Institution: University of Bristol

Unit of Assessment: 17a

a. Overview

Bristol's School of Geographical Sciences is among the world's leading centres for geographical research. Our aims are to investigate the physical and human processes shaping our planet, the social and individual cognition of these processes, and to understand how their interactions may lead to future changes. To fulfil these aims we undertake research in a distinctive, targeted range of geographical areas, with increasing emphases on multi- and inter-disciplinary investigations. Our research is underpinned by state-of-the-art laboratories, field equipment and computing facilities, benefits from collaboration at regional, UK and global levels, is disseminated through publication in peer-reviewed journals and international symposia, and is relayed to policy makers, industry and the public through purposeful, directed knowledge exchange. We support research excellence by assembling critical masses of staff in key areas, guiding and mentoring early career researchers through advice from senior staff, and integrating postdoctoral and postgraduate communities within the School.

We are committed to the development and wellbeing of Geography, as demonstrated by the dissemination of research outputs, and through leadership in research training, research councils, learned societies and collaborative research programmes.

The School's distinctiveness is developed by work in seven formal research groups (Bristol Glaciology Centre, BRIDGE – Bristol Research Initiative for the Dynamic Global Environment, Geographies of Political Economy, Historical and Cultural Geography, Hydrology, Personal Finance Research Centre and Spatial Modelling). While each group has a disciplinary identity, supporting research planning and staff development, interdisciplinary ambition has led to increased collaboration between groups.

The School is managed by the Head of School in consultation with the School Planning and Resources Committee (SPARC). Two Research Directors promote cross-group interdisciplinary discussions through away-days and seminars, and assist Research Groups in organising symposia and developing publicity and knowledge transfer, external opportunities and strategic initiatives. The Research Directors and Research Group heads all sit on the SPARC.

b. Research strategy

b.1 Reflection on RAE2008

Bristol Geography's RAE2008 was considered among the most successful in its Unit of Assessment, with a final profile of 30/40% at 4/3*. All of the research ambitions highlighted in RAE2008 have been fulfilled. Since then, we have built on our long-standing reputations for theoretical and methodological innovation in human geography, and for integrated field, laboratory and computational modelling studies in physical geography. Each research group has benefited from strategic staff hires, such that we are submitting >60% more category A Staff (46.4 FTE compared with 28.5 in 2008). We have grown interdisciplinary research and enhanced research productivity and culture. In doing so, we have increased research income by >85% from ~£1.65M per year in RAE2008 to ~£3.06M per year in REF2013.

b.2 Future aims for next 5 years 2014-2019

Our aspiration is to build upon our world-class status in geographical research and, through the development of core strengths, create new and innovative approaches to social science-physical science relations. The growth of interdisciplinary work is common to many important current debates, and Geography is uniquely placed to lead these intellectual challenges. To this end we will continue to develop and grow the Cabot Institute (Section b.4.1), and similar cross-cutting research initiatives, within the university and beyond (Section e). We will play a leading role in the development of postgraduate training centres, such as Bristol's newly funded ESRC, NERC and EPSRC doctoral programmes (Section c.2.1), which are collaborative ventures outwith both Geography and Bristol, and their success will further enhance our cross-disciplinarity.

We will seek to further increase and diversify our research funding, to fulfil research ambitions and enhance facilities. We will continue to lead developments on High Performance Computing, which is central to most quantitative work in Physical Geography and Spatial Modelling, within University and at Research Council levels. We plan to recruit 4-8 additional academic staff to facilitate research in key fields, particularly at the interfaces between areas of existing strengths.

Each research group has well-developed plans, presented in outline form below, that are founded on established track records (as evidenced by names/numbers that refer to submitted outputs).

b.2.1. Bristol Glaciology Centre. Through our experience in glacier biogeochemical processes, developed by demonstrating the potential for methane hydrate accumulation beneath the Antarctic ice sheet (Wadham1, Telling4), assessing the role of cryospheric microorganisms in the carbon cycle (Anesio3) and defining how microbial activity affects glacial chemical weathering (Tranter3), we plan to determine biogeochemical pathways mediated by microbes during soil formation in the forefields of retreating glaciers, and to understand the magnitude of genetic exchanges between microbial communities in the cryosphere and their relation to the evolution of life in the Snowball Earth scenarios. We aim to further develop our assessments of regional mass loss from the Antarctic and Greenland ice sheets using remote sensing methods (Bamber1-4; Bingham3) and ice-sheet modelling (Payne1-4), to constrain past, present and future ice sheet contributions to sea level rise with an emphasis on the 20th and 21st Centuries. We aim also to acquire and analyse geophysical data to improve ice-sheet boundary conditions and to unveil subglacial landscapes and processes, as we have done in both Antarctica and Greenland (Siegert1-4).

b.2.2. BRIDGE (Bristol Research Initiative for the Dynamic Global Environment). We will build on our success in solving long-standing problems about Earth's environmental history, such as a process-based understanding of the controls on greenhouse gases across a broad range of timescales (Valdes4, Ridgwell1) and causes of Northern Hemisphere glaciation (Lunt2), and use of numerical modelling to provide insight into palaeo-environments during key episodes of the past (Valdes1,2). We will continue to develop a global understanding of carbon fluxes, impacts of future land use and biodiversity (Arndt1,House1,3) and quantify the controls on organic carbon burial in marine sediments (Arndt3,4). We will further strengthen fundamental isotopic data used to constrain the timing (Richards1,4) of climate change, hominin and faunal evolution, and past ocean circulation patterns (Richards2, Flecker1-3). Using experience gained by determining long-term constraints on climate sensitivity (Lunt1) and polar amplification (Valdes3), we will assess the temporal variability and sensitivity of Cretaceous-Cenozoic climate and Earth systems. We will provide policymakers with expert guidance on geoengineering schemes (e.g., reflective crops, Ridgwell2; solar sunshades, Lunt3) and problems of ocean-acidification (Ridgwell3) based on a suite of climate models that includes the novel coupling of ocean ecosystem models (Monteiro3).

b.2.3. Geographies of Political Economy Group. Our future priorities include furthering critical contributions to the following research areas: feminist political economy (Fannin3; Larner1); post-colonialism (Jackson1); institutional governance (MacLeavy1; Dixon2); national (Fairbrother3; Fannin1) and embodied (Fannin2; Larner4) analyses of neoliberalism (Larner3); urbanisation (Fox1; Jackson3); the environment (Laudati1,2; Fairbrother2); social violence (Laudati3,4); finance (Dixon1,3); trade (Fairbrother1); and changing welfare reform (Macleavy2). Ongoing innovations in mixed methods approaches reaching from statistical and survey-based analyses (Fairbrother4), through visual methodologies (Jackson4), to participatory action research (Millner1) will be complemented by new critical work on co-production (Larner2). Work in the emerging field of political ontology (Fannin2; Jackson2) is now transforming applications to postcolonial ecology, socio-technical systems, interdisciplinary conjunctions of physical science with social justice, and advancing biotechnology and bioethics debates. By interrogating modes of economic production and responsively contributing to policy demands, we will continue to shape local, national, regional, and international thinking in the areas of socio-economic justice, sustainability, equality, governance, and the politics of environmental change.

b.2.4. Historical and Cultural Geography Research Group. We will complete a major monograph on non-representational theory, affect and performativity (Dewsbury1,2,4), and further develop theorised reworkings of temporality concepts (Glennie1), both of which will represent the culmination of research undertaken since 2008. We will revise intellectual histories of geographical and environmental thought through another major monograph, emerging from research using ideas of Nietzschean genealogy and book history (Mayhew1,2). We aim to mobilise our interests in performativity and extend their impact on curatorial and other public practice, building on exhibitions and public engagement work already conducted over the past few years (Patchett1).

b.2.5. Hydrology Research Group. Using the experience gained from city-wide flood inundation simulations (Bates2; 2012 Lloyd's Science of Risk prize), new algorithms for regional-scale flood

modelling (Neal1) and global weather predictions for flood forecasting (Freer4), we will develop open-access numerical and computing methods for massively parallel hydraulic models. These will be used to develop a kilometre-scale worldwide inundation forecasting model and to advance the science for the forthcoming NASA/CNES Surface Water Ocean Topography satellite mission. In addition, by employing techniques that led to the quantification of Amazon floodplain water storage (Bates4), methodologies for determining root zone soil moisture and land surface evaporation (Miralles1) and assessments on how desertification is enhanced through the loss of nitrogen and phosphorus during rainstorms (Michaelides1), we will evaluate national-scale environmental models taking into account observational uncertainty and use these to undertake UK-wide hydrology and water quality modelling.

b.2.6. Personal Finance Research Centre. We will continue to expand our research on financial wellbeing and capability among vulnerable groups to further examine international trends and patterns of consumer financial vulnerability (Finney2), to inform the provision of money guidance services to help improve consumer financial capability (Collard3), and to understand the impacts of economic downturn and the experiences of fuel poverty among lower income households (Finney3,4). We will further develop research that informs government policy on capping the cost of credit (Finney1), credit union expansion and modernisation (Collard4), and the delivery of debt advice services for people in deprived communities (Collard1,2). We also aim to focus on the future of debt management and advice, in the context of major changes in credit regulation and public funding for debt advice, mobilising our interests and capability in behavioural economics and economic psychology to increase our capacity to contribute to public policy development in the field of personal finance.

b.2.7. Spatial Modelling Group. By making critical methodological and empirical contributions to the inequality debate (Jones3; Deeming2; Fairbrother3) and demonstrating the role of spatial heterogeneity in understanding change and context (Fairbrother4; Jones2; Harris3), we aim to analyse micro and macro social change, migration, health and wellbeing, neighbourhood change, and the transmission of intergeneration inequalities. We will meet this aim by deploying random-coefficient approaches, allied with instrumental variables, and exploiting and extending the potential of e-science and grid-based parallel computing (Harris4). Our analysis of school choice, ethnic segregation, neighbourhood, migration and health change (Harris2; Jones1; Manley1; Sabel1-4, Wang1), will be progressed by modelling spatial dependence and underlying individual and aggregated space-time trajectories, developing methods for understanding changing ethnic diversity, and considering simultaneously multiple aspects of segregation, including the residential, work-place, school, leisure and social environments. Having already extended measures of electoral bias to n-party situations, and deployed them to evaluate potential impacts of electoral reform (Johnston1,3), we will use them to understand how a 4-party system may work in 2015 UK general election (given the potential rise of UKIP) and assess political party responses to the revealed situation in their detailed campaign plans for that election.

b.3 In the pipeline

All staff have undertaken research that will reach fruition after 2013. Major examples include: (1) Mayhew's British Academy-Leverhulme Trust funded research on the intellectual history of Malthusian ideas on population, politics and the environment over the past two centuries, which will emerge as the Harvard University Press monograph "Untimely Prophet" in 2014; (2) The NERC-funded Lake Ellsworth Consortium (Siegert, Wadham, Tranter), which attempted to acquire direct measurements and samples from an Antarctic subglacial lake in 2012, and which is planning a second season within the next REF cycle; (3) Valdes, Lunt and Ridgwell's contribution to an ERC advanced grant on the Greenhouse Earth System, starting in late 2013; (4) Jones' £0.8m ESRC programme on e-books for quantitative analysis; (5) Wang's £0.5m ESRC study on the causes and effects of reverse migration; and (6) The EU FP7 €3.5 million funded URGENCHE project (2011-2014), which is investigating the social and health impacts of policies to mitigate climate change in China and Europe (Sabel), and has led to the subsequent awarding of a further EU FP7 grant, HEALS (Sabel) (€600k to Bristol, €12 million total) starting in late 2013.

b.4 Priority areas for development

b.4.1 Research topics. A key research priority for Geography concerns climate change and uncertainty. While this priority is at the heart of geographical investigation it requires a multidisciplinary approach involving contributions from other disciplines. Geography must lead the

way, however, and we have done so through the Cabot Institute, a University-wide arrangement that promotes, facilitates and supports solution-focused research relating to the challenges of uncertain environmental change, which we initiated in 2012. Larner and Valdes were among the Cabot Institute's founding members, and Bates was its inaugural Director. It involves ~500 academics across Science, Social Science, Medicine and Engineering and is one of only two University Research Institutes at Bristol – the other being the Elizabeth Blackwell Institute in health, in which we are also collaborators (Sabel, Fannin, Jones).

Building on intellectual strengths, and following the recommendations of the International Benchmarking Review of UK Human Geography, we have prioritised research on the Global South and in Quantitative Human Geography through recent targeted appointments (Fox, Laudati, Manley, Wang and Sabel). We are explicit about the need for internationalisation, and will support comparative, multi-sited and border-crossing fieldwork and the analysis of international data sets. We will continue creating new institutional contexts that foster young scholars, thereby addressing the Review's concerns on precarious early careers and minority representation.

b.4.2 Funding streams. Since 2008 our annual research income has grown by >85%. More than £9m (~62% of total research income) was gained from 59 RCUK grants (NERC – 49, ESRC – 5, EPSRC – 2, AHRC – 2, STFC – 1). We have also secured funding from the UK Government (e.g., Met Office, DEFRA, HM Revenue, Dept. for Work and Pensions, Office for Nation Statistics – 20 awards, totalling >£1.3m), the EU (inc. FP7 and ESA – 18 awards, totalling >£2.2m), the Leverhulme Trust and the BA (10 each, totalling >£1.1m). Industry support (12 awards, totalling >£0.5m) was received mainly in the Hydrology, BRIDGE and Personal Finance research groups, where we have strong ties with end users.

To support collaboration, we have become increasingly involved in larger consortium-style grants (e.g., EU ice2sea, past4future and MedGate; NERC Lake Ellsworth; DEFRA National Demonstration Test Catchment). Jones co-directs the Centre for Multilevel Modelling; the only National Centre Research Methods node that has been continuously funded over 3 rounds by ESRC. While curiosity-driven research remains fundamental to our ambitions, we have increased the level of 'directed research' awards (e.g., from NERC research initiatives including the National Centre for Earth Observation, the Joint Weather and Climate Research Programme and the Centre for Polar Observation and Modelling; through NERC thematic programmes including 'iSTAR' and 'PURE'; and from ESRC's Secondary Data Analysis Initiative).

Our future research income will be strengthened by securing enhanced industry and EU (e.g. ERC Horizon 2020) funding. We are keen to maximise our links with policy makers and industry through externally funded work, leveraging awards where possible to match existing commitments, and securing income from less traditional sources (such as local authorities, alumni and SMEs). The Cabot Institute will be an important delivery mechanism for this ambition.

b.4.3 Postgraduate research activity. Our Graduate School is a vibrant, well-organised effective forum for research training. It is a multidisciplinary school, with 51 PhD students graduating (44.5 FTE), and a growing number (76) starting, since 2008. We have developed a portfolio of Masters courses that provide secure underpinning of research skills. Our 4 year undergraduate Masters is officially recognized as postgraduate research training by the ESRC.

We are currently members of three RCUK funded doctoral training programmes (Section c.2.1). We anticipate these, in conjunction with our increased number of core academic staff, will deliver further growth in PGR studentships to the School in the next 5 years.

We lead a new Bristol-based £1.3M Nuffield Foundation 'Q Centre', involving the Schools of Policy Studies, Sociology, Politics and International Studies, and Graduate Education. Harris is its Director. The centre will develop quantitative methods teaching and learning in UK social sciences, in particular at masters level, which will enhance higher level graduate training in the next 5 years (e.g., it will feed directly into our Advanced Quantitative Methods PhD pathway).

b.4.4. Facilities. Our research success since 2008, combined with increased staff numbers, has led to pressure on existing and planned use of space. We will seek to expand and upgrade our built environment to deliver high-quality facilities commensurate with the excellence achieved academically. We will continue to strengthen laboratory facilities through externally-funded grants and university support. Given the importance of high-quality computing in much of our research, we aim to ensure local computer support remains at the highest standard, and will play leading

roles in maintaining university and national developments in High Performance Computing.

b.4.5. Staffing. Our 5 year plan is to further grow academic staff numbers from 46.4 FTE in 2013 to >50 FTE in 2018, as permitted by healthy School finances, to exploit the research opportunities identified above. Our policy is to build and retain critical staff masses in the seven Research Groups to engender a lively and interactive intellectual atmosphere. We will continue to develop opportunities for externally-funded research fellowships, and will offer proleptic positions to externally-funded research fellows where appropriate. The University operates an 'Exceptional Talent' scheme, by which research leaders can be attracted to Bristol, and we will use this scheme where necessary to enhance our expertise and research agenda, as we have done in the existing review period (Siegert). Through this scheme Prof. Penny Johnes will join Bristol in early 2014.

c. People:

c.1 Staffing strategy and staff development

Currently ~98% of academic staff are research active and included in this submission. To ensure academic staff retain time dedicated to research, we operate a unified work load model to guide managerial decisions on work balance. All academic staff have an annual meeting with the Head of School (staff review) to discuss ambitions, progress and barriers in research. While all academic staff receive a £450 research allocation annually, we offer new staff £1000 and £700 in their first and second years, respectively. School and faculty travel funds, often leveraged by external support, help early career staff attend conferences and workshops. Newly appointed lecturers are supported through the allocation of a senior colleague as a mentor, an initially light teaching load, and faculty and university training courses to help develop research, leadership and teaching skills.

At Bristol, Lecturers 'progress' to Senior Lecturer, negating the need for lengthy and potentially disruptive promotion. Reviews are conducted annually, and no later than 12 months ahead of progression, to ensure expectations are fulfilled and to identify any problems. During the REF period, 6 have progressed from lecturer to senior lecturer (none have been declined). Promotions to more senior grades examine all forms of contribution to establish evidence of 'excellence'. Since 2008, 3 staff have been promoted to Reader, and a further 3 have been awarded Personal Chairs.

Research Group Heads and the Head of School advise staff on promotion prospects. We value collegiality (it is a promotion criterion) in supporting a positive working environment. In 2012, the School's formal external review noted "the strong sense of community and collegial atmosphere that has been created amongst students and staff".

c.1.1 Staffing policy and evidence of its effectiveness. Compared with RAE2008, in which we noted a high turnover of staff, we have experienced very few staff losses since (with only 7 non-retirement departures). We have recruited 12 lecturers since RAE2008 (Dixon, Wang, Laudati, Ligouri, Arndt, Miralles, Patchett, Fox, Neal, Monteiro, Bingham and Millner), and 2 Professors (Sabel, Siegert). These appointments have been carefully targeted in areas of strategic importance as identified by external funding bodies and benchmarking.

We recognise the importance of senior role models in developing a culture of research. To help maintain this, since 2008 the University has awarded honorary degrees to two of the world's most eminent geographers who forged their careers here; Nigel Thrift and David Harvey. In addition, Peter Haggett has emeritus status and continues to take an active part in School affairs, and Joanna Laybourne Parry has honorary status and provides leadership in cryospheric biogeochemical processes.

c.1.2 Prestigious/competitive personal research fellowships. Since 2008, 30 individual research fellowships have been secured, including three EU Marie Curie Fellows (Monteiro, Werder, Wouters), two 3-year NERC postdoctoral research fellows (Arndt, Monteiro), two 3-year Leverhulme Early Career Fellows (Neal, House), one 3-year ESRC Research Leader fellowship (Deeming), one 3-year Royal Society University Research Fellowship (Ridgewell), one 3-year Canadian Research Council Fellowship (Patchett), three 1-year Leverhulme Research Fellowships (Mayhew, Tranter, Wadham), five 1-year University Research Fellowships (Bamber, Della Dora, Dixon, Payne, Dewsbury), two 1-year WUN Research Fellows (Fannin, Dixon), eight externally funded visiting fellowships (Bamber – Colorado, Bates – NASA-JLP, Della Dora – Harvard, Larner – Frankfurt, Kentucky and Queen Mary, Dewsbury – University of New South Wales, Dixon – Heidelberg), one 1-year Willis Research Fellow (Trigg) and one 1-year University Fellow (Harris).

c.1.3 Equality opportunity. The School is committed to ensuring staff equality and diversity. Eight

staff have benefitted from our "Women Returner Scheme", which provides six months' research leave for staff recommencing work after maternity leave. Staff with children under 18 months and those breast feeding are not required to teach on field trips. Wherever possible, all meetings and seminars are scheduled for school-friendly times. Staff with caring responsibilities are able to specify lecture times and dates to avoid problematic timings. We have School-wide policies offering support for family-friendly working arrangements during potentially busy periods (e.g., during half terms), and respect for our increased national, ethnic and cultural diversity. Review of these policies is assured at School assemblies as a fixed agenda item.

c.1.4 Research quality and integrity. The School conducts its research to high standards that are fully consistent with RCUK and DEFRA ethical codes of practice. The School's ethics committee assesses and feeds back ethics advice to research proposals and postgraduate projects. The University ethics committee considers more complex issues, such as those involved with research on geoengineering or those involving human subjects. Where necessary we follow internationally-agreed codes of conduct (e.g., Antarctic fieldwork is undertaken under permit from the FCO after environmental considerations have been agreed by Treaty members).

We offer formal publication advice to early career researchers, clarifying that they are expected to be first author in collaborative work they lead. Occasionally undergraduates publish research projects and, in such cases, they do so as first author.

Where possible we make research tools publically accessible. BRIDGE maintains one of the largest climate model output systems of any non-government agency, with >50Tb of online data. Many of our models are freely available to download (e.g., GENIE earth system, LISFLOOD-FP flood inundation and GLIMMER ice sheet models). Large polar geophysical datasets collected since 2008 are stored nationally (BAS Polar Data Centre) and internationally (NSIDC).

All laboratories benefit from documented procedures and methods and well-trained (to PhD level) technicians to ensure the highest quality observations, and reliable and repeatable results.

c.2 Research students

c.2.1 Prestigious/competitive studentships. The School is a vibrant and growing centre for PhD training. Presently, 57 students are registered and supervised in the School. We have increased the average annual intake of PhD students over the census period from 11 in 2008 to 16 in 2012. Of the 76 PhD students that have started since 2008, 64 are from the UK, 4 from the EU and 8 are from overseas. The majority of our studentships are competitive, and stem from research grants (e.g., the Marie Curie ITN Medgate programme, led by Flecker, funding 10 PhD studentships across Europe), RCUK allocations derived from grant income and, recently, through the ESRC South West Doctoral Training Centre (see below). Over 60% of our PhD students are currently supported by RCUK bursaries. We have a strong record of gaining RCUK CASE awards, with partners such as AXA, Wessex Water, the Environment Agency, Statoil, British Antarctic Survey, Willis Research Network and UCAS. We have won 6 overseas awards from bodies including the Commonwealth, LASPAU and New Zealand Government Bright Futures. Since 2008, 10 of our PhD students have won ESRC Overseas Visit awards to study in the US, Australia and France.

The School has played leading roles in setting up three recent RCUK doctoral training programmes. First, the ESRC-funded South West Doctoral Training Centre (Bristol, Exeter, Bath), which provides 41 studentships annually. We contribute to the centre's Geography programme and its interdisciplinary pathways in Advanced Quantitative Methods (4 bursaries a year specifically to Bristol), Environment Energy and Resilience, and Global Political Economy. Second, the NERC-funded GW4+ Doctoral Training Partnership (Bristol, Exeter, Bath, Cardiff), which is led by Bristol and offers 38 studentships annually. It has formal partnerships with the Met Office, the British Antarctic Survey, the Environment Agency and 29 other organisations, offering external facilities and expertise to support students. Third, the EPSRC-funded Doctoral Training Centre in 'Water Informatics: Science and Engineering' (WISE) (Bristol, Exeter), offering 18 studentships annually.

c.2.2 Training and supervision of PGR students. The census period has seen 44.5 (FTE) PhD students successfully graduate, while only 4 have withdrawn. This success is achieved through the quality of our students and excellence of our supervisors, and through a rigorous and supportive monitoring framework. We operate a formal tri-annual reporting schedule, involving students, supervisors and independent advisors. The procedure ensures we record issues quickly, providing early and effective intervention measures on rare occasions where additional support is needed. At

the end of each year individual student progress is examined through a viva, with an independent panel, and the results are checked at Faculty level. PhD students give formal School-wide presentations in their first year, and annual presentations to research groups in subsequent years.

While we encourage PhD students to gain experience in teaching, undergraduate supervision and practical demonstration, as it is important to early career development, we have protocols to ensure such activities do not obstruct progress. We currently fund 4 Postgraduate Teaching Assistant posts, which combine research and teaching responsibilities, and run for 4.5 years to ensure adequate time for completion.

c.2.3 Evidence of a strong and integrated PGR culture. We operate a formal graduate liaison committee, in which staff and postgraduates meet tri-annually to discuss issues. Postgraduates are represented at both the School Assembly and at Faculty postgraduate committees, which generate and implement initiatives for improving the postgraduate experience. PhD students help organise research seminar series at School and research group levels. Research groups also hold regular meetings in which PGR students develop communication and presentation skills, allowing practice for talks later presented at conferences. PGR students meet with contemporaries outside Geography through a multidisciplinary poster event held annually in the University's Great Hall.

We are very proud of the quality of our PhD students. Of those graduating since 2008, 11 (~25%) have become lecturers (Aisling Gallagher and Russell Prince, Massey, NZ; Sam Kingsley, Pepe Romanillos and Anne Le Brocq, Exeter; Julian Brigstocke, Plymouth; Laura Edwards, Manchester; Paul Simpson, Glasgow; James Ash, Newcastle; Naomi Millner, Bristol; and Bea Caicedo, Antioquia, Columbia), 6 are research fellows (Ruza Ivanovic and Lauren Gregoire, Leeds; Zhixin Feng, Southampton; Marek Stibal, Geological Survey, Denmark; Mark Trigg, Bristol; and Andy Sole, Sheffield), 12 are research assistants (at a variety of locations, including Potsdam, Innsbruck, Imperial, Nottingham, the National Oceanography Centre, the University of California Santa Cruz, CNRS Toulouse, Oxford, Reading and Bristol), and many are now in industry (in, for example, Willis Insurance, the Environment Agency, Lloyds Bank and Sports England). That so many PhD students take on academic and research-related employment after completion is testament to their quality and the environment at Bristol in which they become independent researchers.

d. Income, infrastructure and facilities

d.1. Research funding

Our annual research income has grown by >85% since 2008, from a wide variety of sources (b.4.2). All academic staff are in receipt of external research income commensurate with their fields and point of career. The number of major grant earners has increased, with notable examples from Anesio, Freer, Lunt, Sabel and Wadham. Our focus on Research Fellowships has encouraged the development of early career staff (e.g., Arndt, Monteiro, House, Neal, Deeming, Dixon), allowed the completion of major scholarly works (e.g., Mayhew, BA Fellowship), and led to the formation of external collaborations (e.g., Millner's membership AHRC's Authority Research Network).

d.2 Strategies for generating grant income appropriate to the discipline

To assist staff in attracting research income, we operate four discrete schemes. First, the School provides funding to stimulate the development of research initiatives. Second, the Faculties of Science and Social Sciences and Law provide support to develop consortia. Third, the Cabot and Elizabeth Blackwell Institutes provide funds for multidisciplinary meetings and pump-priming activities. Fourth, Bristol has an Alumni Fund to support larger research initiatives.

The University provides capital investments to support research income generation. A good example is our LOWTEX and BIOGAS facilities, built through infrastructure awards to Wadham of £460k in 2006 and £850k in 2009 (plus two technical staff), which have been used to generate >£4M from external sources.

The University supports research planning, in particular with external partners, and assists early-career fellowship applications through RED (Research and Enterprise Development, see d.3.2). RED also helps to develop impact and data management plans on proposals. Dedicated support staff (Milsom) and streamlined grant submission processes (e.g., electronic costing spreadsheets) ensure that administrative aspects of proposals are delivered effectively and efficiently.

Research Groups offer internal peer-review on proposals prior to submission. Proposals also benefit from a cadre of high-level postdoctoral research associates, providing technical expertise necessary to ensure proposal quality, and rapid start-up of activity once grants are awarded.

Academic staff are given dedicated time to develop proposals in three ways. First, we have relatively light teaching loads (on average one 20 credit unit per year plus fieldcourses, dissertations and tutorial supervision). Second, we offer a sabbatical entitlement of one semester every three years for new staff and one semester every four years for established staff. Third, staff are encouraged to take advantage of externally-funded Research Fellowships (see c.1.2).

d.3 Evidence of infrastructure and/or facilities

d.3.1 Major Infrastructure Funding. Our research infrastructure is of a very high quality, as detailed in the following sections, and has been supported from a number of sources. The university capital investment programme provided initial funding for LOWTEX and BIOGAS (>£1.3M) with further RCUK funding to maintain, support and upgrade hardware. Almost our entire locally dedicated research computing has been secured from external funding sources, including £460k from NERC for the first of our clusters, £200k from STFC for expansion of our disk storage facilities, ~£80k from STATOIL and Fugro-Robertson for other servers, with additional amounts totalling >£300k arising from RCUK and Royal Society grants.

d.3.2 University investment and policies to support the research environment. RED is a University support group, which comprises over 80 staff working with academics and researchers to sustain and grow research activities. This includes identifying funding opportunities, advising on development of research proposals, co-ordinating large collaborative bids, negotiating research and consultancy contracts, management of large projects, and improving impact and commercialisation of our research by working with industry.

University Research Institutes (Cabot and Elizabeth Blackwell) provide strategic funds to develop new research opportunities, particularly in subjects that cross traditional disciplinary boundaries. Similarly, Bristol's Institute of Advanced Studies funds meetings and research fellowships for visitors to Bristol and for staff to work elsewhere.

The University offers a very active development programme, providing support and training for all levels of academic and research staff. Courses range from grant writing, and managing a small research group, to advanced management and leadership programmes. Additionally, the University's Centre for Public Engagement provides help and support in developing "pathways to impact" in research proposals and ensuring research is communicated to a wide audience.

d.3.3 Laboratory Provision. We have expanded the LOWTEX laboratory (Low Temperature Experimental Facility) to include a new Gas-analysis wing (BIOGAS facility – BIOgenic Gas extraction and AnalySis facility) and a geomicrobiology laboratory. BIOGAS includes a lab suite focussed on gas concentration and isotope analyses, and the extraction of gases from rock and ice. It also houses an electronics and chemical sensing laboratory, co-supporting a cross-faculty initiative (with Engineering) to develop a recently acquired unmanned helicopter for very high resolution environmental monitoring of catchment hydrological processes.

We have access to substantial facilities across the University. Michaelides runs the TRACE (Test Rig for Advancing Connectivity Experiments) large-scale artificial hillslope and rainfall simulator, used to study hydrological, biological, chemical and sediment-transport processes. Richards is a member of the Bristol Isotope Group, a collaboration between the Schools of Geography, Earth Sciences and Chemistry, which uses large scale state-of-the-art facilities for measurement of stable and radiogenic isotopes. Tranter, Anesio and Wadham have use of high-end analytical techniques, such as gas chromatography mass spectrometry and compound specific light stable isotope mass spectrometry, available within the Organic Geochemistry Unit (School of Chemistry).

The School's computer laboratory is configured as a powerful condor pool of >100 machines and used extensively for Monte Carlo modelling in hydrology. In addition, we have several school computer clusters totalling >700 cores and 150Tb of storage for earth and climate systems modelling. We also use >20% the University's 5,500-core High Performance Computing Facility (Blue Crystal) machine time, and >40% of the University's Bluepeta storage facility. In addition, we undertake modelling projects using national and international HP facilities such as HECTOR and those delivered through American laboratories.

d.3.4 Technical support staff. We currently have two laboratory staff to run the LOWTEX and BIOGAS facilities. In addition, we employ two dedicated computer staff to support the high-end computing needs. This is in addition to the support provided by University IT Services.

d.3.5 Space/facilities available for PGR students and research groups. The Graduate School

has dedicated open-plan office space in which each student has desk and computer facilities, within an environment that engenders collegiality and enables the cross pollination of ideas from different research areas, and encourages discussion and problem solving between postgraduate students. PGR students are provided with computers and access to printing, library and e-resource facilities, as well as high-performance computing facilities where necessary. Academic offices are clustered by research group in the main Geography building apart from the Bristol Glaciology Centre, which occupies a nearby Georgian town house.

d.3.6 Library. We have a dedicated onsite library for Geographical Sciences, run by 2.3 FTE staff. In addition to the Geography Library, staff and students have access to all other Bristol Library services, offering access to 10,790 e-journals. Bristol has a Special Collections section, which Jackson used to produce an on-line digital exhibition of rare historical atlases in 2013.

d.3.7 IT and AV provision. Besides the high performance computing, we have installed a series of large-scale multiprocessor servers and associated software, providing "beyond the desktop" windows-based platforms targeted at working with large, complex social science datasets, allowing us to build bespoke social sciences software (e.g., MLwiN). General computing is facilitated by state-of-the-art high speed networking. A wireless (including Eduroam) network operates across the entire University. All of our seminar rooms and lecture theatres have internet-linked computers that run presentation software, with high-quality data projection and audio systems. Staff have free access to video-conference facilities in 6 places within the University. We have dedicated transportable audio-visual equipment, used extensively on research (e.g., Jackson4), outreach (e.g., Patchett's work with Cabot's Artist-in-Residence programme) and teaching activities.

e. Collaboration or contribution to the discipline or research base

We assist strategic investments to the discipline through numerous contributions to UK research councils (e.g., Bates, Siegert – NERC Science and Innovation Strategy Board, and NERC 2013-18 Strategy Group; Valdes – NERC National Capability Advisory Group, Chair of the NERC High Performance Computing Management Committee and Chair of the NERC Fellowship Panel; Payne, Valdes – NERC Earth System Modelling Strategy Group; Siegert – NERC Aircraft Review and NERC Responsive Mode Review panels) and peer review colleges (Larner – ESRC Doctoral Training Centre; Deeming, Fairbrother – ESRC; Bamber, Bates, Flecker, Freer, Lunt, Michaelides, Tranter – NERC; and Valdes – NERC Pool of Chairs). We contributed to the ESRC Human Geography Benchmarking Exercise 2012 (Larner – Economic Geography focus group; Dewsbury – Cultural Geography focus group; Harris – Quantitative Geography and GIS). Larner served as an international member of the NZ Performance Based Research Fund (Social Sciences Panel, 2012). Siegert served on the Philip Leverhulme Prize Panel (2010, 2012).

We contribute to the Intergovernmental Panel on Climate Change, exchanging our research in the world's most significant synthesis of global environmental change. In the recent IPCC's 5th Assessment Report Payne was a lead author on Ch. 13 – Sea level change, Bamber was a review editor for Ch. 4 – the Cryosphere, and an expert reviewer for Ch. 13, House was a contributing Author on Ch. 6 – Carbon and other biogeochemical cycles, and Lunt was a contributing author on Ch. 5 – Information from Paleoclimate Archives.

We also offer service to the wider discipline through major editing roles. Anderson is Chief Editor of Hydrological Processes, Bamber is the founding Chief Editor of the EGU Open Access journal The Cryosphere, and Larner was Managing Editor for Antipode (2009-2013). Since 2008 staff in Bristol have been editors on many journals (including Social Politics, Journal of River Basin Management, Geoscientific Model Development, Quaternary Geochronology, Climates of the Past, Journal of Geophysical Research and Journal of Social Policy). We have also served on numerous editorial boards (including Progress in Human Geography, Environment and Planning A, Environment and Planning D, Geoscientific Model Development, Journal of Geophysical Research and Cultural Geographies) and as senior editors for book-series commissioning (e.g., Mayhew – Tauris and Ashgate historical geography series; Johnston – Proceedings of the British Academy).

e.1 Interdisciplinary research

We have stimulated an increase in multi- and inter-disciplinary research by our leadership in several initiatives. Prominent among these is the Cabot Institute (Section b.4.1.), which through the following activities facilitates research on environmental change and uncertainty. The 'Bristol Environmental Risk Research Centre' coordinates interdisciplinary research in environmental

hazard risk assessment and uncertainty (Freer and Bates on steering group). 'Global Change' focuses on the science of climate change and aims to improve our understanding of environmental processes (Valdes, Ridgwell, House on steering group). The 'Bristol Bio-geoengineering Initiative' links staff in Geography, Biology, Chemistry, Earth Sciences, Law and Sociology to investigate the science, legal, economic, and ethical issues associated with biogeoengineering. The 'Bristol Water Initiative' brings together over thirty academics from six faculties (Bates, Michaelides on steering group). 'Productive Margins', an ESRC programme, draws researchers from law, geography, education, sociology, drama and history and nine community organisations to design new regulatory processes (Larner, Manley). 'Politics and Matter' (Jackson, Fannin, Dewsbury, Millner, Patchett) advances engagement with wider turns towards non-human agencies, vital materialisms, hybrid ecologies and assemblage theory. The Centre for Multilevel Modelling (co-directed by Jones), brings together researchers across the social sciences and, through software developed by its 'Multilevel modelling' theme (including MLwiN) has over 18,000 registered users.

e.2 Industry

Industrial links are important to stimulate research directions and diversify income. Valdes and Lunt are funded by STATOIL and the GETECH Consultancy to investigate past environmental change. Bates is part of the Willis Research Network, which supports a research fellow studying the science of flood risk and extreme hydrological events. Anderson is member of the Disaster Risk Management Group (Latin America and Caribbean) at the World Bank, Washington DC, working on optimal ways of delivering landslide mitigation measures (Anderson1). Kempson and Collard are advisers to a World Bank-led programme to measure and evaluate financial capability across the globe. They also offer advice on personal finance to organisations including the UK Financial Services Authority (rollout of a national money advice service), UK Government (policy on credit union expansion and modernisation), Santander (improving financial confidence and capability among lower income households) and Macmillan (assessing the financial costs of cancer).

e.3 Collaboration

Our research is characterised by strong national and international collaborations. Of the 153 outputs submitted to this REF, 74 have co-authors from other UK institutions and 47 include international co-authors. Countries involved in these collaborations include the USA (15 papers), Canada (8), the Netherlands (8), Belgium (5), Norway (5), Germany (3), Australia (3), France (3), China (2), Trinidad and Tobago (2), New Zealand (2), and Switzerland (2) among several others.

To foster collaboration we regularly host international visitors. Examples since 2008 include six Benjamin Meaker Fellows (Luce Irigaray, CNRS, France; Norma Rantisi, Concordia, Canada; Paul Robbins, Arizona, USA; Monowar Khalid, Earthwatch, India; Karen Kohfeld, Simon Fraser, Canada; and Jim Smith, Princeton, USA), two Leverhulme Visiting Professors (Luce Irigaray, CNRS, France; and Tom Dunne, UC Santa Barbara, USA), in addition to Maureen Molloy (Auckland, New Zealand), Yosuke Maeda (Nagoya, Japan), Pauline McGuirk (Newcastle, Australia), Melissa Wright (Penn State, USA), and Dai Yamazaki (JSPS Fellow, Japan).

We play an integral role in one of the leading collaborative higher education associations, the "Worldwide Universities Network" (WUN), by organising workshops and presenting in virtual seminars. For example, 'Political Events and Spaces of Affect', convened by Fannin and Dewsbury, involved academics from ANU, Wisconsin, Alberta and Oxford Universities (Sept 2011); and 'Sea level and isostasy', organised by Payne, Richards and Lunt, gathered colleagues from Penn State, Alberta and Bergen Universities (Sept 2013). Larner convened a WUN conference on the Globalising Geographies of Higher Education Research (Feb, 2012). She also led a conference on Society in the Anthropocene (supported by Economy and Society, June 2013). Richards co-led an ESF workshop on geochronology (Santorini, Greece, October 2012), and Valdes co-led the Palaeoclimate Model Intercomparison Project workshop (Crew, May 2012).

e.4 Seminar series

Fannin, Larner, MacLeavy and Wang organised an ESRC Seminar Series on Feminism and Futurity (March 2010-2011), and edited a special issue of Social Politics out of this seminar. Fannin hosted the Luce Irigaray International Symposium (funded by the Leverhulme Trust and the French Embassy) three times (June 2011, 2012 and 2013).

We maintain two weekly departmental seminar series in physical and human geography. We lead regular University-wide multidisciplinary seminar series through the Cabot Institute (which are also open to the public). The Bristol Glaciology Centre, BRIDGE and Spatial Modelling each organise

weekly seminar series, and Hydrology organises bi-weekly seminars jointly with Engineering.

e.5 Learned societies

During the census period, Larner and Jones were elected Academicians of the Academy of Social Sciences. Larner, an Honorary Fellow of the Royal Society of New Zealand, was confirmed as chair of the 2014 RGS-IBG conference. Jones was made a Fellow of the Learned Society of Wales and was awarded the 2013 RGS Murchison Medal. Mayhew was elected Fellow of the Society of Antiquaries of London. Johnston was the first non-American to be given a Lifetime Achievement Award from the Association of American Geographers and won Political Communicator of the year from the UK Political Science Association. He is a Fellow of the British Academy, a Foundation Academician of the Academy of Social Sciences and was awarded an OBE in June 2011. Siegert, a Fellow of the Royal Society of Edinburgh, was Chair of the UK National Committee on Antarctic Research, a member of the Royal Society's Learned Societies, Scientific Unions and Global Environmental Change committees, and was UK delegate to the Scientific Committee on Antarctic Research – SCAR. As recipient of the 2013 Martha T Muse Prize he is on the steering committee of SCAR's scientific horizon scanning programme. For his services to Polar Research, Tranter was awarded the Polar Medal in 2011 by HM the Queen. Siegert convened an American Geophysical Union Chapman Conference on Antarctic Subglacial Aquatic Environments (Baltimore, March 2010), and edited an accompanying AGU monograph, the 1st UK Antarctic Research Town Hall meeting (Royal Society, London, April 2010), and the 11th International Symposium on Antarctic Earth Sciences (Edinburgh, July 2011). We led three Royal Society meetings (each accompanied by an issue of Philosophical Transactions A): Ridgwell convened 'Geoengineering – taking control of our planet's climate' (London, November 2010); Lunt convened 'Reconstructing and understanding CO_2 variability in the past' (Chicheley Hall, October 2011); and Lunt and Ridgwell convened 'Warm climates of the past – a lesson for the future?' (London, October 2011).

e.6 Collaboration in PGR training

We contribute to three RCUK doctoral training programmes (Section c.2.1): the ESRC South West Doctoral Training Centre (Bristol, Exeter, Bath); the NERC GW4+ Doctoral Training Partnership (Bristol, Exeter, Bath, Cardiff); and the EPSRC WISE Doctoral Training Centre (Bristol, Exeter).

The School provides 3 MSc programmes on Society and Space, Environmental Policy and Management, and Climate Change Science and Policy, which PhD students are encouraged to attend. We contribute to the BRISK summer school for PGR students on risk in environmental sciences. We have been active in developing innovative learning environments with colleagues in the US and Australia through the development of virtual seminars (Dewsbury and Fannin) and shared courses with the University of Wisconsin, funded by the British Council's UK-US Connect Programme. Larner is co-organiser of the Antipode Institute for Geographies of Justice (2011, 2013) which supports PGRs and early career geographers through an intensive week long programme of professional development activities. We teach an annual two-week multilevel workshop at the Essex Summer School (Jones, Wang), and week-long workshops at the Swiss Summer School for Social Science Methodology (Jones). Each year we run three 3-day ESRC funded workshops on MLwiN, a statistical software package for fitting multilevel models (Jones).

Concluding remarks

Since 2008 Bristol's School of Geographical Sciences has continued to produce research of the highest international calibre. The School has a dynamic and lively intellectual atmosphere and first class research infrastructure. We have research strength throughout the school, with a good balance across the human and physical geography domains, from early career to senior academic, and all research groups have critical mass. This strength is built upon a robust and diversified range of funding ensuring that we will have both strength and agility during the next census period when research funding may become even more challenging. We have exceptionally strong links to national research networks and international programmes and are helping to lead many of these activities. The Graduate School is large and intellectually lively, consolidating its reputation as a leading UK training centre. The School is having a major impact on policy, both nationally and internationally, and is doing so through the quality of its rigorous academic approach. In summary, our self-assessment is that Bristol's outstanding research environment has led to world-class achievements in Geography over the census period, and means that we continue to offer a platform of internationally renowned research expertise that will deliver major impacts in the discipline of Geography and its related subjects.