Old growth oaks: the effects of elevated CO_2.

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(1) Background

- Anthropogenic carbon dioxide (**CO_2**) is the main greenhouse gas driving change in the Earth's climate [1].
- Rising CO_2 is expected to stimulate photosynthesis, but limited studies have been conducted on mature forests [2].
- It is uncertain how mature deciduous forest ecosystems will respond to the **future CO_2 emissions**[3].

(2) Research Questions

1. What are the effects of **elevated CO_2** on leaf-level **photosynthesis** and **stomatal conductance**?
2. How are the effects of elevated CO_2 dependent on **environmental variables**?
3. What are the **diurnal** and/or **seasonal differences** in photosynthesis and stomatal conductance?

(3) Materials and Methods

Birmingham Institute of Forest Research Free Air CO_2 Enrichment (**BIFoR-FACE**) facility.

Six (30m diameter) paired woodland plots (n=3):
- Elevated CO_2 (**eCO_2**) - ~550ppm.
- Ambient CO_2 (**aCO_2**) - ~407ppm.

Measurements conducted monthly**, 7am to 7pm**, using a paired plots design, on 12 sampling days.

1,946 instantaneous **gas exchange survey** measurements conducted in **2nd year** of **CO_2 fumigation** (June to October 2018).

In situ measurements conducted on 5 fully expanded leaves per tree, in **upper canopy** of one **oak** (*Quercus robur L.*) tree per plot.

Measurements used a portable gas exchange system (**Li6800**), with clear-top chamber, using ambient temperatures and humidity.

(4) Results and Discussion

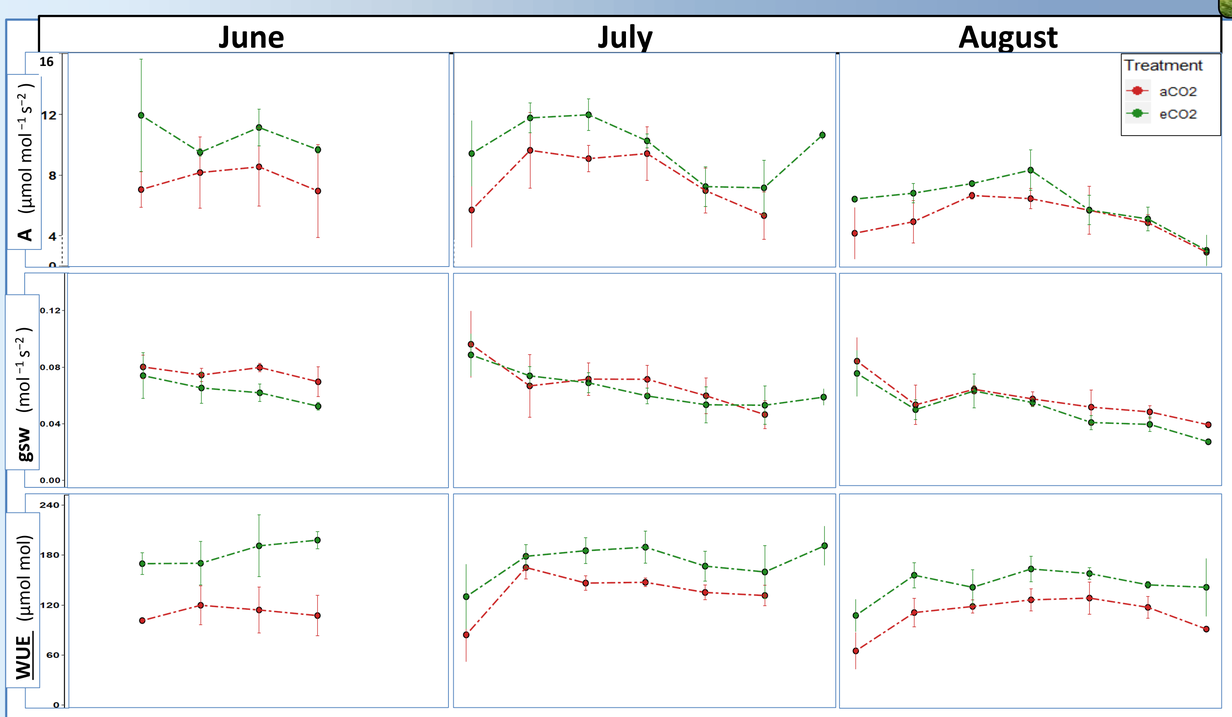

Figure 1, **A)** Diurnal course of net assimilation rates (Anet), **B)** stomatal conductance (gsw) and **C)** water use efficiency (WUE (calculated as A/gsw)) of upper canopy *Quercus robur* leaves exposed to either ambient [CO_2] (400 µmol mol^{-1})(red) or elevated [CO_2] (550 µmol mol^{-1})(green) at BIFOR FACE, UK. Data points are means (+/-SE) of three replicate plots, in a repeated measures (pairs plot design) from June to August 2018. A total of 1946 observations were made in 2018. *p*-values indicate significance of CO_2 treatment (C), Month (M), time of day (TOD) (C×MxTOD) using a linear mixed effects model for **A)** *p*>0.001, **B)** *p*>0.05 and **C)** *p*> 0.05.

- **~20% increase in net photosynthesis rates** (Anet) under eCO_2. Highest Anet in June and July, at midday, and lowest Anet in the August evenings.
- Stomatal conductance (gsw) highest in the mornings, across all months, and gradually reduced across the season.
- Reduced gsw was observed under eCO_2 at all time points in June but treatment differences disappeared in both July and August.
- Water use efficiency (WUE) was significantly greater in trees under eCO_2, on all measurement days and time points. Treatment effect played a larger influence than time of day or month.
- Diurnals indicate that despite a decrease in stomatal conductance, leaves were still able to increase, or at least maintain, higher photosynthetic rates under eCO_2.
- A UK wide drought occurred in July and August, evident in the reduced gsw under aCO_2 and eCO_2. Drought stress response likely removed the predicted positive eCO_2 effect on photosynthesis.

(5) Conclusion

- **Increased** rates of **photosynthesis** rates were seen **under eCO_2**, coupled with a **decrease** in the **stomatal conductance** values.
- 2018: an abnormally **dry year** which likely **reduced** the **+ve eCO_2 effect** on photosynthesis, particularly by August.
- There may be a **stronger** treatment **effect** visible **under non-water limiting** conditions. A further season of sampling is to be carried out.

References:
[1] Stocker TF *et al.* 2013. Climate Change 2013. Cambridge University Press. **[2]** Le QuéréC *et al.* 2016. Earth Syst. Sci. Data 8, 605–649. **[3]** Norby.R *et al.* 2016. New Phytologist209, 17–28

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