The Birmingham Institute of Forest Research

Trees and forests underpin **food and fuel security** in many regions, including the UK, as providers of **sustainable resources** for wood and derived materials, **key ecosystems**, and **recreational areas**.

The role of forests in delivering **underpinning services to society** is consistently undervalued, and will continue to be undervalued until a **robust evidence base** for those services has been provided.

BIFoR aims to provide **fundamental science, social science and cultural research** of direct relevance to forested landscapes anywhere in the world. We will make the case for forests as part of one-planet living.

WORLD VIEW *A personal take on events*

Emerging powers need a more-inclusive science

Fast-growing economies can learn from the West's mistakes and couple social and 'hard' sciences to address their own societal needs, says **Colin Macilwain**.

Fast-growing economies can learn from the West's mistakes and couple social and 'hard' sciences to address their own societal needs, says **Colin Macilwain**.

MAKE NO MISTAKE: THE GEOGRAPHICAL **BALANCE OF POWER** IN GLOBAL SCIENCE IS **SHIFTING.**

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Two fundamental and interrelated challenges:

•the **impact of climate and environmental change** on woodlands, and

•the resilience of trees to invasive **pests and diseases**.

BIFoR Research Priorities

1. Assessing the **resilience** of forests to pests, pathogens and environmental influences;
2. **solutions** to address tree and forest health, addressing plant disease and its control;
3. methods for successful **integration** of trees into farming systems to support production and the services provided by the whole ecosystem;
4. 'barcode of life' whole-ecosystem genomic characterisation to help direct the **restoration** of ancient woodlands; and
5. methods of **governance** which incorporate scientific evidence and which will enable sustainable management of forest estate.

BIFoR plant pathology research trajectory

1. Characterise **transcriptional/metabolomic "fingerprints"** for each of the major biotic challenges facing temperate woodland trees
2. Identify **pathogen resistance/resilience mechanisms** that are already available in local gene pools, either as host resistance traits or via pathogen competitors/predators
3. Highlight **potential treatments** based on field (as opposed to lab) **biomarkers** - e.g., identifying fungicides that target critical early events (such as leaf penetration) in the host-pathogen interaction

BIFoR Infrastructure

Combine field studies with controlled environment studies on campus

The BIFoR Field Facility: Norbury Estate

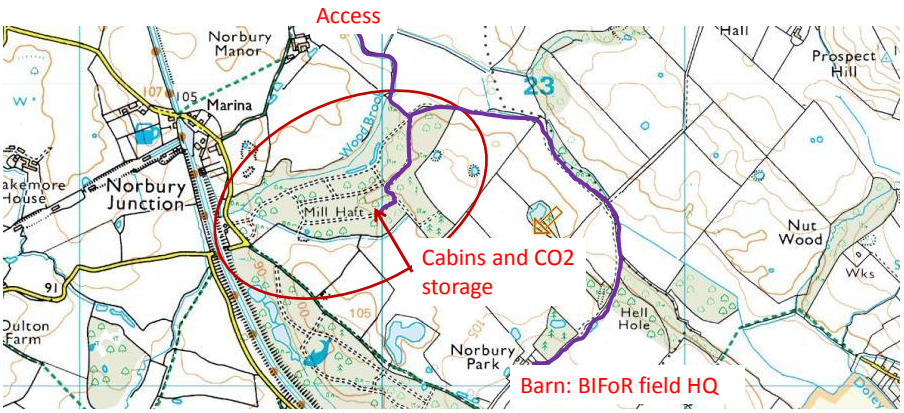
At the field facility:

- trees to be exposed to elevated concentrations of CO_2 and
- manipulate temperature, rainfall and nutrient supply.

Impacts of these environmental variables on

- the structure of the forest, including its biodiversity
- carbon storage,
- nutrient (e.g. nitrogen, phosphorus) and energy cycling,
- hydrology, and
- interactions with pests and pathogens.

The BIFoR Field Facility: Norbury Estate



Free-air carbon dioxide enrichment methodology (FACE) used to minimise the impact of artificial chambers on trees

Pervasive sensing - water, air, soil biogeochemistry - in-situ and remote sensing

Comprehensive sampling and bio-banking

Field HQ: data work-up; simple lab space; **seminar space** for ~20

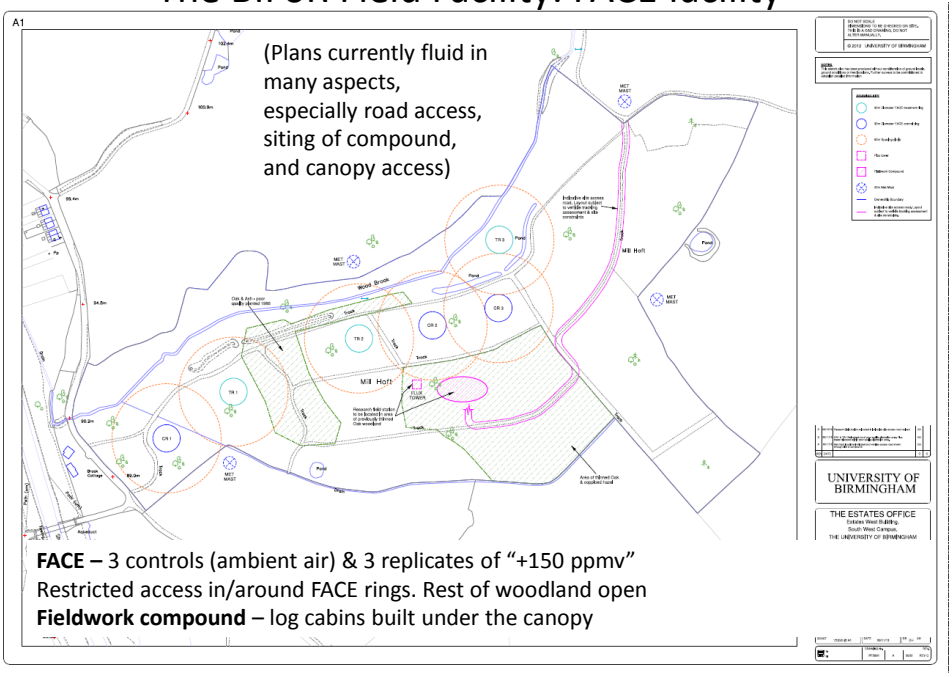
The BIFoR Forest FACE Facility

BIFoR forest FACE facility – a >10-year experiment to study the response of a mature temperate deciduous forest ecosystem to elevated CO_2.

Hawkesbury, University of Western Sydney, is the only other forest FACE currently running

FACE experiment designed by Brookhaven National Lab – every system a bespoke design for context – opportunity to test **innovative engineering solutions**

The BIFoR Field Facility: FACE facility



FACE – 3 controls (ambient air) & 3 replicates of "+150 ppmv"
Restricted access in/around FACE rings. Rest of woodland open
Fieldwork compound – log cabins built under the canopy

BIFoR FACE top-level research questions

1. Does elevated CO_2 increase the **carbon storage** in a mature temperate deciduous woodland ecosystem?
2. Do other **macro- or micro-nutrients** limit the uptake of carbon in this ecosystem now, or are they likely to in the future?
3. What aspects of **biodiversity and ecosystem structure-and-function** alter under elevated CO_2 and how do these alterations feed back onto carbon storage?
4. How can this ecosystem best be **managed for carbon storage** under climate change?

BIFoR FACE specific research questions

1. What **impacts of wet and dry years** on carbon storage?
2. What impacts of elevated CO_2 on **susceptibility and resistance to pathogens**?
3. What impacts of elevated CO_2 on **production, dispersion, and fate of propagules**?
4. What direct and indirect (e.g., through changes in herbivory) effects of elevated CO_2 on the **production of plant volatiles**?
5. What **fluxes of momentum and trace gases** over the agricultural mosaic landscape including the BIFoR FACE woodland?
6. What contributions of gas-phase, aqueous-phase, and aeolian-dust **transport of carbon and nutrients** into and out of the FACE woodland?
7. How does **whole-stand biomass, allometry and stand phenology** alter over time and under elevated CO_2?
8. To what extent does elevated CO_2 impact on the resilience and susceptibility of the ecosystem to **species invasions: plant, microbial and invertebrate**.
9. Which **tree and plant genotypes** are best adapted to increased levels of CO_2?
10. Can information on **gene expression and metabolites** allow us to scale-up plant responses to elevated CO_2 to the whole organism level and inform our fundamental understanding of impacts across plant functional types?
11. …**etc**

Establishing the BIFoR Field Facility

Characterise the woodland as an ecosystem:

- •physical, chemical and biological status
- •above and below ground and
- •in the air and water.

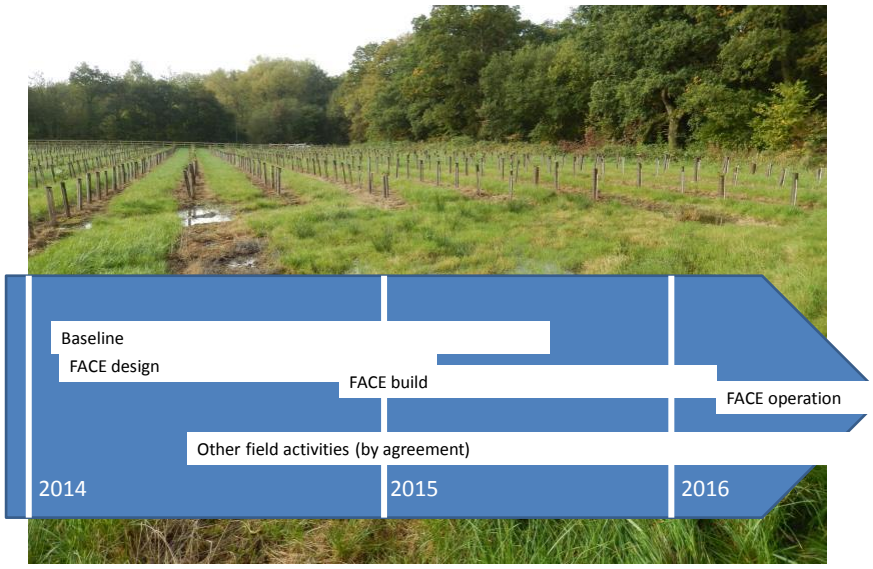
2014 - 2016

Expertise in these areas exists across campus.

Also liaise with research partners

- •Forest Research/ Forestry Commission
- •National Centre for Atmospheric Science; Met Office
- •Centre for Ecology and Hydrology, and
- •University research groups from the UK and overseas

Establishing the BIFoR Field Facility: Timeline



BIFoR will integrate research and education in forests with our global strengths in related areas:

- •microbiology,
- •hydrology, climatology, Earth system science,
- •environmental 'omics and diagnostics,
- •molecular plant cell biology, and modelling.

But also

- •engineering, mathematics, systems science, public health, economics, business, and law

The Institute also connects to long-term ecosystem research networks in the UK, continental Europe, and North America.

BIFoR impacts and outcomes

1. Scientific field and laboratory data from long-term experiments observing the effects of a variety of conditions upon live trees, including elevated carbon dioxide levels, manipulation of temperature, climate and nutrient supply, and interactions with pests and pathogens.
2. Robust evidence relating forest status and agricultural techniques particularly in large-scale clearance and replanting of monocultures (eg. in mass timber production but also relevant to orchard monocultures), and ways to address this issue which will increase biodiversity and provide sustainable, low intensity solutions whilst increasing resilience to environmental impacts;
3. Co-design of research with stakeholders in order to engage them at the start and right through the project; to translate our research findings into management practice on the ground, robust evidence of the value of forests across a range of indicators, not just as factors in economic wealth but as part of an ecosystem service through the provision of clean water, clean and temperate air, pollination vectors and habitats as well as their role in social wellbeing;
4. Research that can be translated into management practice relevant to plantation forestry, tree-based horticulture and botanical collections.
5. High-impact Journal and policy papers which are likely to form the basis of governmental practice and implementation through our stakeholders and collaborations.