UNIVERSITY OF BIRMINGHAM | BIFOR

# BIRMINGHAM INSTITUTE OF FOREST RESEARCH (BIFoR)

## Annual Report 2020

# Contents



Photo credits:
Cover image- Oak tree which is experiencing the atmosphere in one of the BIFoR FACE arrays (see page 5); photo credit University of Birmingham
For all images not mentioned explicitly below, assume the photo credit should be University of Birmingham.
Page 13: Bark beetles strike in the foothills of the German Alps by Dr Tom Pugh

## Introduction

After an unprecedented year for science, the seventh year of BIFoR operations was still one to remember. Despite all the challenges brought by COVID and accompanying restrictions, our fantastic team running the linchpin FACE experiment kept the show on the road, with carbon dioxide enrichment of trees starting and ending on schedule. After implementing strict biosecurity and safety measures, the team were able to accommodate some researchers onto the site to ensure experiments progressed. We have also seen an increase in applications to include the site in grant applications and to study data emanating from the experiment. Indeed, we are delighted to have been recognised by UK Research and Innovation (UKRI) and use of the facility can be costed into National Research Council (NERC) grant applications. The four years of data being obtained from the experiment are also starting to reveal the impacts of elevated $CO_2$ on trees and their ecosystem, so the coming six years of operation, underpinned by a further £5M donation from JABBS and £6.3M from the University, will be fascinating, to see just how impactful higher atmospheric $CO_2$ will be on trees and forests.

As with any science institute, its staff and students are the key to its success and there has been substantial investment to enhance the science base of BIFoR. The BIFoR Chair in Tree Pathology, Prof. **Rob Jackson**, started in January 2020. He was joined in September by Dr **Mojgan Rabiey**, working on a new project in collaboration with the National Institute of Agricultural Botany (NIAB) to study bacterial pathogen evolution in cherry trees. He is also currently recruiting eight new staff and PhD students to work on a range of tree disease questions. Dr **Megan McDonald** is a new Birmingham Fellow and will work on fungal pathogens of plants to study their genomes and evolution of virulence.

Dr **Florian Busch** arrived as a new lecturer studying theoretical and experimental plant physiology, particularly with a focus on photosynthesis. Strengthening our work in ecology, Dr **Laura Graham** joined in 2020, with her focus on how climate and land-use change impacts global ecosystems and human well-being. **Dr Adriane Esquivel-Muelbert** has been appointed to a lectureship to study how global forests are impacted and change according to climate change. We also welcome ***Dr Susanne Suvanto*** joining on a 2-year Marie Curie fellowship (ForMMI). We also pay a huge welcome to key personnel working on: the QUINTUS project, **Angeliki Kourmouli** (Senior Research Technician), **Robert Grzesik** (Research Technician) **James Gore** (Research Technician); the FACE Underground project, **Michaela Reay** (Postdoctoral Fellow); **Hannah Martin** (Research Technician), the FACE technical team, **Thomas Downes (**FACE Apprentice Engineer). Seven new PhD students joined BIFoR in 2020, working on a wide range of interdisciplinary projects (see page 16). 2020 also marked the completion of the first cohort of Doctoral Researchers from the initial BIFoR FACE PhD projects as well as the first major papers to emerge from the FACE experiment. Their research is now out for peer-review ahead of publication.

There were several major activities in 2020 that have effects on the plant and forestry sector: the Future of UK Treescapes Funding call, the UKRI/BBSRC Plant Sciences Strategy, English Tree Strategy consultation, the Science and innovation strategy for forestry in Great Britain, EUExit.

Members of BIFoR have been able to contribute to all these initiatives. Notably, BIFoR colleagues contributed to a POSTNote on Reforestation and submitted the first position piece to the parliamentary enquiry into tree planting and woodlands in November

2020, thus demonstrating our commitment to ensuring a strong institute voice reflecting our science discoveries.

Given the new arrival of staff, and a natural evolution of the institute, there have been several changes in governance. In January 2020, the new Advisory Group (external members) had their first meeting, stimulating excellent discussions on past activities and future ideas and strategies. We have also established a new BIFoR Management Group (BMG) consisting of the four Directors Professors **Rob Jackson, Rob Mackenzie, Jeremy Pritchard and Nicola Spence**; the Science Committee, Dr **Estrella Luna-Diez**, Professors **Christine Foyer, Vincent Gauci and Francis Pope**; BIFoR Operations Manager, Dr **Kris Hart**; and BIFoR Administrator **Deanne Brettle**. The aim of BMG is to enhance communications and management of a range of issues. The Science Committee have also provided invaluable support to institute colleagues for managing publications and grant applications, including workshops and for the UK Treescapes call. **Christine Foyer** led a vibrant and well attended Trees for the Future webinar in association with the Association of Applied Biologists on 10 December 2020. We are also looking at options to expand BIFoR facilities to ensure we can support new ventures in the future as the Institute expands.

Following a £1M award from The Wolfson Foundation and further matched funding from the University, a state-of-the-art Advanced Glasshouse facility is being built at Elms Road on the Edgbaston campus (see page 10).

This facility can house small trees, enable work on category 2 pathogens and has, in addition to temperature, humidity and light controls, provision for $CO_2$ fumigation to study the impacts on tree and pathogen performance in different climates.

Congratulations to Dr **Sami Ullah** who was appointed to the Nutrient Management Expert Group at DEFRA. We also celebrated **Deanne Brettle,** winning the March 2020 Life and Environmental Sciences Excellence Reward and Recognition Scheme. Deanne has been central to running the Institute, managing meetings, supporting BIFoR Management Group colleagues and the wider institute staff and students.

We have also formulated our future plans for education and outreach activities. Although COVID has stymied physical visits of schools to the FACE site, our new virtual tour has proven to be a hit with teachers and school students. We now aim to stimulate new activities that provide online resources for Schools, Colleges and Universities as well as wider stakeholder groups.

Overall, 2020 has been a key year in the realisation of the founding vision for BIFoR:

'BIFoR aims to be an internationally leading Institute that will address two fundamental and interrelated challenges: The impact of climate and environmental change on woodlands; The resilience of trees to invasive pests and diseases.'

We now have the people, expertise and tools to make major progress in researching trees and forests, passing our knowledge on to younger generations, and providing expert knowledge to policy makers and practitioners. We look forward to meeting colleagues at our online Annual Meeting on January 27th and 28th 2021 and in the year ahead.

27 & 28 January 2021, fifth national BIFoR annual meeting. Proceedings and posters can be found on our website:

www.birmingham.ac.uk/BIFoRCom21

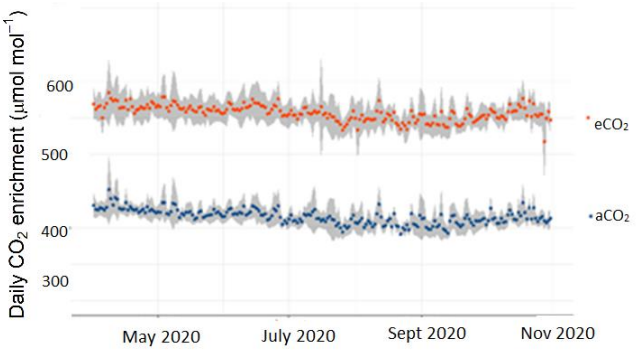
## BIFoR Free-Air Carbon Dioxide Enrichment (FACE)

COVID-19 brought undreamt-of challenges to society & not-insubstantial challenges to research at the BIFoR Free-Air Carbon Dioxide Enrichment (FACE) facility. 2020 was the fourth year we immersed 30-meter-wide plots of mature oak forest in elevated $CO_2$ concentrations and was set to be our busiest growing season yet, due to ever increasing numbers of undergraduate research projects, PhD students (page 16-18) & research collaborations (page 9), including the first growing season for the QUINTUS and FACE Underground projects. In spite of the pandemic, the BIFoR FACE team have been able to keep the facility open throughout 2020. A stringent risk assessment process enabled researchers to return in June. In the interim, the technical team at BIFoR FACE worked tremendously hard to ensure the research carried out by PhD students and academic colleagues was continued uninterrupted.

Weekly meetings considerably helped with logistics & presentations helped keep spirits high so the research community could continue to "talk science". Every team member has gone above and beyond expectations to ensure we have overcome the challenges presented by this pandemic. The long-term impact of the BIFoR FACE experiment has been maintained by the collective efforts of Professional Services and the academic team working together.

The FACE experiment has continued to out-perform expectations and deliver elevated $CO_2$ concentrations at or very near to the target.

Figure 1: FACE performance




There were some logistical challenges in August, but with careful management we were able to avoid any significant downtime. The performance achieved provides strong confidence in the gas delivery system: Array 1 = 99.1%, Array 4 = 98.1%, Array 6 = 101.7%.

The first two BIFoR FACE PhD thesis have been submitted; Liam Crowley will defend his work on "Are insects key drivers of change in woodland systems under climate change?" early in 2021. Clare Ziegler will defend her work on "Quantitative modelling of root growth and carbon allocation: bridging theory and experiment". The first paper based on PhD work using the FACE facility has been submitted (**Gardner et al.**, Is photosynthetic enhancement sustained through three years of elevated $CO_2$ exposure in 175-year old Quercus robur?). Recorded presentations of the initial results are also available online. .

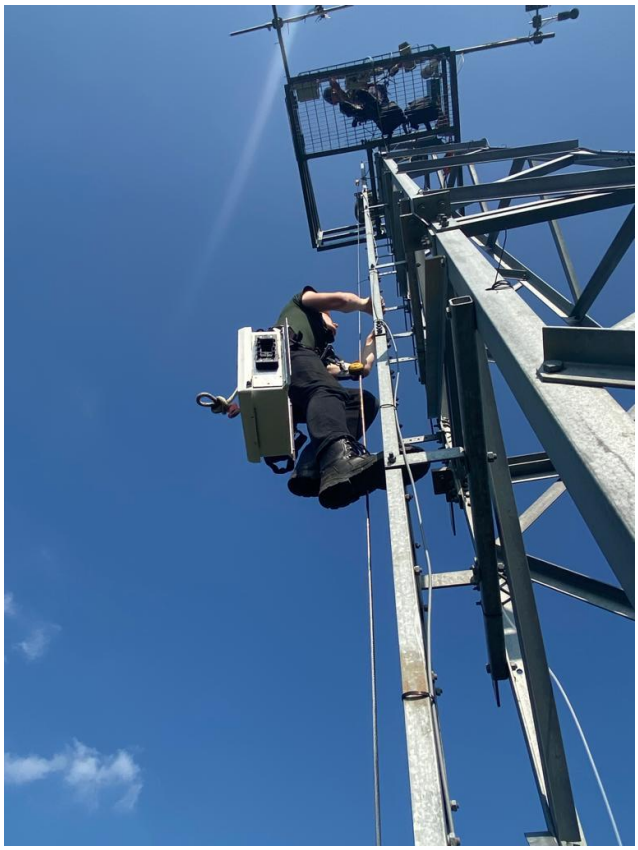
We now have a BIFoR "White Book" a living document which is set to become any FACE researcher's go-to resource. Having the White Book material in one place will help tighten up our procedures, policies, and communications for our ever-increasing team.

Working under new Data Lead, Dr **Adriane Esquivel Muelbert**, Data Manager, Dr **Giulio Curioni** has rolled-out sample-tracking software "Pro-Curo" which will ensure quality control and quality assurance in the curation of BIFoR FACE samples and data. Prof.. Vincent Gauci has been appointed our champion for helping us to gain the valuable space we need on campus for laboratory work.

New internal governance structures are in place including a Science Committee, which reviews project proposals, and the BIFoR Management Group, which takes a strategic overview of the experiments underway at BIFoR FACE.

**BIFoR Professional Service staff have gone over and above to keep the facility running**.

Research Technician, **Gael Denny**, worked late summer nights to set out moth traps



Apprentice **Tom Downes** and Senior Engineer **Nick Harper** have taken excellent care of the instrumentation on the 40-metre flux tower

## Postdoctoral research

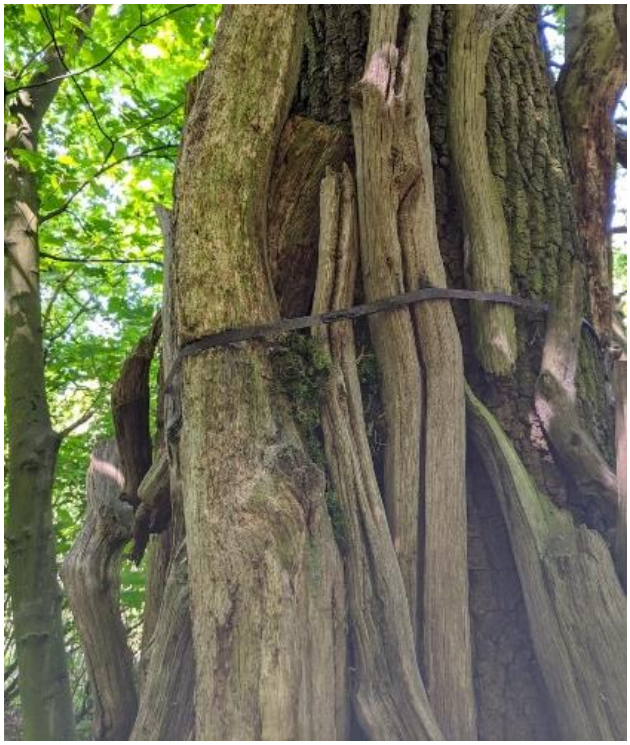
Dr **Joseph Barba Ferrer** demonstrates kit to measure the diffusion of $CO_2$ and methane into/out of an oak stem.

Dr **Marie Arnaud** demonstrates the slanted coring device that is used to insert minirhizotrons into the soil. Minirhizotrons allow images of fine roots to be captured over a season so that root productivity can be measured.

Dr **Michaela Reay** installing root box for accessing roots for exudate collection under FACE Underground project

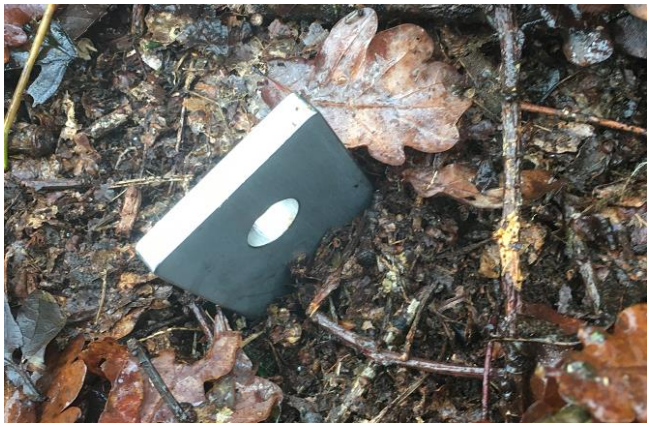
New ladders installed in 2020 make work in the field more efficient & researchers can reach the leaves in the lower canopy

## PhD projects underway in 2020



**Klaske van Wijngaarden** joined a PhD project joint with the University of Western Sydney in which she will investigate the contribution of loss of twigs and branches to the forest carbon balance – an often neglected component

**Liam Crowley** our entomologist of 4 years has submitted his PhD thesis, however **Laura James** has taken over some of the invertebrate sampling. Laura's principle focus though is on the impacts of ozone and elevated $CO_2$ on chemical communication networks



**Manon Rumeau** a new PhD student has joined the QUINTUS team for research on biological N fixation and mineralization under elevated $CO_2$ fumigation This is one of many ion exchange resin probes she has helped to install**.**

**Aileen Baird** is in the third year of her study of soil fungi. **Sophie Mills** will continue aspects of Aileen's work on bioaerosols, including fungal spores.

Final-year student **Anna Gardner** (foreground) measuring chlorophyll of the FACE oak leaves, ably assisted by fellow final-year **Angeliki Kourmouli**.

Tomography of an oak stem to search for cavities; work carried out in support of **Sue Quick's** PhD studies on plant-water relations under elevated $CO_2$.

New PhD student, **Mark Raw** and postdoctoral research fellow Dr **Rosa Sanchez-Moran** scoping the new project "Priming of defence in an elevated $CO_2$ world".

**Ed Bannister** undertook a "pulse & trace" experiment, designed to show how $CO_2$, is carried through the woodland on the wind

## Research Collaborators at BIFoR FACE

BIFoR engages with more than 55 stakeholders. Throughout 2020 we have continued to work closely with national and international research collaborators, strengthening collaborations with:

- Research institutions - Amazon FACE Centre for Ecology and Hydrology, CSIRO Earthwatch Institute, Forest Research, Laboratoire des Sciences due Climate et de l'Environment (LSSCE), Met Office, Max Planck Institute for Biogeochemistry, National Centre for Atmospheric Research (NCAR), NIAB and University of Tennessee.

- Education stakeholders – Forest Research, Met Office, and Universities of Bangor, Bristol, California Davis, Exeter, Harper Adams, Helsinki, Imperial College London, Keele, Leicester Lancaster, Lund, Manchester, Munich, New South Wales (Australia) Plymouth, Reading, Southampton Stafford, Swansea, Tianjin Normal University (China), Warwick, Western Sydney, Unicamp (Brazil) and the Open University.

- Others - Birmingham City University and the STEAMHouse art project (Clare Hewitt), British Bryological Society

**Research Council Funded collaborations:**

QUINTUS (2018 -2024) - a £3.7m NERC funded large grant project, Quinquennial (half-decadal) carbon and nutrient dynamics in temperate forests: Implications for carbon sequestration in a high carbon dioxide world, led by Prof. **Rob MacKenzie** (University of Birmingham)

FACE Underground (2020 - 2023) - a standard NERC funded project. This project will use the FACE experiment to determine whether mature temperate forests will be able to access more soil nutrients under elevated carbon dioxide ($eCO_2$), led by Dr **Sami Ullah** (University of Birmingham)

QUINTUS partner, Dr Andy Smith, from Bangor University at BIFoR FACE.

Disentangling mechanisms of co-adaption between trees and soil food webs in response to environmental perturbations (2019 - 2022) - a NERC funded project, led by Prof. **David Johnson** (University of Manchester)) in collaboration with Prof. **Rob MacKenzie** (University of Birmingham).

Predicting the emergence of host-adapted bacterial phytopathogens (2020-2023) – a Bacterial Plant Diseases collaborative grant between Dr **Richard Harrison** (NIAB) and Prof.. **Rob Jackson** (University of Birmingham).

Distributed Real Time Soil (DiRTS) Monitoring (2020 - 2022) - a NSF-NERC funded project led by Dr **Sami Ullah** (University of Birmingham) and involving the Universities of Keele and Tufts University.

NI: Network for Monitoring Canopy Temperature of Forests (netCTF) - a 2020 NERC funded project led by Dr **Sophie Fauset** (University of Plymouth). This project will increase the global network for infra-red monitoring of forest canopy temperatures (netCTF). As part of that award an instrument will be placed on our 40m flux tower collecting important continuous measurements.

## Forest Health Research

Several new staff (Prof. **Robert Jackson**, Dr **Florian Busch**, Dr **Megan McDonald**, Dr **Laura Graham**, Dr **Adriane Esquivel Muelbert,** Dr **Mojgan Rabiey**) have been recruited to key positions. Three new postdoctoral posts have been advertised as well as a post for a technician.

A new research project funded by Bacterial Plant Diseases call examining Pseudomonas bacterial pathogens of Prunus (Cherry Trees) started in September 2020, with Dr **Mojgan Rabiey** and Prof.. **Rob Jackson**. This collaboration with NIAB will examine how bacterial pathogens evolve on wild, ornamental and sweet cherry varieties and try to understand how we can improve management and control of these diseases.

Despite 2020's challenges due to the COVID pandemic, colleagues in BIFoR have implemented robust health and safety procedures to ensure safe working practice, especially in the outdoor sites.

Funding from the JABBS Foundation has enabled two postdoctoral research fellows, Dr **Rosa Sanchez-Lucas** (working with Dr **Estrella Luna-Diez**) and Dr **Thomas Welch** (working with Dr **Graeme Kettles**), to carry out research projects examining defence mechanisms in oak that can help to protect the tree from pathogen infection. One aim has been to establish and optimise protocols for performing an oak seedling diversity panel screen against the Acute Oak Decline (AOD) bacterial complex and the oak powdery mildew (PM) fungus.

A new protocol for generating stem infections of oak seedlings with AOD bacteria and a medium-throughput image analysis platform for the quantification of foliar disease symptoms induced by the PM fungus on oak leaves has been developed. These will allow experiments to be done that can identify two main components of defence: priming of resistance; and identification of resistance alleles that help fight off infections by pathogens.

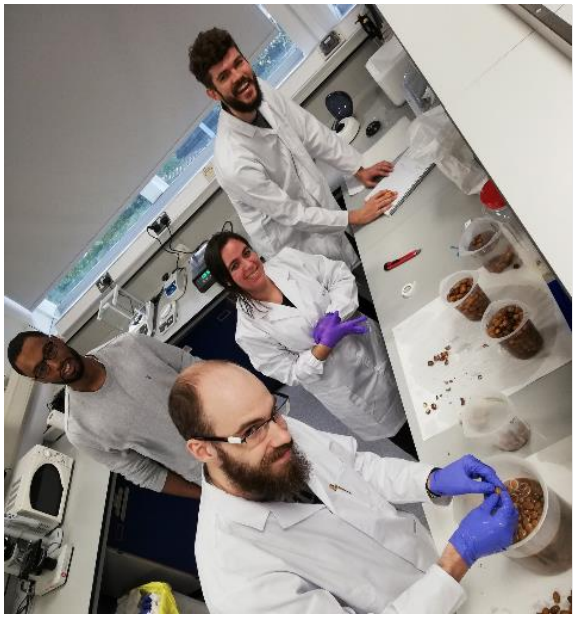
Publications are in-train (**Sanchez-Lucas** et al., Disentangling the effect of elevated $CO_2$ in growth and resistance mechanisms against powdery mildew in oak seedlings; Mayoral et al., Elevated $CO_2$ does not improve the regeneration of a mature oak woodland subjected to biotic stress). BIFoR continues to support the Action Oak (AO) initiative including via a very well attended AO session at the BIFoR conference in January 2020.

The BIFoR annual meeting 2021 has a focus on pest and diseases, but also reflects the broader scope of the institutes research. We are delighted to have four high profile external speakers covering disease resistance and genomics in trees (Prof. **Richard Buggs**, RBG Kew), ecological impact of tree diseases and policy implications (Dr **Ruth Mitchel**l, James Hutton Institute), insights to the resilience of landowners post-Brexit (**Anthony Geddes**, Confor) and How to talk trees with non-experts (**Jon Drori**).

The new Wolfson Advanced Glasshouses facility – kindly support by the Wolfson Foundation - is close to completion and is due to be handed over to the University at the end of March 2021. This facility will enable the plant pathologists and physiologists to carry out state-of-the-art experiments on trees, including provision of $CO_2$ fumigation. An image of the Wolfson Glasshouses can be found on page 23.

Dr **Carolina Mayoral, Dr Estrella Luna-Diez, Dr Rosa Sanchez-Moran and Isabel Okeke**, the team are currently developing the project “Resistance strategies of oak trees in the arms race with pathogens.

**Rachel Bromley** sampling material from ash trees with different levels of ash dieback disease.



BIFoR postdoctoral researchers and Biosciences undergraduate students preparing oak acorns for planting in the glasshouses.

Seed collection in the mast year of 2020 to test the effect of $eCO_2$ in progeny performance.

Preparation of oak leaf extract for culturing microorganisms associated with oak trees.

## Biosphere-Atmosphere Interactions, Dr Tom Pugh

Despite everything going on in the wider world, 2020 has been a busy year for the Biosphere-Atmosphere Interactions group. Several major data compilation and processing activities have been completed, providing globally-unique data infrastructure to support research for many years to come. Specifically:

**What predisposes individual trees to die?** The first version of the TreeMort global forest dynamics database has been completed. Dr **Adriane Esquivel Muelbert** has compiled and standardised 23 million observations from 10 million trees from all corners of the world, coordinating with more than 350 contributors, this provides a unique window into the rates at which trees grow and die in the different forests of the world and is forming the basis for a range of new projects to understand forest function. First results were presented to collaborators in a series of Webinars in November 2020 (Appendix 2).

**What influences the rates of big forest disturbances? Nezha Acil** has delineated and characterised more than 200 million individual disturbance patches across the World's forests that occurred over 2002-2016, providing a basis for numerous investigations into the drivers and roles of these events in the unique structure of different forests. She presented a first biogeography of disturbance sizes at the American Geophysical Union (AGU) 2020 conference.

What strategies do trees adopt to withstand drought? Dr **Daijun Liu** has completed a dataset of functional traits related to drought tolerance for more than 10 000 tree species, enabling studies using empirical and modelling techniques that investigate how tree strategies vary across gradients of resources and stress. Results from this work are showing how the most successful hydraulic strategies of trees – and their diversity – vary across the world.

Articles in the Conversation and Birmingham Briefs give some context as to the importance of these.

Dr **Adriane Esquivel Muelbert** has been promoted to lecturer and begun building her own group around the topic of forest dynamics, welcoming a visiting PhD researcher from Brazil in 2021. She has published a paper in Nature Communications quantifying the ways in which trees in the Amazon die and what predisposes them to high mortality risk. She also contributed to two major analyses in Science and Nature showing how tropical forests are responding to climate change. Dr **Daijun Liu** published a new paper on how drought affects vegetation in Mediterranean forests. **Alex Kulawska** has completed and submitted for publication a synthesis of how boreal forests respond to thawing permafrost, proposing a new hypothesis framework to reconcile the conflicting results in the literature. She is now using dendroecological techniques to test some of these hypotheses. **Lavinia Georgescu** has put together a framework to investigate how satellite observations can be employed to assess how tree water content responds to drought at scales spanning whole continents and is carrying out a first analysis for the Amazon rainforest. **Hector Carmargo** has reparameterised the LPJ-GUESS crop model to reproduce spatial and temporal patterns of major crop yields across the world and prepared a paper describing the evaluation of this model ready for submission. He is now moving on to parameterise a new ozone damage module for these crops. **Sijeh Asuk** has discovered a surprising imprint of how human foraging appears to subtly alter the distributions of tree species in a tropical rainforest in Nigeria. He is now working to expand this analysis across the wider region and, despite the challenges of Coivd-19, is well advanced in a first field assessment of the fruiting phenology of trees that provide important community food sources.

**Joe Wayman** has completed two very substantial analyses of how the taxonomic and functional diversity of birds in the British Isles vary in space and in time, considering the roles of climate, land-use and topography. He is continuing his analyses of biodiversity-climate interactions, looking at a variety of sites across the tropics.

**Nezha Acil** and Dr **Tom Pugh** contributed to a critical response to a recent paper about forest harvest in Europe, which has been accepted for publication in Nature. **Tom** had a paper published in Biogeosciences exploring the reasons why global vegetation models differ so much in their future projections of carbon turnover. He also contributed to a review in Science of how climate and human influence is driving forests towards being both younger and shorter, a paper providing improved model descriptions of tree phenology and, together with Dr **Daijun Liu**, a new representation of leaf water potential for large-scale vegetation models. Both **Adriane** and **Tom** have worked to expand the scope and activities of the International Tree Mortality Work, launching a new global seminar series on the topic of tree mortality (with over 300 participants for the first instalment) and questionnaires to assess the availability of data sources to characterise tree mortality across the world.

The group said goodbye to **Daijun** in December, who left after 2.5 years to take up a fellowship in Vienna, but who will remain a close partner in the future. They also welcomed four new members. **Julen Astigarraga** joined the group as a "virtual" visiting PhD student from the University of Alcalá in Spain. He is using the forest inventory database to look at how tree demographic rates vary across their climatic distributions. Dr **Susanne Suvanto** joined the group on a 2-year Marie Curie fellowship (ForMMI) to investigate how real forest management vary across Europe and North America and link these to tree mortality. **Klaske van Wijngaarden** joined to start a PhD project joint with the University of Western Sydney in which she will investigate the contribution of loss of twigs and branches to the forest carbon balance – an often neglected component. **Jordan Johnson** began his PhD investigating how volcanic eruptions influence the forest dynamics in Chilean temperate forests.

Bark beetles strike in the foothills of the German alps

## Education

BIFoR now has 36 PhD students studying a wide selection of forested landscape topics. This looks set to expand yet again as 2021 starts with 10 opportunities for PhD study being advertised (CENTA, MIBTP)

We can now boast a thriving community, which networks through weekly science seminars and fortnightly through a journal club run by a postdoctoral research fellows Dr **Joseph Barba Ferrer** (GEES) and **Dr Carolina Mayoral** (Biosciences).

**Liam Crowley** is our first BIFoR-funded PhD funded student to have submitted his thesis. During his PhD **Liam** has counted and identified (to various taxonomic levels) a total of 68,399 individual invertebrates. Liam presented his research at the British Ecological Society (BES) annual conference 2020.

We're proud of the Undergraduate and Masters students, who despite the many disruptions, produced some very interesting dissertations in relation to BIFoR FACE data/samples. More details are available in our autumn newsletter.

**Iwan Evans**, a 2020 Geography graduate said, "I feel privileged to have had the opportunity to conduct my research project with BIFoR and that my work will placed in the BIFoR library. The knowledge that my work will be available to inform future researchers, rather than becoming forgotten, is particularly satisfying."

The BIFoR library includes those from other institutions not just University of Birmingham. For example **Jon Page** from Imperial College London completed his masters research on "Modelling the hydrological responses due to elevated atmospheric $CO_2$ at the BIFoR FACE"

The development of forest sciences teaching resources can be considered to have a three pronged approach

- Undergraduate teaching
- A level, GCSE and Key Stage 3
- Outreach

2021 will see a larger working group come together to help push forward with our ambition to weave teaching material with state of the art digital delivery to provide a live, research-rich, distance learning experience for pupils across the UK.

The working group will consist of members of University of Birmingham Schools of GEES and Biosciences, the Higher Education Futures Institute (HEFI) and the School of Education and external collaborators from the Forestry Skills Forum, the Forestry Commission and the University of Birmingham [High] School.

Resources will be embedded to the "Virtual BIFoR" platform. We're investing in employing an experienced part-time, fixed term education officer who will support us in ensuring any resources developed have clear curriculum links and are "teacher ready"

Our thanks go to **Andrew Allott** who after a visit to the FACE facility and communications with PhD student **Anna Gardner** has ensured FACE experiments like BIFoR FACE continue to be included in the 6th form International Baccalaureate Biology, Teacher Resource Materials.

Volunteering with BIFoR in 2020, naturally became more difficult in relation to Covid19. However, in 2020 we still recorded 606 hours of volunteering bringing the total to just under 3,000 hours - the equivalent of employing a full time technician for 80 weeks!

Volunteering with BIFoR comes with many mutual advantages. When looking to fill 3 casual work positions our volunteers were our first port of call.

**Adam Kiani** who volunteered in the summer of 2018 and was employed through autumn 2020 with BIFoR said:

"Having just graduated from university, amid huge uncertainty as a result of the pandemic, I was thrilled to find work contributing to such an exciting research project at BIFoR"

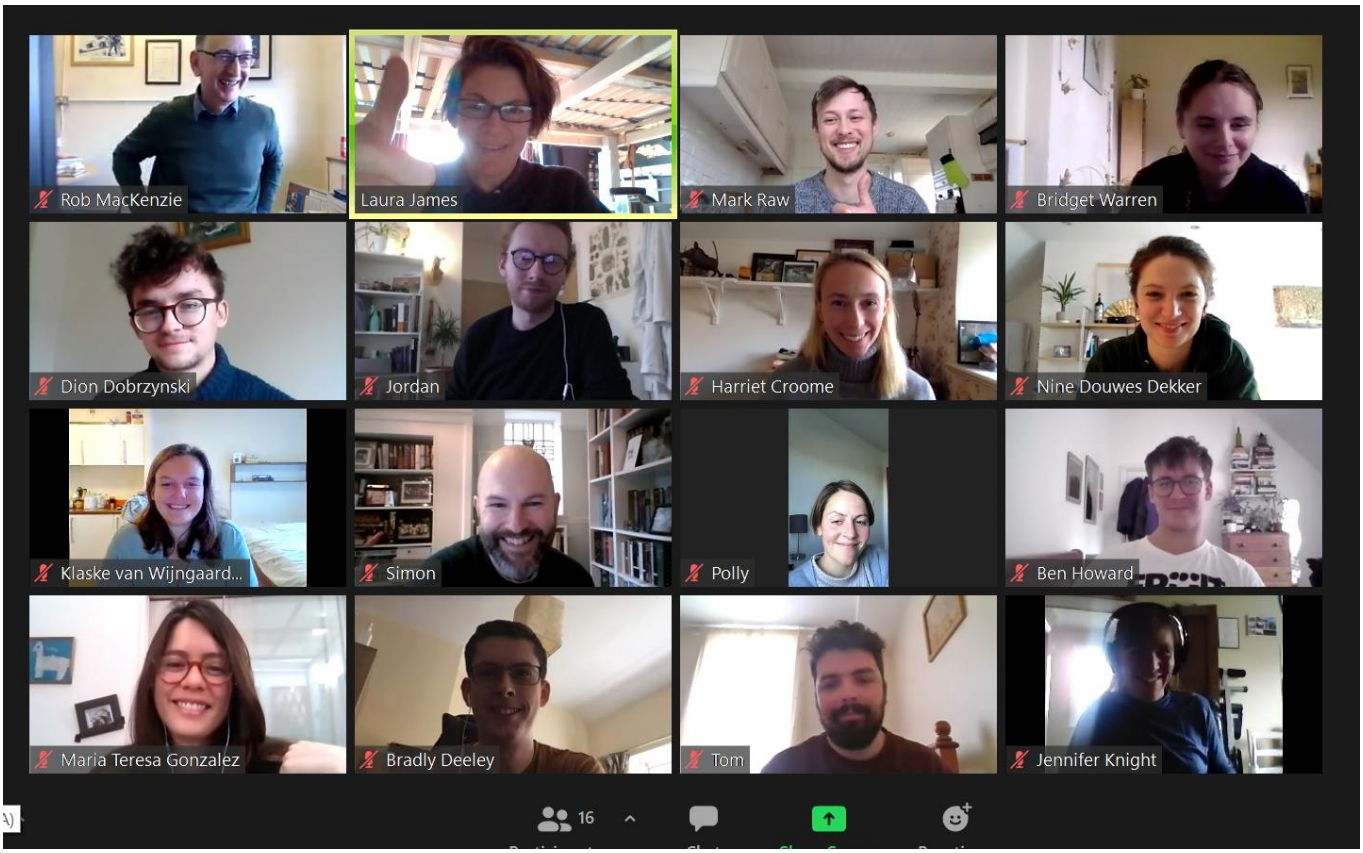
## Leverhulme Trust, Forest Edge Doctoral Scholarship Programme

Forest Edge is a Doctoral Scholarship programme (DSP) funded by the Leverhulme Trust. The programme, launched in 2018, will recruit around 20 PhD studentships over four years and has so far recruited 16 postgraduate students in the first three years (pages 16 – 18, students marked with the * symbol are part of the Forest Edge DSP).

Joining our team of 9 Forest Edge doctoral researchers in 2020 are 7 further students (see page 16). Their research will address very topical areas which might be difficult to find funding for were it not for this new DSP. 2021 will see the final Leverhulme Trust cohort commence – positions will be advertised in early 2021.

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 third full year of the programme. 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, with Forest Edge studentships now based in almost all colleges. 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.



## New doctoral research

We welcomed 8 new PhD students in 2020. The * symbol denotes these students are part of the Forest Edge Doctoral Scholarship Programme (see page 15). The ^ symbol denotes students will carry out their research at the BIFoR FACE facility.

*__Harriet Croome -__ Focusing on interactions between Maasai pastoralists and African elephants in Laikipia, Kenya, my project aims to understand how elephant behaviours have changed with wildlife conservation initiatives in Mukogodo Forest. By relying on the experiences, observations, and understandings of Maasai pastoralists this project will provide insights into how changing human-nonhuman interactions associated with wildlife conservation initiatives can affect the material and ontological existence of dryland forests. Poster 2021

Supervisors: Dr **Brock Bersaglio** (International Development Department (IDD)), Prof. **Fiona Nunan**(IDD)

*__Dion Dobrzynski__, Forest Ecology in Fantasy Fiction: Mobilising the Imaginative Resources of Fantasy Fiction for Living with Forests .

This project explores the various representations of forest ecology in the fantasy fiction of William Morris, J. R. R. Tolkien, and Ursula K. Le Guin. In collaboration with Ruskin Land, situated in Wyre Forest, this project will experiment in combining literary ecocritical and social science methodologies in order to investigate the ways in which fantasy fiction might intellectually, emotionally, and ethically engage the public in real forests. Poster 2021

Supervisors: Prof. **John Holmes** (English), Prof. **Jon Sadler** (Geography Earth and Environmental Science (GEES)), Dr **Will Tattersdill** (English)

*Jordan Johnston - There is a need now more than ever to understand how forest ecosystems react and recover in the wake of a destructive event. The eruption of Chaitén (Chile) in 2008 is an opportunity to study how forests re-establish in the wake of disturbance. The work of this project aims to (i) establish primary succession dynamics in this particular ecosystem, (ii) determine if this re-growth is stochastic (random) or deterministic (controlled spatially in some way), and (iii) ascertain the implications of these findings on the wider context of forest recovery in the wake of disturbance.

Poster 2021

Supervisors: Dr **Seb Watt** (GEES), Dr **Tom Pugh** (GEES), Dr **Tom Matthews** (GEES) and Susanna Ebmeier (Leeds)

*Thomas Kaye, 'Reading the Grain: The Patterns of Wood Rewilding Contemporary Prose and Poetry

Exploring how contemporary writers engage with scientific discourse & forest history to re-imagine our relationship with trees, woodlands, & forests by analysing major works; Barkskins by Annie Proulx; The Overstory by Richard Powers – in conjunction with feminist revisions of the typical wilderness narrative, and poetry – I will investigate how the patterns of wood found in imbricated tree-metaphors, woodcraft/wood-economy, and expansive timescales effect an imaginative, literary rewilding. I will also address how these various re-imaginings trace the often-imperceptible effects of shifting baseline syndrome through their challenging of what one might perceive as 'natural'. Poster 2021

Supervisors: Prof. **Alexandra Harris (**English), Dr **Matthew Ward** (English)

*^__Mark Raw__, Priming of defence in an elevated $CO_2$ world - Rising $CO_2$ levels are a reality of our current world, however the impact of this on plant species is still little understood. Elevated $CO_2$ is believed to result in increased growth in some species however there are reports that elevated levels could negatively impact on plant defence making them more susceptible to pests & diseases. This project aims to understand how elevated $CO_2$ will impact oak defence priming in both juvenile & mature oak trees against the oak pathogen powdery mildew & insect herbivores. This knowledge will allow humans to better assess risks to future forests & allow for better protection of these vital organisms. Poster 21

Supervisors: Dr **Estrella Luna Diez** (Bio) and Dr **Scott Hayward** (Bio)

^__Manon Rumeau -__ Forests under climate change will require more Nitrogen (N) to continue stocking a part of our $CO_2$ emission. The main source of new N in natural ecosystems is Biological N Fixation (BNF). I will be exploring the effects of elevated $CO_2$ on free living N fixation as well as on other N cycle processes in two mature forest, BIFoR FACE (UK) and EucFACE (Australia). By using $^{15}N$ isotopic methods, we will have a better understanding of N cycle response to climate change.

Poster 2021

Supervisors: Dr **Sami Ullah** (GEES) and Prof. **Rob MacKenzie** (GEES)

*Bruno Santos - Wastewater treatment trees: can forests filter helps solve our wastewater crisis?

Develop models for the movement and fate of pollutants in relation to the quantity and quality of tree growth, and the soil and light conditions.

Understand the changing limits to tree growth under nutrient and water availability through the monitoring of changing tree biomass allocation and water use efficiency. Poster 2021

Supervisors: Prof. Philip Davies (School of Engineering) and Dr Joshual Larsen (GEES)

*^**Klaske van Wijngaarden** - will look at the woody carbon dynamics of the trees at the BIFoR FACE and eucFACE experiments. A better understanding of the fate of carbon through increased photosynthetic activity and more insight in the response of complete forest stands to elevated $CO_2$ levels will help increase the accuracy of future carbon budget models. This project will explore the use fieldwork data of different woody compartments to determine turnover rate and chemical composition changes in two different ecosystems exposed to elevated $CO_2$ levels." Poster 2021

Supervisors: Dr **Tom Pugh** (GEES), Dr **Josh Larsen** (GEES), Prof. **Ben Smith** (Western Sydney University (WSU) Prof. **Belinda Medlyn** (WSU)

## Continuing doctoral 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. **Jon Sadler**
- **^Aileen Baird,** Fungal biodiversity, supervised by Prof. **Francis Pope** & Prof. **Robin May** Poster 2021
- **^Ed Bannister,** environmental aerodynamics of the BIFoR FACE site. Supervised by Dr **Xiaoming Cai** and Prof. **Rob MacKenzie**
- **Hector Camargo Alvarez -** describe and model the deleterious effect of ozone pollution on cereal production and its economic consequences in China, supervisor Dr **Tom Pugh**
- **^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** Poster 2021
- ***Bradly Deeley** – Mathematics of biological invasion of plant species poses a major threat both to the ecosystem and the economy. Dr **Natalia Petrovskaya** and Dr **Rosemary Dyson** Poster 2021
- ***^Nine Douwes Dekker** – Greenhouse gas emissions from soils under elevated $CO_2$. Supervisors Dr **Sami Ullah,** Prof. **Vincent Gauci** and Prof. **Rob MacKenzie** Poster 2021
- **^Katy Faulkner,** looking at the resistance and resilience of forest soil microbial communities and greenhouse gas emission to extreme weather events and a high $CO_2$ world, supervised by Prof. **Gary Bending** (Warwick) and Dr **Sami Ullah** Poster 2021
- **^Anna Gardner,** Leaf physiology under elevated $CO_2$, supervised by Prof. **Rob MacKenzie**, Prof. **David Ellsworth** (WSU) and Prof. **Jerry Pritchard** Poster 2021
- **Lavinia Georgescu -** Machine learning to find patterns and relationships regarding droughts and forests at a biogeographical level. Supervisor Dr **Tom Pugh**
- **^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) Poster 2021
- **Dr Anthony Hyacinth,** Plant volatile compounds under elevated $CO_2$, supervised by Prof. **Rob MacKenzie** and Prof. **Francis Pope**

- *^**Laura James** – 'Talking' trees; the impacts of ozone and elevated $CO_2$ on chemical communication networks. Supervisors Dr **Christian Pfrang**, Dr **Robbie Girling** and Prof. **Rob MacKenzie** Poster 2021
- ***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 **Thomas Pugh**, Dr **Nick Kettridge,** Prof. **Rob MacKenzie** & Dr **Sami Ullah**
- **^Sophie Mills** – The effect of elevated $CO_2$ on primary biological aerosol (bioaerosol) production, in particular pollen and fungal spores, in woodlands. Supervisors Prof. **Francis Pope** and Prof. **Rob MacKenzie** Poster 2021
- **^Sue Quick,** Tree-soil-water relations under elevated $CO_2$ – supervised by Prof. **Stefan Krause** and Prof. Rob **MacKenzie** Poster 2021
- Andrea Rabbai, Trends in soil moisture and temperature dynamics in juvenile forests align to those of mature forest from the time of canopy closure – supervised by Prof. **Stefan Krause**, Dr **Nicholas Kettridge** and **Dr Sami Ullah** Poster 2021
- ***Maria Teresa Gonzalez Valencia -** 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. Supervisors Prof. **David Maddison** and Dr **Alan Beltran Hernandez** Poster 2021
- ***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 **James Bendle** and Dr **Florian Busch** Poster 2021
- **Joe Wayman,** biodiversity-climate interactions, looking at a variety of sites across the tropics. Supervised by Dr **Thomas Pugh and Thomas Matthews**
- **^Clare Ziegler,** Quantitative modelling of root growth and carbon allocation bridging theory and experiment, supervised by Dr **Iain Johnston** and Dr **Rosemary Dyson**

**Thesis submitted: Liam Crowley, Anthony Hyacinth, and Clare Ziegler**

**Graduating in early 2021: Dr Alfred Bockarie,** Air pollution emissions from charcoal production and use, supervised by Dr **Eloïse Marais** (Leicester), Prof. **Rob MacKenzie** and Prof. **Roy Harrison**

**Anna Gardner** spent three months as a visiting researcher at the University of Western Sydney's EucFACE facility in January. Anna collaborated with multiple researchers that have been invaluable for the synthesis of BIFoR data.

Bridget Warren travelled to Vietnam in January 2020 to present at a workshop on palaeoclimate reconstruction in south-east Asia. In 2021 she plans to go to Japan for a lab visit. - she has been awarded a small grant from the Great Britain Sasakawa Foundation for this visit.

BIFoR PhD student, **Jenny Knight** was winner of CONFOR's #FutureisForestry essay competition. Jenny won the essay prize by challenging the premise that farmers and landowners need to be motivated to plant trees and saying they just needed more support to make it happen

Jenny has also secured a placement with the Welsh Government starting October 2020, to carry out a short term policy placement to support the delivery of the Woodlands in Wales strategy

## Strategic Stakeholder Engagement

The BIFoR webpages have been refreshed during 2020 and have received over 26,000 views. The BIFoR newsletter circulation outside of the University of Birmingham has exceeded 1,000 people. The newsletter is twice a year. Previous versions of the newsletter are available on the website.

The number of followers on Twitter has increased from 1796 to 2171. We had two main twitter campaigns in 2020: International Day of Forests March 2020 (7801 impressions and Plant Health week (10,911 impressions) There were an average of 27,806 Twitter impressions per month.

BIFoR's reputation for regards to forest sciences is growing and in 2020 we were able to contribute to a number of policy documents (see page 35).

The team have written 2 Perspectives articles for University of Birmingham and 2 articles in The Conversation (page 34). Dr **Adriane Esquivel Muelbert** received a lot of news interest in her research outlined in page 20 (see coverage page 34)

In addition, BIFoR FACE is featured on the Ecological Continuity Trust (ECT) website, along with 59 other long-term experiments. ECT report that BIFoR FACE is top of the table for page views on their site for 2020. We are grateful to the ECT for their continued support, including featuring BIFoR FACE in their British Ecological Society (BES) conference virtual stand.


In December we worked with the Association of Applied Biologists to hold a workshop on "Trees for the Future - diversity and complexity for resilience and carbon storage" This event was well attended and attracted international delegates too – one of the virtues of online meetings is of course that they are more accessible! The notes from the breakout sessions will help inform a white paper in 2021 on this topic and a November 2021 conference of the same title is scheduled to take place although the exact format is yet to be confirmed.

Fortunately, our BIFoR fourth annual meeting was able to go ahead in January 2020. We had the largest amount of delegates yet with over 115 attending each day. The proceedings of the conference are available on our website. The 2021 Annual Meeting is shaping up to have an even bigger audience and a huge increase in international delegates. The proceedings and posters will also be online on the website.

**39,957** views of BIFoR FACE images on Google maps

**26,039** views on the website

**20,000** average monthly twitter impressions

**7,485** views of the BIFoR introductory video

**4,659** BIFoR FACE web page views

**2,147** followers on twitter

## Outputs

2020 saw 6 journal articles published in the first-rank of general science journals (i.e., the *Nature* family, *Science*, PNAS). A full list of papers (n=42) can be found in Appendix 4. Two research highlights are summarised below:

**BIFoR scientists unravel how and why Amazon trees die** The capacity of the Amazon forest to store carbon in a changing climate will ultimately be determined by how fast trees die – and what kills them. Esquivel-Muelbert et al. published in Nature Communications unraveled what factors control tree mortality rates in Amazon forests and helps to explain why tree mortality is increasing across the Amazon basin.

This large analysis found that the mean growth rate of the tree species is the main risk factor behind Amazon tree death, with faster-growing trees dying off at a younger age. These findings have important consequences for our understanding of the future of these forests. Climate change tends to select fast-growing species. If the forests selected by climate change are more likely die younger, they will also store less carbon.

The study, co-led by BIFoR and the Universities of Leeds and in collaboration with more than 100 scientists, is the first large scale analysis of the causes of tree death in the Amazon and uses long-term records gathered by the international RAINFOR network including more than 30 years of contributions from over 100 scientists.

**Esquivel-Muelbert, A.,** Phillips, O.L., Brienen, R.J.W. et al. (2020) Tree mode of death and mortality risk factors across Amazon forests. Nature Communications, 11 5515 https://doi.org/10.1038/s41467-020-18996-3

*3D reconstructions of Genomosperma seeds, showing an open, lobed seed coat that underwent petal-like opening and closing*

**New hypothesis for the evolution of ancestral seed-bearing structures**

Today's forests are mostly made up of seed-bearing plants. But plants have not always made seeds, and understanding how plants first evolved them could tell us important things about how this group of plants came to dominate the Earth's ecosystems. Investigating this question is complicated by the fact that the seeds plants make today are all fully-formed, and no primitive versions are still alive. In this paper we applied 3D modelling and statistical analysis to fossils of an extinct plant species, Genomosperma, that made the most primitive type of seed known. To our surprise, our results suggest that the first seeds developed more like flowers, which have always been thought to have evolved after seeds. This result raises very exciting new hypotheses as to how seeds first evolved and points to specific genes that may have been very important in this process.

**Meade, L., Plackett, A.R.G. and Hilton, J**. (2020) Reconstructing development of the earliest seed integuments raises a new hypothesis for the evolution of ancestral seed-bearing structures. *New Phytologist* https://doi.org/10.1111/nph.16792

## Funding

Further details of all funding received in 2020 can be found in Appendix 5. The funding pipeline reflects the growth in the number of academics within the Institute. Compared to 2019 the amount in our funding pipeline has increased by 43%.

The Future of UK Treescapes is a £14.5 million programme which seeks to significantly improve the environmental, socio-economic and cultural understanding of the functions and services provided by UK Treescapes, in order to inform decision-making on the expansion of future treescapes for the benefits of the environment and society. The call closed in December 2020, so naturally 2020 was an exciting and busy time for the team There is tremendous positivity about how the BIFoR research community came together and worked with internal and external stakeholders to submit funding applications. Early career researchers Dr **Estrella Luna-Diez** and Dr **Lindsey Compton** were commended by the BIFoR Board for stepping up to drive forward applications.

**BBSRC Research Grant, £1.8 million with £373,875 to UoB 2020-2023**

Predicting the emergence of host-adapted bacterial phytopathogens: Using low cost, high throughput genome sequencing we will ask how the population structures of Ps lineages on cultivated and wild cherry varies over time, and how much this is shaped by host genotype and local environment.

Dr **Richard Harrison** (PI, NIAB), Dr **Michelle Hulin** (NIAB), Prof. **Rob Jackson** (Birmingham), Dr **Bo Li** (NIAB), Prof. **John Mansfield** (NIAB), Dr **Mojgan Rabiey** (Birmingham), Dr **Eleftheria Stavridou** (NIAB)

**Marie Curie Fellowship**, **£300,000**, **2020 – 2022, FORMMI:** Forest management-mortality interactions – quantification of management effects on tree mortality and implications for carbon cycling. The fellowship commenced late 2020 when Dr **Susanne Suvanto** (Birmingham) commenced working with Dr **Tom Pugh** (Birmingham)

As key players in the carbon cycle, forests are both emitters and net sinks of carbon. Progress has been made in quantifying the sink and highlighted the need to account for the effects of forest management and tree mortality. However, these two aspects have not been considered together. ForMMI will develop an observation-based methodology to quantify forest management regimes from single-measurement national forest inventory data. It will also create statistical models to link these regimes to mortality rates. These models will be integrated into a dynamic global vegetation model that will used to quantify the implications for the carbon cycle.

**Environmental Protection Agency, Ireland, €298,591, 2020 - 2023, Irish Peatland Resilience (IPR)** to changing climate and increased frequency and severity of drought. Dr **Nick Kettridge** (Birmingham) , Dr John Connolly (Trinity College, Dublin), Ype van der Velde (VU Amsterdam)

IPR will implement a mechanistic ecohydrological modelling approach to simulate the peatland and forest stability states across Ireland. This will be applied to quantify temperate peatland resilience and vulnerability to state shifts driven by climate change and associated extreme events at a national scale. Simulations will identify Irish peatlands most at risk from climate change, define the extent to which effective management and restoration must account for climate change impacts and define the optimal rehabilitation and restoration approach at a national scale to maximise carbon storage for any defined investment.

## Going Forward

Going forward, our main priorities for 2021 are to:

- Develop and implement a research resilience strategy to successfully achieve our research objectives during the pandemic
- Strengthen our contribution to UK and international policy debates
- Map our research onto national schools curricula and provide tailored educational material
- Develop effective communications that bring our research to life for stakeholders, students, and wider publics
- Change cultures and climates, to increase diversity and to nurture greater scientific coherence
- Engage with other organisations to raise visibility and bring BIFoR science to society
- Advocate the extrapolation of FACE experiments to underrepresented forest types of global significance, particularly in the low and middle income countries

Key dates in 2021

**7, 8 and 9 July 2021**

Treescapes 2021

A unique event being led by early career researchers from a number of UK universities and disciplines to stimulate conversations between the research and woodland practitioner communities

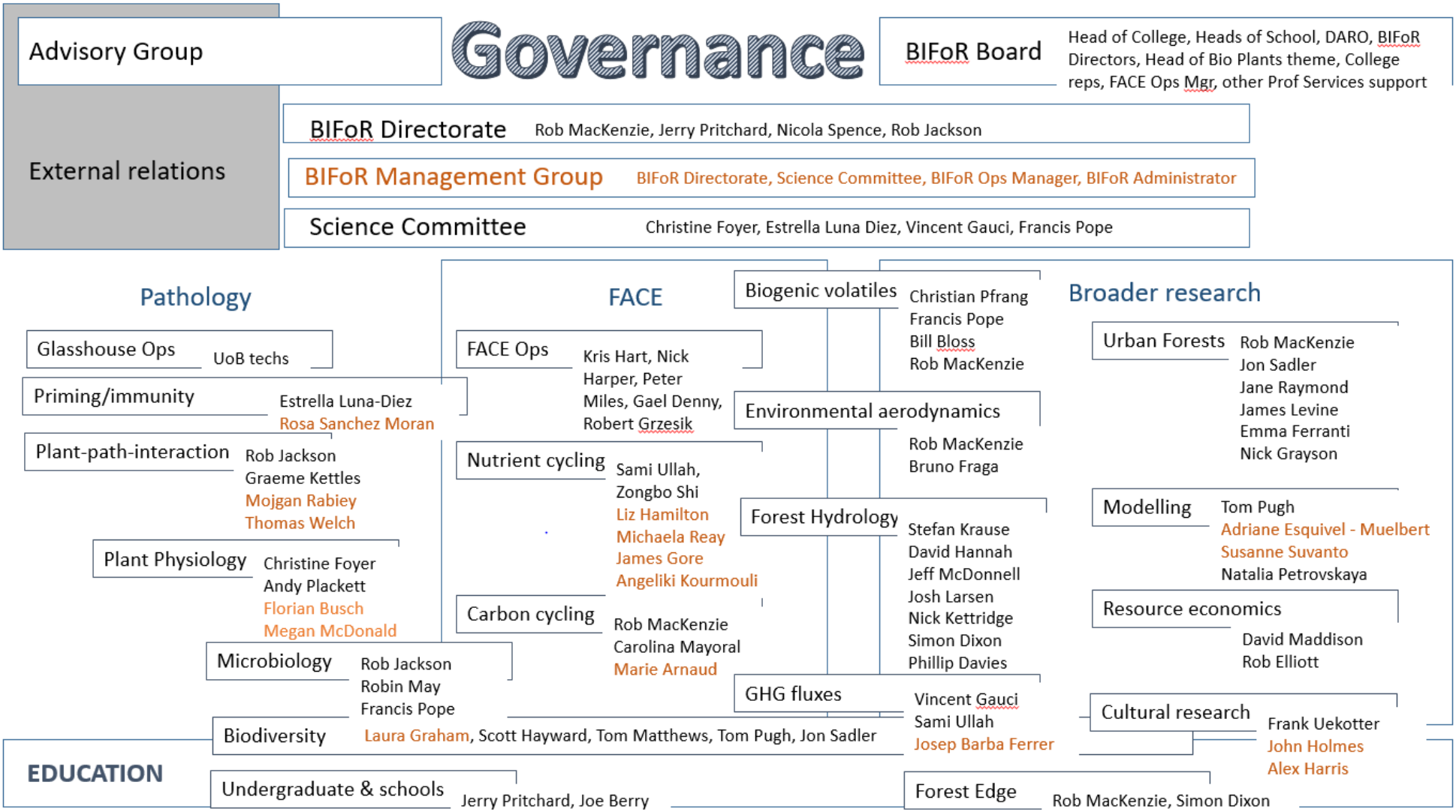
**3rd to 4th November 2021**

Trees for the Future – Diversity and complexity for resilience and carbon storage

A main objective of this conference is to explore state-of-the-art scientific evidence showing that higher tree species diversity enables higher productivity and stability, with a lower susceptibility to biotic and abiotic stress, together with a portfolio of ecosystem services, as well as economic and management benefits.

Wolfson Advanced Glasshouses – kindly supported by the Wolfson Foundation will be operational from spring 2021

## Appendix 1: People




Organisational diagram of BIFoR - new 2020 additions to the team / structure are in red

### *BIFoR Advisory Group Members*

Chaired by Prof. Laura Green, Head of College of Life & Environmental Sciences
Prof. Bradwell, Honorary Professor 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
Caroline Harrison, National Manager for England, CONFOR
Prof. David Johnson, Chair in Microbial Ecology, University of Manchester
Prof. Richard Norby, University of Tennessee, USA
Prof. Sir Ghillean Prance, formerly Director of Royal Botanical Gardens KEW
Prof. Malcolm Press, Vice Chancellor, University of Manchester
Prof. 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 Board*

Chair of the BIFoR Board is Prof. Laura Green, Pro-Vice-Chancellor and Head of College of Life & Environmental Sciences
Louisa Day (Development and Alumni Relations Office (DARO)
Sophie Dent (College Finance)
Lesley Ann Ford (College of Life and Environmental Sciences)
Prof. Christine Foyer (College of Life and Environmental Sciences)
Prof. Vincent Gauci (College of Life and Environmental Sciences - GEES)
Prof. David Hannah (College of Life and Environmental Sciences)
Dr Kris Hart (College of Life and Environmental Sciences)
Prof. Neil Hotchin (College of Life and Environmental Sciences - Biosciences)
Prof. Rob Jackson (College of Life and Environmental Sciences - Biosciences)
Dr Estrella Luna-Diez (College of Life and Environmental Sciences - Biosciences)
Bronwen Lord (Director of Operations - College of Life and Environmental Sciences)
Prof. Robin May (College of Life and Environmental Sciences)
Prof. Rob MacKenzie (College of Life and Environmental Sciences - GEES
Prof. David Maddison (College of Social Sciences)
Prof. Robin May (College of Life and Environmental Sciences)
Dr Jon Oldfield (College of Life and Environmental Sciences - Head of School GEES)
Prof. Francis Pope (College of Life and Environmental Sciences - GEES)
Prof. Jeremy Pritchard (College of Life and Environmental Sciences - Biosciences)
Dr Andrew Quinn (College of Engineering and Physical Sciences)
Dr Frank Uekötter (College of Art and Law)

### *BIFoR Management Group*

Prof. Christine Foyer (College of Life and Environmental Sciences)
Prof. Vincent Gauci (College of Life and Environmental Sciences - GEES)
Prof. Rob Jackson (College of Life and Environmental Sciences - Biosciences)
Dr Estrella Luna-Diez (College of Life and Environmental Sciences - Biosciences)
Prof. Rob MacKenzie (College of Life and Environmental Sciences – GEES)
Prof. Jeremy Pritchard (College of Life and Environmental Sciences - Biosciences)
Prof. Nicola Spence (Defra and Honorary Professor at the University of Birmingham)
Dr Sami Ullah (College of Life and Environmental Sciences - GEES)
Deanne Brettle – Secretary (College of Life and Environmental Sciences - GEES)

### *BIFoR Science Committee*

Prof. Vincent Gauci (College of Life and Environmental Sciences - GEES)
Prof. Christine Foyer (College of Life and Environmental Sciences)
Dr Kris Hart (College of Life and Environmental Sciences – GEES)
Dr Estrella Luna-Diez (College of Life and Environmental Sciences - Biosciences)
Prof. Francis Pope (College of Life and Environmental Sciences - GEES)

### *BIFoR Professional Service Staff*

Deanne Brettle - Project Administrator
Dr Giulio Curioni - Data Manager
Gael Denny - Field Technician BIFoR FACE facility
Thomas Downes - Apprentice Engineer
Robert Grzesik - Research Technician, QUINTUS
Nicholas Harper - Senior Engineer FACE facility
Dr Kris Hart - Operations Manager
Angeliki Kourmouli - Senior Research Technician, QUINTUS project
Hannah Martin - Research Technician, FACE Underground project
Peter Miles - Field Technician BIFoR FACE facility

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

*Academic Staff*

Dr Florian Busch
Prof. Christine Foyer
Dr Scott Hayward
Prof. Rob Jackson
Dr Graeme Kettles
Dr Estrella Luna-Diez
Dr Megan McDonald
Prof. Lynne Macaskie
Prof. Nigel Maxted
Prof. Robin May
Dr Andrew Plackett
Prof. Jeremy Pritchard
Dr Lindsey Compton

*Postdoctoral Researcher*

Dr Carolina Mayoral
Dr Mojgan Rabiey
Dr Jade Taylor-Phillips
Dr Rosa Sanchez Lucas
Dr Thomas Welch

*Doctoral Researchers*

Liam Crowley
Anna Gardner
Richard Hill
Mark Raw
Clare Ziegler

### School of Geography, Earth and Environmental Sciences

*Academic Staff*

**A – L**

Dr Rebecca Bartlett
Dr Lesley Batty
Dr James Bendle
Prof. William Bloss
Dr Chris Bradley
Dr Xiaoming Cai
Dr Lee Chapman
Dr Julian Clark
Dr Simon Dixon
Dr Steven Emery
Dr Adriane Esquivel Muelbert
Dr Emma Ferranti
Prof. Vincent Gauci
Dr Laura Graham
Dr Nick Grayson
Dr Sophie Hadfield-Hill
Dr Liz Hamilton
Dr Jason Hilton
Dr Peter Hopcroft
Dr Nicholas Kettridge
Prof. Peter Kraftl
Prof. Stefan Krause

*Academic Staff*

**L - Z**

Dr Joshua Larsen
Dr Gregor Leckebush
Dr James Levine
Prof. Rob MacKenzie
Dr Thomas Matthews
Dr Domanique Moran
Dr Christian Pfrang
Prof. Francis Pope
Dr Tom Pugh
Prof. Jon Sadler
Dr Zongbo Shi
Dr Sami Ullah
Dr Sebastian Watt

*Postdoctoral Researcher*

Dr Marie Arnaud
Dr Josep Barba Ferrer
Dr Daijun Liu
Dr Jiaojiao Ma
Dr Michaela Reay
Dr Susanne Suvanto

*Doctoral Researchers*

Nezha Acil
Sijeh Asuk
Aileen Baird
Edward Bannister
Alfred Bockarie
Nicolai Brekenfield
Hector Carmago
Nine Douwes Dekker
Lavinia Georgescu
Ben Howard
Tony Hyacinth
Laura James
Polly Jarman
Jordan Johnston
Thomas King
Jennifer Kirby
Jennifer Knight
Angeliki Kourmouli
Alex Kulawska
Kerryn Little
Sophie Mills
Sue Quick
Andrea Rabbai
Jordan Rowling
Manon Rumeau
Klaske van Wijngaarden
Bridget Warren
Joseph Wayman

*School of Psychology*

| *Academic Staff* | *Doctoral Researcher* |
|---|---|
| Dr Ali Mazaheri<br>Prof. Jane Raymond | Eszter Toth |

*College of Engineering and Physical Sciences*

| *Academic Staff* | *Postdoctoral Researcher* | *Doctoral Researchers* |
|---|---|---|
| **Dr Andrew Quinn (College Rep. for BIFoR)**<br>Prof. Phillip Davies<br>Dr Rosemary Dyson<br>Dr Bruno Fraga<br>Dr Mike Jesson<br>Dr Chris Mayhew<br>Dr Natalia Petrovskaya<br>Dr David Soper<br>Prof. Joe Wood | Dr Galene Luo | Bradley Deeley<br>Bruno Santos |

*College of Arts and Law*

| *Academic Staff* | *Doctoral Researchers* |
|---|---|
| **Dr Frank Uekötter (College Rep. for BIFoR)**<br>Dr Angus Brown<br>Dr Louise Hardwick<br>Prof. Alexandra Harris<br>Prof. John Holmes<br>Prof. Corey Ross<br>Dr Will Tattershill<br>Dr Matthew Ward | Dion Dobrzynski<br>Thomas Kaye |

*College of Social Sciences*

| *Academic Staff* | *Postgraduate Researchers* |
|---|---|
| **Prof. David Maddison (College Rep for BIFoR)**<br>Dr Allan Beltran<br>Dr Brock Bersaglio<br>Prof. Robert Elliott<br>Prof. Fiona Nunan | Maria Teresa Gonzalez Valencia<br>Harriet Croome |

## Appendix 2: BIFoR Presence at Sectoral Conferences and Workshops

| Date | Information |
|---|---|
| 29/01/2020–30/01/2020 | Various talks at the fourth annual BIFoR science meeting. See posters and talks on line https://www.birmingham.ac.uk/research/bifor/about/annual-meetings/2020-annual-meeting.aspx |
| 06.02.2020 | Invited speaker, Trees Design and Action Group West Midlands. 'An overview of the current scientific evidence available for the role that trees and other green infrastructure can have in mitigating poor air quality.' By Dr James Levine |
| 11.02.2020 | Invited talk at Amazon FACE Annual General Meeting, Manaus, Brazil. 'BIFoR FACE: seasons 0, 1, 2, 3 of 10' by Prof. Rob MacKenzie |
| 13.02.2020 | UoB-UniCamp collaboration Workshop, Campinas, Brazil, 'The Birmingham Institute of Forest Research' by Prof. Rob MacKenzie |
| 23.02.2020 | Invited speaker to seminar series of Ecological Continuity Trust. 'Data curation & sample archiving at the BIFoR-FACE woodland $CO_2$ enrichment experiment in Staffordshire.' by Dr Giulio Curioni |
| 05.03.2020 | Invited speaker, Futurebuild (Built Environment). 'Developing a Business Model to support Green Infrastructure Valuation' (ExCeL,London) by Dr Emma Ferranti |
| 05.03.2020 | Invited keynote, FutureBuild, London. 'Reduce, Extend, Protect: Practical and evidenced steps to reduce public exposure to air pollution' by Prof. Rob MacKenzie |
| 07.05.2020 | Invited talk at University of Derby (out-reach program termed Climate Action Talks hosted by the Environmental Sustainability Research Centre) 'Climate Change and our Forests' by Prof. Rob MacKenzie. Recording available. |
| May 2020 | Organised session, EGU 2020 'Constraining present and future global vegetation dynamics and carbon stocks) by Dr Tom Pugh |
| May 2020 | Invited speaker, EGU 2020 'What is the natural rhythm of temperate and boreal forest disturbances in the absence of human management?' by Dr Tom Pugh |
| June 2020 | Invited speaker, JULES vegetation dynamics seminar series, 'Drivers of difference in vegetation carbon turnover rates between global vegetation models', by Dr Tom Pugh |

| | |
|---|---|
| 11.06.2020 | Invited speaker, Institute of Chartered Foresters (ICF) members hours meeting, 'Sci-fi forest: propelling an English Oak woodland into 2050' by Prof. Rob MacKenzie, |
| 15.08.2020 | Invited speaker, West Midlands Combined Authority Tree Wardens Online Conference, 'Ash die back – new research and citizen science' by Dr Estrella Luna-Diez. |
| 25 – 27.08. 2020 | Active conference participant, Postgraduate Forum of the Royal Geographical Society IBG, Twitter Conference. By Jenny Knight. Jenny explains her research in 5 tweets! |
| 14-18.09. 2020 | Invited speaker, Royal Anthropological Institute, RGS conference, 'Young people's storying of encounters in their local urban woodlands" by Polly Jarman |
| Oct 2020 | Invited speaker, RTPI CPD (online). 'Urban Trees to Help Address Climate Change and Air Pollution' by Dr Emma Ferranti |
| 13.10.2020 | Invited speakers. West Midlands Geographical Association meeting 'Elevated $CO_2$: How it will affect plants, carbon and water cycles,' by Prof. Rob MacKenzie and Prof. Jerry Pritchard. |
| 02.11.2020 | Invited speaker. Plant Science Virtual Summit, 'Recent Trends and Latest Innovations in Plant Science' by Anna Gardner. |
| Nov 2020 | Invited speaker, Transport for West Midlands: Air Quality, Congestion and Environmental Sustainability: Invited presentation to transport Professionals and local councillors on steps to improve air quality, by Dr Emma Ferranti |
| Nov 2020 | Invited keynote speaker, London Climate Action Week: Impact of climate on urban areas. An international interdisciplinary audience of academics and practitioners on action to adapt, by Dr Emma Ferranti |
| 02.11.2020 | Invited speaker, London Tree Officers Association meeting: 'Bacterial cankers in trees – how do they occur and how do we stop them?' by Prof. Rob Jackson |
| 20.11.2020 | Invited speaker. Institute of Chartered Foresters led Trees People Built Environment 4. 'Understanding Roadside Air Quality and its Impact on Health' by Dr James Levine |
| 3.12.2020 | Invited speaker. Trees People and Built Environment 4 (online international conference): 'Developing a Business Model to support Green Infrastructure Valuation' by Dr Emma Ferranti |
| 10.12.2020 | Invited speaker, Trees for the Future webinar, 'Understanding the responses of forests to climate change', by Prof. Rob MacKenzie |
| 14.12.2020 -18.12.2020 | Speaker and conference participant, British Ecological Society. Festival of Ecology by Anna Gardner. |
| 14.12.2020 -18.12.2020 | Speaker and conference participant, British Ecological Society. Festival of Ecology by Liam Crowley |

## Appendix 3: BIFoR Stakeholder engagement

The following programme of engagement gives a flavour of our stakeholder engagement in 2020. Without stakeholders, our research will lie unused. Emma Ferranti continues in role of Research Lead for the Trees & Design Action Group and organise the bimonthly Seminar Series.

| *External Stakeholder Engagement - Academic* | | |
|---|---|---|
| Feb 2020 | Academic visit to AmazonFACE and University of Campinas, Brazil | Prof. R MacKenzie and Dr S Ullah |
| 02/03 2020 | Visiting fellow at Western Sydney University, January to March 2020 (shortened visit due to Covid19) | Anna Gardner |
| 17.03.2020 - 19.03.2020 | Workshop participant: C-N-P Dynamics of forests under elevated $CO_2$ workshop. Hawkesbury Institute, Western Sydney University | Anna Gardner. |
| Feb 2020 | Invited guest to & speaker to ""Biological Mission of Galicia" | Dr Estrella Luna-Diez |
| Sept 2020 | Online presentation to University of Cardiff's Lynne Boddy's Research group | Aileen Baird |
| Sept 2020 | Invited seminar, ETH Zurich, 'Can we reconstruct the distribution of forest stand age across the globe?' | Dr Thomas Pugh |
| Oct 2020 | Invited seminar, University of Oxford (online), 'Estimating the global carbon sink due to forest demography' | Dr Tom Pugh |
| Nov 2020 | Invited speaker, University of Neuchatel | Dr Estrella Luna – Diez |
| 11.11.2020 | Invited speaker, University of Manchester, School of Earth & Atmospheric Science 'A temperate deciduous forest Free-Air Carbon Enrichment (FACE) facility – overview and early results' | Prof. Rob MacKenzie |

| *External Stakeholder Engagement – Private, Public & Third Sector* | | |
|---|---|---|
| 12.02.2020 | Introduction to Simon Wood, diplomat with UK Foreign & Commonwealth Office British Consul General | Dr Tom Pugh |
| 05.03.2020 | Futurebuild 2020 – workshop Health, happiness, fairness and place | Prof. Rob MacKenzie |
| March 2020 | Participant and questioner at the All-Party Parliamentary Group on Forestry and Tree Planting online webinar/meeting | Jenny Knight |
| 28.07.2020 | Introduction & presentation to Defra Chief Scientific Adviser, Gideon Henderson and Defra colleagues. "The science case for forest FACE experiments" | Rob MacKenzie Nicola Spence & Iain Hartley (Exeter) |
| 08.09.2020 | Visit to Ruskin Land. Exploring potential collaborations | Rob MacKenzie & John Holmes |

| *External Stakeholder Engagement - Education* | | |
|---|---|---|
| 24.01.2020 | MSc Carbon Management UoB Students tour of BIFoR FACE | Francis Pope |
| 03.02.2020 | MSc Health, Safety and Environment Management, UoB students tour of BIFoR FACE | Surinder Desi |
| 13.10.2020 | Invited speakers. Birmingham Geographical Association meeting | Rob MacKenzie Jerry Pritchard |
| July 2020 | British Ecological Society Undergraduate Summer School. Aileen Baird prepared and taught mycology content to undergraduate students from across the UK. | Aileen Baird |

| *External Stakeholder engagement – Public Engagement with Research*<br>Refer to Appendix 4 for a list of podcasts, media mentions and grey literature | | |
|---|---|---|
| 07.03.2020 | Staffordshire invertebrate science fair Liam Crowley | Liam Crowley |

# Appendix 4: BIFoR Papers and other literature/ communications 2020

## Papers

Those directly discussing the BIFoR FACE Facility are marked with an asterisk. Papers from previous years can be found online https://www.birmingham.ac.uk/research/bifor/research/publications.aspx

**Abdulrasheed, M., MacKenzie, A.R.,** Whyatt, J.D., & Chapman, L. (2020) Allometric scaling of thermal infrared emitted from UK cities and its relation to urban form, *City and Environment Interactions,* vol 5, https://doi.org/10.1016/j.cacint.2020.100037

*__Comer-Warner, S. A.,__ Gooddy, D. C., __Ullah, S__., Glover, L., __Kettridge, N__., Wexler, S. K., Kaiser, J., & __Krause, S.__ (2020). Seasonal variability of sediment controls of nitrogen cycling in an agricultural stream. Biogeochemistry, 148(1), 31-48 https://doi.org/10.1007/s10533-020-00644-z

Deshmukh, C. S., Julius, D., Evans, C. D., Nardi, Susanto, A. P., Page, S., **Gauci, V.,** Laurén, A., Sabiham, S., Agus, F., Asyhari, A.D, Kurnianto, S., Suardiwerianto, Y., & Desai, A. R., (2020) Impact of forest plantation on methane emissions from tropical peatland, *Global Change Biology*, vol. 26 (4) pp. 2477-2495. https://doi.org/10.1111/gcb.15019

**Dugdale S.J., Hannah D.M**. & Malcolm I.A (2020) An evaluation of different forest cover geospatial data for riparian shading and river temperature modelling, *River Research and Applications, 36*, 709-723 DOI: 10.1002/rra.3598

Dugdale S.J., Kelleher C.A., Malcolm I.A., Caldwell S. & **Hannah D.M**. (2019) Assessing the potential of drone-based thermal infrared imagery for quantifying river temperature heterogeneity, *Hydrological Processes – Scientific Briefing, 33*,1152-1163 DOI: 10.1002/hyp.133c95

**Dugdale S.J.,** Malcolm I.A & **Hannah D.M**. (2019) Drone-based Structure-from-Motion provides accurate and affordable forest canopy data to assess shading effects in river temperature models, *Science of the Total Environment,* 678, 326-340 DOI: 10.1016/j.scitotenv.2019.04.229

**Esquivel-Muelbert, A**., Phillips, O. L., Brienen, R. J. W., Fauset, S., Sullivan, M. J. P., Baker, T. R., . . . Galbraith, D. (2020) Tree mode of death and mortality risk factors across Amazon forests. *Nature Communications,* 11(1), 5515. https://doi.org/10.1038/s41467-020-18996-3

**Ferranti, E.J**. and Jaluzot, A., (2020) Using the Business Model Canvas to increase the impact of green infrastructure valuation tools. *Urban Forestry & Urban Greening*, *54*, p.126776 https://doi.org/10.1016/j.ufug.2020.126776

*Fayose, T., Thomas, E. Radu, T., Dillingham, P, **Ullah, S.** and Radu, A., (2020) Concurrent measurement of nitrate and ammonium in water and soil samples using ion-selective electrodes: tackling sensitivity and precision issue. *Analytical Science Advances, Earlyview Online* https://doi.org/10.1002/ansa.202000124

Franke, J. A., Müller, C., Elliott, J., Ruane, A. C., Jägermeyr, J., Balkovic, J., . . . **Pugh T.A.M.,** Moyer, E. J. (2020) The GGCMI Phase 2 experiment: global gridded crop model simulations under uniform changes in $CO_2$, temperature, water, and nitrogen levels (protocol version 1.0). *Geosci. Model Dev., 13*(5), 2315-2336. https://doi.org/10.5194/gmd-13-2315-2020

Gibbons, J. (2020) *Conversations on Urban Forestry* – chapter contribution by Rob MacKenzie IDBN: 978-0995780897

Hewitt, C. N., Ashworth, K., & **MacKenzie, A. R.** (2020) Using green infrastructure to improve urban air quality (GI4AQ). *Ambio*, 49(1), 62-73. https://doi.org/10.1007/s13280-019-01164-3

**Hopcroft**, P., Ramstein, R., **T.A.M. Pugh**, S.J. Hunter, F. Murguia-Flores, A. Quiquet, Y. Sun, N. Tan & P.J. Valde (2020) Polar amplification of Pliocene climate by elevated trace gas radiative forcing, *Proceedings of the National Academy of Sciences* 117 (38) 23401-23407 https://doi.org/10.1073/pnas.2002320117

Hubau, W.; Lewis, S. L.; […] **Esquivel-Muelbert, A.** […] (2020) Asynchronous Carbon Sink Saturation in African and Amazonian tropical forests. *Nature* https://doi.org/10.1038/s41586-020-2035-0

Hulin M., **Jackson R.W.,** Harrison R.J., Mansfield J.W., (2020) Cherry picking by pseudomonads: After a century of research on canker, genomics provides insights into the evolution of pathogenicity towards stone fruits *Plant Pathology* Vol 69 (6) 953-118 https://doi.org/10.1111/ppa.13189

James, S. L., **Rabiey, M.,** Neuman, B. W., Percival, G., & **Jackson, R. W**. (2020) Isolation, Characterisation and Experimental Evolution of Phage that Infect the Horse Chestnut Tree Pathogen, Pseudomonas syringae pv. aesculi. *Current Microbiology,* 77(8), 1438-1447. https://doi.org/10.1007/s00284-020-01952-1

Kattge, J.; Bönisch, G.; Díaz, S; Lavorel, S; Prentice, I. C.; Leadley, P.; Tautenhahn S.; Werner G.; [….], **Esquivel-Muelbert, A.;** […] Wirth, C. (2020) Try Plant Trait Database – Enhanced Coverage and Open Access. *Global Change Biology* 26, 1: 119-188 https://doi.org/10.1111/gcb.14904

Klaar M.J., Shelley F.S., **Hannah D.M.** and **Krause S**. (2020) Instream wood increases streambed temperature variability but reduces thermal buffering in a lowland sandy stream, River Research and Applications, 36, 1529-1542 https://doi.org/10.1002/rra.3698

Levia D.F., Creed I.F., Bruen M., **Hannah D.M.,** Nanko K., Boyer E.W., Carlyle-Moses D.E., van de Giesen N., Grasso D., Guswa A.J., Hudson J.E., Hudson S.A., Shin'ichi I., Jackson R.B., Katul G.G., Kumagai T., Llorens P., Ribeiro F.L., Pataki D.E., Peters C.A., Sanchez Carretero D., Selker J.S., Tetzlaff D. and Zalewski M. (2020) Homogenization of the terrestrial water cycle, *Nature Geosciences, 13,* 656–658 https://doi.org/10.1038/s41561-020-0641-y

McDowell N.G., Allen C.D., … **Pugh T.A.M** (2020) Pervasive shifts in forest dynamics in a changing world. *Science.* Vol. 368, Issue 6494, https://doi.org/10.1126/science.aaz9463

**MacKenzie A.R**., Whyatt J.D., Barnes M.J., Davies G. and Hewitt C., (2019) Urban form strongly mediates the allometric scaling of airshed pollution concentrations. *Environmental Research Letters, 14*(12), 124078. https://doi.org/10.1088/1748-9326/ab50e3

**Ma, J., Ullah, S**., Niu, A., Liao, Z., Qin, Q., Xu, S., & Lin, C. (2020). Heavy metal pollution increases CH4 and decreases CO2 emissions due to soil microbial changes in a mangrove wetland: Microcosm experiment and field examination. *Chemosphere,* 128735. https://doi.org/10.1016/j.chemosphere.2020.128735

**Matthews T.,** Rigal F., Kostas K., Trigas P., Triantis K., (2020) Unravelling the small-island effect through phylogenetic community ecology. *Journal of Biogeography* 47 (22) 2341 – 2352 https://doi.org/10.1111/jbi.13940

**Meade, L., Plackett, A.R.G.** and **Hilton, J.** (2020) Reconstructing development of the earliest seed integuments raises a new hypothesis for the evolution of ancestral seed-bearing structures. *New Phytologist* https://doi.org/10.1111/nph.16792

Neale, N., Hulin M., Harrison, R., **Jackson R.W.,** Mansfield J., Arnold D., (2020) An improved conjugation method for Pseudomonas syringae*. Journal of Microbiological Methods,177,* 106025, https://doi.org/10.1016/j.mimet.2020.106025

Papastefanou, P., Zang, C. S., **Pugh, T. A. M., Liu, D.,** Grams, T. E. E., Hickler, T., & Rammig, A. (2020) A Dynamic Model for Strategies and Dynamics of Plant Water-Potential Regulation Under Drought Conditions. *Frontiers in Plant Science, 11*(373) https://doi.org/10.3389/fpls.2020.00373

Pšenička, J., Wang, J., **Hilton, J.**, Zhou, W., Bek, J., Opluštil, S. and Frojdová, J.(2020) A small, heterophyllous vine growing on *Psaronius* and *Cordaites* trees in the earliest Permian forests of North China. *International Journal of Plant Sciences* 181: 616–645 http://doi.org/10.1086/708814

**Pugh, T. A. M.,** Rademacher, T., Shafer, S. L., et al (2020) Understanding the uncertainty in global forest carbon turnover, *Biogeosciences*, 17, 3961–3989 https://doi.org/10.5194/bg-17-3961-2020

Rabin, S. S., Alexander, P., Henry, R., Anthoni, P., **Pugh, T. A. M**., Rounsevell, M., & Arneth, A. (2020) Impacts of future agricultural change on ecosystem service indicators. *Earth System Dynamics., 11*(2), 357-376 https://doi.org/10.5194/esd-11-357-2020

Reis, S.; Marimon, B.; Morandi, P.; Elias, F.; **Esquivel-Muelbert, A.**; […] Phillips, O. L. (2020) Causes and consequences of liana infestation in Southern Amazonia. *Journal of Ecology* https://doi.org/10.1111/1365-2745.13470

Sousa, T.; Schietti, J.; Coelho de Souza, F.; **Esquivel-Muelbert, A**; Ribeiro, I.; Emilio, T.; Pequeno, P.; Phillips, O.; Costa, F. (2020) Palms and trees resist extreme drought in Amazon forests with shallow water tables. *Journal of Ecology* https://doi.org/10.1111/1365-2745.13377

Sullivan M., Lewis, S. L.; […] **Esquivel-Muelbert, A.;** […] Phillips, O. L. (2020) Long-term thermal sensitivity of Earth's tropical forests. *Science* 368, 869-874 https://doi.org/science.aaw7578

Uekötter, F. (2020) *Im Strudel: Eine Umweltgeschichte der modernen Welt [an environmental history of the modern world since 1500] ISBN:* 3593513153

Uekötter, F. (2020) In Search of a Dust Bowl Narrative for the Twenty-First Century*, Great Plains Quarterly 40* (2020): 161-168 https://doi.org/10.1353/gpq.2020.0020

Zang, C. S.; Buras, A.; **Esquivel-Muelbert**, A.; Jump, A. S.; Rigling, A.; and Rammig A. (2020) Standardized Drought Indices in Ecological Research: Why one size does not fit all. *Global Change Biology* https://doi.org/10.1111/gcb.14809

Zohner C., Mo L., **Pugh T.A.M**., Bastin J., Crowther T., (2020) Interactive climate factors restrict future increases in spring productivity of temperate and boreal trees. *Global Change Biology 25* (7) https://doi.org/10.1111/gcb.15098

## Papers by Director Prof. Nicola Spence

**Spence, N.** (2020). Implementation of the GB Plant Health and Biosecurity Strategy 2014–2019 with foresight on a new strategy for 2020. *Outlook on Agriculture, 49*(1), 5-12. https://doi.org/10.1177/0030727020906831

**Spence, N.,** & Grant, S. (2020). Using International Trade Data to Inform the Plant Health and Biosecurity Response in the UK. *Outlooks on Pest Management, 31*(3), 117-120. doi:10.1564/v31_jun_06

Clubbe E., … **Spence, N.,** et al (2020). Current knowledge, status and future for plant and fungal diversity in Great Britain and the UK Overseas Territories. *Plants, People, Planet* https://doi.org/10.1002/ppp3.10142

Macleod, A., & Spence, N. (2020). Biosecurity: tools, behaviours and concepts. *Emerg Top Life Sci* (2020) 4 (5): 449–452**.** https://doi.org/10.1042/ETLS20200343

Sutherland, W., .. **Spence, N.,** … et al (2020). 80 Questions for UK Biological Security. *PlosONE* 16(1):e0241190.https://doi.org/10.1371/journal.pone.0241190 https://doi.org/10.1371/journal.pone.0241190

## Other literature, radio, television and social media

*News*

- BBC News website article and TV Interview Climate change: *Will planting millions of trees really save the planet?* https://www.bbc.co.uk/news/science-environment-51633560
- Earth.com NEWS Scientists identify the cause of tree mortality in the Amazon
- BBC News TV interview Rob MacKenzie 12 February 2020, Do roundabouts make Milton Keynes healthier? and BBC Look East & BBC Home Counties Radio
- Nature News Feature, When will the Amazon hit a tipping point? By Adriane Esquivel Muelbert, February 2020
- Interview for Mongabay online news, 'Impending Amazon tipping point puts biome and world at risk, scientists warn' by Adriane Esquivel Muelbert, January 2020
- BBC Brazil interview, 'O projeto rodoviário que ameaça uma das áreas mais conservadas da Amazônia' by Adriane Esquivel Muelbert, August 2020
- Washington Post, news article Impending Amazon tipping point puts biome and world at risk, scientists warn by Adriane Esquivel Muelbert, December 2020

*Other TV / Radio*

BBC Open Country radio interview, Prof. Rob Mackenzie https://www.bbc.co.uk/programmes/m000hghz

Filiming for Waterbear TV production - becomes live early 2021

*Podcasts*

Birmingham Tree People, podcast by Liam Crowley *Insects and Trees*

Birmingham Tree People, Podcast by Rob MacKenzie *BIFoR*

*Magazines/Newsletters (including online)*

Arb Magazine, Spring Edition article by Rob MacKenzie, *Promise Treescapes not Trees*,

Birmingham Brief (2020, Jan) article by Tom Pugh https://www.birmingham.ac.uk/news/thebirminghambrief/items/2020/01/the-forests-are-burning-what-does-this-mean-for-our-climate.aspx

Birmingham Perspectives (2020, April), Eszter Toth, *Use nature to support your well-being during the Covid-19 pandemic*

Birmingham Perspectives (2020, Dec) Alex Kulawska Thirsty and Drunken Trees

The Conversation, article by Ben Howard, *Green bailouts: relying on carbon offsetting will let polluting airlines off the hook.*

The Conversation, article by Tom Pugh https://theconversation.com/are-young-trees-or-old-forests-more-important-for-slowing-climate-change-139813

Ecological Continuity Trust, quarterly newsletter

Horizon the EU Research and Innovation Magazine July 2020 Understanding why trees are dying may be key to locking up carbon by Tom Pugh

Old Joe Alumni Magazine Spring Edition https://www.oldjoe.co.uk/article/birmingham-in-action-launch

*Small Woods Association, membership magazine, Ben Howard Can Trees Save Us? Spring 2020*

*Small Woods Association, membership magazine, Ben Howard Carbon Uptake. Autumn 2020*

University of Birmingham Postgraduate Researchers Development Blog, article on Equality Diversity and Inclusion by Sue Quick https://uobpgrdevelopment.wordpress.com/2020/11/30/do-i-feel-included-experience-and-thoughts-from-a-part-time-pgr/

## Responses to Government Consultations

Parliamentary Office of Science and Technology (POST) replied to a POSTnote request on reforestation https://post.parliament.uk/research-briefings/post-pn-0636/
Parliamentary inquiry into Forests and Woodland - written response to the
English Tree Strategy – as part of Forestry Skills Forum
as part of Urban Forests and Woodland Advisory Committee
As part of the Forest and Woodland Advisory Committee West Midlands

## Appendix 5: Funding

| Title | Lead HEI | PI | Funder | Total Value | Value to UoB |
|---|---|---|---|---|---|
| Predicting the emergence of host-adapted bacterial phytopathogens | NIAB | Rob Jackson | BBSRC | £1,800,000 | £373,875 |
| FORMMI: Forest management-mortality interactions – quantification of management effects on tree mortality and implications for carbon cycling | University of Birmingham | Tom Pugh | Marie Curie Fellowship | £300,000 | £300,000 |
| Irish Peatland Resilience (IPR) to changing climate and increased frequency and severity of drought | University of Birmingham | Nick Kettridge | Irish EPA | €300,000 | €300,000 |
| Policy Impact Fellowship: incorporating heat resilience into Birmingham's Big City Plan, and beyond | University of Birmingham | Emma Ferranti | QR funding (internal) | £40,000 (including overheads) | £40,000 |
| Sustainable resource governance solutions in sub-Saharan Africa | University of Birmingham | Fiona Nunan | Global Challenges Research Funding | £25,000 | £25,000 |
| Tackling the increase in methane from the Global South | University of Birmingham | Vincent Gauci | Global Challenges Research Funding | £16,263 | £16,263 |
| Knowledge exchange visit with University of Birmingham and University of Illinois at Urban-Champaign for the Foyer Lab | University of Birmingham | Christine Foyer | BRIDGE Seed Fund | £8,500 | £8,500 |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