

NERC ECONOMIC IMPACT BASELINE 2007-08

Executive Summary

The Natural Environment Research Council is the UK's main agency for funding and strategically directing research, training and knowledge exchange in the environmental sciences. The UK is second only to the US in terms of total citations for published environmental research.

The Green Economy

Environmental research is a foundation of the Green Economy through:

Creating environmental markets. NERC provides timely forewarning of major environmental changes allowing the UK economy to prepare, adapt and mitigate these changes. The Treasury's Stern Review on the economics of climate change estimates global agreement to create a low-carbon economy will cost the UK economy at least one per cent of GDP each year now and forever, but states that failing to act will cost significantly more.

Enabling effective policymaking. By 2050, the most significant change to the UK economy will be a shift to a low-carbon economy. The basis for this major policy decision is the massive global effort by the environmental research community in the past two decades to provide forewarning of major changes in the Earth's climate system. The UK is considered world-leading in climate research and NERC is the country's largest funder in this area of science.

Exploiting environmental science. To reduce emissions by 80 per cent from 1990 levels by 2050, the UK will overhaul energy production and use. The UK's Committee on Climate Change, which includes NERC-funded researchers, recommends a focus on renewable energy, carbon capture and storage (CCS) and nuclear energy. NERC-funded scientists are ensuring the UK has a leadership position in driving carbon capture solutions. They have shown nuclear waste can be stored underground safely, and are assessing the environmental changes caused by a Severn Barrage, which could generate five per cent of the UK's energy needs.

Building resilience into the global economy by improved monitoring and predictions of seismic hazards like earthquakes, volcanoes and tsunamis, extreme weather, ice floes and pack ice, storm surges, sea-level rise, disease spread and pollution.

Baseline

Five areas of impact are covered in this report.

- Delivering highly skilled people to the labour market
- Improving the performance of existing businesses
- Improving public policy and public services
- Attracting R&D investment from global business
- Creating new business

Included in these five impact areas is NERC's significant contribution to improving quality of life.

1. Delivering highly skilled people to the labour market.

NERC's post-graduate training schemes deliver the next generation of environmental scientists and contribute to the UK's highly-skilled workforce.

- NERC supports 1000 PhDs every year. About a third find employment in the private sector.

- 370 Masters students each year are supported by NERC. About 50 per cent go on to work in the private sector.
- NERC funds 100 Research Fellows annually. Around 95 per cent stay in academia.
- Nearly a third of NERC-funded PhDs are industry or policy partnerships. More than 120 organisations participate including AstraZeneca, BP, British Gas, Environment Agency, Met Office, RSPB, Schlumberger and Syngenta.
- NERC's postgraduate students are given transferable skills, including parliamentary secondments and entrepreneurship training.
- In the past two years, the British Antarctic Survey has trained over 1000 UK business leaders. This has raised their awareness of climate change and sustainable development.
- The British Geological Survey trains geologists in the developing world, helping economies such as Afghanistan, Ethiopia and Madagascar to grow sustainably.

2. Improving the performance of existing businesses

- **Creating environmental markets.** NERC manages the UK's Earth observation science budget and invests annually around £45 million in the European Space Agency (ESA). The government estimates space science generated £5.8 billion for the UK economy in 2006-07 and directly supports 16,000 jobs in the UK. Earth observation research contributes to these headline figures. By 2016, ESA and EUMETSAT plan to launch 17 Earth observation satellites, leading to further contracts for the UK and helping secure highly skilled jobs.
- **Exploiting environmental science.** British Geological Survey provides information on subsidence and ground instability data to insurers, developers and planning authorities that is predicted to benefit the UK economy by **£70-270 million** to 2030. NERC also actively promotes the commercialisation of the research it supports: One spin-out company from the University of Edinburgh, based on a NERC PhD, was sold for **\$275 million** in 2007 – Scotland's largest academic spin-out.
- **Building resilience into the economy.** NERC scientists measure and predict sea-level rise. Information from NERC's Proudman Oceanography Laboratory informs the operation of the Thames Barrier that protects London from flooding. A conservative estimate of the value of this protection to the city is **£30 billion**.

3. Improving public policy and public services

- NERC-funded scientists are lead authors on the Nobel Prize-winning **Intergovernmental Panel on Climate Change** reports.
- NERC scientists provide the geological basis for UK submissions to the United Nations (UN) to secure UK sovereignty over waters beyond 200 nautical miles of the UK and its dependencies' coastlines.
- Discovery of the ozone hole has benefited the UK economy by **£8-42 million**. NERC-funded scientists have also shown that the subsequent Montreal Protocol on ozone-depleting substances has halved the rise in global average temperatures.
- Providing essential information on flooding and droughts in the UK, for example the summer floods of 2007.
- Helping design and install a tsunami warning system around Africa, the Mediterranean and Arabian Peninsula and assessing the tsunami threat to the UK.
- Storm surge prediction.

- Providing timely information on natural radon to a wide range of users to reduce the health impact of radon. Natural radon is second only to smoking in the UK as a cause of lung cancer, with more than 1000 fatal cases in the UK each year.

4. Attracting R&D investment from global business

One of the world's largest re-insurance companies, Willis Re, has set up the Willis Research Network to address concern about its growing vulnerability to environmental catastrophe. The network involves academic institutions in the UK and globally. It has led to a new partnership with UK climate researchers. The partnership is developing the first climate forecasts to be incorporated into the insurance industry's catastrophe risk models to enable better risk management. The work is helping maintain Willis Re's global competitiveness.

The network is also working closely with UK researchers directly involved in other environmental hazards like landslides and earthquakes.

5. Creating new business

Spin-out company Multichannel Transient ElectroMagnetics (MTEM), from the University of Edinburgh, was sold for \$275 million in June 2007 to Petroleum Geo-Services. The company arose from a NERC-funded PhD completed in 2003 and is Scotland's largest academic spin-out.

New spin-out Microbial Solutions Ltd uses bacteria to break down toxic waste from the transport industry. The company, valued at £1.2 million, competes in the \$1 billion metalworking fluids treatment market.

Oxford Expression Technologies Ltd. (OET) provides products, services and consultancy to the global pharmaceutical and biotechnology industries. It has share capital of more than £1.1 million.

Current Economic Impact - Summary Statistics 2007-08

Grant-in-aid £362m

External funding* £48m

Total NERC staff 2573

Staff in HEIs** employed on research grants 1300

* This includes external research funding plus other operating income including data sales

** Higher education institutions

<p><u>Science to Policy</u></p> <p>Inputs to Government consultations: 80 (academic), 15 (corporate)</p> <p>Inputs to Parliamentary inquiries: 45 (academic), 14 (corporate)</p> <p>Direct provision of data/information/advice to Government bodies: 209</p> <p>Publications aimed at policy makers: 57</p> <p>Government funded research programmes: 62</p> <p>Number of Parliamentary PhD secondments: 6</p>	<p><u>Training & Skills</u></p> <p><u>PhD students</u></p> <p>Total number of PhD students: 969</p> <p>Percentage of PhDs with industry/policy partners (CASE): 31%</p> <p>Expenditure per annum on PhD training £23.0m</p> <p>First destination of PhD students: private sector 34%, public sector 12%</p> <p><u>Masters students</u></p> <p>Total number of Masters students funded: 371</p> <p>Expenditure per annum on Masters students: £4.0m</p> <p>First destination of Masters students: private sector 50%, public sector 9%</p> <p><u>Post Doctorates</u></p> <p>Number of post-docs employed on NERC grants: 1,300</p>
<p><u>User engagement/Products & Research Services</u></p> <p>Contract research income earned by NERC Research Centres: £33.4m</p> <p>Level of co-funding of research: £6.63m</p> <p>Number of commercial users of NERC supported facilities: 149</p> <p>Co-authored ISI publications: public sector 623 (16%), private sector 146 (4%)</p> <p>Knowledge Transfer Partnerships: 12</p> <p>Academic-user networks supported: 10</p>	<p><u>Licensing & Commercialisation</u></p> <p>Market value of spinouts from NERC funded research in 2007/08: greater than £188m *</p> <p>Patents filed by NERC grant-holders: 10</p> <p>Royalties & license income earned by NERC Research Centres: £2.8m</p> <p>Income from licensing of data or software by NERC Data Centres: £1.9m</p> <p>Follow-on funding provided to universities: £195k</p> <p>Invention disclosures by Research Centres: 52</p> <p>Proof of concept funding awarded to Research Centre projects: £143,350 (13 projects in total)</p> <p>License agreements signed (excl. data): 4</p>

All data relates to FY 2007/08 unless otherwise stated.

Sources: NERC Output Framework 2007/08; NERC Research Outputs Database; NERC Annual Report 2007/08

*mostly from MTEM (from University of Edinburgh) buyout by Petroleum Geo-Services in 2007.

NERC ECONOMIC IMPACT BASELINE 2007-08

A. Introduction

NERC is the UK's main agency for funding and strategically directing research, training and knowledge exchange in the environmental sciences. Its research supports environmental sustainability and wealth creation in the UK. NERC tackles major global issues such as climate change, natural resources management and environmental influences on human health and the genetic make-up of life on Earth. It is coordinating some of the world's most exciting research projects like International Polar Year, involving 60,000 scientists from 60 nations.

NERC's strategy "Next Generation Science for Planet Earth", published in 2007, states:

"NERC has a responsibility not only to fund research that addresses the critical environmental issues of the 21st century, but also to ensure that its investments make a real contribution to building a sustainable economy and improving quality of life."

In the last decade, NERC-funded scientists have played a key role in the Nobel Peace Prize-winning **Intergovernmental Panel on Climate Change** assessment reports. This is the basis of global climate policy and the need to move to a low carbon economy. The Stern Review on the economics of climate change estimates that this will cost one per cent of GDP now and forever, if action is rapid. It estimates that taking no action will cost significantly more. In the UK this translates to an 80 per cent reduction in emissions from 1990 levels by 2050. This is the recommendation by the government's independent advisory panel, the Committee on Climate Change, which includes NERC-funded researchers, and was adopted by the government in 2008.

This global leadership has been followed by the ongoing application of science to a range of regional threats.

- **Sea level rise.** NERC science helps measure and predict sea level rise, and inform the operation of the Thames Barrier that prevents London flooding. A conservative estimate of the value of this protection to the city is **£30 billion**.
- **Ocean circulation system.** NERC scientists have shown past rapid changes to one of the most important circulations in the Atlantic ocean has led to the climate of north-west Europe, including the UK, to change quickly. A major change now has been estimated to cost in excess of **£40 billion** to the global economy. The potential cost is now so great that NERC is monitoring this ocean circulation between Africa and the US on a daily basis.
- **Ocean acidification.** By the end of the century the oceans will be more acidic than they have been for 20 million years. This could have a direct economic impact on the goods and services provided by the marine environment to the UK, for example, multi million pound fisheries, fish meal and aquaculture industries that employ tens of thousands of people. Globally coral reefs have been valued at **\$30 billion** and provide food, tourism and shore protection. Any threat to them will be important for the economies of some of the UK's overseas territories. NERC-funded scientists are world-leading in this new area of research.

This document outlines NERC's current impact across five key areas. Examples are chosen from NERC's **Science Impacts Database**, a database of case studies demonstrating policy and economic impact from NERC-funded research. The five areas are:

- Delivering highly skilled people to the labour market
- Improving the performance of existing businesses
- Improving public policy and public services
- Attracting R&D investment from global business
- Creating new business

These areas are followed by NERC's ongoing and future economic impact.

To achieve a step change in economic impact, NERC is committed to supporting an excellent science base with a range of delivery mechanisms from basic to strategic to applied research, at short- to long-term timescales. There is clear evidence that the excellence of the UK environmental science base is being maintained: the number of publications arising from NERC funding has increased by five per cent in the past two years, to nearly 7000. Recent citation studies and impact analyses rate the UK environmental sciences as second only to the US.

B. Key Areas of Impact

1. Delivering highly skilled people to the labour market

NERC funding supports the training of the next generation of environmental scientists, helping provide the UK economy with highly-skilled people.

- NERC funds around 1000 PhD and around 370 Masters students each year.
- NERC funds around 100 new Research Fellows each year. Fellows were the most-cited researchers in the NERC-funded research community in 2008. Around 95 per cent of Fellows remain in research.
- Nearly a third of the NERC funded PhDs have industry or policy partners, known as CASE studentship awards. Over 120 organisations are involved including AstraZeneca, BP, British Gas, Corus, Environment Agency, Met Office, RSPB, Schlumberger and Syngenta.
- Over a third of NERC funded PhD finishers move into the private sector. For Masters, 50 per cent go into the private sector.

Case study Lera Miles

PhD student Lera Miles, funded by NERC, examined how climate change will affect Amazonian rainforests. Her work has contributed to research that has been cited more than 500 times including the IPCC's Fourth Assessment Report in 2007.

Miles is now acting head of the Climate Change and Biodiversity Programme, part of the UN Environment Programme's World Conservation Monitoring Centre.

- NERC supports the **Royal Society Industry Fellowships**, encouraging mid-career scientists to work in industry.
- NERC supports the **Young Entrepreneurs Scheme (YES)** to help train future entrepreneurs within the environmental sciences.
- NERC sponsors **secondments to the Parliamentary Office of Science and Technology** in Westminster and equivalent offices in the Devolved Administrations and the Royal Commission on Environmental Pollution (six secondments during 2007/08).
- The British Antarctic Survey (BAS) has worked with the **University of Cambridge Programme for Industry** to run 37 corporate business-to-business events in the past two years, attracting 1000 business leaders and executives to BAS.
- **Training for capacity building in developing countries**
The British Geological Survey provides extensive training programmes to build geoscience capacity in several developing countries including Afghanistan, Montserrat, Ethiopia, Ghana, Nigeria, Papua New Guinea, Malawi and Mozambique. This initiative is contributing to economic growth in the developing world.

2. Improving the performance of existing businesses

New markets are emerging to drive the Green Economy. From carbon trading to waste management and food security, most markets will have a foundation in environmental research. The Green economy can also exploit environmental science in other ways and research can build resilience into the global economy.

Exploiting environmental science

In 2007-08, NERC research centres attracted £33.4m million of commissioned research. Licensing data and value-added products from their extensive datasets also have been extremely successful.

Creating environmental markets

a) Earth observation. The government estimates that space science generated £5.8 billion for the UK economy in 2006-07 and directly supports 16,000 jobs in the UK. NERC manages the UK's Earth observation budget and invests around £45 million in European Space Agency (ESA) projects annually, primarily in Earth observation satellites. Engineering contracts from ESA in 2004/5 amounted to around £100 million. The ion thrusters used to manoeuvre the recently-launched ESA Earth observation satellite, GOCE, were designed and built in the UK.

By 2016, ESA and EUMETSAT plan to launch 17 Earth observation satellites. NERC's sustained investment in ESA, the UK's pre-eminent position in climate research and Britain's highly-skilled workforce has persuaded ESA to build its latest facility in the UK. Work starts in 2009.

b) Contributing to the Northern Ireland economy. A three-year project funded by the Geological Survey of Northern Ireland (GSNI) has attracted £20 million to Northern Ireland's economy. The project produced new geochemical and geophysical maps that improved our knowledge of the geology, soils, natural resources and environment of Northern Ireland.

c) Ground instability data

The British Geological Survey (BGS) provides subsidence and ground instability data to insurers, developers and planning authorities. PricewaterhouseCoopers estimates this benefits the UK economy by **£70-270 million**. The annual cost of subsidence to the insurance sector was estimated to be around £300 million in 2006. This is expected to increase because of climate change and denser housing.

d) Commercialisation

- Cascade Technologies, formed from a NERC-funded research group at the University of Strathclyde developing laser technology for atmospheric composition detection, now employs 20 people (including several NERC-funded PhD students).

NERC continues to record a high level of commercialisation activity and success from its Research Centres:

- 2007/08 saw the highest number of ideas disclosed (52) in one year.
- Total expenditure on commercialisation of NERC IP has increased by 49% over the last 2 years.
- Two trading companies have spun out of NERC research centres in 2007/08. Microbial Solutions Ltd competes in the \$1billion metalworking-fluids treatment market and at the last investment round was valued at £1.2 million; it is now agreeing sales contracts. Oxford Expression Technologies Ltd has share capital of more than £1.1 million.
- Two further licensing deals have been signed and 10 patents filed.

NERC has actively promoted the commercialisation of the outcomes of its investments:

- NERC has committed nearly £1.4 million to its proof-of-concept **Follow-on Fund** since its launch in 2004.
- Researchers at Lancaster University have discovered and patented a new way of making crops more resilient to pests. Successful crop trials in North America led to the technology being licensed with plans to arrive at market in 2010. The technology has significant promise

in seed treatment markets valued at more than \$300 million in 2003, and as a replacement for insecticide sprays, a market valued at \$7.5 billion in 2004.

- NERC collaborative centre the Sea Mammal Research Unit (SMRU) set up SMRU Ltd in 2006 to help clients in industries like offshore and coastal construction, oil and gas, defence, shipping, fisheries and aquaculture and the marine renewable energy industry. Turnover has increased to about £1.2 million in 2008-09 and is expected to double every 2-3 years over the next six years. A Vancouver office is due to open in 2009. The business model is now being expanded to businesses in other areas of marine science.

NERC science is valuable to industry sectors where predictive environmental science and solutions have immediate commercial impact.

The Ocean Margins LINK programme led to a spin-out company, Geospatial Research Ltd. and research with a potential impact of £100m on risk mitigation and improved site prediction for oil drilling. Other research has contributed to international work on improving extraction efficiency with potential to contribute to a £15 billion increase in revenue for the oil and gas sector. As a spin-off from this, the analytical techniques have been applied to the testing for steroid abuse in sports with a potential market of £10 million per year.

e) Exploiting biodiversity in Western Scotland

NERC collaborative centre, the Scottish Association for Marine Sciences (SAMS), has successfully attracted new biotechnology companies to west Scotland. A drug discovery company, Aquapharm, specialises in developing products exploiting the chemical diversity of marine micro-organisms. These have applications in pharmaceuticals, personal care, nutraceuticals and novel biocatalysts. In four years Aquapharm has grown to 20 staff and has an estimated value of £5 million.

f) Attracting R&D investment from global business

NERC's support for the environmental sciences in the UK plays an important role in making the UK an attractive place to do business. The insurance sector, which has an annual turnover of £240 billion and of which London is a major financial centre, sees the skills and capabilities of the academic environmental risk modelling community as a key reason for staying in the UK. NERC science can also support disaster mitigation technologies designed to prevent, predict, prepare for, respond to, monitor and/or mitigate the impact of disasters such as earthquakes, tropical cyclones and flooding). The global impacts of disasters already exceed \$100 billion in some years and have been increasing exponentially.

Risk management

Researchers from NERC's National Centre for Atmospheric Science are working with the world's largest re-insurance company, Willis Re, to provide predictions and probability analyses of future natural catastrophes like hurricanes, storms and flooding. This is first time climate forecasts have been incorporated into the insurance industry's catastrophe risk models. The insurance group will use the outputs of this research to advise companies on the financial impacts of future catastrophes, enabling (re)insurance and other risk-related solutions.

The work forms part of the Willis Research Network, the largest collaboration between the academic and financial communities. It brings together a unique group of the world's leading research centres across the earth sciences, engineering and mathematics to provide comprehensive, practical and consistent risk analyses.

g) Carbon Capture and Storage (CCS)

In March 2009, UK scientists funded by NERC have shown that for millions of years carbon dioxide has been stored safely and naturally in underground water in gas fields saturated with the greenhouse gas. The findings, which made the front cover of *Nature*, bring commercial carbon capture and storage a step closer.

The British Geological Survey (BGS) was involved in the world's first demonstration that carbon dioxide (CO₂) can be captured at source and stored underground. The UK market in 2012 for CCS is estimated at £2 billion, with a world market of £150 billion. CCS is widely regarded as a critical technology in reducing CO₂ emissions to combat climate change, given the predicted significant role for fossil fuels throughout this century. It is therefore a core element of UK energy policies. CCS would also have positive implications for international relations and pressure on resources.

BGS is monitoring and modelling the distribution of injected CO₂ in the Utsira Sand, in Norway. Researchers are checking that the gas is not migrating out of the intended storage site. This type of demonstration will help satisfy requirements for legal verification and address safety issues.

BGS plays a leading role in the UK in carbon storage technologies. It also contributed to the Strategy for Developing Carbon Abatement Technologies for Fossil Fuel Use, launched by the Government in 2005.

3. Improving public policy and public services

NERC's investments make a significant impact on the development of new policies across a broad range of Government responsibilities.

Quantifying these impacts is challenging, but NERC has been working in this area for several years. In 2000, NERC commissioned a report to investigate the impact of its science on policy development, which indicated significant impact in areas as diverse as air quality, biodiversity, marine and coastal pollution and the Intergovernmental Panel on Climate Change (IPCC).

Some examples are provided below of actual or potential impact, the latter reflecting the often long time lag between scientific discovery or provision of evidence and actual impact.

a) Climate policy

NERC investments over the past decades have given the UK a world-leading position in climate research. The Nobel Peace Prize was presented to the United Nations Intergovernmental Panel on Climate Change (IPCC) and former US vice-president Al Gore on 10 December 2007. The prize was for 'their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change'.

Many UK scientists funded or employed by NERC contributed to the IPCC's four landmark reports.

b) The Law of the Sea

The National Oceanography Centre Southampton (NOCS) provided independent scientific evidence to the United Nations (UN) that could have a major impact on the UK's territorial sovereignty. The UK's sovereignty includes a sizeable area of the seabed which forms the continental margin. According to the UN Convention on the Law of the Sea, a state has sovereign rights to a 200 nautical-mile Exclusive Economic Zone and beyond that, up to a further 150 nautical miles of continental shelf.

NOCS scientists led the technical team that prepared and presented submissions to the UN in May 2006, which could secure UK sovereignty over continental shelf areas beyond 200 nautical miles. Cases for other UK shelf areas and Overseas Territories are likely to follow. NOCS's expertise in continental shelf delimitation has led to a growing number of commissions from governments of other coastal states for its advisory and training services.

c) The Marine and Coastal Access Bill

NERC has made a significant contribution to the new Marine and Coastal Access Bill, currently in its Committee stages. It should attain Royal Assent during 2009. The Bill pledges better management of inshore fisheries and measures to speed up the approvals process for offshore wind farms by about a year.

d) The world avoided by the Montreal Protocol

Scientists at NERC's British Antarctic Survey discovered the hole in the ozone layer in 1985. Their discovery was crucial evidence for a ban on chlorofluorocarbons (CFCs) and led to the Montreal Protocol on Substances that Deplete the Ozone Layer. This international policy is now helping reduce skin cancer cases around the world. Independent consultant PriceWaterhouseCoopers has estimated the benefit to the UK economy is £8-42 million.

In 2008, NERC-funded scientists announced the policy has slowed global temperatures rises – a clear indication that the impacts of science are often not clear until many years after the initial research.

e) Summer Floods of 2007

The summer floods in 2007 left vast tracts of the north-east and southern England submerged. During the crisis, scientists from the Centre for Ecology & Hydrology (CEH), the British Geological Survey (BGS) and NERC's Flood Risk from Extreme Events (FREE) programme provided essential information to the media and operational services such as the Environment Agency, Defra, the Met Office and others. BGS and FREE scientists scrambled research aircraft to survey the affected regions. Following the floods, the National Hydrological Monitoring Programme (NHMP), operated jointly by CEH and BGS, published a comprehensive report which stated that the floods have 'no close modern parallel for the June-August period' and that summer 2007 was a 'very singular episode, which does not form part of any clearly emerging pattern or long-term trend consistent with currently favoured climate change scenarios.'

BGS and CEH scientists also contributed to NERC submissions to The Pitt Review: Lessons learned from the 2007 floods, and to the House of Commons Environment, Food and Rural Affairs Committee inquiry into flooding, drawing attention to the NHMP report.

f) Tsunami warnings and storm surges

Following the Indian Ocean tsunami in 2004, UK scientists at the Proudman Oceanographic Laboratory (POL) played an integral role installing crucial parts of a new warning system around the African coast, the Arabian Peninsula and the Mediterranean Sea. UK researchers have also calculated the tsunami risk to the UK.

These researchers continue to improve sea level rise predictions for this century, both in the UK and internationally, and provide warnings of dangerous storm surges in the UK. With the likelihood of more frequent storm surges due to climate change, the National Tidal and Sea Level Facility (NTSFL), based at POL works with the Environment Agency and the Met Office to give advance warning of storm surges around the UK.

The research is used to help decide when to close the Thames barrier and to advise about likely coastal floods. Accurate advanced warning helped avoid significant damage and disruption on 9 November 2007 when the worst storm surge in 20 years struck the east coast of England.

g) Amazonia – carbon sink and source

NERC funding has demonstrated that the unusual and severe Amazon drought in 2005 led to the region emitting an extra five billion tonnes of carbon dioxide to the atmosphere. This exceeds the annual emissions of Europe and Japan combined. The finding, part of a 30-year study, provides the first solid evidence that drought causes massive carbon loss in tropical forests, mainly by killing trees. The research showed that for at least 25 years the Amazon forest has acted as a vast carbon sink. Over recent decades the world's tropical forests have absorbed one fifth of fossil fuel emissions. The findings concern scientists because some climate models predict that parts of the Amazon will dry out this century, which could lead to increased CO₂ emissions and serious implications for climate change.

h) National Centre for Ocean Forecasting

The UK's National Centre for Ocean Forecasting (NCOF) is a collaboration between the Met Office and a number of NERC's Research and Collaborative Centres. NCOF will co-ordinate the UK's ocean forecasting activities and provide as much information on the short-range (5-10 day) conditions in the oceans as is currently available about the weather. Developments such as this will

ultimately benefit society and the economy by providing support to, for example, oil slick responses, search and rescue, defence, the management of water quality, ecosystems and fisheries, wind farms, oil exploration, safety of shipping and improved weather forecasts.

i) Natural radon hazard potential data-set for England and Wales

The British Geological Survey, in partnership with the Health Protection Agency (HPA), released in early 2008 a digital data-set and atlas showing the potential for natural radon hazard for the whole of England and Wales. The data-set is soon to be expanded to include Scotland. Natural radon is second only to smoking in the UK as a cause of lung cancer, and the HPA estimates that more than a thousand cases of fatal lung cancer occur in the UK each year are caused by natural radon. Householders can very easily find out if their homes lie within areas high levels of natural radon. The data can then be used to determine if special protective measures are required in new-build housing or in the remediation of older housing stock, helping reduce the incidence of potentially fatal lung cancers.

4. Attracting R&D investment from global business

One of the world's largest re-insurance companies, Willis Re, has set up the Willis Research Network to address concern about its growing vulnerability to environmental catastrophe. The network involves academic institutions in the UK and globally. It has led to a new partnership with UK climate researchers. The partnership is developing the first climate forecasts to be incorporated into the insurance industry's catastrophe risk models to enable better risk management. The work is helping maintain Willis Re's global competitiveness. The network is also working closely with UK researchers directly involved in other environmental hazards like landslides and earthquakes.

5. Creating new business

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New spin-out, **Microbial Solutions** Ltd, uses bacteria to breakdown toxic waste from the transport industry. The company, valued at £1.2 million, competes in the \$1billion metalworking-fluids treatment market.

Oxford Expression Technologies Ltd. (OET) provides products, services and consultancy to the global pharmaceutical and biotechnology industries. The spin-out has share capital of over £1.1million.

Tyndall Centre for Climate Change Research scientists have set up a system for governments, local authorities and industry to calculate the most effective way of reducing a region's or city's emissions. In 2008, demand for the new service has led to the launch of a company, Carbon Captured Ltd. So far, ten European capital cities, the Californian government and Washington DC have signed up to this new greenhouse gas inventory system.

C. Economic impact – a forward look

NERC will continue to work towards a step change in increasing the economic impact of its investments and will work closely with stakeholders to identify key scientific priorities.

Environmental research is a foundation of the Green Economy. NERC's role in this emerging economy is pivotal for long-term economic growth. The UK's sustained investment in environmental science has ensured it can capitalise on new opportunities. But population growth and rapid environmental change are creating new challenges.

A successful green economy will:

- make optimal use of environmental resources and processes;
- understand environmental constraints and the process of environmental change;
- develop and implement technologies and solutions that ensure environmental sustainability;
- build long-term resilience into the economy through better prediction.

The UK is currently a world leader in oil and gas, high value consultancy, carbon trading, risk-based insurance services and environmental monitoring. NERC has the opportunity to exploit the UK's environmental sciences to drive successful industry sectors such as carbon storage and sequestration, wave and tidal power, geoengineering, food and agriculture and water.

An important opportunity for NERC is the **Living with Environmental Change (LWEC)** programme, to which it is a major contributor in terms of research programmes as well as being the lead for Knowledge Exchange. This new ten-year interdisciplinary research and policy partnership will provide decision makers with the best information to effectively manage and protect vital ecosystem services, and improve our tools and knowledge needed to build resilience, mitigate problems, and adapt to environmental change.

a) Increasing impact in business

NERC will be addressing key business sectors; the following will act as a focus:

- **Insurance.** This sector's annual turnover is estimated at £240 billion. Environmental data and risk models have direct application to the insurance and re-insurance industry, with a wide range of applications from space weather to flooding. There is therefore great interest in supporting research as a means to business advantage. NERC is working with ESRC and The Technology Strategy Board to address these opportunities.
- **Water.** The water industry is entering its next five-year funding cycle committing £27billion to operations and infrastructure over this period. It faces significant challenges with implementing its response to legislation (e.g. the Water Framework Directive) and responding to climate change and energy pressures – it is the second largest user of electricity in the UK. Within LWEC, NERC will be working with TSB (the Environmental KTN) and other research councils to address these challenges.
- **Construction.** 45 per cent of carbon emissions in the UK come from buildings. Government has instituted a code for sustainable homes which legislates for zero carbon homes. NERC science is directly applicable to understanding the construction sector's vulnerability to environmental change, whether through floods, winds, temperature, precipitation changes or other effects. Within LWEC, NERC is working with TSB's low carbon buildings innovation platform to address these opportunities.
- **Food security.** Food and agriculture make up two per cent of the economy, but Foot and Mouth Disease affected UK GDP by nine per cent, indicating that this is a vulnerable sector. With a predicted 30 per cent shortfall in food supplies by 2030, there is a need for collaborative research on crops and on the environmental context, with NERC working with BBSRC as part of LWEC.
- **Carbon capture and storage (CCS), sequestration and geoengineering.** The UK has strengths in the geology necessary to support carbon storage together with the North Sea oil and gas fields. There is great potential for environmental science to underpin CCS, in conjunction with EPSRC, TSB and ETI, and to look at other approaches to sequestering carbon, possibly through geoengineering.
- **Wave and Tidal power.** The UK has approximately 10 per cent of global available wave power potential and some of the highest tides. The Severn Barrage could generate up to 5 per cent of UK electricity. This approach requires engineering solutions (developed with ETI

and EPSRC) together with an understanding of the environmental context provided by NERC's research.

- **Processes for valuing the environment and carbon accounting and trading.** The City of London is the leading global location for carbon trading, with 50 per cent of the market. Markets are now emerging based on products for emissions and environmental data. Added sophistication can come from Earth Observation data on, for example, forests, and other mechanisms for carbon sequestration, providing an ideal opportunity for NERC, ESRC and TSB-funded activities.

b) Increasing impact with Government

The £1 billion **Living with Environmental Change** research/policy partnership aims to bring climate prediction down to local and regional levels on timescales required by policy-makers. This will benefit decision makers in local and regional government.

NERC has commissioned a study '**Making NERC Science work for Local Authorities**' which will explore how NERC science is currently used by local authorities, how we can improve two-way exchange and take account of their needs in our research, and build on existing good practice.

c) Building the evidence base

NERC has built up a range of methodologies for recording and assessing the impact of its investments - NERC was at the vanguard for the research councils in economic impact quantification with its 2006 case studies report. We will continue to work towards addressing the impact of our investments, by:

- Carrying out an **independent economic impact case study exercise** during 2009-10, as a follow up to the PWC study.
- Establishing a **high-level industry advisory body** to inform on business needs, strategy and championing NERC science across the business community.
- Continuing to populate the publicly-accessible **Science Impacts Database (SID)**, launched in 2008, so that it will make a major contribution to the collection of impact evidence. This collates case studies that demonstrate the impact of NERC science on society, in policymaking, through commercial uptake and in responding to emergencies.
- The **introduction of Knowledge Exchange plans** in our responsive mode grant applications in 2008, and the evolution into **Impact Plans** for all grant applications in 2009, will encourage the scientific community to consider the potential impact of their research. We will use the non-academic members of the NERC Peer Review College to optimise successful Impact Plans to increase the chances of impact occurring.
- Continually improving the **Research Outputs Database**, which all NERC grant holders, Research Programmes and Fellows provide annual returns on, to include revised reporting requirements that better reflect economic impact.
- Reviewing the NERC **Knowledge Exchange Call** in 2009, to which NERC commits up to £2m per year. The review will consider both the impact of the projects that have been supported over the past five years and the potential for the call to be more user-led. In 2008 the KE call introduced economic impact as the main criterion for assessment.
- Using **PSRE4 funds** won in 2008 to employ an environmental economist and a marketing coordinator to identify key business sectors and increase the flow of new products and services from our Research Centres.
- Introducing a **Pathfinder proof-of concept scheme** for HEIs, to support small-scale commercial activities prior to submitting a full Follow-on Fund application.

D. Bibliography

This list contains information on reports, websites, articles and papers that contribute to the evidence base for NERC's economic impact baseline.

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