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Xylem sap dynamics of 175-year-old Quercus robur under elevated CO_2 at BIFoR FACE, UK

Susan Quick[1,2], Giulio Curioni[1], Stefan Krause[1,2], and A. Rob. MacKenzie[1,2]
[1]Birmingham Institute of Forest Research, University of Birmingham , Birmingham, B15 2TT, UK
(seq616@student.bham.ac.uk)
[2]School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham, B15 2TT, UK

Recent research highlights the ability of large trees to maintain transpiration during tree water stress, for example in summer dry periods, by using stored plant water held in the relaxed xylem. Use of soil water at different depths by shallow and deep roots according to soil water content may also vary by species and seasonal climatic conditions to maintain transpiration demands. Here we present daylight tree water usage measurements of mature oaks (*Quercus robur L.*) under future-forest CO_2 conditions, derived from compensation heat pulse (HPC) xylem sap flux transducers deployed at Birmingham Institute of Forest Research (BIFoR) Free-Air CO_2 Enrichment (FACE) forest in Staffordshire UK. We experienced longer dry periods in summers 2018 and 2019 and variable annual summer precipitation overall. Xylem sap flux data is collected half-hourly from eighteen oak trees and a smaller number of subdominant trees (*Acer pseudoplatanus* and *Crataegus monogyna*) in nine experimental patches: 3 patches with elevated CO_2 infrastructure (eCO_2); 3 with infrastructure but ambient CO_2 (aCO_2); and 3 'ghosts' (no treatment, no infrastructure). Each tree has two probesets, E and W facing; long (7 cm 4-sensor) probes in oak and short (4cm 2-sensor) probes, to accommodate the smaller diameter subdominant trees, are deployed. We compare individual tree responses under the three treatments across the leaf-on seasons for early years of the FACE project 2017–2021. Between-individual within-species variability of summertime monthly average of daily daylight water usage in oak is linearly proportional to tree stem radius (ca. 2.9 litres per millimetre radius, range; 274mm ≥ radius ≤ 465 mm) at the point of probeset insertion ca. 1.1–1.3 m above ground level and oak responds sub-daily to solar radiation reduction events during cloud cover. Diurnal stem sap flux responses to canopy photosynthetic demand typically exhibit increased sap flux from dawn to around midday (UTC) and symmetrical decrease to dusk. We describe our continuing investigation of soil-plant-atmosphere flows, monitoring root-xylem-stomatal changes, and discuss how these results, from our tree-centred forest view, provide valuable new perspectives and help to improve our understanding of future-forest-water use at larger scales, contributing to development of more realistic ecohydrological vegetation, soil and landscape models.