Institution: University of Exeter

Unit of Assessment: Earth Systems and Environmental Sciences (UoA7)

a. Overview

This is the University of Exeter's first submission to the Earth Systems and Environmental Sciences (ES&ES) Unit of Assessment (UoA7), totalling 34.7 FTE with a return of 100% intensity. It reflects very significant, continuing expansion in this interdisciplinary research field since RAE2008. This expansion has been enabled by the combination of a core strategic investment in Climate Change and Sustainable Futures (CCSF) as a key theme in the University's Science Strategy (£6M, 18.5 new academic staff), funding for the Environment and Sustainability Institute (ESI) at the University's Penryn campus (£30M, 23 new academic appointments), and the establishment of the European Centre for Environment and Human Health at the University's Treliske campus (£14.2M, 10 new academic appointments). As a result, the University of Exeter has been able to recruit a number of internationally-renowned researchers in ES&ES, and hugely expand research activity through increasing the numbers of associated postdoctoral researchers and graduating 28 PhD students during the REF period. Income, in terms of the total value of research awards held by academics being returned to UoA7, has increased 5-fold from £1.7M to £8.8M.

The research presented here is associated with a broader activity of Sustainability Research which connects three of the University campuses (Streatham in Exeter, Penryn near Falmouth, Treliske near Truro), and its six colleges – three of which are involved in ES&ES (Life and Environmental Sciences-CLES; Engineering, Mathematics and Physical Sciences-CEMPS; Medical School-UEMS). This submission highlights the individuals and research groupings most closely focussed on the science agenda set out in the UoA7 descriptor, but the research presented is necessarily tightly connected to activities that will be submitted to other REF UoAs (most notably UoA17a: Geography and Environmental Studies, and UoA5: Biological Sciences). To build coherence we have established an over-arching strategy for Environment and Sustainability Research that connects our major strategic investments. This strategy is put into practice through a steering group and joint working groups, and through joint seminar series and research retreats.

The Exeter ES&ES group do world-class research in climate science, with a focus on: the carbon cycle and ecological responses to climate and other environmental changes; the effects of environmental pollutants on human health and wellbeing; ecosystem structure, function, and component organisms; and on solutions to problems of environmental change, including strategies to mitigate environmental pollution from local to global scales.

b. Research strategy

The ES&ES research strategy forms part of a broader strategy and investment by the University of Exeter in environment and sustainability research. Our working definition is that this research spans the natural, social, and medical sciences, and the humanities and arts, with a shared focus on the core challenge of achieving a sustainable future for humanity on Earth. In total, the University of Exeter has around 200 staff engaged in sustainability research, earning circa £16-20M research income per annum, 30-35% of the University total. The activity spans several other UoAs including Geography and Environmental Studies (17a); Biological Sciences (5); Mathematical Sciences (10); Engineering (15), Business and Management Studies (19); and Politics and International Studies (21). Such diverse research activity needs to be built on a solid scientific core of understanding environmental systems. This UoA7 submission forms the scientific heart of that understanding, together with the physical geography component of our UoA17a Geography and Environmental Studies submission, and the ecology component of our UoA5 Biological Sciences submission.

Research Groups

The structure of our submission, and the connection to these broader activities, is presented schematically in Figure 1. The ES&ES research activity divides roughly evenly between Earth Systems (15.7 FTE) and Environmental Sciences (19 FTE). Earth Systems has an explicit focus on understanding the planet as a system and tackling global-scale challenges such as climate change. Environmental Sciences focuses on the scales of ecosystems and organisms (including humans), and understanding their responses to, and effects on, environmental drivers, including global changes. There are multiple interactions between these areas.

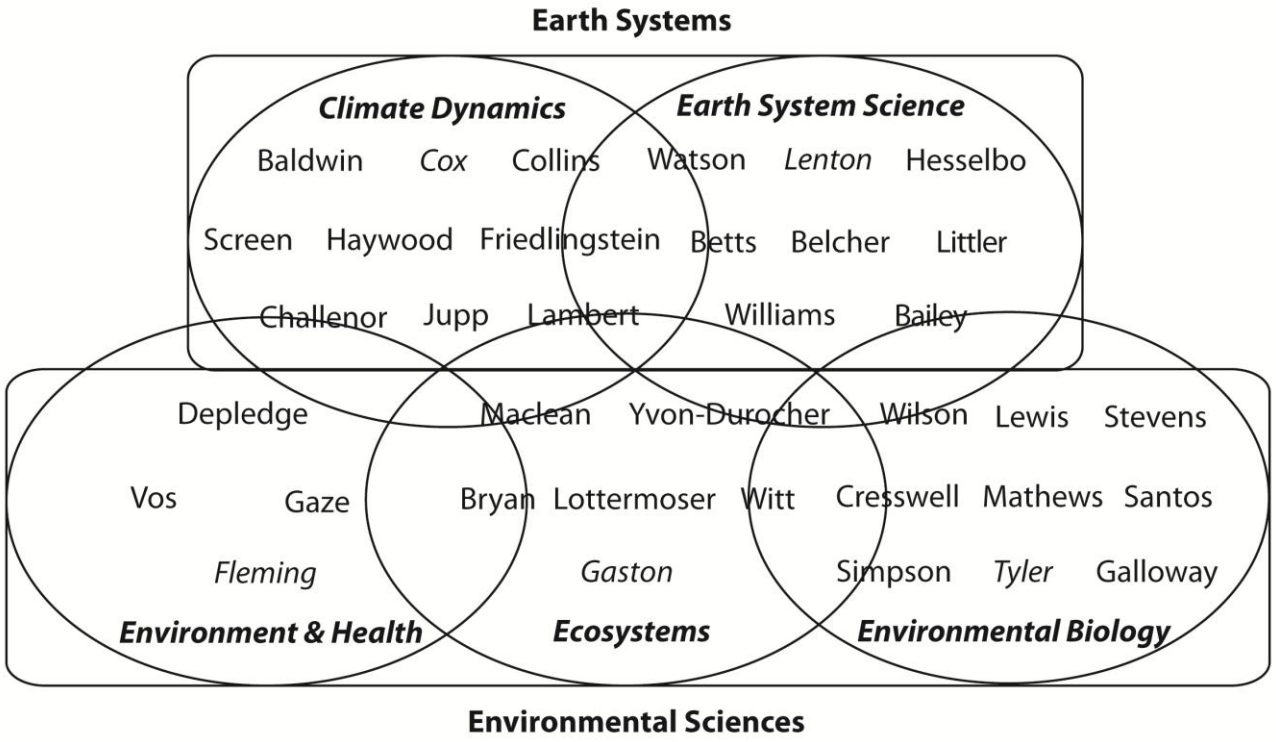

***Figure 1**: UoA7 Submission from the University of Exeter: subject areas (ellipses) with staff.*

Earth Systems research divides into **Climate Dynamics** (8.5 FTE) – with an emphasis on the physical aspects of the Earth's climate system – and **Earth System Science** (7.2 FTE) – emphasising past and present global change and the interactions between the physical, biological and chemical components of the Earth system.

Environmental Sciences research divides into **Environmental Biology** (9 FTE) – focusing on the effects of environmental pollutants on organisms, **Ecosystems** (6 FTE) – focusing on ecosystems and the goods and services they provide, and **Environment and Health** (4 FTE) – focusing on interactions between environmental change and human and animal health.

Climate Dynamics (Cox (lead), Baldwin, Challenor, Collins, Friedlingstein, Haywood, Jupp, Lambert, Screen) – centres on modelling of the climate system, and quantifying and reducing uncertainties in climate projections. This group has a strong link to the Met Office including a Met Office Chair (Collins) and a joint appointment (Haywood), and aims to maximise the pull-through of mathematics and statistics into the improvement of climate models. Expertise in this group spans the understanding and modelling of most of the major uncertainties in the response of the climate system to anthropogenic forcing: clouds and water vapour (Lambert), carbon cycle (Friedlingstein), aerosols (Haywood), sea-ice (Screen), land-surface (Cox), stratosphere (Baldwin). In addition, this group is committed to quantifying the overall uncertainties in climate projections through probabilistic climate projections (Collins), and reducing these uncertainties through the application of statistical emulation methods (Challenor) and data-assimilation (Jupp).

Earth System Science (Lenton (lead), Bailey, Belcher, Betts, Hesselbo, Littler, Watson, Williams) – focuses on understanding, measuring, reconstructing, and modelling the interactions between climate and biogeochemical cycles, across a broad range of timescales and epochs. Research on Earth history has a focus on the co-evolution of life and environment (Belcher, Lenton, Watson), and the reconstruction of high-resolution records of global change through deep time, including work on episodes of major perturbation to the planet's physical chemical and biological systems during 'greenhouse' (Hesselbo, Littler) and 'icehouse' (Bailey) conditions. In the contemporary Earth system, particular areas of expertise include marine biogeochemical cycles (Lenton, Watson), marine ecology (Williams), ocean-atmosphere interaction (Watson), and forest fires (Belcher). The group includes a Met Office joint appointment (Betts) to foster an Earth system approach to climate impacts research.

Environmental Biology (Tyler (lead), Cresswell, Galloway, Lewis, Mathews, Santos, Simpson, Stevens, Wilson) – studies the effects of environmental contaminants and other anthropogenic

activities on organisms and ecosystems, and includes studies on the role of fish in ocean ecology and biogeochemistry (Wilson, Simpson). Key areas of research are endocrine disruption and the biological effects of nanoparticles and emerging pollutants of concern in fish (Tyler, Santos), invertebrates (Galloway, Cresswell [bees]), and humans (Galloway). Understanding mechanisms of action and physiological adaptations of fish and invertebrates (Lewis) to pollutants and other environmental stressors is a key focus. Other key research includes the impacts of wind farms on bat populations (Mathews) and the effects of overfishing and climate change on wild fisheries (Simpson, Stevens). Methodologies applied include field studies, in vivo experimentation, in vitro techniques, the development and application of transgenic fish models (Tyler), and genome-wide sequencing (Santos, Tyler). Molecular tools are utilised in all areas of the Environmental Biology group's research. Research into the basic biology of test and sentinel organisms underpins all of the ecotoxicology work.

Ecosystems (Gaston (lead), Bryan, Lottermoser, Maclean, Witt, Yvon-Durocher) – focuses on ecosystems, and understanding the impacts of environmental change and management on the goods and services they provide. The group forms part of the interdisciplinary ESI and uses a multifaceted approach, combining field, laboratory, and modelling studies, which integrate with the work of engineers, mathematicians, and social scientists in the wider Institute. Studies are carried out in ecosystems ranging from coral reefs to urban areas; across taxa ranging from microbes to vertebrates; and across land uses ranging from protected areas to intensive agriculture. Key issues include: understanding the ecosystem impacts of climate change (Maclean, Yvon-Durocher); the effectiveness of protected areas and the consequences of marine renewable technologies (Witt); and the management of post-industrial landscapes, including the effect of mining pollutants on soil microbes and biogeochemical cycling (Bryan, Lottermoser). This group is based at the ESI and the Camborne School of Mines on the Penryn campus.

Environment and Health (Fleming (lead), Depledge, Gaze, Vos) – carries out research into the interconnections between environmental change, human health, and wellbeing. Particular areas of expertise include: the effects of chemical body burdens (including pharmaceuticals and other anthropogenic chemicals) on human health and the environment (Depledge); the evolution of antibiotic resistance in natural and farmed environments (Gaze); opportunistic pathogens in soils and coastal environments (Vos); and harmful algal blooms and the effects of microbial pollution on human health (Fleming). The influences of climate change and demographic change on chemical and pathogen pollution are key features of this research. The group is based within a larger interdisciplinary research community (45 newly appointed staff and 21 PhD students) at the European Centre for Environment and Human Health, which is part of the University of Exeter Medical School on the Treliske Campus and at the ESI on the Penryn Campus.

There are many interactions between the groups (Figure 1). Strong links exist between the Climate Dynamics and Earth System Science groups through common interests in climate-carbon feedbacks and climate tipping points, and shared outputs such as high-profile co-authored papers and joint involvement in a recent TV series on potential climate tipping points. A core group of these Earth Systems researchers have recently been co-located on the Streatham campus. This co-located group is in an adjacent building to Environmental Biology with whom they collaborate on research which, for example, models the impacts of fish on the ocean carbon cycle and investigates the impact of micro-plastics on marine ecosystems. Earth System Science and Ecosystems collaborate on understanding temperature controls on phytoplankton composition and key biogeochemical processes. Climate Dynamics and Ecosystems collaborate on research into the effect of climate change on species distributions. Climate Dynamics and Environment and Health collaborate on research into the effects of climate change on chemical and pathogen pollution. Environmental Biology collaborate with Environment and Health on the effects of chemical contaminants on wildlife and human health. Within Cornwall, members of the Ecosystems and Environment and Health groups work together on biodiversity, environmental pollutants, and micro-organisms in shared laboratory space at the ESI.

Strategic aims and achievements during the assessment period

The main strategic aims during the assessment period were to establish world-class research capability in climate change (in close partnership with the Met Office), ecosystem services, and environment and human health, and to build on an already strong base in ecotoxicology and environmental biology. Informing policymakers and politicians of our latest findings and increasing

their understanding of sustainability issues has been an important emerging aspect of our work.

Major investments have been correspondingly aligned through four mechanisms: the Climate Change and Sustainable Futures (CCSF) Science Strategy theme, the Environment and Sustainability Institute (ESI), the European Centre for Environment and Human Health (ECEHH), and the Aquatic Resources Centre (ARC). These investments map to the research groupings identified above: CCSF has invested primarily in Earth Systems (Climate Dynamics and Earth System Science); ESI has built capacity in Ecosystems research; ECEHH is the main vehicle for Environment and Health research; and the ARC provides a unique facility for Environmental Biology research.

Climate Change and Sustainable Futures (CCSF) is a flagship interdisciplinary research theme in the University's Science Strategy, led by Cox. The foci of CCSF research have been: predicting climate change and its effects on ecosystems and human and animal health; developing the technology for mitigating its effects; and the study of public attitudes and government policy in relation to the environment. It is the first of these that is most relevant to this submission. The core University investment in CCSF amounts to about £6 million primarily in new staff (18.5 FTE), including 6.5 FTE new staff in Climate Dynamics (Baldwin, Challenor, Collins, Friedlingstein, Haywood, Lambert, Screen).

The **Environment and Sustainability Institute (ESI)** is a £30 million (£22.9m from European Regional Development Fund, £6.6m from South West Regional Development Agency) new institute directed by Gaston, leading cutting-edge, interdisciplinary research into solutions to problems of environmental change, enhancing people's lives by improving their relationships with the environment. The research institute brings together state-of-the-art resources with leading academics and researchers all of whom are co-located in a brand new energy-efficient building. The ESI made its first academic appointments in 2011/12 and occupied its new building in late 2012. It is now approaching capacity with 21 of a total of 23 permanent academic staff appointed, divided into three interacting fields of research activity: natural environment, clean technologies, and environmental social science. Members of the 'natural environment' pillar are being returned here, comprising the director (Gaston), a grouping of staff (Maclean, Witt, Yvon-Durocher) with a focus on ecosystems and the goods and services they provide, and two further clean technologies staff (Bryan, Lottermoser) focusing on mined materials, wastes and their environmental consequences and management.

The **European Centre for Environment and Human Health (ECEHH)** is a £14.2 million (£7.3M from European Regional Development Fund, £1.1 million from the European Social Fund, plus £5.8 million matching-funding from the Medical School) new interdisciplinary research centre, directed by Fleming, studying the interconnections between the environment, human health and well-being. ECEHH has 45 staff and 21 PhD students in total. Strategic links exist between ECEHH and ESI with two members (Gaze, Vos) housing a part of their research group in the ESI building.

The **Aquatic Resources Centre (ARC)** is a unique £9 million state-of-the-art aquarium facility with climate control, providing an exceptional resource for exploring how climate interacts with chemical stressors to damage the health of aquatic organisms. It has transformed the work of the Environmental Biology group since RAE2008 (see Infrastructure and Facilities).

Vision, including Strategic Plans

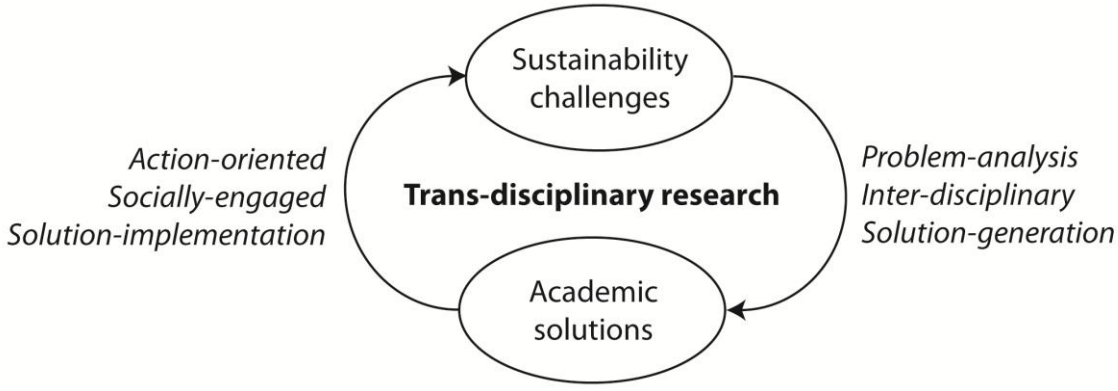

***Figure 2**: From inter-disciplinary to trans-disciplinary research.*

The University of Exeter has undertaken a major review of its sustainability research (led by Lenton) which is directing further strategic activity and investment in this area. We frame our over-arching approach as one of trans-disciplinary research, which combines inter-disciplinary scientific research with action-oriented research to implement sustainable solutions (Figure 2).

The co-located Earth Systems group forms a focal point for the much larger and broader sustainability research activity at Exeter. In the longer term we intend to grow the group to up to 40-50 PIs and 300 researchers in total, to form a new Institute at Exeter to complement the existing ESI – with its focus on ecosystem services – and ECEHH – with its focus on environment and human health. Our over-arching strategy for sustainability research aims to better connect these three Institutes/Centres, through an over-arching steering group (which includes Cox, Fleming, Gaston, Lenton), joint seminar series, and joint research retreats.

We have mature strategic partnerships with the Met Office, Plymouth Marine Laboratory (PML), CEFAS (with whom the Environmental Biology group recently established a £0.7M research programme that includes 8 PhD studentships) and the Food and Environment Research Agency (Fera; with whom we have co-funded and supervised some 20 graduate studentships). To support this integration we have ongoing working groups on Food Security and Coastal Futures, with the Met Office and PML, which also bring together researchers from ESI, ECEHH, and CCSF. The newly co-located Earth Systems group has become the main point of contact with the Met Office and we intend to build on the successful joint appointments of Met Office staff (Betts, Haywood) with further joint positions for leading researchers from the Met Office. We are growing our strategic partnership with PML through a new MoU to facilitate joint appointments, a seed-corn research fund, and the establishment of joint research fellowships – with Galloway leading on this initiative. Building on the recent appointment of Watson and his group, further appointments will strengthen our joint capacity in surface ocean science, including coastal and shelf seas, marine biogeochemistry and ecosystems, and air-sea exchange of biogenic gases. We also aim to build on strong existing collaborations in the areas of oceans and human health (with ECEHH) and marine pollutants (with Environmental Biology).

Co-supervised PhD students are already in place with PML, the Met Office, CEFAS and Fera. We have 17 PhD students funded by the European Social fund engaged in environment and human health research in partnerships with local businesses. We are part of the successful “GW4+” bid for a NERC doctoral training centre - partnering with the Met Office, BGS, CEFAS, PML, and many others, to ensure a pipeline of next generation research leaders in ES&ES.

c. People, including:

i. Staffing strategy and staff development

We have been pro-actively recruiting to achieve world-class status in key areas of Earth Systems and Environmental Sciences, and this is a key element of our staffing strategy that has helped us to return all of the staff allocated to this UoA.

All academic staff are allocated to an *Academic Lead* who is a senior academic working in a related research area, and by the system of academic leads, each research group has representatives within their respective College Management Group. Staff are supported by centralised administration at the College level with this UoA7 submission spanning 3 Colleges.

The University operates a 5-year induction and probationary process for all new lecturers, during which appropriate research goals for each appointee are specified. At the end of a successful probationary period (which may be accelerated by early achievement of goals) the expectation is that staff are promoted to Senior Lecturer grade. The Academic Lead for new staff offers guidance and support from the outset, and Annual Personal Development Reviews monitor and assist with progress. As part of their induction, new academics are encouraged to gain experience of supervising a PhD student within the first two years of appointment as first or second supervisor. New academics are encouraged to apply for appropriate EPSRC, NERC, BBSRC, EU, industry and CASE funding as appropriate, and they are supported in this by: a designated mentor; Directors of Research within each discipline; dedicated Research Administrators within each College and within the University’s Research and Knowledge Transfer service (RKT); and by their Academic Lead. We have high aspirations for the people we recruit and set expected targets for research income at an appropriate level. In the grant application process all applications are first seen at an early stage by the Academic Lead and/or Director of Research for the relevant discipline, and then undergo close scrutiny and internal peer review (and support) in their development to full proposals with the

required pilot data. A Strategic Research Fund of £225k per annum has been established within the College of Life and Environmental Sciences (CLES) to: pump prime research projects; to enable time allocation to allow completion of key pieces of research/papers; and to support new researchers in obtaining vital 'middle tier' equipment for their research.

The Colleges operate workload systems to balance the demands of teaching, research and administration for all staff. New academics are all given a reduced lecturing and administrative load in their first two years to facilitate grant capture. Directors of Research have flexible funds to support academics via a research travel fund for research conferences, visitors and related expenses. The University aims to provide staff of all levels with appropriate training, including an academic leadership programme for senior academics. The University of Exeter is committed to increasing the proportion of female academics, has already gained a Bronze Athena Swan award in 2011, and is now working towards a Silver award.

Two permanent staff hold (or have held) Research Fellowships won in open competition; Belcher (Marie Curie), and Screen (NERC), and research fellow Mander also holds a Marie Curie Fellowship. Two staff hold ERC grants; Gaston (Advanced), and Belcher (Starter). Simpson holds a NERC Knowledge Exchange Fellowship, as do new research fellows Bruintjes and Bloomfield. Cox and Lenton hold Royal Society Wolfson Research Merit Awards. Watson holds a Royal Society Research Professorship. We have been successful in attracting staff from abroad including Baldwin (from Northwest Research Associates, USA), Bryan (from Curtin University, Australia), Fleming (from University of Miami, USA) and Lottermoser (from University of Tasmania, Australia). We host a number of Visiting Scholars (e.g. Professor Evan Ward with Galloway as a visiting Fulbright Scholar from University of Connecticut, USA).

ii. Research students

PhD students are the drivers of a buoyant research community. As a result, the University has increased core funding for PhD students in line with the increasing number of active research staff in ES&ES. For example, CCSF was provided with £600k to support 10 new PhD students as part of the investment in this science theme. This cohort of students will graduate throughout 2013. The Colleges also seek to match fund any PhD studentship obtained by academics with external partners – and the ES&ES group currently hold several such studentships.

PhD intake has been buoyant since the last RAE and ES&ES is continuing to recruit excellent applicants from home and overseas. We have CASE studentships supported by Defra, the Environment Agency, CEFAS, Fera, PML, Met Office, Aquatic Water Services, West Country Rivers Trust, Worshipful Company of Fishmongers, Natural England, Dartmoor National Parks Authority, Syngenta, and AstraZeneca. Recruitment, training, and the development of Postgraduate Research Students are regarded as being of crucial importance for the health and sustainability of ES&ES research. First year PhD students must undertake a programme of attendance and assessment consisting of at least 100 hours of advanced PhD training modules, some of which is associated with taught masters-level programmes (e.g., MSci – climate science), and some specifically catered for PhDs. These provide training in world-leading methods including advanced modelling, statistics, computing, sequencing, and imaging. Students are also encouraged and supported to attend relevant external courses and workshops. Skills training provided by the University of Exeter http://as.exeter.ac.uk/support/development/researchstudents/ is recognised as one of the best in the country. Exeter uses the Research Councils and the QAA interpretation of Generic skills to provide training in research management, personal effectiveness, communication skills, networking, team-working and career management. In addition to formalised Generic Skills training, Exeter also implements employability skills training to equip postgraduates with the necessary skills, knowledge, and training to enter academic or industrial research careers.

Students develop a learning agreement and plan with their supervisor and all meetings are documented and signed off through an electronic 'myPGR' system. Students undergo a formal monitoring process, which is adapted to each department. First year monitoring includes a report, presentation to a small group of academic staff, a viva, and a review of formal training undertaken - only those students who are making progress and have clear objectives on entering their second year are permitted to continue. PhD students must give at least one research seminar during the first two years of their degree, and are actively encouraged and funded to participate in relevant international and national research conferences and workshops. Our students are encouraged to write their thesis chapters wherever possible as research papers, further developing their skills in

scientific writing and helping to ensure they have the currency they need (i.e., papers) when they graduate.

The Colleges have separate Directors of Postgraduate Researchers who champion all aspects of infrastructure and career development. The University's Research and Knowledge Transfer department provides support and guidance to those involved in all forms of research and consultation from providing contacts, negotiating contracts and intellectual property agreements to an annual "impact award" that aims to promote excellence in impact and innovation as well as in research.

d. Income, infrastructure and facilities

Research Council income within the UoA comes from a wide range of sources, with funding streams from NERC, EPSRC, BBSRC, MRC, and ESRC amounting to £1.6 million in 2012/13. We also receive support from ERC, EU FP7 (£2.2 million in 2012/13), and the World Bank. Other income includes funding from industrial partners such as AstraZeneca, Syngenta, the Nanotech Industry Association, BASF, BUPA, Shell, the Australian Cooperative Research Centre for Optimising Resource Extraction, and also from the civil service, government policy customers and regulators including the Met Office, CEFAS, Defra, Fera, Natural England, and the UK Environment Agency. Especially important for ES&ES at Exeter has been membership of the Met Office's Academic Partnership in collaboration with the Universities of Reading, Leeds (and now Oxford). This partnership has co-funded a number of posts in ES&ES (currently Haywood, Collins). Also important are our strategic partnerships with CEFAS, Fera, and Public Health England which have funded several studentships.

This UoA has benefitted considerably from a wider investment strategy by the University of Exeter in infrastructure and staffing at all campuses of the University. This includes: new buildings housing the ESI at Penryn and the ECEHH at Treliske (both in Cornwall); updating and refurbishment of the Geoffrey Pope building on Streatham Campus (where Environmental Biology staff are situated); and refurbishment of the Laver building where Earth Systems staff are co-located.

Some of the work undertaken in ES&ES requires the use of high performance computing, especially the global climate, weather and biogeochemical cycles modelling. This work has been supported by a number of clusters purchased by the University over the last few years, including the *Zen*, *Zeus* and *Neptune* clusters, and the new *Carson* cluster at ESI.

The work of the Environmental Biology group has been enhanced by a £9M investment in the Aquatic Resources Centre (ARC). This world-class research complex houses more than 600 tanks, to maintain and observe a wide range of aquatic organisms, principally fish. These are supported by seven preparation and laboratory rooms that contain specialist microscopes (supported by a Royal Society Wolfson award), cameras, and video and imaging equipment that help analyse development, physiology and behaviour.

The ESI was established with a grant of £30 million and its staff currently hold grant income in excess of £4 million. The ESI houses a series of specialised facilities, including an Isotope Ratio Mass-Spectrometry facility, an 8-chamber Controlled Temperature suite, two large general purpose research laboratories each equipped with a series of specialised prep rooms, and a high capacity research hall capable of accommodating large-scale engineering and renewable energy installations.

The ECEHH was established with a grant of £14.2 million and has since established streams of research income from the research councils (e.g. ESRC, MRC, NERC), the EU, and from private industry (BUPA) totalling >£2 million.

e. Collaboration or contribution to the discipline or research base

The researchers involved in this UoA7 submission are very actively engaged in national and international collaborations. Key partners in the UK include: Bristol (oceans and fisheries), Reading (meteorology), Leeds (aerosols), Oxford (water cycle, isotope geochemistry), East Anglia (geoengineering, global carbon cycle, marine ecosystems), York (fate of pharmaceuticals in the environment), Cambridge (stratospheric dynamics, environment and health), Southampton (oceanography), University College London (geochemistry, environment and health), London School of Hygiene and Tropical Medicine (environment and health), Centre for Ecology and Hydrology (terrestrial ecosystems, ecotoxicology, environment and health), Plymouth Marine Laboratory (marine ecosystems, biogeochemical cycles, ecotoxicology, environment and health),

Birmingham, Brunel, Cardiff, Edinburgh, and UK Water Companies (ecotoxicology), Rothamsted Research North Wyke (food security), Public Health England (antibiotic resistance in the environment), the Met Office (Earth system modeling), the British Geological Survey, Keyworth (geochemistry, dating stratigraphy), and the NHS (carbon accounting, environment and health).

Key international collaborators include: CNRS (France), PIK (Germany), GFDL (US), NCAR (US), MPI-Meteorology (Germany), MPI-Biogeochemistry (Germany), Wageningen University (Netherlands), Rice University (USA), Ministry of the Environment (Japan), INRA (France), EPA (USA), Agriculture and Agri-Food Canada, OECD (Brussels), Tsinghau University (China), University of Hong Kong, The Energy and Resources Institute of India (TERI), School of Public Health Harvard University (USA), WHO (Geneva), European Environment Agency (Copenhagen), EU Joint Research Centre (Ispra and Seville), University of Lund (Sweden), Irish Environmental Protection Agency, University of Siena, Columbia University (USA), the University of Tasmania (Australia), and the University of Cape Town (South Africa). Researchers access international programmes including the Integrated Ocean Drilling Programme (IODP), and the International Continental Drilling Programme (ICDP).

In addition to contributing to the research base through national and international collaboration, and national and international review of grants, academics in ES&ES contribute in several other important ways. Here are some selected examples:

- **Editorial roles:** Baldwin – Editor of the *Quarterly Journal of the Royal Meteorological Society*; Friedlingstein – Editor of *Journal of Climate*; Galloway – Editor of *Chemosphere*; Depledge – Editorial board of *Ecotoxicology*; Fleming – Editorial Board *Harmful Algae*; Wilson – Editor of *Advances in Experimental Biology*.
- **Engagement on international advisory groups:** Tyler and Galloway – OECD test guideline panel; Tyler – Chief Scientific Advisor for the UK-Japan partnership on Endocrine Disrupting Chemicals; Galloway, Tyler – Advisors to US EPA; Depledge – Chairman of the Science Advisory Group, on Environment (including climate change), DG-Research and Innovation, Chairman of WHO committee on Nanomaterials and Human Health, Member of the European Academies Science Advisory Council; Cresswell – EU panel for pesticide regulation; Stevens – advisor to North Atlantic Salmon Conservation Organization.
- **Engagement on UK government advisory groups:** Cox – member of DECC Advisory Group; Tyler and Galloway – Advisors to Defra Chemicals and Nanomaterials Division; Depledge – Member of Defra Hazardous Substances Advisory Committee, Member of the Royal Commission on Environmental Pollution, Natural England Founding Board Member; Gaze – member of joint working group of Defra Antimicrobial Resistance Committee (DARC), Advisory Committee on Antimicrobial Resistance and Healthcare Associated Infections (ARHAI); Simpson – lead author for UK Parliament 2013 Marine Climate Change Impacts Partnership (MCCIP) report on climate change and fish; Mathews – advisor on bats and their conservation to Defra, DECC, Natural England, Resources Wales, Scottish Natural Heritage.
- **Membership of NERC governance bodies:** NERC Council (Watson); NERC Science and Innovation Strategy Board (Cox, Galloway); NERC Peer Review College (Friedlingstein, Galloway, Simpson, Tyler, Wilson, Stevens, Wilson); NERC strategy panels (Wilson, Tyler).
- **Assisting governance of other UK research bodies:** Fleming – Member SAMS Council; Tyler – panel member for the BBSRC National Centre for the Replacement, Refinement and Reduction of Animals in Research (NC3Rs) (2012); Wilson, Stevens – Expert Witnesses UK Environment Agency; Mathews – Chair of Science Advisory Committee of The Mammal Society.
- **Assessments of other research centres:** Cox – Scientific Advisory Board MPI-Meteorology, review group of GFDL; Gaston – Scientific Advisory Board MPI-Ornithology; Lenton – Scientific Advisory Board MPI-Biogeochemistry; Friedlingstein – member of the Met Office Hadley Centre Science Review Group.
- **Involvement in international programmes:** e.g. Baldwin – member of the SPARC scientific steering committee; Cox and Lenton – co-chair and member of IGBP-AIMES; Frieldingstein, member of ESSP-GCP; Galloway – Marine strategy Framework Directive Technical Advisory Group, marine plastics.
- **Involvement in international scientific assessments:** Fleming – member of the SAB NIEHS Gulf Oil Spill Study; Collins, Cox and Friedlingstein – IPCC lead authors (see below).

Intergovernmental Panel on Climate Change (IPCC)
CCSF researchers have a high profile role in creating the world's most comprehensive report on climate change. Three academics in this UoA (Collins, Cox and Friedlingstein) were selected as lead authors for the 5th Assessment Report (AR5), among a total of nine IPCC authors based at the University. Exeter is represented on all three Working Groups of the IPCC as well as the AR5 Synthesis Report (Friedlingstein).

Collaborations with research users
Much of our Environmental Biology research is undertaken in collaboration with environmental regulators (e.g., Defra, The UK Environment Agency), and with industry (e.g., AstraZeneca, BASF, NanoTechs) and actively informs European chemical test methods development and regulation. Our Ecosystems and environmental management research is also tightly linked with regulators (e.g., Fera, Natural England). Depledge and Fleming together with Professor Michael Moore from PML (Honorary Professor in ECEHH) have led the development of the European Science Foundation's new strategy on Oceans and Human Health which will be announced in 2013. Lenton's work developing early warning methods for climate tipping points has informed the UK Government Office for Science, through a meeting (March 2011) and subsequent workshop (September 2011) convened by the then UK Government Chief Scientist, Sir John Beddington; Lenton has also been commissioned by the EU Joint Research Centre to address a major gap in risk analysis, namely assessment of the impacts of crossing different tipping points. The Climate Dynamics and Earth System Science Change groups are working closely with the Met Office and IPCC.

Growing Contribution of ES&ES at the University of Exeter
Investment in ES&ES research at the University of Exeter has yielded excellent returns in terms of grant income, high-profile publications and broader impact. The research has had important impacts on global and national environmental policy and has stimulated public debate through extensive media coverage, with more than 3000 online or print articles featuring Exeter's ES&ES researchers since 2009. The number of citations for climate or sustainability research from University of Exeter authors has grown by a factor of more than five between the RAE2008 and REF2014 assessment periods. The 2013 CWTS Leiden Rankings placed the University of Exeter 26th in the World and 4th in the UK for Life and Earth Sciences, based on citations per published paper.