback to Scottish Government on results and utility of tools for public participation using the Virtual Landscape Theatre

Future directions and challenges

To support societal responses to meeting the challenges of global change, whether progressive changes in adapting and mitigating to a changing climate, or changing economic circumstances (e.g. the 2008/09 finance crisis), an increasing emphasis is placed on involving stakeholders from different domains to participate in the research, and develop the level of co-learning within the research. Scientific challenges include the linking of drivers of change to process and function, and gaining a better understanding of issues of scale and uncertainty in relation to both its propagation through steps in the analysis, and its communication to different target audiences.

To undertake the research in the broad area of sustainability science, a final challenge for the coming few years is to maintain effective interdisciplinary research teams and stakeholder engagement which are able to work constructively through a number of evolving research cycles.

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Society and Countryside

Bill Slee

Our focus on Society and Countryside requires physical and social scientists to work together to develop tools and methods that have broad applications across a wide range of research activities and that help to link science addressing human impacts and policy-making with environmental systems. This will help to provide objective information both for land management and for policy that meets sustainable development objectives while balancing benefits for society, economy and environment.

The aims of our research are to:

- **Understand economic, social, and environmental interactions and how these interactions influence, and are influenced by environmental change**
- **Promote healthy and vibrant societies and environments**

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Context and Rationale

Our approach to researching interactions between society and countryside is rooted in different branches of social, economic, and environmental science, and in developing interdisciplinary projects and programmes that explore society and countryside as coupled human and natural systems.

Our goal is to understand the complex and multiple changes in rural societies, economies and environments. A range of qualitative and quantitative approaches are used to achieve this, particularly with regard to how people and groups perceive and interact both with each other and with the natural resource base of rural areas. We seek to understand the decision-making processes of rural households in the use and management of the environment and natural resources, the functioning of the rural economy, the inter-relationships of urban-rural areas, and the dynamics within rural areas themselves.

Collaboration with stakeholders routinely underpins our work and reflects the strong emphasis that we place on knowledge exchange. Our research involves active collaboration with the Scottish Government, national parks, local councils and a range of institutions and individuals from all sectors to create a knowledge-informed response to contemporary land use challenges.

Figure 1 Multi-functional land use

ScientificActivities

The centrality of rural land use in our work

Socio-economic dimensions of rural land use management are assuming an increasingly prominent place in policy discourse because of growing concerns about the impacts of climate change, potential food scarcity and a need to develop renewable energy systems.

We have been working with SAC and others to develop a better understanding of land management decision making across rural Scotland (Miller et al., 2009). Whilst a wealth of typologies exist to explain the motivations and behaviours of farmers, there is little to no information about the similarities and differences across different land uses. This ignores the fact that increasingly, rural land is multi-functional (Figure 1, page 51). Additionally, the complex ownership and management arrangements for rural land do not fall neatly into different sectors, but comprise multiple holdings and enterprises that combine agriculture, forestry, access and land-based tourism, renewable energy and nature conservation. Our expertise in mixed methods and our interest in understanding institutions and individual behaviour allow us to explore these complexities and add to the existing knowledge base and understanding of Government, agencies, groups and individuals.

There is a growing demand to understand better the contemporary pressures on rural land, not least with respect to whether Scottish rural land use is well-placed to respond to demands for adaptations that reduce impacts of climate change through reduced emissions or renewable energy production, address questions of food and fuel security, and stimulate economic growth in rural landscapes that support vibrant communities (Slee et al., 2009). The extent to which multiple goods and services can be provided through complementary and synergistic land use systems comprise a major research project funded by the Scottish Government with participation from SAC and the University of Aberdeen.

Multifunctionality, post-productivism – or both?

There has been an extensive debate about the key characteristics of the contemporary multifunctional countryside and the extent to which 'post-productivism' is a defining feature. Increasingly the idea of multifunctionality is being developed using the concept of ecosystem services and we have been working on this topic in relation to sustainable forest management and ecosystem services in both the Ukraine and Scotland (Nijnik & Mather, 2008). Multifunctionality is also central to the sustainable management of native forests in Scotland. The extent to which the public goods associated with multifunctional forestry can be and are supplied by private woodland owners is also the subject of research.

Research funded by the Scottish Government is exploring the development of a decision support tool to integrate ecological, socio-economic and aesthetic aspects of woodland development in rural landscapes, and develop knowledge of non-market evaluation of nature components of landscapes. This has involved quantifying public attitudes to landscape content and change development using Q-methodology and contingent valuation methods to complement the method of aggregated ecological indexes (MAEI). The results demonstrate that landscape scale, and land cover interactions with society provide a base for land use development.

A great deal of work on forestry and multifunctionality is also undertaken at an international level, with collaboration with Canadian, Dutch, Ukrainian, Austrian, German, Finnish and Portuguese teams. This international research includes studies of innovation systems in the forest sector, particularly those associated with non-wood products (Rametsteiner et al., 2009).

We are also investigating the meanings farmers and crofters attach to their livelihoods in farming and crofting and to specific land and livestock management practices (Figure 2). This research shows clear contrasts with the meanings attached to land management activities that are directed towards biodiversity conservation. Previous work has hypothesised that farmers can accrue cultural capital, measured as social standing amongst their peers and a sense of pride and self-esteem, from conventional productivist farming activities. Activities directed at biodiversity conservation may not generate cultural capital if they are at odds with the meanings attached to conventional farming practices. Our research is testing these conclusions by interviewing farmers and crofters that work high nature value farm and croft land, using semi-structured interviews to survey farmers' and crofters' beliefs and

Figure 2 Livestock management

attitudes related to the nature value of their holding and length of engagement in biodiversity conservation.

To complement our work on forestry and agriculture, we are conducting research to improve understanding of agri-tourism through examinations of tourist and provider perspectives in Scotland (Blackstock et al., 2008; Phillip et al., 2009; McCrum et al., 2009). An early outcome from this research has been the development of a conceptual typology for defining agri-tourism. Empirical research is now underway to determine stakeholder perceptions, motivations and expectations associated with agri-tourism. Our research on tourism in rural landscapes is also investigating the neglected step of understanding the implicit determinants, helping to shape the development and use of indicators in tourism.

Property rights and access in rural Scotland

The outcomes of the very significant reforms of access laws in the Land Reform (Scotland) Act 2003 constitute a significant research topic for understanding changed relationships between society and Scotland's countryside. One strand of research has focused on how people react to the new access legislation on the ground. Methods based on using head-cameras to record landscape use are providing invaluable insights into how people use and understand the landscape during recreational activities (Brown et al., 2009). We have also worked with the Countryside and Community Research Institute in Gloucestershire to undertake a Scottish Natural Heritage-funded review of access trends in Scotland (Curry & Brown, 2010).

Knowledge Exchange work has facilitated stakeholders running their own participatory video project. Members of the Cairngorm Local Outdoor Access Forum are working with the Access and Recreation section of the Cairngorms National Park Authority to produce a short film that shows how contentious issues are viewed, debated and resolved. This project hands responsibility for the context and the content of the material produced to the participants.

Stakeholders, governance and new institution building

There are many examples of institution building in Scotland, some arising from the devolution settlement, some from European policy changes. Amongst these, the distinctive Scottish National Parks and groups that develop river basin management planning provide two interesting examples that indicate the importance of institutions in management and development of sustainable landscapes, communities, and environments.

As new institutions emerge, they not only need to establish their own credentials with stakeholders but also integrate with other overlapping and established institutions. We are researching how and why the stated desire to move towards a more systemic, collaborative and adaptive mode of planning and governance in integrated water resource management and spatial planning is currently frustrated. Given the emphasis on joined up management within the River Basin Management Plans (RBMP) the Scottish Planning Act (2006) and current policy, it is timely to explore the relationship between RBMP and the new structure plans in Scotland (Blackstock, 2009).

The distinctive objectives of Scotland's National Parks and close working arrangements between the Macaulay Land Use Research Institute and the Cairngorms National Park Authority make the Cairngorms area a major research platform (Figure 3). We have developed research on stakeholder interactions with the implementation of the Cairngorms National Park plan.

Figure 3 Entrance to the Cairngorms National Park

The research draws on a combination of data sources and methods to provide multiple perspectives on planning and management of the Park and the development and implementation of the Park plan.

Research continues on integrated catchment management, particularly in the River Dee catchment and the Lunan Water, as well as in other catchments. Internationally, we have recently completed an EU funded project on integrated catchment management in east Africa.

Attitudes to nature, biodiversity and natural events

Public attitudes to biodiversity management have often been dismissed as uninformed, volatile and 'ad-hoc', and thus not worthy of serious consideration in the policy process. We have explored the rich conceptual contexts in which ideas of biodiversity and, ultimately, public attitudes towards biodiversity management are embedded. Our research suggests that lay-peoples' ways of arguing for certain management options are by no means arbitrary, and structurally are very similar to those of experts. This suggests a clear opportunity for greater collaboration between the public and policy-makers (Lienhop & Fisher, 2009; White et al., 2009).

To investigate social representations of biodiversity and attitudes towards its management, we have a set of studies focusing on local biodiversity issues, including:

- Management of species seen locally as problematic
- Changes in species populations
- Habitat management, e.g. grouse moors and woodland restoration
- Management of protected areas such as the Cairngorms National Park

Some of these studies were part of the EU FP6 funded ALTER-Net Network of Excellence, which included Scottish and other European study sites. A focus of our work has been on social representations of and attitudes towards the management of non-native species.

Closely related to this we have also explored the social dynamics of conflicts over species management, specifically hen harrier and red grouse. We are also exploring the role that ideas of wilderness play in modern conservation policies, and the factors influencing co-operation in conservation activities in developing countries (Marshall et al., 2007).

Policy reform the rural economy and rural livelihoods

Given the major upheavals in the global economy with raw material price shocks followed by global economic downturn, there are compelling reasons for developing a better understanding of the impacts of policy and price shocks in the rural economy.

Because so much of Scotland's rural land is agriculturally less favoured it is unsurprising that some of the major policy debates surround hill and upland areas. Our research is exploring what may happen to the Scottish rural economy if different forms of flattening of European farm payments are implemented. This has potentially profound implications for the hill and upland areas. This work was an element of the Institute's participation in the Royal Society of Edinburgh's inquiry into the Future of the Hills and Islands. We have also contributed to consultations relating to the future of hill farm support schemes in Scotland and at EU level.

Crofting has also been a headline issue recently with the Shucksmith Commission of Inquiry reporting in 2008. The Institute was commissioned to investigate relationships between crofting and population retention (Figure 4). Our key findings were that the research hypothesis, that crofting tenure has impeded population retention, was not supported, and that the proportion of crofts in a parish does not appear to have a statistically significant impact on change in parish population. Thus there appears to be no significant quantitative impact of crofting on population change, either positively or negatively.

Well-being and social inclusion

Addressing social exclusion is a key aim of government policy and there is a strong emphasis on participation in the labour market as the key to social

Figure 4 The drift from the land

inclusion. Modelling labour market participation in order to better understand what has an effect on participation is an important step towards forming policies that address increasing participation in the labour market effectively (Scott et al., 2007). We have explored labour market participation in remote rural areas and urban areas to identify whether remote rural labour markets had a different effect on participation than urban labour markets. Our work has shown that, after controlling for individual characteristics such as age and education, living in a remote rural area increases the chance of being in work compared to living in an urban area for both males and females.

There is a perception that health tends to be better in rural than urban areas. However, those living in rural areas face a number of disadvantages relative to their urban counterparts which may have an adverse effect on health. We have looked at health in rural and urban areas to see if there is a health premium attached to living in either area. The results show that, after controlling for individual characteristics such as education and employment, living in a remote rural or an accessible rural area increased the likelihood of reporting a higher self-assessed health status.

Research at the Institute has also contributed to understanding of the well-being of rural communities. We carried out an empirical application of the recently published measurement framework A Wellbeing Framework for Scotland (Forward Scotland, 2008). Indicators of well-being (and appropriate proxies) were applied to the Loch Lomond & Trossachs National Park and discussed with groups of local residents to examine perceived effectiveness of the indicators in representing both community well-being and drivers of change in well-being. Particular attention was given to the capacity for assessing change and drivers of change experienced by rural communities related to three fundamental areas of Scotland's rural life and well-being: agriculture, cultural identity, and the natural environment and sustainable use of resources.

Climate change, alternative energy and rural development

Regional climate models provide an overview of possible climatic conditions for different forecasts of Global Climate Change. These models are of a relatively coarse resolution and are not informative at local scales and for individual land managers. We have developed methods for down-scaling the outputs from regional climate models so that they can be used to support local case studies and stakeholder workshops on adaptation. Our work has shown that using data from climate models without downscaling can lead to erroneous conclusions on the nature of the challenges that land managers are facing. Significant progress has also been made in defining and presenting agro-meteorological metrics to communicate climate change consequences to land managers.

The land use sector in Scotland is a relatively large emitter of greenhouse gases, both from soils and from the livestock systems that predominate over large parts of the country. This sector, however, also has the potential to mitigate climate change through the adoption of certain land uses and measures that promote certain land management practices. The overall aim is to enhance the carbon sequestration potential in our soils. Soil carbon sequestration has been the subject for a Scotland-wide survey among members of the public. In the survey, we also introduced ideas that such measures may have biodiversity benefits, but could decrease employment opportunities. Early results provide useful information on the public perception of this issue.

We are examining ways in which policy to address climate change offers new opportunities for rural development with the emphasis on renewable energy and land use-based mitigation strategies. Renewable energy could be a new economic activity in rural parts of Scotland. Waterpower, wood energy, wind and other systems (e.g. anaerobic digestion) offer new energy sources that can replace or supplement other sources. We have evaluated strategies that link energy demand at local scales (e.g. for small, remote communities or schools) with new local energy sources. This would re-localise energy generation through taking advantage of local energy generation capacity. In addition to climate change mitigation, this strategy should generate additional impacts including: heritage conservation (for example, the use of old watermills has significant potential for energy generation), diversification of incomes for farmers, new job opportunities, and a reduction of the reliance on fossil fuels.

We are examining the use of different policy mechanisms to explore the scope for climate change mitigation, in response to the Kyoto Protcol and in relation to carbon taxes and cap-and-trade (Xu, 2009; Nijnik & Bizikova 2008).

A second component of this research addresses land-based climate change mitigation strategies (Pajot, 2008). Farming is a significant contributor to greenhouse gas emissions in Scotland and options to reduce emissions have been assessed from an economic perspective. Cooperative solutions to reduce the costs of mitigation have also been considered, as has the possible role of carbon trading mechanisms and carbon offset schemes. These all may improve the cost-effectiveness of land-use based strategies.

The particular role of forestry in climate change mitigation in the UK was explored in our contribution to the Read report (Nijnik et al., 2009).

An alternative perspective based on environmental psychology is also being applied to the imperative to move to a low carbon rural economy. We are investigating the individual and collective behaviour of rural communities and the extent to which people are: i) aware of climate change, and ii) willing to engage in action to mitigate climate change. This work gives an important understanding of how values are shaped and how people are prepared to act, this insight having a vital role in informing interventions.

Environmental stewardship and land management

A strong case can be made that research that underpins decisions on sustainability should go beyond the use of ad hoc indicator sets and develop methods that recognise both the cross-scale and cross-sectoral flows of materials and money, and that take into account outcomes in terms of resource distributions and equity. As part of the EU Framework 7 programme SMILE project, we are developing and applying methods that take a systemic approach to sustainability assessment using social metabolism methods. This approach has potential to markedly improve the characterisation of social-ecological systems, identify issues, evaluate alterative future scenarios and support ongoing adaptive management at practical and local scales. The work is being carried out in exemplar case study areas across Europe, including in the Cairngorms National Park.

The assessment and management of positive and negative externalities from land use systems remains a continuing challenge. Blackstock et al, (2009) have explored the particular challenges of behaviour changes to reduce diffuse pollution and Balana et al, (2010) have taken an economic perspective on the particular challenges caused by diffuse pollution. There remains a major challenge in accurately measuring these environmental goods and 'bads' and this has been addressed by Barkmann et al, (2009) and in work by Spash et al, (2009).

We are also drawing on ideas from the Resilience Alliance to explore both how land use systems evolve over time and why apparently stable systems suffer surprising, catastrophic and irreversible changes. Our analysis uses spatial databases of land ownership, use and management to assess the resilience of Scotland's farming systems by looking at changes in patterns of rotations, the number and size of businesses, and the diversity of enterprises. The databases and GIS maps we maintain and manage also support a wide range of policy relevant assessments, particularly of alternative options for CAP and related payments (Figure 5).

We continue to develop capacity to undertake case-study based analysis of trade-offs between multiple objectives in farm-scale integrated assessment studies. This uses the Land Allocation Decision Support System (LADSS) as the basis for integrated assessment processes. LADSS is a spatial farm-scale systems model with components that represent cropping systems, live-

Figure 5 Arable farmland

stock systems, resources scheduling, resources budgeting and material/financial accounting. LADSS was previously applied in assessment of options for support of organic agriculture within EU FP6 project AgriGRID.

Work funded by RELU with colleagues at the Universities of Leeds, Cranfield, Sussex, Cambridge and Manchester brings together disciplinary perspectives from sociology, economics, geography, ecology and soil science to address the impact of organic farming on the ecological, hydrological, socio-economic and cultural characteristics of their localities and regions. The study seeks to identify the causes of different degrees of spatial concentration in organic farming found across Britain. We have assessed matched pairs of farms situated in landscapes of high, medium- and low-density organic farming. The Institute's research in the SCALE project addresses the development of organic subcultures: the socio-cultural dynamics of organic farming in areas of high and low organic farming density. The neighbourhood effect is of specific interest – the shifting cultural perceptions of organic farming by farmers themselves that results from interactions with their peers. In combination with other modules of the collaborative project this work will contribute to the identification of possible growth trajectories for organic agriculture in England.

In a RELU-funded project we are analysing the development of effective, informed, inclusive, collaborative and sustainable management of wild deer using a multi-scalar case study approach. This allows analysis of the complexity of responses to changes in the ecological and socio-political landscapes of British countryside.

Food and rural development

The food system in Scotland has been under close scrutiny in recent years, not least because of the association between food and health. We have been exploring the discourses evident in the recent Scottish Government food consultation. Food production remains highly important to rural economies through both farming and food processing. Recent volatilities in world food markets have turned attention to food security issues. Two European-funded projects looking at sustainable food chains and rural development have been completed and the Institute was represented as a member of a Scottish Government committee chaired by Professor Annie Anderson exploring the scope for developing, with the food industry, a means of driving forward healthier and more sustainable food choices.

Key findings released in a comprehensive programme of research into rural land use in Scotland include:

- Scotland's rural land delivers a huge range of benefits including income and employment, strong and resilient communities, food, fuel and energy, and carbon sequestration
- The specific pressures likely to face Scotland in the short and longer-term, including the key importance of climate change
- The parts of Scotland in which those pressures are most likely to occur, with intermediate quality land under most pressure from competing demands
- Examples of how land managers are successfully dealing with these competing demands
- The increasing involvement of communities in rural land use decisions
- Information, training and skills development is crucial to ensuring that rural Scotland is equipped to meet fresh challenges

Rural Land Summit

Staff from the Institute presented key findings from a comprehensive programme of research into rural land use in Scotland to over 150 delegates and stakeholders, including Cabinet Secretary for Rural Affairs Richard Lochhead, at Scotland's first ever Land Use Summit held in Inverness on 9th November 2009. The links between different types of land use and their competing demands were discussed at the summit, highlighting the wide range of economic, social and environmental benefits which Scotland's rural land delivers.

In partnership with several other research organisations, the Institute led two of the three research projects: Project 1: Changing land use in rural Scotland – drivers and decision making and Project 2: Realising the potential contributions of Scotland's rural land to delivering sustainable economic growth which comprised the Rural Land Use Study, originally launched at the Institute on 26 September 2008. These projects focused on the drivers and decision-making processes for land use and change in Scotland, and the potential contributions of rural land to the Scottish Government's overarching purpose of delivering sustainable economic growth.

Our research revealed the increasing role that local communities have in decisions relating to land use. This is through their direct management of land, and the increased consideration given to local communities by both public and private land managers. Of particular importance is the increased professionalism required by land managers to inform their choices about financial support mechanisms, technological developments, or diversification into renewable energy. Inequality of the availability of information is a potential concern, and constraint on the uptake of new opportunities, and pressures on land use.

Rural land has a pivotal role in generating well-being for people in Scotland and more widely. This is because land has many values: as a provider of food, fibre and energy and its vital role in important supporting, regulating and cultural ecosystem services.

Because so many of the values of rural land are not captured effectively by markets, getting the right balance in land use is a challenging task. By better understanding the causes of land use conflict and by learning from good examples of complementarities in practice, the Rural Land Use Study provides the evidence-based foundations on which a stronger Scottish land use strategy can be built.

Findings from the Study will help inform a wide range of policies, in particular the Land Use Strategy, where Scotland is leading the way.

Future Direction and Challenges

The wide range of research and knowledge transfer activities reflect our central concern with the many people who depend on Scotland's rural land for their livelihood and wellbeing, including urban based residents who visit the countryside, as well as the land management community. Nurturing sustainable land management activities as well as ensuring the efficiacy of institutions and policies to support the delivery of multiple ecosystem services is likely to be of pivotal importance in meeting the major global challenges of climate change and achieving food and energy security in the years ahead.

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Local Responses to Climate Change

Tony Craig and Robin Matthews

Our focus on Local Responses to Climate Change demands an understanding of climate change at scales from local to global and development of techniques that both downscale climate projections and prepare metrics of weather and climate with meaning for land management practices and land decisions. We also require understanding of individual and societal response to change.

The aims of our research on Local Responses to Climate Change are to:

- **Improve our understanding of the impacts of changing climate on land use, natural resources, and people**
- **Provide information that can assist in developing adaptive mechanisms and capacity to ensure sustainable development through effective policy and land use management**

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Local Responses to Climate Change

Context and Rationale

In the Scottish Executive's Climate Change Strategy (Scottish Executive, 2006a), the need to move to a low-carbon economy by 2050 is emphasised, and, recognising that some climate change will occur even if emissions are successfully reduced, some of the adaptive responses that might need to be supported are outlined. Subsequent policy documents for the forestry and agriculture sectors have also been published (Scottish Executive, 2006b; Scottish Executive, 2006c) both of which acknowledge the contribution of these sectors as both sources and sinks of greenhouse gases (GHGs). Similarly, the Scottish Biodiversity Strategy (Scottish Executive, 2004) explicitly recognises the threat of potential shifts in species' range. In addition, the Scottish Government proposed in June 2007 a target for reduction of GHG emissions of 80% by 2050, and studies are currently underway to evaluate possible means by which this target can be achieved. However, the implications of these GHG reduction targets for other policy initiatives such as the Rural Development Programme, Water Framework Directive, (future) Floods Directive, Biodiversity Action Plans, Soils Strategy and Spatial Planning Guidance need to be clarified, as do the ways in which they will all be implemented by stakeholders.

One of the key issues relating to the science of climate change is the rather overwhelming nature of the problem. The various IPCC reports, European Directives, the national implementation of these Directives, and other such policy frameworks all reinforce the message that climate change is a global problem that requires a global solution, whilst articulating the need for appropriate local responses. Local responses to climate change can appear parochial in the face of such large-scale problems. The need to understand 'local responses to climate change' creates something of a conundrum for science.

How does applied science avoid becoming entrenched in the science of climate change in isolation from the 'real world'? How can the research questions which drive the science be framed in such a way that there is a strategic match with the needs of policy? Similarly, how do attempts to bridge the 'gap' between science and society reconcile the methodological differences between the natural and social sciences?

Since it was established in November 2007, the climate change research theme at the Macaulay Land Use Research Institute has made significant progress in this area. The variety of related scientific activities has continued to flourish, and the transfer of knowledge from this science has gained a significant momentum over the last year, along with the development of appropriate partnerships with key institutions nationally and internationally.

The increasingly interdisciplinary group of both natural and social scientists at the Institute make us ideally situated to explore many of the complex research questions related to climate change. On one hand, we continue to contribute to the mounting scientific evidence base on the impacts of climate change on the various ecosystem services that human systems are embedded in. On the other, we are also contributing in many areas related to the attempts to find 'responses' in the face of such a complex picture.

Although the picture is complex, many of the local solutions offered in the face of global climate change are relatively simple. A key challenge lies in understanding the relationship between the environmental and human 'responses' to climate change. Much of the ongoing scientific work across the Institute continues to help build our understanding of the current and future response of bio-physical processes to changes in climatic conditions, including the impact of climate change on local biodiversity, hydrology, and soil characteristics. Other ongoing work is focused more on understanding the human dimensions of climate change, including the integration of this knowledge at household, farm, community and national levels. Recognising the complexity of the problems to be tackled, our climate change research is organised into an inter-disciplinary and cross-cutting theme, drawing on expertise from the five Science Groups: Ecology, Soils, Catchment Management, Socio-Economic Research and Integrated Land Use Systems.

Scientific Activities

Work at the Institute focuses largely on the impacts of climate change on the ecology, soils, hydrology and land use of Scotland. For example, there is significant effort studying the likely impacts of climate change on changes in species distribution at multiple spatial scales, a key aspect of which is identifying uncertainties associated with such change, rather than simply making predictions of species re-distribution in response to climate change.

Work is also ongoing to assess the stock of carbon (C) in soils and peats across Scotland so as to characterise this potentially vulnerable C pool. In collaboration with the University of Aberdeen, the ECOSSE model of C turnover, has been developed specifically to describe processes in the organic soils prevalent in Scotland. Other detailed modelling studies include an investigation of climate change impacts on dissolved organic matter in soils and rivers, and, in collaboration with SAC, on N_2O emissions from agricultural soils. Together with SCRI, we are also analysing the potential impacts of altered precipitation patterns on both drought and water-logging, and, under more severe conditions, the implications for increased risk of soil erosion. More detailed process-based field research is characterising the C flux within arable, grassland, woodland, moorland and peatland ecosystems.

In the 1970s we developed The Land Capability for Agriculture (LCA) as a classification system for grading the agricultural quality of land (classes 1–7). It is based upon physical limitations: climate, soil and topography, and used average climate data from 1958–1978. The Land Capability for Agriculture dataset has been used extensively as a decision aid by policy-makers, planners and land managers. In analysis using more recent climate data (1981–2000) (Brown et al., 2008) we have identified some subtle changes in the LCA, with a small increase in areas of prime land (classes 1–3) in eastern Scotland. The LCA climate parameters were projected into the future using the national (UK-CIP02) climate change scenarios, showing that climate constraints for many areas of southern and eastern Scotland will be relaxed, but wetness remains the key constraint in western Scotland. The future climate projections would suggest that by the latter half of this century, the proportion of prime agricultural land (i.e. Classes 1 to 3.1) will increase from 5.7% to 19% of Scotland and a fundamental change in agricultural management would be required, possibly requiring a transition towards new farming systems for some areas. Figure 1 shows the comparison of the original LCA and that by 2050, under a Medium-High GHG emission scenario.

A stakeholder workshop highlighted priorities for the evolution of this work. The findings have major implications for land-use planning and management and informed discussions at the launch event for the Scottish Government Land Use Summit, in November 2009. A more detailed study is underway, including consideration of local soil-climate interactions (e.g. drought risk, wetness factors).

Long term data collected from the Environmental Change Network (ECN) provides invaluable information for detecting changes in water quality brought about by climate change, and will assist in the provision of an enhanced evidence base for its impacts. The potential impact of climate change on riparian ecosystems is currently being examined through an assessment of the relationships between vegetation, climate and the thermal regimes of streams. Many surface waters are currently recovering from nutrient enrichment from atmospheric deposition (S, N). The potential implication of climate change on the recovery of these systems is being examined using a space-for-time substitution method.

Research has also focussed on understanding the human response to both mitigation and adaptation strategies. Much of this work has focussed on the human response either at the national level, focussing on issues such as flood risk management, and soil carbon sequestration (see Box 1 and Box 2, page 64) or at the local community level. Recent work at the local community level has examined peoples' attitudes to various renewable energy options in their local area, and also looked at the various factors that are likely to predict individual engagement in local community carbon reduction initiatives.

However, other work focussing on local responses to climate change has a more international flavour. Such work includes emissions from tropical deforestation (see Box 3, page 65) and the research being undertaken on governance, lifestyles and energy demand (see Box 4, page 66), which is looking at mechanisms at different levels of scale, and in different regional contexts to reduce energy-related emissions from private households.

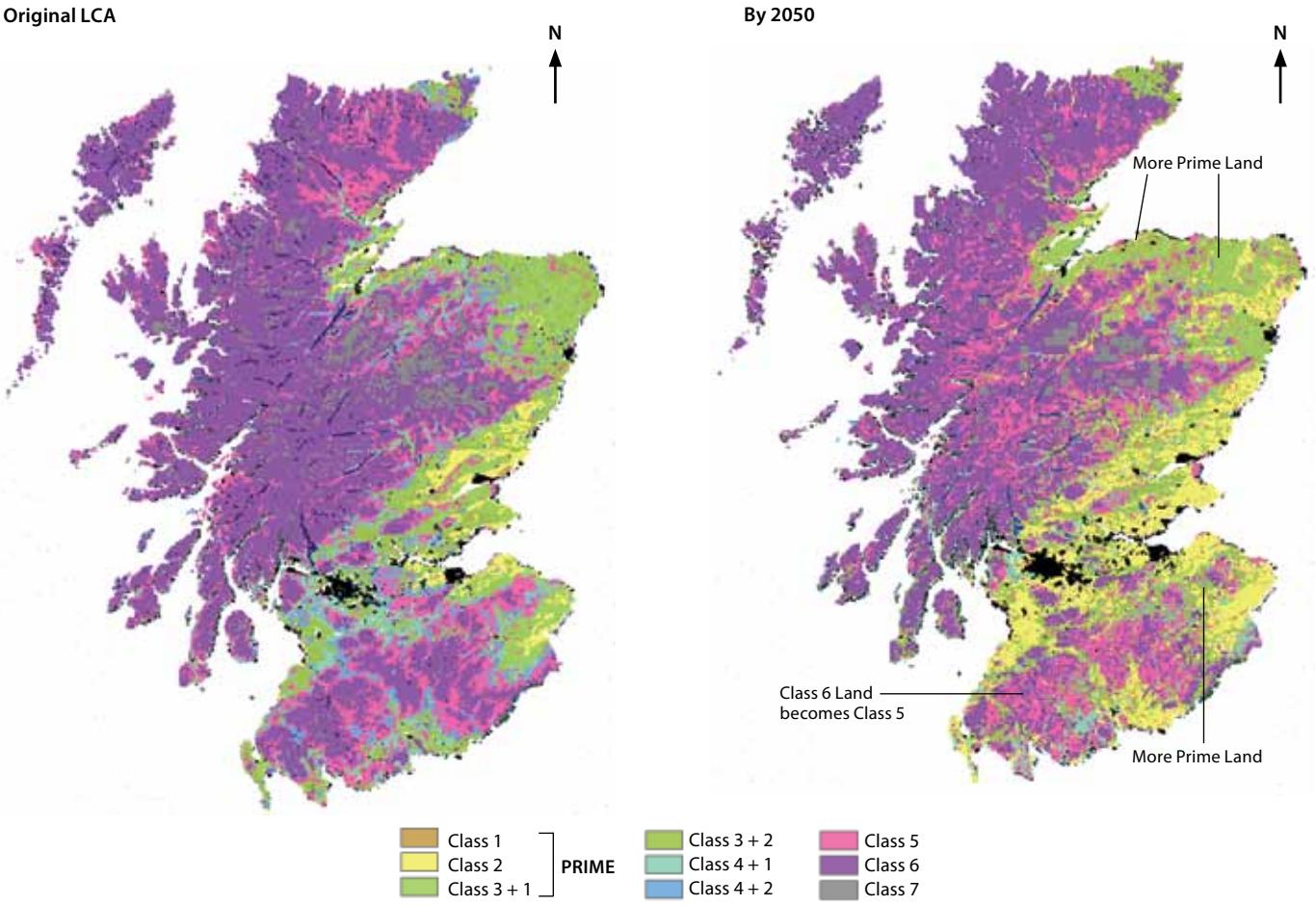


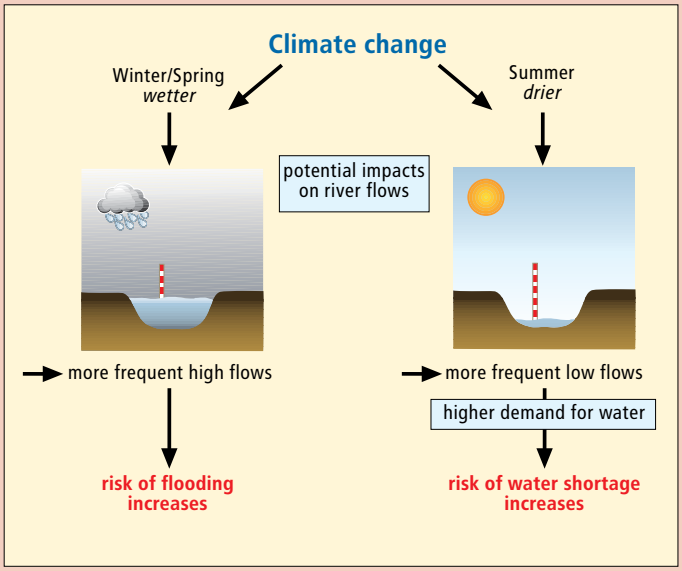
Figure 1 Comparison of the original LCA and that by 2050, under a Medium-High GHG emission scenario (a) Original LCA; (b) By 2050 under a Medium-High emission scenario of UKCIP08

Public preferences for flood risk policy measures

Box 1

Public preferences for adaptation strategies in response to climate change were investigated by means of a Scotland-wide survey that involved face-to-face interviews (n=1000). Public attitudes and economic preferences for two different hypothetical policy options that were designed to address risks from flooding and low flows in the context of climate change were explored. One of these options was a soft engineering scheme that would contribute to sustainable flood management, while the other option involved council insurance against damages to public infrastructure.

Preferences and attitudes were set in relation to process-and outcome-related values, such as efficiency, solidarity and safety, which provides us with a better understanding of the factors underlying public views on policy options.



Other work is focused on assessing the impacts of climate change on farming systems management units, using the farm scale decision support system (LADSS) developed at the Macaulay Land Use Research Institute. This work has included the development of an approach using Hadley Centre Regional Climate Model daily data (linked to the UK-CIP02 scenarios) for site specific impact assessments, and which is evaluating the effect of uncertainty in the climate data on the decision-making processes of farmers (see Box 5, page 66). We are also developing and using the spatially-explicit People and Landscapes Model (PALM) which links human decision-making to soil carbon, nitrogen and water dynamics, in an attempt to understand the complex feedbacks between human and biophysical processes.

Future directions and challenges

The various strands of research threaded together under the cross-cutting theme of climate change all help to strengthen the knowledge base necessary in order to design appropriate local responses to climate change. The future research programme necessary for these large challenges involves a fresh look at the way we conduct research. We need to embrace appropriate interdisciplinary cooperation, forge new trans-disciplinary research programmes, and continue to respect and grow individual scientific expertise and knowledge. Climate change is a complex scientific and political territory, which, in order to break new ground, requires a strong link between the natural and social sciences. This is no simple track to follow, but as the snapshot of research here shows, we have already begun to make considerable progress along this track.

Values + Preferences for measuring soil carbon

Box 2

The land use sector in Scotland, compared to other parts of the UK, is a relatively large emitter of greenhouse gases, both from soils themselves and from the livestock systems that predominate over large parts of the country. This sector however, also has the potential to mitigate against climate change through the adoption of certain land uses and measures that promote certain land management practices. The overall aim is to enhance the carbon sequestration potential in our soils.

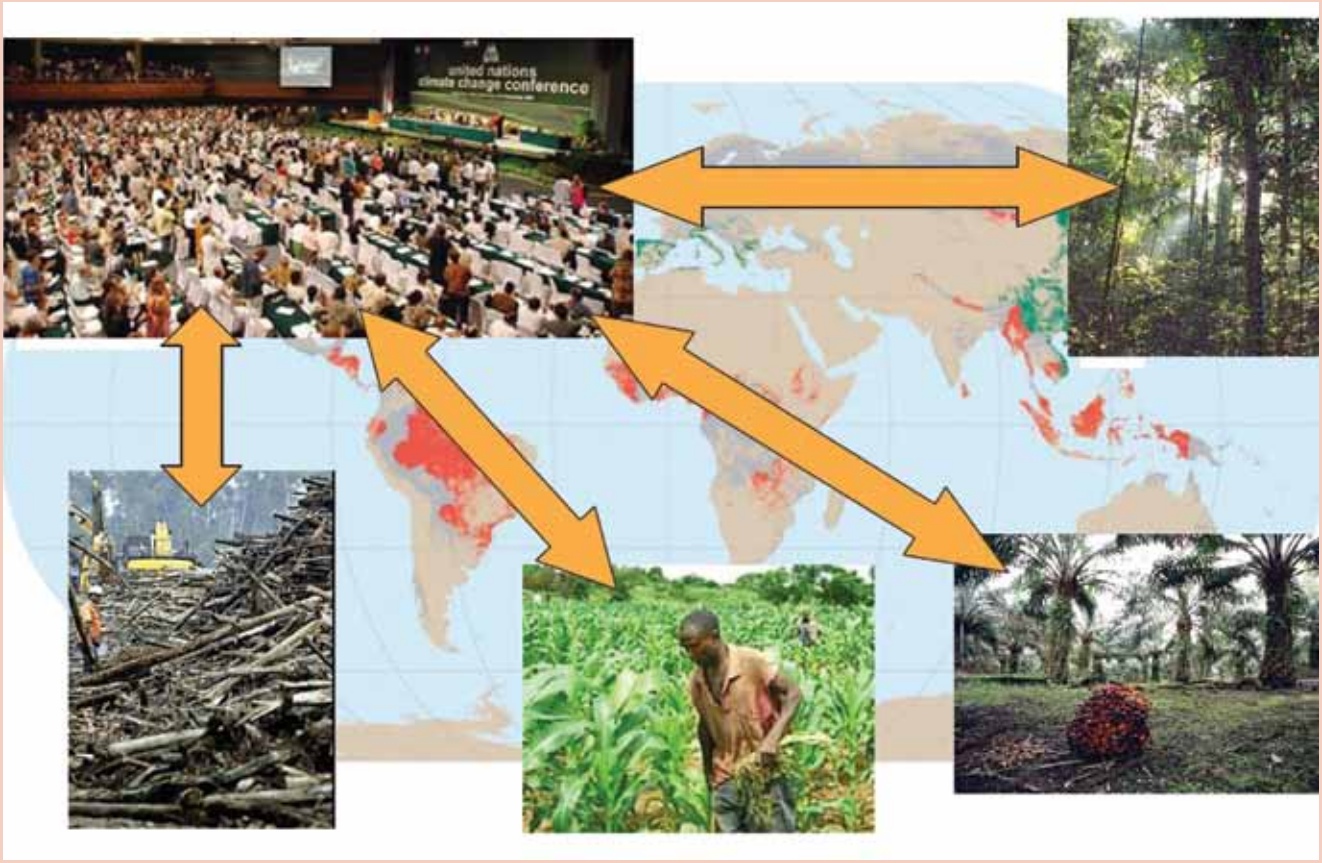
In this context, we made soil carbon sequestration the subject of a Scotland-wide survey among members of the wider public. In addition to assessing the amount respondents were willing to pay for a programme of measures to reduce net emissions of greenhouse gases from Scotland, we accounted for the scientific uncertainty by allowing for the possibility that this programmme may actually fail to deliver climate change mitigation benefits. In the survey, we also introduced ideas that such measures may have biodiversity benefits, but could decrease employment opportunities. Almost 650 members of the public were interviewed face to face using a mixture of text and visual aids (Figure 1). The results and implications of the survey are still being analysed but early indications are that they will provide useful information on the public perception of an issue that is literally hidden from view.

Figure 1 Public surveys require novel techniques to help stimulate engagement

While the influence of delivery uncertainty on preferences for mitigation is useful information for decision makers, it also implicitly places a value on the work of soil scientists who aim to reduce the uncertainty by improving their understanding of the biophysical relationships and soil processes related to mitigation practices.

REDD-ALERT: Evaluating global level climate policy options and their local level implementation

Box 3



There are now discussions within the UN Framework Convention on Climate Change to try and develop ways to reduce emissions from deforestation and degradation (REDD).
A suggested mechanism is to reward countries that demonstrate a decrease in deforestation rates below a baseline based on average historical deforestation rates. However, it is unclear how these national-level rewards will overcome many pressures at the local level leading to deforestation, including the need to produce food, sustain livelihoods, and develop economies. Understanding these local impacts of international climate change policies is one of the key objectives of the REDD-ALERT Project.

For more information: redd-alert.eu

Box 4

GILDED (Governance, Infrastructure, Lifestyle Dynamics and Energy Demand) is a three year collaborative research project funded through European Union Framework Seven, running from December 2008-2011. It is led by the Macaulay Land Use Research Institute in partnership with the Potsdam Institute for Climate Impact Research (Germany), the Institute for Political Science of the Hungarian Academy of Sciences, the University of Groningen (the Netherlands) and The Institute of Systems Biology and Ecology, v.v.i. Academy of Sciences of the Czech Republic. This research will be undertaken by a multidisciplinary team: sociologists, psychologists, geographers and agent-based modellers working together to address the complex issues of household consumption, and responses to climate change.

The overall goal of GILDED is to identify socio-economic, cultural and political changes which could bring about a reduction in carbon-intensive energy demand from the household sector, in urban and rural communities across the EU. The focus of the project is on household consumption as a lens for understanding energy use patterns. Investigating individuals' lifestyle choices and their understanding of energy issues will provide insights into patterns of energy-related behaviours characterising emergent lifestyle types, and the particular drivers impacting on consumption decisions. The social, cultural and political contexts in which these behaviours are embedded will be addressed through analysis of the structural factors and actors (from local to EU level) including governance networks, physical environments, and materialised and institutionalised transport and provisioning networks. This combined 'top down' and 'bottom-up' perspective on household consumption will be utilised to inform the analysis of an energy-reduction initiative in each case study region. Principles derived from these studies will be utilised to structure agent-based models of policy implementation and change response. Resultant policy recommendations will describe the necessary changes at systemic level that need to be initiated in order to develop an environmentally-friendly European model of energy policies that respond to the expectations and needs of European cities and rural communities.

For more information:
gildedeu.org

Box 5

Agro-meteorological indicators project

An important issue in addressing climate change issues is how the information is communicated to stakeholders. A series of workshops was organised around Scotland at which land management stakeholders were shown graphs depicting different agro-meteorological indicators derived from observed weather data and the downscaled future projections. Indicators include such things as the dates on which a phenomenon occurred, i.e. the start and end of the growing season, the last spring frost, the end of field capacity etc. The aim was to find out what form of representation was most useful, and also to stimulate debate on the impacts of the projected future climate on farming systems and what adaptation strategies could be developed. Participants were able to interpret complex representations of information and to discuss their perceptions of how the climate has changed already and what they envisage as possible adaptation options.

For more information:
macaulay.ac.uk/LADSS/climate_change.html

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Analytical Group

Andy Midwood

With a team of highly experienced staff and extensive state-of-the-art laboratory facilities, substantial resources are available at Craigiebuckler to carry out environmental analyses related to plants, soils, water, gas and sediments.

Our Services

More than 50,000 samples are tested each year, of varying complexity, supporting both the Institute's research programmes as well as generating external income.

With a commitment to quality the laboratory has been ISO17025:2005 accredited since 1998. The Analytical Group is audited annually by the United Kingdom Accreditation Service to ensure continued compliance with this standard. A requirement of our accreditation is the participation in various inter-laboratory trials. These currently include AquaCheck, Contest and FAPAS schemes, as well as numerous informal schemes.

Our schedule of accreditation covers a wide variety of methods and much of our work is traceable to recognised international and national standards, achieved through the use of certified reference materials, which in turn ensures validation of our methodologies. Working in collaboration with the European Commission's Joint Research Centre: Institute for Reference Materials and Measurements in Belgium, we have been involved with the characterisation of a number of new certified reference materials and testing the stability/homogeneity of existing stocks.

Our multi-disciplinary capabilities enable us to offer a wide variety of specialist commercial analytical services with the external income generated by the Analytical Group providing a key income stream for the Institute. Often analytical work undertaken for the Aberdeen-based oil & gas sector is non-routine and involves 'problem samples'. It is here

that our in-house expertise separates Macaulay Analytical from many of our competitors. Our client list, however, is not restricted to the oil and gas industry and we undertake work for environmental consultants, the food industry, geoscientists, Scottish Environment Protection Agency and Local Authorities.

Working in partnership with Isotopic Ltd we deliver high precision radiogenic isotope analysis aimed at oilfield exploration. This work utilises our two thermal ionisation mass spectrometers and is used to improve understanding of reservoir layering, stratigraphy, reservoir provenance, reservoir characterisation and reservoir compartmentalisation.

Collaborative Research

Collaborative research forms an important aspect of our work and involves colleagues based in Universities and other research institutes. Within the UK we have collaborative links with the University of Aberdeen, including Oceanlab, their sub-sea research facility, Lancaster University and The University of Dundee. Worldwide we have partners in Sweden, Germany, Switzerland, France, Moldova, New Zealand, USA, Canada, China and Africa.

A typical example of the type of work undertaken for collaborative projects is compound-specific isotope analysis. This involves the analysis of phospholipid fatty acids (PLFAs), a group of compounds which can be used to characterise the microbial population in soils.

MacaulaySoils.com SoilTest

Macaulay Soils

Analysis of soils for a wide range of clients from private gardeners to farmers and professional landscape design companies is provided by MacaulaySoils.com. Analysis of soil pH, nutrient status (NPK) organic matter, nitrate status, electrical conductivity, elemental concentration including trace elements, and total carbon and nitrogen are offered.

For more information:
macaulay.ac.uk/analytical

Partners and Partnership Projects

The Macaulay Land Use Research Institute hosts staff from a number of different organisations and is a partner in many projects and initiatives. These include:

Aberdeen Centre for Environmental Sustainability (ACES)

ACES brings together natural and social scientists to carry out inter-disciplinary research on environmental sustainability. Founded in 2007, ACES achieves this by building from the strengths of two high-profile research institutions – the Macaulay Land Use Research Institute and the University of Aberdeen.

For more information:
aces.ac.uk

Biomathematics & Statistics Scotland (BioSS)

BioSS undertakes research, consultancy and training in mathematics and statistics to improve science and society through an understanding of variation, uncertainty and risk.

BioSS works closely with agricultural, environmental and biological research organisations in Scotland, plays a leading role in collaborative research programmes with UK universities and is one of the leading European groups in its field.

For more information:
bioss.ac.uk

Dee Catchment Partnership

The River Dee is considered to be the best example of a large natural highland river in Scotland. The catchment is relatively unusual in the UK in that it contains predominantly upland, semi-natural land use but has isolated areas of significant pressures on water and habitat quality related to agriculture and urbanisation.

The Dee Catchment Partnership is an independent association of agencies, organisations and individuals committed to the wise and sustainable use of the catchment's rivers, tributaries and lochs, as well as the habitats and species they support.

For more information:
theriverdee.org/

East Grampian Coastal Partnership (EGCP)

EGCP is a voluntary group of individuals, with representatives from local authorities, industry, conservation bodies, recreation and tourism groups, local residents and many others who have an interest in the future well-being of the local coast.

The East Grampian Coastal Partnership was set up to aid in the delivery of Integrated Coastal Zone Management in the area between Kinnaird Head, Fraserburgh and the mouth of the River North Esk, by St Cyrus.

For more information:
egcp.org.uk/

Global Land Project

Profound changes in the Earth's land surface are underway – mainly due to the activities of people. The goal of the Global Land Project is to understand these changes, and how they affect humans and the environment.

For more information:
globallandproject.org/

Water Scotland

The Macaulay Land Use Research Institute is currently helping to shape a new government initiative called Water Scotland that is currently being coordinated by Scottish Development International. Water Scotland will offer a gateway and one-stop shop to the wealth of experience and capability which Scotland has to offer in water for the international development banks and donor agencies.

For more information:
macaulay.ac.uk/waterscotland

Grampian Squirrel Group

The Grampian Squirrel Group's aim is to maintain Grampian as a core area for red squirrels in the UK. Squirrel monitoring programmes collect information on the distribution of red and grey squirrels, allowing areas of importance to be identified where habitat management or grey squirrel control may be beneficial to the goal of protection and conservation of red squirrels.

For more information:
grampiansquirrelgroup.co.uk

The North East Scotland Local Biodiversity Action Plan (LBAP)

LBAP takes action to conserve important species and habitats for our benefit and for future generations.

LBAP is a partnership of local authorities, environmental, forestry, farming, land and education agencies, businesses and many individuals with a common interest in conserving biodiversity in North East Scotland.

For more information:
nesbiodiversity.org.uk/

The Ørskov Foundation

The Ørskov Foundation is a charity set up to promote sustainable development for the poorest rural communities in the world.

This is achieved through the integration of agricultural education with community projects. Sharing knowledge, experience and information are key factors to enable people and communities to find their own solutions to the complex problems they face and move towards self-sufficiency on their own terms.

For more information:
orskovfoundation.org/

International Research Projects and Collaborations

The Macaulay Land Use Research Institute is involved in many international collaborative projects, often leading or co-coordinating the research. These include:

BESSA (Building Ecosystem Service Research Capacity in Semi-Arid Africa)

To help address poverty alleviation in semi-arid Africa. The objective of this project is to establish a network of researchers and a research agenda focused on developing methodologies and tools to analyse trade-offs and synergies between different ecosystem services. This work is part of the directed research programme Ecosystem Services and Poverty Alleviation (ESPA), funded by the Natural Environment Research Council, the UK Department for International Development and the Economic and Social Research Council. Led by the Macaulay Land Use Research Institute, BESSA is a partnership between the School of Biological Sciences – the University of Aberdeen, Environmental Sciences Department – the University of York, the World Agroforestry Centre, the University of Pretoria Centre for Environmental Economics and Policy in Africa, and the Biomechanical and Environmental Engineering Depart-ment – Jomo Kenyatta University of Agriculture and Technology, Kenya.

For more information:
bessa.macaulay.ac.uk/

Biodiversity in Chilean Temperate Rainforests

This multidisciplinary project funded by the Darwin Initiative is developing capacity for biodiversity conservation in the temperate rainforest region of southern Chile. The ongoing research is analysing the influence of fragmentation of primary forests on biodiversity. The partner organisations are the Macaulay Land Use Research Institute, Wildlife Conservation Research Unit, University of Oxford, Fauna Australis, Pontificia Universidad Católica de Chile and Corporación Nacional Forestal, Chile.

For more information:
temperaterainforests.net/en/

Building natural resource monitoring capacity in Ethiopia's key Afro-montane ecosystems

Co-ordinated by researchers from the Macaulay Land Use Research Institute, this Darwin Initiative assists countries that are rich in biodiversity but poor in financial resources to implement the Convention on Biological Diversity through the funding of collaborative projects which draw on UK biodiversity expertise. The project is a partnership between the Macaulay Land Use Research Institute, the University of Aberdeen, the Ethiopian Wildlife Conservation Authority, Wondo Genet College of Forestry and Natural Resources, Oromia Agricultural and Rural Development Bureau, Amhara Parks Development and Protection Authority, Bale Mountains National Park, Simien Mountains National Park, Guassa Community Conservation Area, Abune Yoseph Community Conservation Area, Forum for the Environment and Frankfurt Zoological Society.

For more information:
macaulay.ac.uk/CAMP/

GILDED (Governance, Infrastructure, Lifestyle Dynamics and Energy Demand)

GILDED is a three year collaborative research project funded through European Union Framework Seven Programme, running from December 2008-2011. Led by the Macaulay Land Use Research Institute in partnership with the Potsdam Institute for Climate Impact Research in Germany, the Institute for Political Science of the Hungarian Academy of Sciences, the University of Groningen in the Netherlands and The Institute of Systems Biology and Ecology, Academy of Sciences of the Czech Republic, the goal of the project is to identify social, economic, cultural and political changes which could help rural and urban households in Europe consume less energy.

For more information:
gildedeu.org/

HUNTing for sustainability

HUNTing for Sustainability is an interdisciplinary international research project financed by the European Union Framework Seven Programme, looking into the wider meaning of hunting in the 21st century. The project is being co-ordinated from the Macaulay Land Use Research Institute with partners from Frankfurt Zoological Society, Imperial College, London, Instituto de Investigación en Recursos Cinegéticos, Spain, the Norwegian Institute for Nature Research, Tanzania Wildlife Research Institute, Umeå University, Sweden, the University of Aberdeen, the University of Barcelona, the University of Ljubljana, Slovenia, the University of Stirling and the University of Zagreb. The project runs from January 2009 to June 2012.

For more information:
fp7hunt.net/

North Hunt: Sustainable Hunting Tourism in Northern Europe

North Hunt is a three year international project funded by the European Regional Development Fund which aims to support the development of sustainable hunting tourism to diversify the economic activities of peripheral regions in Northern Europe. Running from May 2008 to December 2010, North Hunt involves a partnership of ten organisations: the University of Helsinki, Ruralia Institute and Haapavesi Vocational School, Finland; the Swedish University of Agricultural Sciences and Umea and Rural Business Development Ltd; the Research Centre of the University of Akureyri, Iceland, the Icelandic Tourism Research Centre and Umhverfisstofnun; the Macaulay Land Use Research Institute and the University of Aberdeen, Department of Geography and Environment, and Newfoundland and Labrador Outfitter's Association, Canada.

For more information:
north-hunt.org/en/forsida/

International Projects

REDD-ALERT
(Reducing Emissions from Deforestation and Degradation through Alternative Landuses in Rainforests of the Tropics)

REDD-ALERT is a European Union Framework Seven project which aims to document the social, cultural, economic and ecological drivers of forest transition and conservation and analyse the local impacts of potential international climate change policies on greenhouse gas emissions, land use and livelihoods. Led by the Macaulay Land Use Research Institute, the project involves three European partners: The Université Catholique de Louvain, Belgium, Vrije Universiteit, Amsterdam, and Georg August University of Göttingen, Germany; four international CGIAR research institutes: World Agroforestry Centre (ICRAF) and ASB Partnership for the Tropical Forest Margins, Kenya; Centre for International Forestry Research, Indonesia; International Institute of Tropical Agriculture, Nigeria and Centro Internacional de Agricultura Tropical, Colombia plus four national research institutes: Indonesian Soils Research Institute, Indonesia; Research Centre for Forest Ecology and Environment, Vietnam, Institut de Recherche Agricole pour le Développement Cameroon and Instituto Nacional de Investigación Agraria Peru.

For more information:
redd-alert.eu/

REEF (Reproductive Effects of Environmental chemicals in Females)

REEF is an European Union-funded research project which will improve our understanding of how environmental chemicals and endocrine-disrupting compounds endanger reproduction and foetal development in the female. In addition to the Macaulay Land Use Research Institute, the project involves the University of Aberdeen, Martin Luther University, Germany, the French National Institute for Agricultural Research, the University of Milan and the University of Nottingham.

For more information:
abdn.ac.uk/reef/

RETPEC

This European Commission Sixth Framework INCO-DEV funded programme which started in March 2007 and will end in 2011, is investigating the biophysical and socio-economic impacts of policy-driven land use change in China's semi-arid regions. Range enclosure, livestock intensification and nomadic settlement are being implemented by the Chinese government at a scale involving millions of people and vast areas of land. The rationale is to restore degraded land, prevent desertification and improve pastoral welfare.

Coordinated by the Macaulay Land Use Research Institute the project involves the Chengdu Institute of Biology, China, the College of Pastoral Agriculture Science and Technology, China, Qinghai Academy of Animal and Veterinary Science, Tibet Academy of Agricultural and Animal Sciences, the University of Oxford, the University of Tromsø, Norway and the University of Leipzig, Germany.

For more information:
retpec.eu/

SMILE
(Synergies in Multi-scale Inter-Linkages of Eco-social systems)

Funded by the European Union Framework Seven Programme the project will further develop and apply the tools developed in previous work carried out by the project partners in a FP6 DECOIN project to analyse the trade-offs and synergies between different aspects of sustainable development. Assessment takes place between: economic and environmental aspects; economic and social aspect; social and environmental aspects, and between all three objectives. The project consortium consists of Turku School of Economics – Finland Futures Research Centre, University of Naples, Institute of Environmental Science and Technology – University of Barcelona, Amsterdam University, the Macaulay Land Use Research Institute, Institute for Economic Forecasting, Romania and Statistics Finland.

For more information:
smile-fp7.eu/

JANEEMO is an innovative 3-year project to develop a sustainable biofuels programme in the Lower Shire district of Chikwawa in Southern Malawi.

Three tree species, Jatropha, Neem and Moringa – collectively known as JANEEMO – are being grown by farmers on land not suitable for food crops and as living fences around households and fields, helping to protect soils from wind and soil erosion and livestock damage.

The trees all have multiple uses: their oil-rich seeds can be processed to produce oil for cooking and lighting, or turned into soap; the residue from this process can then be used to produce biogas for cooking; and then finally as an agricultural fertiliser. In addition, extracts from the Neem and Moringa trees have important nutritional as well as medicinal uses. Moringa leaves have more Vitamin C than oranges; more Iron than spinach and more Vitamin A than carrots and Neem is considered an effective insect repellant.

The JANEEMO project reduces livelihood vulnerability, builds thriving enterprises and delivers income generation, food security and renewable energy. The approach is delivered at the household level and encourages wider enterprise and trade beyond the village helping to builds local skills, knowledge and natural resources.

The project is being led by the Macaulay Land Use Research Institute, and is supported in Scotland by Climate Futures, a multidisciplinary carbon management and climate communication agency.

For more information:
janeemo.org/

Macaulay Scientific Consulting Limited

Macaulay Scientific Consulting Limited (MSCL) is the trading company of the Macaulay Land Use Research Institute, and advertises a wide variety of services performed by the Institute. Our portfolio of project work is diverse and, through the strength of our core competency as a scientific research-based company, we collaborate with conventional environmental consulting firms as partners and subcontractors. We also provide specialist laboratory analytical services to the oil and gas, environmental and food sectors and a range of research, consultancy and data services to UK and international public and private sector customers in land and environmental management, spatial planning and renewable energy.

Macaulay Scientific Consulting Limited

Annual Report 2008–09

Operating Environment

The nature and diversity of our projects has allowed us to weather the UK's economic downturn through consistent workflow. We appreciate that the business environment will continue to remain unsettled, particularly with regard to the outcomes and impacts of public spending reviews on our public sector client base and tightened spend within our private sector customers. Nonetheless, UK Government figures suggest that the national growth rate for renewable energy consulting is likely to reach over 6%, with environmental consulting and monitoring products and services expected to grow 2.5% over 2009/2010. A slight dip is forecast in following years but growth in these sectors is still well above annual inflation. This is encouraging, in that it signals that we are responding appropriately to Scottish and UK-wide policy and legislative drivers, although we will need to be vigilant in forward planning.

Outlook

Despite the financial downturn, we expect that we will continue to work for a number of agencies such as Scottish Natural Heritage and others to undertake environmental/site assesments and make long term change predictions. We have been engaged in work with Scottish Enterprise and Scottish Development International, and anticipate that these good working relationships will continue to grow in the future.

We have promising new technologies and services in the process of commercialisation, with attendant activities concerning intellectual property, patent planning and consideration of appropriate business models to take concepts to market. This is a 5 to 10 year-long series of activities that will require us to interact with a wider range of stakeholders than we have in the past, including seeking investment at appropriate times. Our membership of various professional business fora and partnership in the Genomia Fund and the Rainbow Seed Fund will greatly assist us in accessing specialist advice and assistance.

For more information:
macaulay.ac.uk/mscl

Research Station News

The Macaulay Land Use Research Institute's Glensaugh Research Station is situated at the eastern end of the Grampians and adjoins the Fettercairn-Cairn o' Mount road.

The research station comprises 865 hectares (ha) of semi-natural plant communities, 60ha of predominantly rotational grassland and 88ha of permanent pasture. The predominantly rotational grassland is reseeded with perennial ryegrass and white clover mixtures every 7 – 10 years. This provides grazing for the crossbred ewe flock, swards for experimental work, silage for winter feeding and aftermath grazing for finishing lambs.

Management Ethos

The primary land use activity at Glensaugh is commercial livestock farming. In line with industry trends, recent years have seen a reduction in stocking density and a corresponding reduction in inputs. The farm's management team is committed to developing the sustainable future of Glensaugh's resource base, reducing reliance on purchased inputs and securing future energy supply.

Long-term Measurement and Monitoring of Change

Glensaugh Research Station is one of the 11 UK sites in the Environmental Change Network (ECN). Measurements are being made of the long-term changes in dry and wet aerial deposition, water quality, soil characteristics, vegetation and wildlife. The ECN is sponsored by several UK government departments and agencies, and the Scottish Government and its agencies.

Sustainable Future

Recent work has focused on securing a source of renewable electrical power for the site and a 50kW wind turbine has been commissioned, part funded by the Scottish Government Rural Priorities grant scheme (SRDP). Restoration of the farm's own water supply will also be completed during 2009, ending the reliance on mains water. SRDP funding will also assist in the planting of nine hectares of new woodland, bringing shelter and biodiversity benefits as well as creating a potential fuel source.

The following newsletters (on following pages) have been compiled by Farm Manager, Donald Barrie and offer an insight into a year (October 2008 – September 2009) at Glensaugh.

6 – 17 October 2008

The "big job" of the moment is the submission of our Rural Priorities grant application, covering the wind turbine, woodland planting, public access trail and dyke rebuilding.

As well as planning the grant work we are also looking at other projects for 2009. The replacement of our farm water tank is on the cards.

The long awaited arrival of the Luing cows (our hill breed) allowed us to start the Scottish Government funded cattle grazing study. A period of benign weather has allowed the cows to settle in and so far our electric fencing has been respected and there have been no mix ups. The photograph shows a group of Limousin cross cows (our lowland breed) wearing their radio tracking collars. They are probably not accustomed to the moorland vegetation.

20 – 31 October 2008

The pre-winter destocking of Glensaugh continues with the recent sale of 43 suckled calves. Improved prices for finished cattle have strengthened demand for stores. Three cull cows have also been sold. Although young, these failed the Johnes disease blood test and are being removed from the herd. This costly disease is thought to be transmitted by rabbits (as well as other bovines) and our successful efforts to reduce the rabbit population might reduce its incidence in future years.

Our cattle grazing experiment continues to run smoothly. The four groups of six cows have now been moved in rotation and we are half way through the second two week observation period. The experiment will end on 19 November. The long awaited blood test results for the Thoka Cheviot flock have arrived. The purpose of this exercise was to genotype the breeding stock to identify heterozygous carriers of the Thoka gene for future breeding, and homozygous animals (which are incapable of breeding) for removal from the flock. From the farm's point of view this clears the way to dispose of unproductive stock prior to winter and also determines which animal will/will not be mated in November.

Finally, the photograph shows part of the dyke which we are hoping to rebuild under the grant scheme; this short section runs alongside the Lodge garden and we are using it as a "dry run" for the bigger job further down the field. While it is proving difficult to get this work to score "high" on paper, in reality it ticks many boxes: uses only natural materials available on site, creates livestock shelter, forms a useful microhabitat and above all is pleasing to the eye. The building in the background is the Lodge, the rear part of which we hope to renovate in time for next year's field season.

3 – 14 November 2008

We are about to start another production year as our Texel tups (rams) will shortly be introduced to the flock of crossbred ewes. In advance of this we have had our entire sheep flock dipped. This very important operation safeguards against the spread of sheep scab (a highly infectious disease caused by a skin burrowing mite) and also kills sheep ticks and other ectoparasites. The dipping has been carried out later than usual this year because our contractor has been held up with potato harvesting. The potato harvest has been one of the most difficult ever due to wet ground conditions and has tied up men and machinery for much longer than usual.

Scanning cows has just been completed and most are once again

confirmed in calf. Dovetailed into the scanning operation was a Department of Agriculture cattle ear tag check being carried out as part of our whole farm cross compliance inspection. A successful check of tags and passports has brought the inspection to a close.

Our autumn experimental programme continues to run smoothly. The cattle grazing study is now its third quarter. The sheep in the grazing experiment have been gathered and dipped; meanwhile their GPS collars have been temporarily removed to allow data to be downloaded and batteries changed. Work is about to get underway in the old deer plots on Cairn Henney where the tree browsing behaviour of six hinds will be observed. In the Animal House a met crate experiment is under way involving the feeding of a controlled diet to a group of 16 blackface lambs; this as an adjunct to the WP 2.5 grazing study.

Finally our annual forage analysis has been carried out by SAC. The results were returned with a complementary letter suggesting that our analysis was one of the better ones for the area. A significantly better fermentation seems to have been obtained by fine tuning how we seal the pit. While normally unenthusiastic about competition farming, this year we might be tempted to enter a sample into the annual North of Scotland Grassland Society silage competition.

17 – 28 November 2008

We are continuing to de-stock in advance of the onset of winter. Fattening sheep (lambs and cast ewes) are now running on a mixture of forage rape and stubble turnips. A supplement of concentrate feed is also on offer, the aim being to sell as many as possible before Christmas.

This quieter period of the year allows time for maintenance and improvement projects.

The planning application for the wind turbine project is also coming together, as hurdles like noise and flicker have been overcome. It looks as if all consents could be in place early in 2009, which will be a very busy year if all our projects go ahead.

Javier Perez-Barberia is setting up an interesting experiment on an exposed site overlooking the Slack Den. Two model animals (a sheep and a deer) will be built, containing monitoring equipment to determine heat loss through their skins. The Glensaugh staff recently built a fence round the plot; many quips about how this was to stop the "animals" from escaping, and questions about whose job it would be to feed them at the weekend!

1 – 12 December 2008

Glensaugh had an early taste of winter when a cold northerly outflow brought snow showers and 48 hours of sub zero temperatures. As we are not yet into our winter routine we were "caught on the hop", with cows still out on the hill and no winter feeding regime in place. The photograph shows our yearling heifers out in the Slack Den, covered in snow after foraging in the rushes. This group of youngsters, none of which are in calf, will have to fend for themselves for some time to come, but we have brought in-calf cows inside or on to feed sites for winter feeding.

Tup time (mating) for our crossbred ewes is all but over and we have now gathered our Blackface ewes for tupping. Meanwhile the Blackface hoggs (ewe lambs retained for breeding) have been housed and are receiving a ration of hay and concentrate. Snow at tup time is unusual, but ewes in fit condition will easily stand these conditions and forage for grass beneath the snow-cover.

The cattle grazing experiment has now ended and the cows have been disposed of. This project ran well

and enjoyed fairly benign but not atypical autumn weather. Thanks to all who participated and assisted in its smooth running.

15 December 2008 – 16 January 2009

The darkest days of the year have coincided with the early onset of winter. Regular night frosts have been a feature of recent weeks and Loch Saugh has been frozen over for some time.

On the farm we are continuing to sell from our small remaining pool of lambs and cast ewes, most of which have been finished on our field of forage rape. In January a number of Cheviot ewes will be moved to the Roslin Institute for further study, by which time our sheep numbers should have reached their seasonal low.

Our wind turbine planning application may be determined soon; we have now submitted the last of the documents requested by the planners, a series of photomontages of the proposed development which have been prepared for us and demonstrate how our small turbine looks in the environment.

During 2008 we have run some interesting experimental projects and have continued to maintain and develop Glensaugh's infrastructure base. Useful groundwork has been done for the

future development of the site and the Institute has demonstrated its commitment to developing Glensaugh for the longer term. We're looking forward to a busy and constructive 2009.

19 –30 January 2009

2009 has opened on a high note as our planning work in 2008 begins to bear fruit.

We have received confirmation from SGRPID that our grant application has been approved, which will provide support funding towards the wind turbine, woodland planting, drystone dyke repair and public access trail and interpretation. The first three items fit well with our philosophy of setting Glensaugh up

for a sustainable future while the public access proposal will provide a means of managing visitors to the property, who we hope will want to come to find out more about what we are doing as well as enjoying our local environment.

The drystone dyke pilot project (see photo) was completed on the day we received the good news about the grant application. The dyke replaces an earlier (and long time ruined) dyke on the same alignment. As well as providing shelter to livestock and the garden it has used up a lot of land gathered stone dumped at random along our field boundaries. The style of the new dyke is "Borders", reflecting the origin of the builder (it should be familiar to those of you who knew Sourhope), excepting the three mid courses of roughly dressed granite which is more characteristic of the north-east.

Our third piece of good news was notification from the North of Scotland Grassland Society that we have been awarded second prize in the pit section of their annual silage competition. The analysis of our silage was very good this year, and the judges were also impressed with the management of the site and the livestock feeding systems. This is a reflection on the attention to detail of everyone who works at Glensaugh.

2 – 13 February 2009

Winter livestock work dominates and we have started our vaccination programme against the blue tongue virus (strain 8), but strain 1 has appeared in continental Europe so vaccination could become part of the annual routine.

Planning consent has now been obtained for the wind turbine and a contract is being fine tuned with a view to it being erected in May/June. A management consultant has been appointed to undertake the woodland establishment work.

One of the traditional winter jobs of hill farmers and shepherds is mole catching. These burrowing mammals multiply rapidly in our artificially enriched environment and cause considerable damage to pasture if not controlled. In recent years control has been limited to a small area of the farm (Agroforestry site) and has been done by an outside contractor. We are now doing this work "in house" and are achieving reasonable success. The warren of tunnels suggests that the moles have had a fairly free hand up till now. Trapping is satisfying work and there is considerable skill in knowing where to place traps in a veritable maze of tunnels and galleries.

16 – 27 February 2009

Glensaugh has experienced its first prolonged period of snow cover since February 2001. This has added to the winter feeding routine with hay being offered to some of the Blackface ewes which have been blown off their own ground. There is no free lunch for these animals and efforts are being made to help them return to their own parts of the hill, or to ground from which the snow has been blown clear, often requiring routes to be dug through the deeper drifts. Storm feeding of hill sheep is only ever a stopgap measure and ewes are still expected to forage for themselves. Molasses-based mineral blocks are also used to supplement the diet of the hill ewes; their usefulness is open to debate because ewes congregate round them and their grazing patterns are disrupted.

These arguments would have been well understood by the shepherds who contributed essays to "Herding a Hill Hirsel" which was edited by my late great grandfather and published in 1929. While the basic common sense in hill sheep management has not changed much over the years, the time allowed for carrying out the annual routine has been cut drastically as shepherds' flocks have increased from 600 by a factor of at least two.

The pregnancy scanning of ewes is a recent technological innovation which has assisted management by allowing carriers of multiple foetuses to be segregated and receive preferential management. The crossbred flock was scanned recently, indicating a potential lamb crop of over 200% and many sets of triplets. While lambing is still some seven weeks away, the 2009 production year has already begun; two cows calved this week, both to our new Limousin bull, Butler.

16 – 27 March 2009

Calving is in full swing and we are approaching the half way stage. Once again cows are calving without difficulty and milking well, reflecting their body condition and nutritional status. Pregnancy scanning of ewes is now complete. Results indicate that a potential lamb crop of over 200% exists in the crossbred flock, and while this will not be achievable in practice we are satisfied

that conception rates have been good and pre-natal losses have been low so far.

The contract for the erection of the wind turbine is presently being negotiated. A series of technical meetings were held to discuss logistical details and agree a timeline for the works. Delivery of the wind turbine is the largest component of our SRDP grant scheme. The other parts include the public access trail and woodland planting.

Planting trees should be an annual event and although we have no big schemes for 2009, we are continuing to in-fill the Birnie Burn native woodland with oak and ash, and are also planting hedges of beech, box and yew in and around the garden at Glensaugh Lodge. Trees are a very important asset in our windswept environment, and we have an on-going commitment to plant more. Photographs from the past indicate substantial shelter belts to the north of the agricultural heart of Glensaugh, almost entirely lost to two world wars; their reinstatement is a worthwhile objective.

30 March – 10 April 2009

Preliminary investigation work is under way in advance of the construction of our wind turbine. A geotechnical survey is being carried out to determine the composition of the underlying bedrock (which is reported as "sound") although laboratory analysis is required to give us a complete report. The photograph shows the subcontractor's drilling rig as the second of two cores are drilled seven metres into the underlying rock. The results of the survey will influence the design of the foundation slab and ultimately the cost of the project as a whole.

A week of fine weather allowed us to do some useful heather burning on the Cairn hill. Further old growth has been burned off, as well as some small areas of new growth. The purpose of burning a little of the new growth is to improve the age structure of the sward and is analogous to the premature felling of conifers in a first generation forestry plantation. In our heather, the target age for burning is about ten years. If we maintain our present efforts all old growth should be gone in about another five years, by which time twelve years will have elapsed since we commenced systematic burning in 2002. While the sward structure is not yet ideal it improves every year.

13 – 24 April 2009

We are at the peak of the crossbred lambing, with ewes lambing at about one per hour. This will soon tail off as the lambing will not end until late April. Meanwhile many ewes are now at grass with their new-born. Calving has also gone with a rush, as only six now remain uncalved with over a month to go before the nominal end date of the calving period. A "tight" calving pattern is what we have been working towards over the years. The main benefit is being able to produce large batches of evenly-grown calves, but it is also important to bear in mind that the labour requirement is also reduced; it is more efficient to be busy for a short period than for the job to drag on for months.

27 April – 8 May 2009

Our first lambing (crossbreds) is virtually over and we are now into our second (blackfaces). The "blackies" as they are known colloquially are lambed out of doors and require less supervision that the crossbreds. Ewes with single lambs are returned to the hill within a few days of giving birth.

On the hill there are visible signs of new growth and heather burning finished on 15 April. The season ended well with a fail-safe north east wind and dry conditions allowing us to burn into new areas and further expand our

area of managed moorland. The photograph shows the burning pattern on the Cairn hill; this year's fires are the black patches. A large area of rank old growth was burned close to the top of the Cairn o' Mount which can be seen in the top left of the photograph.

We recently hosted a visit from a group of Aberdeen University biological sciences students. The theme of the visit was animal husbandry and welfare which we are well placed to talk about and have much to be proud of. A discussion about sheep husbandry took place in the lambing shed and there were some convenient lambs to hand to borrow from their mothers to use for illustration.

11 – 22 May 2009

The calving of our blue grey cows is over; cow L1 was last to calve, requiring minor assistance and can be seen in the photograph a few moments later displaying bovine 'motherly love'. Both mother and calf are now doing fine.

Lambing is now also nearly over. The crossbred ewes have finished and the majority of the Blackfaces have lambed. The Cheviots (Thoka flock) are about half way through. Deer will begin to calve soon, and meanwhile the 2008 deer calf crop has been weighed and tagged and the majority have been sold.

8 – 19 June 2009

We have entered the quiet post lambing interlude. Crossbred ewes and lambs have been dosed for worms and moved off our silage fields. These fields have been rolled, fertilised and will be ready to cut in about six weeks from now. All our cows are now outside, and have been weaned off silage as grass growth rates have increased to meet their considerable demands. The bulls are now running with the cows and are being watched closely to ensure that they are serving cows. Our oldest bull, Perry, is now in his tenth year (about 70 in human years) and a new bull has been purchased to replace him.

A significant event in Kincardineshire has been the reopening of Laurencekirk railway station which is only seven miles from Glensaugh. Laurencekirk was once a thriving service centre and has not entirely lost this role. The station is a significant and positive gain to Laurencekirk and the wider community.

20 – 31 July 2009

We are working through one of the year's busiest periods. Shearing our sheep coincides with silage making and a continuing maintenance programme.

Shearing is now almost complete as we work through the Blackface flock. At the same time as shearing we dose the lambs for worms, apply a topical insecticide and run all our animals through the footbath, setting the flock up for the final month before weaning in early August.

The making of good silage requires us to predict the weather for about four days ahead and this is always fraught with difficulty. Failing to make a start in anticipation of bad weather, only to have a succession of dry days is almost as frustrating as making a start and being rained off. After cutting most of our crop a thunderstorm gave us 27mm of rain in little over an hour. Our understanding contractor allowed a 48 hour layover by which time the crop had dried sufficiently for us to ensile it. It should produce a high quality feed with little or no effluent. The weather improved sufficiently for us to contemplate making our fifth and final field into hay. Modern bale wrapping technology allows a fall back option and we eventually decided to bale and wrap the crop as "haylage" which will have a dry matter content of around 60%.

Our new water tank has been installed and is now full. The tank is filled from the bottom, which is possible because of the pressure in the feed pipe. In theory this should keep the water in the tank, which is continually welling up from below, fresh and prevent stratification. When the tank eventually overflowed it came as a huge relief and put paid to many suggestions that the scheme wouldn't work – "trying to make water run uphill, etc.", but common sense and an O Grade in Physics carried the day.

One of the threads of our Rural Development scheme is to improve and encourage public access. The development of our informal public access trail is continuing and work should be completed in the autumn.

3 – 14 August 2009

We are in the "quiet" holiday period when cattle and sheep are grazing contentedly, silage is all made and living should be easy. Against this backdrop summer maintenance is continuing. The desludging of the waste water lagoon after about fifteen years of service was a necessary but unpleasant task. A mixture of rotten leaves and floating vegetation was sucked out by vacuum tanker, which should keep things under control for another few years. It is a good reminder that when we build infrastructure we have to remember to maintain it, and that left to nature everything we build will eventually be colonised by vegetation and ultimately destroyed.

A more pleasant job was the completion of the new water tank [below]. The overflow (which also doubles as a garden feature for Bows Cottage) discharges about 8,000 litres of water per day into the drainage system of the adjoining field. Now that we have more water than we need the next challenge is to bring this up to a potable standard and switch our domestic supplies on to this system. Glensaugh Lodge will be the first to go, where we already enjoy the benefits of unlimited irrigation water in the garden.

31 August – 11 September 2009

We are now all back to work and pressing ahead with seasonal stock work and various maintenance projects.

All of our crossbred lambs were weaned in early August and a small number have now been sold. We are now weaning our Blackface lambs, which will be sold in mid September.

Part of the red deer husbandry routine is the de-antlering of our five stags. This is done for safety reasons, to prevent injury to humans and to other deer. The penning of the stags (much prone to posturing) can be a nerve wracking job, but once in the handling crate the removal of the antlers is an easy task and is done using a bone saw.

For more information:
macaulay.ac.uk/glensaugh

Open Doors 2009

THE MACAULAY LAND USE RESEARCH INSTITUTE
OPEN DOORS
SATURDAY 6 JUNE 2009
People and Environment

On Saturday 6th June, the Macaulay Land Use Research Institute opened its doors to offer members of the public, representatives from partner organisations and friends and relatives of staff and students an opportunity to visit the Institute, find out about our research programmes, discover the range of work we undertake in our research laboratories and facilities, and explore our grounds.

Insect trails, storytelling and a wildlife detective course were available for younger visitors with all visitors able to undertake a self-guided arboretum tour of the estate and grounds and tour an internal exhibition.

The internal exhibition was arranged into six hubs, each of which covered a different area of our work.

Health and Environment Hub

Visitors to this Hub were able to discover how the environment, and our general surroundings, affects us.

Current research focuses on understanding the environment and measuring and monitoring the health of our soils and water.

We also conduct research on what nature means to people. We believe that better environmental policies require a better understanding of public views on the natural environment.

Analysing our Environment Hub

Visitors to our state-of-the art laboratory facilities were able to discover what analysis can reveal about the environment; from understanding how Scotland's soils may respond to climate change to fighting crime, and searching for oil under the North Sea.

Future Climate: Future Environment Hub

The study of the impacts of climate change and how we can best adapt to it requires an integrated approach by many scientific disciplines. A shared understanding of the specific climate change challenges relative to a particular sector is a vital foundation to achieve support for changes to current policies and practices.

Current work at the Macaulay Land Use Research Institute looks at the relationships between climate change, people and the environment.

Visitors to this Hub were able to enter our Climate Controlled Growth Rooms which allow us to alter the heat, light and atmosphere to study how plants grow in different climates. This is important as the trees, crops and plants we grow in Scotland might change in the future due to climate change.

National Soils Archive

The National Soils Archive is a long term store of representative soil samples from all over Scotland. The soil samples are a reference to the state of the soils in the past and are used to test new analyses and to check if soils are changing over time.

Many visitors to this Hub were surprised to learn that soil is alive – in fact there are more living things in just one teaspoon of soil than there are people on the planet.

Like all living things, soil can become unwell and even die if it is not looked after properly. This would be bad news for us because soils play a crucial role in almost every aspect of our lives. If we didn't have healthy living soil we wouldn't have food to eat, or freshwater to drink.

Future Landscape Hub

Transport, housing, energy and flood prevention are issues that affect us all, and imaginative solutions to these will need to come from a wide range of ideas. If we are to succeed, new planning and sustainable development policies require the full understanding and involvement of local people.

Visitors to this Hub were able to participate in a simulated planning decision process using our Virtual Landscape Theatre.

Younger visitors were also able to participate in planning policies by playing Pipe Dreams to decide if land should be used for crops, forestry, natural vegetation or livestock.

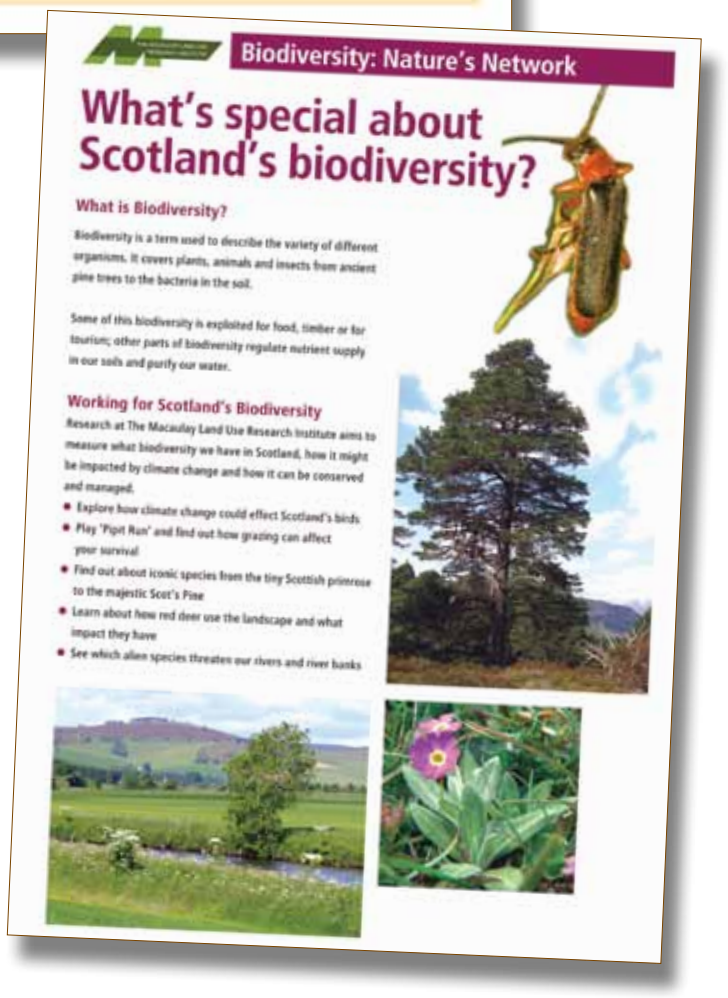
Biodiversity: Nature's Network Hub

Scotland's natural heritage can be best protected and enhanced through the evidence provided by research.

We need to understand what biodiversity is present, and what regulates interactions within and between species, as well as between species and their environment. We also need to determine how biodiversity might be impacted by climate change and how it can best be conserved and managed.

Visitors to this Hub were able to discover some of our research work using Global Positioning System (GPS) collars to monitor foraging and ranging behaviour in livestock and social behaviour in reindeer and some of our work relating to insect conservation.

If you missed the event, more photographs taken at Open Doors along with several exhibition posters are available at: macaulay.ac.uk/OpenDoors2009/



MLURI in the Media

A regular presence is maintained in both local and national broadcast and printed media to promote the Institute's scientific output and enhance our profile and reputation.

Evening Express · Piper · Piper · Herald · Daily Record · Shooting Times · The Courier · The Daily Telegraph · The Scotsman

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Media Coverage 2009

The Daily Telegraph
22 January 2009
Red deer at risk from mating with imported Japanese breed
Scotland's wild red deer may be lost if they continue breeding with a foreign species, scientists warned yesterday.

The Scotsman
22 January 2009
'Alien' threat to iconic red deer
Scotland's most iconic animal is under threat because it is breeding with an alien species, scientists have discovered.
Also reported on BBC News Online and in the Scottish Daily Mail, 22 January 2009

Shooting Times
29 January 2009
Red-sika hybrids are on the up
Research reveals worrying evidence of cross-breeding between these deer species. New research has revealed the extent to which Scotland's indigenous red deer are breeding with non-native Japanese sika deer. Scientists at the University of Edinburgh studied the DNA of 735 deer from the Kintyre region. The research which was funded by the Natural Environment Research Council and the Macaulay Institute, was published in the journal Molecular Ecology on 20 January and showed for the first time the cross-breeding between red and sika deer.

Aberdeen Evening Express
3 February 2009
Kids asked to snap up scenic winner
Pupils are being invited to take photos of North-east towns and countryside.
Also reported in the Aberdeen Press & Journal, 10 March 2009 and 25 March 2009

Inverurie Herald
5 February 2009
Pupils challenged to capture some Moments in Time
Schoolchildren in the area are being challenged to photograph a local scene to preserve it on record for future generations. The Macaulay Land Use Research Institute in Aberdeen this week launched a Moments in Time competition which invites youngsters in Aberdeen and Aberdeenshire to capture a view of their town, city or the countryside to demonstrate how people in the North east lived and worked in the early part of the 21st century.

Aberdeen Evening Express
5 February 2009
School News
Schools have been invited to enter a landscape photography competition.

BBC Reporting Scotland
26 February 2009
Dr Lorna Dawson explains the pitch invasion at Aberdeen Football Club's Pittodrie Stadium by 'leather jackets' the larvae of the Crane Fly, or Daddy Long-legs.

Seminar to explore public interpretations of countryside access rights
Research into how we perceive our right to roam the countryside will come under the spotlight at a seminar at the University of Aberdeen today. Legislation introduced in 2003 has given the people of Scotland what are considered to be some of the best countryside access rights in the world and mean that people have greater freedom in using the countryside. Research by the Macaulay Land Use Research Institute in Aberdeen has focused on the challenges this legislation has brought with it. In particular, the affect it has had on how walkers and mountain bikers using the same space of countryside interact with one another.
Reported in the Aberdeen Press & Journal, 4 March 2009 and on STV News Online, 5 March 2009

Knowledge Scotland
A novel approach to keeping policy makers in touch with the latest research on food, health, environment and rural sectors was launched this week. The 'knowledgescotland' programme is designed to help scientists work more effectively with government and others planning Scotland's future.
Reported in Scottish Farmer, 7 March 2009

Inverurie Herald
12 March 2009
Capture a Moment in Time for Institute competition
The Macaulay Land Use Research Institute is challenging primary and secondary school children in the area to get their camera out and capture a 'Moment in Time'.

MLURI in the Media

BBC Radio Scotland 'Out of Doors'
22 March 2009

Solving the jelly mystery

Have you seen blobs of a strange jelly-like substance appearing across the countryside? Dr Andy Taylor discussed what it could be…!

New Members Elected to Macaulay Institute's Board of Governors

Macaulay Land Use Research Institute, in Aberdeen today announces the appointment of seven new members to its board of governors.

Reported in the Aberdeen Press & Journal, 7 April 2009

International Scientists Gather in Aberdeen for First Plant Interaction Conference

Ecology experts from across the globe are gathering in Aberdeen today for the first ever international conference on positive plant interactions. The two day event, The British Ecological Society (BES) Symposium 2009: Facilitation in Plant Communities, has been organised jointly by the Society and the internationally renowned, Aberdeen-based Macaulay Land Use Research Institute and will take place at the University of Aberdeen from 20–22 April 2009.

Reported in the Aberdeen Press & Journal, 20 April 2009

Best Selling Local Crime Author to Meet With Real-Life CSIs

Crime fiction will come face to face with science fact on the evening of 5th June as the work of local crime writer Stuart MacBride is put under the microscope by a group of real-life CSIs. The Macaulay Land Use Research Institute is inviting you to delve into the science behind fictional crime when it presents, Murder, Mystery & Microscopes.

Reported in the Aberdeen Press & Journal, 21 April 2009

Seminar to explore methods to prevent agricultural pollution

Research into the design and implementation of land and agricultural management strategies to improve water quality and reduce treatment costs will be highlighted at a seminar at the Macaulay Land Use Research Institute tomorrow.

Reported in the Aberdeen Press & Journal, 25 April 2009

Inverurie Herald
14 May 2009

Climate change experts meet in North east

Experts in climate change gathered in Aberdeen recently to discuss how best to measure green-house gas emissions in North east Scotland.

Also reported in the Aberdeen Press & Journal, 30 April 200, 1 May 2009 and 2 May 2009. Also reported in the Turriff & District Advertiser, 8 May 2009

Scottish north-east under microscope in GILDED project

The EC 7th Framework Programme project GILDED, (Governance, Infrastructure, Lifestyle Dynamics and Energy Demand: European Post-Carbon Communities) has been launched.

Reported in the Aberdeen Press & Journal, 18 May 2009

Reducing Greenhouse Gas Emissions from Rainforests

Scientists from the Macaulay Land Use Research Institute are travelling to Indonesia next week to take part in the first meeting of a group investigating carbon emissions from tropical rainforests.

Reported in the Aberdeen Press & Journal, 21 May 2009

Scottish Daily Record
21 May 2009

CSI: Forfar

Dr Lorna Dawson uses skills she learnt on father's potato farm to help capture criminals.

Donside Piper & Herald
22 May 2009

A world without oil or gas

Pupils at Aboyne Academy have been given a unique insight into a world without oil or gas by learning more about the new biomass boiler on their doorstep.

Aberdeen Evening Express
23 May 2009

Malawi shoot for director

An Aberdeen research centre has chosen a BAFTA nominated director to shoot a film in Malawi.

The Scotsman
23 May 2009

Scots scientists join global enquiry on forests' carbon emissions

Scots scientists will travel to Indonesia next week to take part in the first meeting of a group investigating carbon emissions from tropical rainforests. The researchers from the Macaulay Land Use Research Institute will be taking part in the Reducing Emissions from Deforestation and Degradation through Alternative Land uses in Rainforest of the Tropics (Redd-Alert) project.

Aberdeen Evening Express
30 May 2009

Institute opens doors to public

A science centre is opening its doors to the public.

Aberdeen Evening Express
30 May 2009
Top authors to visit Aberdeen
The works of north-east crime writer Stuart MacBride will be under the spotlight at the Macaulay Land Use Research Institute at Craigiebuckler, where three of Scotland's leading forensic experts will reveal the science behind the stories.

Aberdeen Evening Express
2 June 2009
Date with success for young snappers
Youngsters at three North-east schools have snapped their way to success in a photography competition. The pupils were all winners in the Macaulay Land Use Research Institute's Moments in Time contest.

Aberdeen Evening Express
3 June 2009
5 THINGS YOU MUST DO
1. MURDER, MYSTERY AND MICROSCOPES
The science behind the stories with crime writer Stuart MacBride and three of Scotland's leading forensic experts.
5. MACAULAY OPEN DOORS DAY
Macaulay Land Use Research Institute, Craigiebuckler, Aberdeen, fun and educational activities including insect trails, face painting, goo making, role playing and story-telling.
Also reported in the Aberdeen Citizen, 3 June 2009 and the Aberdeen Press & Journal, 4 June 2009

The Daily Telegraph
6 June 2009
Cuttings
Open doors day, 10.30am – 4.30pm, Macaulay Land Use Research Institute, Craigiebuckler, Aberdeen. Free soil and water analysis, fun children's activities.

Aberdeen Evening Express
6 June 2009
Open Day
Macaulay Land Use Research Institute, Craigiebuckler, Aberdeen.

Inverurie Herald
11 June 2009
Two speakers at Oldmeldrum Rotary
The two speakers for the evening were Grant Davidson from the Macaulay Institute and Rotarian Bob Ørskov, who came to enlighten members about the work of the Ørskov Foundation.

Deeside Piper & Herald
3 July 2009
A century of changes at Muir of Dinnet
Historic and contemporary photographs of the Muir of Dinnet formed part of an exhibit investigating landscape change at the Royal Highland Show at the weekend. Recent research by the Macaulay Land Use Research Institute in Aberdeen aims to reveal the type and extent of changes in the Scottish landscape over the past century.

Aberdeen Based Students Win Bursary to Attend British Science Festival
Two Aberdeen based students have battled it out against other science loving students to win a bursary to attend this year's British Science Festival, one of Europe's largest science festivals.
Reported in the Aberdeen Press & Journal, 28 July 2009

BBC Radio Scotland
5 August 2009
Prof Steve Albon Comments on Improved Pass Rates for Standard Grade and Higher Science Examinations
"I am greatly encouraged by the news that Scottish pupils have improved their pass rates in science subjects this year. Youngsters are the future of science in Scotland and it's important that we support and develop these skills all the way through higher and further education."

BBC Radio Scotland
15 August 2009
Jason Owen discusses how to get the most from your soil as part of National Allotment Week.

Institute Confirms Tragic Death of Professor Simon Thirgood
It is with great regret that the Macaulay Land Use Research Institute can confirm an employee has died while working in Ethiopia. Professor Simon Thirgood, 46, from Aboyne, Aberdeenshire died at the weekend when the building he was in collapsed following a storm.

BBC Scotland 'Out of Doors'
4 September 2009
Fungal Forays
Autumn is a great time to learn more about fungi with many organised walks throughout Scotland. Fungi plays a vital role in keeping soil healthy, providing plants with the nutrition they need, and they are attracting more and more of us out to the great outdoors. Dr Andy Taylor talks about some of the fungi found in Scotland and explains the dangers they can pose.

Dundee Courier and Advertiser
25 September 2009
Aiming to count country's worms
SCRI and Aberdeen's Macaulay Land Use Research Institute are joining forces to conduct a study on Scottish farms which may help scientists understand how climate change is affecting the earthworm population.

Aberdeen Evening Express
26 September 2009
Survey of earthworm population
Researchers from the North-east are to count earthworms in a bid to learn how climate change affects their population.
Also reported on BBC News Online and in the Aberdeen Press & Journal, 25 September 2009 and the Glasgow Herald, 26 September 2009

MLURI in the Media

Getting away with murder at Robert Gordon University

In a society where crime fiction is one of the best audience pullers for film, TV and paperback, it's no surprise that an opportunity to find out about the perfect murder is proving so popular in the North-east of Scotland.

Around 300 members of the public are expected to attend a sold out 'Murder, Mystery and Microscopes' event which is taking place as part of TechFest at Robert Gordon University.

Reported in the Aberdeen Press & Journal, 28 September 2009

The Scotsman
29 September 2009

Scots scientists researching CO_2 levels win £500k grant

Scottish scientists have been awarded a grant of almost £500,000 to discover whether climate change could have an impact on carbon dioxide being released from Europe's soils.

Also reported in the Aberdeen Press & Journal, 28 September 2009

Science Institutes Join Forces

The Scottish Crop Research Institute (SCRI) and the Macaulay Land Use Research Institute have agreed in principle to unite, strengthening Scotland's rural-environmental research capacity and further enhancing their international competitiveness.

It will be the first institute of its kind in Europe and the new organisation is expected to create an international office to reinforce its global presence.

Reported in the Aberdeen Press & Journal, 6 October 2009, 7 October 2009 and 10 October 2009

Dundee Courier & Advertiser
7 October 2009

SCRI and Macaulay to form 'super institute'

The Scottish Crop Research Institute (SCRI) and the Macaulay Land Use Research Institute (MLURI) have agreed to merge to form a 'super institute' capable of competing on the international stage.

Also reported in the Dundee Evening Telegraph, 6 October 2009, the Glasgow Herald, 7 October 2009 and Donside Piper, 30 October 2009 and on BBC News Online, 6 October 2009 and STVNews Online, 7 October 2009

Dundee Courier & Advertiser
7 October 2009

Vital role on agri-science

Co-operations already exists between the Scottish Crop Research Institute at Mylnefield, Invergowrie, and the Macaulay Land Use Research Institute. Prodded by the Scottish Government, both organisations have agreed to combine their resources.

The Scotsman
7 October 2009

Plan to create Scots science powerhouse is unveiled

Two of Scotland's leading science institutes are to join forces to create Europe's foremost centre for research into food, land use and climate change, it was revealed yesterday.

Smart Science Boosts the Economy

Pioneering work on human gut disorders potentially worth billions, the development of livestock vaccines and grazing systems to benefit farming, DNA fingerprinting tests to improve water quality and the use of 3-D imagery to inform planning assessments.

These are just a few ways the Scottish Government's Science Institutes transform knowledge into innovative products and support Scotland's economy – as highlighted in a report published today.

Reported in the Aberdeen Press & Journal, 9 October 2009

Dundee Courier and Advertiser
9 October 2009

New 'super institute' attracts another research ally

Who said finding the perfect career isn't science?

Science-based toys such as chemistry sets are a huge hit with children, and have been for years. So why is it that so many grow out of their interest in science?

If you like travelling around the world, meeting interesting people and making a difference to the planet then perhaps a career in science could be for you. Bob Ferrier, a hydrochemist at the Aberdeen-based Macaulay Land Use Research Institute has done just that.

Reported in the Aberdeen Press & Journal, 13 November 2009

The Scotsman
6 November 2009

Butterflies and beetles blow hot and cold as climate change makes mark

Butterfly species that usually like warmer climates south of the Border have been found in growing numbers in parts of Scotland, a 15-year study has shown. Scientists believe that some species of butterflies are migrating north as climate change causes warmer temperatures.

Also reported on Environment Times online, 9 November 2009

The Scotsman
18 November 2009

New flood warming system planned

Communities hit by devastating flooding earlier this month could be the focus of a new study aimed at improving warnings systems ahead of bad weather.

Dundee Courier & Advertiser
18 November 2009

£60,000 flood warming study

Research into ways of improving flood warnings have been ordered by the Scottish Government. The £60,000 project by the Macaulay Land Use Research Institute, Aberdeen, will study the best way of getting flood warnings to the public, local authorities and emergency services.

Aberdeen Evening Express
18 November 2009

'E-mails and texts could warn residents of floods'

Also reported in the Aberdeen Press & Journal, the Glasgow Herald, the Paisley Daily Express, and Public Servant Scotland, and on teletext and BBC News Online, 18 November 2009

Register for coastal green tourism event

Local residents and businesses with an interest in the coast are invited to the East Grampian Coastal Partnership's Annual Seminar. The meeting is free to attend and will be held on 24th November at the Macaulay Land Use Research Institute in Aberdeen.

Reported in the Aberdeen Press & Journal, 19 November 2009

BBC Radio Scotland 'Out of Doors'
28 November 2009

Rachel Helliwell, Alison Hester and Justin Irvine interviewed at a workshop held to explore impacts on biodiversity in the uplands.

Celebrating World Soils Day: Institute announces completion of national soil sampling project

Results of a national inventory of Scotland's soils will provide scientists with invaluable evidence on climate change.

The Macaulay Land Use Institute has completed a national soil sampling project which it will use to compare with samples taken 25 years earlier from the same locations to investigate the impact of climate change on our soils.

Reported in the Aberdeen Press & Journal, 1 December 2009 and the Scottish Farmer, 12 December 2009

Event to highlight land based waste management solutions

Research into potential land based waste management solutions will be highlighted at an event today when waste management practitioners from across the north of Scotland meet at a Chartered Institution of Wastes Management seminar hosted by the Aberdeen based Macaulay Land Use Research Institute.

The seminar, 'Too good to (be) Waste' will examine issues derived from the Zero Waste agenda. In particular, the policy, legislative and practical considerations of putting products derived from waste to land will be highlighted.

Reported in the Aberdeen Press & Journal, 1 December 2009

BBC Reporting Scotland
8 December 2009

Jeff Wilson and Steve Hillier feature in a story on Macaulayite

The Scotsman
9 December 2009

Ever wondered if there's life on Mars?

Samples of a rare bright mineral are now being tested by scientists from the Nasa space agency in the search for clues about the possibility of life on Mars. The compound, named Macaulayite by the scientists at Aberdeen's renowned Macaulay Land Use Research Institute who first identified the rare rock, could be the same type of mineral which gives Mars its distinctive colour.

Also reported in the Aberdeen Press & Journal, Irish Sun, Metro Scotland, Scottish Daily Express and Scottish Daily Mirror, and on BBC News Online, Cryptozoology Online, DailyIndia.com and Northsound1.com, 9 December 2009, and in the International Business Times, 10 December 2009, Wales on Sunday, 13 December 2009 and Inverurie Advertiser, 18 December 2009

BBC 2 'Landward'
18 December 2009

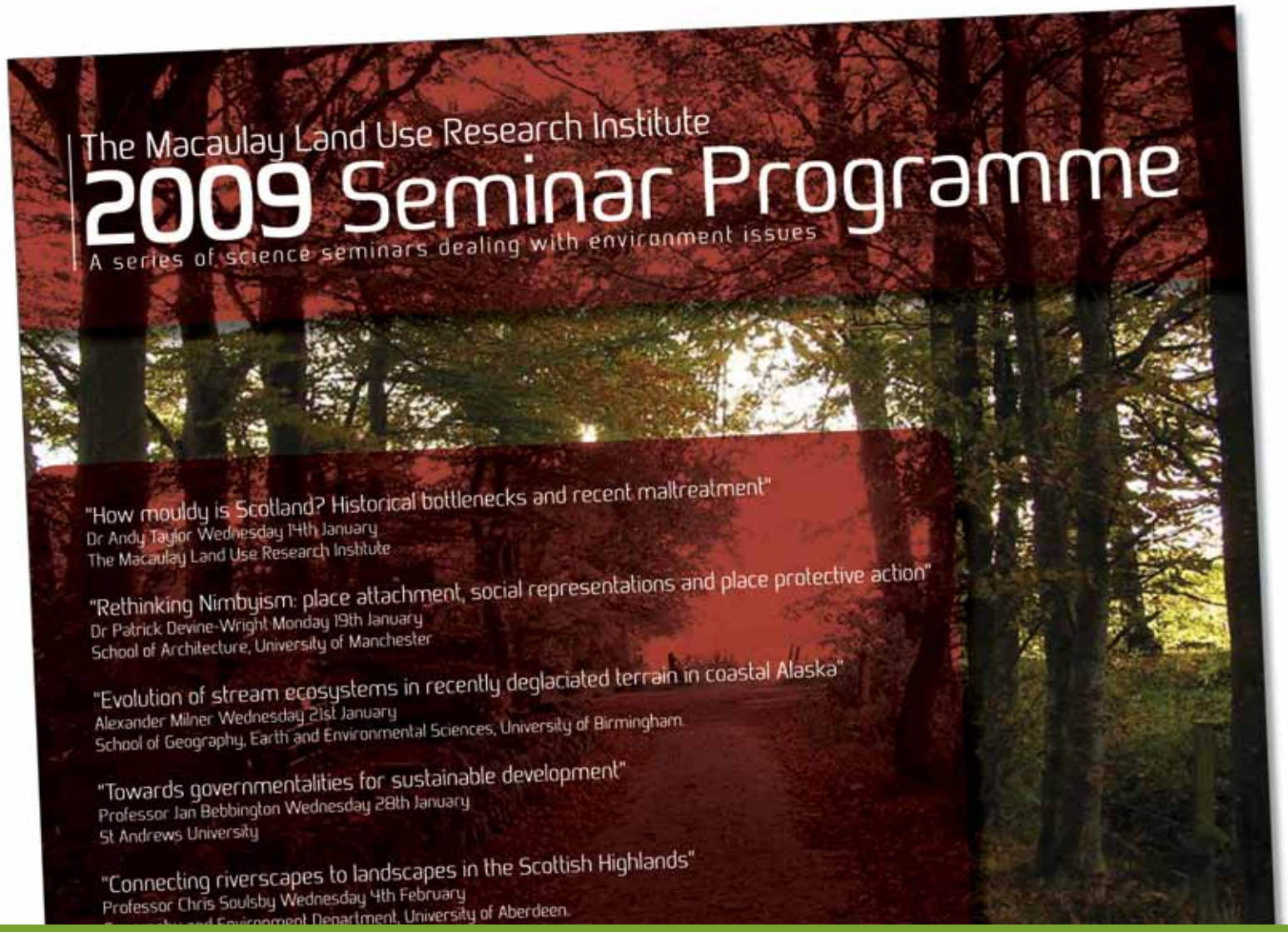
Dr Simon Langan talks to Dougie Vipond about the Institute's flood risk management research.

Institute raises money for cancer charity

Staff from the Macaulay Land Use Research Institute presented a cheque for nearly £1,200 to Friends of ANCHOR, a cancer care charity in Aberdeen. The money was raised during a Quiz Night held at the Institute and was presented to Friends of ANCHOR fundraising manager, Fiona Pearson, during a visit to the Institute.

Reported in the Aberdeen Press & Journal, 23 December 2009

Events and Seminars



As part of our commitment to sharing our knowledge and scientific output, many of the events that we organise or attend bring together experts and interested organisations from across Scotland, as well as internationally, to hear and discuss our research findings and their implications.

Information exchanges offer Government, Local Authorities, landowners and communities an opportunity to make use of our evidence-based policy in understanding the potential of land and informing decisions on how land is used in the future.

*** All the listed events were held at the Macaulay Land Use Research Institute, Aberdeen unless stated.**

Participation in Events 2009

12 February 2009
'Happy Birthday Darwin'
A presentation by Dr Lucy Gilbert, Ecological Epidemiologist.

20 – 22 April 2009
British Ecological Symposium 2009
University of Aberdeen
This was the first ever international meeting dedicated to the rapidly expanding field of facilitation (positive plant-plant interactions) in plant communities.

30 April 2009
Visitor Seminar:
'Mitigating agricultural and moorland water pollution in drinking water supply catchments in northern England'.
Paul Kay, the University of Leeds

5 – 7 May 2009
'Predicting the Future for Highly Organic Soils'
British Society of Soil Science Spring Conference Heriot-Watt Campus, Edinburgh

21 May 2009
Visitor Seminar: 'From Turning the Tide to the Durham Heritage Coast'
Niall Benson, Project Manager for the Durham Heritage Coast, visited the Institute to discuss his work regenerating an interesting piece of coastline in North East England.

5 June 2009
33rd TB Macaulay Lecture: 'Living on a Shrinking Planet: Challenges and Opportunities for Sustaining Global Land Use'
Professor Jonathan Foley, University of Minnesota
Land use has generally been considered a local issue, but is becoming a force of global importance. We face the challenge of managing trade-offs between immediate human needs and the long-term capacity of the biosphere to provide necessary goods and services.

5 June 2009
Murder, Mystery & Microscopes: Unearthing the science behind crime fiction

6 June 2009
Open Doors
Members of the public were invited to visit the Institute to find out about our research programmes, the work we undertake in our research laboratories and facilities, and explore our grounds.

25 – 28 June 2009
'A century of change in the Scottish landscape'
Royal Highland Show
Ingliston,
Edinburgh

3 September 2009
Rural Law Conference: Land Reform in Scotland: 10 Years of a Scottish Parliament
University of Aberdeen

5 – 10 September 2009
Murder, Mystery & Microscopes: Unearthing the science behind crime fiction
British Science Festival
University of Surrey,
Guildford

26 September 2009
Murder, Mystery & Microscopes: Unearthing the science behind crime fiction
Techfest,
Aberdeen

7 – 8 October 2009
Science Policy Success
Our Dynamic Earth, Edinburgh
Two day conference and workshops organised by SCRI and the Moredun Research Institute supported by RERAD as part of the Knowledge Scotland initiative.

31 October 2009
'Today's Geography – Tomorrow's World'
The Scottish Association of Geography Teachers' Annual Conference
Edinburgh

9 November 2009
Rural Land Summit
Inverness
In September 2008, Rural Affairs Cabinet Secretary Richard Lochhead launched a comprehensive review of land use in Scotland to map out suggested uses for rural land across the country and ensure every part of it is being put to best use, whether through agriculture, tourism, housing, industry, forestry, renewable energy or a variety of other ways.

This work has culminated in a Rural Land Use Summit which brought together experts and interested organisations from across Scotland to hear and debate the findings and their implications. Information coming from the research and the summit will provide an evidence base for Government, local authorities and communities to make use of in understanding the potential of their land and informing their decisions on how it is used.

11 November 2009
Science and the Parliament
Our Dynamic Earth,
Edinburgh
An opportunity for the science and political community to come together to discuss some of the key issues facing us today.

For more information on future events: macaulay.ac.uk/events

The 33rd Macaulay Lecture

Professor Foley, Director of the Institute on the Environment at the University of Minnesota, was warmly welcomed to the Macaulay Land Use Research Institute to give the 33rd Macaulay Lecture.

His work focuses on complex global environmental systems and their interactions with human societies. He and his students have contributed to our understanding of large-scale ecosystem processes, global patterns of land use, the behaviour of the planet's climate and water cycle, and the sustainability of our biosphere.

The presentation, *'Living on a Shrinking Planet: Challenges and Opportunities for Sustaining Global Land Use'*, addressed the challenges of managing trade-offs between immediate human needs and the long-term capacity of the Earth to provide food, clean water, and to regulate the climate.

Land use has generally been considered a local issue, but is becoming a force of global importance. Worldwide changes to land resources are driven by needs for food, fibre, water and shelter for six billion people. Global croplands, pastures, plantations and urban areas have expanded in recent decades, accompanied by increased energy, water and fertiliser consumption, and by biodiversity loss. These changes have increased human consumption of the planet's resources, but undermine the capacity of ecosystems to sustain food production, maintain freshwater, regulate climate, and restrict infectious diseases.

Land use and agriculture play an important role in climate change. Agricultural emissions account for one-third of global greenhouse gas emissions, and almost 85% of total global water consumption. In the last 40 years:

- The amount of land allocated to agriculture has grown by almost 12%
- 10% more agricultural land is intensively irrigated
- Fertiliser use has grown 700%

Although there has been a marked decrease in the number of types of crops grown throughout the world, the volume of crops grown specifically for animal feed is rising and, in the last six years, more food has been consumed worldwide than was grown resulting in shrinking global stockpiles of grains. Increasing populations, a preference for meat over a more vegetarian diet and increased use of petroleum have led to an increased vulnerability for global food supplies.

However, there is a growing awareness of the need to link food, water and energy use and to value assets that have previously been ignored in economic calculations, such as the value of land for flood prevention, mitigating natural disasters and storing carbon, plus the role of pollinating species.

Professor Foley planning a Rowan tree, *Sorbus aucuparia,* to commemorate his visit to the Institute

Education and Outreach

The Macaulay Land Use Research Institute is committed to sharing our knowledge and scientific output to all interested parties. We see communication as an opportunity for learning and development and have produced many educational resources in partnership with students, teachers and educational advisors to provide resources suitable for both the classroom and individual studies.

Some materials are specifically tied to the curriculum whilst others provide useful information for both teachers and students from primary school age to undergraduate level.

The **Biosphere: Soils and Succession** has been written to meet the requirements of the Higher Geography curriculum. Consisting of four separate modules, it is designed to be used as a teaching aid in the classroom and can also be used by students for individual study.

The **Countryside Change Toolkit** is an interactive visual activity for 8-13 year olds. It includes modules on renewable energy and woodlands that demonstrate how short and long term changes in the landscape might look.

Exploring Scotland is aimed at secondary pupils through to undergraduates. This resource helps students discover more about the natural resources of Scotland and the relationship between soil and the Scottish landscape.

Future Landscape Workshops are aimed at primary and secondary pupils studying Geography. The workshops introduce pupils to topics of rural land resources, the role of citizenship in development planning, competing demands for the use of rural landscapes, and inter-relationships and conflicts of interest which exist in different environments.

Grazing, Bugs and Birds (GRUB) demonstrates how sheep and cattle grazing affects upland wildlife, and is aimed at family audiences. It is available on loan to organisations involved in communicating science to the public.

The **Knowledge Reservoir** is an educational resource which outlines the importance of water. Catchment Management can also be explored in our game, 'Pipe Dreams'.

Macaulay Videos currently comprises three educational DVDs which have been commissioned by the Macaulay Land Use Research Institute to provide an educational resource to stimulate debate on climate change, explain the complex relationships between us and our precious water resource, and outline how our Virtual Landscape Theatre helps people to explore landscapes of the past, present and future.

The Machair is a digital classroom resource for the Higher Geography Rural Land Resources course. This provides all the necessary information to teach this section of the curriculum or can be used for self-study and was developed in partnership with Learning and Teaching Scotland.

For more information:
macaulay.ac.uk/education

Macaulay Maps

A range of soil maps, computer models and other products are available to provide guidance on sustainable soil management.

Coloured Soil Maps

Soil maps are available at either 1:50,000, or 1:63,360 ("inch to mile") scale. These are coloured for easy reading of soil types. They are suitable for small scale applications, e.g. farm plans, building work.

Uncoloured Soil Maps

Uncoloured soil maps are available at either 1:25,000 or 1:50,000 scale. These are suitable for applications where colour would be a distraction. The 1:25,000 scale is suitable for small areas where maximum detail is required.

Land Capability for Agriculture Maps

These maps cover the principal agricultural areas of Scotland. The sheet lines conform to the Ordnance Survey Landranger series.

Soil and Land Capability for Agriculture Maps

Large scale soil maps are available at 1:250,000 scale. These cover large areas and are suitable for education, strategic planning or study. Similar maps are available for forestry.

Soil Series Description Sheets

Soil series description sheets provide summaries of the soil properties and related environmental factors for many of the more extensive or locally important soil series shown on the 1:50,000 (coloured), 1:63,360 (coloured) and 1:25,000 (uncoloured) soil maps.

For more information:
macaulay.ac.uk/maps

Summary Financial Statements
for year ended 31 March 2009

The Macaulay Group financial statements comprise those of the Institute, the Macaulay Development Trust (MDT), the MacLagan Trust Fund and the three wholly owned subsidiaries of MDT: Macaulay Scientific Consulting Ltd (MSC), Macaulay Research Consultancy Services Limited (MRCS) and Macaulay Enterprises Limited (MEL).

MSC commenced trading on 1 April 2008, taking over the business of MRCS and MEL, both of which ceased trading on that date and have become dormant.

The following figures for the Institute have been extracted from the full Board of Governors' Report and Financial Statements of the Macaulay Land Use Research Institute for the year ended 31 March 2009.

Income & Expenditure

The Institute returned a strong financial performance in the year to 31 March 2009, reporting an operating surplus of £750k for the year before exceptional items and an overall surplus of £932k. This compares with an operating surplus of £476k and an overall surplus of £989k the previous year.

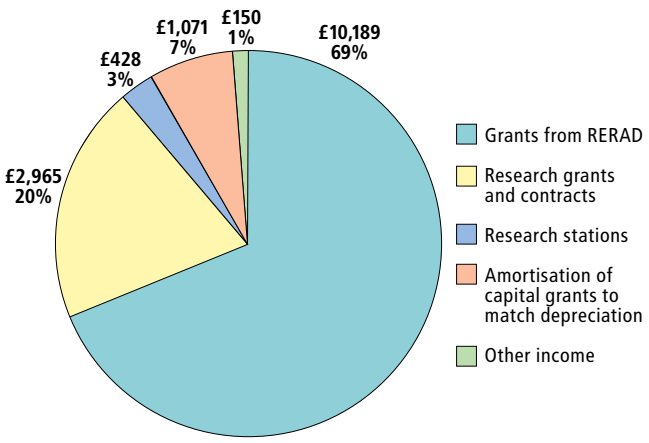
Table 1

SUMMARY INCOME & EXPENDITURE ACCOUNT	Year to 31 March	
	2009 £,000	2008 £,000
INCOME		
Grants from RERAD	10,189	9,766
Research grants and contracts	1,876	1,603
Research stations	428	527
Income from related parties	1,226	279
Other income	1,160	1,076
	14,879	**13,251**
EXPENDITURE		
Scientific salary costs	6,148	5,991
Research expenditure	2,412	1,853
Research stations	583	693
Other costs	4,986	4,238
	14,129	**12,775**
OPERATING SURPLUS	**750**	**476**
Exceptional gain on withdrawal from Sourhope research station	18	334
Gain on asset sales	19	2
Investment income	145	177
SURPLUS FOR THE FINANCIAL YEAR	**932**	**989**

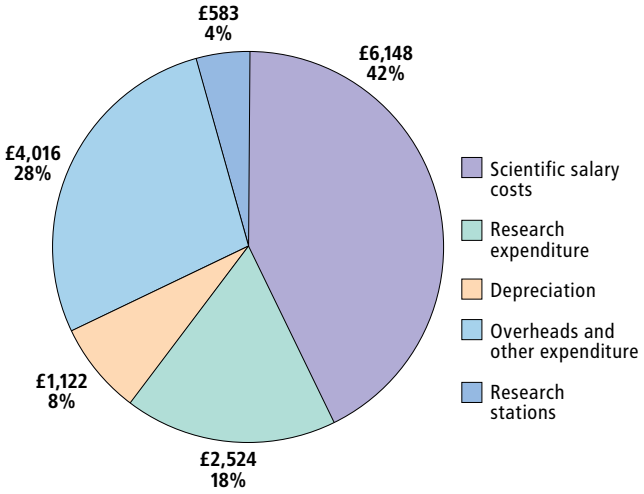
Summary Financial Statements

During the year to 31 March 2009, income from Scottish Government rose by 4% while income from external sources rose by 17%. The exit from the research station at Sourhope reduced research station income by 19%. Overall, operating income rose by 12%.

Expenditure rose by 11%, with the bulk of the increase in direct research costs. During the year the Institute employed 274 staff (2008: 273) and supervised 60 PhD students.



Graph 1. Income breakdown 2008/09 (£,000)



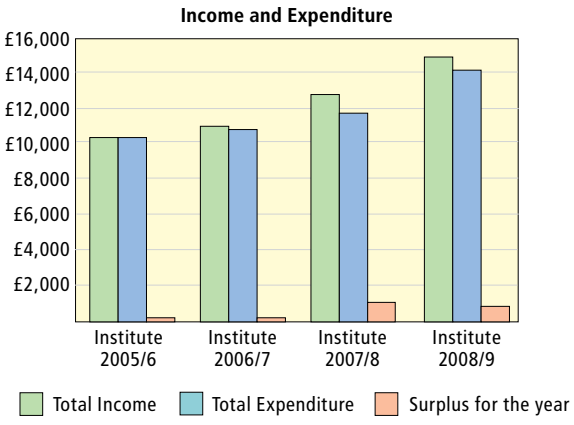
Graph 2. Expenditure breakdown 2008/09 (£,000)

The Institute has shown a significant improvement in overall financial performance over the last 4 years, as summarised in Table 2.

Table 2

SUMMARY PERFORMANCE 2006–2009	2006 £,000	2007 £,000	2008 £,000	2009 £,000
Total Income	10,841	11,969	13,764	15,061
Total Expenditure	10,835	11,677	12,775	14,129
Reported surplus	**6**	**292**	**989**	**932**

Graph 3. Income and Expenditure 2006/07 – 2008/09



Balance Sheet

Fixed assets are shown on the balance sheet at valuation. In the year to 31 March 2009, the Institute net assets rose by £14.9 million. £14 million of this is due to the 5 yearly revaluation of the land and buildings originally gifted to the Institute by its benefactor T. B. Macaulay. The valuation is on a depreciated replacement cost basis. The historic cost of the revalued assets after depreciation was £9 million.

Table 3

Macaulay Land Use Research Institute Balance Sheet for the year ended 31 March 2009		
	2009 £,000	**2008 £,000**
FIXED ASSETS		
Tangible assets	25,031	10,857
Investments	77	144
	25,108	**11,001**
CURRENT ASSETS		
Stocks	303	271
Debtors	1,187	1,362
Cash at bank and in hand	6,133	3,996
	7,623	5,629
Creditors: amounts due within 1 year	(3,965)	(2,727)
Net Current Assets	3,658	2,902
TOTAL NET ASSETS	**28,766**	**13,903**
CAPITAL AND RESERVES		
Endowment funds	166	248
Restricted funds	25,031	10,857
Unrestricted funds	3,569	2,798
	28,766	**13,903**

Grants Awarded

In 2008–09 the Macaulay Land Use Research Institute competitively won over £5 million in new research contracts from projects totalling nearly £16 million, including £1.8 million from the European Commission, £129,000 from the European Regional Development Fund, £73,000 from the Swedish University of Agricultural Science and £61,000 from Unilever.

The tables outline the project title, the awarding body, the timescale of the project and the project leader.

Grants awarded for projects during 2009

PROJECT TITLE	START DATE	END DATE	FUNDING BODY	PROJECT LEADER
SMILE FP7 - Management Activities	01 Jan 2008	31 Dec 2011	European Commission	Dr Keith Matthews
Farmer as Water Manager under Future Climate Regimes	01 Jan 2009	31 Dec 2011	European Regional Development Fund	Dr Keith Matthews
REDD-ALERT Reducing Emissions from Deforestation and Degradation	01 Jan 2009	31 Dec 2011	European Commission	Dr Robin Matthews
REDD-ALERT Reducing Emissions from Deforestation and Degradation - Management	01 Jan 2009	31 Dec 2011	European Commission	Dr Robin Matthews
Support for Additional Knowledge Exchange Activities	05 Jan 2009	30 Jun 2010	RERAD (Rural & Environmental Research and Analysis Directorate)	Dr Dick Birnie
Acidification & Eutrophopication Soil indicators	26 Jan 2009	30 Jun 2009	Scottish Environmental Protection Agency	Dr Helaina Black
Deer populations and trends in Scotland	26 Jan 2009	06 Apr 2009	Deer Commission for Scotland	Prof Steve Albon
Rural SuDS	26 Jan 2009	30 Apr 2009	Environment Agency	Dr Lisa Avery
Prioritising SAPs & HAPs by LBAP area in Scotland	30 Jan 2009	30 Jun 2009	SNH	Prof Robin Pakeman
JMT Carbon Project	01 Feb 2009	31 Jul 2009	JMT	Prof Bill Slee
Rural Land Use Study: Project 2	01 Feb 2009	31 Jul 2009	RERAD	Prof Bill Slee
Spey CMP Appraisal & Development	01 Feb 2009	30 Jun 2009	Cairngorms National Park Authority	Dr Susan Cooksley
Stumps and invertebrate and fungal diversity	01 Feb 2009	31 May 2009	Swedish University of Agricultural Sciences	Dr Andy Taylor
FWP Contractor Survey	15 Feb 2009	30 Apr 2009	SNH	Dr Simon Langan
Rural Land use study: Project 1	16 Feb 2009	30 Nov 2009	RERAD	Prof David Miller
Cumnock Sustainable Urban Extension: Soils and Agricultural Assessment for Environmental Impact Assessment	23 Feb 2009	30 Sep 2009	Jacobs UK Ltd	Andrew Nolan
Impact of climate change on soil functions	01 Mar 2009	30 May 2009	Joint Nature Conservation Committee	Dr Helaina Black
The role of deer carcasses for biodiversity	01 Mar 2009	20 Mar 2009	JMT	Dr Justin Irvine
Making deer choices: Public perceptions of wildlife management	09 Mar 2009	15 Mar 2009	RERAD	Dr Justin Irvine
Social Science – Climate Change – Forestry	09 Mar 2009	01 Dec 2009	Forestry Commission	Dr Maria Nijnik
Impacts of biomass and bioenergy crops	24 Mar 2009	26 Jul 2009	Scotland & Northern Ireland Forum for Environmental Research	Philippa Booth
Building natural resource monitoring capacity in Ethiopia's key Afro-montane ecosystems	01 Apr 2009	31 Dec 2012	Department for Environment, Food & Rural Affairs (DEFRA)	Dr Simon Thirgood

Grants Awarded

PROJECT TITLE	START DATE	END DATE	FUNDING BODY	PROJECT LEADER
Cultural landscapes of tourism and hospitality	01 Apr 2009	31 Dec 2012	Norwegian Forest and Landscape Institute	Neil Sang
GS Soil-European Soil Information	01 Apr 2009	31 Mar 2012	European Commission	Dr Allan Lilly
International Consortium of Scottish Soil Genomics	01 Apr 2009	31 Mar 2012	RERAD	Dr Brajesh Singh
National Ecosystem Assessment – Expert Panel	01 Apr 2009	31 Mar 2010	RERAD	Prof Steve Albon
Behaviour for Well-being, Environment & Life	30 Apr 2009	29 Apr 2010	Economic and Social Research Council	Dr Simon Thirgood
NE Scotland Climate Change Partnership	01 May 2009	31 May 2009	RERAD	Prof Bill Slee
PolicyGrid II: Supporting Interdisciplinary Evidence Bases for Scientific Collaboration and Policy Making	01 May 2009	30 Apr 2012	Economic and Social Research Council	Dr Gary Polhill
EDC in Dog Testes	01 Jun 2009	31 Mar 2011	University of Nottingham	Dr Stewart Rhind
Expert workshops on carbon stocks in Scottish peatlands	01 Jul 2009	31 Oct 2009	RERAD	Dr Steve Chapman
NEA: Scotland Synthesis	01 Jul 2009	01 Feb 2011	World Conservation Monitoring Centre	Prof Richard Aspinall
Soil Corrosivity	01 Jul 2009	31 Aug 2009	Cranfield University	John Bell
Murder, Mystery and Microscopes	15 Jul 2009	31 Jul 2010	Scottish Government	Prof David Miller
Report writing for pot trials run for Helius Energy in 2008	29 Jul 2009	12 Aug 2009	Helius Energy Plc	Dr Eric Paterson
Climate Change Education Pack for Scottish Schools	01 Aug 2009	31 Mar 2010	RERAD	Grant Davidson
River Dee pearl mussel population:linking macrohabitat data with distribution	01 Aug 2009	10 Apr 2010	SNH	Dr Susan Cooksley
LFA EU Criteria: analysis of potential impact on Scotland's LFA	03 Aug 2009	11 Sep 2009	RERAD	Willie Towers
Defra Climate Change Impacts On Soil Biota	01 Sep 2009	28 Feb 2011	Cranfield University	Dr Helaina Black
Feasibility study: translocation of species in northern or montane environments	01 Sep 2009	28 Feb 2015	SNH	Dr Rob Brooker
Cooper Report	01 Oct 2009	02 Oct 2009	Helius Energy Plc	Dr Eric Paterson
Ecohydrological self organisation in temperate hillslopes	01 Oct 2009	30 Sep 2012	RERAD	Dr Sarah Dunn
Farming Outside the Fence? An Analysis of Legal and Policy Supports for Non-Commercial Farming in Scotland	01 Oct 2009	30 Sep 2012	RERAD	Dr Lee-Ann Sutherland
Impacts of small scale hydro on rare bryophytes and lichens	01 Oct 2009	31 Mar 2010	SNH	Dr Benoit Demars

PROJECT TITLE	START DATE	END DATE	FUNDING BODY	PROJECT LEADER
Stream bank Management, Retention and Transport of Phosphorus (SMART-P)	01 Oct 2009	30 Sep 2012	RERAD	Dr Marc Stutter
Beaver Monitoring	10 Oct 2009	15 Jun 2014	SNH	Dr Ben Moore
Photomontages for Damhead Renewables Proposal	12 Oct 2009	16 Oct 2009	Flower Properties Ltd.	Margaret McKeen
Soils & LCA of Hazelbank Quarry Extension	12 Oct 2009	06 Nov 2009	J W H Ross & Co	John Bell
Confidence in Compost QMS Workshop	18 Nov 2009	24 Nov 2009	The Waste and Resources Action Programme	Dr Rupert Hough
Aquatic Carbon Fluxes from UK Peatlands	01 Jan 2010	03 Feb 2011	Scotland & Northern Ireland Forum for Environmental Research	Dr Marc Stutter
Evidence gaps in GHG and C flux from UK peatlands	01 Jan 2010	30 May 2010	Joint Nature Conservation Committee	Dr Rebekka Artz
UK Climate Change Risk Assessment	01 Jan 2010	31 Mar 2011	HR Wallingford Ltd	Dr Iain Brown
WRAP editing	04 Jan 2010	01 Feb 2010	The Waste and Resources Action Programme	Dr Rupert Hough
REstoration, protection and management of European FRESHwater ecosystems in a world of global change MGT Activities	01 Feb 2010	31 Jan 2014	European Commission	Dr Rachel Helliwell
REstoration, protection and management of European FRESHwater ecosystems in a world of global change MGT Activities	01 Feb 2010	31 Jan 2014	European Commission	Dr Rachel Helliwell
REstoration, protection and management of European FRESHwater ecosystems in a world of global change MGT Activities	01 Feb 2010	31 Jan 2014	European Commission	Dr Rachel Helliwell
FAO Soil Biodiversity Website	01 Mar 2010	01 Nov 2010	Food and Agriculture Organization	Dr Rebekka Artz
Subcontract to CEH for Defra Soils Review	01 Apr 2010	01 Sep 2010	DEFRA	Dr Helaina Black

Publications

Our science is communicated to the wider scientific community through the publication of peer-reviewed papers which highlight our work. This communication forms the basis of the documentation of scientific knowledge and we are proud that for the last five years, the number of ISI papers published has shown a consecutive year on year increase.

We also engage with both scientific and non-scientific audiences through the presentation of conference papers and posters, technical reports and popular articles.

The following pages list ISI refereed journals, reviewed papers, book and book chapters, conference posters, technical reports, book reviews and popular articles published during 2009, along with a list of oral presentations and submissions.

ISI Refereed Journals

AALDERS, I., BALL, B., BLACK, H. I. J., CAMPBELL, C. D., GRIFFITHS, B., HOPKINS, D., HOUGH, R. L., LILLY, A., MCKENZIE, B., REES, R. M., SINCLAIR, A., TOWERS, W., & WATSON, C. (2009). Considerations for Scottish soil monitoring in the European context. *European Journal of Soil Science*, vol. 60, no. 5, pp. 833–843.

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RHIND, S. M. (2009). Anthropogenic pollutant impacts on human health and ecosystems. *Knowledge Scotland, Policy Brief – Health and Well Being.*

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Oral presentations and submissions

AALDERS, I. (2009).
BSV11124 Waste Management – Lecture on Management of Landfill Sites. The University of Edinburgh. March 2009.

AVERY, L. M. & VINTEN, A. J. A. (2009).
E. coli movement through catchments. Invited talk, TEAGASC, Johnston Castle, Wexford, Eire. 7 December 2009.

BARKMANN, J., GLENK, K., KOCH, S., & MARGGRAF, R. (2009).
The role of economic valuation in social decision-making processes on biological diversity. A Matter of Mutual Survival – Social Organisation of Forest management in Central Sulawesi. Symposium in memoriam Guenter Burkard, ISOS Witzenhausen, Germany. 4 February 2009.

BLACKSTOCK, K. L., DILLEY, R., TRENCH, H., & MILES, G. (2009).
Multiple understandings of the Cairngorms National Park: What should the Park deliver and for whom? Presented at the University of Aberdeen Rural Law Conference on Land Reform in Scotland: 10 years on. 3 September 2009.

BLACKSTOCK, K. L., MATTHEWS, K. B., & LANGAN, S. (2009).
Introduction to the Aquarius Project. Aquarius Workshop: Advisor and Authority Perspectives on Farmers as Water Managers. Macaulay Land Use Research Institute, Aberdeen. 27 October 2009.

BLACKSTOCK, K. L., MATTHEWS, K. B., & LANGAN, S. (2009).
Planning the first Aquarius transnational workshop: Baselines and barriers to farmers as water managers. First Aquarius Partners Meeting, Hobro, Denmark. 2–5 March 2009.

BOURNE, E., PAKEMAN, R., BROOKER, R., KUNIN, B., & TRAVIS, J. (2009).
Local adaptation to serpentine soils in Arabidopsis lyrata. British Ecological Society Annual Meeting, University of Hertfordshire. 9 September 2009.

BROOKER, R. (2009).
Plant interactions and environmental change. Invited talk for South American students, Coyhaique, Chile. January 2009.

BROOKER, R. W. (2009).
Biodiversity and Scotland's landscapes. KnowledgeScotland Science, Policy Outreach Event, Edinburgh. 8 October 2009.

BROOKER, R. W. (2009).
The nature of Scotland's changing landscapes. The Changing Nature of Scotland, Scottish Natural Heritage Conference, Perth. 17–18 September 2009.

BROOKER, R. W. (2009).
Facilitation in plant communities: the history of a developing research field. Talk to Undergraduate Students, Napier University, Edinburgh. 26 November 2009.

BROOKER, R. W. (2009).
Accentuate the positive, eliminate the negative? Recent insights into interactions in plant communities. Talk to York University Biology Department. 12 November 2009.

BROWN, K. M. (2009).
Key trends in outdoor recreation. Invited presentation to SNH Policy Seminar 'Fit for the Future? Formal provision for enjoying the outdoors in Scotland'. 9 March 2009.

BROWN, K. M. (2009).
Claiming rights to rural recreational space: Scottish access legislation in practice. University of Aberdeen, Institute for Rural Research, Seminar series. 4 March 2009.

BUCHAN, K., RIVINGTON, M., MILLER, D. G., & MATTHEWS, K. B. (2009).
Agro-meteorological indicators of climate change – Tarland case study. Aquarius Workshop: Advisor and Authority Perspectives on Farmers as Water Managers. Macaulay Land Use Research Institute, Aberdeen. 27 October 2009.

CAMPBELL, C. D., HOUGH, R. L., & TOWERS, W. (2009).
WP3.2 and WP3.3 Mid Term Review. Scottish Natural Heritage. 23 February 2009.

CASTELLAZZI, M. S. (2009).
Creating land use scenarios in Lunan catchment using LandSFACTS model. Meeting at Scottish Natural Heritage, Battleby, Perth. February 2009.

CASTELLAZZI, M. S. & JOANNON, A. (2009).
Atelier de modelisation du paysage Biodivagrim. LandSFACTS un model de territoire d'exploitation. INRA, Montpellier, UMR AMAP. March 2009.

CHAPMAN, S. J., BELL, J. S., DONNELLY, D., HUDSON, G., & LILLY, A. (2009).
Estimation of the C stock held within the highly organic soils of Scotland. Predicting the Future for Highly Organic Soils, British Society of Soil Science Spring Conference, Edinburgh Conference Centre, Heriot-Watt University. 5–7 May 2009.

COULL, M. C., BLACKSTOCK, K., FUTTER, M., VINTEN, A., & STUTTER, M. (2009).
Research in the Lunan catchment. Public Meeting, Friockheim. April 2009.

CRAIG, T. (2009).
What is behavioural research and why does it matter? - Some thoughts from a psychological perspective. Invited presentation to the SAC integration event "Moving from Outputs to Outcomes: How can a better understanding of stakeholder motivations and behaviours improve the impact of our research?" 24 June 2009.

CRAIG, T. (2009).
How can local community and rural households respond to low carbon economy? Moving Towards a Low Carbon Rural Economy: Challenges and Opportunities Workshop, Macaulay Land Use Research Institute. 28 May 2009.

CREAMER, R. & TOWERS, W. (2009).
Soil Awareness and Education of the European Soil Bureau. Network Tasks of the Working Group. European Network on Soil Awareness Conference, Museum am Scholerberg, Osnabruck, Germany. 27–29 September 2009.

CUMMINS, R. P. (2009).
Agri-environment schemes and lessons learnt. Presentation to the Crofting Environment Improvement Association. 22 June 2009.

DAWSON, L. A. (2009).
Tackling serious crime using forensics. 3rd International Crime Science Conference, British Library. 15 July 2009.

DAWSON, L. A. (2009).
Macaulay urban soil database information. The British Geological Survey, Edinburgh. 5 May 2009.

DAWSON, L. A. (2009).
Profiling soil for forensic application. Invited plenary at The British Association for Human Identification Conference: 10th Annual Scientific Meeting, Westpark Conference Centre, University of Dundee. 6–8 June 2009.

DAWSON, L. A., DONNELLY, D., & MILLER, D. (2009).
Trace evidence in "Dying Light". Murder, Mystery & Microscopes, Techfest, Aberdeen. 26 September 2009.

DAWSON, L. A., DONNELLY, D., & MILLER, D. R. (2009).
Trace evidence in "Dying Light". Murder, Mystery & Microscopes, British Association Festival of Science, Maltings, Farnham. 8 September 2009.

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DAWSON, L. A., DONNELLY, D., & MILLER, D. R. (2009).
Trace evidence in "Dying Light". Murder, Mystery & Microscopes, British Association Festival of Science, University of Guildford, Guildford. 8 September 2009.

DEMARS, B. O. L. (2009).
Aquatic plants in the River Spey. Highland Rock Garden Club, Nairn.

DUNN, S. M. (2009).
Hydrological pathways, mixing and transit times and their relevance to water quality. Invited seminar presented at Unite INRA Sol et Agronomie et Spatialisation, Rennes. April 2009.

FERRIER, R. C. (2009).
Soaring demand for allotments. BBC Radio Scotland and BBC Reporting Scotland. 13 October 2009.

FERRIER, R. C. (2009).
Understanding water quality – past perspectives and future challenges. International Colloquium, Vision on Water Resources Monitoring in the 21st Century, University of Antwerp. 26 November 2009.

FUTTER, M. N. (2009).
Modelling mercury in boreal catchments. Invited presentation at NIVA workshop on Mercury in Boreal Ecosystems. 31 March 2009.

FUTTER, M. N. (2009).
Catchment biogeochemical modelling. Invited presentation at NERI, Denmark. 31 March 2009.

GARCIA-PALACIOS, P., MAESTRE, T., CHAPMAN, S. J., SOLIVERES, S., ESCUDERO, A., VALLADARES, F., GALLARDO, A., GUERRERO, C., & CASTILLO, A. P. (2009).
Links between vegetation, microbial functional diversity and soil functioning during restoration of semi-arid motorway slopes. British Ecological Society Annual Meeting, University of Hertfordshire. 8–10 September 2009.

GILL, E. (2009).
North East Scotland Local Biodiversity Partnership. Nature Conservation in Britain Course, University of Aberdeen. 23 February 2009.

GILL, E. (2009).
Priority habitats and species in North East Scotland. Scottish Wildlife Trust Lecture Series, University of Aberdeen. 15 October 2009.

GIMONA, A. & FIORINI, S. (2009).
Climate change: a short summary of evidence and some possible impacts. Scottish Natural Heritage, Battleby, Perth. April 2009.

GLENK, K., COLOMBO, S., BLACK, H. I. J., TOWERS, W., & WATSON, C. (2009).
Estimating the benefits of re-accumulating carbon in Scottish soils. Predicting the Future for Highly Organic Soils, British Society for Soil Science Spring Conference, Heriot-Watt University, Edinburgh. 5–7 May 2009.

GOTTS, N. M. (2009).
GILDED: Governance, Infrastructure, Lifestyle Dynamics and Energy Demand. Inaugural meeting of SIMIAN (SIMulation Innovation: A Node), City University, London. 21 April 2009.

GOTTS, N. M. (2009).
GILDED: Governance, Infrastructure, Lifestyle Dynamics and Energy Demand. An EU Framework VII collaborative project within the topic Socio-economic factors and actor shaping the "post-carbon" society. North East Scotland Climate Change Partnership Meeting. 1 May 2009.

GOTTS, N. M., POLHILL, J. G., GIMONA, A., DAVIES, B., & MATTHEWS, R. (2009).
Agent based modelling in GILDED and at Macaulay Land Use Research Institute. University of Groningen, Potsdam Institute for Climate Impact Research, Institute of Political Science, Hungarian Academy of Sciences, University of South Bohemia. 6–13 July 2009.

HELLIWELL, R. C. (2009).
A long term perspective of soil and surface water acidification: Recovery: the future, confounding factors and threats. University College of London Meeting on "20 years of data from the UK Acid Waters Monitoring Network". 9 October 2009.

HELLIWELL, R. C., BRITTON, A., EVANS, C., COULL, M., GIBBS, S., FISHER, J., LILLY, A., ARMITAGE, H., & DAWSON, L. (2009). Modelling soil carbon stocks and nitrogen dynamics in spatially heterogeneous montane environments. Predicting the Future for Highly Organic Soils, British Society for Soil Science Spring Conference, Heriot-Watt University. 5–7 May 2009.

HELLIWELL, R. C., FUTTER, M. F., & AHERNE, J. (2009).
The impact of climate change on nutrient cycling and water quality in the Scottish Mountains. Invited lecture at SNH Head Office, Inverness. 17 December 2009.

HELLIWELL, R. C. & SIMPSON, G. L. (2009).
The present is the key to the past, but what does the future hold for the recovery of surface waters from acidification? Presentation at the 10th Joint Expert Group Meeting, Spain. 28–30 October 2009.

HUBAND, S. (2009).
Seasonal livestock migrations in Romania: anachronistic or sustainable land use? University of Bayreuth (Germany) Geography Department's Migrations Seminar Series. 25 November 2008.

IASON, G. (2009).
Mediation of the extended phenotype of Scots pine by plant secondary metabolites. Research Seminar, University of Savoie, France. 15 January 2009.

IASON, G. (2009).
Mediation of the extended phenotype of Scots pine by plant secondary metabolites, Research Seminar, University of Lyon, France. 15 January 2009.

IASON, G. (2009).
The importance of body odour to Scots pine trees. Lecture to Scottish Wildlife Trust, Pitlochry. 16 March 2009.

IASON, G. R. (2009).
The role of monoterpenes in the ecology of pine woods. Lecture to the Department of Biology, Mittuniversiteitet, Sweden. 4 November 2009.

IRVINE, R. J. & ALBON, S. D. (2009).
Climate change and red deer population trends. Deer Commission for Scotland, Birnam Arts and Conference Centre, Birnam, Perthshire. 30 March 2009.

IRVINE, R. J. & VAN DER WAL, R. (2009).
On the virtues of collaboration: addressing the conflicts in wild deer management. Environmental Sustainability, 1st Annual ACES Symposium, Macaulay Land Use Research Institute, Aberdeen. 27 February 2009.

IRVINE, R. J. & WHITE, R. (2009).
Developing adaptive frameworks for resolving hunting and conservation conflicts: the role of participatory GIS. Human-wildlife conflict resolution, The Mammal Society's Autumn Symposium, The Meeting Rooms, The Zoological Society of London, London Zoo. 20–21 November 2009.

KEITH, A. M., BROOKER, R. W., BURSLEM, D. F. R. P., CAMERON, C. M., CHAPMAN, S. J., ELSTON, D. A., OSLER, G. H. R., & VAN DER WAL, R. (2009).
Tree invasion of heather moorland: impacts of birch and pine on microbes, microfauna and decomposition. Association of Applied Biologists International Conference on Positive Plant Microbial Interaction in Relation to Plant Performance and Ecosystem Function, Olde Barn Hotel, Grantham, Lincs. 15–16 December 2009.

Publications

LANGAN, S. & BLACKSTOCK, K. L. (2009).
Sustainable flood risk management in Scotland. Sustainable Flood Risk Management in Scotland Holyrood Conference, Our Dynamic Earth, Edinburgh. 16 June 2009.

LANGAN, S. & JANES, M. (2009).
River restoration: some experiences from Scotland and the UK. River Restoration Project in Korea. Are We on the Right Track – Concepts, Methods and International Experiences. Centre for Social Sciences, National Assembly Library, Seoul National University. 27 May 2009.

LILLY, A. (2009).
Presentation on Soil Monitoring in the UK and Europe. Workshop on Soil Monitoring, Melbourne, Victoria, Australia. 4 March 2009.

LILLY, A. (2009).
Presentation on hydropedology. Soil Science Group, Future Farming Systems Research, Bendigo, Department of Primary Industries, Victoria, Australia. 23 February 2009.

LILLY, A. (2009).
Testing methods for soil monitoring in Scotland. Soil Science Group, Future Farming Systems Research, Bendigo, Department of Primary Industries, Victoria, Australia. 24 February 2009.

LILLY, A. (2009).
Soil, structure and function. Tatura Research Centre, Department of Primary Industries, Victoria, Australia. 27 February 2009.

LILLY, A. (2009).
Use of soil data in modelling. Workshop on Soil Landscape Parameters for Modelling, Bendigo, Victoria, Australia. 3 March 2009.

LILLY, A. (2009).
Assessing soil erosion in Scotland and Northern Ireland. SNIFFER Workshop on Climate Change, Land Management and Organic Soil Erosion in Scotland and Northern Ireland, Edinburgh. 30 June 2009.

LUMSDON, D. G. (2009).
Peak oil, fossil fuels and food security. Scottish Agricultural College, West Mains Road, Edinburgh. February 2009.

MACDONALD, L. & DAWSON, L. A. (2009).
Does organic matter in forensic soil science? Adelaide Laboratory Public Seminar Series. 2 April 2009.

MATTHEWS, K. B. (2009).
Response to Mid Programme Recommendations – A perspective from WP3.1. Presentation to the 9th P3G Meeting, Edinburgh. 1 October 2009.

MAYOR, D., THORNTON, B., HAY, S., & WITTE, U. (2009).
Carbon cycling in the deep sea. Seminar presented to Fisheries Research Services, Marine Scotland, Marine Laboratory, Aberdeen. 18 June 2009.

MAYOR, D. J., THORNTON, B., WITTE, U., & HAY, S. (2009).
Food quality affects carbon cycling in the deep sea. Stable Isotope Mass Spectrometry Users Group Meeting, University of Glasgow. 14–15 January 2009.

MCCRUM, G. S. & BROWN, K. M. (2009).
Visual methods, Mini Kindrogan, Postgraduate Day, The University of Aberdeen.

MILLARD, P. (2009).
Ecophysiology of carbon and nitrogen storage by trees. Les reserves et leur importance agronomique et sylvicole, International Conference, INRA-UCBN, University of Caen. 9–10 June 2009.

MILLARD, P. (2009).
What drives microbial community structure in pasture soils? Soils and Nutrient Cycling in Grassland Ecosystems: Implications for Sustainable Management, International Workshop, Poitiers, France. 3–4 June 2009.

MILLARD, P. (2009).
Carbon limitation in trees: scaling from leaf biochemistry to ecosystems. Invited lecture given at Department of Soil Quality, Wageningen University, the Netherlands. 1 October 2009.

MILLARD, P. & MIDWOOD, A. J. (2009).
Partitioning soil respiration using natural abundance 13C discrimination. Invited Seminar, School of Biological Sciences, University of Aberdeen.

MILLER, D. R. (2009).
Participatory planning using a virtual reality environment, Guest Lecture, School of Geosciences, University of Aberdeen. 20 March 2009.

MOORE, B. D. (2009).
Chemical warfare in the Australian Bush: Scaling up laboratory studies to understand how plant secondary metabolites affect wild marsupial folivores. Invited seminar at the Institute of Zoology, London. 11 March 2009.

MOORE, B. D. & DEGABRIEL, J. L. (2009).
Chemical warfare in the Australian Bush: Scaling up laboratory studies to understand how plant secondary metabolites affect wild marsupial folivores. Invited seminar to the Department of Animal Ecology and Conservation, University of Hamburg, Germany. 7 May 2009.

MOORE, B. D., IASON, G. R., SIM, D., BEATON, J. K., REID, S., & BARRETT, A. (2009).
Chemical diversity in Scots pine: What, why and where? Aberdeen Ecology Day, University of Aberdeen. 17 April 2009.

MUNANG, R. & RIVINGTON, M. (2009).
Ecosystem management: A key to enhancing food security under a changing climate. Invited Keynote Presentation to Centre for Agriculture and Biosciences International (CABI) Global Summit: Food Security in a Climate of Change, London. 19–21 October 2009.

NOLAN, A. J. (2009).
Soils and agriculture: Uists Blackland Project. Invited presentation to Crofting Environment Improvement Association.

NOLAN, A. J. (2009).
Heather ecology and land use. Invited presentation to Tain and District Field Club. 10 November 2009.

OWEN, I. J. (2009).
The garden, the gardener and his soils. Huntly Street Pensioners Group. 4 March 2009.

OWEN, I. J. (2009).
Gardening group presentation, Kemnay Gardening Group, Kemnay, 18 February 2009.

OWEN, I. J. (2009).
Soil testing. Growing in Glasgow, Trades Hall, Glasgow. 28 March 2009.

OWEN, I. J. (2009).
Specific contaminants – what effect and what can be done? Growing in Glasgow, Trades Hall, Glasgow. 28 March 2009.

PAJOT, G., SLEE, B., WALLACE, J., DUNN, S., & BESTWICK, M. (2009).
Evaluer la ressource hydroelectrique en Aberdeenshire, Ecosse. Research Seminar, University of Bordeaux, France. 19 May 2009.

PAKEMAN, R. J. (2009).
Agriculture, ecology and biodiversity. Presentation to the Crofting Environment Improvement Association. 25 May 2009.

PATERSON, E. (2009).
Measuring carbon fluxes through the eye of the needle – Does Soil Quality and Environmental Quality? Joint British Soil Science Society and Soil Science Society of Ireland Conference, Wexford, Ireland. 9–11 September 2009.

PHILLIP, S., BLACKSTOCK, K., & HUNTER, C. (2009).
What is agritourism? Perspectives from five types of agritourism provider, ESRS Congress, Vaasa. 17–21 August 2009.

PHILLIP, S., BLACKSTOCK, K. L., & HUNTER, C. (2009).
What is agritourism? Perspectives from five types of agritourism provider, RGS-IBG Conference, New and Emerging Rural Researchers (Rural Geography Research Group), Manchester. 25–28 August 2009.

POGGIO, L. & SOILLE, P. (2009).
Land cover detection with unsupervised clustering and hierarchical partitioning. International Federation of Classification Services (IFCS), 11th Conference. Special Interest Session on Spatial Classification, Dresden, Germany. 13–18 March 2009.

POLHILL, G., GIMONA, A., & MCCRACKEN, D. (2009).
Assessment of potential biodiversity impacts of future policy changes: Identifying and prioritising future scenarios. Biodiversity Consultative Group Meeting, Victoria Quay, Leith, Edinburgh. 10 March 2009.

POLHILL, J. G. (2009).
Ontologies for agent-based modelling. Center for Social Complexity, Krasnow Institute for Advanced Study, George Mason University Seminar. 17 April 2009.

REDPATH, S. M., ALBON, S. D., & IRVINE, R. J. (2009).
Managing conflicting goals in the uplands: consequences for biodiversity. Scotland's Changing Rural Biodiversity: Policy and Action Needs, Edinburgh Consortium for Rural Research, Battleby, Perth.

RIVINGTON, M., MATTHEWS, K. B., BUCHAN, K., & MILLER, D. G. (2009).
Future farming systems: investigating sustainability and climate change adaptation. Invited seminar to Centre for the Study of Environmental Change and Sustainability, The University of Edinburgh. 17 March 2009.

SANDIN, L., FRIBERG, N., BERGFUR, J., DEMARS, B. O. L., & PEDERSEN, M. (2009).
Stream communities and food webs along gradients in temperature on local and regional scales. 10th International Congress of Ecology (INTECOL) Ecology in a Changing Climate, Brisbane. August 2009.

SINGH, B. (2009).
Molecular methods for rapid detection of food and environmental pathogens. Invited talk to Rapid Method Conference, Netherlands. 19 January 2009.

SINGH, B. K. (2009).
Response of microbial communities to land-use change, management practice and climate change. Invited talk to Microbial Ecology Workshop, Changsha, China. September 2009.

SLEE, B. (2009).
Looking backwards, looking forwards: re-localisation and sustainable development. Presentation to UHI Centre for Remote and Rural Studies Public Policy Seminar Series. 6 June 2009.

SLEE, B. (2009).
Rural land pressures and issues in North East Scotland. SNH Futures Strategy Team Meeting. 27 October 2009.

SLEE, B. (2009).
Re-imagining forests as multifunctional and sustainable resources for a low carbon rural economy: the potential for forest-based rural development. Keynote address at OECD Conference, Developing Rural Policies to Meet the Needs of a Changing World, Quebec. 13–15 October 2009.

SLEE, B. (2009).
An economic perspective on the English uplands. Presentation to Commission for Rural Communities' Inquiry into the Future of the Uplands, Exeter. 21 April 2009.

SLEE, B. (2009).
An "international" perspective from Scotland: The future of Scotland's hills and islands: The RSE Committee of Inquiry and beyond. Presentation to Commission for Rural Communities' Inquiry into the Future of the Uplands. 6 June 2009.

SMITH, H. M., WALL, G., & BLACKSTOCK, K. L. (2009).
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Editorial responsibilities during 2009

Professor Richard Aspinall	**Editor:** Journal of Land Use Science **Editor:** Annals of the Association of American Geographers (Environmental Sciences section)
Dr Helaina Black	**Editorial Board Member:** Insect Biodiversity and Conservation
Dr Rob Brooker	**Associate Editor:** Journal of Ecology
Professor Colin Campbell	**Associate Editor:** Journal of Applied Microbiology **Associate Editor:** European Journal of Soil Science **Associate Editor:** Soil Use and Management
Dr Stephen Chapman	**Board of Subject Editors:** Soil Biology and Biochemistry
Dr Johann Erhard	**Editorial Advisory Board Member:** Applied Animal Behaviour Science
Dr Bob Ferrier	**Guest Editor:** Hydrology and Earth Systems Science
Dr Pete Goddard	**Editorial Advisory Board:** Applied Animal Behaviour Science
Dr Steve Hillier	**Section Editor:** Elements – International Magazine of Mineralogy, Geochemistry and Petrology
Dr Rupert Hough	**Editor in Chief:** Land Contamination & Reclamation **Associate Editor:** Communications in Waste & Resource Management
Dr Glenn Iason	**Associate Editor:** Wildlife Biology
Dr Jack Lennon	**Associate Editor:** Global Ecology and Biogeography **Associate Editor:** Journal of Applied Ecology
Professor Pete Millard	**Editor:** Tree Physiology
Professor David Miller	**Editorial Board Member:** Landscape and Urban Planning **Editorial Board Member:** Journal of Coastal Conservation, Planning and Management
Dr Benjamin Moore	**Associate Editor:** Austral Ecology **Editorial Board Member:** Journal of Zoology
Dr Scott Newey	**Associate Editor:** Wildlife Biology
Dr Maria Nijnik	**Editorial Board Member:** TEKA – the Commission of Protection and Formation of Natural Environment, the National Academy of Sciences, Poland
Professor Bob Ørskov	**Section Editor:** Livestock Science (Ruminant Nutrition)
Professor Robin Pakeman	**Associate Editor:** Applied Vegetation Science
Dr Eric Paterson	**Subject Editor:** Plant & Soil
Neil Sang	**Editorial Board Member:** Open Environmental Journal
Dr Brajesh Singh	**Editorial Board Member:** Applied and Environmental Microbiology **Editorial Board Member:** Biodegradation **Editorial Board Member:** Environmental Toxicology and Chemistry
Professor Bill Slee	**Editorial Board Member:** Forestry **Editorial Board Member:** Small Scale Forestry
Dr Andy Taylor	**Editorial Advisor:** New Phytologist **Editorial Board Member:** Mycological Progress **Editorial Board Member:** Fungal Biology Reviews
Professor Simon Thirgood*	**Editor :** Journal of Applied Ecology

* In memory: Professor Simon Thirgood
6 December 1962 – 30 August 2009

Staff List as of 1st January 2010

Chief Executive	**Professor Richard Aspinall** BSc, PhD, FRGS, CGeog
Director of Corporate Services and Company Secretary	**Carol Bisset** BSc, FCCA

SENIOR MANAGEMENT TEAM

Science Group Leader – Catchment Management	**Dr Bob Ferrier**
Science Group Leader – Ecology	**Dr Pete Goddard**
Science Group Leader – Integrated Land Use Systems	**Professor David Miller**
Science Group Leader – Socio-Economic Research Group	**Professor Bill Slee**
Science Group Leader – Soils	**Professor Colin Campbell**
Analytical Group Manager	**Dr Andy Midwood**
Business Development Coordinator	**Jeremy Evans**
Financial Controller	**Carol Smith**
Head Librarian	**Lorraine Robertson**
Head of Communication Services	**Dr Dick Birnie**
Head of HR & Training and Deputy to Director of Corporate Services	**Dr Debs Slater**
Head of Technical Services	**Grahame Shaw**
Health and Safety Manager	**Moira McMaster**
Human Resources Manager	**Scott Strachan**
IT Services Group Manager	**David Stone**
Programme 3 Coordinator	**Professor Stephen Albon**
Quality Manager	**Gareth Newman**

CATCHMENT MANAGEMENT GROUP MEMBERS

Dr Bob Ferrier	**Science Group Leader**
Claire Abel	Research Assistant
Dr Lisa Avery	Environmental Microbiologist
Dr Jeffrey Bacon	Senior Scientist
Dr Nikki Baggaley	Environmental Scientist
Christian Birkel	PhD Student
Philippa Booth	Soil and Water Consultant
Stephen Carr	PhD Student
Lynn Clark	Research Assistant
Yvonne Cook	Research Scientist
Dr Susan Cooksley	Catchment Scientist
Pat Cooper	Research Assistant
Dr Julian Dawson	Environmental Biogeochemist
Dr Benoit Demars	Aquatic Ecologist
Nikki Dodd	PhD Student
Dr Sarah Dunn	Senior Post-doctoral Scientist
Sheila Gibbs	Research Assistant
Peter Goude	PhD Student
Emily Hastings	Researcher
Ian Hay	East Grampian Coastal Partnership Project Manager
Dr Rachel Helliwell	Senior Research Scientist
Christian Imholt	PhD Student
Antonio Ioris	Visiting Researcher
Leah Jackson-Blake	Environmental Scientist
Lynne Johnston	Research Assistant
Dr Simon Langan	Work Package Coordinator
Dr Allan Lilly	Soil Hydrologist
Dr David Lumsdon	Research Scientist
Doris Pichler	PhD Student
Samia Richards	Soil and Water Chemistry Research Assistant
Will Roberts	PhD Student
James Sample	Environmental Data Coordinator
Dr Marc Stutter	Post Doctoral Research Scientist
Carol Taylor	Field/Laboratory Assistant
Andrew Vinten	Principal Researcher in CM & Water Quality
Ruth Walker	Field/Laboratory Assistant
Helen Watson	Research Assistant

ECOLOGY GROUP MEMBERS

Dr Pete Goddard	**Science Group Leader & Principal Veterinary Research Officer**
Lorna Anness	Project Assistant North East Local Biodiversity Partnership
Zdenka Babikova	PhD Student
Joan Beaton	Ecologist
Liz Bourne	PhD Student
Rebecca Brassey	Visiting Researcher
Dr Andrea Britton	Plant Ecologist
Dr Rob Brooker	Plant Ecologist
Anja Carlsson	PhD Student
Michelle Clements	PhD Student
Roger Cummins	Research Scientist
Hazel Davidson	Visiting Researcher
Chantel Davies	PhD Student
Jose Ignacio de la Pradilla Villar	PhD Student
Dr Antonia Eastwood	Plant Ecologist
Dr Johann Erhard	Visiting Researcher
Deborah Fielding	Research Assistant
Julia Fisher	Research Scientist
Diana Gilbert	PhD Student
Dr Lucy Gilbert	Ecological Epidemiologist
Dr Estelle Gill	Local Biodiversity Action Plan Coordinator
Dr Alessandro Gimona	Landscape Ecologist
Emily Green	Research Assistant
David Hamilton	Research Scientist
Annabel Harrison	PhD Student
Prof Alison Hester	Senior Scientist
Richard Hewison	Research Assistant – Plant Ecology
Suzanne Hogg	Research Assistant – Population Ecologist
Russell Hooper	Research Assistant
Colin Hunter	Visiting Researcher
Dr Glenn Iason	Senior Scientist
Dr Justin Irvine	Ecological Epidemiologist
Marianne James	PhD Student
Ed Jones	Mathematical Ecologist
Carol Kyle	Research Assistant
Dr Jack Lennon	Spatial Ecologist
Rob Lewis	PhD Student

Staff List as of 1st January 2010

ECOLOGY GROUP MEMBERS (continued)

Dr Nick Littlewood	Invertebrate Ecologist
Craig MacEachern	Stockworker
Dr Bob Mayes	Senior Scientist
Jim McLeod	Software Engineer
Dr Ben Moore	Chemical Ecologist
Dr Scott Newey	Population Ecologist
Prof Robin Pakeman	Plant Ecologist
Dr Javier Perez-Barberia	Population Ecology Research Scientist
Estefania Perez-Fernandez	PhD Student
Ros Porter	PhD Student
Gabor Pozsgai	Entomologist
Gina Prior	PhD Student
Dr Scot Ramsay	Population Ecologist
Prof Steve Redpath	Researcher
Sheila Reid	Ecological Assistant
Dr Stewart Rhind	Research Scientist
David Riach	Support Scientist
Louise Ross	PhD Student
Adam Seward	PhD Student
Dr Angela Sibbald	Research Scientist
Dave Sim	Ecological Research Assistant
Jenni Stockan	Insect Ecologist
Clare Trinder	Visiting Researcher
Dr Rene Van der Wal	Researcher
Dereje Wakjina	PhD Student
Melanie White	PhD Student

INTEGRATED LAND USE SYSTEM GROUP MEMBERS

Prof David Miller	**Science Group Leader**
Dr Inge Aalders	Research Scientist
Dr Innocent Bakam	Complex Systems Modeller
Richard Blake	PhD Student
Chris Brown	PhD Student
Dr Iain Brown	Work Package Coordinator
Kevin Buchan	Software Engineer
Marie Castellazzi	Landscape Ecologist
Gavin Donaldson-Selby	Landscape and Visualisation Modeller
David Donnelly	GIS Consultant
Jenny Farmer	PhD Student
Dr Nick Gotts	Simulation Modeller
Paula Harthill	Research Scientist
Dr Sally Huband	Social Geographer/Rural Sociologist
Luz-Maria Lozada-Ellison	PhD Student
Dr Robin Matthews	Climate Change Theme Cordinator
Dr Keith Matthews	Senior Research Scientist
Gillian McCrum	Qualitative Social Researcher
Margaret McKeen	Digitizer
Dave Miller	Research Assistant
Jane Morrice	Research Scientist
Dr Shibu Muhammed	Ecosystem Modeller
Dr Jose Munoz-Rojas	Spatial Planner
Edoardo Pignotti	PhD Student
Dr Laura Poggio	Spatial Modeller
Dr Gary Polhill	Human-Natural Systems Research Scientist
Mike Rivington	Land Use System Modeller
Neil Sang	Research Scientist
Dr Lee-Ann Sutherland	Social Scientist

SOCIO-ECONOMIC RESEARCH GROUP MEMBERS

Prof Bill Slee	**Science Group Leader**
Koen Arts	PhD Student
Dr Bedru Balana	Ecological/Environmental Economist
Dr Kirsty Blackstock	Qualitatitve Social Scientist
Dr Katrina Brown	Researcher
Dr Tony Craig	Environmental Psychologist/Sociologist
Dr Benjamin Davies	Researcher
Dr Elizabeth Dinnie	Qualitative Social Researcher
Jill Dunglinson	Research Assistant
Dr George Dyer	Rural Economist
Diana Feliciano	PhD Student
Dr Anke Fischer	Researcher
Carlos Galan-Diaz	Research Assistant
Dr Alana Gilbert	Research Economist
Dr Klaus Glenk	Natural Resource Ecological Economist
Adekunle Ibiyemi	Research Assistant – GIS
Dr Wendy Kenyon	Senior Research Fellow
Antoinette Kriel	Sandwich Student
Dr Keith Marshall	Researcher
Dr Maria Nijnik	Researcher
Sharon Phillip	PhD Student
Dr Katrin Prager	Social Researcher
Sebastian Selge	PhD Student
Heather Smith	PhD Student
Julie Urquhart	PhD Student
Sander Van der Jagt	PhD Student
Kerry Waylen	Social Researcher
Dr Yan Xu	Rural Economist

Staff List as of 1st January 2010

SOILS GROUP MEMBERS

Prof Colin Campbell	**Science Group Leader**
Dr Matt Aitkenhead	Soils Modeller
Dr Fabrizio Albanito	Visiting Researcher
Anwar Alizai	PhD Student
Dr Roxane Andersen	Visiting Researcher
Dr Ian Anderson	Honorary Researcher
Dr Rebekka Artz	Post Doctoral Research Scientist
John Bell	Soil Scientist
Dr Helaina Black	Soil Scientist
Clare Cameron	Research Assistant
Emily Carroll	PhD Student
Dr Katherine Chadwick	Visiting Researcher
Dr Steve Chapman	Senior Scientist
Malcolm Coull	Soil Database/GIS Technician
Dr Lorna Dawson	Research Scientist
Dr Barbara Drigo	PhD Student
Dr Geoffrey Elliott	Molecular Microbiologist
Luca Giaramida	Casual Researcher
Gillian Green	Field/Laboratory Assistant
Dr Gwen-Aelle Grelet	Visiting Researcher
Katherine Grundy	PhD Student
Richard Gwatkin	Field/Laboratory Assistant
Anke Herrmann	Visiting Researcher
Carolyn Hillier	Visiting Researcher
Dr Stephen Hillier	Soil Mineralogist
Robert Hobkirk	PhD Student
Kenny Hood	Research Assistant
Dr Rupert Hough	Soil Science Coordinator
Dengke Hu	PhD Student
Yao Huaiying	Visiting Researcher
Gordon Hudson	Soil Data Manager
Susan Jarvis	PhD Student
Ully Kritzler	PhD Student
David Limmer	Student
Angela Main	Research Assistant
Jonathan McAllister	Visiting Researcher
Prof Pete Millard	Researcher
Loic Nazaries	PhD Student
Andy Nolan	Head of Ecology & Land Evaluation Unit
Ingrid Oborn	Visiting Researcher
Shona Osborne	Research Scientist
Dr Eric Paterson	Root Physiologist/Biochemist
Dr Ian Phillips	XRD Clay Mineralogist
Sam Quin	PhD Student
Atefeh Ramezanian	PhD Student
Eileen Reid	Research Scientist
Lucinda Robinson	Research Assistant
Jasmine Ross	Research Assistant
Dr Charlie Shand	Senior Research Scientist
Allan Sim	Research Scientist
Dr Brajesh Singh	Molecular Microbial Ecologist
Catherine Smart	Research Assistant
Dr Martin Sommerkorn	Plant Carbon Physiologist
Dr Emma Sproston	Molecular Microbiologist
Dr Andy Taylor	Molecular Fungal Ecologist
Nadine Thomas	Research Assistant
Caroline Thomson	Research Assistant
William Tottey	Student
Willie Towers	Research Scientist
Sam Vanlaningham	Visiting Researcher
Dr Renate Wendler	Soil Chemist
Dr Duncan White	Laboratory Manager – Microbiology
Mike Whitfield	PhD Student
Anna Wilkinson	PhD Student
Alison Williams	Research Assistant

ANALYTICAL GROUP MEMBERS

Dr Andy Midwood	**Analytical Group Manager**
Ann Brands	Laboratory Technician
Ann Bruce	Laboratory Glassware Cleaner
Dr Carol-Ann Craig	Head of Inorganic Isotope Analysis
Carol Curran	Research Assistant
Evelyne Delbos	Head of Electron Microscopy
Carrie Donald	Research Assistant
Bill Donald	Head of Commercial Analysis
Tony Fraser	Chemist
Evina Gontikaki	Visiting Researcher
Nia Gray	Sandwich Student
Dr Helen Hill	Research Assistant
Christine Kerr	Research Assistant
Catherine Kite	Research Assistant
Donna Macdonald	Research Assistant
Gillian Martin	Research Scientist
Dr Dan Mayor	Visiting Researcher
Louise McDonald	Research Assistant
Susan McIntyre	Research Scientist
Kelly McKenzie	Analytical Chemist
Evelyn McMurray	Research Scientist
Gareth Newman	Head of Inorganic Analysis & Quality Manager
Mark Osprey	Research Assistant
Dr Jason Owen	Head of Soils Section – Analytical Group
Stephen Peatfield	Commercial Organic Chemist
Dr John Price	Senior Analytical Chemist
Maureen Procee	Research Assistant
Dr Jean Robertson	Head of Infrared Spectroscopy
Diane Smith	Research Assistant
Fiona Sturgeon	Research Assistant
Dr Barry Thornton	Section Leader of the Isotopes Section
Esther Williams	Laboratory Assistant
Dr Kyari Yates	Analytical Chemist
Dr Zulin Zhang	Organic Chemist

ADMINISTRATION GROUP MEMBERS

BUSINESS DEVELOPMENT

Jeremy Evans	**Business Development Coordinator**
Arek Chociaj	Contracts Administrator
Grant Davidson	International Development Coordinator
Emma Wing	Contracts Officer

COMMUNICATION SERVICES

Dr Dick Birnie	**Head of Communication Services**
John Brown	Graphic Designer
Pat Carnegie	Graphic Designer
Jenna Gray	Communications and PR Assistant
Jane Lund	Events Manager
Lauren Farr-Miller	Graphic Designer
Clara Macindoe	Web Editor
Clare Neely	PR & Communications Manager
David Riley	Photographic Officer
Ian Williamson	Graphic Designer

Staff List as of 1st January 2010

ADMINISTRATION GROUP MEMBERS (continued)

FINANCE

Carol Smith	**Financial Controller**
Linda Duncan	Assistant Accountant
Barbara Green	Personal Assistant to the Director of Corporate Services
Janice Laing	Assistant Accountant
Julie MacArthur	Accounts Assistant
Briony Stewart	Accounts Assistant
Lynne Thomson	Purchasing Officer
Jackie Wales	Accounts Assistant – Purchase Ledger

GLOBAL LAND PROJECT

Prof Richard Aspinall	**Director**
Dr Carol Ann Stannard	Executive Officer

GROUP ADMINISTRATION

Elsa Brown	Group Administrator – Soils & ITS
Lesley Forbes	Group Administrator – Ecology
Vivienne King	Group Administrator – ILUS & SERG
Anne Marsden	Group Administrator – Business Development, GIS & IFRU
Kelly Owen	Group Administrator – Catchment Management
Jo Skoyles	Group Administrator – Analytical
Carol Smith	Assistant to HR & Training Manager and Communication Services

HEALTH AND SAFETY

Moira McMaster	**Health and Safety Manager**

HR AND TRAINING DEVELOPMENT

Dr Debs Slater	**Head of HR & Training and Deputy to Director of Corporate Services**
Liz Healy	Receptionist
Yvonne Massie	Administrative Assistant
Stacey Scragg	Human Resources Administrator
Kay Stewart	Human Resources Administrator
Scott Strachan	Human Resources Manager
Jane Thompson	Administrative Assistant

LIBRARY AND INFORMATION SERVICES

Lorraine Robertson	**Head Librarian**
Elaine Mackenzie	Assistant Librarian and Data Manager

PROGRAMME 3

Prof Stephen Albon	**Programme 3 Coordinator**
Baerbel McRitchie	Personal Assistant to Programme 3 Coordinator

TECHNICAL SERVICES

Grahame Shaw	**Head of Technical Services**
Izzy Aitchison	Cleaner
Ian Alexander	General Handyperson
James Anderson	Officer Responsible for Institute Vehicles
David Clark	Electrician
Anna Fedorowicz	Cleaner
Graham Gaskin	Project Engineer
Kathy Hake	Cleaner
Con Harley	Security Person
Brian Kemp	Head Groundsman
Barbara Luka	Cleaner
Mustapha El Machrouhi	Security Person
Catherine Milne	Hostel Caretaker
Ernie Milne	Patrolman
John Mundie	General Craftsperson
Alan Rhynas	Security Person
David Sim	Maintenance Manager
Alison Wilkinson	Joiner
Allan Wilson	Engineer in Charge of Mechanical Engineering Workshop

INFORMATION TECHNOLOGY SERVICES MEMBERS

David Stone	**IT Services Group Manager**
Bababode Akitoye	Research Systems Administrator
David Bryant	Network Manager
Malcolm Collie	Systems Administrator
Alan Crawford	IT Analyst
Shiraz Hussain	Database Administrator
Gearoid King	Novell Systems Engineer
Jack Spain	Helpdesk Manager
Andrew Thorburn	Webmaster/Web Application Developer/ Spatial Database Manager
Benjamin Watt	Deputy Network Manager and PC Development Officer

RESEARCH STATION STAFF MEMBERS

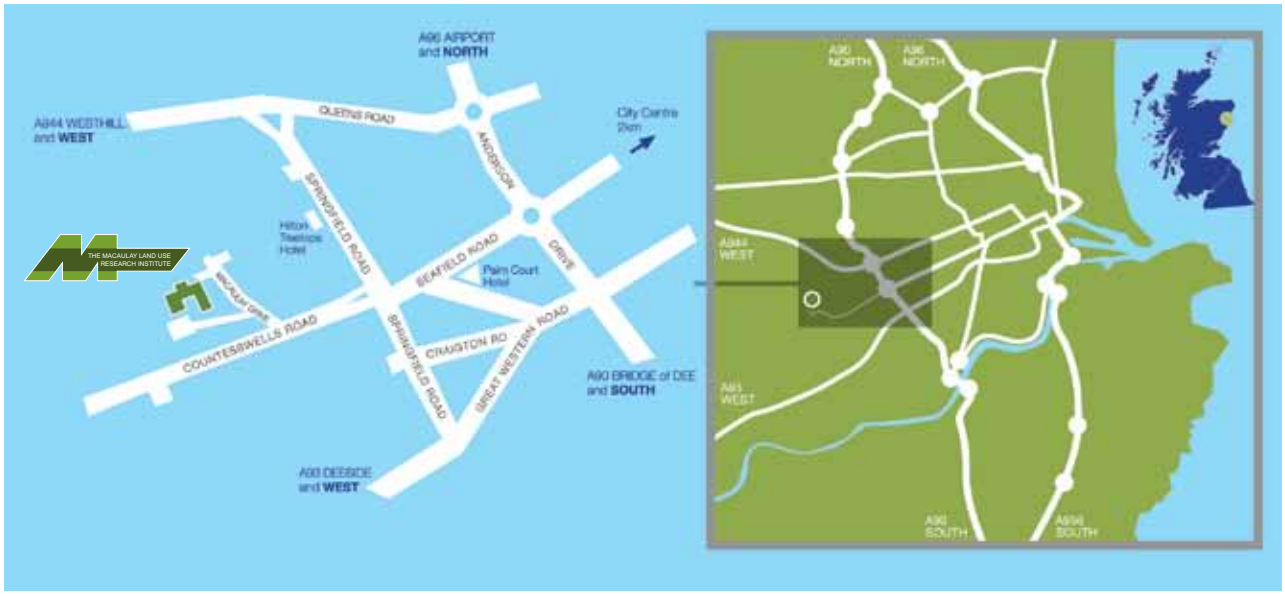
George Corsar	**Head of Farms**
Donald Barrie	Farm Manager – Glensaugh
John Black	Grieve
Derek Hague	Stockperson
Jim MacDonald	Stockworker
Owen Main	Trainee / Assistant Stockperson
James Scott	Shepherd / Stocksman
June Scott	Cleaner
Ian Waddell	Caretaker

INTERNATIONAL FEED RESOURCES UNIT

Professor Bob Ørskov	**Director**
Dr Tintin Kustantinah	Visiting Researcher

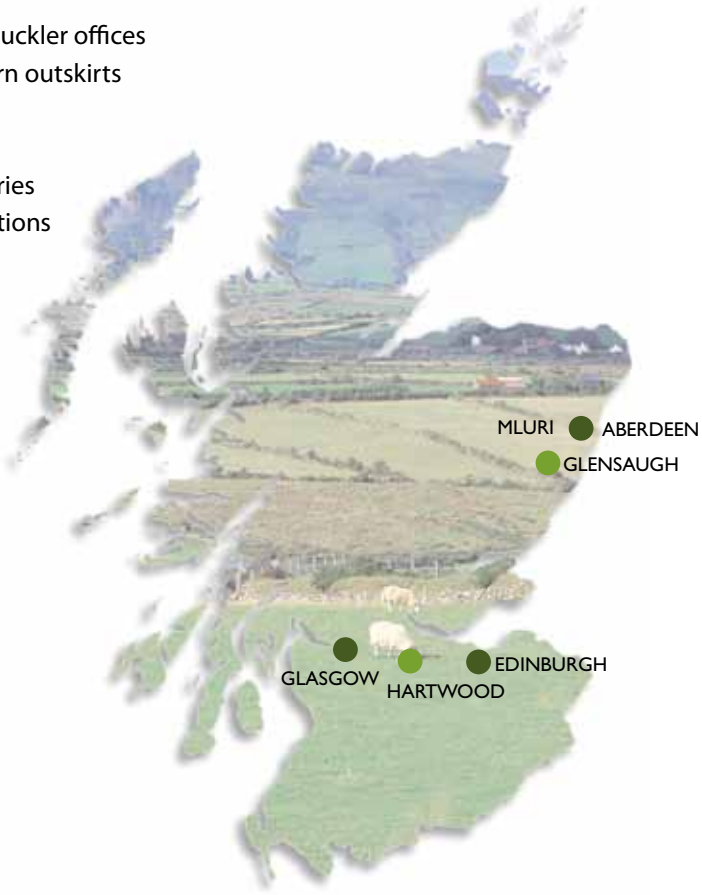
For more information:
macaulay.ac.uk/staff

MLURI Connections



The Macaulay Land Use Research Institute's Craigiebuckler offices are based on the east coast of Scotland in the western outskirts of Aberdeen.

In addition to the purpose built offices and laboratories in Aberdeen, the Institute operates two research stations at Glensaugh Farm in Aberdeenshire and at Hartwood Farm near Shotts in Lanarkshire.



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