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Living Trees are a Major Source of Methane in the Temperate Forest

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Globally, forests sequester about 1.1 $\pm$ 0.8 Pg C yr-1, an ecosystem service worth hundreds of billions of dollars annually. Following the COP21 meeting in Paris, an international consensus emerged: The protection and expansion of forests worldwide is a necessary component of climate mitigation strategies to limit warming to less than 2°C. The physiological processes governing sequestration of CO_2 in living trees are well studied and the resulting pattern in global forest carbon sequestration is clear. The role living trees play in the production and emission of methane (CH4) remains unclear, despite the fact it has the potential to offset climate benefits of forest CO_2 sequestration. A known but largely unexplored pathway of forest CH4 production involves microbial-based methanogenesis in the wood of living trees. In the first regional-scale study of tree trunk gas composition, we examine the ubiquity and potential source strength of this pathway. Trunk methane concentrations were as high as 67.4% by volume (375,000-times atmospheric), with the highest concentrations found in older angiosperms (18,293 μL·L-1 $\pm$ 3,096). Bark flux chambers from 23 living trees show emissions under field conditions, and large static chambers demonstrate high rates of production in felled Acer rubrum trunk sections. Diffusion flux modeling of trunk concentrations suggests wood-based microflora could produce a global CH4 efflux of 26 Tg CH4 yr-1. Applying these fluxes to provide a spatially explicit map of trunk-based CH4 flux, we estimate the potential relationship between carbon sequestration rates and CH4 emission by forest trees in Eastern North America. Methane emissions from the trunk-based methanogenic pathway could reduce the average climate mitigation value of these temperate forests by 10-30%. We highlight the need to improve earth systems models to account for the full complexity of forest climate interactions and provide a data layer useful in reducing large uncertainty in global methane budgets.