

UNIVERSITY OF
BIRMINGHAM

BIFoR

BIRMINGHAM INSTITUTE OF FOREST RESEARCH (BIFoR)



Annual Report 2019



Forest Health Research see page 16 for more details

Five week-old oak seedlings growth in controlled environment under ambient (above) and elevated CO₂ (below) conditions.



Photo credits:

Cover image- automated and manual sensors on a tree at the BIFoR Free-Air Carbon Enrichment (FACE) facility. Equipment is measuring stem diameter and sap flow. PhD student Laura Brammeld is helping to take manual measurements of tree growth from the silver dendrometer bands, photo by Prof Richard Norby

Page 1 – Estrella Luna-Diez, University of Birmingham

Page 4 - 7 – BIFoR Technical Team, University of Birmingham

Page 18 – Tom Pugh, University of Birmingham

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Introduction

The Birmingham Institute of Forest Research was formed in 2014 as a direct result of a £15 million donation from the JABBS Foundation that was match-funded by the University. The focus of JABBS funding, and a core focus of BIFoR, is to investigate the impact of climate and environmental change on woodlands and the resilience of trees to invasive pests and pathogens. Central to the JABBS donation was co-funding of the set up (£15M total cost) and running (£0.8M p.a. for facility and core staff) of the FACE facility, the only such facility in the northern hemisphere, and one of the three largest climate change experiments in the world¹. BIFoR FACE has placed scientists at Birmingham in a globally unique position to investigate the impact of climate change on trees. The donation from JABBS, and University match funding, have also enabled the recruitment of new positions, a Chair in Tree Pathology (made possible by a further £2 million gift from JABBS) and bioscientists working on pathology and physiology of trees. In addition, more than 12 academics with expertise in environmental science, including Prof Rob MacKenzie the key academic lead for FACE and BIFoR, have re-aligned a substantive element of their research to work on forest research.

BIFoR would not have been formed without the JABBS donation; JABBS has been instrumental to an explosion in forest research across the University. BIFoR is a virtual institute of over 100 academics, primarily from the schools of Geography Earth and Environmental Sciences and Biosciences but also including members from Mathematics, Engineering, the Business

School, International Development, Psychology, English, and elsewhere. Along with Prof Rob Jackson, Dr Estrella Luna Diez, and Dr Graeme Kettles, recruited directly in response to JABBS investments, the Institute can point to academics at all levels (Profs Christine Foyer and Vincent Gauci, Drs Sami Ullah, Tom Pugh, Christian Pfrang, Andy Plackett, and Liz Hamilton) for whom BIFoR was a deciding factor in joining the University. Through these newly arrived staff and those who have re-aligned their research, BIFoR supports a wide range of forest related projects that address our overarching vision:

“To provide fundamental science, social science and cultural research of direct relevance to forested landscapes anywhere in the world”.

Significant moments in the year include the development of tree pathology research within the national Action Oak initiative. The highly successful Thinking Higher conference, hosted in Birmingham and organised by Estrella Luna Diez, and Graeme Kettles, brought together over 80 international researchers to exchange the latest knowledge across plant pathology and tree research.

The BIFoR team focused on environmental change impacts maintain a vigorous research programme, with notable grants being awarded this year. An assessment score of a ‘perfect 10’ for the FACE Underground project led by Sami Ullah, the QUINTUS £3.7m NERC large grant, and the substantial investments into wildfire research

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by Nick Kettridge and colleagues, stand out as particular achievements.

The team-building touched upon above leads to academic reward. We are delighted to record the elevation to Chair this year for Francis Pope, the adjunct position at University of Alberta awarded to Nick Kettridge, and the Royal Society Research Fellowship awarded to Andy Plackett.

BIFoR is primarily concerned with knowledge-making through its research and educational initiatives, but recognises that such knowledge must be useful and put to work in societal decision-making. The Institute has been involved in shaping the national research agenda, resulting in the pre-announcement of the “The Form, Function and Future of UK Treescapes” [Strategic Programme Area](#) and in the recognition of BIFoR FACE in the national research [infrastructure roadmap](#).

Urban treescapes loom large in the national debates on climate and sustainability. Emma Ferranti, James Levine, and Nick Grayson continue to make a real difference to urban green infrastructure through their close ties to practitioners channelled through the [Trees & Design Action Group](#), the [WM Air project](#), and the soon-to-be-released Green Infrastructure for Roadside Air Quality [GI4RAQ](#) tool. Emma’s [‘First Steps’](#) practitioner guides, the latest of which was published in 2019, are gaining national prominence.

As 2019 ended a new political landscape

emerged. During the election campaign, for the first time, a ‘bidding war’ developed to see who could promise the most tree planting. Rob MacKenzie’s online [perspective](#) on the revived political focus on trees was warmly received (700 views). It advocated the planning of functional landscapes – ‘treescapes’ – rather than a narrow focus on numbers of trees in the ground. Tom Pugh responded to the 2019/20 forest fires in Amazonia and Australia in the [Birmingham Brief](#) ‘The Forests are burning. What does this mean for our climate?’ Susannah Thorpe and Jackie Chappell used the International Day of Forests to advocate that behavioural ecology inform the treatment of chimpanzees rescued from trafficking so that they maintain wild-type behaviour.



The University’s new fundraising and volunteering campaign, Birmingham In Action, also launched late in 2019, and features BIFoR heavily in its focus on climate and environmental resilience. BIFoR exists because of far-sighted philanthropy, and philanthropy continues to make a huge difference to what BIFoR can deliver. The achievements recorded in the following report are testament to the game-changing vision and impetus provided by those who very generously support the work of the Institute.



BIFoR Free-Air Carbon Dioxide Enrichment (FACE)

The [BIFoR FACE](#) facility design has been published* in the international peer-reviewed literature, complete with statistics showing that the system is working superbly well. In 2017, the elevated CO₂ target was achieved for 98% of the scheduled operating time, and cross-talk between treatment and control patches occurred less than 1% of the time. This performance has been maintained throughout the 2018 and 2019 growing seasons. In November 2019, we were alerted by publisher Wiley's analytics company, Altmetric, that the facility design paper was in the top 5% of all research outputs they had ever tracked**.

Research Council investments into the science of BIFoR FACE totalled £6M in 2019: The QUINTUS Large Grant (£3.7M); a UKRI-NSF grant called DiRTS (£1.5M); and the FACE Underground grant (£0.8M) (see page 19). These grants will run concurrently, interacting closely and collaborating with existing projects, such as the University of Manchester-led '[Food Webs](#)' project (£0.8M) and those Forest Edge and other doctoral studentships with a strong focus on BIFoR FACE.

The funded projects cover carbon-nutrient relationships and food web dynamics under elevated carbon dioxide for the first half of the decadal programme, but many aspects remain to be studied.

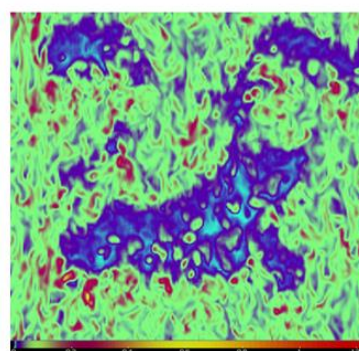
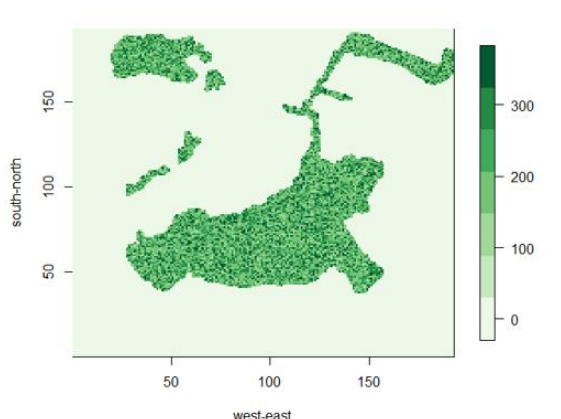
Early results from BIFoR FACE have been presented at international conferences

throughout the year, with particularly strong showings at the European GeoSciences Union Congress (Vienna, Austria) and the World Congress of the International Union of Forest Research Organisations (Curitiba, Brazil).

Many of the parameters measured in BIFoR FACE show some effect of the elevated carbon dioxide treatment (see figure on page 7). An intensive effort is underway to produce the first peer-reviewed papers from these results.

The facility's four meteorological masts came fully on-stream during 2019, making a total of 16 sonic anemometers deployed across the site. These instruments record wind speed and direction 20 times a second and will provide some of the most detailed analysis of flow in and around a forest patch available anywhere, and a suitably stiff challenge to the state-of-the-art modelling being undertaken by doctoral researcher Ed Bannister under the supervision of Xiaoming Cai and Rob MacKenzie (image below).

The human resource at BIFoR FACE is also strengthening. The technical team now consists of seven members: Kris Hart leads Nick Harper, Peter Miles, Gael Denny and Robert Grzesik at the field site, and Selvakumar Dhandapani and Angeliki Kourmouli in the analytical labs on campus. The facility took a very substantial step forward when Giulio Curioni took up the post of BIFoR Data Manager in autumn 2019.



(left) random distribution of foliage across the BIFoR site and neighbouring woodland. The foliage characteristics calculated from point cloud data generated by terrestrial laser scanning inside the BIFoR rings; (right) snapshot of turbulence at a height of 10 m in a moderate northerly wind. Turbulence is mostly low in the woodland (blue and purple shading). However, patches of coherent turbulence are visible in the woodland (warmer colours).

* Hart, K.M.H, Curioni, G., Blaen, P., Harper, N., Miles, P., Lewin, K. Nagy, J. Bannister, E., Cai, X.M., Thomas, R., Krause S., Tausz, M., MacKenzie, A.R., (2019) Characteristics of free air carbon enrichment of a northern temperate mature forest *Global Change Biology*, <https://doi.org/10.1111/gcb.14786>

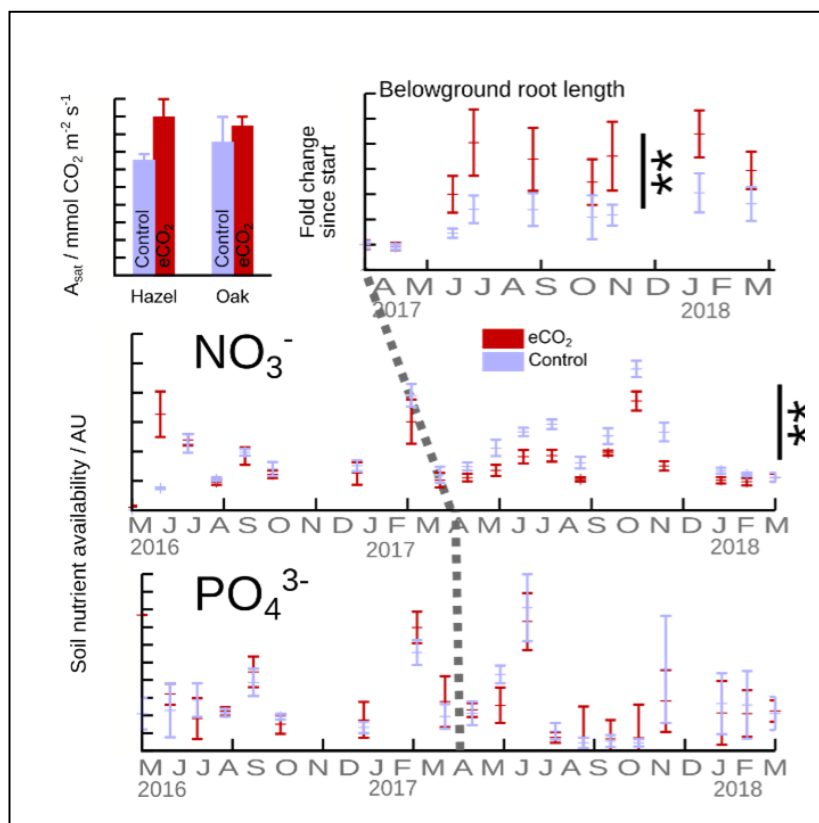
** <https://wiley.altmetric.com/details/64532946#score>



FACE Engineer, Nick Harper working at one of the 4 met masts, work continues throughout the seasons!



The BIFoR technical team climb the 25 metre high masts of each array as part of their winter maintenance programme.



January 2020, sees the fourth national BIFoR community meeting. The science activity underway at BIFoR FACE is shared through a series of presentations and posters available on our website at <https://www.birmingham.ac.uk/biforcom20>

Left: Early indicative BIFoR FACE results showing some prompt and persistent treatment effects. Sabine Tausz-Posch, Michael Tausz, Clare Ziegler, Iain Johnston, Rosemary Dyson, Angeliki Kourmouli, Liz Hamilton, Zongbo Shi, Iain Hartley, Sami Ullah, Kadmiel Maseyk, Alasdair McArthur, Jon Atherton, Kieran Wood, Rick Thomas, Sue Quick, Anna Gardner, Alex Kulawska, all unpublished data.



Establishing a physiological performance baseline of the 5 main tree species in BIFoR-FACE by Carolina Mayoral



Preparing to install new automated dendrometer bands



One of 68 automated dendrometer bands installed in 2019



Fungi identification, by PhD Aileen Baird



Lab based soils research



Invertebrate identification by Liam Crowley (right), Chris Griffin and Laura Brammeld. Image above is a pale tussock moth caterpillar



Liam Crowley on his way up to the canopy to collect invertebrate samples



Deadwood experiment from Dr Moya Burns, University of Leicester



An experiment underway at the Wood Brook river that runs alongside the BIFoR FACE facility



Undergraduate students arrive at BIFoR FACE for a day of sample collecting

Research Collaborators at BIFoR FACE

Throughout 2019 we have continued to work closely with national and international research collaborators, strengthening collaborations with the Amazon FACE, Exeter University, Forest Research, Met Office, and Universities of Bristol, California Davis, Gloucester, Helsinki, Imperial College London, Keele, Lancaster, Lund, Manchester, Reading, Southampton, Swansea, Warwick, Western Sydney and the Open University. Our QUINTUS project (page 19) brings together collaborations from:



Other new collaborations in 2019 include:

University of Leicester

PI Moya Burns has commenced a project to assess the functional contribution of saproxylic invertebrates to wood decay and carbon cycling under changing CO₂ conditions.

University of Warwick

PI Prof Gary Bending, has commenced a project looking at resistance and resilience of forest soil microbial communities to extreme weather events in a high CO₂ world.

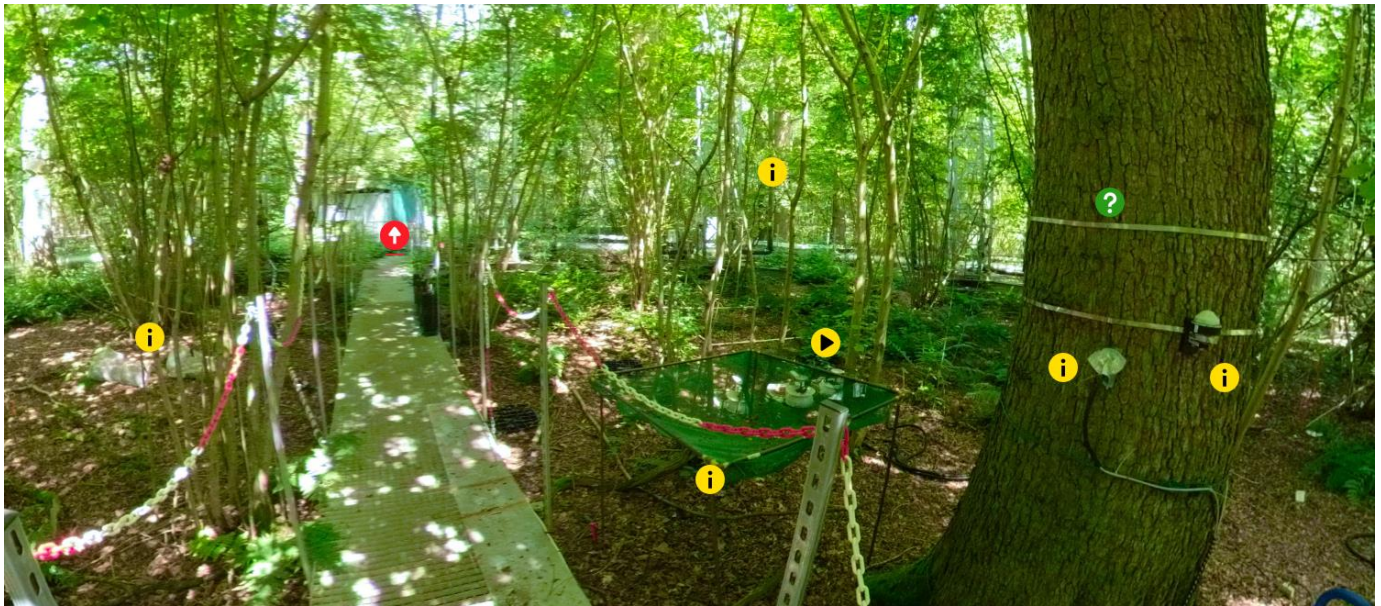
ETH Zurich

PI Tom Crowther requested wood samples to be sent to Switzerland to help his research looking at how atmospheric CO₂ enrichment affect patterns of tree water use.

University of Saskatchewan

PI Jeffrey McDonnell commenced a project looking at how atmospheric CO₂ enrichment affect patterns of tree water use. Magalli Nehemy took the opportunity to take samples whilst visiting as part of the PGR international summer water catchment school visit.

Education



BIFoR has catalysed some game-changing education initiatives at the University of Birmingham. In collaboration with Joe Berry and his team at [Higher Education Futures Institute \(HEFI\)](#) we have developed a number of teaching materials around the water and carbon cycles which are being embedded both in the GCSE curriculum and our own undergraduate teaching.

Virtual BIFoR is available through a public link <https://canvas.bham.ac.uk/courses/41982>. Visitors to the site can explore the BIFoR FACE facility (see image above), clicking on the yellow dots will either provide written information or a video about the experiment. Clicking on a question mark leads to an education resource such as a dendrometer dataset investigating how eCO₂ affects tree growth or a task looking at how fungal pathogens will respond to climate change. It is an exciting opportunity to engage schools and other members of the public who may not be able to visit the FACE site. With the support of the Royal Society of Biology, the Forestry Skills Forum and the Forest Education Network we are growing and disseminating the resource.

A series of internet dashboards will support these initiatives and provide a live window on the work of BIFoR and climate change to the public.

During 2019, we took part in **25** education engagement events and hosted **17 education visits** to the BIFoR FACE facility - including two international summer school visits (Appendix 3).

There are now **26 PhD students** completing research related to forested landscapes and **14** PhD students are working on research directly linked to the BIFoR FACE facility (pgs 13 &14).

In 2019, we had **21 masters / undergraduate students** complete research at the BIFoR FACE facility/use samples from BIFoR FACE. We hosted **3 ERASMUS+** study abroad scheme students and **5** students on the [Nuffield Research Placement](#). Some students have written about their experience on our blog site <https://biforuob.wordpress.com>

Student volunteering with BIFoR has gone from strength to strength. Since we started offering the opportunity to volunteer with BIFoR we have recorded over 2,415 hours.

52 active student volunteers (completed over 5 hours of volunteering)

85 students on the new undergraduate module

14 BIFoR FACE doctoral students

17 educational visits to the BIFoR FACE facility

Leverhulme Trust Forest Edge Doctoral Scholarship Programme

Forest Edge is a Doctoral Scholarship programme (DSP) funded by the Leverhulme Trust. The programme will recruit around 20 PhD studentships over four years and has so far recruited nine people in the first two years (pages 13 & 14), students marked with the * symbol are part of the Forest Edge DSP. At its core, Forest Edge is about exploring the fundamental science, social science and cultural importance of forested landscapes. Projects are rooted in a strongly disciplinary setting, but set out to explore interdisciplinary challenges around themes of: values and meanings of forests, change drivers and resilience of forests in a changing environment, and communication cascades at molecular, ecological and social scales. The key philosophy behind the programme is to provide support for projects and lines of enquiry which would not normally be funded by UK research councils. We are into the second full year of the programme, with the third [recruitment process](#) in full swing (see table). As the programme has become more established there has been increasing engagement from schools and research areas which have not hitherto had strong connections to BIFoR. We anticipate the activities of Forest Edge will continue to reinforce these links and act as a catalyst to strengthen the presence of BIFoR as an institute cutting across all colleges within the university.



Perceptions and preferences for landscape and trees for Natural Flood Management

Image by Forest Edge second year student [Jennifer Knight](#) submitted to the UoB [Images of Research](#) 2019/2020 challenge

Projects advertised for 2020	First supervisor
From branch to forest to globe: How do trees' choices regarding growth affect forest responses to increased carbon dioxide levels?	Tom Pugh
Priming of defence in an elevated CO ₂ world	Estrella Luna-Diez
Investigating how changing interactions between humans and elephants affect forest socio-ecological systems in drylands: A case study of Mukogodo Forest, Kenya	Brock Bersaglio
Forest resilience and recovery through the lens of volcanic disturbances	Seb Watt
Identification of filamentous pathogens in leaves using Raman spectroscopy	Pola Goldberg Oppenheimer
Fusion Forest : securing disease resilience through pattern variability	Bruno Fraga
The impact of somatic DNA variation on tree adaptation and evolution	Marco Catoni
Understanding and improving wind risk assessment for forests - combining geotechnical and wind engineering and plant science	Mark Sterling
Wastewater treatment trees: can forest filters help solve our wastewater crisis?	Philip Davies
Forest Ecology in Fantasy Fiction: Mobilising the Imaginative Resources of Fantasy Fiction for Living with Forests	John Holmes

Doctoral level study

We welcomed 7 new PhD students the * symbol denotes these students are part of the Forest Edge Doctoral Scholarship Programme (page 12)

***Laura Brammeld** - Trees function as highly sensitive and responsive communication hubs within ecosystems; transmitting, receiving and responding to critical information from the environment, often by means of volatile organic compounds (VOCs). “I will be exploring the potential effects of elevated CO₂ and pollutants, such as ground-level ozone (O₃), on the chemical communication between trees and other organisms, by examining qualitative and quantitative changes to VOCs released by trees.”

***Bradly Deeley** - Biological invasion of plant species poses a major threat both to the ecosystem and the economy. My research involves developing a mathematical and computational model of biological invasion, to predict how invasive plants will be spreading when the landscape conditions in the forest are changed by building a road. The main hypothesis I investigate is that roads provide an ideal environment for invasive species to spread.

***Nine Douwes Dekker** – “I will look at the greenhouse gas (GHG) emissions from soil and unravel the role of the soil microbial community. The GHGs considered are primarily methane (CH₄) and nitrous oxide (N₂O). We hypothesise that thresholds of soil water, nitrogen and carbon contents will determine the net fluxes of GHGs, and that the spatio-temporal dynamics of hydrological conditions will play a key role in predicting the ultimate global warming potential of forests with climate change.”

Lavinia Georgescu - Trees are dying from drought - why care? Forests are huge stores and sinks of carbon. Droughts will become worse under climate change - more frequent, hotter, and drier. The extent to which drought plays a role in tree mortality across ecosystems is unknown. This project will use machine learning to find patterns and relationships regarding droughts and forests at a biogeographical level. This scale is most relevant for understanding feedbacks of tree mortality on future climate change.

***Maria Teresa Gonzalez Valencia** - Forests are a terrestrial carbon sink, a home to biodiversity, provide clean air etc. Forest fires threaten these ecosystem services and also pose physical danger to households located on the vicinity. The high and increasing economic costs of forest fires can be reduced if we have a better understanding on the factors shaping the perceived risk of households. By using satellite and house price data our research will identify the size and persistence of the impact of pure information effect on the perception of forest fire risk.

Sophie Mills – “I will be investigating the effect of elevated CO₂ on primary biological aerosol (bioaerosol) production, in particular pollen and fungal spores, in woodlands as part of the BIFoR FACE experiment. Bioaerosols transport genetic material of plants and fungi, can cause and exacerbate severe health issues afflicting humans, and they can act as cloud condensation and ice nuclei, impacting our atmosphere and climate. This research will contribute to informing predictive climate models (e.g. JULES land surface model) used at the Met Office.

Hector Camargo Alvarez - Hector is an agronomist engineer from the Universidad Nacional de Colombia focused in modelling the response of crops phenology, physiology and productivity to environmental factors. During his PhD research, he will try to describe and model the deleterious effect of ozone pollution on cereal production and its economic consequences in China.

PhD students continuing BIFoR-related research

- **Nezha Acil**, global forest dynamics – storm related tree mortality and its influence on global forest cycling. Supervised by Dr Tom Pugh and Prof Jon Sadler
- **Sijeh Asuk**, Population ecology and phenological responses of food-producing forest trees to climate change: implications for rural food security; supervised by Dr Tom Pugh, Dr Nick Kettridge & Prof J Sadler
- **Aileen Baird**, Fungal biodiversity, supervised by Prof Francis Pope and Prof Robin May
- **Ed Bannister**, environmental aerodynamics of the BIFoR FACE site. Supervised by Dr Xiaoming Cai and Prof Rob MacKenzie
- **Alfred Bockarie**, Air pollution emissions from charcoal production and use, supervised by Dr Eloïse Marais (Leicester), Prof Rob MacKenzie and Prof Roy Harrison
- **Liam Crowley**, Insects as key drivers of change in woodland systems under climate change, supervised by Dr Scott Hayward, Prof Jeremy Pritchard, Prof Jon Sadler
- **Edward Eaton**, Stem respiration under elevated CO₂, a joint PhD between BIFoR and Forest Research Our thoughts are with Edward Eaton and his family as Ed has withdrawn for medical reasons.
- **Katy Faulkner**, looking at the resistance and resilience of forest soil microbial communities and greenhouse gas emission to extreme weather events and a high CO₂ world, supervised by Prof Gary Bending (Warwick) and Dr Sami Ullah
- **Anna Gardner**, Leaf physiology under elevated CO₂, supervised by Prof Rob MacKenzie and Prof Jerry Pritchard
- **Richard Hill**, Cotutelle/Dual Award based initially at EucFACE, Western Sydney University. Supervised by Dr Jonathan Plett and Dr Graeme Kettles
- ***Ben Howard**, Coppice management to reduce nutrient loads in forest streams. Supervised by Prof Stefan Krause, Dr Nick Kettridge, Dr Sami Ullah and Ian Baker ([Small Woods](#))
- ***Polly Jarman**, Young people's experiences of and learning in urban woodlands. Supervised by Prof Peter Kraftl and Dr Sophie Hadfield-Hill
- ***Jennifer Knight**, Exploring the desirability of forest landscapes in a natural flood management context. Supervised by Dr Steve Emery and Dr Simon Dixon
- **Thomas King**, based at Lancaster University: Ecophysiology of plant volatiles under elevated carbon dioxide. Supervised by Dr Kirsti Ashworth (Lancaster) and Prof Rob MacKenzie
- **Angeliki Kourmouli**, Soil respiration and biogeochemistry at BIFoR FACE – supervised by Dr Rebecca Bartlett, Dr Liz Hamilton, Prof Iain Hartley (Exeter University) & Dr Zongbo Shi
- **Aleksandra Kulawska**, On thin ice: predicting the effects of future permafrost thaw on boreal forest ecosystems. Supervised by Dr Nick Kettridge, Dr Thomas Pugh, Prof Rob MacKenzie & Dr Sami Ullah
- **Sue Quick**, Tree-soil-water relations under elevated CO₂ – supervised by Prof Stefan Krause and Prof Rob MacKenzie
- ***Eszter Toth**, Focus on Cognition: Can forests balance the brain? Supervised by Dr Ali Mazaheri and Prof Jane Raymond
- ***Bridget Warren**, Development and application of novel ecological and environmental proxies based leaf wax lipids. Supervised by Dr Yvette Eley and Dr James Bendle
- **Clare Ziegler**, Quantitative modelling of root growth and carbon allocation bridging theory and experiment, supervised by Dr Iain Johnston and Dr Rosemary Dyson

Post doctoral staff and student achievements

Graduated in 2019/Graduating early 2020

- **Vilane Goncalves-Sales**, Satellite monitoring of deforestation and the role of clouds in Maranhão
- **Anthony Hyacinth**, Plant volatile compounds under elevated CO₂
- **Jennifer Kirby**, High resolution leaf fall monitoring and low adhesion forecasting using hemispherical near-infrared imagery

Aileen Baird has been involved in four Brilliant Club placements, teaching courses she designed about her research at BIFoR and the wider science around climate change to local high school children in years 5, 9 and 10. Two students have had their work from their placement published in the Brilliant Club's academic style journal "The Scholar". Aileen has also taken part in 5 "Skype a Scientist" sessions

Liam Crowley was nominated for a University of Birmingham Light of Understanding Award for Excellence in Public Engagement. He was awarded a special commendation for his portfolio of work promoting the work of BIFoR and in particular his work on the successful insect podcast, Entocast. Liam helped at many outreach events over the summer, his encyclopaedic knowledge of invertebrates and fun facts make his enthusiasm completely infectious.

Sue Quick did a tremendous job working with some residents local to the BIFoR FACE facility who expressed an interest in volunteering with us. Further to some initial training she gave them they were then able to help with spring observations of seasonal changes in the woodland. The team (including children) visited designated spots within the BIFoR FACE facility weekly in the spring and carefully recorded when they saw differences. Our thanks go to these volunteers too of course! A new volunteer will be trained in observing and recording in 2020.

Dr Jingxi Luo and student intern **James Shaw**, have developed the public engagement exhibit "Virtually real plants: Mathematical models and real data of plant growth in immersive Virtual Reality (VR)", funded by the Alumni Impact Fund. This immersive VR experience takes participants through the key elements of plant growth, and allows them to explore simulations based on our current research, based on their own choices of parameter values. They trialled this technology during the September 2019 UoB Undergraduate Open Day to very positive feedback.

PhD students continue to support "I'm a Scientist get me out of here" this has been supported by **Olusegun Gabriel Fawole**, **Aileen Baird** and now **Anna Gardner** continues the support as one of four scientists in the 'Plants' section of the "I'm a Scientist get me out of here: Engaging school children with scientists. Online question and answer with schools throughout the UK. In fact Anna was voted the winning scientist for the Plant Zone in 2019. With the prize money she would like to set up a series of practical and outdoor workshops.

Forest Health Research

Dr Luna-Diez and Dr Kettles are currently developing the project “Resistance strategies of oak trees in the arms race with pathogens” under the umbrella of the Action Oak initiative and funded by the JABBS foundation. In this project, they are studying genetic and metabolomic markers of resistance to the Acute Oak Decline (AOD) bacterial complex and the oak powdery mildew fungus. In this holistic project, they are investigating both innate and adaptive immunity of oak trees at different stages. In the first stages of the project, they are working in oak seedlings under control environment in order to reduce environmental variability. In a second stage, the project will move into working in the fields of Staffordshire and in the FACE facilities in mature trees. The project funds the work of two postdoctoral researchers that joined their teams in October 2019: Dr Tom Welch and Dr Rosa Sanchez-Lucas.

Dr Luna-Diez is also working in a project aiming to understand the impact of mixed species forests in the resistance of ash trees to ash dieback disease. Funded by Gatsby and a panel of scientific Societies Dr Luna-Diez led a summer project where 5 undergraduate students surveyed over 7,000 trees in the Norbury Estate. This project has identified tree species that drive enhanced resistance and susceptibility to the disease. These results could inform planting strategies to increase resilience of future forests.

Dr Kettles received funding from the British Society of Plant Pathology (BSPP) and the Royal Society of Biology (RSB) to initiate projects aimed at developing tools to understand tree disease resistance, and investigate the microbial communities (microbiomes) that inhabit oak trees. These projects, started by two undergraduate summer students (Adriana Iamandi and Chris Griffin) and have since been continued back in the lab at the Edgbaston campus.

Biosphere-Atmosphere Interactions

Within the Biosphere-Atmosphere exchange group, led by Tom Pugh, two major publications have originated from the [TreeMort](#) project, one describing the role of young forest stands in the global carbon sink, published in PNAS, and another quantifying the contribution of stand-replacing forest disturbances to carbon turnover across global forests, published in Nature Geoscience. Data behind these papers is fully available via [dataguru.lu.se](#). Two major data compilation activities are nearing completion. Daijun Liu has assembled a dataset of tree functional traits related to drought tolerance for more than 10,000 species, whilst Adriane Esquivel Muelbert has created a global dataset of tree growth and mortality rates based on forest inventories for several million trees. Both these efforts are now moving forward into analysis, with the ultimate aim of enabling more accurate projections of tree mortality rates at continental-to-global scale. Nezha Acil presented a first analysis of an enormous computational effort to quantify the characteristics of every stand-replacing disturbance event across the globe over 2000-2018, and is continuing to refine these calculations with the aim of attributing the drivers of these disturbances. Both Nezha and Adriane have engaged in supervising student volunteers within their projects.

Sijeh Asuk has spent several months in the field establishing a run of new forest plots in the Cross River national park in Nigeria, with the aim of studying the phenology of food-producing trees over the next 2 years. In addition, three more PhD students have joined the group in 2019:

Hector Carmargo working on ozone effects on crop yields, with a focus on China. Aleksandra Kulawska working on effects of permafrost thaw on boreal forest productivity and tree mortality. Lavinia Georgescu working on interactions between droughts and tree mortality.

Tom Pugh has also become a co-leader of the International Tree Mortality Network, which was launched at the IUFRO meeting in October. The network aims to bring together the global ecological, forestry, remote-sensing and Earth-system science communities to:

- **Quantify trends in tree mortality rates globally**
- **Attribute the causes of tree mortality**
- **Develop the capability to accurately predict tree mortality trend**

Strategic Stakeholder Engagement

We are delighted to be part of the Birmingham In Action campaign (see the back page of this annual report) and look forward to working with the team over the next few years.

The [Thinking Higher](#) conference took place on the 11th July 2019. The event gathered over 80 attendees from different research and governmental institutions. This conference was based on the scientific topic of forest tree pathology and brought together speakers from 8 different European countries with the overall aim of promoting global biosecurity of forest trees. This event provided the ground for the setup of a new consortium, "Priming in Trees" <https://lunadiezlab.com/priming-in-trees-consortium/> It is an alliance of researchers studying the way that trees can sensitise their defence mechanisms to fight pests and diseases better. It consists of researchers from 9 different countries and 20 different institutions.

Six [people](#) from BIFoR contributed to the International Union of Forest Research Organisations (IUFRO) World Congress 2019. Rob MacKenzie and Angeliki Kourmouli gave presentations and Sue Quick and Anna Gardner gave electronic poster presentations. The Tree Mortality network (page 15) was officially launched at the congress with presentations by Tom Pugh and Nezha Acil.

Professor Rich Norby of Oak Ridge National Laboratory, visited BIFoR under the auspices of the Distinguished Visiting Fellows scheme offered through the University's Institute of Advanced Studies. Prof Norby is now the tenth visiting fellow to visit BIFoR since 2015. Prof Norby's visit was extremely useful to staff and students and we look forward to welcoming him again in early 2020.



UNIVERSITY OF
BIRMINGHAM

THE INSTITUTE
OF ADVANCED
STUDIES

To date we have hosted 180 tours of the BIFoR FACE facility. Our visitor book is full of positive comments.

A fascinating tour from Kris [Hart] at BIFoR for I think it is fair to say that we are all questioning the future of carbon capture & ways in which we can start to implement more widely some of the ideas.

Robert Browne of Staffordshire
Agricultural Valuer's Association

BIFoR FACE joined the Ecological Continuity Trust (ECT) network of 30 active long-term experiments at 27 sites in the UK.



BIFoR Field Technician, Peter Miles wrote an article for [Heated Magazine](#), which brings together information, ideas and resources to support technicians in FE and HE institutions. A full list of stakeholder engagement can be found in Appendix 2, 3 & details of media coverage can be found in Appendix 4.

500,000 views of the
Birmingham In Action campaign [video](#)

35,166 views on the [website](#)

20,000 views of the BIFoR FACE
facility image on google maps

6,468 BIFoR FACE [video](#)
views

2,591 BIFoR PhD [web page](#)
views

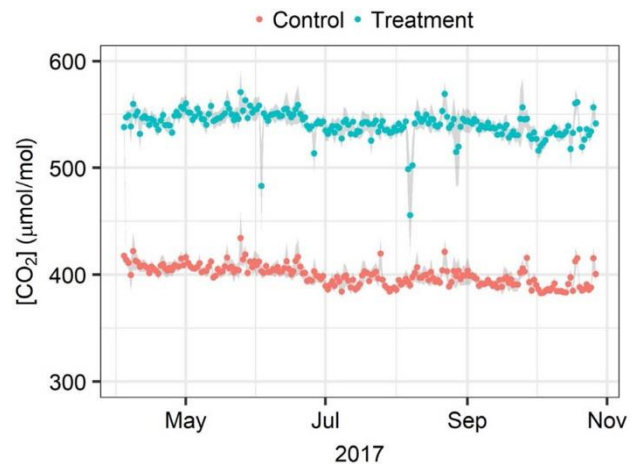
1,763 followers on [twitter](#)

794 more visitors to [blog site](#)

Outputs

2019 saw 7 journal articles published in the first-rank of general science journals (i.e., the *Nature* family, *Science*, PNAS) and another 24 published in top disciplinary international peer-reviewed journals. A full list of papers can be found in Appendix 4. Two highlights are summarised below.

Characteristics of free air carbon dioxide enrichment at BIFoR FACE - This paper reports the behaviour of CO₂ in the BIFoR FACE facility. It demonstrates that in its first year of operation, 2017, the facility successfully delivered an extra 147(±21) parts-per-million (or μmol/mol) of CO₂ to the treatment patches of forest for 98% of the scheduled operating time (see figure). Contamination of the control patches occurred less than 1% of the time. The results presented provide confidence that BIFoR FACE is operating well in excess of expectations.



Hart, K.M.H, Curioni, G., Blaen, P., Harper, N., Miles, P. Lewin, K. Nagy, J. Bannister, E., Cai, X.M., Thomas, R., Krause S., Tausz, M., MacKenzie, A.R., (2019) Characteristics of free air carbon enrichment of a northern temperate mature forest *Global Change Biology*, <https://doi.org/10.1111/gcb.14786>

Role of forest regrowth in global carbon sink dynamics – The world’s biggest terrestrial carbon sinks are found in young temperate and boreal forests. More than half of the carbon sink in the world’s forests is in areas where the trees are relatively young – under 140 years old. These trees have typically ‘regrown’ on land previously used for agriculture, or cleared by fire or harvest. Using a new combination of observations of forest age and computer modelling, Tom Pugh and co-workers showed that it is the young age that drives half of carbon uptake in young forests, with the remainder driven by CO₂ fertilisation.

Pugh, T.A.M. et al (2019) Role of forest regrowth in global carbon sink dynamics. *Proceedings of the National Academy of Sciences*, 116 (10), 4382-4387. [doi:10.1073/pnas.1810512116](https://doi.org/10.1073/pnas.1810512116)



Funding

Further details of all funding received in 2019 can be found in Appendix 5.

NERC Large Grant, £3.7 million, 2018-2024

QUINTUS: Quinquennial (half-decadal) carbon and nutrient dynamics in temperate forests: Implications for carbon sequestration in a high carbon dioxide world. Having more carbon dioxide (CO₂) in the atmosphere promotes greater tree growth and carbon storage in forests. But, looking forward, it is highly uncertain whether such high rates of uptake will continue, because the production of plant biomass also requires the availability of nutrients in soils to support tree growth, thus raising a concern that future carbon uptake might be limited by the amount of available soil nutrients. **QUINTUS** aims to carry out the detailed measurements of nutrient and carbon cycling (more than 24,000 analyses) to quantify ecosystem-scale pools and fluxes of carbon and nutrients (mainly nitrogen and phosphorus) at BIFoR-FACE to be able to evaluate how a mature temperate forest responds to rising atmospheric CO₂. The project is led by R. Mackenzie at BIFoR and involves co-investigators from national institutes including Birmingham University (S. Ullah, Z. Shi, L. Hamilton), Exeter University (I. Hartley, L. Mercado and S. Sitch), Bangor University (A. Smith), and UK Centre for Ecology and Hydrology (D. Clarke and E. Rowe). The project also benefits from the active support of partners across nine international institutes (see page 10).

NERC Discovery Grant, £0.8m, 2020 – 2023

FACE Underground: can trees in mature forests gain greater access to soil nutrients under elevated atmospheric CO₂? The proposal was awarded a science excellence score of 10/10 by the NERC panel while commenting that “the proposed research merits the highest possible priority for funding”. This project will directly address a global challenge and uncertainty – how future elevated atmospheric carbon dioxide (CO₂) concentrations (eCO₂) will influence forest productivity and carbon sequestration, and how soil nutrient availability will constrain such a CO₂ fertilization effect. **FACE Underground** aims to investigate the extent to which mature forests can alleviate nutrient limitation through increased below-ground carbon allocation under eCO₂. Experimental work will be undertaken at the BIFoR-FACE over a 38 month duration (2020-2023). Ultimately, this project will generate the first detailed assessment of whether, and how, mature trees can increase nutrient uptake under eCO₂, thus generating the detailed mechanistic understanding required to inform coupled nitrogen, carbon and phosphorus and Earth System Models for predicting mature forests responses to future climate change. S. Ullah (PI) & L. Hamilton (CoI) University of Birmingham, I. Hartley (CoI) Exeter University & E. Sawyer (CoI) at Lancaster University together with H. Rennenberg (project partner) at Freiburg University, Germany.

EU COST action grant, £0.5m, 2020-2023

CA18226 – New Approaches in Detection of Pathogens and Aeroallergens

Prof Francis Pope (GEES) (as a CoI & work group leader)

Bioaerosols are among the most complex components in the atmosphere, they include pollen, fungal spores and bacteria. Bioaerosols are relevant as important pathogens in crops and on trees, as aeroallergens in relation to human health and as catalysts for physical processes in relation to climate such as cloud formation processes. This grant will enable international exchanges between BIFoR and other internationally leading EU institutes interested in bioaerosols.

Joint UKRI-NSF Grant, £1.5m, 2020 -2022

Distributed Real Time Soil (DiRTS) Monitoring, project (a total ~£1.5 million with £422,000 to the University of Birmingham) is funded under the joint NERC-NSF “Signal in the Soils” programme. Lack of real time soil nutrient sensors, particularly for nitrogen hampers our ability to accurately assess soil fertility and ecosystems productivity. **DiRTS** aims to develop a sensing ‘mote’ capable of onsite measurements of soil ammonium, nitrate, and potassium in addition to moisture and salinity at different depths over large areas. The project will develop an artificial root as a sensor, which will be designed in labs followed by validation in soils at BIFoR with concomitant measurement of nitrous oxide emission from soils. The outcomes of such a real time, high resolution (in time and space) quantification of key soil processes will lay the foundation for its extrapolation and application to diverse land use types for sustainable management of soil resource under natural and agricultural ecosystems. The project involves BIFoR (S. Ullah as a lead), University of Keele, UK (A. Radu) and Tufts University, USA (Prof S. Sonukslae, overall PI with CoIs E. Miller and U. Khan) brings together experts in biogeochemistry, sensing, wireless communication, electronics, microfluidics, signal processing and sensor network.

NERC Highlight Grant £2.4M with ~£560k to Birmingham, 2020 – 2024, Birmingham partners: Dr Nicholas Kettridge

Toward a UK fire danger rating system: Understanding fuels, fire behaviour and impacts

Wildfires have traditionally been perceived as a threat confined to regions such as Southern Europe or Australia. However, the global wildfire threat is expanding and recognition of wildfire hazard in the UK has grown substantially. Between 2009 and 2017 over 250,000 wildfire incidents were dealt with by the Fire and Rescue Services in England alone. Individual events have been spatially extensive, challenging to fight (e.g. Saddleworth Moor, 2018), and have threatened property, transport and other infrastructure (e.g. Swinley Forest, 2011). In response to significant fire seasons, 'severe wildfire' has been included on the National Risk Register and two cross-sector national Wildfire Forums established. These initiatives evidence the need for appropriate fundamental scientific understanding and systems to manage and mitigate the current and future UK wildfire threat. Fire danger is a description of the combination of both constant and variable factors that affect the initiation, spread, and ease of controlling a wildfire on an area. Wildfire Danger Rating Systems (WFDRS) are designed to assess the fuel and weather to provide estimates of flammability and likely fire behaviour under those conditions. This project will undertake the fundamental science and analyses required for building a UK-specific WFDRS, designed for UK fuels, its complex land cover mosaics and infrastructure, and changing land use patterns and climate.

EU ITN, €4M with €600K to Birmingham, 2019 – 2023

PyroLife: European training programme for next generation of wildfire experts

Birmingham partners: Dr Nicholas Kettridge, Prof Rob Elliot, Dr Julian Clarke

The EU-project PyroLife will train a new generation of experts in integral fire management. The PyroLife project brings together knowledge from different countries, scientific disciplines and practices. Southern European leadership in fire expertise will be used to understand and predict wildfires in Northern Europe, whilst Northern European lessons learned in the prevention of floods will be applied in Southern Europe. PyroLife provides 15 PhD candidates. The project is the first large and integrated doctoral training programme on wildfires globally.

University of Birmingham, Institute for Global Innovations (IGI), £30,000, 2019 – 2020

MangRoot: Getting to the roots of the carbon in mangrove forests: a case study in Vietnam, Marie Arnaud, Dr Sami Ullah, Dr Nicholas Kettridge, Prof Vincent Gauci, and Prof Stefan Krause

Mangroves are among the most carbon dense ecosystem in the world and provide ecosystem services worth US\$194,000 per hectare per year. Located at 90% in developing countries, mangroves are a strong support for livelihood of local communities. Mangroves are, however, deforested at twice the rate of tropical forest. Payment for their ecosystem services - notably for carbon storage – has been increasingly promoted to avoid the deforestation of mangroves. Large programs of conservation and restoration have already taken place; however, under future climatic conditions, we do not know if mangroves will i) be resilient to sea level rise or get submerged, and ii) continue to sequester and store carbon or become a net source of greenhouse gases (GHG). Our project aims to generate preliminary data to provide a mechanistic understanding of the belowground carbon dynamics that is currently lacking. It builds up on the previously IGI funded project to inform policy-makers and practitioners how to manage mangroves to maximise C sink while minimising their greenhouse gas emission potential.

Royal Society - international collaborations scheme as part of GCRF, £208,473, 2019 – 2022

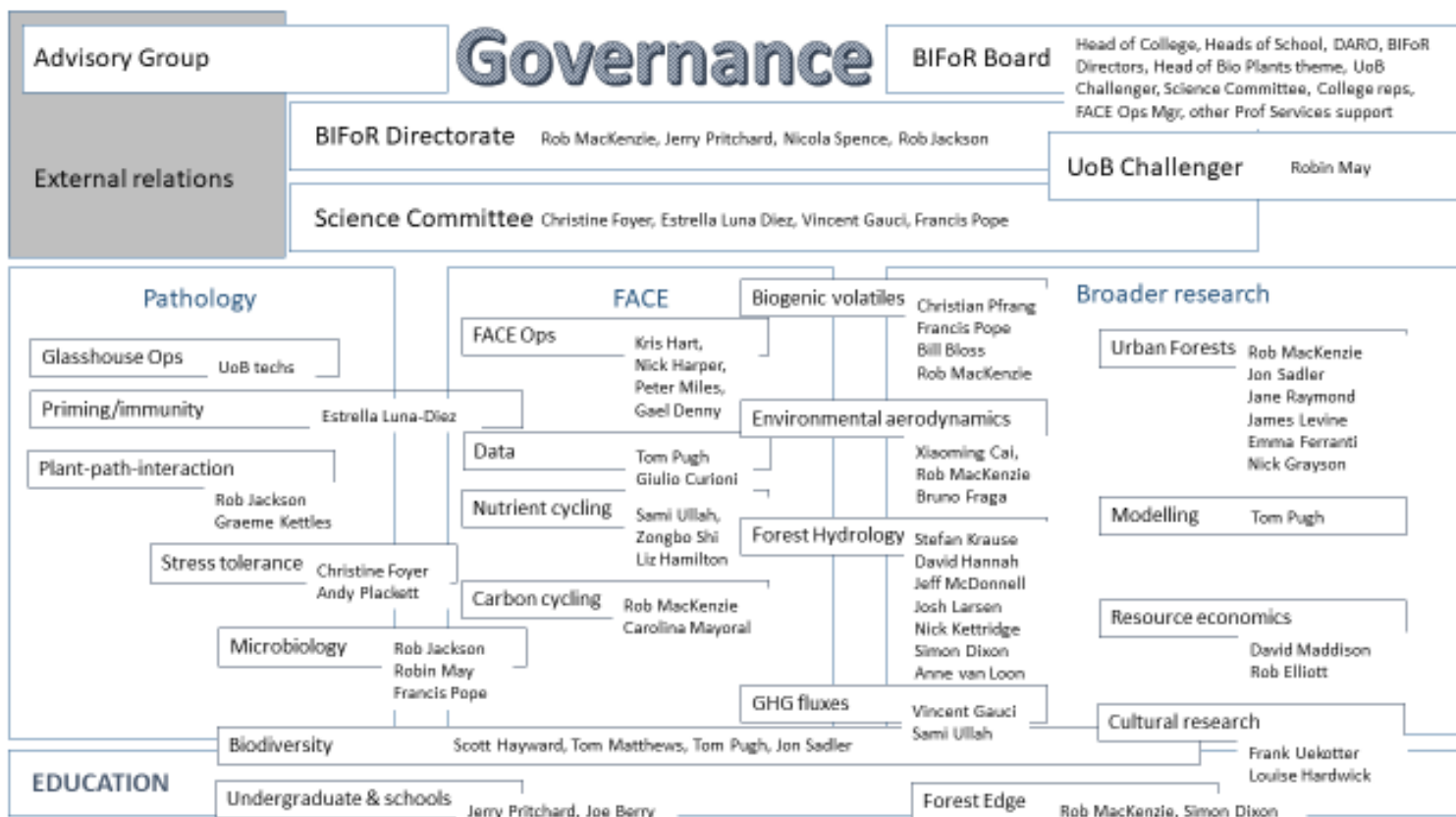
Mitigation of CH₄ and N₂O emissions from tropical peatland plantations under a changing water table regime – MitiMeN

As a result of the large El Nino fires of 2015, the Indonesian government introduced legislation (PP) No. 57/2016, directing land concession holders to raise water levels to 40cm beneath the peat surface in order to reduce future fire vulnerability of the peat. We have evidence, however, from a range of tropical wetland ecosystems, that such water table elevation, while reducing CO₂ emissions from arrested peat mineralisation, may have the unforeseen consequence of elevating emission of CH₄ and N₂O from a new and large pathway of trace gas emission from wetland soils: trees. The project seeks to identify the response of methane and N₂O emissions to peatland re-wetting, through a combination of detailed scientific investigation of methane and N₂O emission from trees, soils and drainage channels in a Sumatran plantation setting that facilitates local capacity building within Indonesia while making use of the opportunities afforded by a new, extensive tropical research infrastructure in development at a commercial plantation in Riau, Indonesia.

Going Forward

During 2019 we passed very substantial landmarks in terms of academic staff, researchers, and technical staff. Our key foci for 2020 will be:

- To host and deliver two nationally important conferences:
 - [Treescapes 2020](#)
 - Trees for the Future - Diversity and complexity for resilience and carbon storage and maximise the output from these events.
- To maintain our strong track record in high-impact published outputs in the broad BIFoR remit.
- To publish first findings from BIFoR FACE and from BIFoR pathology research.
- To complete the QA/QC and curation of previously collected BIFoR FACE samples and data, and have a robust system in place for storage and tracking of incoming data and samples.
- To consolidate the working of the new BIFoR governance (see below), ensuring efficient exchange of information between Institute members, the BIFoR Science Committee, the BIFoR Institutional Board, and the BIFoR Advisory Group.



Appendix 1: People

BIFoR Advisory Group Members

Chaired by Professor Laura Green, Head of College of Life and Environmental Sciences (LES)
Professor Bradwell, Honorary Professor of Immunology University of Birmingham
Dr Alice Broome, Project Leader for Protected Species, Forest Research
Dr Anna Brown, Head of Tree Health and Contingency, Forestry Commission England
Dr Matt Elliott, Policy Advocate, Tree Health & Invasives, Woodland Trust
Dr Clive Elphick, independent Director with the National Grid Gas Place and National Grid Electricity Transmission Plc, on the Board of the Environment Agency.
Dr Jeanette Hall, Woodland Advisor, Scottish Natural Heritage
Professor David Johnson, Chair in Microbial Ecology, University of Manchester
Professor Richard Norby, Oakridge Laboratory, USA
Professor Sir Ghillean Prance, formerly Director of Royal Botanical Gardens KEW
Professor Malcolm Press, Vice Chancellor, University of Manchester
Professor Nicola Spence, Chief Plant Health Officer, Defra and University of Birmingham

BIFoR Directors

The Directors of BIFoR are Professors [Rob Jackson](#), [Rob MacKenzie](#), [Jeremy Pritchard](#) and [Nicola Spence](#).

BIFoR Champions

We have BIFoR Champions throughout the University, most are members of the BIFoR Board and champion BIFoR within their colleges. Our College representatives are:

- Professor [William Bloss](#) (College of Life and Environmental Sciences)
- Professor [Neil Hotchin](#) (College of Life and Environmental Sciences)
- Professor [David Hannah](#) (College of Life and Environmental Sciences)
- Professor Jeff McDonnell (College of Life and Environmental Sciences)
- Prof [Jeremy Pritchard](#) (College of Life and Environmental Sciences)
- Professor [David Maddison](#) (College of Social Sciences)
- Dr [Andrew Quinn](#) (College of Engineering and Physical Sciences)
- Dr [Frank Uekötter](#) (College of Art and Law)

The number of academic members of staff affiliated to BIFoR has continued to grow. The Institute is open to University of Birmingham staff and students whose research interest is related to the natural science, social science or cultural relevance of forested landscapes.

College of Life and Environmental Sciences
School of Biosciences

Ben Brown	Juliet Coates	Liam Crowley	Christine Foyer
Anna Gardner	Scott Hayward	Richard Hill	Graeme Kettles
Hazel Lodhi	Estrella Luna-Diez	Lynne Macaskie	Nigel Maxted
Robin May	Carolina Mayoral	Jade Phillips	Andrew Plackett
Jeremy Pritchard	Rosa Sanchez-Lucas	Karen Staples	Susannah Thorpe
Rakesh Tiwari	Thomas Welch	Clare Ziegler	

School of Geography, Earth and Environmental Sciences

Nezha Acil	Sijeh Asuk	Aileen Baird	Edward Bannister	Josep Ferrer	Barba
Rebecca Bartlett	Lesley Batty	James Bendle	William Bloss	Alfred Bockarie	
Chris Bradley	Laura Brammeld	Nicolai Brekenfield	Deanne Brettle	Xiaoming Cai	
Lee Chapman	Hector Carmago	Julian Clark	Giulio Curioni	Nine Dekker	Douwes
Gael Denny	Selvakumar Dhandapani	Simon Dixon	Yvette Eley	Steven Emery	
Adriane Esquivel Muelbert	Ian Fairchild	Emma Ferranti	Vincent Gauci	Lavinia Georgescu	
Nick Grayson	Robert Grzesik	Sophie Hadfield-Hill	Liz Hamilton	Nicholas Harper	
Kris Hart	Jason Hilton	Peter Hopcroft	Ben Howard	Alex Hurley	
Tony Hyacinth	Polly Jarman	Nicholas Kettridge	Thomas King	Jennifer Kirby	
Jennifer Knight	Angeliki Kourmouli	Stefan Krause	Alex Kulawska	Joshua Larsen	
Peter Lee	James Levine	Gregor Leckebush	Daijun Liu	Peter Kraftl	
Jeff McDonnell	Rob MacKenzie	Hannah Martin	Thomas Matthews	Peter Miles	
Sophie Mills	Domanique Moran	Christian Pfrang	Francis Pope	Tom Pugh	
Sue Quick	Andrea Rabbai	Michaela Reay	Jim Reynolds	Jon Sadler	
Greg Sambrook-Smith	Zongbo Shi	Roberto Sommariva	Sami Ullah	Anne van Loon	
Bridget Warren	Sebastian Watt	Joseph Wayman			

School of Psychology

Jane Raymond	Ali Mazaheri	Eszter Toth
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College of Engineering and Physical Sciences

Phillip Davies	Bradley Deeley	Rosemary Dyson	Bruno Fraga	James Hale
Mike Jesson	Galene Luo	Chris Mayhew	Natalia Petrovskaya	Andrew Quinn
David Soper	Joe Wood			

College of Arts and Law

Angus Brown	Louise Hardwick	Corey Ross	Will Tattershill	Frank Uekötter
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College of Social Sciences

Robert Elliott	Vilane Goncalves-Sales	David Maddison	Fiona Nunan	Maria Teresa Gonzalez Valencia
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BIFoR volunteers create a welcome addition to the team.

Volunteers (mainly University of Birmingham undergraduates) gave 1334.50 hours of their time in 2019 to help us with our research and public engagement with research activity

Appendix 2: BIFoR Presence at Sectoral Conferences and Workshops

Date	Information
21/10/2018	'Old oak leaf physiology under elevated CO ₂ ' ' The Tree Conference Network ' in Frome by Anna Gardner
08/01/2019	Urban Tree Stakeholder workshop, with Government's Tree Champion, Sir William Worsley, Birmingham
09/01/2019	Urban Forestry and Woodlands Advisory Committee, presentation to members on Green Infrastructure, by Rob MacKenzie
11/01/2019	Speaker at the Association for Science Education (ASE) Annual Conference, "Under Pressure! Why plants can't survive without osmosis" by Jeremy Pritchard
28/01/2019	Round table discussion with Jim Skea from Imperial College, as part of the Provost's 'Leading Thinkers' series
16/01/2019	Royal Geography Society (RGS) School Member lecture, "The central role of plants in the carbon cycle and the impact of climate change" by Jeremy Pritchard
30/01/2019 – 31/01/2019	Third annual BIFoR science meeting., See posters and talks on line https://www.birmingham.ac.uk/research/activity/bifor/get-involved/Third-annual-BIFoR-community-meeting.aspx
08/02/2019	2018 Wildfires, lessons learned, DEFRA review workshop. Nottingham 8th February 2019 (Nick Kettridge)
12/02/2019	Invited speaker, University of Leeds Institute for Climate and Atmospheric Sciences (ICAS) "Early results from a forest Free-Air Carbon Enrichment facility – seasons 0, 1 & 2 out of 10" by Rob MacKenzie
14/02/2019	Invited talk "BIFoR FACE: overview of early results. Part of "Cinq conférences en écologie fonctionnelle/changement global", Institut Méditerranéen de Biodiversité et d'Ecologie, Marseille, by Rob MacKenzie
16/02/2019	Tedx talk at University of Birmingham, "Are we making a better Future for our Forests?" by Rob MacKenzie
20/02/2019	3rd UK Wildfire Research Group workshop, London, 20th February 2019 (Nick Kettridge)
04/03/2019	"Climate change impacts to the Amazon forest - carbon, forest dynamics, and species composition", by Adriane Esquivel Muelbert. Guest Lecture modules Biodiversity Management in Tropical Ecosystems and Climate Change Adaptation and Mitigation, as part of the BSc Environmental Sciences, University of Plymouth, UK
05/03/2019	University of Birmingham Professional Services Forum, BIFoR: Engaging UoB School children with climate change, by Jeremy Pritchard
5/03/2019-06/03/2019	Invited talks at EcoBuild 2019 i) First Steps in Valuing Trees and Green Infrastructure by Emma Ferranti ii) Strategic green infrastructure to manage urban air pollution for improved public health, by James Levine
05/03 - 07/03/2019	Invited participant, to RCUK/DEFRA funded workshop "In dialogue". "Sustainable Intensification" and "Valuing Nature", Estrella Luna-Diez
12/03/2019	Invited talk, 'BIFoR FACE: How to study forests in the future' Staffordshire Centre of the National Trust, by Anna Gardner

21/03/2019	Invited talk by Liam Crowley to the Royal Entomological Society Post Graduate Forum, Bristol
20-21/03/19	DREAM Symposium, Birmingham, Oral presentation and poster by Aileen Baird
27/03/2019	National Science Museum Lates event, "Climate change: water and carbon cycles collide in leaves" by Jeremy Pritchard
7/04/2019 – 12/04/2019	European Geosciences Union Conference Poster from Angeliki Kourmouli <ul style="list-style-type: none"> • Active distributed temperature sensing for high resolution monitoring of soil moisture and temperature – a field case study. Giulio Curioni • Peatland heterogeneity and its control on spatiotemporal complexities in peat surface temperature Rhoswen Leonard, Paul Moore, Stefan Krause, Kevin Devito, Richard Petrone, Carl Mendoza, James Waddington, and Nick Kettridge • Learning's From Opportunistic Wetlands: The Role of Substrate and Landscape Position On Reconstructed Landforms Kevin Devito, Mika Little- Devito, Carl Mendoza, Laura Chasmer, and Nicholas Kettridge • Control of landscape characteristics on inter-pond water level responses to decadal climate cycles Samantha Leader, Kevin Devito, David Hannah, and Nicholas Kettridge • Dynamic connectivity within small, forested wetlands impacts runoff generation in Aspen-dominated catchments of the sub-humid Boreal Plain (Canada) Alexander Hurley, Kevin Devito, Kelly Hokanson, Carl Mendoza, and Nick Kettridge • Resilience of peatland-forest landscapes in the Canadian Boreal Plains Ype van der Velde, Maarten Braakhekke, Nickolas Kettridge, Carl Mendoza, and Kevin Devito • Investigating the potential of coppice wood bundle installation to enhance biogeochemical cycling in low-land rivers Ben Howard, Stefan Krause, Sami Ullah, and Nicholas Kettridge
16/04/2019– 17/04/2019	British Society of Soil Science Early Career Conference, Sheffield Posters from Angeliki Kourmouli and Samuel Walrond
23/04/2019	Hosts and invited speaker of the Royal Entomological Society - Forest insects and their allies, annual group meeting, Liam Crowley and Scott Hayward
30/04/2019	Attendance to Institute of Chartered Foresters (ICF) workshop shaping the forestry sector response to current thinking in the development of post-Brexit land management support mechanisms, Birmingham
14/05/2019	Melaleuca Forest Workshop, Vietnam (Sophie Comer, Sami Ullah Nick Kettridge, Stefan Krause)
21/05/2019 -22/05/2019	Ecological Continuity Trust Long-term Experiments in Plant-Soil Ecosystems annual conference, Buxton, Derbyshire Keynote speech by Rob Mackenzie Aileen Baird –Fungi of the future: Assessing the effects of increased carbon dioxide on fungal communities in temperate forests Susan Quick –Bridging generations of tree-soil-water data to reveal tree-water behaviour under increasing atmospheric carbon-dioxide Posters from Angeliki Kourmouli, Giulio Curioni and Anna Gardner
29/05/2019	British Society of Soil Science Midlands Soil Discussion Group, Loddington, UK Liz Hamilton - Partitioning of autotrophic and heterotrophic respiration under elevated CO ₂ at the BIFoR Free Air Carbon Dioxide Enrichment (FACE) experiment.

	Angeliki Kourmouli - Dynamics of bioavailable nitrogen and phosphorus under elevated CO ₂ at BIFoR FACE
19/06/2019	Poster presentation Birmingham PGR research poster conference, by Aileen Baird
02 – 05/07/2019 2019	Invited talk Society for Environmental Biology SEB 2019, Seville, Spain. Clare Ziegler: The impact of elevated carbon dioxide on fine root growth in a temperate oak forest in the Time temperature and a transforming world session Invited talk, Clare Ziegler: Likelihood-free inference reveals physical mechanisms and parameters governing root architecture in the In silico plants session.
11/07/2019	Conference Organisers, Thinking Higher – Towards the biosecurity of Forests, University of Birmingham
16/08/2019	Invited talk, Adriane Esquivel-Muelbert, “Drivers of tree mortality in Amazonia”, Symposium: Mechanisms, Patterns, and Implications of Large Tropical Tree Mortality, At the Ecological Society of America, Louisville, KY, US
4/09/2019	Invited talk, Anna Gardner, People Plant Planet conference, London.
21/09/2019	Poster presentation: Nature-based solutions, Greensand Trust, Ben Howard
1/10/2019 – 5/10/2019	International Union of Forest Research (IUFRO) World Congress Rob MacKenzie – invited talk Angeliki Kourmouli – invited talk Anna Gardner – Poster Susan Quick – Poster Tom Pugh and Nezha Acil – Presentations
5/10/2019	Invited speaker Bristol Fungus Day, Aileen Baird
12/2019	Invited speaker, England and Wales Wildfire forum, the impact of wildfire on contaminated moorland catchment water quality, Cardiff Wales, Dr Nick Kettridge



Some of the BIFoR students and staff at the BIFoR third annual meeting 2019

Appendix 3: BIFoR Stakeholder engagement

The following programme of engagement gives a flavour of our stakeholder engagement in 2019. Without stakeholders, our research will lie unused. In 2019 we have held or contributed 83 stakeholder events, 46 of these were at BIFoR FACE.

<i>External Stakeholder Engagement - Academic</i>			
Date		BIFoR contact	Location
Oct – Jan 2019	Visitor, Kevin Devito, University of Alberta including IGI seminar Applying understandings from natural systems for sustaining hydrologic function of constructed landscapes	Nick Kettridge	Edgbaston Campus
01/02/2019	Delegates from the BIFoR third national science meeting visit the BIFoR FACE facility	Nick Harper & Peter Miles	BIFoR FACE
22/03/2019	BIFoR stand at World Water Day event	Giulio Curioni Sue Quick	Edgbaston Campus
27/03/2019	Visitor Scott Allen from ETH Zurich, seminar and visit to the BIFoR FACE facility	Stefan Krause	BIFoR FACE Edgbaston
02/04/2019	Visitor Prof Belinda Medlyn Theme Leader, Ecosystem Function & Integration. Hawkesbury Institute for the Environment, Western Sydney University	Rob MacKenzie	Edgbaston Campus and BIFoR FACE
08/04/2019	Prof Rich Norby visit to campus. Prof Norby is corporate research fellow in the Environmental Sciences Division and Climate Change Science Institute of the Oak Ridge National Laboratory	Rob MacKenzie	Edgbaston Campus
08/05/2019	Visitor Prof Josep Peñuelas. Global Ecology Unit CREAM-CSIC-UAB, Center for Ecological Research and Forestry Applications (CREAF) - National Research Council (CSIC) Universitat Autònoma de Barcelona	Tom Pugh	Edgbaston campus and BIFoR FACE
13/05/2019	Midlands Outdoor Learning Research Hub inaugural meeting	Peter Kraftl	BIFoR FACE
17/05/2019	Visitor Dr Fernando Espírito-Santo, University of Leicester	Tom Pugh	Edgbaston Campus
19/06/2019	Stand at the Evolving Forest conference, south Devon	Nick Grayson	Other
05/06/2019	Hosted Oliver Phillips, tropical forest ecologist from the University of Leeds	Tom Pugh	BIFoR FACE
7-12 /06/2019	Academic visit to Peking University	R MacKenzie	Other
4/07/2019	Green Infrastructure for Roadside Air Quality meeting	James Levine and RMK	Edgbaston Campus
12/07/2019	Workshop follow on from Thinking Higher	E Luna Diez & G Kettle	BIFoR FACE
24/07/2019	UoB Plant Science Team visit to BIFoR FACE	Estrella & Graeme	BIFoR FACE
31/07/2019	Visitor, Prof Malcom Press, University of Manchester	R MacKenzie	BIFoR FACE
08/08/2019	Visitor, Yadvinder Mahli University of Oxford	S Hayward	BIFoR FACE

15/09/2019 21/09/2019	Scott Hayward Visiting Professor at University of Rennes - involved discussing ideas for collaborative projects	Scott Hayward	Other
20/09/2019	Visiting Fellow Prof Rich Norby seminar. Prof Norby stayed for two weeks under the auspices of the Institute of Advanced Studies, Distinguished Visiting Fellow scheme	Many	Edgbaston
25/09/2019	Attendees of atmospheric chemistry/ air quality workshop visit to BIFoR FACE	Bill Bloss	BIFoR FACE
10/10/2019	QUINTUS partner kick off meeting	Many	BIFoR FACE
15/10/2019	Visitor Florian Busch – Australian National University	R MacKenzie	BIFoR FACE
29/10/2019	West Midlands Air Annual Meeting	R MacKenzie	BIFoR FACE
31/10/2019	University of Leeds potential collaborators visit to BIFoR FACE	Rob MacKenzie	BIFoR FACE
05/11/2019	Knowledge exchange visit to Rothamstead Research Facility	Kris Hart and Giulio Curioni	Other
7-13/12/19	Delegation visit to UNICAMP, USP and UNESP, Brazil	R MacKenzie	Other

External Stakeholder Engagement - Education

Date	What	BIFoR contact	Location
10/12/2018	Lesson at Harborne academy 'Rainforests and climate change'.	Liam Crowley	Other
16/01/2019	Royal Geography Society (RGS) School Member lecture, "The central role of plants in the carbon cycle and the impact of climate change" by Jeremy Pritchard. This was attended by 6 th form pupils and teachers from four schools (10-15 from each school)	Jeremy Pritchard	Other
19/01/2019	Careers talk at UTC Healthcare Future event. Audience was 30 year 10 and 11's	Aileen Baird	Other
25/01/2019	Masters students from UoB's Carbon Management course visit to BIFoR FACE	Francis Pope	BIFoR FACE
19/02/2019	Tour for students from the University of Gloucester (Masters)	Kris Hart	BIFoR FACE
28/02/2019	Skype a scientist Aileen Baird talks fungi with Concord Academy	Aileen Baird	Other
05/03/2019	UoB Postgraduate Occupational Health & Safety students	Kris Hart	BIFoR FACE
07/03/2019	Hosts for the Forestry Skills Forum meeting	D Brettle	Edgbaston
13/03/2019	Undergraduate volunteers visit BIFoR FACE	D Brettle	BIFoR FACE
18/03/2019	Imperial College London MSc Hydrology class tour of BIFoR FACE	Kris Hart and Sue Quick	BIFoR FACE
09/04/2019	University of Cumbria students visit to BIFoR FACE	Rob MacKenzie	BIFoR FACE
17/04/2019	Harper Adams University MSc students tour of BIFoR FACE	Liam Crowley	BIFoR FACE

31/05/2019	CENTA Training Day, visit to BIFoR FACE and afternoon collecting data from dendrometers	Rob Mackenzie	BIFoR FACE
6/06/2019	Hosts of Forestry Skills Forum	Deanne Brettle	Edgbaston Campus
27/06/2019	University of Birmingham, A Level geography students tour of the BIFoR FACE facility	Jerry Pritchard	BIFoR FACE
25/07/2019	BISS summer school visit to BIFoR FACE	R MacKenzie	BIFoR FACE
04/09/2019	PGR Water Catchment summer school	Many	BIFoR FACE
18/09/2019	Hosts of Forestry Skills Forum	D Brettle J Pritchard	Edgbaston Campus
19/09/2019	Harper Adams and UoB teaching workshop	J Pritchard	BIFoR FACE
31/10/2019	University School, Birmingham, staff visit to BIFoR FACE	R MacKenzie	BIFoR FACE
11/2019	I'm a scientist get me out of here	A Gardner	Other
12/11/2019	Harper Adams University – final year geography students and staff	Kris Hart	BIFoR FACE
20/11/2019	University of Birmingham undergraduate student volunteers	Deanne Brettle	BIFoR FACE
10/12/2019	St Peter's School, Wolverhampton, geography year 13 student visit to BIFoR FACE	Kris Hart	BIFoR FACE

<i>External Stakeholder Engagement - Private, Public & Third Sector</i>			
19/01/2019	Urban FWAC network meeting, Birmingham	R MacKenzie	Other
06/03/2019	Royal Forestry Society meeting at the Long Barn	Kris Hart	BIFoR FACE
25/06/2019	Royal Forestry Society held meeting at BIFoR FACE	Kris Hart	BIFoR FACE
24/07/2019	Forest and Woodland Advisory Committee (FWAC) meetings, Staffordshire	Rob MacKenzie	Other
13/08/2019	DEFRA team away day	Kris Hart	BIFoR FACE
10/09/2019	Henan Provincial Department of Forestry	Tom Pugh & Liz Hamilton	BIFoR FACE
11/09/2019	Earthwatch Institute discovery meeting	Many	Edgbaston
12/09/2019	Hortech Ltd	Kris Hart	BIFoR FACE
31/10/2019	Delegation of GEES to Eden Project	David Hannah	Other
20/09/2019	Air Liquide (senior management team)	J Pritchard	BIFoR FACE
17/10/2019	Forest and Woodland Advisory Committee (FWAC) meetings, Birmingham	Rob MacKenzie	Other
27/11/2019	Steering Group meeting of the National Tree Improvement Strategy	Nigel Maxted	Other
08/10/2019	Attendee to Vice Chancellor dinner for Ambassador of Brazil to the UK	Rob MacKenzie	Edgbaston Campus
29/10/2019	Members of BBSRC to BIFoR FACE for visit	Estrella Luna-Diez	BIFoR FACE
27/11/2019	Urban FWAC network meeting, London	R MacKenzie	Other

<i>External Stakeholder Engagement - Public Engagement with Research</i>			
Date		BIFoR contact	Location
Dec 2018	Aileen Baird was finalist in the UoB Images of Research Competition	Aileen Baird	Edgbaston Campus
10/01/2019	John Powell visit to BIFoR FACE facility	R MacKenzie	BIFoR FACE
18/03/2019	Training session for local community volunteers – Phenology and species recording	Susan Quick	BIFoR FACE
21/03/2019	International Day of Forests, social media, twitter takeover and news story by Susannah Thorpe		Edgbaston campus
01/04/2019	Clive Elphick visits	R MacKenzie	BIFoR FACE
16/04/2019	Local National Farmers Union tour	Kris Hart	BIFoR FACE
30/04/2019	Visual artist Gaia Fugazza	Kris Hart	BIFoR FACE
02/05/2019	University of 3rd age, local group visit to their evening meeting	Liam Crowley	Other
04/05/2019-06/05/2019	Norbury Canal Festival – BIFoR stand to update local residents about BIFoR FACE	D Brettle	Other
07/6/2019	Green Heart Festival	D Brettle	Edgbaston Campus
12/06/2019	Haugthon Women’s Institute tour of BIFoR FACE	Kris Hart	BIFoR FACE
23/06/2019	North Staffordshire Geographical Association	Peter Miles	BIFoR FACE
06/07/2019	CoCoMad Festival	Many	Other
18/07/2019	Staffordshire Agricultural Valuers Associations	Kris Hart	BIFoR FACE
26/09/2019	Welcome Week – Public Engagement with Research tent	Deanne Brettle	Edgbaston Campus
2/10/2019	Birmingham In Action launch	J Pritchard D Brettle	Edgbaston Campus
11/10/2019	Birmingham in Action launch	R MacKenzie A Gardner	London
4/11/2019	Low Carbon 2020 Conference BIFoR FACE featured on UoB CBI’s Energy and Climate Change team	Lauren Davies	Other
11/2019	Birmingham in Action launch	Many	New York
20/11/2019	Stand at the Clean Air for All: the effect of air pollution on everyone’s health and how you can take action	Emma Ferranti	Other



Birmingham In Action launch 2019

Appendix 4: BIFoR Papers and other literature/ communications 2019

Papers

Those directly discussing the BIFoR FACE Facility are marked with an asterisk. Papers from previous years can be found online at <https://www.birmingham.ac.uk/Documents/college-les/gees/bifor/BIFoR-related-papers.pdf>

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Article by Ben Howard, The Truth Seekers in Small Woods Association members Autumn 2019 magazine (Research Themes) PDF available on request

Article in Ecological Continuity Trust newsletter 2019 - September 2019

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Article in the Geographical Association Newsletter – Summer 2019

Article in 'Forestry Journal' a report on the Thinking Higher conference – September 2019 <https://www.forestryjournal.co.uk/events/conferences/17892400.thinking-higher-towards-biosecurity-forest-trees/>

Article on AirQualityNews.com by Dr James Levine and Dr Emma Ferranti – October 2019
<https://airqualitynews.com/2019/10/04/why-green-infrastructure-is-critical-for-improving-air-quality/>

Article by Susannah Thorpe & Jackie Chappell to coincide with International Day of Forests, 'Improving the Livelihoods of Chimpanzees Rescued from Trafficking' – March 2019
<https://www.birmingham.ac.uk/schools/biosciences/news/2019/Improving-Livelihoods-of-Chimpanzees-Rescued-from-Trafficking.aspx>

BBC Farming Today interview by Rob MacKenzie covering woodlands today and current and future threats to our woodlands – March 2019

Radio interview of Tom Pugh for Radio 4's Inside Science about his new work on carbon uptake by young forests – February 2019

TedX talk by Rob MacKenzie, "Are we making a better Future for our Forests?" March 2019 available online, 154 views <https://www.youtube.com/watch?v=hdw8ynlcNJE&feature=youtu.be>

Interview of Rob MacKenzie for podcast 'Reasons to be Cheerful' with Ed Miliband and Geoff Lloyd - July 2019

Endorsements

Support to the Strategy for UK Forest Genetic Resources
<https://www.kew.org/science/our-science/projects/uk-forest-genetic-resources-strategy>

Support to the Forestry Skills Action Plan
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Dr Tom Pugh explaining how new forests contribute to the world's carbon sink on BBC Radio 4's Inside Science February 2019

Appendix 5: Funding 2019

Title	Lead HEI	PI	Funder	Total Value	Value to UoB
QUINTUS	University of Birmingham	A R MacKenzie	NERC Large Grant	£3,259,157	£2,527,538
FACE Underground	University of Birmingham	Sami Ullah	NERC Discovery Grant	£795,600	£724,380
Action Oak research	University of Birmingham	Estrella Luna-Diez and Graeme Kettles	JABBS Foundation	£565,000	£565,000
Toward a UK fire danger rating system: Understanding fuels, fire behaviour and impacts	University of Manchester	Nicholas Kettridge	NERC Highlight Grant	£2,400,000	£560,000
PyroLife	Wageningen University, Netherlands	N Kettridge	ITN	£4,000,000	£537,000
CA18226: New Approaches in Detection of Pathogens and Aeroallergens	University of Worcester	Francis Pope	EU Cost Action	£500,000	TBD
Distributed Real Time Soil (DiRTS) Monitoring	Tufts University, USA	Sami Ullah	Joint UKRI-NSF Grant	£1,500,000	£422,000
MarshFLux: Greenhouse gases & blue carbon under global change	University of Birmingham	S. Ullah, Krause & Comer-Warner	Marie Curie Global Fellowship	£276,490	£276,490
MitiMeN	University of Birmingham	Vincent Gauci	Royal Society	£208,473	£181,241
Future Leaders fellowship to Dr Estrella Luna-Diez	University of Birmingham	Estrella Luna-Diez	BBSRC	£200,000	£200,000
Towards smart phone-assisted sensors for monitoring soil nutrients.	Keele University	Sami Ullah	Newton Fund Institutional Link Scheme	£100,000	£2,500
Mangrove forests and greenhouse gas fluxes, Vietnam	University of Birmingham	Sami Ullah S Comer-Warner	UoB Institute of Global Innovation	£ 45,000	£ 45,000
MangRoot: Getting to the roots of the carbon in mangrove forests: a case study in Vietnam	University of Birmingham	Sami Ullah Marie Arnaud	UoB Institute of Global Innovation	£30,000	£30,000
A molecular toolkit for the dissection of oak tree diseases	University of Birmingham	Graeme Kettles	Royal Society Research Grant	£18,000	£18,000

Sponsorship of FACE engineer	University of Birmingham	Kris Hart	Air Liquide private sector donation	£10,000	£10,000
Declining nutritional quality of pollen under elevated CO ₂ impacts on pollinator health.	University of Birmingham	Scott Hayward	BRIDGE Seed Fund	£5,700	£5,700
Thinking Higher Tree Pathology conference 2019	University of Birmingham	Estrella Luna-Diez	British Society of Plant Pathology	£4,000	£4,000
Understanding neighbouring effects in the tolerance to ash dieback disease	University of Birmingham	Estrella Luna-Diez	Gatsby Grants to Exceptional Researchers	£3,000	£3,000
Summer student placement	University of Birmingham	Graeme Kettles	Royal Society Summer Placement	£3,000	£3,000
Summer student placement	University of Birmingham	Graeme Kettles	British Society of Plant Pathology (BSPP)	£3,000	£3,000
Thinking Higher Tree Pathology conference 2019	University of Birmingham	Estrella Luna-Diez	Birmingham International Engagement Fund (UoB)	£2,500	£2,500
Sample tracking	University of Birmingham	Kris Hart	Ecological Continuity Trust Small Grants	£2,000	£2,000
Thinking Higher Tree Pathology conference 2019	University of Birmingham	Aileen Baird	Applied Mycological Society	£2,000	£2,000
Thinking Higher Tree Pathology conference 2019	University of Birmingham	Estrella Luna-Diez	Spanish Embassy	£1,000	£1,000
Thinking Higher Tree Pathology conference 2019	University of Birmingham	Estrella Luna-Diez	Institute of Advanced Studies (UoB)	£750	£750





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TACKLING THE WORLD'S BIGGEST CHALLENGES, TODAY

Birmingham In Action brings together the University of Birmingham's expertise, to take action on five big challenges facing our generation and the next:

- Protecting our planet
- Access to education
- Treating and preventing cancer
- Young people's mental health
- Refugees fleeing war and violence

Alumni, students, staff and friends are giving time and making gifts to support these vital programmes.

BIRMINGHAM TREETOPS

BIFoR exists today thanks to the generous support of visionary philanthropists, alumni and foundations.

Volunteers have given over 2,415 hours of their time to date to help identify fungi and insects at BIFoR, which will help spot any significant changes to our forest ecosystem.

How students are supporting BIFoR through Birmingham In Action

I was the first in my family to go to university. Today, I am discovering the future biology and ecology of our beloved British oak trees. As part of my PhD, I get to study at the top of the canopy, investigating the response leaves may have to future levels of carbon dioxide. I get to ask questions regarding the water use of these trees and the fate of carbon dioxide, as well as bigger questions regarding whole forest carbon uptake. I believe my scholarship to study at the University of Birmingham truly enabled me to develop and achieve my First Class BSc in Biological Sciences. Without it, I would not be asking significant scientific questions or contributing to real-world discoveries.

Anna Gardner, PhD Researcher at BIFoR



JOIN A FORCE FOR CHANGE AT WWW.BIRMINGHAM.AC.UK/ACTION