



**NATURAL
ENVIRONMENT
RESEARCH COUNCIL**

NERC IMPACT REPORT 2011

Environmental science for UK economic growth and wellbeing



Natural Environment Research Council
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1. Environmental science for UK economic growth and wellbeing

The Natural Environment Research Council (NERC) strategic goal for the period 2011 - 15 is:

To secure competitive advantage for the UK in the race to a global green economy, and ensure the nation is resilient to environmental crisis.¹

The natural environment provides business, Government and society at large with the essential resources and beneficial services to sustain life and for economic growth and societal wellbeing. These include: food; energy; minerals; clean air and water; regulation of flood, climate and disease; mental and physical health and life expectancy.

Human activities are causing large changes in the environment, jeopardising both natural resources - such as food, water and energy - and the resilience of society and its infrastructures to extreme natural hazards. These same environmental pressures create major opportunities for the UK to seize new markets in the global race to a green economy. A successful green economy will simultaneously support economic growth, increased resilience, use less carbon and energy, and sustain environmental services. NERC science and partnerships enable the UK to rapidly absorb and exploit new knowledge and technologies, and to overcome risks that act as barriers to private investment in new technologies and businesses.

This Impact Report forms part of the performance monitoring system required by BIS, focusing on the impact generated by NERC science and what is being done to maximise prospects for future impact. NERC's performance targets are detailed in our Delivery Plan 2011-2015 with further evidence of what we achieve, including research highlights, showcased on our website.² Our overall organisational performance is reviewed and summarised in the NERC Annual Report,³ whilst comprehensive monitoring for BIS on Delivery Plan targets is given in our Scorecard.⁴

Section 2 of this Impact Report illustrates the value of NERC environmental science for delivering the green economy through:

- **UK competitive advantage:** finding new ways to exploit environmental resources and services optimally, to create and grow new markets and businesses.
- **UK policy leadership:** policy and regulation informed by foresight of environmental opportunities and constraints, and understanding of the process of environmental change.
- **Improving UK business performance:** using environmental technologies, services and solutions to optimise business and environmental sustainability.
- **Transforming UK public services:** enabling a resilient society - protecting vulnerable people, places and infrastructure - providing a secure supply of food, energy and water.

Section 3 highlights the excellence of the UK environmental sciences, the investment being made by NERC in training to sustain the science base, and how skilled people themselves are an important mechanism for knowledge exchange with the wider economy. NERC's sustained excellence is demonstrated by the UK environmental sciences consistently leading amongst the G8 between 2006 and 2010 as measured by citations impact.

Section 4 shows how NERC is:

- Transforming its support for translation by targeting knowledge exchange programmes towards green economy growth markets;
- Leading a cultural change amongst the wider NERC science community to increase the translation of research to benefit users.

2. Impact

2.1 UK competitive advantage

NERC already works with a wide range of business sectors, including leading companies in oil and gas (such as BP, Shell, Chevron Texaco, Esso), mining (such as Rio Tinto, BHP Billiton, AngloAmerican, XStrata, Boliden) and water (e.g. Anglian, Southwest, Thames, Wessex). We support the UK's global environmental consultancies (such as Atkins, Halcrow, Enviro) as well as emerging business sectors such as space, renewable energy and carbon financing. Many of the businesses engaged in NERC projects are SMEs who provide a significant proportion of the innovative products and services in the environmental sector.

Over the next four years NERC will target and strengthen its engagement with business in five key sectors: marine renewable energy; environmental management for food and agriculture; water security; resource management (including minerals and waste); plus financial services risk management and valuation.

In the marine renewables sector, for example, NERC has launched a joint Marine Renewable Energy Research Programme with Defra and established a Marine Renewable Energy Knowledge Exchange Programme. The latter provides a hub for business and policy users to access NERC research capability and knowledge in Research centres and HEIs. These initiatives help to unlock new economic growth by providing:

- Understanding of the energy resource that is available and can be realistically extracted from given wave and tidal conditions;
- Knowledge of where best to locate devices and arrays
- Capability to monitor the impacts of deploying devices, and hence to mitigate and de-risk new technologies;
- Information and risk assessment for regulation, planning and licensing.

Figure 1: Shale gas⁵

NERC's British Geological Survey (BGS) is assessing the potential for shale gas extraction in the UK as well as how to extract it in a way that safeguards the public and the environment.

- BGS has estimated the volume of UK onshore shale gas to be as high as 150bn cubic metres, 25-times conventional gas sources, with a potential wholesale market value of **£28bn**, influencing the investment decisions of major oil and gas companies.
- Shale gas reserves in the Blackpool area could create up to 5,600 jobs in the region.
- NERC science is providing Government with essential evidence on: validating the potential of this technology when applied in new locations; and assessing and mitigating the risks of shale gas extraction and the methodologies used;

Figure 2: Tidal power

The SeaGen tidal turbine at Strangford Lough, Northern Ireland, is the world's first commercially operational tidal turbine. David Ainsworth of the company Marine Current Turbines (MCT), says that the NERC Sea Mammal Research Unit (SMRU) was critical in unlocking economic growth in this sector: "Demonstrating the environmental compatibility of SeaGen is just as crucial as demonstrating its technical and economic viability. A crucial hurdle for the sector is whether its environmental impact is going to be acceptable in the long-term. SMRU have played a key role in assembling an evidence base that demonstrates that tidal stream power can be compatible with environmental protection in a highly sensitive location."

Enabled by NERC science, MCT aims to deploy 500-1000 tidal turbines in UK waters by 2020. Such growth in marine renewables would offset up to £70m pa of carbon emissions by 2020 and generate **£150m to £1bn pa** for the UK economy by 2050.



Figure 3: Carbon capture and storage⁶



NERC scientists from BGS and Edinburgh University working through one of the largest academic and industrial partnerships in the UK have identified pathways to deploy new carbon capture and storage technology. The prospects are now good for the first full-chain demonstrator in Europe of carbon capture from a coal fired power station to storage under the North Sea, making the UK an international leader in this technology.

- Research has shown that Captain Sandstone off Scotland's North East coast can store 360m tonnes of CO₂ now and up to 1,200m tonnes with further investment.
- This capacity equates to 15 to 100 years of CO₂ output from Scotland.
- Global CCS consultancy could be worth up to **£9.5bn pa** (GVA) by 2025, potential value added in UK of £5-9bn pa together with **27,000 jobs**.

2.2 UK policy leadership

The UK's success in the green economy depends on having the right policy and regulatory frameworks to enable sustainable economic growth. Recent examples where NERC research has made major contributions to policy include: the UN Intergovernmental Panel on Climate Change; the Climate Change Act (2008); the EU Water Framework Directive; the UN Law of the Sea; the Marine and Coastal Act (2009). NERC research will continue to directly inform such policy and regulation.

NERC research translated through the Living with Environmental Change (LWEC) partnership underpins the UK National Ecosystem Assessment, the world's first valuation of ecosystem services and natural capital. Recognising and valuing the benefits of nature is the first step to creating new market opportunities in ecosystem services that will drive green economic growth. Policy action is now critical to exploit this scientific lead and translate it into competitive advantage for UK business.

Figure 4: Defra Natural Environment White Paper 2011

NERC research is enabling the UK to deliver a healthy, sustainable and productive natural environment by informing policy development.

- The ecosystem approach, which underpins the whole of the White Paper, has been developed from NERC and ESRC research translated through the UK National Ecosystem Assessment (**figure 5**).
- The assessment was grounded on decades of NERC research and monitoring, such as the countryside survey, supported by NERC Research Centres like the Centre for Ecology & Hydrology.
- Defra now value the UK Biodiversity Action Plan at **£1,366m pa** with a potential **£746m pa** extra from an increased spend scenario.⁷ The UK BAP was developed to meet the Government's commitment to the Convention on Biological Diversity signed at the Rio Earth Summit in 1992.

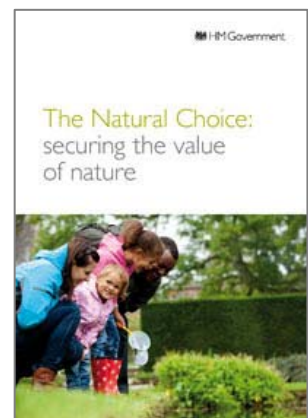


Figure 5: National Ecosystem Assessment 2011⁸

“The natural world is vital to our existence, providing us with essentials such as food, water and clean air, but also other cultural and health benefits not always fully appreciated because we get them for free. The UK National Ecosystem Assessment is a vital step forward in our ability to understand the true value of nature and how to sustain the benefits it gives us.”⁹

**Environment Secretary
Caroline Spelman**

Research funded by NERC and partners in LWEC is critical for understanding and valuing the essential services provided by nature. These services are being degraded, giving rise to a mitigation opportunity valued at **£1.2- 2.7 trillion**¹⁰ globally. Illustrative opportunities include:

- **Providing carbon storage**
NERC research on peatland shows it can be managed to store rather than release carbon to the value of **£9bn-15bn**.¹¹ Zero use of peat in horticulture alone would save **£880m** (UK and internationally) over a 20 year period through emissions reductions of 21m tonnes of CO₂.¹²
- **Supporting water cycling**
NERC groundwater research enabled the Environment Agency to issue **£40m pa** worth of additional groundwater extraction licenses yet maintain a sustainable supply of water.
- **Regulating soil erosion**
Defra catchment policy was informed by the NERC science discovery that conversion of pasture to ploughed fields was causing erosion and soil loss into southern England’s rivers at a cost of **£45m pa** in water treatment.
- **Preserving crop pollinators**
Scientists showed that about 80% of British plant species use insect pollinators and that low cost seed mixes could boost declining bumblebee populations. **75% of world crops** depend on insect pollinators to produce **\$1 trillion pa** of world produce.

2.3 Improving UK business performance

Enabling delivery through strategic partnerships

By operating through strategic partnerships NERC is better able to translate its science to benefit business, policy and society. Early user involvement in formulating science programmes – co-design and co-delivery – ensures that research outcomes will be relevant to user needs. Working in partnership also brings significant co-funding to add to NERC contributions.

The pioneering Living with Environmental Change (LWEC) partnership provides foresight, tools and knowledge relevant to policy-makers and business, and accelerates the translation of research. A unique group of senior business leaders act as the Business Advisory Board¹³ (BAB) to identify and prioritise:

- Business challenges requiring environmental knowledge and solutions;
- Environmental knowledge and skills gaps for business;
- How to engage business people in existing and new research to meet business needs;
- Commercial opportunities for research activities;
- How policy can best enable business opportunities.

The BAB’s advice has already influenced the direction of the LWEC partnership, notably contributing to the roadmap to a green economy and engagement with the Science Minister, David Willetts.

Figure 6: LWEC research for policy and business

- The LWEC AVOID¹⁴ programme provided key advice to the UK Government to inform the UK negotiating position on greenhouse gas emissions for the 2010 UN Climate Change talks in Copenhagen.
- Many low-carbon technologies rely on rare-earth metals so the UK needs to know it has a sufficient and secure supply. The LWEC Minerals and Waste programme uses data on global metal production and trading to provide crucial information to UK and EU policy-makers and businesses.
- The NERC - Met Office Joint Weather and Climate Research Programme is pooling the expertise of hundreds of scientists to provide improved weather and climate forecasting, so that information and advice can be fed more quickly to policy-makers, emergency planners, farmers and other business users.
- The LWEC Thames Estuary 2100 project has carried out a detailed assessment of the actions that the Environment Agency and others will need to take over the coming century to protect London from flooding. These could include building a new Barrier by the year 2070. The cost of a storm surge flooding London could be **£31bn** in damage and lost business productivity, and its avoidance has been valued at **£2.1bn pa** in retained foreign direct investment.¹⁵



Partnership with the Technology Strategy Board¹⁶

NERC is already delivering specific projects in partnership with TSB as illustrated in **figure 7**. Existing partnership between NERC and TSB has been primarily through Knowledge Transfer Networks (KTN) to engage business communities with NERC researchers. For example, engagement with the Financial Services KTN has increased the number of Knowledge Transfer Partnerships which NERC is funding with the finance sector and is also increasing knowledge exchange on hazards with the insurance sector (**figure 8**). Future partnership is being explored with TSB, priority being given to key growth sectors and potential Technology and Innovation Centres (TICs): for example in marine renewables, water and future cities.

Figure 7: Cleaning up low-level radiation in soils



A NERC sponsored Knowledge Transfer Partnership (KTP) has trialled a cleaner and cheaper product to cleanse soils of low-level radioactive contamination. Half a million cubic metres of contaminated ground in the UK has been declared as low-level radioactive waste. Handling large volumes is expensive, with disposal capacity to be used sparingly and as a last resort.

- Removing radionuclides from soil minimises bulk avoiding **£25-40m** in transport costs.
- Experimental field trials at the Atomic Weapons Establishment (AWE) tested the technique.
- The KTP led to improved understanding of physical and chemical processes and how to up-scale the technology for practical use.
- PhD graduate being employed by AWE, embedding new knowledge into industry.

Figure 8: NERC support for UK insurance industry¹⁷

NERC's catastrophe weather modelling is being used by insurance companies to assess and manage insurance risk. Unexpected accumulation of risk may lead to large losses which could destabilise the insurance industry. A 5% reduction in average insured losses due to storm damage alone would be worth **£62-130m pa** to the UK insurance industry.

NERC's investment in high-resolution climate modelling at Reading University has led to the Willis Research Network entering into a long-term partnership with the university. So far Willis Re has paid more than **£0.8m pa** for resources, including PhD students tasked with turning academic knowledge into practical applications for the insurance industry.

The **£7.2 bn pa** UK insurance industry is the largest in Europe and the third-largest in the world: it employs 313,000 people. Creating and exploiting new knowledge in fields such as catastrophe weather modelling helps maintain the UK's competitive position as a centre for reinsurance and supports future growth.



A report for HM Treasury stated:

‘In the case of climate change, the aim of greater cooperation between the Government, the insurance industry and (research) institutions would be to make better predictions of environmental change and its impact... This could be achieved by prioritising high resolution climate models and the need for enhanced super-computing power to be able to make the predictions needed by industry and society. This is an area of UK leadership that must be maintained, requiring significant investment in super computer facilities and personnel.’¹⁸

2.4 Transforming UK public services

NERC contributes to public services in providing science to inform policy (see **section 2.2**), involving public services in the partnership working (see **section 2.3**), and by transforming its own operations, through initiatives like the Research Councils’ Shared Service Centre Ltd, and integrating NERC’s national capability.

NERC plays a further role in support of public services in responding to emergencies brought about by natural hazards, or human disasters that have an environmental context. NERC’s role seeks to protect the UK public and the UK economy, or to offer our support and expertise internationally in times of need.

Our response can take the form of expert advice or the rapid deployment of NERC infrastructure, such as planes, to perform science, or the use of monitoring and data to provide timely information. This is all part of the national capability function provided by NERC and delivered mainly through its Research Centres and facilities based in universities.

In the last 12 months NERC scientists have played a significant role in supporting civil contingencies management, such as emergency responses to severe winter weather, pandemic flu and volcanic ash, often through inputs to meetings of COBR attended by Cabinet Ministers. On behalf of the UK Government, NERC has also provided advice to other countries following emergencies, such as the Hungarian waste spillage and the Japanese earthquake, and for international development.

Figure 9: Volcanic ash and aviation industry



In 2010 the Eyjafjallajökull ash cloud closed UK and European airspace, at an estimated cost of **£200m per day** to the aviation industry.¹⁹

- NERC scientific flights and advice led to a revised safety standard for ash concentrations enabling UK airspace to be reopened.
- The NERC National Centre for Atmospheric Science (NCAS) with the Icelandic Meteorological Office set up better monitoring in Iceland so that observations of the 2011 Grímsvötn volcano fed into the UK Met office ash dispersion model that enabled the UK Civil Aviation Authority to keep UK airspace open.
- Better data and the new emissions limits helped reduce disruption and economic loss to UK air traffic.
- NCAS is developing and commercialising a sensor for use by commercial aircraft to detect and measure volcanic ash, thus increasing safety and reducing downtime for airlines.

Figure 10: Space weather

Solar storms pose a risk to our technology-dependent society when large quantities of radiation from the Sun damage satellites and the electricity grid, and interfere with communications signals such as GPS. The UK defence secretary Liam Fox highlighted that essential infrastructure could be paralysed by a once-in-a-century solar flare²⁰.

- A US National Research Council report estimates costs of **\$1-2trillion** in the first year after a large solar storm. The damage caused to satellites alone could be **\$30billion**.²¹
- The NERC British Antarctic Survey (BAS) is leading an EU project to use satellite data and a BAS model of the Earth's radiation belt to predict when satellites will be at most risk so that mitigating action can be taken.
- NERC supports ground-based UK capability for monitoring and predicting the effects of solar activity on Earth, including the British Geological Survey (BGS) geomagnetism service, monitoring of the South Atlantic Anomaly (region where the Earth's magnetic field is weakest), and the UK subscription to the international EISCAT radar.



Figure 11: Radiation recovery



Experts in radioecology from the NERC Centre for Ecology & Hydrology (CEH) responded to the Fukushima nuclear accident in March 2011. CEH advice helped Japan to reduce the costs of clean-up and to minimise the potential risks to the environment and human health.

CEH also played a leading role in the European Radioecology Alliance to integrate European research, gaining European Commission (EURATOM FP7) support for a Network of Excellence in Radioecology.²²

Previous CEH work has included the UK Recovery Handbook for Radiation Incidents produced for the Health Protection Agency.

Figure 12: International Geoscience Services Ltd

The NERC British Geological Survey (BGS) has set up a new limited company, International Geoscience Services (IGS). The new company builds on BGS' capability in research, survey and monitoring to seize commercial opportunities in institutional strengthening and capacity-building programmes. Recent BGS achievements in international development include:

- Supporting the Nigerian Government to identify and exploit its mineral reserves and attract investors in mineral extraction. This will allow Nigeria to diversify away from an economic over-dependence on oil and to improve its long-term economic stability.
- Supporting the Afghanistan Geological Survey in reforming mining law. This led to copper extraction licences worth **£755m pa**²³ over 30 years, creating jobs and helping to build a sustainable economy whilst indirectly improving UK national security.
- Supporting the Ghanaian gold mining industry to avoid the use of mercury, removing a significant source of environmental pollution and reducing the long-term risks to human health.



2.5 Impact assessment and methodology

NERC collects evidence for the impact of its science from a variety of sources, including:

- Annual returns from NERC-funded scientists and Research Centres;
- Entries to the NERC Science Impacts Database (SID includes qualitative and quantitative evidence from scientists, government officials and business partners);
- Interviews with researchers and users;
- Commissioned economic valuation studies;
- Commissioned bibliometric and citation studies;
- Statistical and econometric analysis of the BIS Innovation Survey dataset.

Bottom-up performance metrics, such as annual returns and SID, tend to focus on individual research projects and have limited perspective in time and scope. Hence NERC also seeks to identify and quantify impacts that flow from a larger body of research over a longer time. In the future, we would like to work with BIS and HEFCE to establish how we can share impact evidence in cooperation with, and minimising reporting burdens on, the research community.

During 2010-11 we have made progress in developing our in-house assessment capability:

- Trialling Social Return on Investment on a sample case to explore the appropriateness of this methodology for NERC research;
- Working with Research Centres to increase impact assessment understanding and capability;
- Completed the econometric analysis of the BIS Innovation Survey dataset on how research council inputs influence private sector innovation (this study will be published in 2012);
- NERC's environmental economist has also been working on knowledge exchange and the green economy, again in collaboration with colleagues at BIS.

NERC is currently developing:

- Plans for follow-up statistical analysis using the BIS innovation dataset on energy, infrastructure, resources, and services;
- 'Big Picture' analysis on NERC contribution to industry sectors such as water, marine renewable energy, and resources;
- An assessment of the contribution of RCUK research to the Green Economy;
- A science timeline project demonstrating the incremental steps, interdependencies and long time horizons to impacts in science;
- An assessment of the value of NERC PhDs to the UK, building on the RCUK PhD impact evaluation;
- Impact case studies that respond to topical issues at the time they occur (such as examples of NERC impacts in water, to coincide with publication of the water white paper).

Such evidence allows us to exemplify economic, policy and societal impacts across a wide range of NERC science and user sectors as given in **figure 13**. Note, however, that figure 13 illustrates only a partial subset, not the totality, of the benefits arising from NERC science. Many of these examples are drawn from recent valuation reports produced by consultants DTZ using the Treasury Green Book methodology for quantifying net present value. A number of assumptions have to be made in order to aggregate the figures to obtain the value of markets supported and the total benefit accruing to the UK.

Figure 13: Recent NERC impact examples with indicative valuations²⁴

Item	impact	market (£bn)	benefit (£m)
Ecosystem services ²⁵	Research by NERC and LWEC partners identifying ecosystem services critical to economic growth and human wellbeing	2,700	2,113
Space weather ²⁶	NERC researching threats and mitigations given potential vulnerability of modern technological infrastructure	1,000	-
Afghanistan copper ²⁷	NERC's BGS helped establish potential of Afghan copper reserves and supported development of regulatory environment, leading to major mining deal with China	18	755
Geoengineering ²⁸	NERC, working through LWEC, is exploring the potential of different geoengineering technologies and their possible social, political and environmental impacts	104	-
Autosub - stimulated UK lead in AUVs development sector ²⁹	NERC's technology needs have stimulated AUVs development capability in UK to gain part of growing market. NERC also collaborating with NASA on aerial autonomous systems	4.1	-
Storm surge prediction ³⁰	NERC's NOC informs when and where storm surges will hit, as well as the consequences of sea-level rise for contingency planning, including defence of London from flooding	150	2,100
Water industry: addressing priority issues for UK ³¹	NERC science through LWEC is helping to improve efficiency and effectiveness of UK water industry	27	-
Shale gas ³²	BGS research helps validate the potential of shale gas extraction and assesses its risks	28	-
Bees and pollinators ³³	NERC is working in partnership through LWEC to protect threatened pollinators	0.4	-
Modelling the UK in 3D ³⁴	NERC's BGS modelling has multiple applications, such as Oxford flood protection, London water extraction licensing London, reducing North Sea CO ₂ storage costs	-	162
Soil contamination and urban renewal ³⁵	NERC has developed tests to identify risks from soil contamination protecting health, saving remediation costs and to cover market failure	0.2	70
High resolution climate modelling and the reinsurance industry ³⁶	NERC supported climate models give UK re-insurance industry a competitive advantage, safeguarding jobs and drawing inward investment	7.2	130
Air quality ³⁷	NERC research has informed setting and evaluation of air quality standards. Reductions in air pollution have avoided 35k premature linked deaths in UK	103.8	1,000
Nitrogen pollution ³⁸	European Nitrogen Assessment Report, led by CEH, highlights how to avoid impacts, such as red tides from fertiliser overuse	280	-
Marine renewables ³⁹	Supporting sustainable growth of sector (e.g. tidal turbines, offshore wind) by de-risking introduction of new technologies	1	95
Geothermal energy ⁴⁰	NERC's BGS supported successful Newcastle test drill	9.3	-
Space research ⁴¹	NERC supports world-leading space research, e.g. Cryosat-2. Space industry is a major industrial sector in which UK excels	6.5	-
Volcanic ash clouds ⁴²	Informed change in aviation industry ash density standards, reducing time European airspace might have to be closed due to Icelandic eruptions	-	200
Carbon Capture and Storage ⁴³	NERC expertise contributing to safe development of CCS through geological feasibility, policy formulation, environmental impact legislation with Scottish CCS consortium	10	-
Water quality monitoring ⁴⁴	NERC has supported development of water quality monitoring devices for commercial use	-	48
Scottish fish farming ⁴⁵	NERC research is supporting sustainable growth of the fish farming industry by helping to inform their regulation	60	158
River flooding and the grid-to-grid hydrological model ⁴⁶	NERC research has developed higher resolution models for better local prediction of extreme weather, to better safeguard lives and property	-	173
Marine Environmental Impact Assessments ⁴⁷	NERC environmental data is supporting sustainable use of the marine environment through Environmental Impact Assessments, e.g. for aggregates industry	46.8	120

3. Research and training priorities for impact

3.1 Science excellence

Environmental science excellence is an essential component of the UK “innovation ecosystem” that provides international leadership and makes the UK an attractive place for inward investment by multi-national companies. Here we provide evidence for the world-class excellence of NERC-funded environmental science.

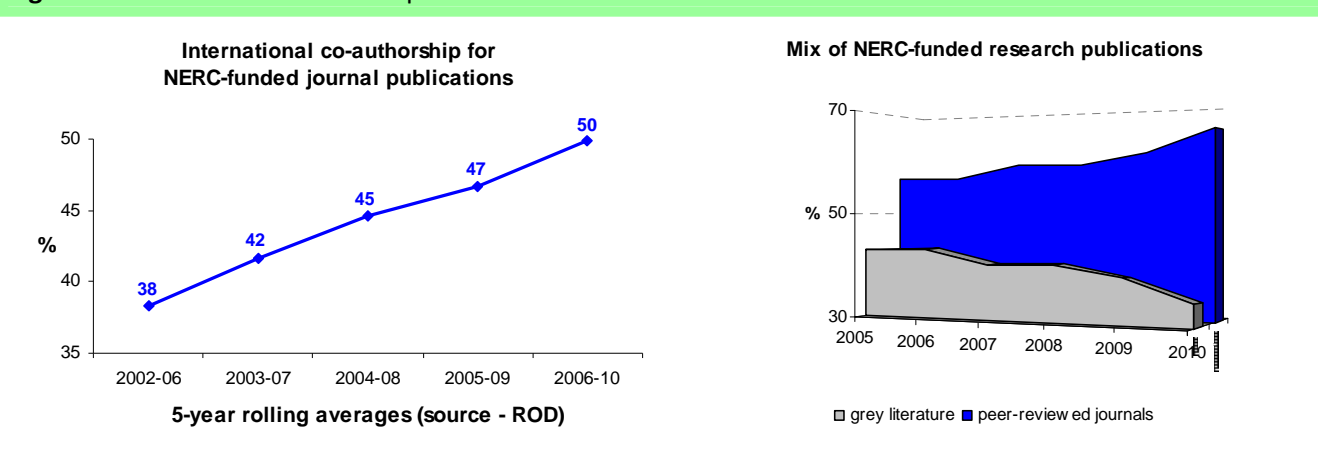
Citations are a means to quantitatively compare the academic impact of research publications amongst countries and across research fields. Whilst there are limitations to the methodology, citations can offer a proxy for research quality at the national level. **Figure 14** gives BIS data tracking the performance of the G8 research economies (USA, Germany, France, Italy, Canada, Japan, China and the UK). The UK environmental sciences have consistently led amongst the G8 between 2006 and 2010 as measured by citations impact. A NERC Citations Study in 2008 demonstrated that NERC-funded research showed a quality premium, outperforming the UK average for the environmental sciences.

Figure 14: Citations - international comparisons for UK environmental sciences⁴⁸

	2006	2010
Share of world peer reviewed journal papers	7.23%	6.62%
Rank G8	2nd	2nd
Rank EU-27	1st	1st
Share of world citations	10.96%	10.74%
Rank G8	2nd	2nd
Rank EU-27	1st	1st
Citation impact score	1.30	1.42
Rank G8	1st	1st
Rank EU-27	5th	6th

Another proxy measure for quality is breadth of international collaboration. **Figure 15** gives international co-authorship data for NERC, showing a long term and continuing rise. Whilst not conclusive in itself, it gives some quantitative evidence of positive changes in behaviour to broaden international collaboration and thereby to strengthen science quality and impact. This is complemented by a long-term rise in the volume of peer-reviewed publications produced from NERC-funded research, with an increasing majority of publications going through peer review as a form of quality control (**Annex A**, metrics 30 & 31).

Figure 15: Bibliometrics on NERC publications



3.2 Skilled people

Importance to UK economy

A strong supply of skilled people is important to the long-term health of the research base and the economy, and attracts inward investment. NERC is committed to providing trained people to sustain environmental research, provide jobs to the economy and leaders for the future through the funding of PhD students.

Figure 16: UK innovation survey

In 2010 NERC seconded its environmental economist to BIS to investigate the role of the public research base in facilitating innovation in the green economy. Data on 2,060 companies from the BIS innovation survey was analysed to look at how public research is taken up by industry. Some results are given below. The results have informed the design of NERC knowledge exchange programmes.

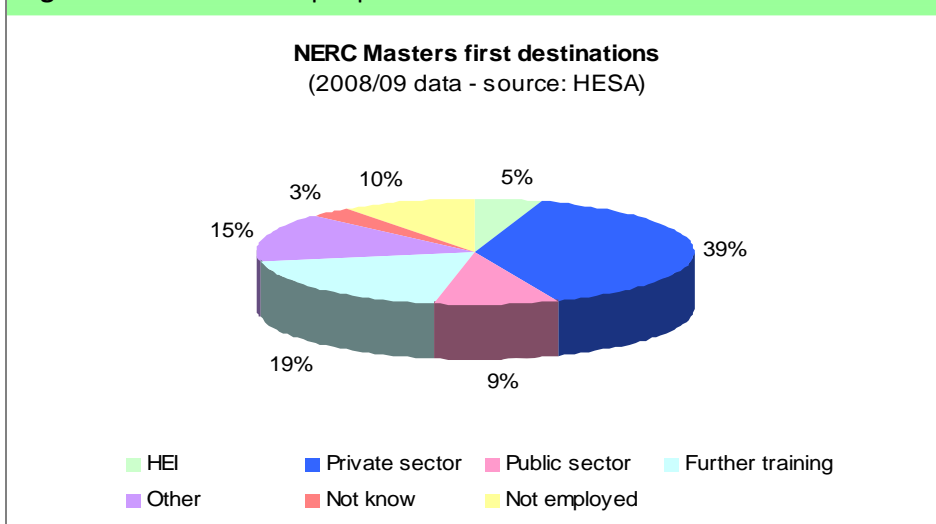
- Confirmed importance of trained graduates moving into business as a major mechanism for exchanging knowledge and for sustaining innovation;
- Highlighted significant variation in approaches to innovation by business sector;
- Radical innovators (those introducing products new to market) and those who innovate in response to environmental, health, safety and other regulatory pressures are much more likely to engage with public research;
- Public research therefore sets the conditions for and then informs the innovations that drive the green economy;
- Large companies are more likely to use knowledge from public research;
- Targeting engagement at large companies is a more efficient way to deliver Knowledge Exchange.

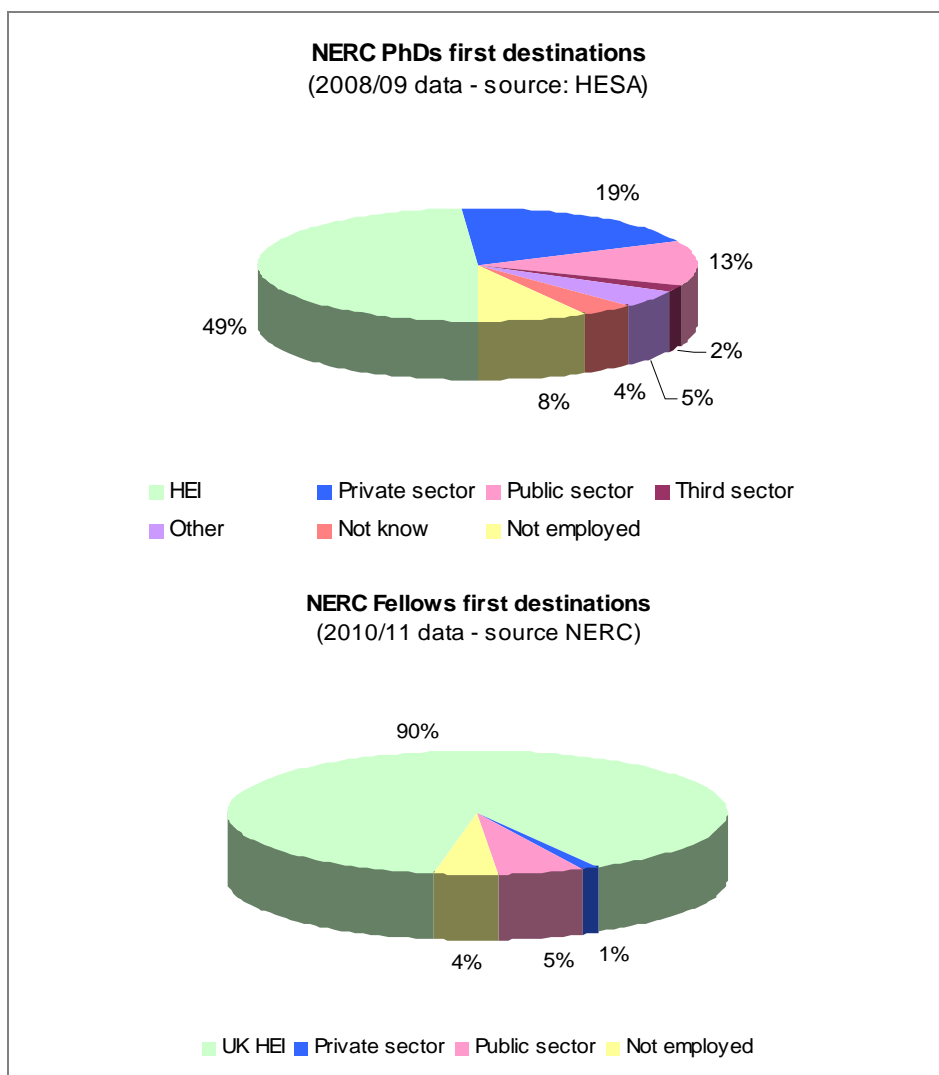
Over the past four years NERC has invested £135m in training of Masters, PhDs and Fellows. Over 2,000 post-graduate students have been funded ensuring the UK has a flow of highly skilled people essential for economic growth.

NERC training schemes

One of the key means of knowledge exchange is through the transfer of people across organisations and sectors. Destinations of PhD and Masters students are monitored through HESA. Data are requested via HEIs from all postgraduate completers giving a 70% return rate. NERC collects its information on the destinations of Fellows. With a proportion of PhD and Masters students choosing not to pursue an academic research career by moving into the private and public sector the economy derives a significant benefit from these students with scientific training.

Figure 17: NERC trained people - destinations





Examples of careers for NERC-trained PhDs include:

- HEIs: postdoctoral positions and fellowships; senior Professors and lecturers, overseas appointments.
- Private sector: environmental consultancy; senior positions in the oil and gas industry; founders and directors of companies.
- Public sector: Environment Agency; Defra, BBC, HM Revenue and Customs; overseas appointments.

The value of NERC-trained people

A major contribution to the health of disciplines is made through the NERC fellowship scheme. Fellowships are awarded to outstanding environmental scientists to develop their research careers and produce work of international importance. In addition to the main scheme NERC funds fellowship policy placements and supports the Royal Society industry fellowships promoting the flow of people and knowledge between academia, policy and business.

At the heart of NERC's science strategy is a holistic view of the Earth system, helping to understand complex inter-connectivities in nature and yielding insights on new trends or how the introduction of novel technologies might lead to unexpected consequences. A strategic perspective comes naturally to NERC scientists and a key contribution to impact is made by those scientists holding influential policy positions close to or in Government, such as:

- Professor Sir John Beddington, current Government Chief Scientific Adviser⁴⁹
- Professor Anne Glover, CSA for Scotland 2006-11 and first Chief Scientific Adviser for the EU⁵⁰
- Professor Sir John Lawton⁵¹, former Chair of the Royal Commission on Environmental Pollution.

Figure 18: A career timeline - Professor Sir Roy Anderson

Sir Roy Anderson - Professor of Theoretical Epidemiology, Imperial College London

Has published over 450 scientific papers on the epidemiology, population biology, evolution and control of a wide variety of infectious disease agents, including HIV, BSE, vCJD, parasitic helminths and protozoa, and respiratory tract viral and bacterial infections



1971	NERC PhD - ecology of parasitic disease
1975	NERC grant - population ecology of a fish parasite <i>Transversotrema patialensis</i>
1982	NERC grant (with M.P. Hassell) to set up the NERC Centre for Population Biology at Silwood Park, Imperial College, London
1982	Appointed to the World Health Organisation HIV advisory committee as AIDS epidemic broke
1990	Conducted epidemiological studies on HIV treatment with anti-retrovirals; found that good patient adherence to drug treatment regimens essential for effective suppression of viral loads and patient survival
1990s	HIV policy and drug treatment providers put into practice recommendation on drug adherence
1991	Appointed Director of Wellcome Trust Infectious Disease Epidemiology Centre at the University of Oxford
1991	Expert advice given to UK Government on BSE crisis
2001	Expert advice given to UK Government on Foot and Mouth crisis
2004 - 2007	Seconded to Ministry of Defence as Chief Scientific Adviser
2006	Knighted in Queen's Birthday Honours List
2007	Joined board of GlaxoSmithKline as a non-executive director
2009 - 2010	Expert advice to UK Government on influenza A pandemic control

Figure 19: NERC-trained people benefiting economy - Zinc industry example

John Ashton of Boliden Tara Mines Ltd said: Much of the science that has been completed at Tara over the past 30 years has been in collaboration with NERC PhD students and this work has not only been at the forefront of carbonate-hosted zinc science globally, but has helped in better understanding of the ore-body and in extending the life of the mine through the discovery of new zinc reserves.

As commodity analysts have pointed out, there is a gap looming in the next few years between zinc demand and supply. This is due to several of the big deposits becoming exhausted and economic expansion in the BRIC countries. If it was not for Tara finding more ore, the gap would be larger - NERC can take some credit for this.⁵²

4. Supporting translation for impact

4.1 Linking strategy to delivery

This section illustrates how NERC supports the translation of research to benefit users.

NERC has taken a more strategic approach to knowledge exchange to drive a step-change in economic impact. All our investments and partnerships now focus on delivering excellent research with impact. NERC is delivering the next level of impact by engaging more strongly with business, targeting those sectors where research has the strongest potential to boost economic growth.

To shift NERC’s culture towards embracing the diversity and need for an impact-based approach, strong leadership and a clear set of KE priorities is essential. Support for innovation, entrepreneurship and appropriate risk-taking is encouraged to support NERC’s KE agenda.

Figure 20 shows the translation mechanisms that NERC employs, whilst **figure 22** shows an example of impacts generated through NERC support for translation.

NERC income from contract research and IP generated by its Research Centres is given in **figure 23**. Commercial income, especially from contract research has to be balanced with obtaining a sustainable business model for Research Centres and the proportion of income from commercial sources varies by Centre. **Figure 24** provides an example of a NERC spin-out company with potential medical applications.

Figure 20: How NERC supports translation

Strategic	Linking	Specific
<ul style="list-style-type: none"> • Reform of funding processes to encourage an impact culture amongst the research community • Rebalancing of investment portfolio to increase proportion invested in strategic research programmes • More working by strategic partnership to: <ul style="list-style-type: none"> - transform how users are involved at an earlier stage in the research process - better inform research objectives to maximise the potential for application - access expertise and - lever additional research funds 	<ul style="list-style-type: none"> • User involvement in defining the NERC Strategy, including science themes and action plans • Leading partnership programmes to deliver science priorities, such as LWEC • Establishing the Belmont Forum to co-ordinate with international research funders • Technology Strategy Board partnership • KE programmes target sectors of green economy for near-term impact: <ul style="list-style-type: none"> - marine renewables - environmental management for food and agriculture - water security - resource management and - financial services, risk management and valuation • Joined-up information and data services. 	<ul style="list-style-type: none"> • KTPs delivered with TSB • Follow-on funding for HEIs to seed commercialisation • Commercialisation of NERC IP • KE fellows and entrepreneurs-in-residence embedded within Centres to facilitate a cultural change • Pathways to impact statements for grant proposals to encourage impact planning from the outset of research • A strong business link for LWEC through its business advisory board • Establishing networks to facilitate future research collaborations • Policy placement fellows and researchers seconded to Government departments and agencies to deliver specific projects which meet both the policy partners and NERC’s needs (50:50 funded)

Figure 21: Huntingdonshire's Great Fen⁵³

"The Great Fen is not only an area of unique and intense raw beauty, but is vital in helping conserve our wildlife, protecting local communities from floods, and providing them with business opportunities."

**Environment Minister
Richard Benyon**

Restoration of the Great Fen is one of Britain's most ambitious habitat restoration projects, aiming to create 3,700 hectares of wetland. The benefits stretch far beyond biodiversity, and include reduced flood risk, better educational opportunities, improved health and wellbeing, job creation and boosting the region's tourist industry. CEH scientists have been involved throughout, providing expert guidance to, and exchanging knowledge with, project stakeholders. They have helped assess feasibility through specially-developed hydro-ecological models, addressing climate change and potential solutions.



Figure 22: Follow-on-Fund: A green revolution⁵⁴

Crop pests can wreck livelihoods and put lives at risk, but the chemicals farmers use to control them cause problems in their own right. A NERC follow-on-fund award has researched, trialled and brought to market the use of a class of fungi, as a natural pathogenic agent, that could transform pest control and give growers an environmentally friendly and sustainable alternative to chemical pesticides. Metarhizium fungi are found in soils around the world and each strain has a different host range, so that specific pest species prevalent in a local environment can be targeted. Controlling the pests also addresses the vectors that transmit animal and human diseases.



- Fungal pest control methods could be used to control cotton leaf curl virus, which causes **£610m pa** harm in Pakistan alone.
- Small scale trials were able to cut the population mosquito larvae in a body of water by 80%, with benefits for malaria control, one of the major killers in topical zones and a root cause of poverty.
- Biocontrol with fungi will not replace pesticides entirely, but has the potential to cut their use by 90% or more.
- Researchers are currently working in developing countries to show that Metarhizium can be produced sustainably.
- Metarhizium has already been shown to be producible in bulk, at a reasonable cost and to have sufficient shelf life to be commercially viable. Products have been launched by Novozyme in the past 12 months and used in Nigeria.

Figure 23: Income from contract research and IP

	2009/10	2010/11
External funding for Research	39.1	36.8
IP income: Royalties and licences	1.9	2.5
IP income: Software and data sales	0.2	0.3
Total	£41.2m	£39.6m

Figure 24: IXO Therapeutics Ltd

NERC biotechnology start-up IXO Therapeutics Ltd was launched December 2010 with a significant opportunity to deliver both medicinal and economic value to the UK as the company develops its products. The company was formed to research and develop novel medicines from natural sources for the treatment of immune-mediated and inflammatory diseases. It will develop intellectual property (IP) derived from both Professor Pat Nuttall's group at the Centre for Ecology & Hydrology and the University of Oxford.

4.2 Using data and creating information products

Enhancing user access to data and information products is a NERC Delivery Plan target to support translation of research knowledge for impact. A recent JISC report⁵⁵ highlights how NERC data are being better used with an increasing number of collections, larger individual holdings, more users, and with more frequent use. Two NERC data centres feature in the report: the British Atmospheric Data Centre, reporting usage of 14 million downloads of data per annum and the National Geoscience Data Centre, reporting 11 million visits per month.

Figure 25: Land cover map⁵⁶



The UK's new Land Cover Map, published in July 2011, provides a continuous, high-resolution coverage of habitat distributions across the countryside. The map, produced by CEH on behalf of the Countryside Survey partnership, was developed using a combination of satellite images and national scale digital mapping data. CEH has produced three digital land cover maps, which have been successfully used in a wide range of applications over the last 20 years, such as:

- A key component for multi-tiered approaches to habitat monitoring and management that have supported the UK Biodiversity Action Plan;
- Informing environmental policy on biodiversity, ecosystem services, landscape planning, habitat connectivity and catchment management;
- Informing a more accurate valuation of natural capital in the UK.

Figure 26: Soils portal⁵⁷

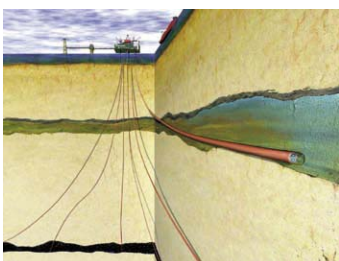
The NERC Soil Portal provides a gateway to discover, view and download large-scale soils property datasets from across NERC Research Centres.

- It aims to bring together resources to improve our understanding of soils and to help answer key, policy led questions.
- Soils contribute to numerous ecosystem services and supply a range of benefits to society. It is therefore essential that the soil resource is protected.
- Through the improved knowledge and services developed using integrated data, the soil portal will ultimately help to create sustainable land management solutions to prevent degradation.



A new NERC data policy⁵⁸ was introduced in January 2011 with NERC undertaking to achieve more complete data collection from research and to supply the environmental data it holds free, but for a small number of exceptions. Long-term, open access to the data that underpin research publications helps ensure the integrity of the research process, and improves the availability of data to external users, enabling benefits to follow to the economy.

Figure 27: Oil industry data



NERC's British Geological Survey earns **£1.4m pa** by licensing geomagnetic reference data products to the oil and gas industry. These data are used in hundreds of wells to the value of £50k pa for each well. NERC data therefore enables directional drilling, a technology which has transformed the North Sea oil industry by reducing costs and increasing the proportion of oil and gas it is economically viable to recover, and through this increased recovery helping with the UK balance of payments.

4.3 Translation through people

NERC PhD interns bridge gap between science and policy

NERC PhD policy internships help address a critical skills gap for the UK environment sector. The scheme places PhD students in policy research offices at the UK and devolved parliaments, where they learn about the policy process and communicating science to policy-makers. Alumni of the scheme now work with policy-makers and in the private and third sectors. NERC has supported these internships since 2004, and over 40 students have so far taken part in the scheme.

Dr Jonathan Butler, who completed an internship at POST in 2006, now works for Johnson Matthey plc as Publications Manager. Another 2006 POST intern, Dr Jane Strachan, works as a Willis Research Fellow investigating the impact of climate catastrophe on the insurance industry. After completing her PhD, 2007 POST intern Dr Lyndsey Dodds began working for the WWF. Other former policy interns have worked for organisations such as the UN Environment Programme, the Scottish Government⁵⁹ and the Micropower Council.⁶⁰

Figure 28: NERC policy intern - a career profile

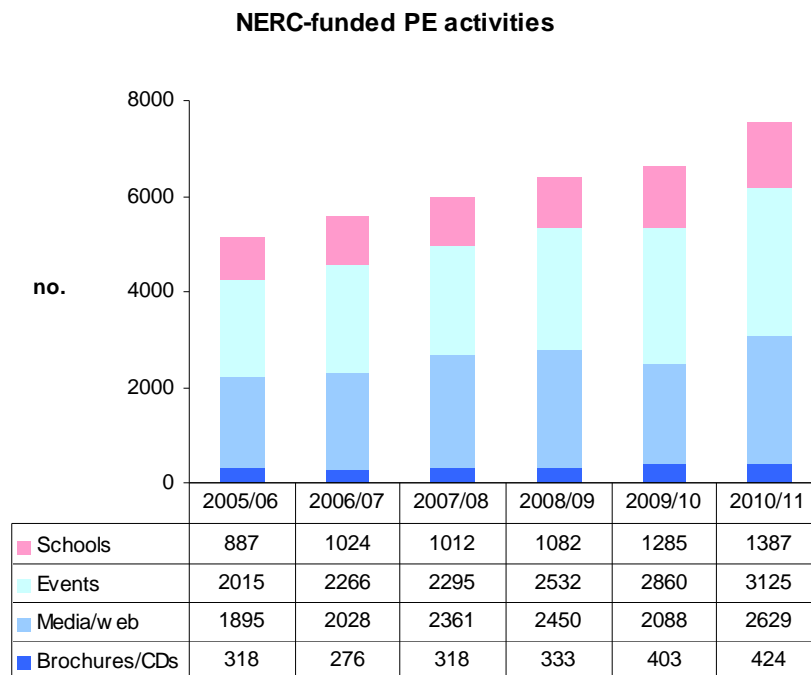
Dr Nicola Ranger (NERC PhD, Fellow and policy intern)

- “In spring/summer 2005, I was successful in securing NERC funding for a 3-month fellowship at the Parliamentary Office of Science and Technology (POST). The fellowship took place in the final year of my NERC-funded PhD in Atmospheric Physics within the Space and Atmospheric Physics group at Imperial College London. The experience and knowledge gained and networks created during my fellowship at POST have been crucial in my career development since 2005.
- After finishing my PhD in December 2005, I went on to work as a policy analyst at HM Treasury on the Stern Review on the Economics of Climate Change. The networks created during my time at POST led directly to me securing this post, as well as laying the ground for subsequent positions. In addition, the knowledge I gained in probabilistic climate projections and abrupt climate change through my work at POST were incorporated into the Stern Review.
- The awareness of policy and science communication developed during my time at POST also allowed me to make a smoother transition into working in the policy environment at HMT and later, the Department for Environment, Food and Rural Affairs (Defra) and subsequent positions, and enabled me to work more effectively as a policy analyst and scientific advisor.
- The fellowship at POST allowed me to broaden my knowledge and research interests beyond atmospheric physics and into areas including climate change policy, environmental economics and risk management. This broadened knowledge facilitated my transition into a multi-disciplinary research and policy analysis environment, first in government, then in the private sector at Risk Management Solutions Inc. and today, at the Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Science.”

Public engagement

There has been a sustained increase in the number of public engagement (PE) activities undertaken by the NERC research community over the last 6 years (**figure 29**). Not only is this important for the public awareness of science it is a major channel for communicating to users. Growth in media/web activities highlights a trend in placing more material online.

Figure 29: Volume of public engagement activities



Note, whilst more effort went into public engagement with research over the last financial year, the trends in the mix of output types (**figure 30**) show that this was not at the expense of the generation of other output types.

Figure 30: Trends in mix of output types

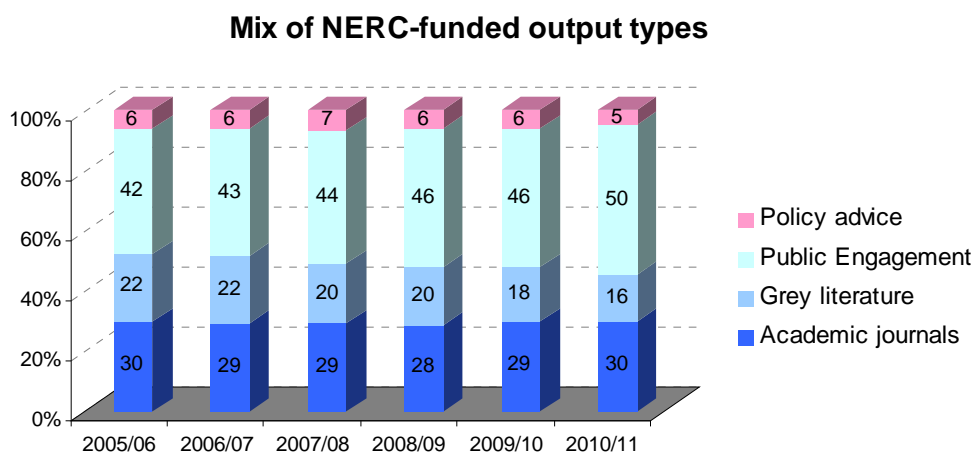
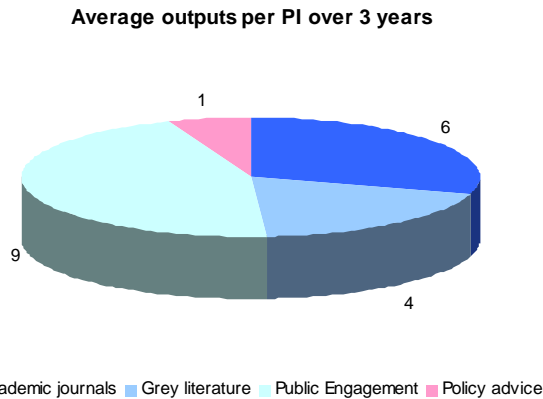


Figure 31 shows the average mix of outputs you can expect from a PI over three years, a period chosen to reflect the typical length of a standard grant. These data offer the prospect of considering whether and how the mix might be rebalanced in future to maximise the prospects for successful translation.

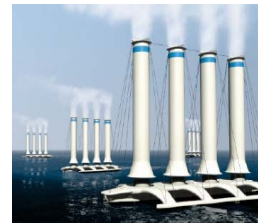
Figure 31: Mix of outputs per principal investigator (over the 3-year life of an average grant)



Figures 32 & 33 illustrate the range of NERC-led campaigns that have been run to engage the public, from a geo-engineering debate to conker tree science. NERC also works very closely with the other Research Councils, delivering joint PE schemes through the RCUK, such as the Beacons for Public Engagement initiative that seeks to share best practice amongst researchers.

Figure 32: Geo-engineering⁶¹

Geo-engineering technologies involve the deliberate and large-scale manipulation of the Earth's climate system to reduce the impact of climate change and include for example afforestation, biochar, liming the ocean, iron fertilisation, air capture, sulphate particles, cloud whitening, mirrors in space, white roofs. NERC, working through LWEC and in partnership with EPSRC, is researching the potential of different geoengineering technologies and their possible social, political and environmental impacts. Public dialogue has informed the research needed to deploy and regulate this emerging technology.



- The global market for mitigating the impacts of dangerous climate change could be worth **\$49-171bn pa** in which geoengineering technologies, if proven, could play a part.
- In 2010 NERC led a dialogue to explore public attitudes towards potential geoengineering methods, such as afforestation, biochar, liming the ocean, iron fertilisation, air capture, sulphate particles, cloud whitening, mirrors in space, white roofs. This is leading to a framework for assessing the effectiveness and side effects of geoengineering proposals and technologies to aid development of UK and international geoengineering regulation.
- This informed the SPICE geo-engineering feasibility experiment now starting and supported by EPSRC and NERC.

Figure 33: Conker tree science



Horse-chestnut or conker trees can be found in towns up and down the country. Suburban trees have a role in regulating temperature and air pollution as well as bringing pleasure.

A campaign launched in 2010 by NERC with the universities of Bristol and Hull has involved 2,000 members of the public and school children in collecting evidence of damage to conker trees from an invasive species of leaf-mining moth. Run via the web www.ourweboflife.org.uk has featured widely in the media, with new iphone application to report results commended by Stephen Fry on twitter.

The study was interested in how the moths are spreading and the damage they are causing, together with the spread of natural pest controllers (tiny parasitic wasps) that kill the developing moths, to inform control methods. Conker trees can be found in towns up and down the country and such urban trees have a role in regulating temperature and air pollution, as well as offering pleasure.

Annex A: BIS metrics and NERC data

type	item	metrics	UNITS	2007/08	2008/09	2009/10	2010/11	
INPUTS	1	Total Funds Available ⁶²	£mil	437.2	469.9	500	498.5	
	2	Budget Allocation	£mil	388.9	417.2	439.4	447.1	
	3	Leverage	£mil	48.3	52.7	60.6	51.5	
	4	<i>Of which Private</i>	£mil	12.3	13.0	17.4	12.8	
	5	<i>Of which from other Research Councils</i>	£mil	1.3	1.0	0.6	2.2	
	6	<i>Of which from other source: Govt departments</i>	£mil	13.2	10.8	11.2	9.5	
	7	<i>Of which from other source: other operating income</i>	£mil	14.4	17.0	21.0	14.2	
	8	<i>Of which from other source: miscellaneous</i>	£mil	7.1	10.9	10.4	12.8	
	9	<i>Of which Private</i>	%	25	25	29	25	
	10	<i>Of which from other Research Councils</i>	%	3	2	1	4	
	11	<i>Of which from other source: Govt departments</i>	%	27	20	18	18	
	12	<i>Of which from other source: other operating income</i>	%	30	32	35	28	
	13	<i>Of which from other source: miscellaneous</i>	%	15	21	17	25	
		Analysis of expenditure						
	14	Research grants	£mil	61.4	70.9	72.5	90.3	
	15	Research contracts	£mil	32.9	39.8	48.0	34.0	
	16	Training	£mil	34.2	33.3	33.7	34.1	
	17	Total grants and training	£mil	128.4	143.9	154.2	158.4	
	18	Staff costs	£mil	108.2	105.6	109.3	114.1	
	19	Other Operating Costs ⁶³	£mil	139.4	157.7	168.9	169.8	
	20	Other	£mil	31.3	26.5	40.9	27.0	
	21	Net expenditure	£mil	407.2	433.7	473.3	469.2	
	22	<i>Of which Grants and Training</i>	%	32	33	33	34	
	23	<i>Of which Staff Costs</i>	%	27	24	23	24	
	24	<i>Of which other Operating Costs</i>	%	34	36	36	36	
	25	<i>Of which Other</i>	%	8	6	9	6	
		Human Capital						
	26	Principal Investigators	#	1059	1063	1064	1184	
27	Research Leaders in Sponsored Institutes	#	-	-	86	95		
28	Research Fellowships	#	100	87	86	88		
OUTPUTS	Knowledge Generation							
	29	Number of Grants reporting their outputs	#	1691	1663	1579	1752	
	30	Refereed Publications	#	4035	4090	4336	4644	
	31	Non Refereed Publications	#	2729	2805	2710	2419	
	32	Co-authorship of refereed publications - International	#	1709	1998	2248	2593	
	33	Co-authorship of refereed publications - Business	#	158	155	169	161	
		Human Capital						
	34	Number of PhD Students Supported (starting in year)	#	332	329	293	320	
	35	Number of Masters Students Supported	#	371	362	382	378	
	36	Finishing Rates (in 5 yrs)	%	90	90	88	91	
	37	Student funding/training schemes	£mil	34.1	33.3	33.7	34.1	
	38	<i>Of which PhD</i>	£mil	23.0	23.0	23.3	24.4	
39	<i>Of which Masters</i>	£mil	4.0	4.0	3.6	2.9		
40	<i>Of which Fellows</i>	£mil	7.1	6.3	6.8	6.8		

type	no.	metrics	UNITS	2007/08	2008/09	2009/10	2010/11
OUTPUTS cont.	Knowledge Transfer and Exchange						
	41	KE spend ⁶⁴	£mil	11	13	13	16
	42	KE schemes	£mil	-	-	6.2	7.0
	IP Activity						
	43	Patents applications	#	10	7	11	7
	44	Income from IP activity	£mil	4.8	4.4	2.1	2.8
OUTCOMES	Human Capital: Destinations of leavers (PhDs)						
	45	<i>Of which University</i>	%	28	42	49	49
	46	<i>Of which Wider Public Sector</i>	%	12	8	11	13
	47	<i>Of which Third Sector</i>	%	4	8	5	2
	48	<i>Of which Private Sector</i>	%	34	27	21	19
	49	<i>Of which Other</i>	%	12	8	6	5
	50	<i>Of which Unknown</i>	%	3	1	0	4
	51	<i>Of which Unemployed</i>	%	7	6	8	8
	Public Policy						
	52	Instances of influence	#	957	890	882	706
	Public Engagement						
53	PE schemes (activities count)	#	6088	6566	6784	7720	

Annex B: List of figures

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Annex C: Glossary

AUV	Autonomous Underwater Vehicle
BAS	British Antarctic Survey
BGS	British Geological Survey
BIS	Department for Business, Innovation and Skills
bn	billion = 1,000,000,000 or 1×10^9
BRIC countries	representing Brazil, Russia, India and China, all being deemed as at a similar stage of newly advanced economic development
CASE	Co-operative Awards in Science and Engineering
CCS	Carbon capture and storage
CEH	Centre for Ecology & Hydrology
COBR	Cabinet Office Briefing Rooms where the Prime Minister and other members of Cabinet are briefed on responses to emergencies. Supported by the civil contingencies unit in Cabinet Office. Contingencies' planning is informed by a risk register including a number of environmental hazards, such as flooding and extreme weather
CSA	Chief Scientific Adviser
CSR	Comprehensive Spending Review
DECC	Department for Energy and Climate Change
DEFRA	Department for Environmental, Food and Rural Affairs
DEL	Departmental Expenditure Limit
EISCAT radar	European Incoherent Scatter Scientific Association operates radars funded by research institutes and research councils of Norway, Sweden, Finland, Japan, China, the United Kingdom and Germany.
ESA	European Space Agency
ESRC	Economic and Social Research Council
EURATOM FP7	A stream of funding within the EU 7th framework programme dedicated to nuclear research and training activities
Fellows	NERC Fellowship scheme. It is not a funding stream as such, but is identified separately in some performance comparisons. Most Fellows map to Responsive Mode.
FRS	Fellow of the Royal Society
funding streams	a classification of NERC funding introduced with the 2007 strategy, comprising Responsive Mode, Research Programme, National Capability and Knowledge Exchange www.nerc.ac.uk/about/delivery/processes/funding.asp
HESA	Higher Education Statistics Agency
HEI	Higher Education Institute
IP	Intellectual property
IPGP	Institut de Physique du Globe de Paris, ie Earth Physics research
JISC	Joint Information Systems Committee - funds programmes of research to improve information and data technologies for UK education and research
JWCRP	Joint Weather and Climate Research Programme involving principally NERC and the UK Met Office
LWEC	Living With Environmental Change research programme
KE	Knowledge Exchange
KTP	Knowledge Transfer Partnerships now managed through Technology Strategy Board
NC	National capability funding stream
NCAS	National Centre for Atmospheric Science
NGO	Non-Governmental Organisation
NOC	National Oceanography Centre
OGD/NDPB	other Government department/non-departmental public body
pa	per annum/every year
PI	Principal Investigator
RM	Responsive Mode funding stream
RP	Research Programme funding stream
RCUK	Research Councils UK
ROD	Research Outputs Database
scheme	Responsive Mode research is delivered through a number of specific schemes, running over a number of years and funding a number of individual grants or awards meeting scheme criteria
SPICE	Stratospheric Particle Injection for Climate Engineering collaborative project between HEIs and Marshall Aerospace
trill	trillion = 1,000,000,000,000 or 1×10^{12}

Annex D: References

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- 3 NERC Annual Report www.nerc.ac.uk/publications/annualreport/
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- 5 www.publications.parliament.uk/pa/cm201012/cmselect/cmenergy/795/795.pdf assuming 53 pptherm; Cuadrilla estimate 6bn m3 of gas around Blackpool www.guardian.co.uk/business/2011/sep/21/gas-field-blackpool-dallas-sea
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- 23 www.bgs.ac.uk/news/news/AfghanCopper.pdf and www.bbc.co.uk/news/world-south-asia-13717471
- 24 www.hm-treasury.gov.uk/d/green_book_complete.pdf
- 25 see ref 10
- 26 see ref 21
- 27 see ref 23
- 28 United Nations Framework Convention on Climate Change market valuation \$49-171bn pa, see <http://bit.ly/kBCA6Z> and <http://pubs.iied.org/pdfs/11501IIED.pdf>; also www.iagp.ac.uk/ and <http://planetearth.nerc.ac.uk/news/story.aspx?id=803>
- 29 www.nerc.ac.uk/research/programmes/tropopause/background.asp; valuation www.bbc.co.uk/news/technology-12564717
- 30 £150bn = total value of UK property at risk; £2.1bn pa = foreign direct investment in London safeguarded
- 31 www.nerc.ac.uk/using/casestudies/documents/storm-surge-report.pdf
- 32 www.nerc.ac.uk/about/perform/documents/eibaseline2010.pdf
- 33 see ref 5
- 34 www.parliament.uk/documents/post/postpn348.pdf
- 35 www.nerc.ac.uk/using/casestudies/documents/modelling-uk-3d-report.pdf

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- 35 www.nerc.ac.uk/using/casestudies/documents/bioaccessibility-report.pdf; see also AWE partnered KTP decontaminating low level nuclear waste <http://casestudies.ktponline.org.uk/casestudies/results>
- 36 see ref 17
- 37 <http://planetearth.nerc.ac.uk/news/story.aspx?id=390>; for market valuation see www.dh.gov.uk/en/MediaCentre/Pressreleases/DH_120676; for benefit calculation based on reduced all-cause mortality rate applied to 62.3m UK population with 10.02/k death rate (UN source): www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@ab/documents/digitalasset/dh_108152.pdf at box 2, p. 40; and value of life based on UK gross income av. of £544 per week, ONS, www.ons.gov.uk/ons/dcp171766_231681.pdf
- 38 www.nine-esf.org/ENA-Book
- 39 www.nerc.ac.uk/using/casestudies/documents/developing-marine-energy.pdf
- 40 see ref 10
- 41 www.ukspaceagency.bis.gov.uk/assets/pdf/SandH2010.pdf
- 42 see ref 19
- 43 see ref 6
- 44 www.nerc.ac.uk/using/casestudies/documents/water-quality-report.pdf
- 45 www.nerc.ac.uk/using/casestudies/documents/scottish-fish-farming.pdf
- 46 www.nerc.ac.uk/using/casestudies/documents/river-flooding-report.pdf
- 47 www.nerc.ac.uk/using/casestudies/documents/marine-planning-report.pdf; for economic valuation of UK marine industries see http://chartingprogress.defra.gov.uk/feeder/PSEG_Section_2_Overall_Assessment.pdf fig 2.3, p.30
- 48 data extracted from a report by Elsevier Report for BIS on the [international comparative performance of the UK research base 2011](http://www.nerc.ac.uk/using/casestudies/documents/international-comparative-performance-of-the-UK-research-base-2011.pdf)
- 49 Professor Sir John Beddington was previously a member of NERC Council for 6 years
- 50 See NERC Economic Impact Baseline 2010. p.16 (<http://www.nerc.ac.uk/about/perform/documents/eibaseline2010.pdf>) for Professor Glover's career timeline; for recent announcement of appointment as European Union Chief Scientific Adviser see <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/11/1497&format=HTML&aged=0&language=en&guiLanguage=en>
- 51 Professor Sir John Lawton was NERC Chief Executive 1999 - 2005
- 52 Tara Mines in Navan, Co Meath, Ireland, is the largest zinc mine in Europe and the fifth biggest in the world. It became a part of the Swedish based Boliden Group in 2004 www.boliden.se; comments made at Zinc 2010 conference, organised by the Irish Association for Economic Geology.
- 53 Project stakeholders include the Wildlife Trust for Bedfordshire, Cambridgeshire, Northamptonshire and Peterborough, the Environment Agency, Huntingdonshire District Council, Middle Level Commissioners and Natural England; picture taken from www.greatfen.org.uk/documents/WT_GreatFenBrochu1A.pdf
- 54 www.nerc.ac.uk/publications/planetearth/2011/autumn/aut11-revolution.pdf
- 55 Data centres: their use, value and impact, Report, September 2011, Research Information Network, JISC www.rin.ac.uk/our-work/data-management-and-curation/benefits-research-data-centres
- 56 www.ceh.ac.uk/LandCoverMapping.html
- 57 www.bgs.ac.uk/nercsoilportal/
- 58 www.nerc.ac.uk/research/sites/data/policy2011.asp
- 59 <http://sid.nerc.ac.uk/details.aspx?id=167>
- 60 <http://sid.nerc.ac.uk/details.aspx?id=165>
- 61 see ref 28
- 62 Financial data in metrics 1 to 25 extracted from NERC Annual Reports and Accounts www.nerc.ac.uk/publications/annualreport/
- 63 Mainly professional and research services by outside bodies - includes international subscriptions
- 64 In addition to the KE budget there is an unquantified element of KE embedded within research that generates the outputs in metrics 52 & 53.