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Variation in phenolic root exudates and rhizosphere carbon cycling among tree species in temperate forest ecosystems

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Temperate forest tree species composition has been highly dynamic over the past few centuries and is expected to only further change under current climate change predictions. While aboveground changes in forest biodiversity have been widely studied, the impacts on belowground processes are far more challenging to measure. In particular, root exudation – the process through which roots release organic and inorganic compounds into the rhizosphere – has received little scientific attention yet may be the key to understanding root-facilitated carbon cycling in temperate forest ecosystems. The aim of this study was to analyze the extent by which tree species' variation in phenolic root exudate profiles influences soil carbon cycling in temperate forest ecosystems. In order to answer this question, we grew six temperate forest tree species in a greenhouse including Acer saccharum, Alnus rugosa, Fagus grandifolia, Picea abies, Pinus strobus, and Quercus rubra. To collect root exudates, trees were transferred to hydroponic growing systems for one week and then exposed to cellulose acetate strips in individual 800 mL jars with a sterile solution for 24 hours. We analyzed the methanol-extracted root exudates for phenolic composition with high-performance liquid chromatography (HPLC) and determined species differences in phenolic abundance, diversity and compound classes. This information was used to design the subsequent soil incubation study in which we tested the effect of different phenolic compound classes on rhizosphere carbon cycling using potassium hydroxide (KOH) traps to capture soil CO_2 emissions. Our findings show that tree species show high variation in phenolic root exudate patterns and that these differences can significantly influence soil CO_2 fluxes. These results stress the importance of linking belowground plant traits to ecosystem functioning. Moreover, this study highlights the need for research on root and rhizosphere processes in order to improve terrestrial carbon cycling models and estimate forest ecosystem feedbacks to climate change.