photo credit Andrew Priest Photography http://www.pro-photographers.co.uk/

The plant-water conundrum:

root-xylem-stomatal response of Quercus robur/ (pedunculate oak) to elevated CO_2 in a temperate future-forest experiment.

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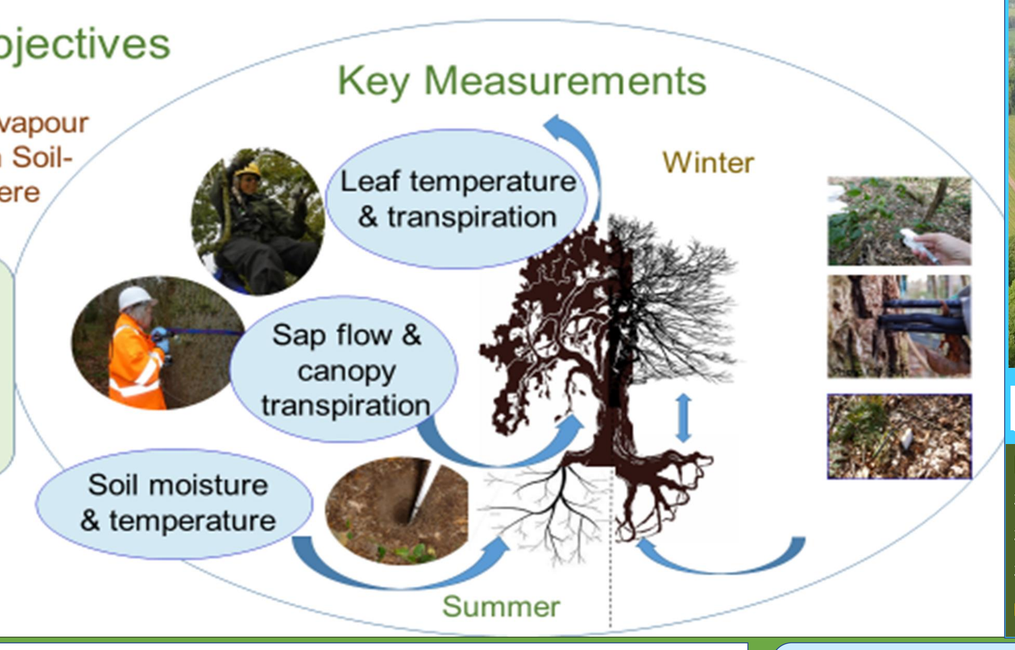
1 ECO-HYDROLOGICAL PROJECT & METHOD

Project Objectives

To investigate:
Water / water vapour cycling through Soil-Plant-Atmosphere continuum

How does elevated CO_2 influence plant water usage and transpiration?



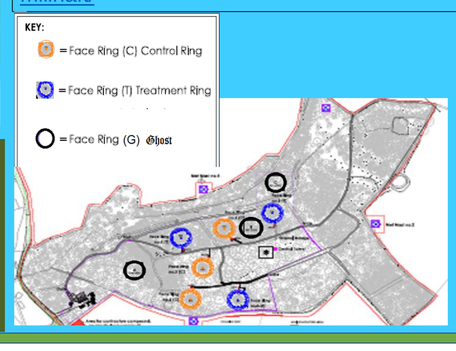
BIFoR FACE

Baseline 2015/16 eCO_2 2017-2026

Free-Air Carbon-dioxide Enrichment (FACE)
3 no-infrastructure ambient air (natural/ ghost arrays)
3 ambient-air infrastructure FACE rings
3 treatments of +150 ppmv CO_2
https://www.birmingham.ac.uk/research/bifor/face/index.aspx

BIFoR FACE is a 2nd Generation forest FACE experiment in semi-natural 170-yr old mature temperate oak forest By 2050 increased temperatures, atmospheric carbon dioxide (CO_2)/ greenhouse gas content and more extreme weather systems are predicted. Our BIFoR FACE experiment helps to predict how forests will respond.

You can watch the seasons change with our Phenocam: https://phenocam.sr.unh.edu/webcam/sites/millhaft/



2 DATA COLLECTED & PROCESSED

Stomatal conductance

Top canopy data from Aug 2019 onwards

Cut-twig

Array_number: 7, 8, 9

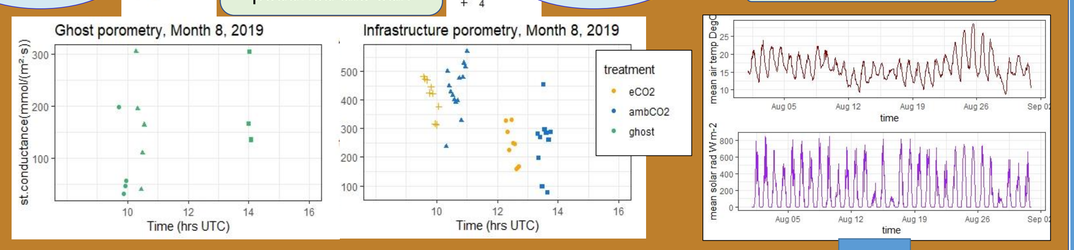
Porometry data from 7 *Quercus robur/* pedunculate oak

In-situ

Array_number: 1, 2, 3, 4

August 2019

FACE Engineering data -



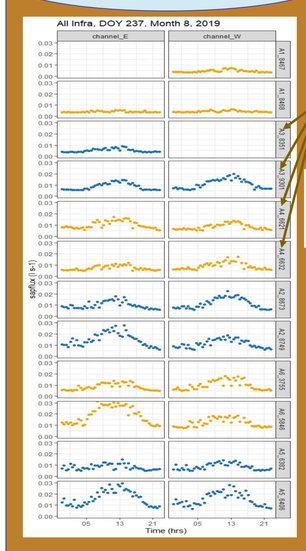
Raw data processed using solar azimuth to filter daylight responses

Stem xylem sap flow

diurnal sap flux

Quercus robur – total 18 trees, 2 per array *x2 probesets with x4 radial sensor positions each*

daily daylight xylem sap flux



trees

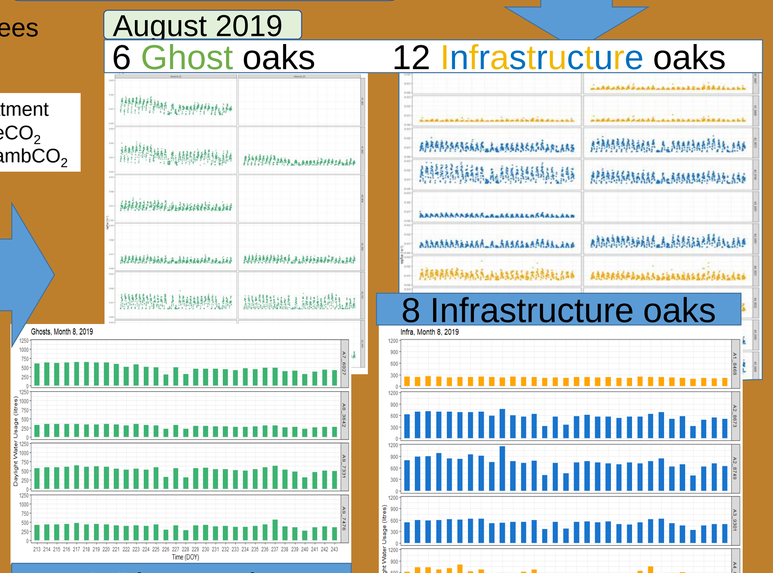
treatment
eCO_2
$ambCO_2$

August 2019

6 Ghost oaks

12 Infrastructure oaks

8 Infrastructure oaks

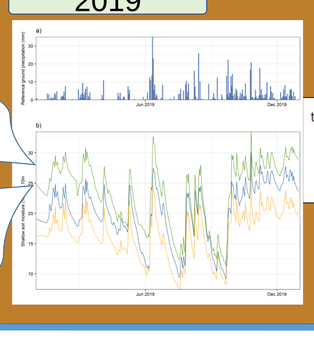


4 Ghost oaks

daily daylight oak tree water usage

Soil moisture & precipitation

2019



Ghosts patches wetter

Water availability affected by previous season's drought

Water Input from total precipitation & shallow soil moisture (12 cm depth) measured during 2019 demonstrating the variability of inputs to the soil-plant-atmosphere continuum (SPAC). Data is being normalized to pre-2017.
Throughfall/ intercept and soil moisture profile data (10 to 100cm depth) also captured

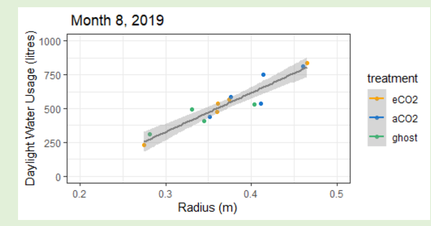
Confounding factors
- Tree & canopy size
- xylem width
- wood characteristics
- precipitation
- sap speed
- wounding
- sun/ shade

Porometry top canopy stomatal conductance.
In-situ data is captured, accessed using the Canopy Access System (CAS). Cut-twig from arborists.
Suitable statistical methods are being used to reveal the effects of elevated CO_2 (eCO_2) at leaf level.
FACE engineering solar radiation 30 min data used to filter sap data. Top canopy air temperature and relative humidity data will enable VPD calculation

Sap probesets measure xylem sap flow
- E & W facing probesets.
- Data collected over a 5.5 min period every 30 mins on a 24/7 whole year basis.
- Calculated sapflux in litres/ sec for each functional probeset

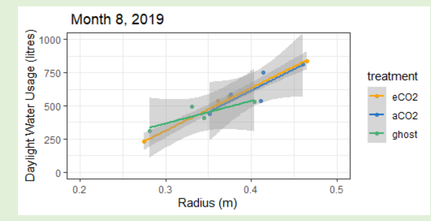
Whole tree daylight water usage (litres) calculated across active xylem cross-sectional area. using the modified weighted average method (Hatton, 1990).

3 FINDINGS



The results are preliminary. Methods of normalisation can be applied across treatments as there is a wide variation between trees in the same treatment category. Canopy size and xylem area vary between trees.

A. We find that daily daylight oak tree water usage varies linearly with stem radius (∝DBH) by 2.9 litres per millimetre during August.



B. There are similar linear tree water patterns under eCO_2 and ambient CO_2 whilst Ghost trees' slope is less.

C. Volumetric soil water shows *some reduction under eCO_2 treatment *adding to the plant-water conundrum.***

D. * *full analysis not yet complete*

4 DISCUSSION

More or less tree water usage under eCO_2***?*** We have not yet resolved the ***plant-water conundrum.*** Leaf-level assimilation of elevated atmospheric CO_2 would be expected to reduce daytime plant water usage but we have not found this. This response is confounded by the complexity of canopy and stem growth.

BIFoR PUBLICATIONS

MacKenzie, A. R., **Krause, …**, **Quick, S. E., …** (2021). BIFoR FACE: Water–soil–vegetation–atmosphere data from a temperate deciduous forest catchment, including under elevated CO2. *Hydrological Processes*, *35*(3), e14096. https://doi.org/https://doi.org/10.1002/hyp.14096

Hart, et al. (2019) Characteristics of Free Air Carbon Dioxide Enrichment of a Northern Temperate Mature Forest. *Glob Change Biol*. doi:10.1111/gcb.14786

Quick et al. (in prep)

DATA OUTPUTS

Tree-soil-water processed data now available – all open access by c2023.

Acknowledgements
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