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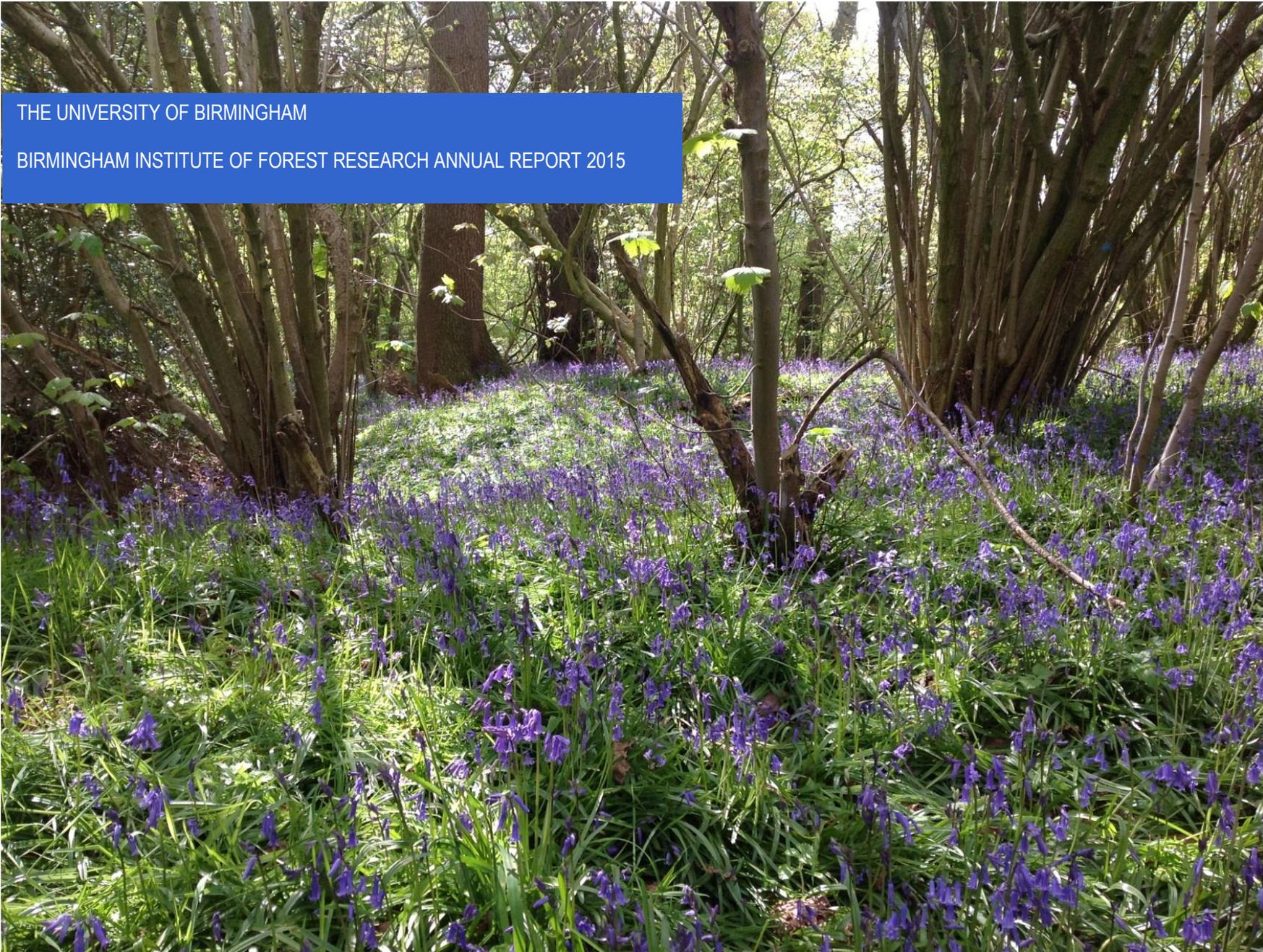


Birmingham Institute of Forest Research (BIFoR)

Annual Report

2015





THE UNIVERSITY OF BIRMINGHAM

BIRMINGHAM INSTITUTE OF FOREST RESEARCH ANNUAL REPORT 2015



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Summary

On 6 November 2013, in response to a visionary gift from the JABBS Foundation, the University of Birmingham launched the Birmingham Institute of Forest Research (BIFoR). The vision for BIFoR is that it will become a world-leading centre in the understanding of how forests react to the combined threats of climate change, invasive pests and diseases. Our purpose is to provide fundamental science, social science and cultural research of direct relevance to forested landscape anywhere in the world.

We are on track to deliver the key infrastructure for BIFoR: a Free Air Carbon Dioxide Enrichment (FACE) experiment in a completely different setting to those which have been done before - in an unmanaged coppice-with-standards¹ woodland of mature trees. The BIFoR FACE facility has received planning permission and construction is well on-course for completion in spring 2016.

The creation of BIFoR also allows the University of Birmingham to generate a renewed focus within the UK on woody plant pathology and physiology. The Institute has also been busy in bringing together a wide range of expertise from across the University, from bioscientists and ecologists to economists and sport and literature researchers, in response to inquiries from stakeholders from across the climate-forest-timber sector.

¹ <https://en.wikipedia.org/wiki/coppicing>



BIFoR - VISION AND AIMS

World leading and interdisciplinary research

FUNDAMENTAL
SCIENCE

SOCIAL
SCIENCE

CULTURAL
RESEARCH



FORESTS MUST BE A CENTRAL PART OF
ONE-PLANET LIVING.

Who's who in BIFoR

The Director of BIFoR is Professor Rob MacKenzie and the Director for Education within BIFoR is Dr Jerry Pritchard.

The BIFoR Advisory Group, an external panel of outstanding scientists and industrialists, provides top-level guidance to the Institute. This group meets bi-annually and is chaired by Pro-Vice Chancellor and Head of College of Life & Environmental Sciences, Professor Myra Nimmo. We also have an internal panel, the BIFoR Institute Board, whose membership includes the Heads of School of Biosciences and Geography, Earth & Environmental Sciences (GEES), along with representatives from other colleges within the University of Birmingham.

We have a team of staff that have been working on the BIFoR FACE Facility design and build. These are Dr Kris Hart (Operations Manager), Dan Holmes (Estate Lead) and Brigit Ayling (Project Manager). We are currently recruiting for two field technicians who will be based at BIFoR FACE from early 2016.

Next year we will recruit up to two senior lectureship/lectureship posts in plant-pathogen interactions or tree health. In addition, Dr Tom Pugh will join the University in March 2016 as a lecturer in GEES. He is a forest biogeochemistry modeller with interests currently focused on drought effects and tree mortality.

We also have a team of researchers who have been busy gathering samples to characterise the BIFoR FACE site.



Dr Phillip Blae



Responsible for "all things water-related at BIFoR FACE"

Dr Liz Hamilton



Interested in "all things soil related at BIFoR FACE"

Dr Alex Poynter
Alex is



interested in "all things ecological and biogeographical"

Dr Rick Thomas



Rick leads the team.

Dr Francis Pope



Academic lead biosphere-atmosphere interactions.

BIFoR FACE

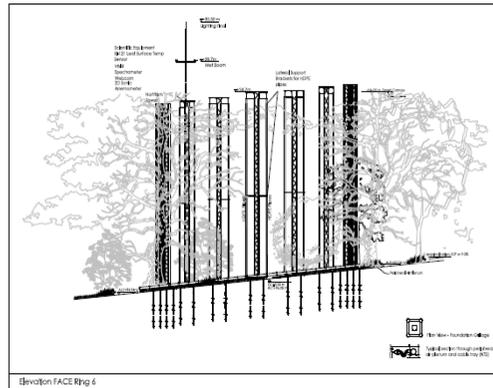
A unique experimental test of environmental resilience — the BIFoR Free-Air Carbon Dioxide Enrichment (FACE) facility

BIFoR FACE is in the vanguard of a global initiative to investigate the effects of climate change on real, mature, complicated forest ecosystems². The establishment of a global network of FACE experiments in different climatic zones will allow BIFoR scientists to test the generality of results derived from BIFoR FACE.

How can this woodland best be managed for carbon storage under climate change, and what general lessons can be learnt from BIFoR FACE and the global network of second-generation forest FACE experiments?

Do other macro- or micro-nutrients limit the uptake of carbon in this ecosystem now, or are they likely to in the future?

Plan of a BIFoR FACE array. Each mast reaches above the canopy. The masts form a circle around an area of about 30m in diameter.



3 experimental rings – elevated CO₂
3 control rings – ambient air
3 control rings - no infrastructure rings

What aspects of biodiversity and ecosystem structure-and-function alter under elevated CO₂ and how do these alterations feed back onto carbon storage?

Does elevated CO₂ increase the carbon storage in a mature temperate deciduous woodland ecosystem?

² Norby, R. J., M. G. De Kauwe, T. F. Domingues, R. A. Duursma, D. S. Ellsworth, D. S. Goll, D. M. Lapola, K. A. Luus, A. R. MacKenzie, B. E. Medlyn, R. Pavlick, A. Rammig, B. Smith, R. Thomas, K. Thonicke, A. P. Walker, Xiaojuan Yang, and Sönke Zaehle, Model-data synthesis for the next generation of forest FACE experiments, *New Phytologist*, 2015, DOI: 10.1111/nph.13593.

Building BIFoR FACE

Planning permission was granted by Stafford Borough Council on the 16th December 2014 following submission of a detailed planning application and courteous consultation process.

Throughout 2015 the BIFoR FACE Facility at Mill Haft was a hive of activity with construction works well underway by contractor Shaylor Group. The site compound is now complete including a biometric entry system which ensures the site remains safe and secure and allows for thorough induction of all persons on site. Access to the site has been formed including installation of incoming services and the formation of a tarmac access road. The new forest track is progressing very well, allowing other trades to access the 'FACE rings'.

Piling has commenced to the welfare units and the FACE rings with the steel grillages having been assembled and carefully placed in to position (Fig1). These form the bases to support the latticework masts that will form the FACE rings.

The position of the CO₂ pipework and services in the forest have been set out. Approximately one thousand metres of pipework will carry CO₂ throughout the woodland (Fig 2).

The components of the masts have been delivered to a field north of Mill Haft where they have been assembled. The next stage is the placing of these masts in position by helicopter.

The BIFoR site received a high score at a recent visit from the Considerate Constructors Scheme and has also been nominated for an award from our external Health and Safety consultants, Building Safety Group.

The design team meet fortnightly, enabling Shaylor Group, the University of Birmingham, BIFoR itself, and our subcontractors to ensure that this project runs to the highest of standards.



Fig 1. Typical FACE Array Grillage with piles installed



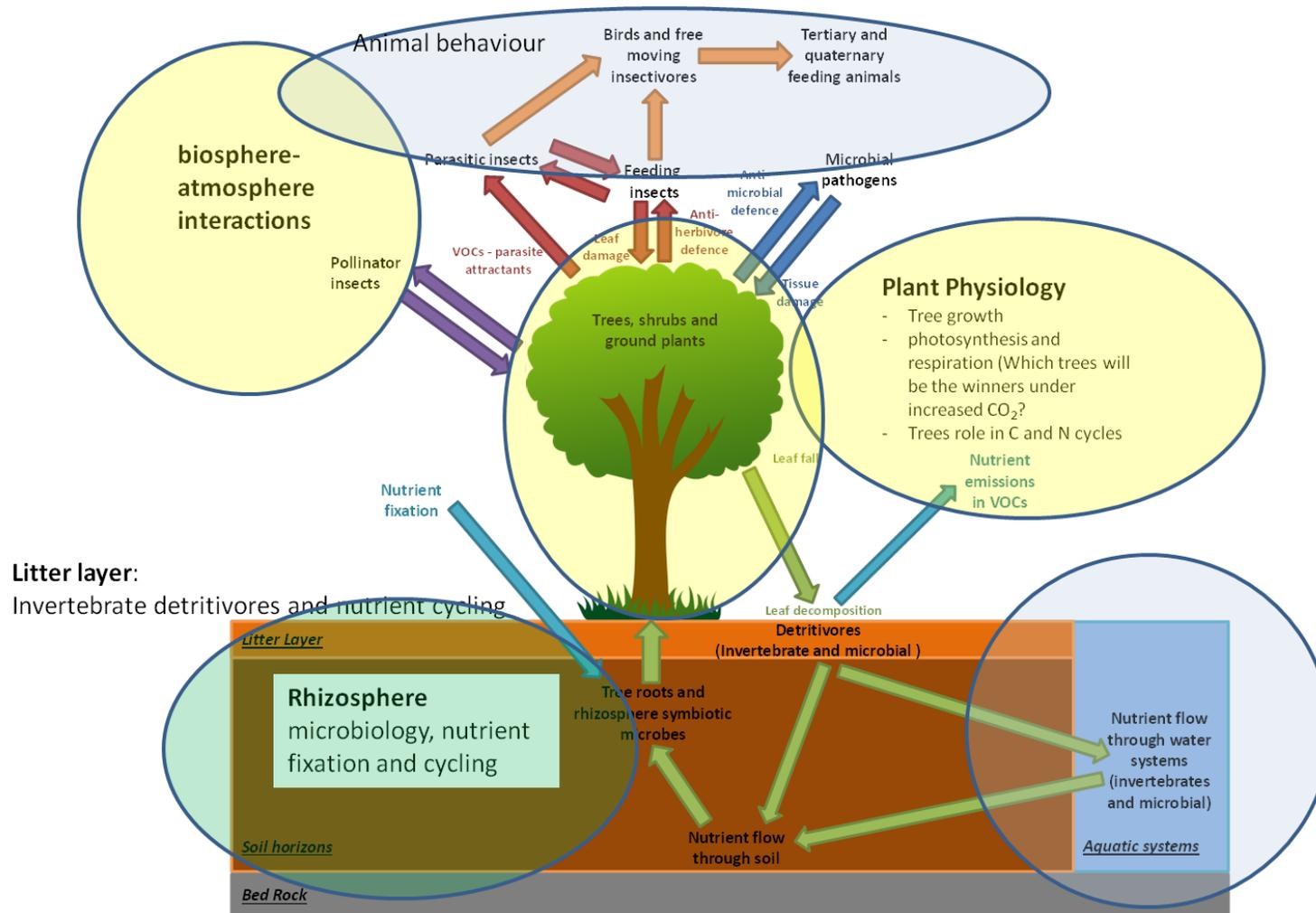
Fig 2.0 Plenum Construction



Fig 3.0 CO₂ tank manufactured in Czech Republic

Scientific Activity at BIFoR FACE

Early science results are essential and integral to BIFoR FACE. An overview of the scientific activity is presented in the diagram below:



Phenology camera live at <http://ow.ly/XQ3WY>

Stream physics and chemistry live at <http://ow.ly/XQ3L2>

Outputs

The principal modes of delivery for BIFoR are:

DATA

from long-term experiments on the effects of elevated carbon dioxide levels on woodland ecophysiology;

CO-DESIGN

of research with stakeholders – engaged at the start and throughout; robust evidence of the value of forests not just as factors in economic wealth but as part of an ecosystem service: clean water, clean and temperate air, pollination vectors and habitats as well as their role in social wellbeing;

Research that can be translated into **MANAGEMENT PRACTICE** relevant to plantation forestry, tree-based horticulture and botanical collections.

High-impact Journal and policy **PAPERS** which are likely to form the basis of governmental practice and implementation through our stakeholders and collaborations.

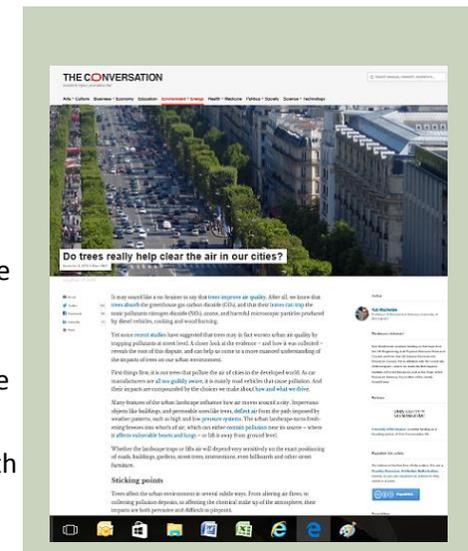
Other outputs

We present the science behind BIFoR regularly to academics and practitioners: see Appendices 1 and 2.

Winter 2015: BIFoR by R, Donovan, L Hamilton, D Holmes and AR MacKenzie, a 3-page article in the Arboricultural Association magazine.

BIFoR Spring 2015: BIFoR, by Hannah Eno, a 3-page article in the AXE magazine a publication from the Municipal Tree Officer's Association.

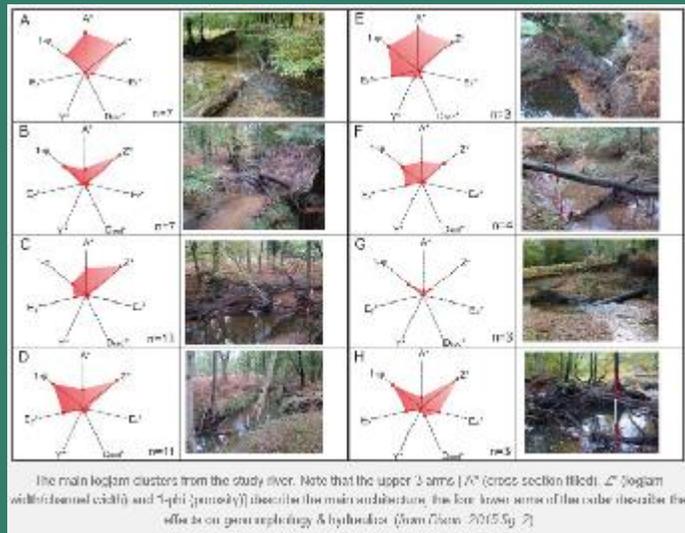
November 2015: ["Do trees really help clear the air in our cities?"](http://www.theconversation.com) an article written by Rob MacKenzie for the website www.theconversation.com. The Conversation is a collaboration between editors and academics to provide informed news analysis and commentary that's free to read and republish. The article attracted over 61,000 reads in the month of November and was the most-read article contributed by the University of Birmingham in that month.



BIFoR Papers (see Appendix 3 for full list)

BIFoR Paper Number 4: A dimensionless statistical analysis of logjam form and process

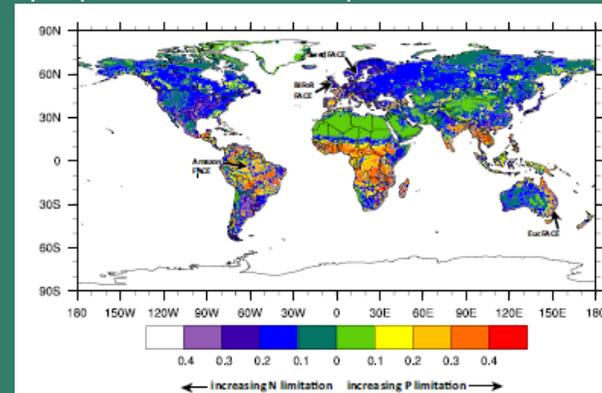
Dr Simon Dixon of University of Birmingham, has had a paper accepted in the *Journal Ecohydrology*. This paper looks at how trees make rivers interesting and diverse biologically. Simon hopes that his research could prove to be really useful for river restoration and river management.



Dixon, S. J., A dimensionless statistical analysis of logjam form and process, *Ecohydrology*, 2015 in press
<http://onlinelibrary.wiley.com/doi/10.1002/eco.1710/abstract>

BIFoR Paper Number 5: Model–data synthesis for the next generation of forest free-air CO₂ enrichment (FACE) experiments

Rob MacKenzie and Rick Thomas teamed up with forest-FACE experts world-wide for this paper, published in the *New Phytologist*. The paper summarises the successes of first stage FACE experiments and discusses how the next phase of FACE experiments to be set in mature forests in different biomes and over a wide range of climate space and biodiversity will significantly expand the inference space.

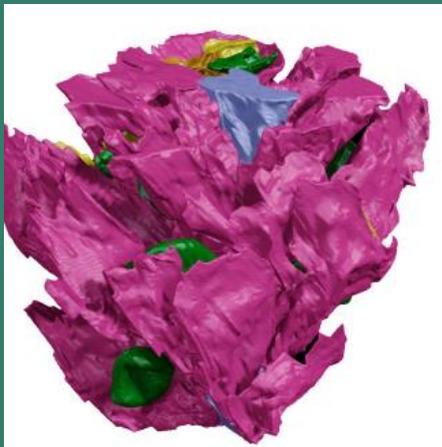


Norby, R. J., M. G. De Kauwe, T. F. Domingues, R. A. Duursma, D. S. Ellsworth, D. S. Goll, D. M. Lapola, K. A. Luus, A. R. MacKenzie, B. E. Medlyn, R. Pavlick, A. Rammig, B. Smith, R. Thomas, K. Thonicke, A. P. Walker, Xiaojuan Yang, and Sönke Zaehle, Model-data synthesis for the next generation of forest FACE experiments, *New Phytologist*, 2015, DOI: 10.1111/nph.13593
<http://onlinelibrary.wiley.com/doi/10.1111/nph.13593/abstract>

BIFoR Paper Number 8: Conifer evolution

Dr Jason Hilton, a palaeobotanist and evolutionary plant biologist provided a deep-time perspective to BIFoR, published in the prestigious *American Journal of Botany*. A seed-cone that constitutes the earliest anatomically preserved evidence for the diverse conifer family Cupressaceae has helped Jason and colleagues to analyse how the structures of conifer cones have changed through time in response to changing environments and climate.

Spencer, A. R. T., G. Mapes, R. M. Bateman, J. Hilton, and G. W. Rothwell (2015) Middle Jurassic evidence for the origin of Cupressaceae: a paleobotanical context for the roles of regulatory genetics and development in the evolution of conifer seed cones, *American Journal of Botany*, Vol 102, No 6 June 2015 <http://www.amjbot.org/content/102/6/942.full.pdf+html>



BIFoR Paper 13: Variation in species' habitat associations

Ecologist Dr Scott Hayward and colleagues published in *Global Change Biology* a paper studying how macro- and microclimatic interactions can drive variation in species' habitat associations.

The study looks at how habitat associations of the speckled wood butterfly, *Pararge aegeria*, in the UK have changed over time in line with variation in specific aspects of climate (temperature and moisture availability). These changing patterns in habitat associations reflect the butterfly's responses to local climate ('microclimatic') differences in its favoured (woodland) habitat versus more open habitats.

Pateman, R. M., Thomas, C. D., **Hayward, S. A. L.** and Hill, J. K. (2015), Macro- and microclimatic interactions can drive variation in species' habitat associations. *Glob Change Biol.* doi:10.1111/gcb.13056



By Quartl (Own work) [CC BY-SA 3.0], via Wikimedia Commons

Strategic Stakeholder Engagement

BIFoR Communications

Social Media

BIFoR has a refreshed public website (<http://www.birmingham.ac.uk/bifor>) and a Twitter account: @BIFoRUoB.

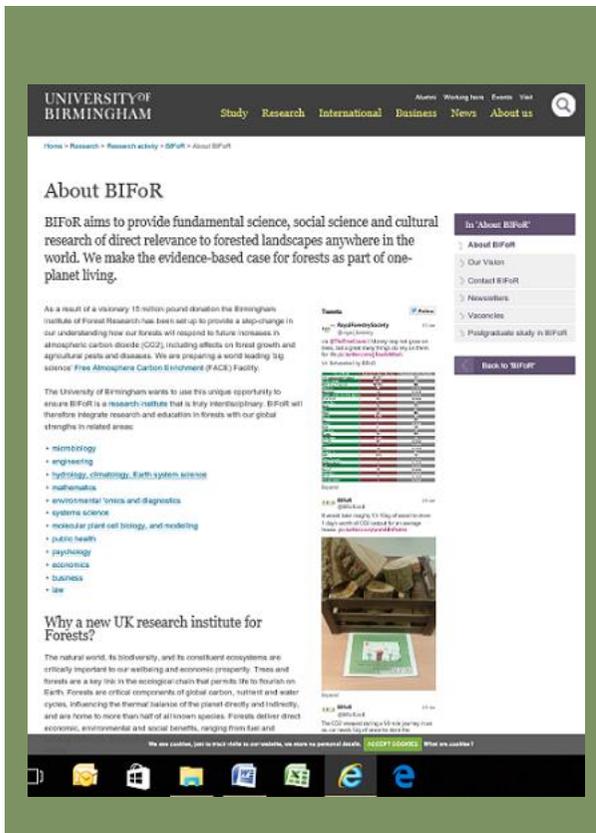
We also have a BIFoR video called “If you go down to the woods today..” which has been viewed many times and describes the importance of BIFoR FACE. The following link takes you to this video <http://ow.ly/Uehp2> or alternatively you can watch it on our website.

The BIFoR FACE Facility was awarded the “Forest of the Month” by the British Ecological Society in February 2015 see <http://ow.ly/UQgOk>

We produce two newsletters a year

— ‘Bud Burst’ and ‘Last Leaf Fall’ —

and these are circulated to almost 500 people.



Strategic Stakeholder Engagement

There has been significant engagement with key stakeholders throughout the past year. We have worked very hard at ensuring we link up to other Higher Education Institutes (HEIs). A flavour of the relationships we are building with Businesses, Government Organisations and Non-governmental Organisations(NGOs) follows:



Amorim Cortico (the world's largest producer of cork products) In June BIFoR Director, Rob MacKenzie went on a fact finding mission and met with senior colleagues.

DRAX
(Key UK power provider)

We were pleased to meet with the Head of the Sustainability team for Drax when she came to the University of Birmingham campus to meet with us, and we have since expanded our touch points with Drax.

Forestry Commission

We are in contact with many of the employees from the Forestry Commission and we are working closely with Forest Research.

A senior representative of the Forestry Commission continues to sit on our Advisory Group.

The Small Woods Association

Further to a site visit by the Small Woods Association to Mill Haft we continued conversation and met with them at their site in April 2015.

USDA Forest Service -
Rich Guldin from the USDA visited in April and was impressed with the scale of the BIFoR FACE Facility. Rich has provided invaluable connections into the US Forest Service and its North American research partners.

Woodland Trust

In April 2015 we met with the CEO and on 10 November 2015 hosted the seminar "Unlocking the Benefits of Woods and Trees: Funding Models and Mechanisms." The details of this event were outlined in the webpages of the Telegraph website.



Other organisations we continue to work with to develop research and educational opportunities are: Arboricultural Association, Bergen Energi, Cornerways Nursery, Continuous Cover Forestry Group, Crown Estates, Earthwatch, Grown in Britain, Heart of England Forest Project, Interserve, Institute of Chartered Foresters (ICF), Joint Research Centre- ISPRA, Italy, Marston Vale Community Forest, Natural England, Royal Forestry Society, Sylva Foundation, Trees for Cities.

Strategic Stakeholder Engagement - Public engagement

BBC Countryfile

On 17 April 2015 BIFoR were the only university to be featured in an hour-long programme discussing the state of the nation's woodlands and forests.



Norbury Canal Festival

Over the May bank holiday BIFoR were invited to have a stand at the Norbury Canal Festival. Over the 3 days we spoke to over 200 people about BIFoR. We also had some interactive displays for the children to get involved with.

We have had BIFoR displays at each of the **University of Birmingham Undergraduate recruitment days**.



Royal Welsh Show

In July 2015 BIFoR attended all 4 days at the **Royal Welsh Show**, displaying alongside the Institute of Chartered Foresters (ICF) and other HEIs offering forestry related programmes of study and research.

In September we took part in the **University of Birmingham Community Day**. There were many thousands of visitors. Families came to our stand to hear about the exciting "big science" experiment"



Grown in Britain Week

In October a master class was run by Dr Jerry Pritchard for **Grown in Britain Week**.

Funding

The JABBS Foundation

We continue to work closely with the JABBS Foundation who in November 2013 committed to provide a £15 million gift to the University of Birmingham. A representative of JABBS recently commented that the building of the BIFoR FACE Facility just minutes' drive from his office was "exceptionally well-run."

The John Horseman Trust



Following a visit to the BIFoR FACE facility in March 2015, alumnus John Horseman and his wife Moyra have very generously donated a second gift to the project, bringing their total donation to £150,000.

HydEOMEx

(£25k; PI Stefan Krause)

Demonstrating the potential of real-time EO for hydrological situation monitoring and early warning in the sentinel era - a NERC climate services pilot grant (linking BIFoR and in particular soil moisture data to new real-time EO and COSMOS), awarded in Dec/2015

Dr Louise Hardwick, AHRC Early Career Leadership Fellow (2012-2014)

European Research Council – Starter Grant Scheme, Biopolitical Ecocriticism in the Caribbean. Duration: 5 years Approx. total sum: 1.5 million Euros.

Help in-kind

In October 2015, we received a very large donation of books and journals from Andrew Packham, son of the late Professor John Packham of Wolverhampton University. Prof Packham was a distinguished scholar, with interests in woodland ecology that resonate strongly with those of BIFoR. For example, he was a founding member of the Continuous Cover Forestry Group, which is committed to the development of "close to nature" forest management techniques, and a group which has provided guidance and support to BIFoR during its inception. His bequest will form the basis of an on-site library at the BIFoR FACE Facility.

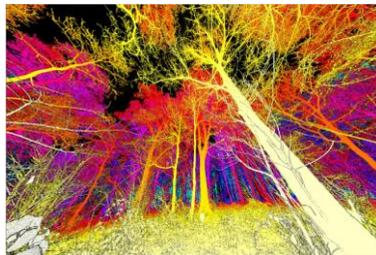


Next Steps

The capability and reputation of BIFoR is growing quickly, internally and externally, nationally and internationally. We have a dedicated and passionate team working directly for BIFoR and many BIFoR Champions across the University.

Our key foci for 2016 will be;

- to nurture our newly recruited staff
- to appoint up to 2 lecturer/senior lecturers in plant-pathogen interactions or tree health
- to expand and deepen science at BIFoR FACE and submit early scientific deliverables, i.e.:
 - A peer-reviewed paper on the baseline biogeochemical and ecophysiological state of Mill Haft prior to the FACE experiment
- to conclude and snag-test the build of the BIFoR FACE Facilities
- to deepen our relationships with external stakeholders including, when appropriate, joint funding and help in-kind to BIFoR



Appendix 1: BIFoR Science Presentations

The following scientific talks have been presented during January 2015–November 2015.

“BIFoR FACE: A ten-year Free-Air Carbon Dioxide Enrichment (FACE) Experiment in Old Growth Deciduous English Woodland”	American Geophysical Union (AGU) Fall Meeting, by Rick Thomas, December 2015.
“Resilience: a research perspective How can the research community contribute to the resilience challenge? What are likely to be the most fruitful lines of enquiry?”	Royal Forestry Society, Annual Conference, 1 st October 2015
“The BIFoR FACE facility: the ecohydrological responses of a mature deciduous woodland to elevated carbon dioxide”	Keynote presentation, British Hydrological Annual Meeting, University of Birmingham 16 th September 2015
“Trees Resilience and radical urban interventions”	Seminar organised alongside Trees for Cities, London, 30 June 2015
"A New Multi-disciplinary Institute of Forest Research"	HEaTED Conference by Kris Hart, 10 June
“The role of forests in the carbon cycle and renewable energy”	Bergen Energi Conference 2015, Bergen, 20-21 st May 2015
“The influence of urban form and urban trees on air quality: current patterns and systems-thinking for change”	COST event at the Mediterranean Forest Week, Barcelona, 17-18 th March 2015
“The BIFoR Free-Air Carbon Dioxide Enrichment Facility, Mill Haft”	Invited seminar, Dept of Plant & Soil Science, University of Aberdeen, 15 May 2015
“The influence of urban form and urban trees on air quality: current patterns and systems-thinking for change”	Invited lecture, GreenInUrb COST meeting, Barcelona, 16-18 March 2015
“FACE and the terrestrial carbon cycle”	Invited lecture, RFS NW Midlands Branch Winter Evening Seminar - Resilient Woods and Forests. Harper Adams University, 17 Feb 2015

Appendix 2: BIFoR presence at sectoral conferences and workshops

An essential part of establishing BIFoR as a major new research initiative has been presence at conferences, as listed below. This has allowed the BIFoR team to scan the sectoral terrain and identify its distinctive strengths.

Month	Event
March	Speaker and attendee COST event at the Mediterranean Forest Week, Barcelona
	Attendee EcoBuild, London
April	Exhibitor at UK PlantSci Conference Simon Dixon attended the EGU Annual Conference 2015 [Vienna] The effects of floodplain forest restoration and logjams on flood risk and flood hydrology, 14 Apr 2015
	Grace Garner attended and presented at the Institute of Fisheries Management Specialist Conference , 21–22 April 2015
June	Attendee at Big Barn Conference, Ely, Cambridgeshire
July	Attendee Westminster Energy, Environment & Transport Forum Seminar: Carbon Capture and Storage in the UK: policy priorities, collaboration and long-term confidence
Sept	Exhibitor and speaker at the British Hydrological Association Meeting, University of Birmingham
	Attendee of the World Forestry Congress, Durban, South Africa
	Chair of session at the Arboricultural Association Annual Conference, University of Warwick
October	4th SCAR Foresight Conference. Sustainable Agriculture, Forestry and Fisheries in the Bioeconomy – A challenge for Europe
	Nick Kettridge attended a 2 day UK event is called Soil-Plant-Atmosphere-Continuum 2015 organised by Rothamsted Research and Delta-T Devices
	Attendee and Speaker - Royal Forestry Society, Annual Conference, 1 st October 2015
November	Louise Hardwick attended the National Forest Company seminar - Innovation in landscape-scale conservation, restoration and engagement
	Rob MacKenzie, David Maddison and Graham Squires contributed to the meeting “Unlocking the Benefits of Woods and Trees: Funding Models and Mechanisms”, organized by the Woodland Trust

Appendix 3- BIFoR Publications

1. Dixon, S. J., A dimensionless statistical analysis of logjam form and process, *Ecohydrology*, 2015 <http://onlinelibrary.wiley.com/doi/10.1002/eco.1710/abstract>
2. Hale, J, and 20 others (2015) Delivering a multi-functional and resilient urban forest, *Sustainability*, ISSN 2071-1050 www.mdpi.com/journal/sustainability
3. Levine, J. G., MacKenzie, A. R., and 20 others: Isoprene chemistry in pristine and polluted Amazon environments: Eulerian and Lagrangian model frameworks and the strong bearing they have on our understanding of surface ozone and predictions of rainforest exposure to this priority pollutant, *Atmos. Chem. Phys. Discuss.*, 15, 24251-24310, doi:10.5194/acpd-15-24251-2015, 2015.
4. Norby, R. J., M. G. De Kauwe, T. F. Domingues, R. A. Duursma, D. S. Ellsworth, D. S. Goll, D. M. Lapola, K. A. Luus, A. R. MacKenzie, B. E. Medlyn, R. Pavlick, A Rammig, B Smith, R Thomas, K Thonicke, A. P. Walker, Xiaojuan Yang, and Sönke Zaehle, Model-data synthesis for the next generation of forest FACE experiments, *New Phytologist*, 2015, DOI: 10.1111/nph.13593 <http://onlinelibrary.wiley.com/doi/10.1111/nph.13593/abstract>
5. Pateman, R. M., Thomas, C. D., Hayward, S. A. L. and Hill, J. K. (2015), Macro- And Micro-Climatic Interactions Can Drive Variation in Species' Habitat Associations. *Glob Change Biol.* doi:10.1111/gcb.13056
6. Spencer, A. R. T., G. Mapes, R. M. Bateman, J. Hilton, and G. W. Rothwell (2015) Middle Jurassic evidence for the origin of Cupressaceae: a paleobotanical context for the roles of regulatory genetics and development in the evolution of conifer seed cones, *American Journal of Botany*, Vol 102, No 6 June 2015 <http://www.amjbot.org/content/102/6/942.full.pdf+html>
7. Shi-Jun Wang, Jun Wang, Alan R. T. Spencer, Richard M. Bateman, Longyi Shao, and Jason Hilton: Ventralistachyaceae, *Fam. Nov.: Anatomically preserved strobili and shoots from the Permian of China suggest that noeggerathiopsids are a divergent class of sophisticated eusporangiate ferns rather than sphenopsids or progymnosperms.*, *American Journal of Botany*, submitted April 2015
8. Uekötter, F. "Recollections of Rubber," Dominik Geppert, Frank Lorenz Müller (eds.), *Imperial Sites of Memory. Commemorating Colonial Rule in the Nineteenth and Twentieth Centuries* (Manchester: Manchester University Press, 2015), 243-265.
9. Uekötter, F. "You Ain't Seen Nothing Yet. A Death-Defying Look at the Future of the Climate Debate," Heike Greschke, Julia Tischler (eds.), *Grounding Global Climate Change. Contributions from the Social and Cultural Sciences* (Dordrecht, 2015), 175-181.
10. Wyche, K. P., P. S. Monks, K. L. Smallbone, J. F. Hamilton, M. R. Alfarra, A. R. Rickard, G. B. McFiggans, M. E. Jenkin, W. J. Bloss, Annette C. Ryan, C. N. Hewitt, A. R. MacKenzie, Mapping gas phase organic reactivity and concomitant secondary organic aerosol formation: chemometric dimension reduction techniques for the deconvolution of complex atmospheric datasets, *Atmos. Chem. Phys. Discuss.*, 15, 1651-1702, 2015
11. MacKenzie, A. R., (2014) Launching an Institute of Forest Research in the 21st Century, in *Forestry for the Curious: Why Study Forestry*, V. Kishor (ed.), ISBN 978-1-925128-52-9
12. Uekötter, F., (edited collection) *Comparing Apples, Oranges, and Cotton. Environmental Perspectives on the Global Plantation* (Frankfurt: Campus, 2014).
13. Uekötter, F., (monograph) *The Greenest Nation? A New History of German Environmentalism* (Boston: MIT Press, 2014).
14. Uekötter, F. "Ein Haus auf schwankendem Boden. Überlegungen zur Begriffsgeschichte der Nachhaltigkeit," *Aus Politik und Zeitgeschichte* 64:31 (July 28, 2014): 9-15
15. Wyche, K. P., A. C. Ryan, C. N. Hewitt, M. R. Alfarra, G. McFiggans, T. Carr, P. S. Monks, K. L. Smallbone, G. Capes, J. F. Hamilton, T. A. M. Pugh, and A. R. MacKenzie (2014), Emissions of biogenic volatile organic compounds and subsequent photochemical production of secondary organic aerosol in mesocosm studies of temperate and tropical plant species, *Atmos. Chem. Phys.*, 14, 12781-12801, doi:10.5194/acp-14-12781-2014, 2014

Stay in touch



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