Linking *Quercus robur* tree-water usage to soil-water dynamics within a forest FACE experiment.

UNIVERSITY OF BIRMINGHAM | BIFOR

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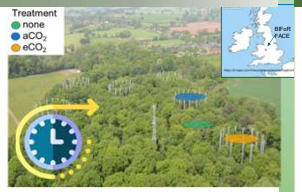
1. INTRODUCTION

Birmingham Institute of Forest Research (BIFoR) FACE facility is an . Oak (*Quercus robur L.*) dominated wood planted mid C19th. Triplicate arrays of the three treatments form the future-forest experimental platform.

We explore concurrent measurements of soil moisture from multiple depths down to 1 metre alongside daylight water usage of 18 Oak trees derived from stem sap transducers. The soil is dystric cambisol of sandy-clay texture.



2A. METHOD SOIL MOISTURE

Soil moisture **volumetric water content** (VWC, θ, %) is measured using two transducer types:

- CS655 using triple monitoring points in all arrays, (2 sets in all infrastructure arrays) at 12cm depth.
- Enviroscan at 10, 20, 40, 60 and 100cm depth.

Relative extractable soil-water (REW) is calculated, firstly for all shallow data, then comparatively across the Enviroscan profile data.

$$REW = \left\{ \frac{(\theta - \theta min)}{(\theta max - \theta min)} \right\}$$

In each plant hydraulic year (Nov – Oct) we extracted **field capacity** (θmax, %) from dormant season (Nov – Mar) VWC data and **wilt point** (θmin, %) from growing season (Apr –Oct) VWC data.

Q2:
Is daily REW profile consistent across depths to 1 metre?

2B. METHOD SAP FLUX

Diurnal tree canopy transpiration is estimated using xylem sap flux from tree stem data, two probesets per tree.

Tree water usage (TWU) is then calculated for the whole tree canopy. TWU is then normalised by tree radius (TWU_n).

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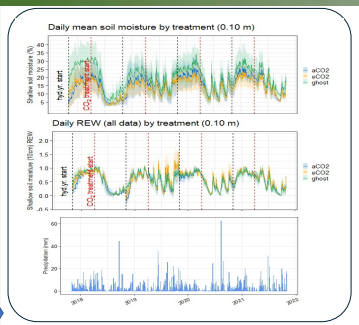
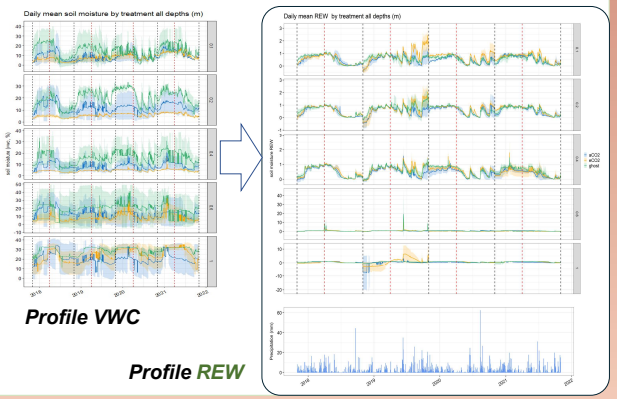
Q1:
How does elevated CO_2 influence daily oak tree water usage and is this linked to soil water availability?

3. RESULTS



Daily VWC % and REW from all shallow (circa 10cm depth) soil moisture transducers is shown across all seasons for hydraulic years 2018-2021, averaged by treatment.

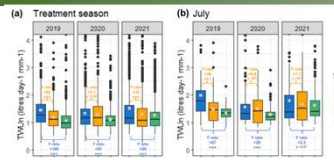
Daily VWC % and REW from profile soil moisture transducers is similarly shown below.



Profile VWC

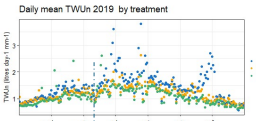
Profile REW

4. COMBINED RESULTS

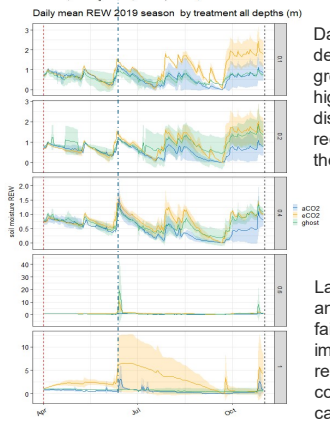


Quick et al. (2024, in review), Biogeosciences

Statistical analysis of variance between trees' TWU_n.in the 3 treatments.

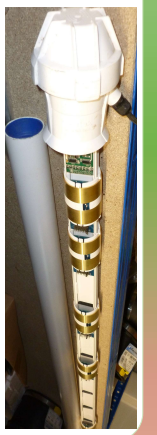


TWU_n.in the 3 treatments is shown daily for the 2019 growing season.



Daily REW from all depths in 2019 growing season highlight the discharge and recharge cycles in the top layers.

Lack of calibration and some probe failures have impacted VWC results. Partially corrected by REW calculation.



5. DISCUSSION

Normalisation of individual tree water usage, **TWU_n**, enabled analysis of eCO_2 treatment effects measured during growing season (Apr- Oct). Soil moisture storage capability in dormant periods in the deciduous forest enables growing season discharge unless wilt point levels are reached. In the short term **TWU_n** is inversely affected by rain/ soil recharge events shown by REW to 40cm depth.

Q1 findings: Statistical response of REW to eCO2 not yet complete

Normalisation to REW clarifies the relationship between treatments. In comparison VWC data gives false offset levels distorting the apparent relationships. REW is used to overcome the heterogeneity of soil condition, soil horizons over time and enable use of data not fully calibrated for soil type.

Recharge and discharge cycles in top soil layers 10, 20, 40cm depth correlate inversely with growing and dormant periods in the deciduous forest. The perched groundwater table, at variable 1 to 5 m depths, also alters with dormant/ growing seasons resulting in switched hi-lo soil moisture values at 60 & 100cm depths.

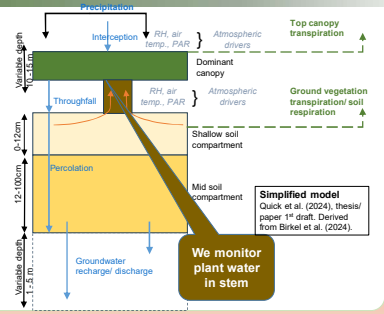
Q2 findings: REW profile differs by depth and season

Hart, K. M. et al., Characteristics of Free Air Carbon Dioxide Enrichment of a Northern Temperate Mature Forest. Glob. Chang. Biol., 26, 1023–1037, https://doi.org/10.1111/gcb.14786, 2020.

Quick, S. E., Curioni, G., Harper, N. J., Krause, S., and MacKenzie, A. R.: Water usage of old growth oak at elevated CO2 in the FACE of climate change, EGUsphere [preprint],https://doi.org/10.5194/egusphere-2023-1522, 2023.

6. NEXT STEPS

- Complete REW analyses 2018-21
- Compile simple models of REW usage by mature trees under current and future elevated CO_2 levels.
- Support soil-water-respiration, tree-root-water and nutrient dynamics studies BIFoR FACE.
- Publish findings of this project to help clarify tree-water versus soil-water interactions.



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- For access to data please see publications or else contact bifor@contacts.bham.ac.uk