A new multi-disciplinary institute of forest research and a new ten-year+ experiment in environmental resilience...potential for future collaborative work

Rob MacKenzie on behalf of the BIFoR team
FOREST VALUE
UK forest industries - £4.2bn Gross Value Added per annum
11,000 direct jobs and ~100,000 downstream jobs.

TRADE GAP
Timber is UK’s 6th largest import; 1M tonnes of hardwoods imported annually.
Annual UK trade deficit in wood-based construction materials is ~£1bn
→ Zero-carbon new UK housing would require >>£1bn offsetting just to cover timber

SKILLS GAPS
50-80% of UK woodlands and forests unmanaged (and is the rest managed sustainably?)
“Most Wanted” postgraduate skills: plant pathology, taxonomy, soil science, environmental microbiology, and modelling

SKILLS LEADS
Climate (inc LSM), bioscience (medical), biogeochemistry

KNOWLEDGE GAPS
The value chain and one-world living
Carbon sink – wood and soil
Resilience to biotic and abiotic challenge
1. **resilience** of forests to pests, pathogens and environmental influences;

2. **solutions** to address tree and forest health, addressing plant disease and its control;

3. **integration** of trees into farming systems;

4. ‘**barcode of life**’ whole-ecosystem genomic characterisation of ancient woodlands; and

5. **governance** incorporating scientific evidence and enabling sustainable management.

November 2013:
£15M cash gift
£1M in-kind gift
£3M university funding in-kind

Staff

Field Facility
BIFoR Infrastructure

Combine field studies with controlled environment studies on campus
The BIFoR Field Facility: Mill Haft

Classic English woodland-arable mosaic
Intermittent canopy  ~1 x width
   ~ 10 x height

150-year-old oak canopy ~ 25m

Coppiced hazel, birch and sycamore understorey  ~ 8m

Gently undulating terrain – steep wooded slopes on aquaducts
Mill Haft: complicated canopy structure

150-year-old oak canopy ~ 25m
Overstooled hazel, birch and sycamore coppice ~ 8m
Gently undulating terrain – steep wooded slopes on aqueducts
150-year-old oak canopy ~ 25m
Small patches cleared and re-planted ~25 years ago
Repeat active and passive remote sensing - UAVs and towers
The BIFoR Field Facility

**FACE** – 3 controls (ambient air) & 3 replicates of “+150 ppmv”

Central **tower** and peripheral **met masts**

**Fieldwork compound** – built under the canopy

**Pervasive sensing** throughout canopy
Frugal use of CO₂

Artificiality of chamber methods compromises results

• Use small, young plants, often in pots
• Chamber micro-climate
• Useful to study individual processes but can be misleading when applied to environment
FACE = Free-air Carbon Dioxide Enrichment

Substantial CO₂ requirements

FACE method minimises chamber effects

• Mature plants – canopy, sub-canopy, ground shrubs – in their own soil
• Free-flow of water, air, and animals
• Studies the system in-situ
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 woodland best be **managed for carbon storage** under climate change, and what general lessons can be learnt?
BIFoR FACE specific research questions

1. What **impacts of wet and dry years** on carbon storage?
2. What are the impacts of **threshold environmental events** (e.g., snow, flood)?
3. What impacts of elevated CO$_2$ on **susceptibility and resistance to pathogens**?
4. What impacts of elevated CO$_2$ on **production, dispersion, and fate of propagules**?
5. What direct and indirect (e.g., through changes in herbivory) effects of elevated CO$_2$ on the **production of plant volatiles**?
6. What **fluxes of energy, momentum, and trace gases** over the agricultural mosaic landscape including the BIFoR FACE woodland?
7. What contributions of gas-phase, aqueous-phase, and aeolian-dust **transport of carbon and nutrients** into and out of the FACE woodland?
BIFoR FACE specific research questions

8. How does whole-stand biomass, allometry and stand phenology alter over time and under elevated CO$_2$?

9. To what extent does elevated CO$_2$ impact on the resilience and susceptibility of the ecosystem to species invasions: plant, microbial and invertebrate.

10. Which tree and plant genotypes are best adapted to increased levels of CO$_2$?

11. 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?

12. What are the effects on wood quality, assessed by non-destructive techniques?
BIFoR Field Facility: Timeline

- Baseline
  - FACE design
- FACE build
- FACE operation
- Other field activities (by agreement)

JULES 4.0

2014

2015

2016

2026

JULES 14.0??
JULES 14.0 ...SEX AND DEATH???

Plant-pathogen molecular interactions
- Current tree pathogens
- Which pathogens will emerge or cause most devastation in the changing environment?

Plant Physiology
- Tree growth
- photosynthesis and respiration (Which trees will be the winners under increased CO₂?)
- Trees role in C and N cycles

Animal behaviour

Plant-insect interactions and chemical ecology

Rhizosphere microbiology, nutrient fixation and cycling

Litter layer:
Invertebrate detritivores and nutrient cycling

Aquatic zoology and animal behaviour

Trees, shrubs and ground plants

Leaf fall
Nutrient emissions in VOCs
Leaf decomposition
VOCs - parasite attractants

Trees, shrubs and ground plants

Nutrient flow through soil

Nutrient flow through water systems (invertebrates and microbial)

Aquatic systems

Bed Rock

Soil horizons

Litter Layer

Detritivores (Invertebrate and microbial)
BIFoR Stakeholders

JABBS Foundation
Norbury Estate
Grown in Britain
Woodland Trust
National Association of Cider Makers
John Horseman Trust

Brookhaven National Laboratory
University of Illinois at Urbana-Champaign
Hawkesbury Inst of Environment
Oak Ridge National Lab
China National GeneBank
Forest Research/Forestry Commission

120 person-months of visiting fellowships – travel and subsistence and small consumables budget.

Prof Dave Ellsworth (Hawkesbury); Dr Debbie Hemming (Met Office)

Site for field Intensives

Data to challenge models – ensure measurements are fit-for-purpose
Thank you