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Mediterranean tree carbon allocation dynamics revealed by pulse labeling and a flux-coupled detection method

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Fixed Carbon (C) allocates to plant tissue biomass and is released to the atmosphere or the rhizosphere in respiration and exudation, respectively. Traditionally, tree C allocation is estimated by either an isotopic, or a mass balance approach. To follow C quantitatively and study its sink partitioning, we developed a $13CO_2$ pulse-labeling method, with a flux-coupled, three-phase detection. C allocation patterns were examined in 2-year-old saplings of two conifer (Pinus, Cupressus) and three broadleaf (Quercus, Ceratonia, Pistacia) evergreen Mediterranean forest tree species. Integrating C mass balance and isotopic approaches enabled its fractionation to sinks and tissues along days. Our 13C mass balance succeeded in balancing C source with C sinks. Across the five species, C moved from leaves to stem and roots following the expected exponential decay, yet with species-specific nuances. Eight days post-labeling, conifers allocated $\sim$40% of the C belowground, and broadleaves <20%. Respiratory fluxes (mainly leaf) accounted for 10-35% of the C; allocation to root exudation was detected, though at marginal amounts. Our approach opens the way to a detailed investigation of C management in forest trees, and its belowground fraction in particular. Such high-resolution measurements might also resolve the unexpected observation of 'retro-fluxes', e.g. from roots to stem.