Rivers of the dammed: the impact of beavers on methane emissions

Sarah Fairbrother[1], Joshua Larsen[1], Vincent Gauci[1], Annegret Larsen[2] & Stewart Clarke[3]

[1]University of Birmingham, UK, [2]Wageningen University, Netherlands, [3]The National Trust, UK

Introduction

- The beaver's ability to create valuable wetland habitat, amongst other benefits, has led to widespread reintroduction programmes across Europe and more recently in the UK.

- While the role of beavers in carbon sequestration, through dam building and sedimentation, is evidenced our understanding of their full impact on terrestrial and aquatic carbon cycling is less well-developed.

- Beavers increase lateral connectivity in the landscape through their damming activity with the aquatic-terrestrial interface becoming an increasingly important zone in biogeochemical cycling. However, the effect of this evolving interface has not been properly examined.

- My project is exploring the impact of beavers on the structure and function of the interface and the effect that those changes have on carbon fluxes in aquatic and terrestrial ecosystems through the measurement of methane fluxes from tree stems, soil and water bodies.

- This will improve our understanding of the role that beavers play in carbon sequestration and release, support land management decisions whilst also contributing to wider understanding of the mechanisms and scales by which methane sinks and sources occur in temperate wetlands.

Methods

Study site:

- **15 hectare study site** in south east England: mosaic of landscape/habitat types associated with one stream at the head of the Wey catchment including lowland pasture, broadleaf woodland, wetland and wetland grassland habitat.
- Pair beavers released March 2021 - though for majority of study there was only one adult female present

- **27 study trees** (8 species) in wet and dry conditions running upstream to downstream monitored
- **Soil fluxes** monitored from soil collars installed adjacent to study trees where feasible
- **Aquatic fluxes** measured for five water bodies across the site
- Seasonal monitoring of all tree stem fluxes: June 2021–March 2023 (stem chamber placed at 70cm & 100cm)
- More focused monthly monitoring trees stem fluxes of 16 trees (7 species): May-November 2023 (stem chamber placed at 30cm, 70cm & 100cm)

- Fluxes captured and measured using soil, tree stem and aquatic chambers attached to Los Gatos Microportable Greenhouse Gas Analyzer

Results

Figure 1: Willow tree stem methane flux rate

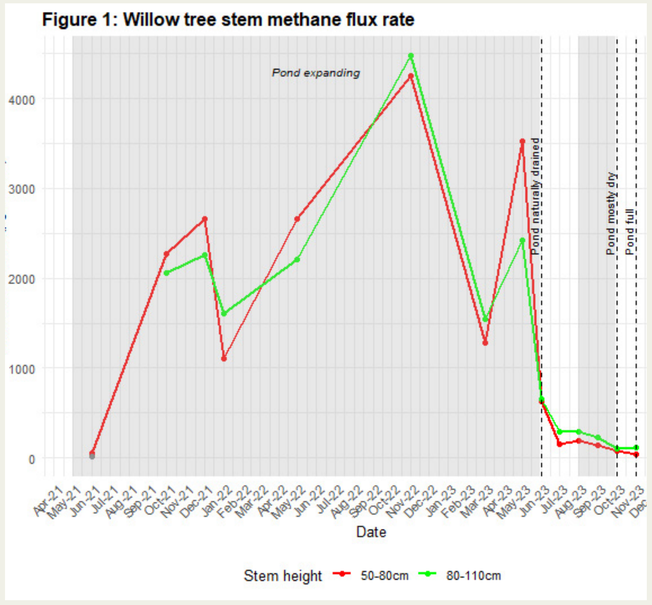


Figure 2: Mean monthly tree stem methane methane flux rate

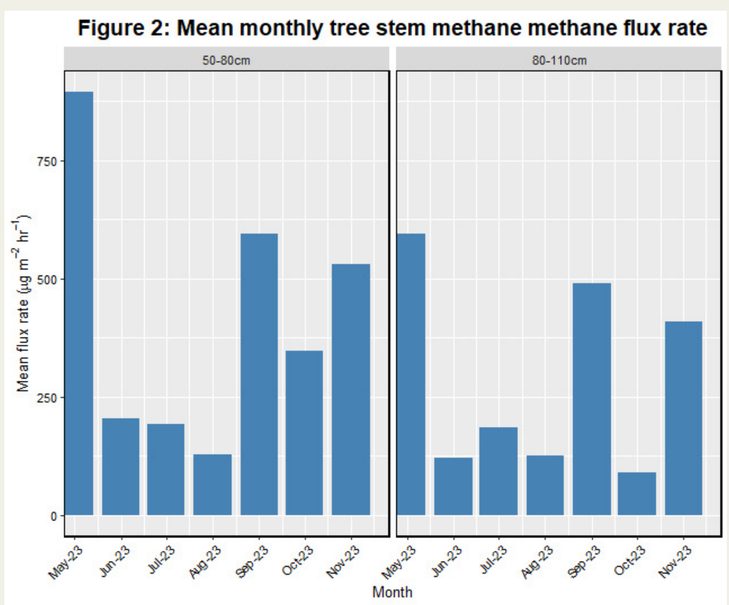
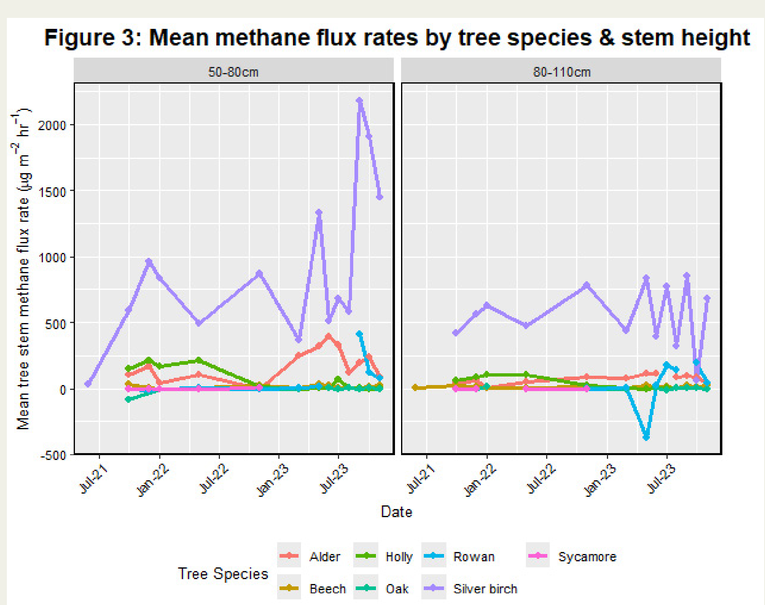


Figure 3: Mean methane flux rates by tree species & stem height



What happened to the study trees?

- Large pond with six study trees inundated for 26 months, naturally drained overnight in June 2023 – and rose/fell over a period of 5 months (figure 1).
- One study tree in a different pond blown over in storm. Half of root ball in the air but still alive.
- Number of trees completely ring-barked - the larger ones are still alive 3+ years later, though some have died

What patterns were observed in the tree stems methane fluxes?

- Generally **trees stem methane fluxes decrease with stem height** (figure 2).
- Some examples of emissions switching to uptake at higher stem levels (figure 3)
- **Variation in scale of fluxes between species** (figure 3) – this will be examined against wood densities for each species.
- V**ariation within species** also observed - environmental factors seem to be driving these difference (e.g. wet versus dry conditions)
- Emissions occurring all year round but with general trend towards peak in spring/summer and autumn, often followed by rapid decreases in winter (figure 3)
- **Different seasonal variation observed between tree species,** for example alder had less variation than other species

What patterns were observed in soil and aquatic fluxes?

- Although not shown the soil and aquatic fluxes show a similar seasonal pattern to the tree stem emissions with peak fluxes in the spring/summer and autumn

Discussion

Wetland-adapted trees are known to transport soil-produced methane (CH_4), an important greenhouse gas, to the atmosphere yet there has been little research on the emission response of trees to sudden and prolonged inundation during wetland creation in temperate zones. Changes in pond levels at the study site clearly impacted on tree stem emissions not just for those trees inundated within the pond but also those nearby. The scale of fluxes varied between and within species, likely due to differences in proximity to the water table. The relationship between fluxes and water table level will be explored to determine what impact this has on methane fluxes. While both willow and alder trees are both well-adapted to wet and flooded conditions their methane flux response is markedly different, likely due in part due to differing wood densities (and therefore capacity to transport methane produced in the soil via the tree's root and vascular system) (Pangala *et al.,* 2015). The variability of tree species response both in terms of scale of fluxes and seasonal variation will also be explored through the further data analysis.

Flux rates for tree stems, soil and aquatic bodies will be compared to other studies including those with beavers present. The opportunity to upscale fluxes to tree and wetland level will be explored using methods applied in other relevant studies (Pangala *et al.*, 2017, Jeffrey *et al.,* 2020). Importantly, the implications of the findings will be considered in the context of the role of beavers as a nature-based solution to wetland maintenance and creation and carbon sequestration, and what this might mean in the context of wider land management policy in England.

References:
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Pangala, S. R., Enrich-Prast, A., Basso, L.S., Peixoto, R.B., Bastiviken, D., Hornibrook, E. R., et al. (2017). Large emissions from floodplain trees close the Amazon methane budget. Nature, 552(7684), 230-234.
Jeffrey, L. C., Moras, C. A., Tait, D. R., Johnston, S. G., Call, M., Sippo, J. Z., et al. (2023). Large methane emissions from tree stems complicate the wetland methane budget. Journal of Geophysical Research: Biogeosciences, 128.

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