Contents

Key Messages ......................................................................................................................................................... 2
1. Introduction .................................................................................................................................................. 3
   1.1. Environmental science and innovation for a changing world ....................................................... 3
   1.2. Environmental science for UK economic growth and wellbeing .................................................. 4
2. NERC Impact ............................................................................................................................................. 5
   2.1. NERC science grows the food industry ............................................................................................ 5
   2.2. Flooding: NERC science saves £billions in lives, homes, business .............................................. 10
   2.3. Creating growth using NERC’s big data ......................................................................................... 14
   2.4. NERC delivers top talent and skills for UK economic growth ..................................................... 19
3. 50 years of NERC impact ....................................................................................................................... 23
   3.1. Benefiting from natural resources ................................................................................................. 24
   3.2. Resilience to environmental hazards ............................................................................................ 26
   3.3. Managing environmental change .................................................................................................. 28
4. Evaluating our Performance .................................................................................................................... 30
   NERC input and output metrics ................................................................................................................. 34
Annex A: Notes and References .................................................................................................................... 36

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This impact report shows that NERC environmental science funding:

- Supports the whole economy
- Targets government growth priorities
- Engages business across our whole portfolio
- Leverages private R&D investment (£130m pa)
- Creates prosperity through growth and cost saving

These themes are woven throughout the report.

**Box 1: Government growth priorities**

<table>
<thead>
<tr>
<th>Professional Business Services</th>
<th>Offshore Wind</th>
<th>Information economy</th>
<th>Agri-Sci</th>
<th>Big Data</th>
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<tr>
<td>Construction</td>
<td>Agri-Tech</td>
<td>Oil &amp; Gas</td>
<td>Robotics</td>
<td>Satellites</td>
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**Industrial Strategy**  
**8 Great Technologies**
1. Introduction

1.1. Environmental science and innovation for a changing world

NERC’s strategy – *The business of the environment* – explains why the environment is everyone’s business. We depend on the environment for shelter, heat, light, food and water – all provided by globally interconnected trade, transport and communications. The world’s population is growing by around one billion every 12 years. Now more than half of us live in cities and more than half the countryside is used for agriculture. People are the dominant source of change in the UK and across the planet. We aspire to escape poverty and improve our living standards. Achieving this whilst living within the Earth’s limits is the great challenge of the 21st century.

NERC funds the science that is vital for meeting this challenge. NERC works in partnership with business, government and civil society. Each year we invest £330m in cutting-edge research, training and innovation in UK universities and research centres. We invest in discovery science to understand how the Earth works: past, present and future. We invest in strategic research so that society can benefit from natural resources, build resilience to environmental hazards and manage environmental change. And we invest in translation activities that help business, government and society use our science knowledge. Together we innovate new ways of living, doing business, escaping poverty and growing economies.

**Box 2: NERC strategy: The business of the environment**

<table>
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<tr>
<th>Our vision</th>
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<tr>
<td>To place environmental science at the heart of responsible management of our planet.</td>
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<th>Our goals</th>
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<tr>
<td>To fund excellent, peer-reviewed environmental science that helps us:</td>
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<tr>
<td>• Understand and predict how our planet works</td>
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<tr>
<td>• Manage our environment responsibly as we pursue new ways of living, doing business, escaping poverty and growing economies.</td>
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**Making it happen**

We will foster UK and international partnerships so that business, government, civil society and scientists work together to:

| • Address the challenges and opportunities of managing the environment |
| • Co-design and co-deliver new environmental science |
| • Find and apply existing scientific knowledge |
| • Drive UK innovation, economic growth and societal wellbeing. |
1.2. Environmental science for UK economic growth and wellbeing

Every business, public service and citizen depends on, and in turn impacts on, planet Earth’s environment. Because of this NERC environmental science naturally supports the whole UK economy. It fuels innovation across every industry sector (Box 3). It delivers prosperity, both through growth (eg Section 2.1 Scottish fish farming) and through cost-avoidance (eg Section 2.2 Flooding).

**Box 3: NERC is a natural business partner**

<table>
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<tr>
<th>All businesses depend on:</th>
<th>NERC science, skills and data help businesses:</th>
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<tbody>
<tr>
<td>• Access to sustainable natural resources and environmental services</td>
<td>• Benefit from natural resources and services, whilst living within the Earth’s limits</td>
</tr>
<tr>
<td>• Secure supply chains, logistics and customer service</td>
<td>• Understand business risks and vulnerabilities to natural hazards, and build resilience to them</td>
</tr>
<tr>
<td>• Operating safely in the environment, and managing the environment responsibly.</td>
<td>• Understand the opportunities and risks arising from environmental change, and manage business impacts upon the environment.</td>
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</table>

NERC supports the government’s growth strategies for specific industry sectors and technologies by targeting strategic investment towards national priorities. We work with Innovate UK (formerly TSB) and others, to ensure that NERC science makes significant contributions to growth in: agri-tech (sustainable food); energy (oil & gas, offshore wind); financial services (insurance); construction (national infrastructure); big data and the information economy; and robotic technology.

And, by supporting the science that informs responsible environmental management, NERC also contributes to public policy and wellbeing across a broad range of government, regulatory agencies and planning sectors. For example, NERC science makes significant policy contributions to: food and farming; water supply and flooding; energy and mining; transport; infrastructure planning; environmental quality and status (EU legislation); climate impacts and monitoring.

Overall, NERC funding supports a broad and balanced portfolio of discovery and challenge-led research. Many of the greatest advances in environmental science have been driven by curiosity-driven research to discover how our world works. Strategic research directly addresses the pressing challenges facing society. Importantly, business and other users collaborate across our whole portfolio of strategic and discovery research, so that NERC’s public funding attracts private R&D investment (more than £130m a year) to translate and amplify the impacts of all our research.

This report provides evidence of NERC science generating innovation, growth and public wellbeing across a range of industry and policy sectors (Sections 2 and 3) and explains how we evaluate these beneficial impacts (Section 4).
2. NERC Impact

2.1. NERC science grows the food industry

Investment

Feeding a growing population – in the face of increasing pressures on climate, land use, water and energy – is one of the great challenges facing the world. The UK agri-food industry is worth £96bn a year and supports 3.8 million jobs\(^2\). The government’s agri-tech strategy\(^3\) identifies agriculture as a UK growth industry, where the challenge is to increase productivity whilst reducing environmental impact.

NERC invests £10m a year in research that supports the government’s agri-tech strategy (Box 4). NERC science and data helps the industry to produce more food whilst reducing the use of scarce or costly inputs (such as energy, water, nutrients and chemicals) and minimising adverse environmental impacts.

Box 4: Investing in innovation for the food industry

Business-led research, translation and innovation

During 2014 NERC, BBSRC and ESRC launched a Sustainable Agriculture Research and Innovation Club (SARIC) with a £10m budget for five years. SARIC will commission research and translation projects that solve business challenges affecting the productivity, efficiency and sustainability of UK crop and livestock sectors. Thirteen companies have already joined the club including food producer associations, farm service suppliers (eg Bayer, Monsanto), water companies (eg Anglian Water, Welsh Water) and food retailers (eg Marks & Spencer), and the first five projects have been awarded.

NERC also supports Knowledge Exchange Fellows to work with companies like Sainsbury’s, Marks & Spencer, Unilever and horticulture growers to help them access research knowledge and translate it for innovation.

‘When I meet [the science minister] I will be singing the praises of SARIC as a model for companies, academics and government to focus on important agri-food challenges.’

Dave Russell, Director of Technology Prospecting, Monsanto

Challenge-led strategic research partnerships

NERC is a founding member of RCUK’s Global Food Security (GFS) programme alongside BBSRC, Defra, Scottish Government and others. Current GFS investments include Soil Security (NERC £5m 2013–18) and Soil And Rhizosphere Interactions for Sustainable Agri-ecosystems (SARISA, NERC £0.7m).

Other NERC programmes that support the agri-food industry include Insect Pollinators Initiative (NERC £1.6m 2009–14), Biodiversity and Ecosystem Services Sustainability (NERC £13m 2011–17) and Valuing Nature (NERC £5m 2013–18).

Agri-environment research at the NERC Centre for Ecology & Hydrology (CEH)

CEH currently spends £1.2m a year on agri-environment research, leveraging around £3.3m a year from business (eg Syngenta, Energy Technologies Institute, Jacobs Engineering) and policymakers (eg Defra, Natural England, DECC, Welsh Government, EU). CEH works on agri-environment and biodiversity schemes, insect pollinators, soil and water nutrients, plant pests, ozone damage to crops, energy crops, and emissions from agriculture.
Impact

A study of 36 NERC-funded projects showed that NERC science delivers impact across the entire food industry (Box 5). Specific examples (Boxes 6–8) – from fish-farming to biological pesticides to food waste – show how NERC science and innovation delivers benefits to the entire food sector. Food producers, processors, retailers and service companies are achieving higher productivity and growth in UK and global markets. Smarter regulation enables innovative products to reach the market sooner, driving economic growth with environmental sustainability. Consumers can be more confident in the safety and content of the food they eat.

Box 5: NERC science supports the entire food sector

Each dot represents an impact case study. Many case studies illustrated multiple benefits (multiple dots). Source: NERC Agrifood Impact Study
Box 6: Growing the Scottish fish-farming industry

The Scottish fish-farming industry, including its supply chain, had a turnover of £800m in 2012 (£270m GVA). NERC environmental science and data directly supports the sustainable growth of this industry. It enables regulators to issue fish-farm licences, and it helps farmers avoid sudden catastrophic losses of fish due to harmful algae.

NERC Impacts

- £800m pa industry supported: £79m pa additional capacity; millions of fish deaths avoided.
- New export markets: UK environmental assessment and regulatory tool exported to 25 countries; algal monitoring service now being rolled out to Europe and shipping sector.
- Smarter regulation enabled economic growth with environmental sustainability.

Fish-farm licencing

NERC scientists at the Scottish Association of Marine Sciences developed an environmental modelling tool, Autodepomod, that predicts the impacts of fish-farm discharges (mainly fish faeces) on the seabed. From 2005 the Scottish Environmental Protection Agency (SEPA) required fish-farm operators to use this tool. The European Commission then recommended the tool to be used to assess environmental impacts and authorise aquaculture even in the most strictly protected sites.

Autodepomod is now the industry standard tool in Scotland and its use is spreading across the world. In 2010 it was estimated the tool had enabled an extra £79m a year output from Scottish fish-farms, and it was licenced to 106 users in 20 countries. By 2013 there were 122 licence holders in 25 countries.

Autodepomod has been essential for SEPA to grant more licences at more sites and for larger farms.

Protecting fish farms from deadly algae

Large masses or ‘blooms’ of toxic floating algae can develop when ships transport them in ballast water or excess nutrients run off land and stimulate algal growth. The Scottish Executive estimated that 2.2 million salmon were killed by algal blooms between 1999 and 2002. Such mass deaths of fish can be sudden and catastrophic.

NERC scientists at the Plymouth Marine Laboratory developed an algal bloom monitoring service. This service processes satellite data in near-real time and provides early warning so fish-farmers can take action to protect their stock. Farmers value this service so highly they now fund it themselves:

'We are convinced this [service] prevented us from suffering losses.'

'I would not feel secure enough to go blind in future. We need this information.'

Harmful algal bloom detected around Scotland

(Dr Peter Miller / PML)

Fish farm, Mid Yell, Shetlands

(Mike Pennington/Wikimedia)
**Box 7: Smarter regulation unlocks innovation in biopesticides**

Harmful chemical pesticides are being withdrawn from use for regulatory and safety reasons. So NERC scientists are working with the food industry and regulators to enable alternative and sustainable pest control solutions. The advantage of biological pesticides is they can target and kill specific pests whilst being harmless to humans and beneficial insects such as crop-pollinating bees.

**NERC impacts**
- Supports a UK market worth over £350m pa.
- Smarter regulation freed up innovation.
- New markets and exports for innovative products.
- Food safer for humans; reduced environmental impact.

**Smarter regulation**

Despite the urgent need for more biopesticides, and their many benefits, few are coming onto the market. Through the Rural Economy and Land Use programme (2004–13), NERC with BBSRC and ESRC funded a groundbreaking multidisciplinary research team led by Professor Wyn Grant at the University of Warwick to understand the barriers to commercialising and regulating biopesticides. The researchers provided expert advice and training for UK and European regulators, as well as biopesticide manufacturers and food retailers.

As a result, regulatory frameworks designed for controlling synthetic chemicals were adjusted to encourage biological control and integrated pest management. The expert advice and more amenable regulation helped manufacturers, many of which were relatively small and not set up to deal with the regulatory process, to achieve a higher registration rate for new biopesticide products. Food retailers such as Marks & Spencer used the research findings to revise their pesticide strategies.

**Innovative biopesticides**

The UK soft-fruit market was valued at £351m in 2013. The vine weevil is a serious pest of soft fruits that significantly reduces crop yields. NERC funding enabled Professor Tariq Butt from Swansea University to research and develop a fungal biocide that targets and kills specific pests like the vine weevil. They used the funding to improve production of the fungus and to field-test potential products.

The resulting product Met52 provides long-term protection for crops whilst being harmless to beneficial insects, and increases productivity for growers. Met52 is marketed by horticulture distributor Fargro, who report that usage increased by 50% between 2011 and 2013 through market growth in the UK and Europe. Paul Sopp, Fargro Managing Director, said:

*The product has proved popular with growers and is a significant advance for biopesticides in the UK. As persistent chemicals are withdrawn, the choice for growers is limited. For the first time [Met52] offers a chemical-free alternative to conventional chemicals.*
Box 8: Reducing food waste to boost productivity

The food industry suffers huge losses through spoilage and contamination before food reaches the consumer. NERC-funded scientists at the University of Newcastle, led by Professor Jerry Barnes and Dr Ian Singleton, built on their existing research and technology to spin out innovative new food preservation and testing companies. These new technologies and companies help food producers and retailers reduce waste, and hence boost productivity and growth.

NERC impacts

- New start-ups and service innovation: new jobs, markets and exports.
- Less food waste: reduced cost, higher productivity for producers.
- Less contamination: safer food, consumer confidence, reduced environmental impact.

Innovation in food preservation

After three years of market research, the team launched a start-up company, Biofresh, to protect stored food from spoilage. They adapted technology that controls small concentrations of gas, and discovered that even low levels of ozone suppress fungi, bacteria and mould in high-value fruit and vegetables. They also developed a commercial solution for using low-levels of ethylene to suppress sprouting of potatoes. Low concentrations of both gases break down naturally into harmless by-products, eliminating the need for persistent chemical treatments.

Producers benefit from less wastage and higher productivity, while consumers benefit from less chemical contamination in their food and in the wider environment. Biofresh has now been taken over by Freshpallet and its products are marketed internationally. The treatment is used on more than 200,000 tons of potatoes worth £25m, including many sold by UK retail chains and the largest crisp manufacturer in SE Asia. The same technology is now clearing regulatory hurdles for other markets. A food storage company said:

‘In response to customer demand to minimise chemical residues, we installed Biofresh systems in a number of our potato stores. We have been very impressed with their effectiveness.’

Innovation in food testing

Professor Barnes and colleagues went on to launch a second start-up company, Geneiuslabs, which tests the safety and authenticity of food and drink. They are amongst the first to commercially launch genetic technology to detect food contaminants – such as bacteria, mould, genetically modified or unlisted ingredients – and to measure nutritional and allergen content for food labelling. The testing approaches are quicker and more precise than previous methods. Benefits for producers include less risk to brand reputation and less food waste, while consumers can have more confidence in food authenticity and safety.

Geneiuslabs has rapidly grown from three to more than 50 employees and is already one of the UK’s top ten food and drink testing companies in a market worth up to £1bn a year.

A customer, Innocent Drinks, said: ‘Geneiuslabs has transformed the way we screen our drinks and manufacturing process and supply chain, saving our company hundreds of thousands of pounds already.’

Potatoes undergoing ethylene treatment

Geneius equipment in action
2.2. Flooding: NERC science saves £billions in lives, homes, business

Investment

Risks from extreme weather events are increasing in frequency and severity due to a combination of climate change and population growth. A recent Royal Society report estimated that the risk to individuals from floods will rise more than four-fold by 2090\textsuperscript{22}. The winter storms that hit the UK in 2013–14 set a host of new records for wind-speed, wave energy, coastal storm surges, rainfall, groundwater levels, river flows and flood levels. Apart from the human misery and insurance costs, flooding costs the UK £2.2bn each year in building defences and restoring damage.

NERC invests £58m a year in world-leading weather and climate research (Box 9). 50 years of sustained funding has given us a wealth of scientific data and expertise for atmosphere and climate, river and groundwater flows, tides and storm surges.

**Box 9: Investing in innovation for flood protection**

**Accurate real-time weather and flood forecasting**

NERC environmental science and data provide the unseen but vital information behind the Met Office’s world-leading weather and climate prediction models, the UK Flood Forecasting Centre and the Thames Barrier. We invest in critical, multi-disciplinary research and innovation in weather, rainfall and water flows to continually improve the accuracy of 1–5 day forecasts and flood warnings.

Current NERC programmes, in collaboration with the Met Office and Environment Agency, include Storm Risk Mitigation (NERC £4.2m 2009–14) and Flooding From Intense Rainfall (NERC £5.2m 2012–17). NERC research centres provide much of the essential national capability – large research infrastructure plus long-term research and monitoring programmes – that, together with the Met Office and Environment Agency, makes coordinated UK-wide research and innovation possible. As members of the cross-government Natural Hazards Partnership, NERC centres\textsuperscript{23} provide 1–30 day outlooks for coastal, river and groundwater levels and flooding.

**Coping with future extremes and risks**

The Changing Water Cycle programme (NERC £10.4m 2009–14) has already found that very wet winters and flash floods in summer will be much more common in the UK by 2100 due to climate change. Researchers are now working with industry and public agencies to improve future flood management and sewer design.

In 2013–14, NERC launched an Environmental Risks to Infrastructure innovation programme. An initial nine projects worth £0.6m support researchers to collaborate with industry (eg Arup, Network Rail, London Underground, Thames Water), port authorities, national and local government, to design future infrastructure solutions for cities, transport, energy, ports and coastal defences.

The NERC Centre for Ecology & Hydrology is working with customers including Welsh Government to develop land management options for flood mitigation – such as tree-planting, shelterbelts and wetland construction.
Impact

NERC data enables increasingly accurate and earlier predictions, giving more time for government, public agencies and citizens to take the right action to protect lives, homes and businesses. Early warning avoids or reduces clean-up and rebuilding costs. Loss of life is now mercifully rare compared with the hundreds or thousands killed in the 1953 east coast storm surge, the 1928 London flood, and the 1607 Bristol Channel tsunami that inundated the Somerset Levels.

We work with the Met Office, Environment Agency, Defra and emergency responders to translate NERC’s ‘big data’ into vital prediction tools:

- NERC environmental science and data are essential for the Met Office’s world-leading weather and climate prediction models.
- NERC data are used by the UK Flood Forecasting Centre to give earlier and more accurate flood warnings.
- NERC tide and storm-surge information is used by the Thames Barrier control centre to safeguard the London flood plain.
- NERC experts advise government to help coordinate nationwide emergency response and brief the media – working through the Cabinet Office Civil Contingencies Unit, Cabinet Office briefing Room (COBR), Scientific Advisory Group for Emergencies (SAGE) and Natural Hazards Partnership.

Boxes 10 and 11 show how NERC investment in weather and climate research saves lives and benefits the economy by reducing the costs of flooding.
The winter 2013–14 floods were more severe than the 2007 floods. Yet, thanks to the use of NERC science for better forecasting and earlier warning, more properties were protected and fewer homes were flooded.

According to the Environment Agency, more than one million properties were protected while only 6,000 homes were flooded, just one-tenth of the number in 2007. The Association of British Insurers estimates that the 2013–14 floods will cost £1.1bn, compared to the £3bn bill in 200724.

The Thames Barrier protects around 1.25 million Londoners, £200bn property and £230bn annual economy25. The barrier was closed 28 times between 6 December 2013 and 12 February 2014, an unprecedented number of closures over such a period, protecting the city and saving £2.6bn (£94m each day) in lost working26.

NERC experts from the University of Reading (Dr Hannah Cloke, who was seconded to the Cabinet office for two weeks), Centre for Ecology and Hydrology (CEH) and British Geological Survey (BGS) directly advised the Government Chief Scientific Advisor, SAGE and COBR. They provided scientific evidence and advice on the rarity of the events, the importance of groundwater flooding, worst case scenarios and options for managing the floods.

CEH and BGS hosted a media event at the Wellcome Trust to make appropriate data and analysis available to the media and public, and provided expert commentators for national and local media interviews.

NERC Impacts

✓ More than one million properties protected; 50,000 fewer flooded.
✓ £2bn less insurance pay-outs.
✓ £2.6bn of lost working saved in London alone.
Box 11: Reduced infrastructure costs and greater resilience

NERC climate science is used by infrastructure planners, such as the Thames Estuary 2100 Partnership, and developers to reduce costs and build resilience to future flood threats.

For example NERC data and understanding of future weather and climate showed the existing Thames Barrier can continue protecting London until 2070, avoiding £billions in premature infrastructure replacement costs. Meanwhile NERC’s British Geological Survey (BGS) provided groundwater science evidence to a parliamentary select committee scrutinising the Flood and Water Management Act 2010, and informed the Environment Agency’s Preliminary Flood Risk Assessment upon which local authorities take their planning decisions.

BGS data on the susceptibility of groundwater flooding informs local authorities and the construction industry on the risks of inland flooding, with benefits estimated up to £20m per year. The NERC Centre for Ecology & Hydrology publishes the award-winning Flood Estimation Handbook which is now the industry standard used by planners and 300 companies to estimate local flood risk and develop resilient infrastructure. In 2006 PriceWaterhouseCoopers estimated that the Handbook generated annual economic benefits worth up to £30m a year through reduced damage from flooding.

NERC science is used by agriculture and water regulators to design smarter land management subsidies and reduce infrastructure costs. A NERC-funded business intern at South West Water helped to design the UK’s first ‘valuing nature’ auction, a Payments for Ecosystem Services (PES) scheme. South West Water paid farmers to reduce pollution at source, rather than investing in expensive infrastructure and operations to treat polluted water downstream. This benefited the farmer, the water company (saving 20% of operating costs), the water customer (better water quality), the wider environment (greater environmental benefit per taxpayer £ spent), and the floodplain (reduced peak water flows and flooding). Research showed the auction was 20–40% more efficient than previous fixed-price mechanisms, and generated an overall benefit-to-cost ratio of some 65:1.

NERC impacts

- £billions saved by avoiding premature replacement of the Thames Barrier.
- £50m pa saving from NERC data on flood risk.
- Benefit-to-cost ratio of 65:1 from reducing water pollution at source.
2.3. Creating growth using NERC’s big data

Investment

The government has identified ‘big data’ as one of the UK’s ‘eight great technologies’ that will drive future economic growth and societal wellbeing. The direct value to the economy of public sector data alone is estimated at £1.8bn a year, with wider social and economic benefits bringing this up to around £6.8bn\(^3\).

‘Big data is one of our Eight Great Technologies, and for good reason – its potential impact is so significant that it could transform every business sector and every scientific discipline.’

Ministerial foreword, Government Data Strategy\(^3\)

NERC creates and holds large and ever growing volumes of data and information – our six environmental data centres hold more than 4,000 terabytes of digital data, plus a huge volume of biological, chemical or physical samples and specimens. We are a custodian of the environmental record, stretching back far beyond NERC’s 50-year history. Now NERC is harnessing the rapid development of information technology to open our big data to the wider world. With partners, we are using our scientific data and knowledge to develop products and services that directly address the needs of business, government and society (Box 12).

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**Box 12: Investing in innovation that uses NERC environmental data**

**Capital investment making data available for innovation**

The potential economic and societal benefit of NERC’s big data is enormous, so NERC has invested £13m capital over the last two years in new technology to make it easier for researchers and other users to access and work with our data.

**Business-led innovation**

With Innovate UK (formerly the Technology Strategy Board), in 2013/14 NERC invested in 50 innovation projects to solve business problems using environmental data (£1.3m NERC, £3m Innovate UK, £1.4m leveraged from industry partners). Businesses, including SMEs, are working with researchers on a broad range of applications – from decision tools for the marine renewables sector, to breeding strategies for the agriculture sector, to making financial commodity markets more transparent.

Further co-investment with Innovate UK, and collaboration with the Satellite Applications Catapult Centre at Harwell, will promote growth in the space industry. We will support the development of satellite-based observing instruments and of applications that use the data collected by satellite instruments.

**Public data partnerships for service innovation**

Through the Environmental Science to Services Partnership (ESSP – with the Met Office, Environment Agency, Ordnance Survey and Defra) and the cross-government Natural Hazards Partnership (NHP), NERC is making its environmental data available for new services. ESSP is building data service portals for the construction industry and for resilience planners that enable users to access and combine, in one place, a range of data from different partner organisations. New NHP services include the *Daily Hazard Assessment*, an ‘at-a-glance’ summary of potential natural hazards. It provides 1, 5 and 30–day outlooks to increase the UK’s ability to respond to, and be prepared for, single and multi-hazard events.
The process of collecting, curating, translating and disseminating NERC data and information generates external economic and societal benefits through a number of routes (Box 13). It is very difficult to predict the future usefulness of scientific data, yet experience shows it may prove valuable in unexpected new ways. Physical collections are as important as digital data because they remain available for analysis of new environmental resources, hazards or change, and can yield more information as analytical technology develops. For example geological drill-cores going back to the 19th and 20th centuries are now being used to assess UK shale gas potential, saving £billions in new drilling\textsuperscript{35}.

**Box 13: How NERC data and information generates economic impacts**

- **New technology to collect scientific data** (eg sensors, instruments, mobile apps)
  - Finds wider commercial and regulatory uses, and generates new spin-out products or businesses

- **Scientists and translators trained to understand and interpret environmental information**
  - Skilled people enable business and government to innovate in products, services and policy

- **New software to visualise and interpret data** (eg models, tools, apps)
  - Finds wider commercial and policy uses, and generates new spin-out products or businesses

- **Clear definitions and standards for environmental objects** (eg rocks, species, habitats and data)
  - Enables information exchange, trade and regulation

**Impact**

A review of 44 case studies revealed that NERC data and information – including digital and physical collections – have delivered widespread impacts\textsuperscript{36}. Many industry sectors have benefited, including: energy (Box 14); water (Box 15); minerals (Box 16); agri-food; manufacturing; transport; construction; and insurance. NERC data and information helps businesses locate and extract natural resources and services, build resilience to environmental hazards, and operate safely whilst managing the environment responsibly. The following boxes illustrate just some of the beneficiaries and benefits of NERC environmental data and information products.
One of the great challenges facing society is to meet rising energy demand whilst reducing carbon emissions. Renewable energy makes an increasingly important contribution to meeting this challenge. In 2013 renewables contributed 5.2% of the UK’s energy consumption, and the UK target for 2020 is 15%\cite{37}. The UK is naturally rich in wind, wave and tide energy potential. NERC scientific data is enabling government and business to unlock this potential and build a low-carbon economy.

A century of research data on UK coastal tides and currents, from NERC’s National Oceanography Centre (NOC), were used to produce the *Atlas of UK Marine Renewable Energy Resources*\cite{38} for DECC. This atlas informed the government’s *Marine Energy Action Plan*\cite{39} and is used by DECC to decide which areas should be auctioned to companies to develop marine energy.

NERC data and expertise are used by regulators, energy companies and investors to reduce the risks and costs of renewable energy developments. For example to assess the safety of wave energy turbines to seals and other marine mammals\cite{40}, the effects of wind turbine installations on coastal erosion\cite{41}, and the feasibility of tidal barrages. One company decided not to proceed with a tidal barrage across the Mersey estuary because the project was not economically viable – NERC data speeded the decision and helped the company to avoid unnecessary costs\cite{42}.

NERC investment in a Knowledge Transfer Partnership (KTP) enabled NOC to collaborate with Pelamis Wave Power Ltd, the world leader in wave energy\cite{43}, to develop new technologies for exploiting wave energy. Pelamis used NOC data and modelling expertise to develop software that can predict wave energy production anywhere in the world, giving them a competitive edge over their market rivals.

Back on land, research data is unlocking the potential of geothermal energy – using heat from deep underground. NERC-funded research at Bristol University used satellite data to help a company locate the best place to drill for heat from deep beneath the African Rift Valley in Ethiopia\cite{44}. The NERC British Geological Survey is helping cities like Glasgow to exploit geothermal energy, whilst NERC funding enhanced Durham University’s capability to spin out Geoenergy Durham in 2013 – creating new jobs and growth in north-east England\cite{45}.

**NERC impacts**

- Economic growth in the UK renewable (low-carbon) energy sector.
- Enabled DECC and industry to identify the best sites to develop renewable energy.
- Reduced risks and costs of developing renewable energy.
NERC invests £58m a year in world-leading weather and climate science, working with the UK Met Office to develop and improve the world’s leading climate models and projections. One product of this collaboration is UK Climate Projections 2009 (UKCP09), a cross-government information service that incorporates NERC observation data on climate, sea level and river flows. The user interface for UKCP09 was developed jointly by NERC’s British Atmospheric Data Centre with the Environment Agency.

UKCP09 data are used extensively by the water industry for planning future infrastructure. In 2012 the UK water sector had a turnover of £31bn (£16bn gross value added) and 162,000 jobs.

Atkins, a global infrastructure consultancy, worked with UK Water Industry Research to develop a planning model based on UKCP09 data. The model allows users to explore and understand the effects of climate change on local rainfall intensity, including levels of uncertainty. This means they can design new sewers with the right capacity to cope with surges of water, reducing the risk and cost of flooding.

Severn Trent Water used the UKCP09 data to understand how low rainfall with high temperature in summer, as experienced in 2003 and 2006, may affect water supplies in 2050–2080. They found that such conditions could be common by 2050, and are working with Defra to plan future infrastructure that maintains water supply and distribution.

Other NERC data saves UK water companies up to £350m a year. The NERC Centre for Ecology & Hydrology developed a model to predict natural concentrations of heavy metals in water. The EU adopted the model to set environmental quality standards for water bodies under the Water Framework Directive. This new methodology significantly reduced the number of breaches of water quality standards, so reducing the investment needed in water treatment infrastructure.

NERC impacts

- Economic growth in the £31bn UK water industry.
- Reduced water-treatment costs, saving the industry up to £350m pa.
- Making UK water infrastructure resilient to future climate change.
Box 16: Securing the supply of essential minerals

The distribution of mineral resources depends upon geological processes that created and shaped the Earth’s crust. 50 years of NERC investment in geological research and monitoring provides the data, and new ways of visualising the data, that help us find and extract the minerals that are vital to our economy. Four of the top-five mining companies that operate globally are listed in London. In 2012, UK-listed mining companies had a total capitalisation of £260bn, more than any other financial market in the world51.

NERC impacts

✓ Economic growth in the UK mineral extraction and manufacturing sectors.
✓ Secure supply of critical and scarce minerals for the UK.
✓ Reduced environmental impact of manufacturing sector.
✓ Economic growth in developing nations, meeting UK goals for international development and security.

NERC’s British Geological Survey (BGS) provides authoritative, independent data on mineral resources and production. BGS maps of UK land-based mineral resources are used by regulators to approve planning applications for mineral extraction52. BGS’s global mineral production statistics53 dating back to 1913, including ‘risk lists’ for particular commodities and countries, are used by government (eg Defra, BIS, MoD54) and manufacturers. Small companies (SMEs) access BGS data through Defra’s Critical Resources Dashboard55.

Large manufacturing companies like Boeing, Rolls Royce, Honeywell and Tata Steel use BGS minerals data to design products and plan the supply of materials needed to make them56. Granta Design, a Cambridge University spin-out, incorporates materials information into computer-aided design tools. This allows manufacturers to consider materials, transport, energy and waste requirements throughout the product lifecycle, bringing products to market faster and reducing their environmental footprint57.

The capability of BGS to survey and visualise data from the Earth’s crust, in three dimensions, has also been used to assess the potential of mineral deposits in developing nations, so securing their economies as well as the supply of critical minerals for the UK. BGS worked with Regency Mines and the Sudanese Government to train local geologists, and with the Afghanistan Geological Survey and government to rebuild their capabilities. When conflict subsides, Afghanistan is ready to generate £150m a year in copper-mining revenues58.
2.4. NERC delivers top talent and skills for UK economic growth

**Advanced skills are vital for the UK economy**

A fifth of UK workers, 5.8 million people, are employed in science-based jobs, and this number grew by 9% between 2010 and 2013\(^59\). The 2013 CBI Employment and Skills Survey\(^60\) showed that 39% of firms are struggling to recruit workers with the advanced STEM skills they need, and 41% say shortages will persist for the next three years.

‘Growth and jobs in the future will depend on the UK having a workforce that can exploit new technologies and discoveries. The growing skills vacuum is threatening the recovery, as demand from firms is outstripping supply.’

Katja Hall, Chief Policy Director, Confederation of British Industry

Two recent studies of innovative firms\(^61\) and a study of PhD graduate careers after 7–9 years\(^62\) found that public investment in research and training provides multiple benefits. It is good for doctoral graduates (who are highly employed and increasingly mobile) and it is good for innovation, where it increases demand as well as supply:

- More than half the surveyed doctoral graduates were working outside academia, most of them directly involved in initiating and creating innovation.
- Doctoral graduates are vital to business success: three-quarters of employers said that the loss of their doctoral graduates would have either a business-critical or significant impact on operations, and one fifth said their business could not function without them.
- Postgraduates who work outside academia enhance the capacity of industry to absorb knowledge. They stimulate demand for innovation; they are more likely to initiate innovation within their companies; they reduce the costs of innovation and increase its economic benefits.
- Those postgraduates who remain in higher education contribute to the supply of new knowledge, technology and training that businesses need for innovation.

**NERC investment**

Because high-level skills in environmental science are so important to the UK economy, NERC has reformed the delivery of its postgraduate training and set a target to grow its investment by 20% between 2014 and 2017.

At least 1,000 PhD students a year benefit from NERC doctoral training. 250 non-academic partners are currently engaged with HEIs in delivering this training to cohorts of students. Of these partners, 60% business, 23% third-sector and 17% government or public agency.

During 2013–14 NERC launched new vehicles for its focused training investment. Centres for doctoral training (CDTs) deliver specific skills that NERC and our partners in business and government identify as national priorities. NERC will grow a balanced portfolio of CDTs that support government’s industrial growth strategies and emerging new technologies. This year we announced the first three CDTs, in oil and gas (see Box 17), soil science supporting agri-food and other sectors (to launch with BBSRC in 2015) and managing and mitigating risk using big data, supporting financial services and insurance (to launch with ESRC in 2015).
Advanced skills short courses deliver skills to PhD students and early-career researchers that our partners in business, government and research identify as strategic priorities. Current priority areas include: risk and uncertainty; data and information management; and statistics. Following a competition, NERC recently funded 29 institutions to deliver 50 short courses in a variety of formats including summer schools, field courses and online resources.

**Box 17: NERC invests in high-level skills for UK industry**

The government’s UK Oil and Gas Industrial Strategy recognises the importance of this sector for our future energy supplies and for the transition to a low-carbon economy. The sector supports 400,000 UK jobs and is experiencing significant skills shortages.

NERC’s £9m CDT will provide a national training focus to deliver key skills that are transferrable across the energy sector and wider environmental services sectors. It will equip students to address the challenges of exploration, extraction and carbon storage whilst reducing environmental impact – working with researchers, industry and regulators to put innovation in environmental sciences at the heart of responsible management of natural resources.

‘NERC’s CDT will support the growth of the UK’s oil and gas resources and attract overseas investment, keeping the UK ahead in the global race.’

David Willetts, Universities and Science Minister (2013)

Following open competition, NERC awarded the CDT to a consortium led by Heriot-Watt University in Edinburgh. The consortium includes 16 top universities plus NERC’s British Geological Survey and National Oceanography Centre. NERC funding of £2.7m is leveraging an additional £5.2m from consortium partners plus growing commitment from industry – so far BP, Shell, BG, EON, ConocoPhillips and Total have together pledged more than £1m for the centre. From October 2014 the CDT will train a minimum of 30 PhD students each year.

‘The NERC CDT is a truly game-changing initiative and represents the most exciting development in training for the UK energy industry during my career. The consortium includes all the major UK providers of world-class teaching and research in petroleum geoscience and related subjects. The inclusive nature of this initiative is extremely attractive to the industry and will create a ‘one-stop shop’ for industry and academic collaboration in research and recruitment.’

Keith Gerdes, President of AAPG Europe and Global Exploration Advisor for Shell

**Impact: NERC PhDs deliver economic growth with responsible environmental management**

NERC’s broad and balanced training portfolio delivers highly skilled people who are prized by employers for driving innovation and economic prosperity. Environmental science PhDs contribute to a very wide range of industry and policy sectors. The last four NERC Impact Reports have showcased the economic and societal impacts of NERC PhD graduate careers in biotechnology, chemicals, health, infrastructure, insurance, minerals, nuclear, oil & gas, marine planning and climate change policy. Boxes 18–21 highlight the contributions of four NERC PhD graduates to economic growth and responsible environmental management in insurance, energy, water quality and flood forecasting.
Box 18: Kirsty Styles – Building competitive advantage in the insurance sector

Kirsty Styles, Earthquake Risk Scientist at reinsurance company Aspen Re, uses the knowledge, skills and independence gained during her NERC-funded PhD in seismology to build her company’s competitive advantage.

She works in the research and development team, which uses scientific models to estimate the risk of earthquakes in different regions of the world. Kirsty applies the knowledge and modelling skills gained during her PhD to ensure that these models are based on rigorous, up-to-date science.

Her modelling work strengthens Aspen Re’s competitive advantage by ensuring that the company’s financial risk exposure from catastrophes is clearly managed and finely balanced with the price it charges for insurance. This benefits the UK economy, as most of Aspen Re’s insurance and reinsurance policies are sold and underwritten from the UK.

Box 19: Dan Graham – Driving inward investment and growth in renewable energy

Dan Graham’s NERC-funded PhD in geophysics gave him high-value transferable skills in data processing, computer modelling and software development.

After completing his PhD in 1992 Dan moved to the oil industry, where he used his skills in seismic data processing and modelling to help his company find new oil reserves. To pursue his interest in software development he joined the Met Office then moved to the telecoms industry as a software engineer.

Since 2009, Dan has been working for DNV GL, a leading consultancy to the energy industry, where he develops software for designing wind-farms. The Windfarmer software helps energy companies across the world decide where to locate wind turbines to maximise energy production whilst minimising noise and visual impact.

‘I’m still using skills I learned doing software development during my PhD, like numerical modelling and signal processing.’

Dan’s work benefits the UK economy in several ways. His software enables UK energy production and export sales. His high-level skills contribute to pool of talent that attracted DNV, a multinational company, to locate in the UK and create 1,400 jobs.
Box 20: Jill Crossman – Protecting our drinking water

Jill Crossman’s PhD in hydro-ecology equipped her to tackle some of the critical environmental challenges facing the world today. During her PhD, she acquired many of the skills that are most wanted by the environmental sector including ecology, taxonomy, hydrology, remote sensing and mathematical modelling.

Based at the University of Oxford, Jill also works as a consultant for Water Resource Associates. She advised the UK water industry on how to improve water quality in rivers where pollution by sewage and fertilisers can cause algal blooms that threaten drinking water supplies and damage ecosystems. Jill also worked with the Canadian environment ministry to model flood risk from melting glaciers in Alaska and to provide water quality guidance for farmers.

Now Jill helps to run the Macronutrient Cycles research programme for NERC, Defra, the Environment Agency, and the Scottish and Welsh governments. The programme is studying how nitrogen, phosphorus and carbon move through the environment and interact with each other, taking into account the impacts of climate change. The results will help policy makers identify the most effective and efficient ways to protect water supplies in the future.

Box 21: Crystal Moore – Protecting us from environmental hazards

A NERC-funded PhD in environmental toxicology provided Crystal Moore with transferable skills in research, leadership, integrity, accountability and perseverance, setting her up for a varied and successful career.

Crystal’s career has been dedicated to supporting UK prosperity and wellbeing by reducing environmental risks and costs. She started as an environmental consultant for SWAP Ltd, where she managed a national oil-pollution prevention campaign with the Environment Agency (EA). Next she joined BusinessLink, working with the petroleum and retail sectors to reduce oil pollution by raising awareness and influencing legislation.

Moving to the EA, Crystal worked in a variety of local and national roles: developing regulatory guidance for different industrial sectors; leading the EA’s fisheries, recreation and biodiversity responsibilities in Devon; planning for environmental emergencies at the 2012 Olympics; managing change projects; and re-engineering environmental regulations in response to the government’s ‘red tape challenge’.

Crystal is now head of the UK Flood Forecasting Centre, run by the Environment Agency and Met Office, using NERC science to provide guidance and early warning on flood risk. This helps government and communities to be better prepared for floods, saving lives and livelihoods.
3. 50 years of NERC impact

For 50 years NERC has been funding world-leading environmental science that helps us:

- Understand and predict how our planet works.
- Manage our environment responsibly as we pursue new ways of living, doing business, escaping poverty and growing economies.

Whilst the NERC name may not be widely recognised, we have led and shaped many great scientific advances that profoundly affect all our lives.

NERC was established by Royal Charter in 1965 to support research in ‘Earth sciences and ecology’. This remit encompassed geological, atmospheric, oceanographic and terrestrial sciences, with polar science added two years later. From the beginning NERC science was strongly applied to natural resources (notably minerals, water, forestry and fisheries), natural hazards (initially focussed on weather and earthquake hazards), pollution and nature conservation (which evolved to embrace wider environmental change issues).

50 years later we can evaluate and celebrate the enormous economic and societal benefits of public investment in environmental science.

Taking stock of these achievements, three important lessons emerge about the pathway from NERC funding through scientific discovery, knowledge exchange and skills to innovation, and eventually to impact:

1. Impact takes a long time – the pathway typically involves many steps and actors, often taking decades from initial investment to demonstrable economic and societal benefit.
2. Long-term investment is vital for sustaining both the development of new knowledge and its onward pathway into innovation and impact.
3. A balanced portfolio of NERC investment is needed to support the pathway to impact:
   - national capability to enable large-scale, long-term monitoring and investigation of our planet;
   - discovery science to ask fundamental questions about how the Earth works;
   - strategic research to tackle the greatest challenges facing society;
   - doctoral training to sustain the flow of top talent for science, business and government;
   - innovation funding to help business and government find and use the knowledge they need.

In this section we celebrate just a small selection of the many benefits generated by 50 years of sustained NERC investment.
3.1. Benefiting from natural resources

Natural resources sustain life, wellbeing and economic activity. Ever-growing UK and world populations make ever greater demands on food, water, energy, minerals and other essential services we get from nature.

50 years of NERC investment in science across many disciplines has significantly advanced our understanding of how the Earth’s physical, chemical and biological processes control resource availability. This knowledge helps us use and recycle resources safely and efficiently, live within the Earth’s limits, and steward natural resources for future generations.

Section 2.1 of this report showed how NERC science is growing the food industry. Below we describe how 50 years of NERC science is used for responsible management of marine resources (especially fisheries) and mineral resources (including oil & gas).

Box 22: Leading international policy for sustainable fisheries

Today’s international agreements on sustainable stewardship and commercial fishing in the Southern Ocean are built on 30 years of science evidence led by NERC’s British Antarctic Survey. The Convention for the Conservation of Marine Living Resources (CCAMLR) now has 24 member states plus the EU and covers 15% of the world’s ocean around Antarctica including UK Overseas Territory.

Commercial exploitation of seals and whales in the Southern Ocean began after Cook visited South Georgia in 1775, and turned to fish and krill in the 1960s and 1970s. BAS research on marine ecosystems, animal populations and food-webs provided critical evidence on the responsible use and of natural resources, for example: establishing CCAMLR (1980); re-listing South Pacific humpback whales as an endangered species (2008); and designating the world’s first entirely ‘high seas’ marine protected area (2009) that provides refuge for wildlife including commercial fish stocks. Scientists from BAS also worked with the fishing industry and bird conservation organisations to end the unintentional killing of albatrosses and petrels caught in fishing lines.

BAS scientists remain very active in leading the policy evidence to set sustainable catch limits and licenses for fishing. Now they are providing deeper ecological understanding to enable massive but sustainable expansion of krill fishing, one of the last underutilised sources of marine protein that could help feed a growing human population.
Box 23: Geological data gold-mine fuels the UK economy

The NERC British Geological Survey (BGS) and its predecessors have been collecting and curating geological specimens since 1835. Today these geological records provide immense value to the UK economy across a range of industries, including natural resources and construction.

Since 1965 NERC has invested £50m in the National Geological Repository (NGR) at BGS, which now holds 175 years of geological data. The collection includes 500 km of cores from 23,000 boreholes drilled by construction, mining, water and oil and gas companies, and by researchers. The collection is available to visiting students, researchers and companies, and much of it is now freely accessible as data and images via the BGS website. The NGR collection saves the costs of new drilling – at £20m per well it would cost £160bn simply to replace the 8,000 offshore drill cores collected since the 1980s.

Over the last 50 years the NGR collection has supported oil, gas and mineral exploration, construction projects, groundwater management and nuclear waste disposal. Many oil and gas companies use the collection, together with NERC scientific knowledge of forces that shape the Earth’s crust and control fluid flow through rocks, to plan exploration and extraction operations.

Oil & gas has created immense prosperity for the UK over the last 50 years. NGR data currently supports around £15bn a year of UK oil and gas activity, and generates around £500m pa value.

Now NGR data is being used to understand the potential volume of UK shale gas, and the potential for storing our carbon emissions underground in empty oil and gas reservoirs.

NERC impacts

✓ Innovation and cost reduction across a range of UK industry sectors.
✓ £15bn pa of UK oil & gas activity supported; generating £500m pa value.
✓ Growth of new UK industries: shale gas and carbon storage.
3.2. Resilience to environmental hazards

Extreme weather, volcaones, earthquakes, space weather, pollution, new diseases and invasive species all do serious harm to people, supply chains and essential infrastructure. Many of these hazards are becoming more frequent and severe as populations and cities grow, and our environment changes.

Over the last 50 years NERC scientists have advanced our understanding of the processes that create natural and man-made hazards. We are now better equipped to manage vulnerability, risk, response and recovery. We work with our partners to make people, business and infrastructure more resilient to environmental hazards and emergencies.

NERC has responded to emergencies to restore the UK environment and economy – from the Torrey Canyon oil spill on our coast (1960s), to radioactive fallout from Chernobyl in our milk (1980s), to keeping our airspace open when Icelandic volcanoes erupted (2010s). Section 2.2 of this report showed how long term investment in NERC research, tools and people protects us from flooding. Below we describe how 50 years of NERC science has cleaned up our air and halted the use of harmful pesticides.

Box 24: Cleaning up our air

Air pollution costs the UK economy £15bn every year in damage to human health, not including the cost to our environment and crops. NERC investment of around £3m a year has been critical to cleaning up our air.

NERC impacts

- International protocols reduced UK sulphur pollution and acid rain by 80%.
- Protected human health: established safe emissions limits.
- Recovery of soils and waterways; benefiting agriculture and tourism.

In the 1970s and 1980s NERC evidence showed how airborne sulphur was deposited as acid rain in UK lakes and soils. This scientific understanding was pivotal in establishing international protocols that successfully reduced sulphur pollution in the UK by 80%.

Since 2000 ground-breaking NERC research has shown how airborne nitrogen oxides are reducing biodiversity and damaging our soils. The Europe-wide cost of nitrogen pollution is £280bn a year.

Now NERC science continues to be used by UN, EU and UK legislators to establish safe limits for emissions and to set quality standards for our air, water and soil.
Box 25: Saving our wildlife from harmful pesticides

From 1956 thousands of birds were found dead and dying each spring in recently sown cereal fields across Britain. Victims included seed-eaters such as finches, pigeons and game birds, but also birds of prey. Affected birds usually died in convulsions, yet otherwise seemed in good condition. Within a few years sparrowhawks and peregrine falcons disappeared from large parts of the country.

Suspicion fell on new organochlorine pesticides – such as aldrin, dieldrin and DDT – used by farmers to protect cereal seeds from insect pests. At the time, the long-lived nature of these chemicals was seen as an advantage in providing once-and-for-all protection for crops.

From the early 1960s scientists at what is now the NERC Centre for Ecology & Hydrology began to study the effects of toxic chemicals on wildlife. Over the next decade they worked with fellow scientists, volunteer birdwatchers, museums and government chemists, to solve the mystery using cutting-edge new methods to detect very small amounts of chemicals in animal body tissues.

NERC research showed that organochlorines were not only directly toxic to seed-eating birds, but dissolve and accumulate in the body fat of animals, including humans, up the whole food-chain. Even birds of prey nesting far from farmland suffered long-term harm. Brilliant detective-work revealed that organochlorines cause thinner egg shells, which break easily, meaning birds of prey failed to breed chicks.

The scientists actively communicated their findings to the agriculture industry, government committees and policy-makers. This led to phased withdrawal and, by 1984, to complete bans of organochlorine pesticides across the UK and EU. Pesticide testing in Britain was revamped and the precautionary principle was adopted in the 2004 Stockholm Convention on Persistent Organic Pollutants. UK bird populations recovered slowly at first, due to the long life of the chemicals, but by 1991 peregrines exceeded pre-war numbers.

The whole episode was widely seen as a turning point in UK science’s contribution to reducing pollution, conserving nature and raising public awareness.

Today NERC continues to invest in the Predatory Bird Monitoring Scheme and the Wildlife Disease and Contamination Monitoring and Surveillance Network, revealing the effects of rodenticides on owls and informing government (Defra) policy.

NERC impacts

✓ International bans on harmful pesticides.
✓ Recovery of UK wildlife populations.
✓ Safe food supply for people.
3.3. Managing environmental change

The environment varies naturally, but human activities are directly causing additional changes – often at scales and speeds never before experienced. Such environmental changes pose huge opportunities and challenges for our economy and way of life.

50 years of NERC science tells us how the processes of natural and man-made change work – as a whole Earth system, from global to local scale, from millions of years past to the present and future. We help society use this whole-system knowledge to manage the environment for multiple benefits – for example to understand the consequences of deliberately ‘engineering’ our environment and climate.

Earlier in this section we described how NERC science was used to support sustainable fisheries whilst stewarding natural resources for future generations. Below we illustrate how 50 years of NERC science protects us from harmful ultraviolet radiation and helps us manage our environment responsibly in the face of environmental change.

Box 26: Restoring our protective ozone shield

NERC scientists were first to discover a hole in the layer of ozone high in the Earth’s atmosphere that naturally protects us from harmful ultraviolet (UV) light. Their research triggered the Montreal Protocol to curb the use of man-made chemicals that deplete ozone, which is now recognised as the most successful international agreement to date – “for the first time ever, rich and poor nations alike set out together to save our planet from a serious danger” (Margaret Thatcher, 1991).

NERC impacts

- International agreement to avert major environmental change.
- 2m cases of skin cancer prevented per year by 2030.
- Cut UK healthcare costs by £42m.
- Reduced potential global warming.

Since 1957 NERC’s British Antarctic Survey (BAS) has monitored the ozone layer as part of a research programme to understand our atmosphere. From the late 1970s BAS researchers noticed a thinning of the ozone, which their records showed was anomalous and by 1985 was widely reported as an “ozone hole”. NERC scientists at BAS, Cambridge University and elsewhere found the hole was caused by CFC chemicals used in fridges and aerosol sprays. Their evidence shocked the world, leading directly to the 1989 Montreal Protocol and its subsequent expansion to curb other ozone-depleting substances.

UV light causes sunburn, skin cancer and cataracts. By 2030 it is estimated that action through the Montreal Protocol will have prevented at least 2 million cases of skin cancer across the world each year, saving at least £42m healthcare costs in the UK alone. Some ozone-depleting chemicals are also potent greenhouse gases that cause climate change. Estimates suggest that the Montreal Protocol has reduced the rate of climate change by 5-6 times more than the Kyoto Protocol climate target.

NERC scientists now monitor the improving health of the ozone layer, which will be fully restored by 2075 if current recovery persists, so that international action is maintained.
Box 27: Monitoring and sustaining a healthy environment

We benefit from unparalleled knowledge of the UK’s wildlife, thanks to records collected by amateur and professional naturalists since the 16th century. These rich records allow us to detect environmental change, identify the causes and take action to manage our planet responsibly.

NERC has invested £35m over 50 years in the Biological Records Centre (BRC), which was established in 1964 as the national centre for recording terrestrial and freshwater wildlife. Hosted by the NERC Centre for Ecology & Hydrology, BRC works with NERC scientists and thousands of volunteer recorders who contribute time worth more than £20m a year. By harnessing cutting-edge information technology, including smartphone apps for recorders in the field, the BRC can collect and verify more data than ever before. The centre now has more than 100 million wildlife records and, with partners, has contributed to printed atlases for more than 10,000 species.

From 1965 maps showing the distribution of plants and lichens were used by NERC researchers to investigate the effects of air pollution74. Over the next two decades their evidence informed new regulation of airborne sulphur to reduce acid rain, and continues to monitor the effectiveness of actions to clean up our air.

Farmland ‘weeds’ are actually essential wildflowers which provide nectar food for the insects that pollinate our food crops – an essential natural service worth £430m a year to UK agriculture75. BRC data from the 1970s onwards revealed an alarming decline of farmland weeds, informed the 1994 UK Biodiversity Action Plan, and confirmed their subsequent recovery.

Today freely available BRC records are being used by government in national statistics to monitor the health of the UK environment and the effectiveness of controls to curb the spread of invasive species. It is also used by regulators to enable sustainable growth through appropriate planning permissions, water abstraction licences and waste management permits.

NERC impacts

- Ability to monitor health the health of the UK environment.
- Protected nature’s services worth £430m a year to UK agriculture.
- Sustainable growth through local planning and development decisions.
- Reduced impacts of environmental change.
4. Evaluating our Performance

The big picture

The economic and societal benefits of science investment are notoriously challenging to evaluate and quantify. It is often easier to demonstrate the process of generating impact, and the kinds of impact we achieve, than to measure the impact itself. Impact evaluation methodology is a dynamic and evolving field of study and practice.

As yet, there are no robust and widely accepted metrics for impact. There are a number of reasons why real-world impacts (ie beyond academia) are challenging to measure. Impacts tend to accrue from large bodies of research knowledge over long periods of time (often decades – see Section 3), seldom from single grants or projects. Impact is a messy, non-linear process that often involves many players – funders, scientists, translators, intermediaries and users. The economic benefits of any particular outcome can be difficult to quantify in the absence of counter-factual evidence, or if beneficiaries cannot place a value on the benefit they receive.

Other nations seek to emulate the UK’s capability to evaluate impact through a combination of macro-economic studies and illustrative case studies. At a national level, BIS and others commission or conduct studies of innovation and impact performance across the whole UK research and innovation system. Using econometrics (statistical analysis of economic data) and other approaches it is sometimes possible to correlate system inputs and outputs, and to compare performances between different sectors or nations. Such approaches are more robust when the underlying causation between input and output can be demonstrated through more detailed surveys or studies of pathways to impact.

Individual actors, such as research councils, are not well-placed to conduct these whole-system studies, though NERC does collaborate with BIS and its partner organisations. For example NERC is currently involved in a stock-take of the UK impact policy landscape (with BIS, Innovate UK, HEFCE), an analysis of 7,000 impact case studies submitted to the 2014 research excellence framework (HEFCE REF), and a survey of engagement by publicly-funded academics with non-academic users (with the National Centre for Universities and Business, NCUB). NERC also provides the Research Councils UK (RCUK) impact evidence champion, and works with other BIS partners to share best practice and resources in demonstrating the value of public investment in science.
Measuring NERC’s performance

Econometric studies of the UK research and innovation system highlight the important role of research councils. However it is rarely possible to isolate the performance of individual councils or to estimate their individual return on investment. So BIS has established an agreed performance management framework for research councils that monitors performance against each of our Royal Charter objectives, including impact. Our impact is evaluated by analysing the recent input and output metrics that lead to larger, longer-term impact outcomes, and by analysing case studies of impact outcomes. The results are then presented in this annual Impact Report.

NERC’s goal is to provide robust evidence of the impact of our investment, which is then used by NERC, RCUK, BIS and HMT to inform spending reviews, investment decisions, policy formulation and minister’s speeches. For the reasons discussed above, it is not possible to track every previous NERC investment, or to identify every current impact that arises from past NERC investments, or to quantify the economic benefit of every case study. Hence we cannot demonstrate the total impact or return on investment of all NERC funding. What we can do is develop a substantial portfolio of in-depth case studies – both qualitative and, where possible, quantitative. As our portfolio grows, we analyse collections of case studies to provide a richer picture of NERC’s impact in particular research topics, societal challenges or industry sectors. Our case studies provide vivid evidence of the extent and variety of NERC impacts across the whole economy. They also demonstrate the underlying pathway and causation, from NERC investment to impact, that makes correlations found by econometric analyses more compelling.

Taken together, the metrics, case studies, and econometric studies demonstrate the economic and societal benefits the UK derives from sustained, long-term public investment in science (Box 28).

Box 28: NERC science leads the world

Many organisations play a role in the UK research and innovation system. The research councils have a unique role in funding the most excellent research proposals, and in enabling business and other users to innovate using our world-leading research.

NERC science leads the world on excellence:

- UK is ranked first in the world for environmental science, ahead of USA, on citation impact (a measure of quality).
- UK environmental science leads all other UK research fields on citation impact.
- UK environmental scientists produce more top-ranked publications per pound invested than any comparable nation.
- NERC funds the best of UK environmental science: NERC-funded scientists achieve twice the world average for citations.

We are a partner of choice for research funders and scientists in 80 nations: more than half of NERC-funded scientific publications are co-authored with international partners.

This excellence drives greater impact. It promotes UK leadership, influence and competitive advantage: for environmental science and technology; for UK businesses competing in global markets; for responsible environmental policy and management; and for wider government policy goals such as national security and overseas development.
NERC input and output metrics 2013–14: what they mean

The table below shows five years of data, representing the last two years of the previous spending review (CSR) period 2009–11 and the first three years of the current CSR period 2011–14.

When interpreting five-year data trends, readers need to be aware of discontinuities in some of the metrics (marked with an asterisk *) where changes to NERC’s performance reporting system in 2012–13 and 2013–14 mean that data may not be comparable between years. For metrics marked † the new methodology has been retrospectively applied to recalculate all years in the series, so this data is consistent and comparable. For metrics marked ‡ it has not been possible to retrospectively adjust previous data, so 2012–13 and 2013–14 data are not consistent or comparable with previous years.

The following commentary explains significant trends in the five-year data.

Funds available

Total funds available (item 1) are the sum of NERC’s budget (item 2) plus leverage income (item 3). NERC’s budget comprises three separate allocations: programme (from the ring-fenced science budget), capital and administration. As a result of the 2010 CSR allocation, NERC’s programme budget (the largest element) was flat 2010–14. The variation in items 1 and 2 is due to NERC’s capital budget, which fluctuates significantly between years, due to major projects (eg a new research ship).

Leverage (items 3–13) represents non-BIS income flowing through NERC accounts. NERC generates very little income in its primary role as a research funder. However NERC owns research centres (institutes) who generate income through their operational activities: approximately two-thirds of their external income derives from contract research, one-third from the sale or licensing of information products.

2013–14 saw a noticeable upturn in external income by centres, with private sector income the largest single source. This results partly from NERC’s new strategic focus on engaging business more actively.

Expenditure analysis

Items 14–25 reflect the spending plans set out in NERC’s Delivery Plan for the CSR period 2011–15. One of NERC’s top goals was to shift resources into front-line science, hence other operating costs (items 19 and 24) have been driven down so that grants expenditure (items 17 and 22) and the number of principal investigators supported (item 26) could increase. Some training expenditure (item 16) has fallen permanently in line with the RCUK-wide decision to withdraw from funding taught masters courses, and some temporarily while NERC transformed its doctoral training provision (see below).

Knowledge generation (publication output)

Data for 2013–14 are not yet available. Data for the previous year, 2012–13, should be interpreted with caution due to a previous change of reporting system in 2012.

Observers may be watching for a potential decrease in publication output commensurate with real-terms decline in the overall science budget under a flat-cash allocation since 2010. For NERC, any such trend cannot yet be detected for at least three reasons: the time lag between grant award and journal publication is typically at least three years; NERC has deliberately grown its research grant volume over the same period (as discussed above); and two changes in reporting system confound the data trend.

Human capital (postgraduate training output)

Output data for 2013–14 are not yet available. The number of PhD students trained (item 34) per pound invested (item 37) was more or less constant over the previous four years. The 2013–14 dip in PhD investment, which may be reflected in lower output, was caused by NERC’s transition from an algorithm-based allocation to competitive doctoral training partnerships (DTPs). Doctoral training investment and outputs should recover, and indeed grow, over the next two years as: the transition to DTPs is now
complete; and NERC has committed to increase the proportion of its funds invested in doctoral training. Masters training has been deliberately phased out, as discussed above.

IP activity (knowledge exchange and innovation output)

Item 40 shows IP income to NERC from the operations of its owned research centres. Growth in IP income over the past two years reflects conscious effort by centres. By contrast, item 39 shows reported patent applications across all NERC-funded research organisations (HEIs and centres), where the fall in recent years (2013–14 data are not yet available) probably reflects HEFCE and RCUK policy to encourage research organisations to focus more on collaborating with business than direct commercialisation.

NERC recognises that its primary role as a funder is to enable business and other users to translate environmental science for innovation and economic growth. The UK gains more benefit when we allow inventors, innovators and entrepreneurs to capitalise on NERC science and IP than when NERC tries to retain and commercialise its own IP. Hence items 39 and 40 provide a very incomplete measure of the wider environmental science IP benefits realised by the UK as a whole.

BIS increasingly considers a wider basket of measures to evaluate the UK’s overall knowledge exchange and innovation performance (see endnote references 48 and 49). Such measures are diverse and may include, for example: license revenue; patent citation share; cross-sector article usage; cross-sector researcher mobility; invention disclosures; start-ups and spin-outs, and more. In this context it is clear that items 39 and 40 present a particularly narrow view. As yet it is difficult to assess NERC’s wider performance against a more diverse basket of metrics. However earlier sections of this Impact Report provide robust evidence of NERC’s performance in training PhDs who drive innovation in industry (section 2.4) and in creating innovation and growth across the economy (sections 2.1, 2.2, 2.3).

Human capital (destination of PhD leavers)

Data for 2013–14 are not yet available. However section 2.4 of this report shows that more than half of doctoral graduates work outside academia and, during their careers, they drive innovation for economic growth and societal wellbeing.

Public policy influence

Data for 2013–14 are not yet available, and the 2012–13 data should be treated with caution due to a previous change of reporting system. However earlier sections of this report highlight the considerable impact of NERC science on UK and international policy and regulation.
NERC input and output metrics
(see commentary explanations above)

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9 NERC. (2013) *Satellite Monitoring of Harmful Algal Blooms (HABs) to Protect the Aquaculture Industry*. Internal document available on request.


17 Interview [Personal communication] with Paul Sopp, August 2014.


19 Interview [Personal communication] with Jerry Barnes, August 2014.

20 Available from: http://www.geneiuslabs.co.uk/

21 Interview [Personal communication] with Jerry Barnes, August 2014.


impact@nerc.ac.uk - 36
23 Four NERC research centres are members of the Natural Hazards Partnership: British Geological Survey; Centre for Ecology and Hydrology; National centre for Atmospheric Sciences; National Oceanography Centre.


35 Based on testimonies from oil and gas executives in an as-yet unpublished case study on the National Geological Repository. Available on request.


Information available from http://ukclimateprojections.metoffice.gov.uk/.


impact@nerc.ac.uk - 38
Information available from http://www.nerc.ac.uk/funding/available/postgrad/advanced/atsc/.


Available from: http://www.nerc.ac.uk/about/perform/reporting/reports/.


Before 2012 NERC used its own research outputs database (ROD) to collect performance information. In 2012 NERC adopted a different research outputs system (ROS) with several other research councils. In 2014 all seven research councils moved to a harmonised system, ResearchFish, which is shared with other funders. During this transition year, the collection of some output metrics for 2013–14 is six months later than previous years.

New basis of reporting since 2012–13 (retrospectively applied to all years in the series): Item 26 unique count of PIs for grants active in calendar year.

New basis of reporting since 2012–13 (retrospectively applied to all years in the series): Item 29 grants active in calendar year; Item 30 unique count of refereed journal publications matched to Thomson-Reuters Web of Science (WoS) using digital object identifier (DOI) codes for increased accuracy; Items 32 and 33 co-authorship based on authors address information from WoS.

From 2014 refereed publications are now sourced from InCites data rather than self-reporting via ResearchFish. This new methodology has been retrospectively applied to all years in the series, hence numbers are higher than quoted in previous reports.