Institution: University of Gloucestershire

Unit of Assessment: 14

1. Unit context and structure, research and impact strategy

Research Highlights

During the current REF period we far exceeded our strategic aims of

(i) **increasing** the **number** of research-active staff: resulting in a >75% rise, with positive spin-off of more than a third of the UoA's academic staff to new UoA21;

(ii) **increasing** the **quality** of our published output: >95% of submitted outputs for UoA14 are externally rated 3* and 4* for REF2021;

(iii) **developing research with impact,** in line with the University's strategic aim: in 2019, one of the UoA's Impact Case Studies won an inter-national **First Prize** for '**Research with Impact**'

In addition, we successfully implemented strategic changes to enhance the research base by

(i) **aligning our research and teaching strategies and internal structures**, in the context of the University's strategic aim of research-informed teaching, ensuring **greater coherence** between teaching and research, and through involving students in research publication;

(ii) **increasing our postgraduate research cohort** by offering bursaries for research Masters students;

(iii) **developing** a more **balanced** research structure: moving from **one** internationally recognised Research Centre to **three Research Themes** that encompass the research aspirations of **all** the UoA's staff.

Unit context and structure

UoA14 is based in the School of Natural and Social Sciences, which includes academic staff across a wide range of cognate disciplines. At the start of the current REF period, UoA 14 was expanded to include Social Sciences staff, to foster and generate greater research activity through integrating research support and co-publication with Human Geographers. So successful was this strategy that the number of active researchers in the UoA with REF-able publications increased >75% between 2014 and early 2019.

Our submitted cohort in UoA14 includes Academic Staff with substantive posts in Biology, Geography (Physical and Human), Ecology and Environmental Science. The UoA's academic staff posts are primarily financed by Teaching, and so most submitted Academic Staff are on Teaching and Research contracts, with two fractional appointments on Research-only. During the course of the REF period our research activity was re-structured *internally* so that it more closely aligned with the taught programmes, to provide recognisable identity for academic staff, MSc and PhD students. Our UoA's research is now focused formally into three Research Themes within the UoA: **Changing Environments**; **Applied Ecology and Biology**; **Social Vulnerabilities**, and these will prevail through the next REF period.

Internal Funding

Across the University, following competitive bids in 2014–5, six interdisciplinary Research Priority Areas (RPAs) were identified as centres of excellence, receiving significant internal investment (>£100k p.a.) to enhance research and impact capacity and to solicit competitive research bids. Our UoA received QR research funding through its 50% participation in one of the six RPAs: 'Environmental Dynamics and Governance' (EDG; the other 50% comprises the Countryside and Community Research Institute, entered in REF2020 as UoA13).The RPA

promotes interdisciplinary projects with significant and measurable impact, nationally and internationally, as evidenced by our UoA's prize-winning research-impact entry to the Green Gown Awards (see below). The UoA also has access to the Global Challenges Research Fund (GCRF) through the RPA.

Research Excellence

Our UoA incorporates research that has been conducted under the *external* marque of the '**Centre for Environmental Change and Quaternary Research**' (CECQR), which has been leading innovative, international research in **Changing Environments** since 1995 and since 2010 on the biotic impacts of climate change in **Applied Ecology and Biology**.

The external success of this Centre over decades (reflected in being singled out for praise in RAE2008; in leading EU-financed research; and in high-quality, REF-submitted publications) prompted our 2019 move to re-balance the UoA's external promotion of our international research excellence across the whole UoA. Henceforth, our three **Research Themes** will be used for both internal and external advancement of our research.

Research Management and Administration

Within the university, research administration is supported by a Research Development Office that oversees specific elements of research policy and practice: the training programme for research supervisors; the processing of research student applications; registration and training of PGR students; processing of research project forms; Research Ethics training; and allocation of supervisory and examination teams. Research Ethics approval is overseen within the School by a dedicated member of staff who requires independent scrutiny of research proposals by senior academic staff, with their recommendations sent to a Research Ethics Committee. The UoA is led by a Coordinator (**Chambers**), who works closely with that office and with line management of academic staff (vested in **Toms**).

Research Strategy

The university's Strategic Plan mandates teaching to be research- and practice-informed, to enhance the student experience. Following successful international scientific coordination from UoG (by **Chambers**, through CECQR) of a 1.4M Euro EC-Framework project, it became clear from the EU-Referendum result of 2016 that the *leading* of future EC-funded research would become increasingly challenging, and despite initial Government assurances over Horizon 2020 participation, might be ruled out post-2020 *if* the UK only had 3rd country status. The UoA is also not eligible for formula-funded Research Council studentships. Recognising these two constraints, we deliberately embarked on a radical, 6-point research strategy for the UoA that aligns with the university Strategic Plan and involves maximising the return from guaranteed (QR) income, accessing GCRF, and focusing income generation on international excellence in geochronology. We sought to maximise the research base by inclusion of the full diversity of researchers into the enquiry process, integrated according to their skills and abilities. The 6-point research strategy involved

(1) increasing the **number** of REF-able research-active staff in the UoA: from 2014 (11.10 fte submitted);
(2) maximising the **quality** of publication output from academic staff through internal pump-priming of research projects: compared with REF2014, in which 55% of submitted outputs were rated below 3*, External Review for REF2021 (including by experienced ex-sub-Panel Member) indicates >95% of our UoA14 REF2021 submitted outputs are ≥ 3*;
(3) **collaborating** with other HE institutions internationally, e.g. in China (**Chambers**), Africa (**Lynch; Toms**), Norway (**Scott**), in specific projects, with the international collaboration

and combination of expertise designed to ensure subsequent high-quality publication output;

(4) internal **student** (UG, Masters and PhD) **involvement** in academic staff research, including embracing wider, citizen-science projects (notably in **Applied Ecology and Biology**, led by **Goodenough** and **Hart**);

(5) internal and external funding of research in collaboration with non-academic applied partners to **maximise research impact** (notably Impact Case Study 1, led by **Goodenough** and **Hart**);

(6) internal funding of Research Fellow, research students (Masters and PhD), and research assistance (for Geochronology), with a view both to **maximising** high-quality publication research output (e.g., Research Fellows: **Patrick** and **Jarman**) and to ensure continued **external research income**, especially through our world-class Geochronology facilities.

As illustration of (2): in the 5 years from 2014–19, a combined total of 25 internal awards, all under £5k, were made to Academic Staff; at least half of these resulted in published papers rated by our external assessors as minimum 3*, and several contributed toward PhD completions, including a PhD by (six) published papers. For (6), internally funded research assistance has ensured smooth operation of our Geochronological (esp. Luminescence) Laboratories, led by **Toms**, which over the REF period have had research income of >£500,000 involving research collaborations on five continents.

Research Impact Strategy

Our UoA conducts pure and applied research, but with an emphasis on the latter. Our research impact strategy involves (i) co-publishing with contract funders and with collaborating HEIs; and (ii) working with collaborative partners to ensure that research is genuinely applied in real-world situations. For the current REF, we initially identified five areas that provided candidate Impact Case Studies (ICSs), of which only one was a development of an area submitted for REF2014. In finalising our selection for the current submission, we have targeted (a) a timely, tightly focussed and vital piece of research (led by **Goodenough** and **Hart**) that has profound implications for the survival of the declining white rhino and the critically endangered black rhino; and (b) the Human Geographers' research within a cross-disciplinary Social Vulnerabilities Research Group (led by **Lynch**) on using social science research to facilitate more effective policy intervention and support for 'at-risk' groups (led by **Scott** and **Lynch).**

The success of our Research Impact Strategy is evidenced by the **winning of First Prize** in the 2019 international EAUC UK and Ireland **Green Gown Awards** across ***all*** subject areas and ***all*** entered HEIs for '**Research with Impact**' (**Goodenough/Hart:** ICS1 re African rhinos).

Future Research Strategy

Our current strategy has produced excellent results, been sustainable, and therefore is intended to continue, with focused enhancements. This means using future QR research funding in targeted project support, each with a clear pathway to publication and to research impact. The three research themes—**Applied Ecology and Biology (AEB)**; **Changing Environments (CE)**; **Social Vulnerabilities (SV),** which were established internally since REF2014 and became external-facing from late-2019—will continue as the new structure through the next REF period. Research collaboration with contract funders and end-users will be increased, as this is seen as the best way to ensure high research impact. The Unit will continue to ensure that its research is conducted according to appropriate ethical, legal and professional frameworks, with recourse to the University's Research Ethics Committee for guidance in any specific instances not obviously covered by existing guidelines.

Having formulated three Research Themes (**AEB, CE, SV**) for promoting the excellence of our research, we intend to develop all into world-leading centres of excellence. Amongst areas of focus are (i) in **AEB**, the optimisation of wildlife survey, developing from our ICS1; and the acknowledged international excellence of our research into bird and ant behaviour; (ii) in **CE**, new applications of Geochronology; research into ice extent, past and present; and research into Natural Flood Management, to form a new ICS; (iii) in **SV**, policy-informing research into wellbeing and into vulnerable communities.

Section 2. People

Staffing strategy

Our staffing strategy has been to increase the numbers of Academic Staff, and to grow the research activity in the UoA. The emphasis in our UoA has been on **permanent appointments**, rather than fixed-term. We protect the teaching load of newly appointed staff to ensure their research activity and research development, through mentoring, support groups and monitoring. So successful was this strategy during the current REF period that by early 2019 the total REF-able staff within the widened UoA had increased by >75% from the number submitted in REF2014, to 20, the majority being 1.0 fte. The decision was taken to split the UoA, spinning off more than a third of the staff into a new submittable UoA21, in line with the University's strategic aim of submitting more UoAs to REF2021 than in 2014. From 2021, we will foster and mentor a University initiative in Biomedical Sciences, with cross-fertilisation into **AEB** and **SV**, following the model we used so successfully for Social Sciences.

Over the current REF period, two promotions to existing staff within UoA14 have been made to Professor (**Goodenough:** Biology; **Toms**: Physical Geography), in recognition of research achievements and to enhance research leadership. There have been new appointments in Biology (**O'Connell**: Ecology; **Stones**: Microbiology), Human Geography (**Bennett:** Population Health and Aging) and Physical Geography (**Clarke**: Fluvial Geomorphology). We have increased the proportion of fte for a female member of staff (**Webb**), previously on Maternity Leaves (two), for which no claim is made; a new professorial appointment (**Hill**) is female, helping towards redressing the previous M:F senior imbalance in the UoA to the current 2.2:2 at 31/7/20, with the 0.2M retiring in Spring 2021.

Academic Staff

We now have a research leadership team of five Professors and a Reader; a staff cohort in UoA14 (as submitted) with a gender balance that in the current mid-REF period (excluding UoA21) was almost equal, but is now 4.8F: 7.4M, and an age profile that extends from early-30s to post-65. All academic staff are on permanent contracts, except for two post-65s, both on fixed-term 0.2 fte; one of these has been Professor in Physical Geography at the university since 1994. He (**Chambers**) will in 2021 become Emeritus; another Professor in Physical Geography (**Toms**) was appointed in 2018, demonstrating that our succession planning for leadership in research ensures resilience, stability and future direction into the next REF cycle. In addition to the School staffing, and included in our UoA submission, is a new Professorial appointment (**Hill**) to the university in a central leadership role, whose research is so closely aligned to our **Changing Environments** theme that her research activity is being fully integrated within the UoA. Senior UoA14 staff have the top and second-highest GoogleScholar citation scores for the

whole university, and the highest h-indices: **Healey** (Emeritus: h-index 45); **Chambers** (h-index 43 at staff Census date).

Staff Development

A new feature since REF2014 has been the support given to staff for writing-up research, including a monthly Writing Group: annual one- or two-day Writing Retreats away from campus for Human Geography and for those Social Science colleagues now in UoA21; for Physical Geography/ Environmental Science/Biology; and for the whole Unit. Until the coronavirus shutdown, we ran in-house, whole-UoA 'Shut-up-and-Write' communal sessions, for writing research grant applications and drafting research papers. Specifically within Human Geography and Social Sciences, the group (led by **Lynch**) conducted research plan reviews, one-to-one advice, and research mentoring, plus detailed critique of draft research papers and grant proposals. All this activity latterly went online-only, using Microsoft Teams, during coronavirus restrictions. There is a School-wide Early Career Research Network (ECRN) that hosted monthly development sessions led by established researchers, and a seminar series to showcase and disseminate staff research and to promote research collaboration. All of the above are resourced by QR funds, via EDG, to promote REF-related activity, and the result has been an outstandingly successful increase in fte submission in this REF from 11.1 to 19.8, split between UoA14 (12.2 fte) and UoA21 (7.6 fte).

Research Management

The UoA embraces the new *Concordat to Support the Career Development of Researchers* (Revised Sept 2019), and adheres to its principles concerning Environment and Culture, Employment, and Professional and Career Development. Annually, all staff have a mandatory Staff Review and Development session, which for academic staff includes a research focus that reviews past achievements and identifies research priorities and targets for the coming year(s). There is six-monthly monitoring of individual staff progress to achieve research outputs, with scrupulous input to the institutional Research Repository, for which additions are overseen daily, with details incorporated in spreadsheets sent at regular intervals to the UoA Co-ordinator.

The UoA Coordinator reports on a three-monthly basis to University Research Committee on progress in (a) overall shape and health of the UoA, including staffing and Equality issues; (b) publications and other outputs; (c) research impact, impact strategy and progress with Impact Case Studies; (d) research student progress; (e) research income and other financial metrics; (f) overall REF targets. These reports are copied to the RPA Co-ordinator, who provides an overall summary of progress against budget received by the RPA, which in our case funded research activities in two of the university's UoAs (now three). The shared learning that results from this reporting enhances focussing of research and the allocation of internal funding against receipt of internal bids.

Research Students

Research students form a growing cohort within the UoA, researching projects that are linked closely to academic staff expertise and research interests. From whole- or half-funding three PhD researchers in the early part of the REF period from QR funding, the UoA switched in the latter period to part-funding MA/MSc-by-Research students, with projects closely allied to staff research. This resulted in a doubling of the number of part-funded research students, and increased the overall research activity in the UoA. There is, in addition, a small number of self-funded research students.

Overseeing the postgraduate experience is a dedicated member of staff (**Wood**) who ensures that PGR students are integrated within the School; he organises events and fortnightly Research Seminars (latterly online) and is a direct link to the central Academic Development Unit's administrative function, which coordinates the research training programme for the postgraduate cohort. The UoA places emphasis on ensuring that research is not confined within theses, but is also disseminated by attendance at international conferences, and published in international, peer-reviewed literature. Co-publication with supervising staff is encouraged; this emphasis starts with final-year undergraduates with selected dissertations, and continues with taught Masters students, such that there is already an expectation upon research students (Masters and PhD) that their research will be co-published. Indeed, one of our internally funded research students in 2019 successfully submitted for a PhD by six peer-reviewed publications in international journals—a route hitherto unused.

Research students have the same entitlement as academic staff to computing and other resources, and follow a rigorous training programme, with taught elements in their first year on research philosophies and research methods. These are informed by and align with the Vitae Researcher Development Framework. Research students have the opportunity for external training courses relevant to their research topic. All PGR students have a minimum of two supervisors; the supervisory team must have two supervised successful completions at (or above) the sought degree level; an external advisor (for example, in topic-relevant Government Agency or NGO) may also be appointed. The university came 6th nationally in the latest Postgraduate Research Experience Survey (PRES), which is an excellent achievement.

Research supervisors undertake mandatory university training for supervision, and are responsible for encouraging high-quality output from postgraduate research; **Bennett** and **Hart** contribute sessions to university-wide PG research training, and **Clarke** contributed externally to the NERC Windsor Workshops for PhD students nationally.

Table of Doctorates awarded

	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
PhD	1	3	1	1	2	0	4
Prof. Doc.	--	-	-	-	-	-	-

Equality and Diversity

The Vice-Chancellor in 2019 made a formal commitment to the AthenaSwan Charter. The University embraces all its principles in contributing to gender-equality issues, including STEM subjects in our UoA, and features (unusually, for UK HE) a xx.15 start-time for all room-booked meetings and teaching timetabling, and no lectures before 09.15, in recognition both of child-care commitments, and ensuring more sustainable commuting for staff and students after the morning peak. Equal opportunities and diversity training is mandatory for all new staff; recruitment and selection training is mandatory for all sitting on an interview panel (one of the actions in our Gender Paygap Action Plan); and Unconscious Bias training is a requirement for leaders in the REF process.

Compared with REF2014 (none) the UoA has two female professors, comprising **half** of its full-time professors; [Profs] **Goodenough** and **Hill** are members of the University's Women Professors' Group, which is intended, *inter alia*, to work towards gender equality in pay in the university by encouraging more professorial applications from women, to redress gender imbalance in senior academic positions elsewhere in the institution and to be role models and mentors for others. There is a university-wide Women's Network, to support female academics.

The UoA is mindful of the requirement to ensure equality with respect to persons with protected characteristics, to allow them to research effectively; testament to our success in this is the outcome that, over the REF period, three female academic members of staff obtained research positions at pre-1992 HEIs, showing that their research was developed here to *more than equivalent* standing in the sector.

Academic staff on fractional appointments have access to the same research support as full-time staff, and a rigorous work allocation model (WAM) ensures they are not allocated duties disproportionally. Early-career academic staff have the guidance of a senior mentor and have a protected teaching load in initial years. The age-range of our research students has extended from 23 up to 67, in a diverse cohort. The University has achieved Level 2 of 'Disability Confident' and is actively working to reach Level 3, which would identify us as a Leader. Within the UoA we have made adjustments to enable academic staff with various disabilities to use workstations effectively, including free provision of computer spectacles, back-support office chairs, and wrist- and foot-rests. The School initiated safeguarding of identified vulnerable staff during initial stages of the coronavirus outbreak, permitting them to work exclusively from home, well before a university shutdown.

Section 3. Income, infrastructure and facilities

Income

Our QR income (of *c*. £100k p.a., via EDG) has been targeted to enhance research activity, the quality of research outputs, and increasing the significance and reach of research impact. In the current REF cycle, a Research Fellow (**Patrick**), PhD by publications (**Jarman**) and multiple small research grants to staff, successfully exemplify the success of all three aims. Much of our external income has been won through collaborative partnerships, including a BA/Leverhulme small grant (through UoA21).

Key grant wins

In theme **Social Vulnerabilities**, research partnerships with **Scott** won total grant funding of £927,000 [>£37k to UoG] from the Norwegian Research Council in 2016, £30,000 [>£3.5k] from the Director of Labour Market Enforcement (DLME) in 2018 and £9,825 [£3.2k] from DLME in 2019. These projects underpin Impact Case Study 2. **Lynch** collaborates with Bangor University and Cranfield in a £50k **ESRC** project.

In **Changing Environments, Toms** has >£500k in luminescence research projects; **Chambers** had in-kind support of >£40k from **NERC** for biomarker analyses.

In **Applied Ecology and Biology**, most research is underpinned by **in-kind** support: Research Impact Case Study 1 benefited from *c*. £60k on-the-ground support from the Nkombi Volunteer Programme; citizen-science research led by **Hart** on spiders (a £10k app), flying ants (£4.5k) and wasps (Royal Entomological Society grant £6k; supplemented by in-kind support of 5000

hours, plus £2k facilities, NHM); **Goodenough**'s research on bats (Ecotricity: £4k; Grassroots Ecology: £1.4k) and starling murmuration (Royal Society of Biology: £1.5k); **Wood**'s sea-bird research, from the RSPB.

Infrastructure and Facilities

The UoA is located in the East Quad (QU) at Francis Close Hall Campus, with all academic staff co-located in offices on the first floor. Laboratory facilities are conveniently positioned on the mezzanine above, the top floor, and on the ground floor. The suite of facilities was purpose-designed to enable our research; the range of kit and technical assistance is tailored to ensure maximum return in quality of outputs and research impact.

Description of infrastructure and facilities is presented below by Research Theme area, but multi-purpose kit (e.g., furnace; balances; Total Station) and some other items are shared to make maximum use of facilities. These include a Furnace/Atomic Absorption Spectroscopy Laboratory (QU109b) and a Specialist Computer Laboratory (QU024). During the long vacation, it is possible for research (principally Masters) students also to make use of space for thesis research in teaching laboratories, which include a Biosciences Teaching Laboratory (QU027), Environmental Sciences Laboratory (QU109), Environmental Sciences Field store (QU109a) and Microscopy Teaching Laboratory (QU210).

Changing Environments

Research Labs: Gamma Spectroscopy Laboratory (QU018); Geochronology Preparation Laboratory (QU106); Research and Dissertation Laboratory (QU107); Palaeoecology and Water Quality Laboratory (QU108); Geochronology Analysis Laboratory (QU226).

Prime amongst the laboratory suite listed above are the Cheltenham Geochronological Laboratories (QU018; QU106, QU226), housing state-of-the-art luminescence dating kit, including *Risø* TL/OSL readers and Freiberg LexSygSmart Luminescence System, using a $^{90}Sr/^{90}Y$ beta source. For field-collection there is a portable Gamma-Spec. The Laboratories resulted from a University Investment Fund bid; they opened formally in March 1997, with kit more recently upgraded and expanded to two active *Risø* readers, supported by both Research Technician time and a Research Assistant. **Toms** leads the luminescence dating research, which through international collaboration, funded by NERC and EU, *inter alia*, seeks to uncover the timing of past environmental changes and human evolution, dispersal and occupation. The facility is supported by kit in QU018, which includes an Ametek high-resolution Gamma Spectrometer, with a High-Purity Germanium (HPGe) detector and research grade electronics, used to establish the background radiation that a sediment sample has been exposed to over time.

QU107 houses a Malvern Mastersizer 2000-series that measures particle size and distribution of clasts in soils, sediments or other media, and is currently enhancing research impact through PhD research on river-bed sediment in conjunction with the Environment Agency.

The Palaeoecology and Water Quality Laboratory (QU108) provides a fume cupboard for hydrofluoric acid digestion of lake and soil samples, plus pollen preparation facilities of peat samples in a positive-pressure laboratory to reduce contamination. Water quality is assessed using a continuous segmented flow analyser that includes an auto sampler with auto-analyzer control and evaluation software (AACE); it is used for chemical analysis of water and soil

samples to ppb, and is currently enhancing research impact in PhD research in conjunction with CCRI and the Environment Agency in analysing nutrients in farm soils.

A Total Organic Carbon (TOC) and Total Nitrogen (TN) Analytik Jena Multi N/C 3100 Analyser determines total carbon content and total nitrogen content in aqueous samples and total carbon in solid samples by thermocatalytic digestion in the presence of a special catalyst, with measurement capability from ppm to ppb; it is currently used in a staff research project contributing towards the BIFoR Free-Air Carbon Dioxide Enrichment (FACE) project, analysing soil carbon and microbial processing of C and N within soils and soil water. The lab also houses a 'River in a Box' River Model (Little River Box Company—EMriver EM2 system) to mimic *in situ* river sediment, to model river channel and bedform characteristics (by **Clarke**).

Applied Ecology and Biology

Research Labs: Molecular Biology Laboratory (QU017); Animal Behaviour Laboratory (QU019); Biosciences Laboratory (QU025); Biosciences Dissertation Laboratory (QU025a); Biosciences Preparation Laboratory (QU026).

We have a custom-built invertebrate Animal Behaviour Laboratory (QU019), housing various species of tropical ants, with set-ups that allow investigation (by **Hart**) of foraging trail dynamics and responses to changes in temperature. Research-quality microscopes and imaging equipment support this and other research work. Linking directly to Impact Case Study 1, the UoA has a suite of thermal imaging equipment (Flir T620 and i7 Thermal Imaging Cameras), software and related expertise. Field equipment supports research impact activities that include terrestrial and aquatic invertebrate sampling, small-mammal trapping, bat surveying, water quality assessment, environmental and ecological impact assessment, bird surveying and African savannah and wildlife survey. Labs are supported by dedicated technical support, a well-appointed balance room, a furnace room and several customisable lab spaces for specific projects.

Recent investment since 2017 in a containment level 2 (CL2) laboratory space for work with Hazard group 2 pathogens, along with licensing, to create genetically modified microorganisms, facilitates microbial research led by **Stones**. Molecular and Microbiological Preparation and Analysis research equipment in QU017 includes 2 x PCR (Polymerase Chain Reaction) Thermal Cyclers and 1 x Real Time PCR Thermal Cycler for amplification of DNA molecules; Jenway Genova Nano Micro-Volume Spectrophotometer, for measurement of concentration and purity of nucleic acid and protein samples, and the density of bacterial cell cultures; BioRad Gel Doc EZ Imager for automated digital imaging and analysis of electrophoresis DNA gels; Biolog OmniLog and Microstation for rapid automated/manual incubation and identification of aerobic bacteria; Walker Class II Microbiological Safety Cabinet for the safe handling of pathogenic materials, whilst avoiding potential airborne contamination; Nuaire Glacier -86 Degree UltraLow Temperature Freezer, used for the long-term storage of temperature-sensitive molecular and microbiological samples.

Social Vulnerabilities

The principal internal tools used by researchers in this theme are the specialist computer facilities, which include Geographical Information Systems to produce and analyse digital maps portraying the location of hotspots of social vulnerability, with statistical analysis using SPSS and R.

Field Kit Enhancing Research Impact

In addition to the purposing of laboratory facilities for research impact **referred to above**, field kit has been specifically purchased to that end. A recent acquisition is an unmanned aerial vehicle (UAV: a DJI Inspire Quadcopter), currently used for dual purposes: (i) in a field-survey project with Gloucestershire Wildlife Trust to survey river channels pre- and post-installation of natural flood defences (**Clarke**, in **Changing Environments**; and (ii) to survey seabird populations on Skomer and Skokholm with the RSPB (**Wood** in **Applied Ecology and Biology**). Digital Field Survey Equipment (specifically a Leica Viva GS16 Differential GPS RTKplus and Smart link compatible GNSS receiver with CS20 controller, and compatible Leica Flexline TSO2 Plus Total Station) supports enhancement of research impact and is currently supporting the Environment Agency Project (in **Changing Environments**).

4. Collaboration and contribution to the research base, economy and society

Introduction

The UoA's three Research Themes—**Changing Environments**, **Applied Biology and Ecology**, and **Social Vulnerabilities**—exhibit a wide range of collaborations internally and externally. We reference examples from those themes within the major sub-headings for this section: **Research Collaborations and Partnerships**, highlighting also **Relationships with Key Research Users and Beneficiaries**; and **Contributions to the Research Base, Economy and Society**.

A new feature in our UoA from 2019 has been the deliberate funding by bursaries of five research Masters students, with their projects tied to research users, research- and practitioner collaborations and networks in some of our research areas of focus. Current projects include optimising nocturnal wildlife surveying, with Wildlife Trusts; Natural Flood Management, with links to the Environment Agency and Local Authorities; minimising people trafficking; international generational equity in housing; researching policy advancement in wellbeing and vulnerable communities.

The rationale here follows from our deliberate alignment of teaching and research: research activity is imbued from the outset, from undergraduate dissertation, through postgraduate (taught) theses, to research Masters and PhD, including PhD by publication—all potentially working on co-publishing their results with academic staff and end-users. The payback in the most successful instances is threefold: effective provision of research assistance to academic staff; development and enhancement of our research portfolio; and maximising research with impact. The linkages with end-users and practice organisations means that these projects facilitate pathways to impact; the in-kind and financial support from such organisations means that these studentships are CASE-like in character, with similar benefits.

Research Collaborations, Networks and Partnerships

External collaboration with other Universities, Research Groups and International agencies is a particular feature of the UoA's research. In many of these external collaborations, research funding has been in the first instance to other institutions in the research consortia, but the participation of researchers from the UoA has enhanced the research excellence in the collaborations, networks and partnerships.

For example, in **Social Vulnerabilities**, **Scott**'s £37k collaboration in a near £927,000 project with UC Davis (USA) and NTNU (Trondheim) has leveraged international comparators for country-specific case studies (see Impact Case Study 2). Similarly contributing to ICS2, **Lynch** collaborates with a wide international conspectus of researchers, including at Fourah Bay College, Sierra Leone; University of Otago, New Zealand; University of Hyderabad, India; Arava Institute, Israel; and Stellenbosch University, South Africa. He collaborates in research with Bangor and Cranfield Universities on urban water, sanitation and health, and with the University of Bath in social and policy studies. **Bennett**'s research on ageing involves productive collaboration with researchers from a range of institutions internationally, including UNED (Spain), the University of Limerick (Ireland) and the UK Open University.

As examples of international collaborations in both the **Changing Environments** and **Applied Biology and Ecology** theme areas, the **Centre for Environmental Change and Quaternary Research** (CECQR) is linked internationally in a range of research consortia, covering, *inter alia*, peatland research, palaeoecology, luminescence dating, ancient tree and landscape study. These have resulted in a number of landmark, multi-author research papers, in for example *Geochimica et Cosmochimica Acta* (on global peat-specific temperature pH calibrations), *Nature Geoscience* (on recent drying of European peatlands)—for which the EU ACCROTELM 1.4M Euro project, led by **Chambers**, was crucial in providing site data from Finland, Estonia and the UK—and *Journal of Ecology* (setting the research agenda for palaeoecology). International research on sweet chestnut origins and dispersal involved multiple collaborations led by **Jarman** with, *inter alia*, the Future Trees Trust; IRET (Italy) and CNR (Italy); Universities of Greenwich and Warwick; Historic England; and 93 individual researchers. This resulted in six research papers in international journals, including in *PLOS One* and *Tree Genetics and Genomes,* which has set the research and practice agendas for others (see later sub-section on Policy Advice for External End-users).

In the **Changing Environments** theme area, **Clarke** is involved in NERC-funded research with the British Antarctic Survey, Cambridge, and the University of Newcastle into glacial change in the 21st century in Antarctica (which has resulted in two multi-author publications); and in alluvial fan dynamics, with Utrecht University. **Toms**, who heads the Cheltenham Geochronological Laboratories, is involved in research consortia through applying luminescence dating to solve research questions in environmental change and into human origins and evolution. These research links include academics at the universities of Leicester, Reading, Southampton, Sussex, Winchester, and EMM Consulting, Australia. **Webb** is involved as a stakeholder in a multi-institution project—CHERISH (Climate Change and Coastal Heritage)—involving her leading the palynological study of Skomer and Skokholm Islands.

New professorial appointment **Hill** contributes to the **Changing Environments** research of the UoA. **Hill** researches into aspects of geoecology (chronosequences of ant nest mounds from glacier forelands and succession in alpine vegetation) and landscape change (Schmidt-hammer exposure-age dating to understand regional Holocene chronologies and morpho-dynamics of small rock-slope failures, snow-avalanche impact craters, sorted stripes and cryoplanation terraces) in the arctic-alpine environment of the Jotunheimen mountains and neighbouring regions of western and central southern Norway. She also undertakes methodological research such as developing an index of the degree of rock-surface micro-weathering based on Schmidt hammer R-values. **Hill** undertakes this research in collaboration with colleagues from across the UK (Swansea University, Ulster University, University of Manchester, University of the West of

England Bristol), Europe (Julius-Maximilians University Würzburg, University of Vienna) and the USA (University of Kentucky).

In **Applied Ecology and Biology**, there is a particular strength in research in avian species, and during the REF period, Research Fellow **Patrick** enhanced that strength through collaboration with the University of Oxford on a range of aspects of seabird behaviour. **Goodenough** collaborates nationally and internationally on applied ecological research, focused on developing maximally effective survey protocols (acoustic monitoring, thermography, automated computer processing of digital imaging, use of indicator species) and informing conservation and management strategies (birds, land mammals, bats, butterflies, woodland and grassland flora). An ornithological researcher at the outset, **Goodenough** is part of a pan-European research group involving 80 researchers from 60 institutions in 20 countries that has resulted in multiple high-impact publications in the REF cycle on the biotic impact of climate change of birds at a continental scale. She has also researched collaboratively in southern Africa on grassland and wildlife management. **O'Connell**'s collaborative research with University of Brighton is on the causes of changes in bird species diversity; his international collaboration with the Smithsonian Institute is on development of conservation capacity building metrics; his collaboration with the 5 Gyres Institute in the USA is investigating the role of sea plastics on global seabird extinction risk. **Wood** coordinates long-term studies of seabirds on Skomer Island, to understand environmental influences on population dynamics, such as climate change, with colleagues from the Universities of Oxford, Glasgow, Liverpool and Cork. **Wood** also works on microplastics in marine environments, while **Stones**, a recent appointee, researches various aspects governing gut health from ingested environmental material, including host–pathogen interactions and immune responses during inflammatory bowel disease and cancer. **Stones** undertakes this research in collaboration with partners from the UK (University of Birmingham) and USA (University of Texas Houston).

Links to other UoAs

A strength of the Unit is its interdisciplinarity, not merely across the Unit, within and between the three Research Themes, but also within one of the University's six Research Priority Areas (RPA: Environmental Dynamics and Governance [EDG]), which now includes UoAs 13, 14, 21. The expertise provided by researchers from UoA 14 here has been crucial to project success. For example, **Clarke**'s **Changing Environments** collaboration with UoA13 in flood management has resulted in a successful PhD completion, three research papers, joint grant proposals for EU H2020, NERC and ESRC, and a joint conference for Natural Flood Management practitioners, hosted at UoG. **Lynch**'s leadership and mentoring of staff over the REF period in **Social Vulnerabilities** has led to co-authored publications submitted in UoA21; and in 2020 a successful UoA21/UoA14 BA/Leverhulme research grant application.

Relationships with Key Research Users, Beneficiaries and Audiences

A particular research strength of our international Research Centre (CECQR) in the **Changing Environments** theme area has been its leading of research with end-users into the recent vegetation history of moorlands and blanket bog, with a view to informing effective conservation. A research studentship here was part-sponsored by the Yorkshire Wildlife Trust to investigate sites in North Yorkshire, which has led to three research publications (co-authored with the end-user) in international peer-reviewed journals, while a multi-site study with Natural England led to a co-authored publication (including **Chambers** and **Webb)** that included an assessment and evaluation of the effectiveness of a range of applicable palaeoenvironmental techniques, which

other researchers and practitioners can now follow. Users of this CECQR research include Natural England, for moorland management and restoration, and Cyfoeth Naturiol Cymru (Natural Resources, Wales), for blanket bog conservation and management.

New appointee **O'Connell** came from an applied research background and in **Applied Biology and Ecology** he has successfully built upon a wide research network in leading the development and running of a major recent international conference 'Capacity Building for Conservation' (2019), held in London, which had participation of delegates from 51 countries, majoring on direct engagement with conservation managers and practitioners.

In **Social Vulnerabilities**, **Bennett**'s work has been featured in blogposts for Understanding Society and Worklife. She is a Member of the International Network on Transnational Families, which conducted two workshops (St Andrews; Maastricht Universities) on similarities and differences in the effects of family migration across world regions, which resulted in a Special Issue of *Population, Space and Place*. She was a team member on two consultancy projects for the United Nations Population Fund Eastern Europe & Central Asia Office, on progress towards the Madrid International Plan of Action on Ageing in the region; and gave an invited seminar at the International Gender Studies Centre, University of Oxford.

Also in **Social Vulnerabilities**, **Lynch** engaged end-users in the Greater Hyderabad Metropolitan Authority, India, on Rural–Urban Sanitation Transformations. He has given Keynote presentations at the Interdisciplinary Research for Food & Water Security, Bilateral Early Careers Researcher Workshop, American University of Cairo, Egypt; and a Keynote and 1-day field trip at the Interdisciplinary Research for Food & Water Security, Trilateral Early Careers Researcher Workshop (UK, South Africa, Egypt), Stellenbosch Institute of Advance Studies (STIAS). In communicating research to a wider public audience, he is co-Editor of *The Routledge Handbook of African Development* (50 chapters; 700 pages).

Esteemed Roles in Relationships with User Audiences and Enhancement of the wider Research Base

As part of the UoA's contribution to Relationships with Key Research Users, Beneficiaries and Audiences, staff hold editorships of both academic and professional journals, and have other senior roles. For example, **Goodenough** is Associate Editor of *Bird Study* and (during the REF period) of *Microbial Ecology*; she is a STEM ambassador. **Hart** is on the Council of the Royal Entomological Society and Chairs their Outreach and Development Committee, Editorial Board member for *Insects*, former Editor-in-Chief of *Ecological Entomology*, and continues as Associate Editor. **Wood** is Associate Editor of *Ibis: International Journal of Avian Science*. **Chambers** is Associate Editor of *The Holocene*, and until 2020 was also an Editor of *Mires and Peat*, and Associate Editor of *Biodiversity and Conservation*. **Bennett** co-edited a Special Issue of the *International Journal of Ageing in Developing Countries* on the Madrid International Plan of Action on Ageing. **O'Connell** was Editor of *Ecological Informatics* proceedings in 2015, 2018 and 2019; he is Associate Editor for the journal *Ecological Solutions and Evidence*, and is editing 18 papers of Conference Proceedings, to be published in the *International Journal of Conservation*, aimed particularly at the engagement of conservation managers and practitioners.

Clarke was Co-organiser of the 2015 Alluvial Fan Conference in Christchurch, New Zealand. She contributed to the wider future research base by being Coordinator of the Windsor training workshop for 1st-year PhD students, involving an audience of *c*. 30 research students annually

from across Europe. She gave Keynote talks in 2015 on alluvial fans at the Binghamton Geomorphology Symposium at Buffalo University, New York, and at the 5th International Alluvial Fans Meeting, Christchurch, New Zealand. She led the Fixed-Term Working Group, funded by the British Society for Geomorphology, which ran conference workshops and research focus groups.

Bennett won an ESRC bursary award for the National Centre for Research Methods Training, and participated in research training sessions in Sweden. **Lynch**, with attendees **Bennett** and **Clarke**, co-led the Newton-funded Early Career Research Workshop in Stellenbosch (2016); **Lynch** and **Bennett** contributed to the UK 'Parliament for Researchers', by the Parliamentary Office for Science and Technology in 2019. Throughout the REF period, **Chambers** has been an active member of the national CROS/PIRLS* Steering Committee, and he helped devise the UK-wide 2020 CEDARS* survey, both as Steering Committee member and as a Principal Investigator pilot tester.

**CROS: Careers in Research Online Survey; PIRLS: Principal Investigator and Research Leaders [Survey]; CEDARS: Culture, Employment and Development in Academic Research Survey.*

Contribution to the Research Base, Economy and Society

Policy Advice for External End-users

Chambers was chosen to pilot the Department for Business, Energy and Industrial Strategy (BEIS) survey of UK researchers on the impact on research of COVID-19 (May 2020), after which essential amendments were made before its release.

In **Changing Environments**, **Clarke**'s collaborative Natural Flood Management monitoring in the south-west Midlands (£20k funding awarded; with HLF bid submitted subsequently) informs Local Authorities and the Environment Agency on how best to reduce flood risk.

Using expertise from both the **Changing Environments** and **Applied Biology and Ecology** research themes, results from an innovative, multi-proxy study into the status and Eurasian origin of sweet chestnut in Britain and Ireland (**Jarman**, with **Chambers** and **Webb**) informs the National Trust, Historic England and national conservation agencies about seven identified landscape types that currently contain sweet chestnut; and advises forestry organisations as to the suitability of sweet chestnut for future planting, including for example in the extensive Midlands Forest.

In a similar combination of expertise across the same two theme areas, **Webb** is involved in Forensic Science applications of palynology, which have wider applications for society in ensuring successful prosecutions for criminal activity. Our **CECQR** Research Associate, Prof. Pat Wiltshire, is the world's leading researcher and practitioner in Forensic Ecology, having herself pioneered and established that sub-discipline internationally, and contributes crucial evidence in high-profile murder cases.

In **Applied Biology and Ecology**, close collaboration with and training of end-users (by **Goodenough** and **Hart**) in wildlife reserves has resulted in the introduction of remote measures

for better detection of poaching, and thereby to ensure more effective conservation of white rhino in South Africa and Botswana and black rhino in Namibia (see Impact Case Study 1). In addition, research (through CECQR) on pied flycatcher and other bird species (by **Goodenough**) has informed RSPB and Natural England on effective bird nest-box siting and orientation. Working in collaboration with the Royal Society of Biology, **Hart**, and latterly, **Hart** and **Goodenough** have developed a nationally recognised strength in applying citizen-science techniques to ecology. A BBC series, fronted by **Hart**, resulted in collaboration with York University to produce a position paper on invertebrate ethics, enhancing the wider research base.

With **O'Connell** and **Goodenough**, **Wood** advises on seabird monitoring methods and policy, locally for Wildlife Trusts and nationally for JNCC's Seabird Monitoring Programme; he led international workshops on the use of unmanned aerial vehicles (UAVs) in seabird monitoring (based on UoG-funded work with **Clarke**) and is co-lead for the World Seabird Union's workshop on citizen science approaches. Funding from JNCC and Natural Resources Wales has permitted development of innovative survey methods in acoustic survey in collaboration with the Universities of Oxford and Cardiff, revealing historical changes in island seabird populations to inform evidence-based decisions on conservation status.

In **Social Vulnerabilities**, collaborative research has been conducted (by **Scott**) with UCL and LSE in two projects for the Director of Labour Market Enforcement (DLME), focussing on the scale and nature of non-compliance in the UJ labour market. **Scott** has also collaborated in a Norwegian Research Council project on global labour in rural societies. These research projects are, respectively, designed to inform Governments regarding labour market standards and protections, and migrant labour recruitment and integration, both having important bearings for economy and society.

Communication of Research Findings to a wider Audience, and encouraging Public Engagement

Public engagement and science communication has developed as an important theme within the UoA, led by **Hart** who is Professor of Science Communication. Research work by him, **Goodenough** and **Wood** has led to a great deal of media coverage over the reporting period across news platforms, including citizen science, conservation, climate change and seabird ecology. **Hart** is a regular presenter for BBC Radio and during the period he has written and presented more than 15 documentaries, seven of which were based on his research. He also presented the global BBC World Service science magazine programme *Science in Action* for four months during which research in the UoA was covered several times. **Hart** also has a "*Science Hour*" slot on BBC Radio Gloucestershire that has run monthly since 2006 and highlights research within the UoA. Research from the UoA has also featured, via **Hart**, in events at Cheltenham, Edinburgh and the Northern Ireland Science Festivals, the Malta Science Festival, the *New Scientist Live* event and the *A-Level Live* events. **Hart, Goodenough** and **Wood** are regular speakers to local and national interest groups. The UoA also has close links to schools locally and nationally, and several members of the group are involved in school curriculum enhancement visits. **Hart**'s Instar feature on development of the sub-adult stage in insects engaged 24,000 schools.

Working with researchers in CEH Wallingford, in 2020 **Hart** co-hosted a one-day online event to contribute to a "hack-a-thon", funded and facilitated by the British Ecological Society. This

allowed 25 citizen science projects from across the world to share data and to co-author a paper outlining a framework for understanding citizen engagement in different project stages. **Hart** also co-hosted an online conference (*c.* 100 attendees) with CEH Wallingford and the British Ecological Society where marketing, design, motivation and engagement academics and experts from the commercial sector linked with citizen science researchers from across the UK to develop more effective engagement strategies.

Nationwide studies of ants, spiders and starlings resulted in considerable media attention (BBC 'Most Read' stories, Radio 4 Today and PM, Radio 1, Radio 2, 5 Live, Countryfile, most national newspapers and many local radio stations) across the reporting period in addition to highly rated research papers. Researchers in **Applied Biology and Ecology** also used Twitter mining to investigate the possibility of using social media to study phenology—research that was reported by the BBC and was a 'Most Read' story. **Hart** has been working on a study of wasp abundance, with University College London, which attracted considerable media attention and which led to a BBC Radio 4 and World Service series written and presented by **Hart** on the ethics of entomology.

Overall

In REF2014: "The subpanel noted areas of particular strength in the reconstruction and dating of environmental change in various environments, the impacts of environmental change on bird populations, and some areas of human geography"; of these, all but human geography were in our Research Centre (CECQR). Over the course of the REF period we have moved from this one external-facing, internationally recognised Research Centre (CECQR) that co-researches and co-publishes with end-users, to three internal- and external-facing Research Themes (**Changing Environments**, **Applied Biology and Ecology**, and **Social Vulnerabilities**), each, separately or together, engages with end-users at the outset of research, and develops clear pathways to impact. Our latter strategy of funding Research Masters bursaries has enhanced both our research capability and the significance of our research collaborations, networks and partnerships, including relationships with key research end-users and beneficiaries. Based on External assessment, our research output has strengthened markedly. The great advantage of our having an in-house Professor of Science Communication is that our research achieves a quite outstanding reach to a wide audience, nationally, internationally and globally.