Institution: Buckinghamshire New University

Unit of Assessment: 7 - Earth Systems and Environmental Sciences

1. Unit context and structure, research and impact strategy

This is a new submission since REF 2014, representing the work of an active and growing research group focusing on Earth Systems and Environmental Sciences. At the core of this diverse group are the 2.2 staff with significant responsibility for research (SRR) being entered into REF 2021: Dutca (0.2), Ioras (1.0) and Mather (1.0).

Multi-disciplinary teams are flexibly established to meet the needs of specific research projects, with the additional expert involvement of current and past University colleagues and other external collaborators. Reference is made to staff that left during the REF cycle (Buck), staff retired or that left who still continue to collaborate with the UoA (Render, Sawyer, Williams), post-doctoral research assistant (Bandara) and postgraduate researchers (Grover, Lee, Saatsakis and Winning). The combination of new and existing staff has provided a focus in the areas of Earth Systems and Environmental Sciences for current REF cycle. In 2014 REF Ioras' research on sustainability was reported as Impact case study in UoA19 (Business and Management Studies) and as outputs in UoA34 (Art and Design: History, Practice and Theory). Since than staff work has been aligned with the University's longer term REF strategy around UoA7.

The UoA is highly multidisciplinary and unites quality expertise in forest management, ecology, specific natural disturbance types, forest supply chain management and logistics, remote sensing, wood product markets, forest policy and rural development, water treatment, solar disinfection technology and product design. Furthermore, the UoA supports an interdisciplinary rather than disciplinary work approach. To give an example, carbon footprint assessments involve developing policy and socio-economic scenarios, human impact frequency and intensity scenarios, policy development and simulations using allometry, assessments of ecosystem services and biodiversity outcomes of the simulated resources management development, simulation of the supply chains' functioning in the wake of climate change disturbances, stakeholder-oriented assessments of the resulting full scenarios in participatory workshops followed by a Delphi survey of practicing resources managers. In addition, most of the listed steps will involve participation by the non-academic vested interest parties.

The strategies outlined in the REF2014 document have evolved towards an impactful research approach with 'Effective management of natural resources underpinning a climate change mitigation strategy' and 'Safe drinking water technologies supported by solar disinfection' as new, vibrant and sustainable areas of focus.

With regards to 'Safe drinking water technologies supported by solar disinfection', significant progress has been made towards delivery of the objectives documented in REF2014. The H2020 project "WATERSPOUTT" was successfully concluded, with the publication of several journal articles and the confirmation of a new H2020 spin-off project called "PANIWATER".

- Polo-López, M. I., Martínez-García, A., Abeledo-Lameiro, M. J., Gómez-Couso, H. H., Ares-Mazás, E. E., Reboredo-Fernández, A., Morse, T. D., **Buck, L.**, Lungu, K., McGuigan, K. G. and Fernández-Ibáñez, P. (2019). Microbiological Evaluation of 5 L- and 20 L-Transparent Polypropylene Buckets for Solar Water Disinfection (SODIS). *Molecules*, 24 (11). e2193. ISSN 1420-3049.
- Morse, T., Luwe, K., Lungu, K., Chiwaula, L., Mulwafu, W., **Buck, L.**, Harlow, R., Fagan, G. H. and McGuigan, K. (2020). A transdisciplinary methodology for introducing SODIS to rural communities in Malawi - formative research findings. *Integrated Environmental Assessment and Management*. ISSN 1551-3793.

Research related to 'Effective management of natural resources underpinning a climate change mitigation strategy' has included pursuit and publication of extended theoretical work on the reduction of emissions from deforestation and forest degradation in Zambia.

- Ratnasingam, J., Ng'andwe, P., **Ioras, F**. and Abrudan, I.V. (2014). Forestry and forest products industries in Zambia and the role of REDD+ initiatives. *International Forestry Review*, 16(4), pp.474-484.

Work on economic development and certification non-conformities at European Level was commended by the below listed journal as being Best paper for outstanding contribution to knowledge on sustainable resources management in Europe.

- Halalisan, A.F., **Ioras, F**., Korjus, H., Avdibegovic, M., Maric, B., Malovrh, S.P. and Abrudan, I.V. (2016). An analysis of forest management non-conformities to FSC standards in different European countries. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 44(2), pp.634-639.

Research using historical data on the relationship between site exposure and biomass values, and the predicted modelling patterns that are likely to arise as climate change proceeds led to two publications.

- **Dutcă, I., Mather, R**., Blujdea, V.N.B., **Ioraş, F**., Olari, M. and Abrudan I.V. (2018). Site-effects on biomass allometric models for early growth plantations of Norway spruce (*Picea abies* (L.) Karts.). *Biomass and Bioenergy*, 116, 8-17.
- **Dutcă, I.**, **Mather, R.** and **Ioraș, F**. (2020). Sampling trees to develop allometric biomass models: How does tree selection affect model prediction accuracy and precision? *Ecological Indicators*, 117, p.106553.

The work around the use of wood in residential construction in Malaysia and carbon sequestration in rubberwood plantations was highly acclaimed in two publications, the second of which was bestowed with the BioResources Journal Publication Award for Industrial Impact and was rated as one of the top three articles of 2019.

- Ratnasingam, J., Ramasamy, G., **Ioras, F**. and Parasuraman, N. (2017). Assessment of the Carbon footprint of rubberwood sawmilling in peninsular Malaysia: challenging the green label of the material. *BioResources*, 12(2), pp.3490-3503.
- Ab Latib, H., Cheong, L.W., Halis, R., Kasim, M.R.M., Yi, L.Y., Ratnasingam, J. and **Ioras, F**. (2019). The Prospects of Wooden Building Construction in Malaysia: Current State of Affairs. *BioResources*, 14(4), pp.9840-9852.

Our REF2014 research strategy identified four key foci:

1. Grow external academic strategic collaborations.
2. Grow externally-funded, applied research with external professional and industry partners.
3. Extending social policy research and community projects with a clear applied focus to health and wellbeing.
4. Investment in physical infrastructure.

These strategies are also in line with the University's research strategic goals as specified in the institutional environment statement:

a) increase the volume and quality of research and impact;
b) maintain research and enterprise income;
c) ensure research and enterprise activity enriches the student experience; and
d) secure improved external recognition for the impact of our research and enterprise.

During the REF period (2016/17 to 2018/19), the University implemented a transformation programme to achieve significant efficiencies, and this presented some change for the research focus across the institution coupled with the departure of the longstanding green technology product design lead (Buck). Despite this, progress has been made and it should be highlighted that this new research group has emerged, and derived benefits from historical and continuing domains of expertise at the University, in discipline areas such as, business management and data analysis (submitted under UoA19 in REF2014), product design and environmental engineering (submitted under UoA34 in REF2014). This organisational knowledge and capability has then been adapted and applied to address current global priorities around environment and sustainability. For example, research originating from the Forest Products Research Centre, formerly a leading UK academic department specialising in wood science, has informed and evolved into research directed at the reduction of carbon emissions through more effective forest and wood industry management. The University retains connections and co-operative working with previous employees, including, Render, Sawyer and Williams, and their respective organisations.

Much of the most effective and cited work of the research group is significantly based on collaboration with national and international partners. Inter-disciplinary and transnational working has encouraged creativity in the delivery of research advances and the implementation of solutions. Noteworthy achievements relate to carbon sequestration, decarbonisation, natural resources management and sustainable engineering (climate change mitigation). Many of these contribute to the University's **Energy Strategic Initiative** which seeks to utilise the University's range of expertise through cross-disciplinary projects to tackle the grand technical and intellectual challenges in energy that require integration of science, technology and policy research.

The Earth Systems and Environmental Sciences research group is a small **multi-disciplinary team**. The core disciplines of the team are natural resources management (Ioras and Dutca), GIS and ecosystem services (Mather), carbon footprint and climate change mitigation (Dutca and Ioras). The current REF cycle has also seen a number of research staff move on, including Lyndon Buck (left August 2020). Much of our most effective and cited work has involved significant collaboration nationally and internationally. Many of the major advances to which we have contributed occurred at the boundaries between disciplines; such as carbon sequestration, decarbonisation, natural resources management and sustainable engineering (climate change mitigation). Income for the current REF period can be reported as £1.7 million, which represents substantial growth in comparison to REF 2014, when the team reported £350,000 across two UoAs.

Our research attracts post-graduate students who make a vital contribution to our vibrant research culture. We have **strong collaborative links with industry** (for example, through research on aerial image processing for ecosystem management in partnership with Queensland University of Technology, South32 and other mining sector stakeholders; research on carbon management in relation to marina management in Partnership with La Laguna University, University of Palermo and Frederick University), which exploits our fundamental research advances, provides access to important data, and has facilitated the design and construction of policies. Our **multidisciplinary team** encourages creativity and new initiatives with a high degree of intra- and inter-departmental collaboration.

Whilst this is BNU's first submission for this UoA, the research certainly builds on longstanding expertise in environmental engineering, product design and data analysis, reflecting adaption for current global priorities and sustainability. For example, research originating from the Forest Products Research Centre, now focusses on reduction of carbon emissions through forestry industry management which feeds into the UoA through our participation in three Horizon 2020-funded projects. These projects have focussed on product design for solar water disinfection in Africa and India and natural resource management and its impact on carbon emissions and climate change.

BNU has an **Open Access Policy (2015)** which outlines an institutional commitment to:

- Provide greater visibility for BNU research, benefitting audiences of researchers, practitioners, and the public;
- Ensure long term preservation of outputs;
- Stimulate new research opportunities and collaborations;
- Enable compliance with funders' requirements; and,
- Enable the University to submit to future REF exercises.

The University has adopted the Green route to open access as a sustainable approach. Staff are encouraged to upload all outputs, including conference presentations, videos and original performance pieces, to the repository to enhance public access for their research and improve impact.

BNU participated in the JISC open-data pilot project through GuildHE Research and will explore options to enable sustainable open data sharing through this affiliation.

Strategic aims for research and impact

Our goal is to carry out **impactful innovative research** to make major advances. Our strategy is to maintain strength in several key areas so that we can apply a **broad-ranging interdisciplinary approach** to a wide spectrum of problems, ranging from natural resources management and climate change to the physics and fundamental properties of materials. This strategy is reinforced through **interdisciplinary research** and reflects the overall intention of the university to focus on the needs of external stakeholders and to this end researchers in this unit will join newly formed impact centres that have a wider multidisciplinary and supplier led focus in Environment, Sustainability and Innovation.

The **Buckinghamshire New University Strategy 2016-21** formalised strategic priorities for research and knowledge exchange for the REF period, as follows:

a) Increase research and enterprise income to enable growth and investment;
b) Improve the volume and quality of research outputs to grow international profile for excellence in fields of professional, creative and translational research and enterprise practice;
c) Ensure that Research & Enterprise activity enriches and enhances the student experience;
d) Secure improved external recognition of the contribution and impact of research and enterprise work.

A self-assessment of performance against these objectives within this UoA, can be summarised:

a) Over £1.7 million of research income has been received over the REF period, through a range of Erasmus+ capability awards supporting innovative environmental education and more recently three Horizon 2020 awards. These projects have focussed on product design for solar water disinfection in Africa and India and natural resource management and its impact on carbon emissions and climate change.
b) Submitting staff have been publishing for over 25 years, with over 48 peer reviewed publications produced between 2014 and 2020, compared with 30 in the previous cycle. Staff have been co-opted as editors or reviewers by 12 Peer Reviewed Journals, covering specialist areas, such as, sustainability, forests, conservation, water, remote sensing, to name but a few.

c) A key aspect of research in this UoA has involved the delivery of innovative pan-European educational projects, educating the future employees in the sector, with specific focus on developing expertise and capability within Eastern Europe. These have included the development of an international Master's degree for the environmental security sector to support policy-related projects and activities on two key themes: the international, national and human security repercussions of climate change and biocapacity loss; and, the opportunities, challenges and limitations for security forces to help governments and societies manage, mitigate and adapt to these repercussions. All these in line with the targets identified as part of the EU's Modernisation Agenda (2011).

d) A key example of improved external recognition of research in this area is from impacts on decarbonisation policy changes through research evaluating natural resources management for residential construction with increased use of wood in Malaysia, and frequency of non-conformities on several EU countries including the UK in certification. Research undertaken in the design and development of solar water disinfection technology has already achieved public health impact in Africa with wide potential for further impact in developing water treatment suitable for the removal of CECs (Contaminants of Emerging Concern). CECs are pollutants that can have some deleterious effect on aquatic life and human health but are not yet included in routine monitoring programs.

Major long-term research priorities

Our work can be loosely grouped into three thematic areas to provide an effective way of distributing responsibility for teaching, mentoring and providing support for grant applications. Consistent with our values, we also align our research and impact with the UN's Sustainable Development Goals (SDGs) for 2030.

- **SDG 4 (Quality Education).** European innovative learning environments and education programmes have been developed that stimulate engineering creativity, furniture manufacture and entrepreneurial capability, with a specific focus on Eastern Europe. In line with our widening participation commitment, funding from the OfS National Collaborative Outreach Programme enabled research to underpin development of on-line resources for children in low HE participation areas.
- **SDG 6 (Clean Water and Sanitation).** Our research on developing solar disinfection products has helped improve access to safe drinking water for communities previously relying on unsafe sources in Ethiopia, Malawi, South Africa, Uganda and India.
- **SDG 13 (Climate Action).** Our research has increased the long-term resilience of forest production systems, enhancing environmental impact, and developed innovative aerial monitoring technologies to evaluate remote landscapes in Australia.

Natural resource management and climate change mitigation: The group will be working on topics such as Climate Smart Forestry (i.e. increasing the climate benefits from forests and the forest sector) and on improving the relevance of forest-based mitigation of climate change. Starting from a reality where forest biomass estimations are associated with large uncertainties, our research aims to reduce the uncertainty of forest biomass estimations, improving the relevance of forests within climate change mitigation actions. An improved relevance of forests combined with increased climate benefits from the forestry sector and forests will have a pivotal role in the fight against climate change with an important impact on the economy and society. Our work on climate change-informed policies and practices will continue to investigate ongoing struggles over resources, energy access, land, water and 'space', particularly when these are unlikely to have a climatic cause, and to explore how such intersections ignite, fuel or transform (existing) conflicts or social cooperation.

Environmental and water resources engineering: Urban water systems and water/wastewater treatment in Africa and India. New methods for solar water disinfection in

developing countries have been developed, initially supported by two H2020 projects. Novel techniques have been created to use solar radiation to disinfect polluted water to levels that are drinkable within safe parameters at very low cost. Our work on treatment technologies will be extended to new approaches to neglected water-related diseases in developing countries in collaboration with the natural resources management group.

Remote sensing for monitoring ecosystem quality in mined environments: Mineral extraction licenses are subject to compliance with regulatory standards for the environment. Past work at BNU has been concerned with automating the processing of satellite and aerial imagery to report the progress of environmental rehabilitation and re-vegetation following open-cast mining. Current research exploits the higher definition and stereoscopic qualities of imagery acquired using Unmanned Aerial Vehicle (UAV) platforms. This is now being applied to mapping palustrine vegetation according to type and structure, with a view to monitoring vegetation signals as possible indicators of hydrological changes resulting from mining activities. Much of both past and present work is funded by the Australian Coal Association Research Program (ACARP).

Monitoring of progress against these goals will be conducted by the University's Research and Enterprise Committee. The University's Research and Enterprise committee, a Senate sub-committee, has oversight of all institutional research activity, including research degrees. It has responsibility for ensuring adherence with our Code of Good Research Practice and Research Ethics policies, both revised and updated in 2019. The Committee collates data annually for our compliance statement on the Concordat to Support Research Integrity and investigates any reports of research misconduct. The University Research Ethics Panel has a wide membership from across the University, with oversight of the sub-committees in Academic Schools which review student research. BNU subscribes to the UK Research Integrity Office and has completed the UKRIO self-assessment exercise during the REF period.

2. People

Staffing strategy and staff development

Our strategy for research and impact is to build strength sustainably through the support and development of staff who are either already research active or have that aspiration. Our approach has had considerable success. Our academic staff have diverse backgrounds in a range of disciplines like forestry, mathematics, engineering, product design and economics, with many being involved in more than one subject area. Over the next 5 years we anticipate refilling 1 post which will fall vacant by retirements. Since 2012, we have been able to **refill all vacancies** arising from retirement or resignation with excellent new appointments. The University recognises the importance of attracting the very best staff from both a national and international pool; these new appointments have refreshed our strategic areas and ensured critical intellectual mass in each one. Dr Dutca, a recipient of the **Leverhulme Research Fellowship** (2013-2015) and connected with exploring the technical aspects of carbon modelling of the wood processing sector, has further strengthened the University's research base. Dr Dutca is currently only 0.2 FTE while he is part of the European Commission's ICOS (Integrated Carbon Observation System) Ecosystem Network to improve standardization, integration and collaboration between databases that are part of European research projects. The University has acknowledged the Group's overall performance by institutional investment in the Professorship of Ioras from 2015 and an Associate Professor for Mather from 2016.

Distinguished active **Honorific academic staff** and **collaborators retired from senior positions in industry** contribute significantly to the Group's vitality through their research, experience and ambassadorial roles, fostering commercial interactions and attracting visits from leading international figures. Dr Mike Render has produced the Guidance on State Aid Rules in the UK's Agricultural and Fisheries Sector (https://www.gov.uk/guidance/state-aid-for-agriculture-and-fisheries). Gervais Sawyer is the Chief Editor of International Wood Products Journal. Dr

Hugh Mansfield-Williams is the Technical Manager for the assessment and certification of construction products and systems at BM TRADA. All three have continued to collaborate with the research group on publications and research student support. Honorific Dr Lu Wenming, Subdirector General of The International Bamboo and Rattan Organisation (INBAR), has been supporting the Group to collaborate with the Chinese Academy of Forestry. Ioras and Wenming have been cochairs of the IUFRO Regional Congress for Asia and Oceania 2016 in Beijing and published a number of publications in Chinese journals on forest certification. The Group's reputation, unique research insight and international research collections, combined with opportunities for collaboration, attract visitors of stature; each year we welcome many short-term visitors and 6-8 **overseas academic visitors** staying for a month or more, including some on long term sabbaticals. Prof Ratnasingam of Putra University (2017) and Prof Korjus of Estonian University of Life Science (2016) are just two examples of scholars who undertook such short visits to develop research papers with the group:

- **Ratnasingam, J.,** Ramasamy, G., **Ioras, F**. and Parasuraman, N. (2017). Assessment of the carbon footprint of rubberwood sawmilling in peninsular Malaysia: challenging the green label of the material. *BioResources*, 12(2), pp.3490-3503.
- Halalisan, A.F., **Ioras, F**., **Korjus, H.**, Avdibegovic, M., Maric, B., Malovrh, S.P. and Abrudan, I.V. (2016). An analysis of forest management non-conformities to FSC standards in different European countries. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 44(2), pp.634-639.

Staff development.

All **new academic staff** receive an intensive induction at both research departmental and University level. All researcher development opportunities are run centrally, as outlined in the institutional environment statement, with a specific focus during the period on developing early career researchers. Activities have focused on developing academic writing, research funding bids and research impact. Additionally, staff are supported through central funding to undertake research qualifications, including Doctoral study as many staff join BNU from industry or professional practice in their first academic post.

Our staff research strategy follows the three principles: *Engage; Enable; Excel*.

Engage:
Engagement starts at the recruitment stage where applicants and new staff are encouraged to share their research interests so that synergies with our existing research hubs can be identified. This allows us to identify potential mentors and opportunities within existing projects. This is further enhanced by the university research activity including research seminars, internal research publications, and research student conferences, which allow new researchers to share their work and ideas in a supportive environment.

Enable:
Staff with a research focus have been able to access centralised university funding and support for continued professional development and research development activities. Staff are able to request study leave, remote and flexible working in accordance with Human Resources policy and management support. Part time staff (e.g, Associate Lecturers) are supported by inviting colleagues to meetings focused on research and to share opportunities for career progression (e.g., permanent roles).

Excel:

With central funding arrangements in place from 2014 to 2020, UoA staff were supported to present at international academic Web of science Proceedings Conferences (a support of £5,000). This included:

- **F. Ioras**, J. Kaner, I. Bandara, J. Ratnasingam (2015) University–industry cooperation for supporting sector restructure: wood industry case study, EDULEARN15 Proceedings, pp. 1325-1330.
- Santamarta, J.C., Ritter, A., Neris, J., Rodríguez-Martín, J., García, J.L., Lario-Bascones, R.J., Arraiza, M.P. and **Ioras, F**. (2015). University studies and professional skills in the field of integrated water resources management: the case of Spain. Procedia-Social and Behavioral Sciences, 191, pp.2747-2752.
- **F. Ioras,** M.P. Arraiza, M.C. Gimenez, J. Garcia, F. Garcia Robredo, J. Lopez, C. Cordon, J.C. Santamarta (2016) Development of an e-learning graduate programme in management of sustainable and ecological tourism, in order to get a change in tourist strategies for natural areas conservation, ICERI2016 Proceedings, pp. 3781-3784.
- C. Calderón-Guerrero, M.P. Arraiza, J.V. López Álvarez, **F. Ioras** (2016) Current strategies for student recruitment and retention in forest engineering and environmental-related degrees in Madrid Spain), INTED2016 Proceedings, pp. 3483-3490.
- N. Cruz-Pérez, J.C. Santamarta, J. Rodríguez-Martín, **F. Ioras**, M. Bruccoleri (2020) Incamp: master's degree in the carbon neutral management of sport marinas, EDULEARN20 Proceedings, pp. 151-156.

In 2019 we introduced the BNU Academic Framework (BAF) in part to create a sustainable research culture (Figure 1) by giving greater recognition of and clarity to the diversity of academic roles. The BAF identifies four career pathways, articulating movement between them, and progression from Lecturer to Professor for each:

- Education with Research
- Research with Education
- Education with Professional Practice
- Professional Practice with Education

Figure 1: Defining the themes of Research and Enterprise within the BAF.

The BAF underpins our definition of staff with significant responsibility for research, as outlined in our Code of Practice, and was used to make professorial promotions in 2020. Decisions are made according to clearly advertised criteria. The Director of Enterprise and Research provides personal and individual advice and guidance to staff applying for promotion. BNU uses the principles of the Concordat to Support the Career Development of Researchers to underpin staff development for all academic staff. Its commitment to staff development is reflected in BNU's Learning and Development Policy and supported by centralised funding. In 2019-20, 1 staff was promoted to Associate Professor (Mather). Academic staff are entitled to **paid sabbatical leave** to encourage their research at the rate of one term for every six terms of service, up to a maximum of three terms at any one time; typically 3 staff/year take a term or more sabbatical leave. Mather has utilised two periods of sabbatical leave during his employment with BNU that have enabled him to conduct research on location in Nepal on Community Forest Management (during 1998-2002). He was thus able to progress his work around UAV imagery and reporting vegetation using combinations of conventional image processing and machine learning. Staff are also entitled to generous sick and maternity leave with the opportunity for a graduated return. The support of **Early Career Researchers** (ECRs, including postdocs) is driven by the Learning and Development Policy with a commitment to the three underlying principles of the Concordat to Support the Career Development of Researchers of environment and culture, employment, and professional and career development,.

An **appraisal system**, based on the University's **Performance Development Review** process, reviews all staff on completion of their probation and every year thereafter. It consists of: self-assessment by the staff member; assessment by the reviewer; a face-to-face discussion of progress, training and development needs, and plans for the next review period; and creation of a written action plan. This system is the means of identifying staff track on the BNU Academic Framework, which recognises and clarifies expectations of academic staff roles beyond teaching. Submitting staff within this UoA include Mather and Ioras on the "Research with Education" track, with Dutca employed on a dedicated research contract.

The external funding in this area has enabling continued employment of dedicated research staff. Dutca, undertook a Leverhulme fellowship at BNU to 2012-2013 exploring technical aspect of carbon modelling of the wood processing sector and continues to work on funded projects. Bandara, who completed his PhD at BNU in 2009, is employed to work on a range of EU projects.

Support mechanisms for, and evidence of the training and supervision of, PGR students

Seven PGR students have been registered during the REF period aligned with this UoA. These include two funded full-time PhD students on bursaries through Horizon 2020 projects (Harlow, Russell) and five self-funded (Grover, Marinoiu, Amoah, Lee, Winning). Through BNU core GCRF funding, each of these students has been funded to undertake an additional field trip to Africa and India to support development of their design research (a total of c£3000). University support and development schemes for research students are mirrored by similar schemes for ECRs.

Our research student community is flourishing and diverse. Most are studying for PhDs, typically 1-2 are registered for an MPhil by research. The projects of research students range across the whole spectrum of the Earth Sciences, and a number are jointly supervised with other departments including Materials Science. Some projects are devised and tailored with prospective students. We aim to provide excellent research facilities (e.g. Satellite Imagery - IKONOS and QuickBird, Image Processing Software ArcGiS, Erdas, Flux tower access, Think stations P340, 3D Printing EDS, Wood Specimens and Furniture Design Archives). The Research and Enterprise Development Unit scrutinizes rigorously all studentship projects to ensure scientific viability, sound training for the student, and that all required facilities are available.

Postgraduate recruitment.
Some 3-5 high-quality applications are made each year from those with first degrees in earth sciences, physics, chemistry, mathematics, materials science and biological sciences. About **50% of the applications are from the UK**, with a growing overseas proportion. Short-listed prospective students are invited to visit us for a full day, to discuss their potential projects with supervisors and to be interviewed separately by a panel of four members of staff. Taking into account comments from potential supervisors, the panel ranks candidates by ability and research potential irrespective of field, and offers are made on this basis. **Overseas students** are admitted on the basis of paper submission, references and interviews. Where possible we seek assessments through academics personally-known to us in their home country.

We typically admit 1-2 students each year, of whom about **50% are from overseas self-funded**.

Over 30% of our intake has first degrees in subjects other than Earth Sciences, strongly enhancing a culture of interdisciplinary research. We regularly consult with our long-term **industrial partners** who support these recruitment strategies.

Postgraduate Training and Support.
Graduate students are assessed on entry to determine whether they should attend further courses in mathematics and sciences, computing, statistics or some of our specialist advanced undergraduate courses. In addition, they benefit greatly from exposure to a wealth of ideas, stimulating environment, exceptional facilities, and the **large and active community of fellow** postgraduates. Students are strongly encouraged to attend **Colloquiums** covering the whole range of the Earth Sciences, in order to widen perspectives, expose them to argument and debate, and to develop sound critical judgment. Annually, there are about four such events.

Skills Training is provided in the form of generic courses by the University, and training embedded in the research environment. Overseas students must meet the University's stringent language requirements on admission, but the University arranges extra tuition if language difficulties persist. **Teaching experience** is a valued part of postgraduate education. Graduate students develop their skills by demonstrating in laboratories and on field courses. The more experienced give supervisions to small groups of undergraduates, usually after having attended University-provided courses for supervisors, reinforced by the Department's own written guidelines and subject-specific guidelines.

All students have access to Postgraduate taught modules, in addition to dedicated workshops (e.g., Quirkos, NVivo) and Epigeum's 15 online research toolkit, which includes modules on entrepreneurship, transferable skills, ethics and integrity. In addition to the centralised development activities, as outlined in the institutional environment statement, specific training and conferences funded for these students have included:

- Translating across cultures workshop at UEA
- GuildHE Research Media communication workshop
- Glasgow design conference (Harlow)
- Attendances at GuildHE Research Summer School (Harlow, Russell)

We attach a high priority to students **attending international meetings,** and give training in oral and poster presentations. In these ways they are encouraged to recognize that the communication of science is an important part of research. **Department travel funds** allow us to provide a £150pa travel allowance to every postgraduate, regardless of other support, to help meet the cost of attending conferences or fieldwork.

Equality and Diversity

All staff recruitment and appointments of research positions are in line with institutional policies on equality and diversity as indicated in the institutional statement. BNU is a vibrant, inclusive learning community that strives to create an environment free from discrimination and which actively celebrates and values diversity. We are committed to the fullest equal opportunity. Equality, diversity and inclusion (EDI) underpins our values and influences everything we do, with annual action plans led by an EDI working group, reporting to a new University-wide EDI committee chaired by the Vice-Chancellor.

At undergraduate, postgraduate and postdoc level our gender distribution is very close to 50%. Options for career breaks or secondments are also available and part-time working to support staff at various stages in their career development. We follow all of the University policies and procedures on equal opportunities, disability, and dignity@work. The University has made a submission to renew its bronze Athena SWAN award. BNU is working to develop further accreditations for its EDI work, which include:

- Disability Confident Employer accreditation from Jobcentre Plus
- Mindful Employer Charter signatory
- Commitment to Race Equality Charter, working towards application for the award in 2020.
- Time to Change pledge
- BNU created GTRSBintoHE, a sector-wide pledge to support students from Gypsy, Traveller, Roma, Showpeople, and Boater communities
- HR Excellence in Research - working towards application
- Member of Advance HE, running the Aurora programme for women's leadership development in HE
- Technician Commitment

All staff undertook training on equality and diversity, including unconscious bias. We aim to make reasonable adjustments and supply additional support for staff whose circumstances may impact their research productivity. In preparing for REF, staff were asked confidentially to submit details of any such equality-related circumstances during the REF period; staff absent from work received this request via letter from HR. No equality-related circumstances requiring consideration were declared.

3. Income, infrastructure and facilities

Income

The Group currently holds over **8 research grants with a total value of c. £0.4M**. Research grant expenditure in 2018/19 was over £0.5M. We have worked hard to diversify the sources of our research funding; at present c.**10% is provided by UK based grants** and **90% from EU-funded** projects (amounting to c. £0.5M,). Research grant income from **industrial collaborations (Coal and Minerals Mining, Forestry Commission)** has been between 5-10% over each of the previous 5 years, amounting to over £0.3M during this period. Industry has also provided free use of satellite imaging and analysis and has provided high-quality datasets and commercial software packages for data handling, which helps make this research area less vulnerable to changes in research council funding.

Total research income in the REF period in this UoA is £**1.7M (34.7% of University total)**, aligned with each of the three main themes.

For projects relating to Carbon emissions, a total of £400,000 has been granted to BNU during the REF period. BNU is partner in the Horizon 2020 funded project "Socio Economic Valuation of Climate Impact Chains and Decarbonisation Pathways in European Islands", worth a total of £4m, with £134k going to BNU.

Additional projects have been funded by Erasmus+ funding streams, with BNU leading on "INCAMP - Carbon Neutral Management of Sport Marinas International Master Modules Programme" (£337k) and "Development of a European study program: International Master's Degree for the Environmental Security Sector" (£300k) and as partner in the "European Hub on New Challenges in the Field of Essential Oils / EOHUB" (£119k).

Two papers entitled 'Comparative study of the environmental footprints of marinas on European islands' and 'Marina operation from an environmental point of view' are currently awaiting respective publication in Scientific Reports and Greenhouse Gases: Science and Technology Journals, the reviewing processes having been delayed by the Covid19 disruption.

Remote sensing for evaluating vegetation status has been conducted in partnership with the Queensland University of Technology (QUT) and funded by the Australian Coal Association Research Program (ACARP). Two projects have been funded, "Monitoring hydrological status of complex upland heath communities using canopy conductance and thermal imaging" (£41k to BNU) and "Developing a framework package for change detection in complex vegetation communities" (£45k).

BNU is a partner in two Horizon 2020 projects led by the Royal College of Surgeons in Ireland, providing product design and social science expertise for sustainable solar water disinfection in Africa (WATERSPOUTT: Sustainable Point-Of-Use Treatment Technologies, £141k) and India (PANIWATER Photo-irradiation and Adsorption based Novel Innovations for Water-treatment, £222.5k).

Established processes are in place to ensure BNU research is rigorous, adheres to its Code of Good Research Practice and complies with ethical best practice. Ethical review processes and senior research staff also provide a peer-review role in developing research protocols, to ensure they are completed with rigour and are reproducible.

Further initiatives have been undertaken during the REF period to support and enhance generation of research income.

- Researcher development: 'Getting started in research funding' workshops and grant camps to support writing of a first draft, have supported ECRs to submit their first research funding proposal.
- Project initiation process: A new process was introduced in 2017 to support staff applying for funding, specifically to improve quality of bids submitted.
- In-kind support: Institutional support is usually given to enable staff to apply for research funding which does not cover FEC, supporting staff to build their research profiles. For example, this enabled a successful £2.8m bid to the National Lottery Heritage Lottery for our Chalk, Cherries and Chairs Landscape Partnership with the Chilterns Conservation Board.

Infrastructure

At the organisational level, the university supplements QR (c. £225k pa during the REF period) with its own resources to fund the Research Enterprise Development Unit (RED), staff research activity, and development and dissemination initiatives. The unit comprises the Director of Research and Enterprise, administrators, and a dedicated PGR registrar, together with a Head of Business Engagement. RED has responsibility for the institutional repository, ethical review processes, project management, funding bid support, reporting, governance, REF and KEF. The University has appointed a Knowledge Transfer Manager to establish KTPs across the organisation. In 2020, the university created a Professorial forum to provide a leading role in the intellectual life of the University. In this UoA, members include Ioras, and Mather. The Professoriate will play an important role for this UoA to build public and community engagement.

Over the past 10 years, BNU has invested c. £100m in developing its infrastructure and facilities, including our RIBA-award winning Gateway building, housing state-of-the-art IT and Image processing facilities. Our spaces enable public dissemination of research outputs, and our audio-visual support team enables creation of digital media.

Facilities

The UoA team has access to c. 4,000m^2 of specialist facilities including prototype labs, 3D scanning and printing, in addition to dedicated workshops supported by expert technical staff.

We share resources with other institutions, e.g., our partnership with Queensland University of Technology enables access to state-of-the-art Unmanned Aerial Vehicle survey technologies and facilities for processing large UAV datasets.

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

We are fully engaged with a wide range of international collaborative research programmes and our staff fulfil leadership roles in many World Bank and UNDP initiatives in **Africa (**Public Private Partnership Project Ghana). Since 2012 our staff have led or participated in 19 EU Framework projects in **Europe (3 H2020, 2 COSME, 14 Strategic Partnerships and 1 Knowledge Alliance).** Over 90% of the research outputs we have submitted to the REF involve **co-authors from overseas**, providing a further indication of the level of international collaboration. Collaborative research, in association with smaller **companies,** is currently supported by grants amounting to £0.4M. This work covers a variety of energy-related projects. Many of these contribute to the University's **Energy Strategic Initiative** which seeks to utilise the University's range of expertise through cross-disciplinary projects to tackle the grand technical and intellectual challenges in energy that require integration of science, technology and policy research.

Research collaborations

Queensland University of Technology. Following earlier development of technology for automating image processing for purposes of monitoring the progress of land rehabilitation following open-cast mining (in partnership with the University of Queensland and Xstrata), Mather continued working in partnership with Dr Andrew Fletcher (Queensland University of Technology) and representatives from South32 (mining) and ACARP (funding body). Key outcomes include evaluations of approaches for mapping wetland margins, automation and novel techniques for segmenting UAV imagery and reporting vegetation using combinations of conventional image processing and machine learning with surface models derived Structure from Motion photogrammetry (*SfM*-photogrammetry).

As noted earlier, much of the work of the research group has been conducted in collaboration with other universities. Peer-reviewed journal articles have been published since 2014 based on collaborations with the Transylvania University, Romania; University Putra, Malaysia; Universitad Politecnica de Madrid, Spain; Palermo University, Italy; University of La Laguna, Gran Canaria University, Murcia University, Spain; Frederick University, Cyprus; Madeira University, Portugal; KU Leuven University, Belgium; Estonian University of Life Science, Estonia; Chinese Academy of Forestry-Beijing, China; SLU Sweden, Leicester University, US Forest Service, University of Minnesota Twin Cities, Norwegian University of Life Sciences, Wageningen University & Research (Ioras and Dutca).

Networks

Our culture of interdisciplinary research is fostered by several active **collaborative networks**, including:

- *The Cambridge Centre for Carbon Capture and Storage*. On issues which include 're-shaping'; modeling alternative demand strategies; what alternative models can be drawn upon; anticipating what future shocks might be; how to frame desired choices and actions in relation to climate change (Ioras and Dutca).
- *The ARC Oxford Cambridge University Group*. BNU coordinates work on local nature recovery strategies and the Arc's contribution to the Nature Recovery Network for England (Ioras and Mather).
- *Forest Stewardship Council (UK and International) on issues* which include conservation of IFLs (Intact Forest Landscape) in Ghana (Ioras).
- *International Union of Forest Research Organisations co-chairing session on The role of higher education in promoting sustainable forest management at IUFRO regional congress for Asia and Oceania 2016 in Beijing, China (Ioras).* A paper entitled "The Impact of internet of everything on forestry e-learning education" was presented by Ioras during the session.

Partnerships

Much of the UoA's research involves partnership with users of research; several examples have already been given under other headings. In Climate Change, we have collaborated with government agencies and NGOs in Ghana, Romania, Portugal and Malaysia, to influence public policy, providing the scientific evidence that led to the inclusion of leisure boating in the 2019 Climate Change Act, and subsequent recognition by government that shipping should also been included.

Wider activities and contributions to the research base, economy and society
Conferences:

Our staff are fully engaged with the research community beyond the Group at all levels. In the **international arena** our staff hold key strategic positions such as Co-Chair of the IUFRO regional congress for Asia and Oceania 2016 in Beijing. Several have served on the Appointment review boards of overseas and UK institutions, including Transilvania University, Madrid Polytechnic University, Chinese Academy of Forestry, and Leicester University. They have also participated as PhD examiners for several overseas institutions.

At a **national level** our staff play a significant role in the UK local enterprise partnerships and Newton Foundation. They make important contributions to the dissemination of science as members of the **Editorial Boards** of 7 different peer-reviewed journals (such as Acta Botanica, Open Conservation Biology, International Wood Products Journal, etc.) and act as reviewing or advisory editors to many more. The contributions of our staff to the subject have been recognised by many **prizes** during the past 5 years, including international awards from Chinese Academy of Science Friendship Award.

Our staff contribute substantially to the strategic direction of the discipline by serving in an advisory capacity on scientific matters to a range of **governmental and commercial bodies**. Since 2014 these have included representation on the Board of the Parliamentary Office for Science and Technology *(Ioras),* BP's Technology Advisory Council *(Ioras)* and the COST Action CA16226 - Management Committee (Ioras).
Ioras and Dutca were remembers of the Scientific Committee and Ioras acted as organiser for the stream on "Natural Resources Quality Management" for the Forest and Sustainable Development

Conference, held in Brasov in 2014, 2016, 2018 and 2020. Ioras arranged for this stream to be sponsored by the IUFRO.

Reviewers

Ioras is reviewer for Environmental Monitoring and Assessment, Bioresources, International Forestry review, Land, Sustainability, Forests, International Journal of Environmental Research and Public Health Manuscript, Marine Science and Engineering, Remote Sensing, Applied Sciences and a member of the editorial board for: Acta Botanica, Transilvania University Techology letters, Open Conservation Biology Journal, Notulae Scientia Biologicae, Journal International Wood Products Journal, Journal of Science and Arts Valahia University.

Ioras is also reviewer for H2020 and COSME, Newton Fund, British Council. He has made funding applications related to natural resources management, decarbonisation, and is an external subject reviewer at Technological University Dublin.

Dutca is a reviewer for the following scientific journals: Annals of Forest Science, Annals of Forest Research, Applied Vegetation Science, Biomass and Bioenergy, Central European Forestry Journal, Forest Ecology and Management, Forestry, Forests, Silva Balcanica, Scandinavian Journal of Forest Research. He is also a reviewer for H2020.

Honorary posts, awards

Ioras holds the ‘Chair of Conservation and Sustainability’, the designation of ‘Distinguished Professor of Environmental Ecology (Unitbv)’ and is a ‘Doctor Honoris Causa at Transylvania University, Romania’.

European Cooperation in Science and Technology (COST) frameworks, such as the 'Protected Forest Areas in Europe - Analysis and Harmonisation’. (Ioras)
National representative for the ‘Indoor living space improvement: Smart Habitat for the Elderly’ programme (Ioras)

Dutca has been advisor to European Community for the Land Use, Land Use Change and Forestry (LULUCF) under the United Nations Framework Convention for Climate Change (UNFCCC) part of EU GHG inventory task force.