全球增温背景下自然湿地的温室气体汇功能大幅减弱

Weakening greenhouse gas sink of pristine wetlands under warming

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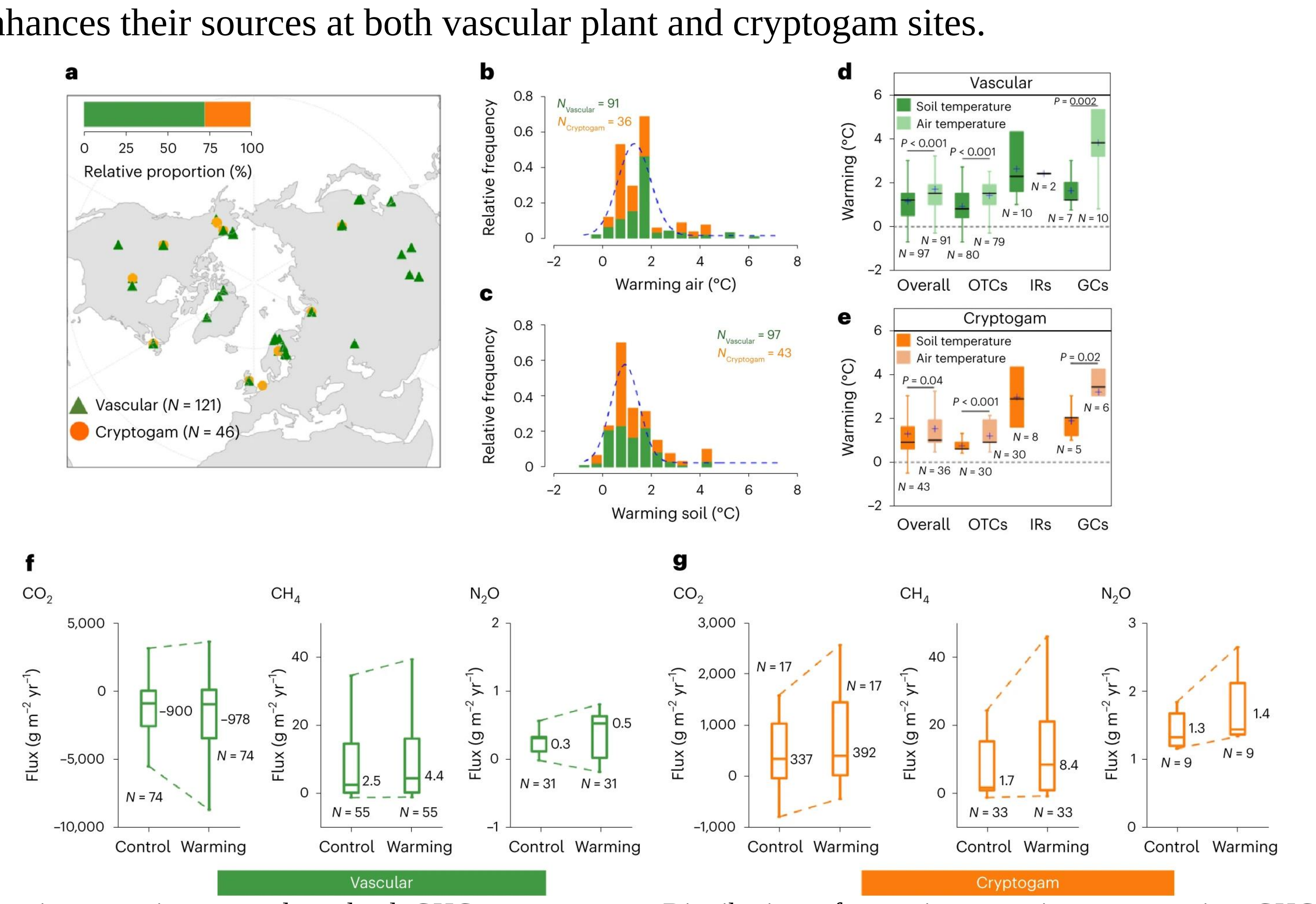
Introduction

- Wetlands store about one-third of the global soil organic carbon (SOC), which play an outsized role in regulating and stabilizing the global climate, and offer ideal locations for the production, consumption, and exchange of greenhouse gases (GHGs) due to their own active biogeochemical cycling of carbon and nitrogen.
- The considerable uncertainty in wetland GHG feedbacks to warming increases the challenge of limiting climate warming to a specific temperature threshold to meet climate change mitigation target.
- Here, we compile a database comprising observations from 167 sites with measured responses of wetland GHG emissions including CO_2, CH_4 and N_2O, to manipulated warming of 1.5-2°C.
- Our results highlight that warming undermines the mitigation potential of pristine wetlands despite achieving the Paris Agreement goal of limiting temperature to 1.5-2 °C.

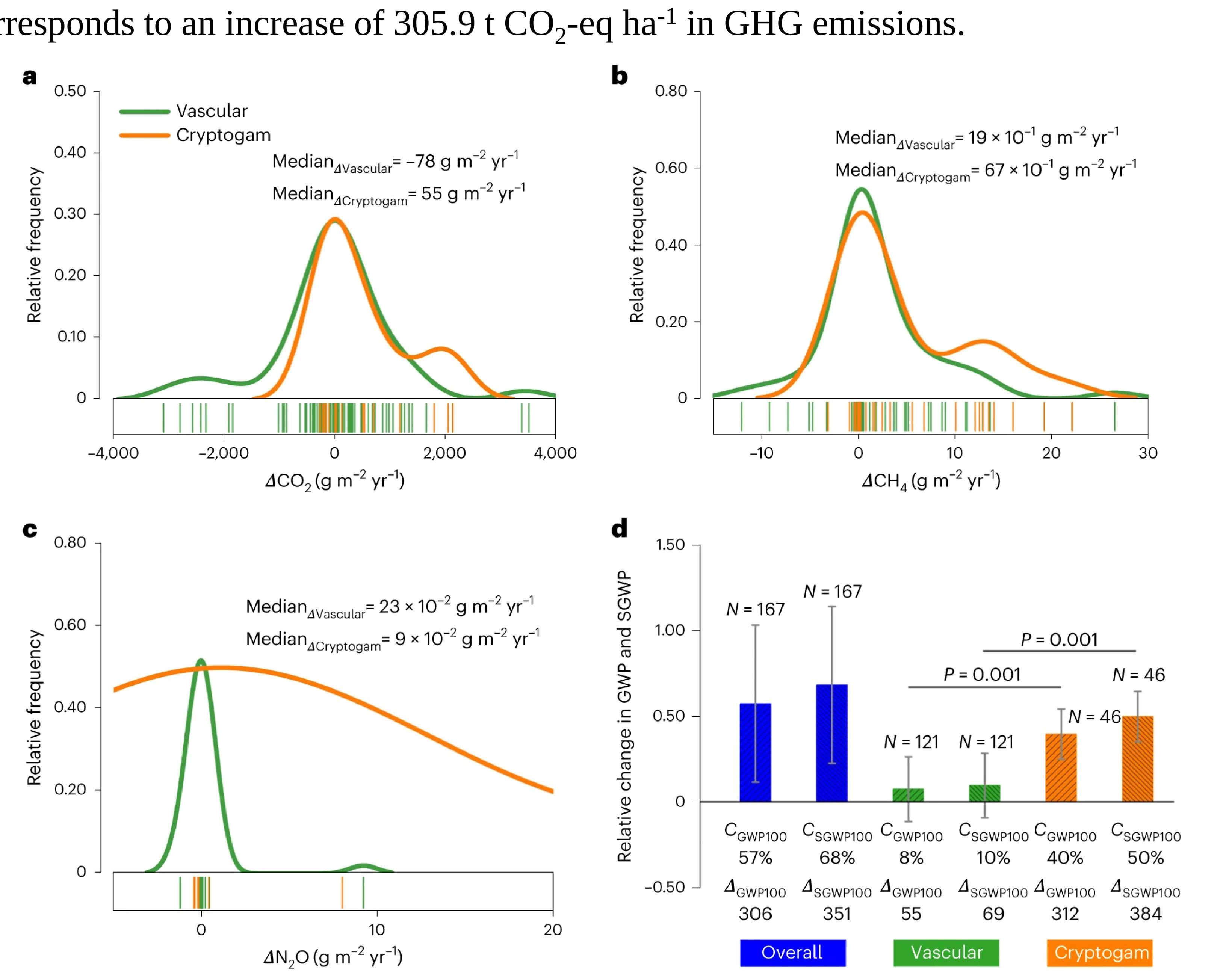
Greenhouse gas sink under warming

The wetlands are a net sink of GHGs under ambient condition before warming treatments. The sink of GHGs is weakened under warming. Wetlands dominated by vascular plants act as CO_2 sink before warming treatments, while wetlands dominated by cryptogams act as CO_2 source. Warming increases the magnitude of CO_2 sink and source at vascular plant and cryptogam sites, respectively. For CH_4 and N_2O, warming enhances their sources at both vascular plant and cryptogam sites.



Warming experiments and wetland GHG responses. **a**, Distribution of warming experiments reporting GHG emissions. **b**,**c**, Frequency distribution histograms of air (**b**) and soil (**c**) temperature increases at sites with vascular plants and cryptogams. **d**,**e**, Effects of different warming methods on the air and soil temperatures at sites with vascular plants (**d**) and cryptogams. **f**,**g**, GHG flux changes in response to warming treatments at vascular plant (**f**) and cryptogam (**g**) sites.

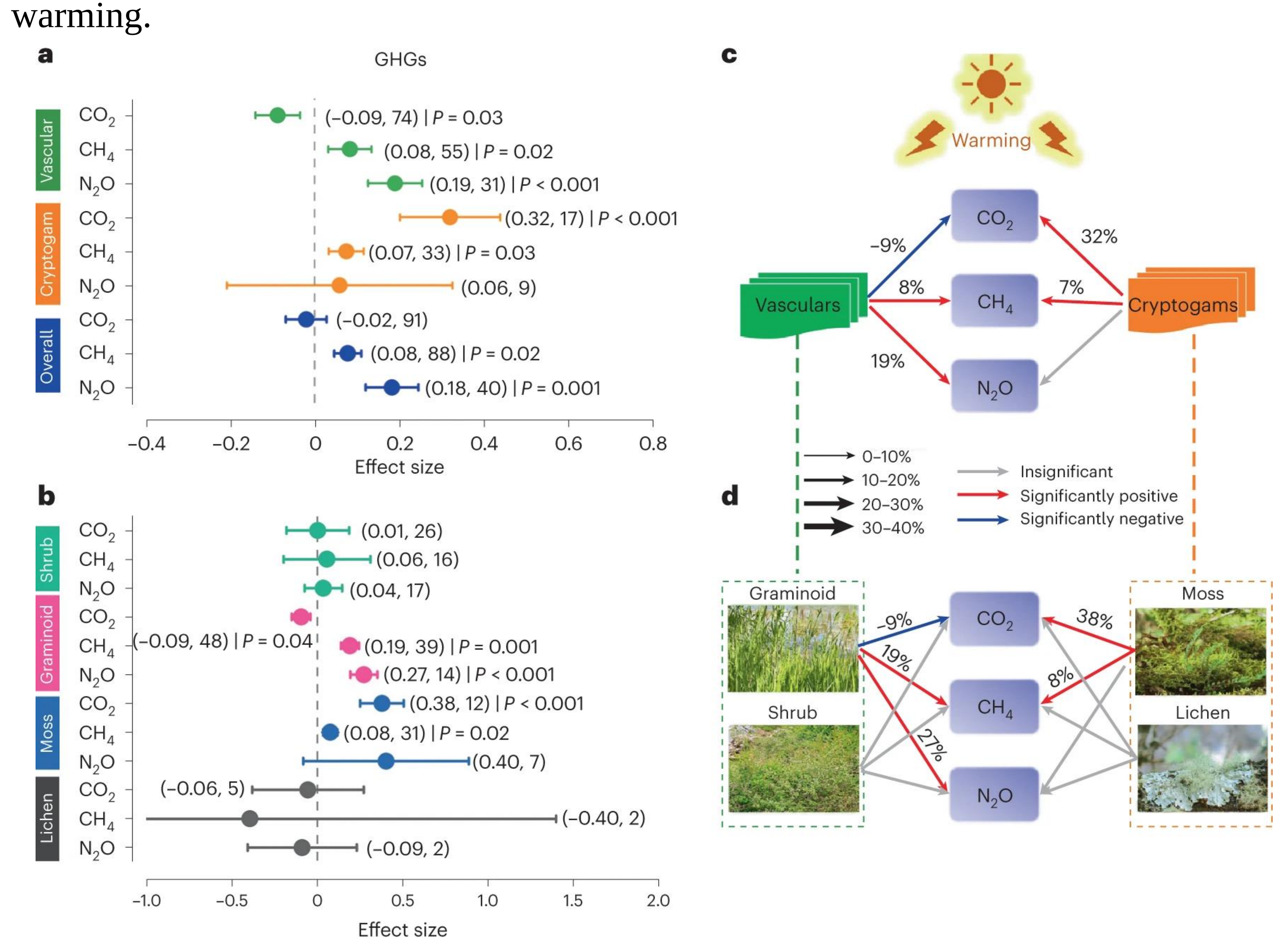
Global warming potential over 100-year time span (GWP_{100}) of wetland GHG emissions is increased by 57% in response to the prescribed warming, which corresponds to an increase of 305.9 t CO_2-eq ha^{-1} in GHG emissions.



Global warming potential and sustained-flux global warming potential of wetlands. **a**–**c**, Frequency distribution histograms of changes (Δ) in CO_2 (**a**), CH_4 (**b**) and N_2O (**c**) emissions under warming treatment at sites with vascular plants and cryptogams. **d**, Changes in GWP_{100} (C_{GWP100} (%) and Δ_{GWP100} (tCO_2e ha^{-1})) and $SGWP_{100}$ ($C_{SGWP100}$ (%) and $\Delta_{SGWP100}$ (tCO_2e ha^{-1})) at sites with vascular plants and cryptogams as well as overall values.

Emissions and sink by plant functional type

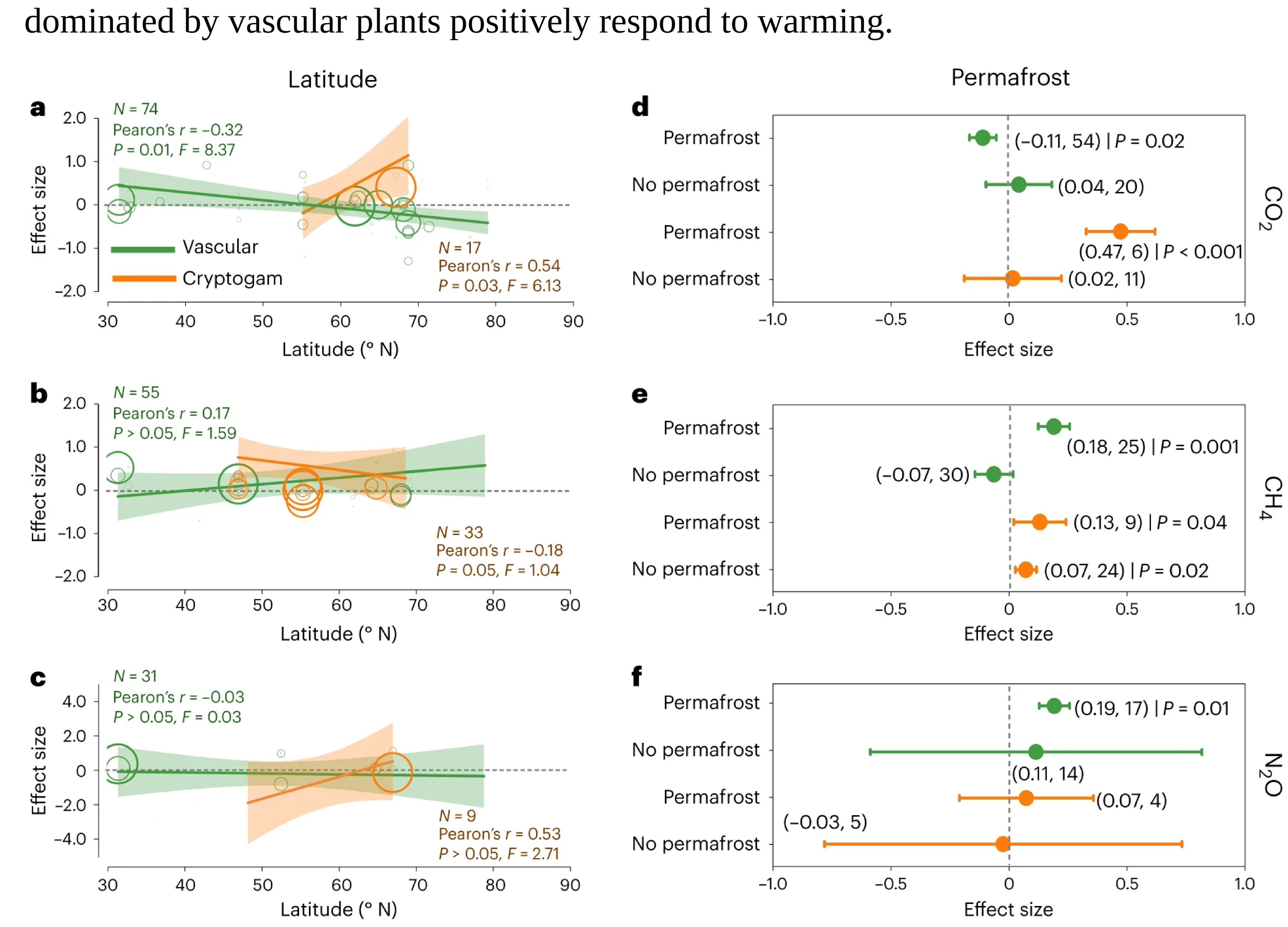
The weak response of CO_2 emissions to warming is due to a trade-off between warming-induced enhancement of CO_2 sink at vascular plant sites and CO_2 source at cryptogram sites. Warming enhances wetland CH_4 source. Response of CH_4 emissions is particularly high for graminoid and moss sites. Warming also enhances wetland N_2O source. Across all four PFTs, only N_2O emissions of graminoid sites are stimulated by warming.



Effects of warming on GHG emissions. **a**,**b**, The mean effect size of warming on CO_2, CH_4 and N_2O emissions at vascular plant and cryptogram sites (**a**), and at sites where shrub, graminoid, moss and lichen dominate (**b**). **c**,**d**, A conceptual diagram illustrating the response of wetland GHG emissions to warming (**c**,**d**).

Emissions and sink by latitude

Warming-induced increase in CO_2 sink for vascular plant sites and CO_2 source for cryptogam sites is enhanced with latitude. Warming increases CO_2 sink at vascular sites underlain by permafrost, as compared to sites where permafrost is absent. In contrast, CO_2 source at cryptogam sites with permafrost increases compared to sites without permafrost. As a net source of CH_4 and N_2O, the permafrost wetlands dominated by vascular plants positively respond to warming.



Spatial heterogeneity of wetland GHG emissions under warming. **a**–**c**, Latitudinal variations of the effect sizes of warming for CO_2 (**a**), CH_4 (**b**) and N_2O (**c**) emissions. **d**–**f**, Comparison of the mean effect sizes of warming for CO_2 (**d**), CH_4 (**e**) and N_2O (**f**) emissions in regions with and without permafrost.

References & Acknowledgments

Bao, T., Jia, G. & Xu, X*. Weakening greenhouse gas sink of pristine wetlands under warming. Nature Climate Change (2023). https://doi.org/10.1038/s41558-023-01637-0.

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