frontiers | Frontiers in Forests and Global Change

TYPE Editorial
PUBLISHED 03 May 2023
DOI 10.3389/ffgc.2023.1200668

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OPEN ACCESS

EDITED AND REVIEWED BY
Jaana Bäck,
University of Helsinki, Finland

*CORRESPONDENCE
Junbin Zhao
junbin.zhao@nibio.no

RECEIVED 05 April 2023
ACCEPTED 19 April 2023
PUBLISHED 03 May 2023

CITATION
Zhao J, Chi J and Jocher G (2023) Editorial: Greenhouse gas fluxes in forest ecosystems. *Front. For. Glob. Change* 6:1200668. doi: 10.3389/ffgc.2023.1200668

Editorial: Greenhouse gas fluxes in forest ecosystems

Junbin Zhao[1]*, Jinshu Chi[2] and Georg Jocher[3]

[1]Department of Biogeochemistry and Soil Quality, Division of Environment and Natural Resources, Norwegian Institute of Bioeconomy Research, Ås, Norway, [2]Earth, Ocean and Atmospheric Sciences Thrust, The Hong Kong University of Science and Technology (Guangzhou), Guangzhou, China, [3]Department of Matters and Energy Fluxes, Global Change Research Institute Czech Academy of Sciences, Brno, Czechia

KEYWORDS

nitrous oxide—N_2O, methane—CH_4, carbon dioxide—CO_2, palm plantation, tree roots, tree stem, fertilization

Editorial on the Research Topic
Greenhouse gas fluxes in forest ecosystems

Forests play a crucial role in mitigating climate change by absorbing carbon dioxide (CO_2) from the atmosphere. However, recent research has revealed that forests also emit significant amounts of other greenhouse gases (GHGs), such as methane (CH_4) and nitrous oxide (N_2O), from both tree and soil sources. These GHGs have a much greater warming potential than CO_2, making it essential to accurately assess their emission levels to fully understand the role of forests in climate change mitigation.

Despite the critical role of forests in mitigating climate change, our understanding of the magnitude, variability, and drivers of all GHG fluxes from forests of different regions is still incomplete. Before initiating this Research Topic in 2021, we carried out literature research and found that only a very small fraction of the forest studies measured CH_4 fluxes from trees (i.e., leaves and stems, 11 out of 340 studies) or at the ecosystem scale (13 studies) (Figure 1). These studies are particularly lacking in boreal and tropical regions due to various factors, including limitations in site accessibility, availabilities of instrumentation and skilled labor as well as regional/national policies. Since only a limited number of studies were conducted at the ecosystem level, the role of forests in CH_4 exchange is largely uncertain, varying from a weak CH_4 sink to a strong source, calling for more observations in different forest ecosystems. Studies on ecosystem scale N_2O fluxes in forests are even less (Eugster et al., 2007; Mammarella et al., 2010).

This Research Topic aims to cover the current state of research regarding processes associated with GHG fluxes in forest ecosystems and their biotic or abiotic drivers. Studies in this Research Topic cover GHG fluxes at soil, tree and ecosystem scales and include a wide range of ecosystems (from a boreal forest in Europe to a temperate forest in Oceania and tropical forests/plantations in Asia and south America), providing new knowledge on how environmental changes, especially land managements, affect the GHG potentials of forests.

Nitrogen (N) fertilization has been a forest management practice to enhance the tree growth in Scandinavia countries for many decades (Hedwall et al., 2014). Besides the increased CO_2 sequestration, the N addition via fertilization may also act as substrates that boost N_2O emissions from forest soils. Rütting et al. investigated the consequences of long-term fertilization on N_2O emissions in a boreal forest in Northern Sweden using a combination of manual/automatic chambers and gas probes. Although the overall N_2O emissions were low, the fertilization generally doubled the emissions. Surprisingly, N_2O emissions were higher in the winter than in the growing seasons. Winter has conventionally

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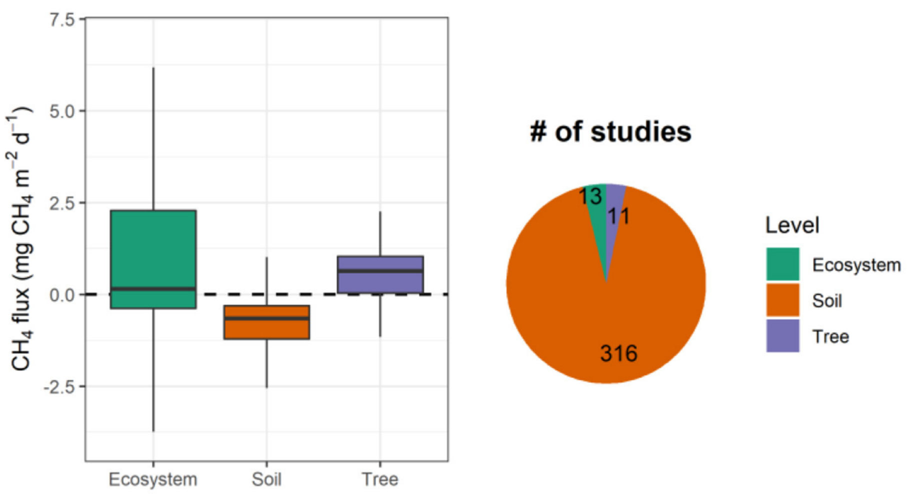
been assumed as a dormant period for most biological processes and the observed high winter N_2O emissions suggest that the winter GHG fluxes must be considered in annual budgets. At the same time, the large variance in winter N_2O emissions also calls for more studies to investigate the underlying processes under various winter environments (e.g., microbial communities for denitrification).

In Southeast Asia, N fertilizations are heavily applied to the widespread oil palm plantations in the region. Between the plantations and nearby rivers, an area of natural riparian forests is often kept as buffer zones for local ecosystems. The added N in the plantation could substantially contribute to soil N_2O emissions in the plantation as well as the adjacent riparian forests via leaching. So far, data on GHG emissions from oil palm plantations are limited, particularly for N_2O (Skiba et al., 2020). The study of Drewer et al. has confirmed the soil in oil palm plantation as a strong source for both N_2O and CH_4. Importantly, they found that N_2O emissions from the riparian forests were even higher than in the oil palm plantation themselves, highlighting the unexpected effects of land management on ecosystems around the managed areas. Long-term observations are still needed to further evaluate how the GHG potentials will evolve over time from both oil palm plantations and the surrounding buffer zones.

Soil decomposition is an important process that releases CO_2 into the atmosphere, where tree roots are a direct source of carbon substrates for decomposition (Dijkstra et al., 2021). Carrillo et al. found that root morphological traits (e.g., root diameter) play a critical role in determining the decomposition rates. Changes of root traits have significant importance, especially when plants are under environmental stresses (e.g., drought), because they can lead to increased CO_2 emissions through decomposition. Besides the contribution to carbon emissions via roots, tree stems are also known as an important emitter of GHG (Covey and Megonigal, 2019). Soosaar et al. focused on the aguaje palms (*Mauritia flexuosa*) and boarwoods (*Symphonia globulifera*) in a Peruvian Amazon and found that the CH_4 emission rates from tree stems can reach up to 44% of those from soils. However, the large variances in stem CH_4 fluxes among different locations, stem heights and species highlight the necessity to further study the mechanisms and drivers of these fluxes.

So far, our knowledge regarding the forest GHG fluxes and their underlying processes is still very limited and the conventional notion of mitigating climate change by simply planting trees has faced growing criticism. To ensure that forests remain an effective tool for mitigating climate change, we need to improve our understanding of the dynamics of GHG emissions from forests and their controls. Further research is needed to better understand the mechanisms of GHG fluxes, particularly CH_4 and N_2O fluxes from trees. Moreover, long-term observations at the ecosystem level can help reveal the potential changes in forest GHG emissions in response to climate change and land use. Filling these knowledge gaps are essential for developing mechanism models, estimating GHG balance at regional and global scale. Ultimately, the knowledge will enable the development of effective strategies to manage forest ecosystems to maximize their potential as carbon sinks and minimize the release of potent GHGs such as CH_4 and N_2O.



	Number (#) of studies		
	Ecosystem	Soil	Tree
Boreal	3	74	2
Temperate	9	167	8
Tropical	1	77	1

FIGURE 1
Summary of the studies that measured CH_4 fluxes in forests (not including wetland forests) based on a literature search on Web of Science. Positive flux values indicate CH_4 release to the atmosphere and negatives indicate CH_4 uptake.

Author contributions

JZ initiated the original draft writing. JC and GJ edited and revised the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding

This work has been supported by funding from the Department of Biogeochemistry and Soil Quality at Norwegian Institute of Bioeconomy Research, the Norwegian Research Council (NFR-245927 and NFR-281109), the CzeCOS program (LM2023048, Ministry of Education, Youth and Sports of Czech Republic), the CLIMB-FOREST project (no. 101059888, Horizon Europe), and the Center for Ocean Research in Hong Kong and Macau (CORE).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Covey, K. R., and Megonigal, J. P. (2019). Methane production and emissions in trees and forests. *New Phytol.* 222, 35–51. doi: 10.1111/nph.15624

Dijkstra, F. A., Zhu, B., and Cheng, W. X. (2021). Root effects on soil organic carbon: a double-edged sword. *New Phytol.* 230, 60–65. doi: 10.1111/nph.17082

Eugster, W., Zeyer, K., Zeeman, M., Michna, P., Zingg, A., Buchmann, N., et al. (2007). Methodical study of nitrous oxide eddy covariance measurements using quantum cascade laser spectrometery over a Swiss forest. *Biogeosciences* 4, 927–939. doi: 10.5194/bg-4-927-2007

Hedwall, P. O., Gong, P. C., Ingerslev, M., and Bergh, J. (2014). Fertilization in northern forests - biological, economic and environmental constraints and possibilities. *Scand J. Forest Res.* 29, 301–311. doi: 10.1080/02827581.2014.926096

Mammarella, I., Werle, P., Pihlatie, M., Eugster, W., Haapanala, S., Kiese, R., et al. (2010). A case study of eddy covariance flux of N_2O measured within forest ecosystems: quality control and flux error analysis. *Biogeosciences* 7, 427–440. doi: 10.5194/bg-7-427-2010

Skiba, U., Hergoualc'h, K., Drewer, J., Meijide, A., and Knohl, A. (2020). Oil palm plantations are large sources of nitrous oxide, but where are the data to quantify the impact on global warming? *Curr. Opin. Env. Sust.* 47, 81–88. doi: 10.1016/j.cosust.2020.08.019