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The dynamics of annual carbon allocation to wood in European forests is consistent with a combined source-sink limitation of growth.

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The extent to which forest growth is limited by carbon (C) supply (source control) or by cambial activity (sink control) will strongly determines the responses of trees to global changes. However, the physiological processes responsible for the limitation of forest growth are still under debate. The aim of this study was i) to evaluate the key drivers of the annual carbon allocation to wood along large soil and climate regional gradients in four tree species representative of the main European forest biomes (Fagus sylvatica, Quercus petraea, Quercus ilex and Picea abies) ii) to implement the identified key drivers in a new C allocation scheme within the CASTANEA terrestrial biosphere model (TBM). Combining field measurements and process-based simulations at 49 sites (931 site-years), our analyses revealed that the inter-site variability in C allocation to wood was predominantly driven by an age-related decline. The direct control of temperature or water stress on sink activity (i.e. independently from their effects on C supply) exerted a strong influence on the annual woody growth in all the species considered, including deciduous temperate species. The lagged effect of the past environment conditions was a significant driver of the annual C allocation to wood. Carbon supply appeared to strongly limit growth only in deciduous temperate species. Our study supports the premise that European forest growth is under a complex panel of source- and sink- limitations, contradicting the simple source control implemented in most TBMs. The implementation of these combined forest growth limitations in the CASTANEA model significantly improved its performance when evaluated against independent stand growth data at the regional scale (mainland France, >10000 plots). We finally discuss how the sink imitation affects the CASTANEA simulated projections of forest productivity along the 21th century, especially with respect to the expected fertilizing effect of increasing atmospheric CO_2 concentration. The new C allocation scheme will allow refining the projections of the impacts of global changes on forest growth, with implications on the predicted evolution of the forest C sink, forest dieback and tree species distributions.