Tree Growth in an Oak Woodland Exposed to Elevated Atmospheric CO_2

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BIFoR FACE

This study was conducted at the Birmingham Institute of Forest Research (BIFoR) Free Air CO_2 Enrichment (FACE) facility located in Staffordshire UK (Hart *et al.* 2020).

The site is a 19 ha temperate broadleaf deciduous woodland with a 24-m overstory canopy dominated by ~175-year-old pedunculate oak (*Quercus robur*) and a dense understory comprising hazel coppice (*Corylus avellana*), sycamore maple (*Acer pseudoplatanus*), hawthorn (*Crataegus monogyna),* ash (*Fraxinus excelsior*), and elm (*Ulmus* sp.).

Three plots ~30 m in diameter have been receiving air enriched with 150 ppm CO_2 since 2017. Three control plots receive ambient air.

Measurement plots within the arrays were 575 – 678 m², with a 2.5 m wide buffer area from the vent pipes.

Research Questions

Photosynthesis in the upper oak canopy has been 33% greater in elevated CO_2 (eCO_2)plots compared to controls (Gardner *et al.* 2021).

The allocation of the increased assimilated carbon to different tree organs and processes has important implications for the longevity of carbon in the ecosystems, the interactions between carbon-water-nutrient cycles, and numerous biotic interactions.

An increase in wood production in eCO_2 represents increased sequestration of C in the ecosystem and an important negative feedback on rising atmospheric CO_2.

Our objective is to assess whether wood production has increased at BIFoR FACE in eCO_2, or in short, *are the trees growing more?*

Approach

All trees with dbh>10 cm were fit with dendrobands, and the change in tree circumference was measured monthly during the growing season.

Wood dry mass and annual dry mass increment (DMI) were calculated using published species-specific allometric relationships with diameter (Forrester *et al.* 2017).

Annual wood production in each plot was calculated as the sum of DMI of all trees in the plot divided by plot area.

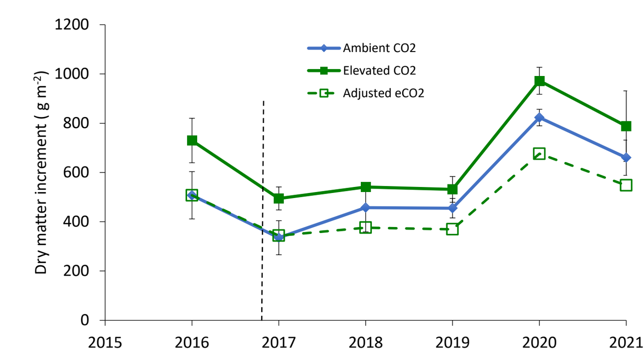
Increment cores were collected from each oak tree to establish a multi-year baseline of pretreatment wood production.

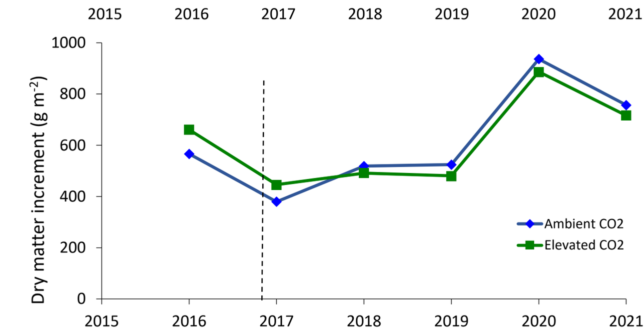
Stand Characteristics

Oaks comprise >90% of the basal area and production in these plots. There are many hazel coppice shoots < 10 cm diameter that are not included in this analysis. Further analyses will be based solely on the oaks.

Species	# of trees per plot (mean and range)	Average tree diameter (cm)	Basal area (cm²/m²)	Dry matter increment (g/m²)	Fraction of total DMI (%)
Oak	7.83 (5-11)	63.5	40.31	491.4	90.95
Sycamore	2.50 (0-7)	21.8	1.59	38.3	7.09
Hawthorn	3.5 (0-9)	16.6	1.28	4.7	0.87
Hazel	0.67 (0-2)	14.3	0.19	5.9	1.09
Ash & elm	1.00 (0-5)	21.9	0.61	ND	

Growth response to elevated CO_2





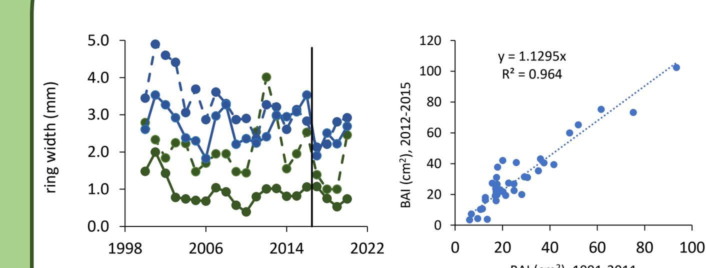
Oak growth in eCO_2 was 48% greater in the first year of treatment (2017) and 16-19% greater in 2018-2021.

However, this difference cannot necessarily be ascribed to an effect of CO_2 because growth also was 44% greater in eCO_2 arrays in the pretreatment year (2016).

With growth in eCO_2 and control plots adjusted to have equal growth in 2016, all evidence of a positive effect of CO_2 disappears.

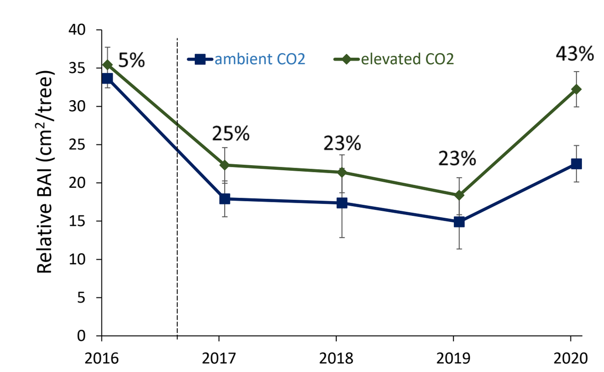
In the lower graph, growth has been relativized to a constant pre-treatment leaf area, and there is no apparent effect of eCO_2.

Tree ring analysis



Tree ring analysis provides an opportunity to establish a longer-term baseline of tree growth, aiding detection of departure from the baseline due to a CO_2 effect.

Despite substantial year-to-year variation in ring width among trees, basal area increment calculated from rings and averaged over multiple years provides good predictions of future growth.



Basal area increment from 2016 (pretreatment year) to 2020 was adjusted based on plot differences from 2012-2015.

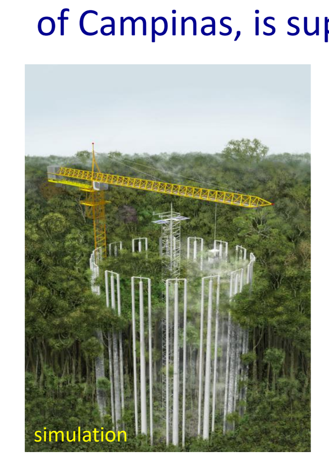
There was little difference in adjusted BAI in the pretreatment year. Average tree response to eCO_2 in 2017-2020 is a 28.5% increase (P = 0.015).

The tree core analysis provides the first evidence for a positive effect of elevated CO_2 on tree growth in this system

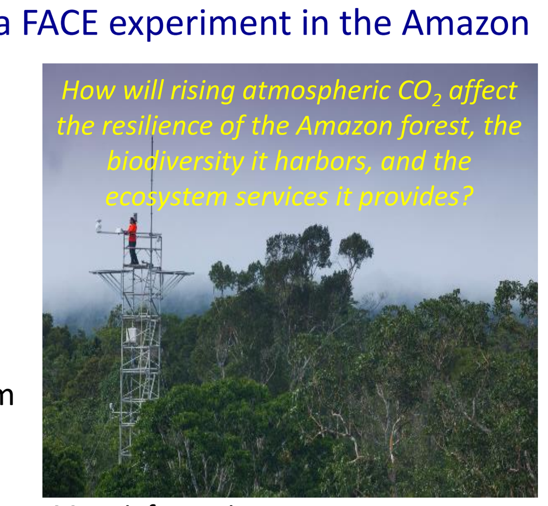
This analysis demonstrates the importance of pretreatment data for detection of an effect of elevated CO_2 in a spatially and temporally heterogeneous forest

Breaking News!

As announced at COP26, the UK Foreign, Commonwealth & Development Office, in cooperation with the UK Met Office, the Instituto Nacional de Pesquisas da Amazônia (Brazil), and the University of Campinas, is supporting construction of the infrastructure for a FACE experiment in the Amazon rain forest in Brazil



- Consideration of this experiment started 10 years ago in Manaus
- The site is now well characterized (Martins *et al.* 2021; Menezes *et al.* 2021; Cordeiro *et al.* 2020; Pereira *et al.* 2019; Fleischer et al. 2019)
- The experiment will comprise six 30-m diameter FACE plots, with eCO_2 (+200 ppm) in three of them
- Canopy cranes will allow access to the 30-m tall canopy
- Construction of a pair of FACE rings is starting immediately, with full implementation in late 2023



More information:
https://amazonface.inpa.gov.br
youtube.com/watch?v=FWHjWL_Fu8

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