

Institution: University of Birmingham
Unit of Assessment: 14 – Geography & Environmental Studies
<p>1. Unit context and structure, research and impact strategy</p> <p><i>Key indicators of vitality and sustainability from strategic investment in people and facilities, 2014-20:</i></p> <ul style="list-style-type: none"> • REF-eligible staff grew from 28 to 40.2 FTE, increasing the proportion of female staff from 17.9% to 29.1% • Athena SWAN bronze renewed, and the first woman promoted to Professor of Geography at Birmingham for 20 years • Significant increase in the number of BAME staff • £13.1m in research income • Partners in five doctoral training centres, leading NERC-CENTA2 and Leverhulme Forest Edge • Bringing the £30m Birmingham Institute for Forest Research on-stream as an exemplar of multi-disciplinary, impact-led research • Creating the Birmingham Environmental Research Suite with internal investment of £3.1m, including a new flume stream mesocosm facility, air quality supersite, meteorological facilities and controlled environmental chambers • Publishing 855 Scopus outputs January 2014-July 2020 with 14,292 citations. 68% of these outputs were in top 10% journals by CiteScore and 58.8% were co-authored with international collaborators from 69 different countries. <p><i>1.1 Structure of research across the submitted unit</i></p> <p><u>Position of the unit within institutional structures</u></p> <p>UoA14 sits within the School of Geography, Earth and Environmental Sciences, one of four schools within the College of Life and Environmental Sciences at the University of Birmingham (UoB) [REF5a 1]. The School also includes UoA7 (30.8 FTE) with significant synergies between the two units and other Schools across campus, including shared facilities. The size of the unit combined with a collaborative ethos drives a particular emphasis on interdisciplinary research examining the processes affecting our planet and its people. This activity cuts across the natural and anthropogenic, operating at scales from the nano to the global.</p> <p>UoA14 is organised into two research themes, Human Geography and Physical Geography, with considerable collaboration between the two. Each theme has subthemes open to all, promoting interdisciplinarity. Collaboration within and across themes, as well as with UoA7, is facilitated by fully integrated committee structures at School-level, dedicated research support at College-level and interdisciplinary institutes at University-level.</p> <p><u>Research theme structures and achievements</u></p> <p>Both human and physical geography look outward for collaborations beyond UoA14 but also undertake interdisciplinary work within the unit. This can be seen in, for example, Hannah and Clark's work on mountain ecosystem services for poverty alleviation, our socio-hydrology reading group, and work on urban air and water quality. There is also a significant cross-cutting interest in the use of real-time sensors, including physiological monitoring (Pykett, Jones),</p>

water quality (Hannah, Bradley, Krause) and climate and air quality (Chapman, Ferranti, Sadler and with links to UoA7). This interdisciplinary work is, however, built on the foundation of strong research within the subdisciplines.

Physical Geography (PG): was established as a research theme in 2015 following a review of research strengths within the School. It operates across three subthemes:

Water Sciences remains a major focus of UoA14 and was highlighted as one of our 'particular strengths' in feedback from REF 2014. This area has been designated as one of UoB's research 'hotspots', leading to major staffing investments since 2014, including McDonnell, Ullah, Dixon and Larsen. The subtheme leads the *Water Council*, a joint initiative between UoB and the University of Illinois at Urbana-Champaign [REF5a 2.1.8] delivering world class research around global water challenges. Hannah has been appointed as the **UK's first UNESCO Chair in Water Sciences** and has established a UNESCO UniTwin network on Ecohydrological Interfaces. Theme highlights include developing new methods for meaningful comparison of stream solute transport processes across different discharge conditions and spatial scales (Krause) and the impact case study protecting freshwater fish from high water temperatures under climate change (Hannah).

The Institute for Global Innovation's (IGI), [REF5a 2.3] 'Water Challenges' theme led by UoA14, supports over 20 pump-priming projects with international stakeholders to develop solutions to global water challenges in low- and middle-income countries. This work has produced several projects with a global scope including 100 Plastic Rivers (Leverhulme) and FAR-GANGA (NERC). It has also led to emerging pollutants such as microplastics becoming a central theme for fundraising by UoB's Development and Alumni Relations Office [REF5a 4.1], driving new interdisciplinary research opportunities with industry and public sector partners.

Ecology and Biogeography developed from the strength of our freshwater ecology research highlighted at REF 2014. This expertise has expanded to include terrestrial environments with the appointment of Gauci at Professor alongside Matthews and Graham as Birmingham Fellows [REF5a 3.4.1]. The subtheme has members from across UoAs 14, 7 and 5, focusing on global environmental change issues in a range of systems including tropical forests, peatlands, urban areas and oceanic islands. The subtheme's work spans the theoretical, empirical and methodological spheres including combining large datasets and complex biological models. Publication highlights include demonstrating that there are exceptionally large methane emissions from Amazon floodplain trees with major implications for climate change (Gauci) and that greater attention needs to be paid to the type of species-area curve used in ecological analyses as they can lead to fundamentally different results (Matthews).

Meteorology and Climate has a particular focus on urban climates, statistical downscaling and managing risk from extreme events. There is considerable interdisciplinary collaboration with colleagues from UoA7 as part of activities studying urban air pollution, including the WM-Air project (£5m, NERC). **Applied meteorology** is a key strength of the subtheme, with impact activity around urban sensors led by Chapman, including Birmingham being part of the Urban Observatories network (£8m, UKCRIC). Impact and knowledge exchange activity has been enhanced by EPSRC / NERC KE fellows Ferranti and Jaroszweski working on the implications of climate change for transport and infrastructure. Highlights include Widman's prize-winning monograph which meets the demand from decision makers to produce more useful information

to better manage climate change impacts and Chapman's impact case study transforming decision making in road maintenance using low-cost sensor networks.

The depth and breadth of research within PG is reflected in the range of funders supporting its activities, including NERC, ESRC, EU, Innovate UK, EPSRC, British Council, Leverhulme and the Royal Society as well as industrial partners (e.g. RS Hydro). The PG team have also attracted five highly esteemed visitors to Birmingham via UoB's Institute for Advanced Studies (IAS) Distinguished and Vanguard Fellows schemes [REF5a 2.3].

Human Geography (HG): conducts theoretically and empirically grounded research on the interrelationships between people, place, and environment. It replaced the previous Society, Economy and Environment research theme in 2015, reflecting a **significant expansion** (new appointments starred*), with a realignment of expertise and new facilities. This has allowed HG to build on the strengths highlighted by REF2014 in political geography and geopolitics (appointments of Kama* and Richardson*) and qualitative methodologies (investment in the Playful Methods Lab, see 3.3). Theme members are driving international research agendas in carceral geographies (Moran, Griffiths*) and children's geographies (Kraftl*, Hadfield Hill*). There has also been significantly expanded expertise in LMIC contexts (Sugden*, Kuznetsova*, Cornea*, Clark, Round, Noxolo*, Hadfield-Hill*). Five research subthemes have been developed:

Adapting to Energy and Environmental Uncertainties is concerned with societal adaptive capacities and strategies for energy transitions and environmental change. This includes pioneering work by Day on the capabilities of local communities to address energy uncertainties (AHRC), and Kraftl's exploration of the food energy water nexus in coastal Brazil (ESRC-Newton-FAPESP).

Geopolitics and the Carceral explores the opening and closure of space through geopolitics, the tensions and power dynamics behind these spatial processes. Highlights include Richardson's* examination of hyperreal borders in the Kuril islands and Moran's world leading analysis of the spaces of carcerality and recidivism which forms one of our impact case studies.

Urban and Regional Studies focuses on dynamic change in the world's urban areas, resilience and adaptation processes. Highlights include Round and Kuznetsova's* examination of how migrants and immigration policies reconstitute urban spaces (Open Society/British Academy) and Lee's USE-IT project (ERDF) collaborating with Birmingham City Council and other regional stakeholders on the implementation of a major new urban redevelopment project.

Embodied Geographies examines the intersections between bodies, landscapes and materialities in explaining humans' interaction with the world. Highlights include Pykett's work on the intersection of neuroscience and geography, Noxolo's* examination of the embodied securityscape and Jones' work on digital geographies.

Geographies of Children, Young People and Education was established following investment from IAS [REF5a 2.3] in 2016 creating the UoB-wide *Children and Childhood Network*. This is an interdisciplinary group bringing together over 130 academics working on a range of themes (including environment, health, technology and community) in projects worth over £15m. Highlights from within UoA14 include Kraftl's* cutting edge monograph exploring the relationship

between children and the environment and Hadfield-Hill's* impact case study examining the position of children in the design of new settlements in the UK and developing world.

The depth and breadth of research within HG is highlighted by the range of funders supporting its research, including ESRC, AHRC, NERC, EPSRC, ERDF, H2020, FAPESP, Marie Curie, Leverhulme, Wellcome Trust and the British Academy. Oldfield* and Kraftl* have secured prestigious Leverhulme Fellowships.

HG has a strong emphasis on interdisciplinary working, with members **leading cross-campus activities funded by the IAS**, including: Intercontinental Academia; the Children and Childhood network; Bodies 2.0; Dancing Maps; and Atmospheres of Terror and Security. HG also hosted Mark Paterson (University of Pittsburgh) as part of an IAS Vanguard Fellowship. The strength of this interdisciplinary activity has been reflected in theme members leading and contributing to large-scale UKRI consortium projects, including a significant GCRF component as well as connections to physical geography and UoA7, for example: young people and the food, energy, water nexus in Brazil; planning education in South Africa; citizen science for water-dependent ecosystem services in Nepal, Peru, Kyrgyzstan and Ethiopia; and narratives of change around droughts and floods in Southern Africa.

1.2 The unit's research objectives and strategy during the assessment period and next five years

Objectives underpinning the 2014-21 research strategy

Research strategy in UoA14 is driven from the bottom up. Discussions at research theme-level are used to inform wider strategy via the School Research Committee. This Committee comprises the Director of Research, Research Theme leads, REF leads, an early-career representative and facilities leaders, meeting every two months.

Three future objectives were identified at REF 2014: i) to enhance our culture of interdisciplinarity; ii) to reinforce our international partnerships and; iii) to grow strength in our areas of excellence. We subsequently refined and expanded the ambition of these, underpinned by the reorganisation of our research theme structures. Our strategy for the 2014-21 REF period has therefore been guided by five core objectives:

O1) Enhance interdisciplinary expertise: increasing the permeability between research themes and between UoA14 and UoA7; promoting activity within and beyond the discipline; and substantially expanding staff numbers.

O2) Invest in areas of strength: existing 'hotspots' such as water sciences received significant internal investment during this REF cycle, while other areas of strength such as climate, biogeography, political geographies and advanced methodologies have been enhanced through investments in people and infrastructure.

O3) Strengthen international leadership and collaboration: including the appointment of Hannah as the first UNESCO Chair in Water Sciences. The unit has also taken advantage of institutional partnerships in Brazil, India, China, the EU and North America [REF5a 2.1.8] to enhance our research power through joint activity with world leading centres.

O4) Developing senior leadership in human geography through hiring a new 'global professor' (Kraftl) and developing/promoting mid-career staff (e.g. Moran and Oldfield to Professor, Clark, Lee and Jones to Reader).

O5) Refining internal processes to facilitate research excellence with an emphasis on enhancing EDI via: introducing pump priming schemes for innovative research and impact activity; extending the reach of study leave; strengthening internal review of research grants and papers; and offering mentoring for staff at all career stages.

Delivering the 2014-21 research strategy

UoA14 has produced internationally leading research in **water sciences**, the **carceral, biogeography, children's geographies, meteorology, geopolitics** and **qualitative methodologies** among other areas. These specialisms are characterised by a significant degree of interdisciplinarity, with growing expertise in low- and middle-income country (LMIC) contexts. As we enter the next REF cycle our trajectory sees us extending our leading role within the increasingly challenge-focussed international research landscape. This is driven by the unit's proven capacity to flexibly assemble interdisciplinary teams to deliver world-leading theoretical and applied projects (O1, O3).

Research in UoA14 has been significantly enhanced through new appointments during this REF cycle: UoA14 is returning **40.2 staff** (up from **28 eligible staff in REF2014** of which 27 were returned). This includes 11.7 female staff and 3 BAME staff (up from 5 and 1 at REF 2014). Expanding staff numbers alongside improvements in research support and mentoring have resulted in a **significant growth in research income** during this REF period. In seven years, 2013/14-2019/20 researchers in UoA14 generated £13.12m compared to £6.13m across the five years of the previous REF cycle (O2, O4, O5).

Interdisciplinary collaboration specifically between UoA14, UoA7, UoA5 and UoA8 has also helped to drive **research facility investment within the School to over £21.8m** 2014-2021, not including investment from research grants. The School also has a 25% share of UoB's new £80m capital investment in a Molecular Sciences laboratory building, due to open in 2023 [REF5a 4.2.1], with 6 UoA14 staff due to move to the new facility. Other examples of our leading interdisciplinary research include the **Urban Initiative, EcoLaboratory, the Water Council** (jointly established with University of Illinois Urbana Champaign), the UKCRIC **Birmingham Urban Observatory** and the **Children and Childhood network**. UoA14 also plays a leading role in **five interdisciplinary doctoral training programmes** including NERC-CENTA2, Leverhulme Forest Edge, NERC-ESRC DREAM (Data, Risk and Environmental Analytical Methods) and regional DTPs for ESRC and AHRC (O1, O3).

The unit is home to major initiatives and facilities with reach across the College, University and, in many cases, internationally. A highlight in this regard is the **Birmingham Institute for Forest Research (BIFoR)** [REF5a 4.2.3] which has matured during this REF cycle (see 4.5). Created with a £15m gift from the JABBS Foundation and £15m from UoB, this unique institute takes a **social and natural systems approach to understanding forest environments**, integrating activity from the terrestrial through to the atmospheric, including close collaboration with both UoA7 and UoA5 (O1, O2, O3).

Equality, Diversity and Inclusion (ED&I) is embedded in all operational and decision-making activities and is a standing agenda item on all School Committees. The ED&I Committee includes academic and professional services staff, varied contract types and PGRs, with a range of abilities, ages, ethnicities, religions and sexual orientations represented.

Research Committee and the ED&I Committee both input directly to the School Executive Committee and College Board (O1-5).

Our **investment and growth has been maintained since the start of the Covid-19 period**, with new appointments (including Graham) being made, promotions processes operating as normal and capital spend on facilities such as the Molecular Sciences Building continuing.

Objectives underpinning the 2021-26 research strategy

Building on our strategy for 2014-2021, our renewed research structure enables UoA14 to lead the increasingly challenge-driven research agenda to 2026 and beyond. This aligns with the wider UoB strategy [REF5a 2.4] to significantly increase research as a proportion of the university's activity by 2026 as we emerge from the uncertainties of the Covid-19 period. To deliver on these aspirations, the objectives for 2021-26 in UoA14 are to:

- 1) **Establish Birmingham as a global centre of excellence for research in water sciences and in urban studies** by capitalising on investments made 2014-20. This will build upon the creation of the *Water Council*, the IGI-funded [REF5a 2.3.3] Water Challenges theme and leading the *Urban Initiative* (see 4.5).
- 2) **Deliver additional investment in infrastructure and equipment**, including the £80m Molecular Sciences building [REF5a 4.2.1] currently under construction and continued investment in BIFoR [REF5a 4.2.3] and EcoLaboratory.
- 3) **Increase the proportion of female staff**, particularly in Physical Geography, aspiring to bring the proportion of female staff above the average for UK geography departments (>37%). Investment in this area will continue notwithstanding Covid-19.
- 4) **Increase the numbers of female and BAME staff in senior roles** via enhanced support and mentoring to improve promotion success alongside recruiting to new posts.
- 5) **Further enhance support for engagement and impact activity** both through expanding regional links and capitalising on investments in LMIC expertise to generate interdisciplinary projects tackling global challenges.
- 6) **Continue to bring taught students into the research culture of the School** including embedding UG/PGT students in staff research 'labs' for project work in both human and physical geography.

1.3 How the unit has sought to enable and facilitate the achievement of impact arising from their research

There has been **continued investment to develop impact activity** building on the unit's strength in this area recognised by REF 2014. The key underpinnings of our impact strategy are i) investing additional resources, ii) training and mentoring, iii) embedding impact in all grant applications, iv) enhancing activities with external partners.

The UoB strategic goal 'Expand the impact of our research' [REF5a 2.1.3] has helped increase the proportion of impact-centred research. The College has a new Business Engagement team helping to deliver UoA14's engagement strategy by proactively cultivating new partnerships and enhancing existing relationships. **College-level engagement and impact funds** are available to work with partners at all stages of project development; **School-level funds** facilitate face-to-face meetings with industry.

Chapman's sector-leading impact expertise led to his appointment as the College Deputy Director of Research and Knowledge Transfer; he has also served as a member of the NERC Innovation Advisory Board. He runs the School's '**engaging with engagement**' activity, which

includes dedicated sessions at School meetings and annual retreats as well as bespoke workshops. The effectiveness of UoA14's investment and support strategy can be seen in the diverse range of impact case studies contained in this submission.

We have achieved a sustainable pipeline of impact activity by placing relationships with end-users at the heart of our grant application process. Moran's international work with prisons, for example, highlighted the relationship between poor environments and recidivism through a series of impact-led projects. Similarly, business engagement schemes run by the research councils e.g. Knowledge Transfer Partnerships (KTP), CASE PhDs and the industry links embedded in DTCs such as NERC-CENTA are used as a tool to build trust with end-users. A KTP with RS Hydro resulted in the project's research assistant winning Innovate UK's Young Business Leader of the Year 2016.

1.4 The submitting unit's approach to supporting interdisciplinary research

A culture of interdisciplinary working is built into the unit's approach to research, through i) **encouraging colleagues to sit across multiple research subthemes**, ii) integrated research management at School- and College-level to encourage collaborative projects including via dedicated funding, iii) significant engagement with the UoB structures promoting interdisciplinarity.

UoA14 is a major hub for interdisciplinary activity across the wider College and University. The **Urban Initiative**, for example, was developed to integrate our critical mass of expertise across Infrastructure Resilience and Urban Planning, Urban Ecology, Pollution and Environmental Health Sciences, connecting to colleagues in Engineering and the Business School (see 4.5). We also received significant University and College investment during this REF cycle to support interdisciplinary facilities such as BIFoR [REF5a 4.2.3], EcoLaboratory and the Playful Methods Lab (see 3.3). The School also provides targeted funds for novel early-stage research with an interdisciplinary focus.

UoA14 has been central to developing the agenda of UoB's Institute for Advanced Studies / Institute for Global Innovation (IAS/IGI) [REF5a 2.3]. This deep involvement is signalled by Moran being appointed Deputy Director of IAS/IGI [REF5a 2.3], while Krause leads the inaugural IGI theme 'Water Challenges'. In its first year alone, the Water Challenges theme led to externally-funded collaborative grants for Ullah (Newton) and Krause (NERC). UoA14 researchers also led 14 IAS workshops 2014–2020 providing opportunities to explore collaborative interdisciplinary opportunities around blue skies topics.

1.5 Progress towards an open research environment

The School's Director of Research (Sambrook Smith) sits on UoB's Open Research Board [REF5a 2.2] and is an **open research champion**. A School-wide strategy on Open Research has been developed and applied in UoA14, recognising the benefits of openness for both the academy and wider society. Key actions include:

- 1) **Maximising Open Access publications** by: accessing UoB funds for Gold OA of key papers not supported by the RCUK block grant; requiring Green self-archiving of all research outputs wherever possible on our institutional repository; and encouraging posting of pre-prints in appropriate subject-specific repositories.

- 2) Establishing an **interdisciplinary Open Research joint working group** for UoA14 and UoA7 which runs **Open Research training sessions** and briefings as part of School Retreat, induction meetings for new staff and research theme meetings. Good practice is also shared via the School newsletter.
- 3) Training about **open data sharing via subject-specific repositories** and the UoB Research Portal in line with the Concordat on Open Research Data.
- 4) **Promoting work to non-specialist audiences** by encouraging members of UoA14 to run/contribute to research blogs, produce articles for platforms such as *The Conversation* and deliver public talks e.g. via our *Lapworth Lates* programme. This activity is supported by the UoB Public Engagement team and the College Research Communications officer.
- 5) Tweeting links to UoA14 Green and Gold OA **papers of relevance to the GCSE and A-level curricula** as part of #teachertuesday

Our climate facilities¹ and BIFoR² [REF5a 4.2.3] are exemplars of providing open data via live feeds and there are plans to extend this to ecological and other datasets. Another highlight is a collection of open access R packages created by Matthews which fit the gambin distribution to species-abundance distributions from ecological data. These have attracted c.500 downloads per month from GitHub.

1.6. How the unit supports a culture of research integrity

UoA14's culture of research integrity builds off the approach to open research in ensuring that transparency is at the heart of our research practice. This is supported through i) staff training sessions and briefings (especially for ECRs, see 2.1.3), ii) research theme leaders providing advice and guidance, iii) a programme for postgraduate training (see 2.2.2). These approaches are underpinned by robust institutional processes for ensuring ethical research practices [REF5a 2.2]. All new research projects (staff and PGR), and all research involving human subjects or with other potential ethical issues (e.g. work with animals) are reviewed by the UoB Ethics Team. Undergraduate and PGT projects are subject to ethical review at School level but can be referred to the UoB panel in more complex cases. The University has clear Regulations and transparent, supportive processes for whistle blowing in cases of alleged research misconduct to ensure that research integrity is maintained. UoB also subscribes to the UK Research Integrity Office to provide support and training.

2. People

2.1. Staffing strategy and staff development

Key principles of our staffing strategy are:

- 1) **recruiting new staff** to complement areas of international expertise;
- 2) **increasing the numbers of female and BAME staff** in all roles including tackling barriers to promotion through targeted support and mentoring;
- 3) developing and promoting colleagues to **enhance succession and leadership**;
- 4) increasing the numbers of **independently funded research fellows**.

There has been a **major investment in new posts**, significantly expanding the HG and PG teams in UoA14 to 40.2 FTE. For comparison, at REF2014 **27** staff (96% of those eligible) were

¹ <https://data.birminghamurbanobservatory.com/>

² <https://www.birmingham.ac.uk/research/bifor/face/Live-Data.aspx>

returned to UoA17 (PG=13, HG=13, archaeology=1). The HG theme has now been expanded to 21 staff (M=11, F=10) and the PG theme has grown to 20.2 staff (M=18.5, F=1.7). 95% of UoA14 staff are employed full-time, and 95% are employed on open-ended rather than fixed-term contracts.

Strategic investments have been enhanced through **UoB's Birmingham Fellows scheme** [REF5a 3.4.1], a 5-year research fellowship leading to an open-contract academic position (Kuznetsova, Griffiths, Fregonese, Matthews and Graham) and through the appointment of independent fellows (Hadfield-Hill, Kama) into lecturing positions. These appointments have built critical mass in emerging areas of research excellence including ecology and children's geographies.

The School received a Bronze Athena SWAN award (2014 renewed 2019). **Shortlisting and appointment panels pay enhanced regard to equality and diversity** questions, including: adding an ED&I statement to all job adverts naming a female staff member to contact informally; encouraging applicants from underrepresented groups; targeting potential BAME/female candidates through subject networks; use of gender-neutral language; contextualising outputs/achievements in relation to career breaks in our shortlisting processes and interview procedures; only approving shortlists if there is realistic gender balance; and unconscious bias training for all panel members. These efforts have resulted in **a 95% increase in female applicants since 2015, 100% increase in females shortlisted (gender parity reached in 2017), and 320% increase in females appointed**, although the proportion of female staff within the unit remains low, due to the historical imbalance and our high staff retention rates.

2.1.1. Staff development strategy.

Staff follow a comprehensive system of probation, annual appraisal, mentoring and training. Academic staff probation is typically three years framed by a Probationer's Personal Development Plan outlining agreed objectives, combined with mentoring and an **annual Performance Development Review (PDR)** [REF5a 3.4.3]. Peer and thematic **mentoring** are available to all staff (addressing topics such as research focus, time management, career progression for women, adapting to UK academic life). Coaching opportunities provided by UoB's People and Organisational Development team were taken up by 4 UoA14 staff 2014-2020.

A diverse set of **training opportunities** are available. A **new induction programme** developed by the School builds a sense of cohort among new staff, enhances personal development skills and introduces the current HE landscape. CPD opportunities [REF5a 3.4.4] include the University's Research Leaders' Programme (3 UoA14 participants 2014-20), Emerging Leaders' Programme (10 participants) and Senior Leadership Programme (4 participants) as well as the College Rising Stars programme (3 participants). The success of these programmes is evidenced by colleagues from UoA14 taking senior leadership roles at College level (Director and Deputy Director of Research, Director of Internationalisation, Director of Postgraduate Taught Students) and University level (Deputy Director of IGI-IAS).

ED&I training is available to all UoA14 staff. **ED&I is a standing feature of the weekly School Bulletin**, with regular vignettes from ED&I role models, information on events such as Women in Science, Black History Month and UoB LGBT and BAME networks [REF5a 3.4.5]. There have

also been specific themed events such as the 2017 workshop ‘Embodying Geographies: research intensive diversity work’.

The career pathways for **part-time** staff are equivalent to full-time. Promotions panels follow a code of practice which emphasises that: ‘Where a member of staff works part-time, the quantity of their inputs/outputs and other responsibilities will be considered in relation to their working hours.’ Of UoA14 staff being returned to REF, 2 work part-time (1 female, 1 male); this proportion has not changed significantly during the REF cycle.

Staff on **maternity, shared parental and adoption leave** remain on mailing lists (without expectation of messages being read), continue to receive the School Bulletin, and can use ‘keeping in touch’ days to attend research events and meetings (see 2.3.2). Funding is automatically allocated to replace staff on such leave, ensuring colleagues are not expected to take on additional responsibilities. Tailored support is provided for career progression of returning staff and long-term changes can be made to working hours to accommodate caring responsibilities.

Requests for **flexible and remote working** are considered by the Head of School and implemented by the HR team where possible [REF5a 3.4.5]. Flexible working is highlighted in job adverts and options are set out within induction packs. Staff can trial flexible working before making a final decision and it is possible for staff working flexibly to revert to previous working patterns.

Staff are surveyed annually to collect flexible working requests. In the first year implemented (2018/19), requests were received from 19 staff in UoA14, 16 of which were supported. Children are welcome in the School, and we have an ED&I webpage with images highlighting our family-friendly workplace, including male staff and same-sex couples as family role models. Research seminars and key meetings are scheduled within core working hours (10am–3pm), aligning to the needs of those with caring responsibilities.

2.1.2. Staffing and recruitment policy.

Disciplinary leadership has been nurtured throughout this REF cycle with 6 promotions to Chair, 4 to Reader and 7 to Senior Lecturer. We acknowledge that the **proportion of senior female research staff within UoA14 remains low** (only 1 of 8 chairs within UoA14 is female). We are actively addressing this through:

- improving the PDR process [REF5a 3.4.3] to include explicit discussion of promotion criteria and how these might be achieved;
- the Head of School proactively encouraging female staff to apply for promotion when ready, plus one-to-one meetings with all staff considering applying;
- dedicated promotions workshops;
- mandatory equality and diversity and unconscious bias training for staff on (gender-balanced) promotions panels;
- appointment of an equality and diversity representative to promotions panels;
- development of an ED&I promotions protocol/checklist.

This has led to increases in this REF cycle in female applicants and success rates for promotion (25% of applications 2014-20, 38% successful compared to 33% successful for male applicants). We recognise that we have more to do here. Increasing the proportion of female research staff, particularly in physical geography through pro-active recruitment, and increasing

the numbers of senior female staff across the unit, are priority actions identified within our Athena SWAN Bronze award.

2.1.3. Support for early-career researchers (ECRs).

UoA14 has a vibrant community of ECRs. These include externally and internally funded independent fellows, including 5 via the Birmingham Fellows scheme [REF5a 3.4.1]. We support independent research fellows to become competitive applicants for open-ended staff positions at UoB or externally, with 4 UoA14 staff making this transition 2014–2020. ECRs are provided with specialist training opportunities and mentoring as part of their induction and probation (see below and 2.1.1 above). **Independent fellows are treated as full members of academic staff**; postdoctoral research fellows are constitutionally involved in School governance through roles on Research and other committees.

The PERCAT (Postdoctoral / Early Researcher Career Development and Training) initiative provides ECRs access to training courses, career advice, funding opportunities, workshops and other events [REF5a 3.3]. It is designed to meet the principles of the Concordat to Support the Career Development of Researchers and the Vitae Researcher Development Framework. This document is provided as part of the School's Staff Handbook.

In 2018 the School reached gender parity in numbers of academic staff on fixed term contracts, but the majority (77%) on open ended contracts were male. We have established a number of actions as part of our School Athena plan to address this imbalance, including working with PERCAT to provide additional support to female ECRs wanting to secure permanent posts such as training via the Aurora programme.

2.1.4. Policy for research leave for all staff.

Our workload model (see 2.1.6 below) is designed to maximise the time that staff have available for research. Wherever possible, the majority of an individual's teaching is concentrated into a single semester to reduce time fragmentation. We enhanced our study leave programme in 2014, encouraging staff via the PDR process to take academic leave to develop their research activity. The programme is open to all academic staff (full or part time) who have worked at Birmingham for at least three years. In 2014–2020, 4 male and 5 female staff within UoA14 took study leave. Applications are particularly encouraged where staff with significant caring or other responsibilities are seeking to enhance their research activity.

2.1.5. Procedures to support exchanges between academia and business, industry or public or third sector bodies.

Our Business Engagement Lead drives the UoA14 strategy for impact and knowledge exchange, meeting monthly with the College Research Support Office and a dedicated Business Engagement Partner. Rapid response pump-priming funds at School-level facilitate knowledge exchange activity. Our recruitment strategy considers impact potential, and utilisation of KE Fellow schemes boosts the number of impact-focussed staff. Staff are supported in undertaking consultancy (examples in 4.3 below) and CASE studentship applications as a route to build larger scale business engagement.

2.1.6. Recognition and support for staff delivering research and impact.

Staff in the School led the development of principles and tariffs for the College-level workload model calculating research, impact-activity, teaching and administrative load. All UoA14 staff were invited to validate the weightings used in the model which were built on best practice elsewhere in the UK. Data are gathered annually and used to inform discussions in Personal Development Review meetings where workloads and annual targets are examined. **Where new grant or impact activity has been secured, teaching and administrative roles are redistributed.** The workload model includes a standard tariff for citizenship duties, with FTE-adjustments for part-time staff, and is monitored annually for gender bias.

Research theme leads receive an **annual research allocation** of £500 per staff member to support conference attendance, away days, writing retreats, small pieces of equipment etc. Funding for **international networking activities** is available via the UoB International Office and dedicated College funds.

In line with the Knowledge Exchange Concordat, **impact is viewed as having equal importance to blue-sky research** and this is reflected in the promotion criteria (e.g. Moran and Chapman were promoted to Chair based partly on their impact activity) [REF5a 3.4.6]. The workload model ring-fences time to develop impact activity. Training is also provided in many aspects of impact including public engagement with research, policy and commercialisation (e.g. the flagship Medici programme for research staff wanting to explore the commercial potential of their work).

At University level, Impact is celebrated through annual Impact Awards at which we have had great success (e.g. Moran, overall winner for Impact in Society category 2018 alongside Hannah and Ferranti who were both shortlisted, with Chapman overall winner for Outstanding Impact in Technical Innovation 2019).

2.2. Research students

Research doctoral degrees awarded in academic years 2013/14 to 2019/20:

2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	Total
9.50	11.00	12.51	15.75	8.35	11.5	12.85	81.46

2.2.1 Recruitment and funding

PGRs aligned with UoA14 are funded through three pathways: doctoral training partnerships (DTPs); overseas scholarships; self-funding. The **College PGR Studentship Fund** also offers partial support, typically 25%. **UK/EU PGRs based in UoA14 have access to 5 major DTPs:**

- NERC (CENTA2, £8.1m 2014-22, led by UoB);
- AHRC (4 Cities);
- ESRC (Midlands Graduate School);
- ESRC-NERC big data and risk (DREAM);
- Leverhulme (Forest Edge, £1.05m, led by UoB).

Co-led with UoA7 CENTA2 is the joint-largest NERC DTP, expanded by 50% at renewal in 2019. Forest Edge is linked to BIFoR and made 20 studentships available 2018-20 with interdisciplinary projects across physical and social sciences.

2.2.2. Monitoring and support mechanisms

Students undertake a Development Needs Analysis (DNA) annually with their supervisors to identify skills gaps and training opportunities, including around research ethics. Supervisions take place at least monthly with a formal record made of progress and agreed actions. PGRs have a documented Postgraduate Board meeting every six months with the PGR lead, their mentor and supervisory team. These ensure the project is on track and the supervisory team is working in the interest of the PGR. Based on this meeting, further support interventions can be put in place.

Enhanced support for PGRs was implemented throughout the Covid-19 pandemic, with supervisory meetings and Postgraduate Boards continuing as normal online. Evolving impacts on PGR work were recorded within these meetings, providing support as well as documentation for extension applications. Social support structures were co-constructed with the PGR community and continued after the initial period of lockdown.

2.2.3. Skills and career development

Campus-based training courses for PGRs are curated by the Graduate School, giving access to modules from across UoB [REF5a 3.2]. There are significant regional training opportunities available through the DTPs for NERC, ESRC and AHRC. **McDonnell** leads our prestigious Catchment Science Summer School. **Unique international training opportunities have also been provided through EU networks** including the INTERFACES and HypoTrain ETNs and the HiFreq RISE ITN. The College has a dedicated member of academic staff who develops PGR training opportunities. The postgraduate careers officer in the University Graduate School [REF5a 3.2] provides training and one-to-one consultations.

The College has a PGR travel fund and resources for supporting PGR organised conferences and workshops. PGRs organise the annual School-wide Postgraduate Conference, where in year 1 they give a poster presentation, in year 2 an oral presentation and in year 3 chair a session. The Postgraduate Conference builds skills in both presentation and workshop organisation. This activity supports the presentation of research at larger international conferences and enhances interdisciplinary interactions across the PGR and staff communities.

2.3 Equality and diversity

2.3.1 Conference attendance and travel support for staff and PGRs with caring responsibilities, ill health etc.

UoA14 staff are eligible to apply for the **College Equalities Travel Support fund**. Up to £500 can be awarded to an individual per year to cover costs around, for example, additional childcare, needing a family member to accompany travel or providing personal assistance relating to disability. Travel funds are explicitly available for support for incoming visits as well as outgoing trips.

2.3.2 Support for staff and research students returning from periods of leave (including parental leave) or ill health, managing long-term illness or with caring responsibilities

Staff on adoption/maternity/shared parental leave have up to 10 optional **'Keeping in Touch'** days. These allow training and development to continue and provide an opportunity to catch up with current developments. Upon return from such leave, staff are entitled to a term of workload remission from one of the three elements of their contract. Where the quantity of academic outputs has been impacted as a result of leave, part-time working arrangements or restrictions on activities due to breast-feeding (e.g. lab work), this is recognised in the promotions processes, REF output expectations and any other exercise that uses quantity of outputs as a performance measure. There are **clear pathways within university policy for flexible and part-time working practices** as appropriate for the individual, including parental leave, ill health and caring responsibilities. Phased return planning with Occupational Health provides support for those coming back from long-term illness.

2.3.3 Support for staff with protected characteristics (e.g. disabilities) to enable them to research productively

UoB provides training to ensure that the requirements of the Equality Act are well understood [REF5a 3.4.2]. This helps to ensure that structures are put in place for individuals with one or more protected characteristics such that reasonable adjustments can be made where appropriate to working patterns to allow them to research productively. The Employee Disability Service provides disabled staff with practical support and guidance in the workplace, particularly in relation to workplace adjustments.

2.3.4 Approach to supporting staff and PGR wellbeing

The Employee Advice and Listening Service helps staff make informed decisions about work and personal issues. Counselling services are also available via Workplace Wellness. There is a dedicated Harassment Advice Service, Employee Disability Service and University Mediation Service. PGR students have access to the services provided via the Student Hub, including Counselling, Wellbeing, Disability, Mental Health and Learning Support [REF5a 3.4.5]. An annual workplace wellbeing week is held in the autumn term to raise awareness of these services. Events associated with wellbeing have been held at College and School level, including tours of the Lapworth and Map Collections and staff-student netball matches.

2.3.5 Approach to ED&I in construction of REF submission

Within this REF cycle the University launched its Equality Scheme 'Promoting Equality, Valuing Diversity 2016-2020'. This is explicit that: 'As we prepare for our next Research Excellence Framework... we will ensure that equality remains integral to our research activity, particularly in relation to race & age, as well as gender, and is taken into account in our processes.'

All UoA14 staff were given the opportunity to comment on the Environment Template through two rounds of internal review. In line with the UoB code of practice, a School-level panel was convened to review the algorithmically-generated selection of outputs for UoA14 to examine representativeness by gender, BAME, part/full-time status and age using equality impact assessments (EIAs). The selection was approved by College and University panels as an appropriate representation allowing for career stage.

3. Income, infrastructure and facilities

3.1 Funding and strategies for generating research income

Grant income has grown significantly, in line with growth in staff numbers, reaching £13.12m in this REF cycle compared to £6.13m for REF 2014. As highlighted in section 1.1, research themes and individuals have been successful in drawing on funding from a diverse portfolio of sources across RCUK, charities, the EU and industry.

A core element of the UoA14 research strategy has been **flexibly assembling teams across disciplines** for nimble grant applications. The College Research Support Office helps with identifying opportunities, drafting applications, bringing external partners on board and organising mock panel interviews [REF5a 4.1]. This support works in conjunction with a **rigorous system of mentoring and internal peer review of applications** introduced as part of the reconfiguration of research themes in 2014-5. **The success of this strategy has been seen in increasing grant income** during this REF period, with colleagues acting as PIs or major work package leads on grants from 28 different funders. Highlights not detailed elsewhere include projects examining: risk assessments and climate change (Met Office, Leckebusch); the complex processes underpinning hyporheic zones (H2020 ITN, Krause, Hannah); prison visitation (ESRC, Moran) and; the intellectual legacies of Soviet climate science (AHRC, Oldfield).

New hires in HG have created much greater expertise in low- and middle-income countries, which has driven interdisciplinary grant success in the GCRF space. Highlights include: enhancing community resilience to drought in South Africa through arts and creative approaches (AHRC, Day); and examining ecosystem services provision in mountainous regions of Nepal (NERC, Clark and Hannah).

3.2 Organisational structures supporting research and impact

The UoB 'research that matters' strategy supported a unit-level review of outcomes from REF2014. The result has been enhanced support for creating high-quality outputs, impact and business engagement alongside increased research inputs. This support takes a number of forms.

9 staff took **study leave** [REF5a 3.4.3] during 2014–2020, targeting improved output quality. An annual **residential writing retreat** is available to all staff across PG and HG. Research themes also organise **pre-submission review of papers** and **peer review of grant proposals** as well as identifying opportunities to enhance the quality of outputs through additional data collection.

An internal **pump-priming fund** initiated in 2015 allocates funds (£2-5k) for proof-of-concept research and impact activity with potential to deliver world-leading outputs. Applicants face a 'Dragons Den' pitch-to-peers (School Research Committee) to give experience of funder interviews. The fund received 19 applications from UoA14 2015-20 (11 male, 8 female) with 12 receiving funding (6 male, 6 female). The School also uses a competitive bidding process to allocate **£50k annually for small equipment items**.

Both College and University-level funding is available for **international networking activities** particularly for activities relating to LMIC partnerships. There is also funding for work with specific international partners e.g. UoB's strategic link with the University of Illinois Urbana Champaign [REF5a 2.1.8].

The institution has been successful in obtaining **Impact Acceleration Accounts** from all research councils that offer these. In addition, School, College and university-level impact and enterprise funds have been created. All submitted impact case studies as well as other projects in UoA14 have benefitted from these schemes, in many cases extending the international reach of activities.

3.3. Infrastructure

The biggest highlight this REF cycle has been the £30m investment in BIFoR (see 4.5). There has also been major UoB investment (£3.1m plus substantial external funding) to create the **Birmingham Environmental Research Facility** [REF5a 4.2.3], comprising the EcoLaboratory, BAQS, Glasshouses and Meteorological facilities.

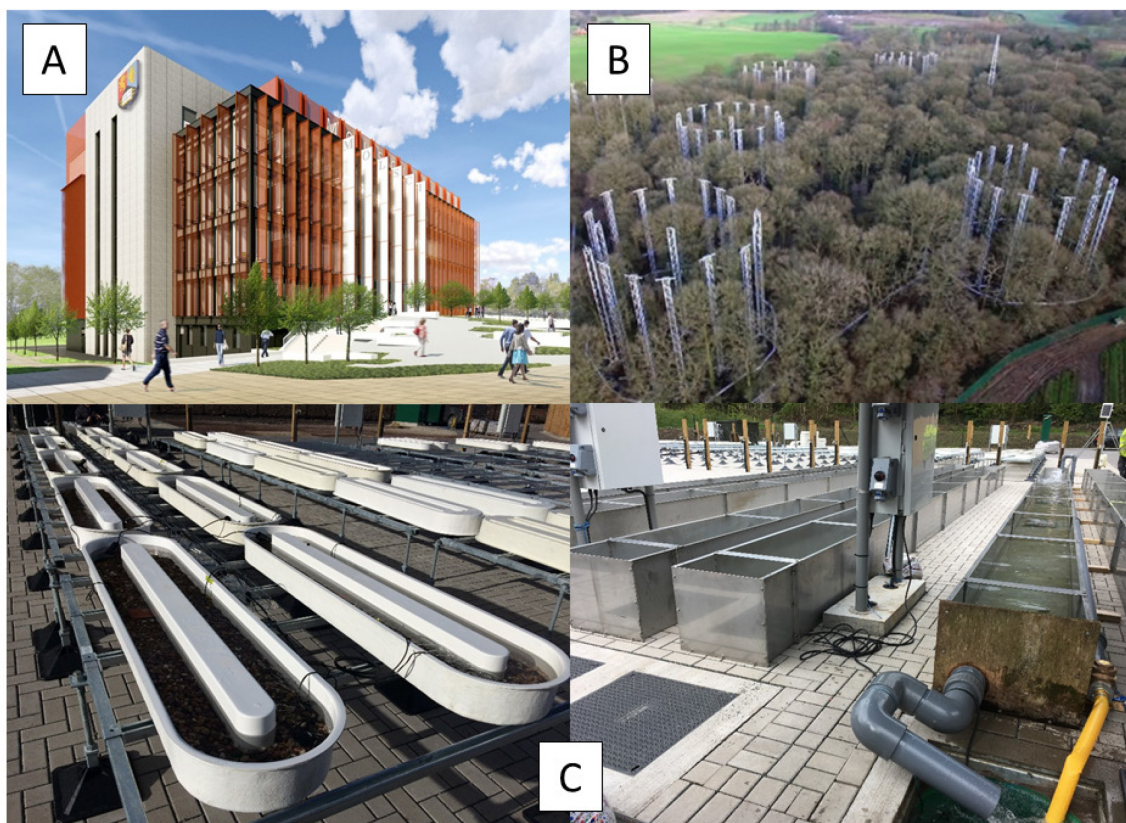


Figure 1: A) Forthcoming Molecular Sciences Building; B) BIFoR FACE; C) EcoLaboratory

EcoLaboratory (Environmental Change Outdoor Laboratory, opened 2017) is a £1.4m UoB-funded facility for producing experimental water and sediment environments **comprising over 100 flume mesocosms**. This is a unique facility in the UK, providing high replication and sensors for real-time monitoring. Built to enable interdisciplinary collaboration, EcoLaboratory provides tools for environmental risk assessment including multi-stressor interactions, alongside novel 'genes to ecosystems' approaches.

BAQS (Birmingham Air Quality Supersite) is one of only three national air quality research supersites, developed through a £670k NERC capital equipment investment (plus ~£100k support from UoB). Operated in collaboration with colleagues from UoA7, BAQS includes advanced instrumentation to characterise gaseous and particulate components of the urban atmosphere. This allows the identification of variation in atmospheric composition due to policy changes and other influences. Data from BAQS is open-access, fed into the national supersite network repository, UoB website and Birmingham City Council's monitoring network.

Meteorological facilities: UoA14 operates two weather stations, one for research and a second integrated into the UK Met Office network. Our meteorological facilities, including the Birmingham Urban Climate Laboratory, have been the base for a number of funded projects during this REF period, notably the **£1.1m investment by EPSRC UKCRIC in Urban Observatories**.

Glasshouses: this newly redeveloped facility, due to reopen in 2021 (delayed from 2020 by the Covid-19 pandemic), has been funded through a £1m Wolfson Foundation award alongside £1.6m from UoB. It provides a series of controlled environmental chambers to study the interactions of plants and biological systems with physical and biological environmental stressors. The facility represents an **interdisciplinary collaboration between UoAs 14, 7 and 5**. The glasshouse features twelve self-contained sub-chambers, varying CO₂, heating, lighting and irrigation. UoA14 staff are using the glasshouses to undertake climate change experiments around greenhouse gas emissions adding value to research undertaken within BIFoR.

Aerial robotics: The miniaturization of sensors is a distinctive element of our interdisciplinary research across UoAs 14 and 7. This includes NERC-funded deployment of meteorological payloads on tame and wild birds for measurements in settings unsuitable for drones. We also have a large fleet of drones for use in aerial photogrammetry and surveying.

Stable Isotope Laboratory: provides state-of-the-art Continuous-Flow Isotope-Ratio Mass Spectrometry (CF-IRMS) for the investigation of environmental and biological samples.

UoA14 researchers also have access to the UoB **high performance computing cluster** (BEAR). This includes high-capacity batch processing, cloud-based virtual machines, rapid data transfer, a Git-style code repository and large dataset storage [REF5a 4.5]. These facilities support the activities of UoA14 scholars particularly working in big data, ecological modelling and meteorology.

The **Playful methods lab** is a **unique facility among UK geography departments** that enables experimentation using different technologies within qualitative human geography research. VR headsets, biosensing wristbands, gaming consoles, touchtable, 3D printer and a portable video studio are available for use by colleagues across UoA14. This was funded in part through the College Basic Equipment Renewal Grant, with the investment reflecting feedback from REF 2014 which noted the strength of qualitative methods research at Birmingham.

The **Peart Map Collection** is one of the largest held by a UK university, with ~500,000 sheets, more than 600 atlases and many rare items. There are regular public engagement events, including activities linked to the annual UoB Arts and Sciences Festival. An IAS [REF5a 2.3]

workshop on the map collection in 2017 attracted interdisciplinary participants from across UoB. Parts of the collection have been digitised for public display on a museum-grade touchtable, the software for which was developed with AHRC funding.

The School hosts the **Lapworth Museum of Geology**, designated an 'outstanding' collection by Arts Council England [REF5a 4.3]. The Museum was subject to an award-winning **£2.7 million redevelopment** 2014–2016. Visitor numbers tripled and the Lapworth was shortlisted for Art Fund Museum of the Year 2017. The Museum runs an extensive schools' education programme, reaching over 15,000 school children in 2016–2020. For staff within UoA14 the Lapworth Museum is a key facility for undertaking public engagement work, hosting a range of events (including 'Lapworth Lates') to showcase research.

Looking forward, construction work has commenced on the £80m **Molecular Sciences Building** [REF5a 4.2.1]. This will be a focal point for strengthening our core research capabilities across campus in the chemical, environmental and bio-molecular sciences. ~6 academic staff (plus associated postdocs, PhD students and technicians) from UoA14 will move into the new building, due for completion in 2023. This will facilitate much greater collaboration between UoA14 and the School of Chemistry.

3.4 Equality and Diversity support in research funding/infrastructure

The School Research Committee has **equality and diversity as a standing item on its agenda** and also within its terms of reference:

'As part of the University's legal Equality Duty, we will regularly consider the potential equality impacts of processes overseen and decisions made by the Committee, specifically where they affect individuals or groups with protected characteristics (age, disability, gender reassignment, pregnancy and maternity, race, religion or belief, sex and sexual orientation, marriage/civil partnership). To these ends we will (1) have due regard to the need to eliminate unlawful discrimination, harassment and victimisation, (2) advance equality of opportunity and (3) foster good relationships between people who share a protected characteristic and those who do not.'

The Research Committee has undertaken an analysis which has shown similar success rates in grant proposals but lower applications by female staff members. Increased mentoring and support have been targeted at female staff in order to improve the rate of applications.

3.5 Infrastructure, facilities and expertise used to create impact

BIFoR and the Birmingham Environmental Research Suite were built with impact-led work in mind. Likewise, scholars within UoA14 are able to take advantage of impact-related expertise from the University of Birmingham Enterprise team [REF5a 4.1], established in 2014 to build relationships with external partners.

3.6 Cross HEI and shared facilities (UK and overseas)

UoB is part of **Midlands Innovation**, giving access to equipment and facilities across Midlands universities [REF5a 2.1.5]. BIFoR features in the UKRI infrastructure roadmap published in 2019. The meteorological facility is part of a national network of urban observatories that have been brought together as part of a £1.1m EPSRC-UKCRIC investment.

3.7 Benefits-in-kind

BIFoR was established immediately prior to the current REF cycle (November 2013) as part of a £15m gift to the University from the JABBS Foundation. Alongside the donation, the Foundation also provided the site at Mill Haft for the Free Air Carbon Enrichment experiment as an in-kind benefit, as well as making the Long Barn available as a research and meeting space. Smaller scale examples of in-kind benefits include the use of NERC facilities by Barrand (Isotope Geosciences Facility) to examine glacial and hydrological change in Iceland.

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

4.1 Collaborations

Researchers within UoA14 have field sites and collaborations spanning every continent and the research power of the unit is significantly enhanced through association with high performing groups and individuals globally. 58.8% of our total Scopus outputs published within this REF cycle were with an international collaborator.

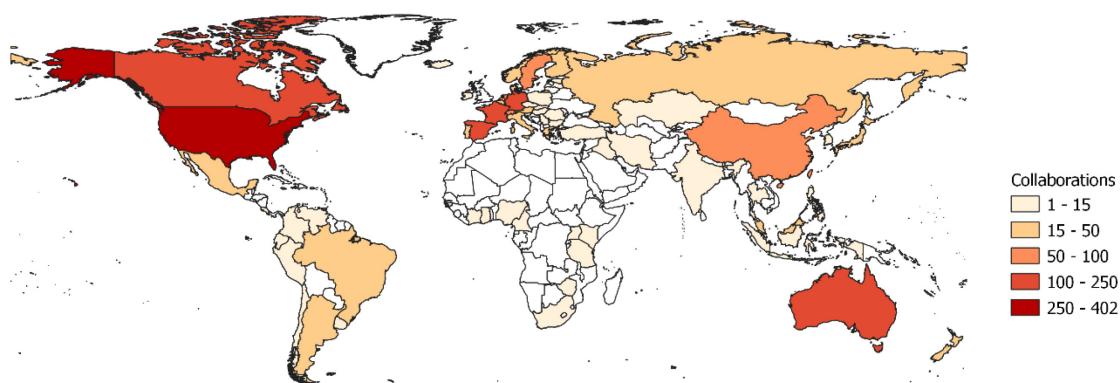


Figure 2: UoA14 colleagues produced Scopus outputs with international co-authors from 69 different countries 2014-2020 (Source: SciVal).

Within this REF cycle, significant working relationships have been forged through grant applications, joint projects, fellowship visits and invitations to give keynote talks in more than 32 different countries. This activity includes **significant engagement and collaboration with global agencies** including UNESCO, water.org, the International Water Management Institute, Panta Rhei, International Centre for Integrated Mountain Development, the UNHCR, UNEP, UN-Habitat and the IPCC. There have also been significant regional and community-focussed activities (examples in 4.3).

UoB has a **Brussels office to facilitate engagement with European partners** and policymakers. Colleagues from UoA14 sit on committees setting the agenda for UoB internationalisation activity. Priority regions are Brazil, China, India and North America, each of which has a dedicated team responsible for promoting engagement, with funds available to pump prime research activity [REF5a 2.1.8]. An example of this is the BRIDGE (Birmingham-Illinois Partnership for Discovery, Engagement and Education) initiative established between

UoB and the University of Illinois Urbana-Champaign. BRIDGE funding allowed the international **Water Council** to be set up between the two institutions. This has led to joint initiatives tackling the issue of microplastic pollution in freshwater systems.

A mapping exercise created a database of all international collaborations within the School and College. This makes it easier to find partners to work on GCRF and Newton fund applications. The College also has an internationalisation fund (up to £1000 per award) to facilitate international collaboration and networking for more junior staff. This fund can also be used to bring key collaborators to Birmingham where staff are unable to travel because of caring/other responsibilities.

4.2 Interaction and development of relationships with key users

UoA14 staff engaged with over 150 different public, private and third sector end users during the period 2014-20 (examples in 4.3). Collaborations range from simple networking and contract research through to formal collaborations on research activity, acting as named project partners, CASE studentships, studentships funded via CENTA, KTPs and other Innovate UK-funded projects.

4.3 Wider contributions not captured by impact case studies

HG members have been highly successful in securing funding for impact-led work. USE-IT, for example, is built around a collaboration with Birmingham City Council and regional partners undertaking a major regeneration project (Lee). UoB's ESRC impact accelerator account has funded projects including examining community adaptation strategies in rapidly eroding coastal areas (Clark) and work with the Welsh Government on mindfulness and behaviour change (Pykett). **PG staff have been particularly successful in using the various NERC funding schemes in developing new technologies.** For example, creating a water quality sensor with RS Hydro via a NERC knowledge exchange fellow (Bradley and Hannah) and developing a groundwater sensor with Silixa via a NERC technology proof of concept grant (Krause). Work aligned with the Industrial Strategy Challenge Fund has been undertaken as part of a project undertaken with major water companies (Affinity, Thames Water) to reduce storm-induced contamination risks to water supply infrastructure using active fibre-optic distributed temperature sensing.

Allied to our impact case study by Chapman, we also have growing **expertise in climate and infrastructure**. Jaroszweski, in collaboration with Network Rail, has mapped the vulnerability of transport networks to weather-induced natural hazards. Likewise, Ferranti has held both a NERC knowledge exchange fellowship and an ESRC Living with Environmental Change fellowship. These have allowed her to explore transport resilience in the face of climate change and produce guidance on the use of Green Infrastructure to improve urban environmental quality, including a new Landscape Standard for HS2. There has also been work at the interface of HG and PG around issues of sustainable water resources led by Hannah and Clark alongside Sugden's work with the International Water Management Institute. Milner worked on the IPCC *Special Report on the Ocean and Cryosphere in a Changing Climate*, acting as lead author on the 'High mountain areas' chapter. Chapman and Hannah also contributed to both the second and third UK climate change risk assessments which inform the National Adaptation Programme.

Members of both PG and HG have been active in **undertaking impact-led consultancy** work during this REF cycle. These include: identifying land management options for solar panel sites; acting as an expert witness on licensing of groundwater extraction representing the first legal test of the Habitats Directive; advising DEFRA and Environment Agency on the implementation of the 25 Year Plan for the Environment; working with the British Council on the use of science in cultural relations in Russia, Argentina and Iran; serving on the Measurement and Policy Advisory Board for the Centre for Thriving Places; advising the Met Office on their new surface observation strategy; working with Birmingham City Council on a regeneration scheme framed by a new hospital development; and providing a geophysical field survey as part of a project cleaning up New York's Passaic River.

4.4 Contribution to the sustainability of the discipline

We have a productive relationship with the Royal Geographical Society (RGS) and have run five **CPD events in collaboration with the RGS** for local secondary school teachers (over 200 participants). An output from these events has been '**Ask the Geographer**' podcasts used in classrooms across the country. We also promote the discipline via our **Explore Geography days for local schools**. Staff in UoA14 have collaborated with PGDipEd students in the School of Education, putting together resource packs on specialist topics for use by GCSE and A-level teachers.

4.5 Exemplars of interdisciplinary research

As has been highlighted throughout this document, interdisciplinary research is a key focus for UoA14 (see also 1.4). An exemplar of this approach is the interdisciplinary **Birmingham Institute of Forest Research (BIFoR)**, bringing together UoAs14, 7 and 5 to **create a step-change in UK forest research**. BIFoR's flagship facility is a Free Air Carbon Enrichment (FACE) experiment which came on stream in 2016 supported by a £15m gift from the JABBS foundation and £15m from UoB. BIFoR FACE assesses the impact of rising CO₂ levels on whole forest ecosystems in mature woodlands. This facility is the only such experiment in the northern hemisphere and represents a significant advance on Phase 1 FACE experiments which used vigorously growing recently planted forests. Mature forests behave differently, especially in critical aspects of water and nutrient cycling, stress responses, resilience and intraspecific competition. Early results indicate increased carbon assimilation and cycling processes in response to elevated CO₂.

BIFoR has a significantly wider remit than managing the FACE experiment, driving interdisciplinary work considering all aspects of forests and forest management. The £1.04m Forest Edge initiative, for example, provides Leverhulme funding to 20 PhDs working between the humanities, physical and social science – 7 of 15 studentships allocated to date have a Uo14 researcher as supervisor. The Institute is also part of a global initiative investigating the effects of climate change on forest ecosystems in different climatic zones, enabling BIFoR to test the wider application of its data. International collaboration puts BIFoR at the heart of discussions on land management decision-making.

Launched in 2017, and led by UoA14, the **Urban Initiative (UI)** acts as a virtual centre bringing together researchers across UoA14, UoA7, the Business School and Engineering. It has **generated original and transformative research based on interdisciplinary collaborations**

between researchers interested in **urban environments and systems**. The UI emphasises partnership with international universities, funding bodies and other private and public organisations. Its primary foci are in the intersections between urban planning, environmental, ecological and health sciences; it currently comprises over 50 academic members, plus postdocs and PhD students alongside alumni and stakeholders interested in the urban.

The UI consolidates considerable expertise in urban research in UoA14 and UoA7 relating to health and environmental changes, risks and resilience (from flooding to volcanic hazards), liveability, biodiversity and greening, as well as urban planning, regeneration and community engagement. This expertise cuts across both the Global North and South spanning physical environments, social practices, policy and future prospects, with partnerships in Brazil, India, China, Australia and Mexico.

The UI has been a catalyst for inter-disciplinary collaborations particularly in the area of environmental changes, including air quality and water. This includes ASAP East-Africa (DFID, £1.2m) and WM-Air (NERC, £5m). Both these projects involve genuine collaborations between researchers based in UoA14 and UoA7 across physical and social sciences.

4.6 Responsiveness to national and international priorities and initiatives

UoA14 has major advantages of scale, low barriers to interdisciplinary collaboration and flexibility of administrative structures that make it well placed to respond rapidly to emerging questions and priorities. This can be seen in successful GCRF, Newton and DfID bids across UoA14. This activity ties into a new emphasis on international development as a UK research priority.

4.7 Wider influence and esteem

UoA14 staff have made important contributions to the vitality and sustainability of the discipline and the broader academy while widening engagement with stakeholders, policy practitioners and publics. **Highlights for this REF cycle** include:

Academic leadership:

- In 2016 UNESCO invited the School to join its prestigious global universities network; **Hannah** became the first UNESCO Chair in Water Science.
- In 2020 **Kraftl** was elected as a Fellow of the Academy of Social Sciences and won the 2020 RGS-IBG Murchison Award, recognising his outstanding work in the field of children's geography. He was also elected as Honorary Treasurer of the Research and Higher Education Division of RGS-IBG Council.
- **Moran** and **Jones** were central to establishing two new working groups of the Royal Geographical Society (respectively Carceral and Digital Geographies).

Colleagues have also served on committees of other learned societies, including: UN Habitat Global Expert Group; British Hydrological Society; UNESCO; Association of American Geographers International Members Task Force; EGU Cryospheric Sciences Division.

Prizes:

- Royal Meteorological Society Innovation Award 2015, the Harry Otten Foundation Award 2017 (€25,000) and Highways UK's 2017 Intelligent Infrastructure Award (**Chapman**).
- Most Productive Young Researcher Award 2015 from the Scientific Commission of the Azorean Biodiversity Group (£500) (**Matthews**).

- Howard Journal 2019 Best Article Prize for work on the prison-military complex (**Moran**)
- PROSE Award 2019 of the Association of American Publishers in the Environmental Science category (**Widman**).
- RGS-IBG Political Geography Research Group Book award 2019-20 (**Fregonese**).
- Editorial excellence award 2017 for work with the Journal of Hydrology (**Larsen**).
- Area Prize for New Research in Geography 2018 (**Dixon**)

Editorial roles: members of UoA14 have served as editors of: Transactions of the IBG; Children's Geographies; Area; Geography Compass; and Eurasia Border Review. They have also served on the editorial boards of 14 major peer reviewed journals.

Grant Panels: UoA14 staff have served on major grant panels, including: Royal Society; AHRC Panel and Peer Review College; ESF College of Expert Reviewers; GCRF Peer Review College; Newton Fund Social Sciences Panel; ESRC Peer Review College; EPSRC Peer Review College; various NERC panels; Innovate UK; NASA Cryosphere Land Ice Panel. Two UoA14 staff have served on the NERC Advisory Network.

Invited keynotes: have been undertaken at a number of prestigious institutions, highlights including UN Habitat, the World Bank, the British High Commission in Delhi, and Columbia University.

International fellowships: have been secured at a number of respected global institutions including: University Louvain-la-Neuve; International Water Management Institute; University of Alberta; Centre for Asia-Pacific Futures, Kyushu University; Japan Society of the Promotion of Science; Institute of Freshwater Ecology Berlin; RMIT University; University of the Azores; University of Melbourne.

Summary

This document evidences the successful strategy to significantly enhance our research environment in this REF cycle. There has been a major increase in staff numbers, reflecting UoB's policy of investing in areas of research excellence. We have restructured our research themes to facilitate a genuine culture of interdisciplinarity to lead the challenge-led research agenda. Major strategic investment has been secured for flagship initiatives such as BIFoR and the Birmingham Environmental Research Facility. Enhanced processes have been developed around staff induction, study leave, pump priming funds and internal review of grants. The success of these measures is seen in low staff turnover, substantially increased grant capture and an increasing number of new fellows. We have developed 'best-in-class' doctoral training, embraced the open research agenda alongside enhanced engagement and impact beyond HEI, while actively diversifying our staff intake. Investment has continued despite the constraints of Covid-19. Our vibrant research environment enables us to deliver world-leading research and impact, now and into the future.