Elevated CO_2 exacerbates peatland carbon loss under extreme drought and warming

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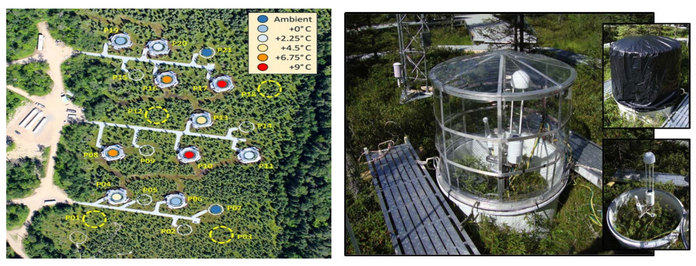
Motivation

- Extreme drought events are predicted to become more frequent with climate warming.
- Most studies have investigated their effects on ecosystem carbon (C) dynamics under contemporary climates.
- How extreme drought events will influence ecosystem C cycling in a future world with higher temperatures and elevated CO_2 (eCO_2) remain unclear.

Methods



SPRUCE experiment

- CO_2: aCO_2 (+0 ppm), eCO_2 (+500 ppm)
- Whole ecosystem warming: +0, +2.25, +4.5, +6.75 and +9°C

Extreme drought in 2021

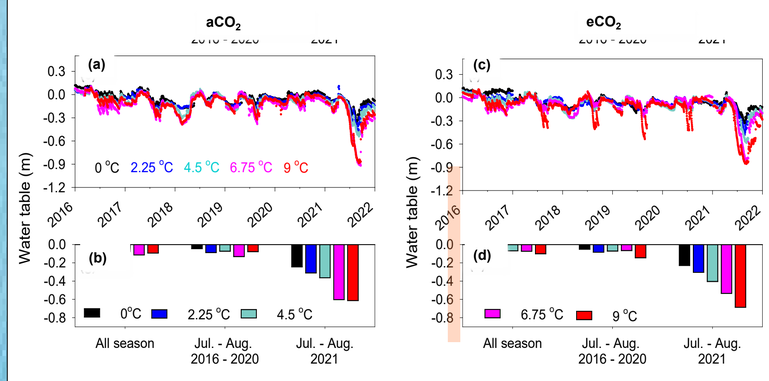


Figure 1 | Pattern of water table depth (WT) fluctuations (a,c) from 2016 to 2021 under different warming and CO_2 treatments. Seasonal means of WT (b,d) across years and during drought periods in non-drought (2016-2020) and drought (2021) years under different warming and CO_2 treatments.

Results

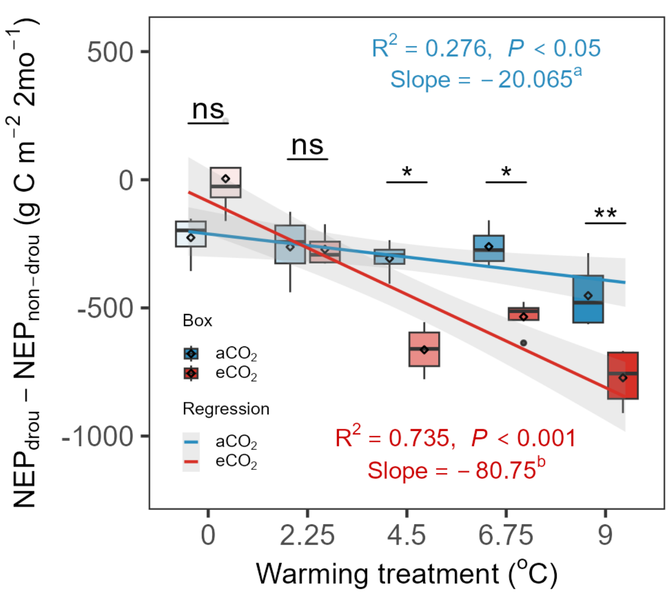


Figure 2 | Effects of extreme drought on net ecosystem productivity (NEP) under different warming and CO_2 scenarios. NEP_{drou} and $NEP_{non-drou}$ represent NEP in the two months in drought year and non-drought years, respectively. Different letters denote significantly different slopes. P values are adjusted using the Benjamini-Hochberg FDR correction for multiple comparisons.

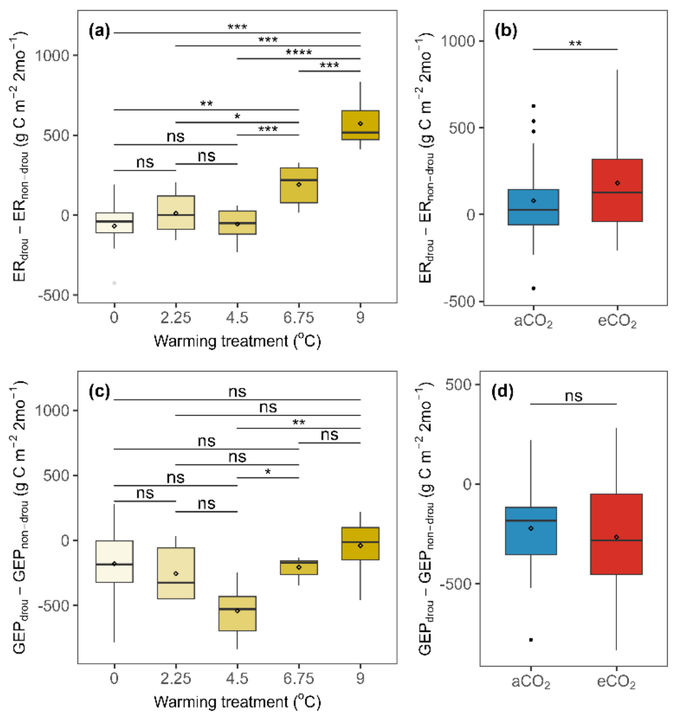


Figure 3 | Effects of extreme drought on (a, b) ecosystem respiration (ER) and (c, d) gross ecosystem productivity (GEP) under different warming and CO_2 treatments. Different letters denote significantly different slopes. P values are adjusted using the Benjamini-Hochberg FDR correction for multiple comparisons.

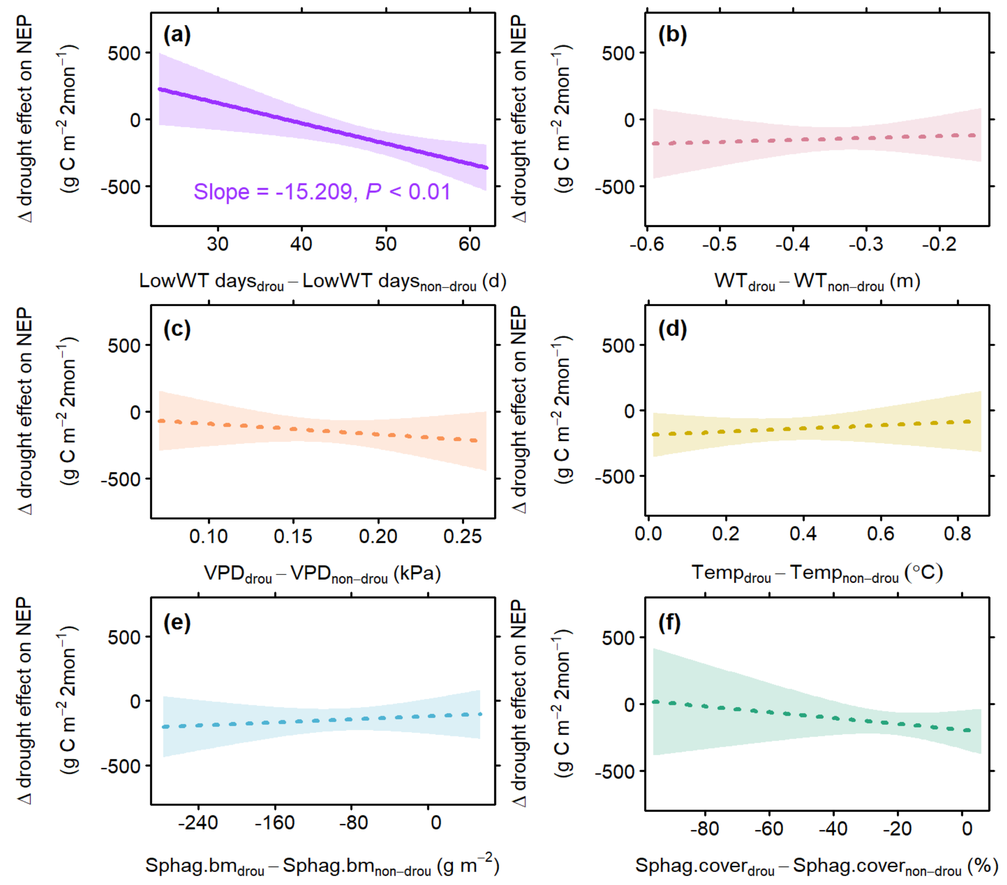


Figure 4 | Difference in drought effects on net ecosystem productivity (NEP) between ambient and elevated CO_2 treatment. The difference, denoted by Δdrought effect on NEP, depends on drought-induced changes in (a) number of low-water-table (LowWT, below -0.25 m) days, (b) water table depth (WT), (c) vapor pressure deficit (VPD), (d) temperature (Temp), (e) Sphagnum biomass (Sphag.bm), and (f) Sphagnum coverage (Sphag.cover), respectively. Solid lines indicate significant effects and dashed lines indicate insignificant effects with a significance level set at α = 0.05.

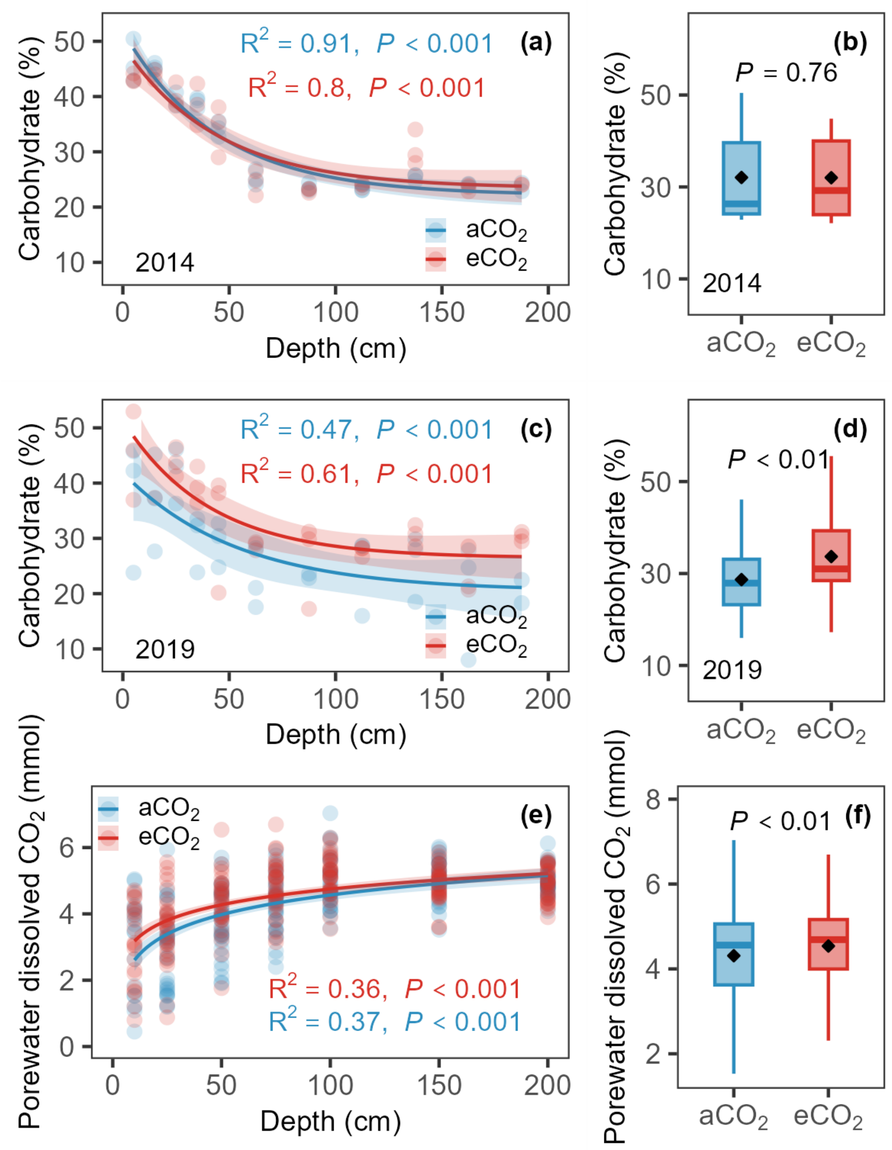


Figure 5 | (a,b) Carbohydrate concentrations in 2014 (before the eCO_2 treatment) and (c, d) in 2019 (after the eCO_2 treatment). (e, f) Porewater dissolved CO_2 concentrations between aCO_2 and eCO_2.

Conclusion

- **warming and eCO_2 greatly exacerbated drought-induced C loss in this peatland**
- **The pronounced impacts were mainly due to warming-aggravated water table drawdown and eCO_2 induced increases in substrate availability.**

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