**Title:** (Understanding the decoupling of CO2 uptake and woody production) *(many commentaries have clever, catchy, somewhat informal titles)*

**Authors:**

Kristina J. Anderson-Teixeira1,2\* ( Orcid ID : 0000-0001-8461-9713)

Steven A. Kannenberg

**Author Affiliations:**

1. Conservation Ecology Center; Smithsonian National Zoo & Conservation Biology Institute; Front Royal, Virginia 22630, USA
2. Forest Global Earth Observatory; Smithsonian Tropical Research Institute; Panama, Republic of Panama

\*corresponding author: [teixeirak@si.edu](mailto:teixeirak@si.edu); +1 540 635 6546

**keywords:** *(5-8)*

**quote:** *(A brief quote extracted from the Commentary should be included after the article title.)*

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As the climate changes and scientists seek to project its future course, an important uncertainty lies in the response of forests. Will rising atmospheric carbon dioxide (CO2) and lengthening growing seasons relieve limitations to tree growth, allowing increased carbon (C) sequestration in long-lived woody tissues and providing a negative feedback to climate change? Or will increasing heat and drought stress reduce growth and increase mortality, resulting in a positive feedback to climate change? To answer this question, global C cycle models simulate photosynthesis under future conditions, using simple plant C allocation schemes to determine the amount of C sequestered in woody growth versus that allocated to short-lived pools and rapidly respired back to the atmosphere as CO2 (Fatichi *et al.*, 2014). Yet, there is growing evidence that these schemes are too simplistic, as wood production is in fact decoupled from photosynthesis, being itself directly influenced by climatic drivers (Delpierre *et al.*, 2016; Etzold *et al.*, 2022). Needed, then, is an understanding of how woody growth is jointly shaped by photosynthesis and climate variables under a range of conditions. In this issue of *New Phytologist*, Martinez-Sancho *et al.* (pp. 000-000) exemplifies the type of research needed to improve our ability to predict forest C sequestration under climate change, using an innovative approach to describe the seasonal course of carbon sequestration in tree stem growth and how this is affected by drought.

*(summarize/ explain Martinez-Sancho method)* (Builds on methods pioneered by Cuny *et al.* (2013), Pérez-de-Lis *et al.* (2022), Cuny *et al.* (2015).)

*(describe typical seasonal patterns, including what was known and what Martinez-Sancho contributed.)*

*(talk about drought impacts)* Martínez-Sancho *et al.* (2022) showed that C sequestration was reduced 67% during a 41-day period of extreme summer drought in 2015, during which time rates of cell enlargement and thickening were slowed. Meanwhile, ∂13C isotopes indicated increased C isotope discrimination, indicative of water limitation resulting in higher intrinsic water use efficiency during the drought. *(GPP less affected?)(Kannenberg et al., 2022)* However, the total number of cells formed was unchanged, and higher compensatory growth and C sequestration rates after the drought resulted in similar total C sequestration during the drought and reference years (Martínez-Sancho *et al.*, 2022). Thus, study of intraannual dynamics of wood formation revealed dynamics that would have gone undetected at the annual scale.

The findings of Martínez-Sancho *et al.* (2022) point to the importance of the timing of drought. *(some content on how drought timing affects annual growth – e.g., D’Orangeville et al. (2018))*

The Martínez-Sancho *et al.* (2022) study adds to growing evidence that CO2 uptake and woody production are decoupled. …(Cabon *et al.*, 2022) ….*GPP* is less senstiive to drought than *ANPPwoody* (Kannenberg *et al.*, 2022). …(Dow *et al.*, in press) …(Jiang *et al.*, 2020) Of course, these observations of decoupling do not imply that *ANPPwoody* is completely decoupled from *GPP*; rather, the two show some level of correlation both in relation to interannual climatic variation at a single site (Cabon *et al.*, 2022) and across broad climatic gradients (Banbury Morgan *et al.*, 2021). However, we now have clear evidence that it is not realistic to expect that a constant allocation of photosynthate will be allocated to woody growth on either intraanuual or interannual time scales. This fact has implications for our understanding of the relationship of annual tree growth to climate – both in the past and in the future.

*(Paragraph on implications for tree-ring studies:)* The annual growth records recorded in tree rings are routinely used to understand the climate sensitivity of tree growth and thereby to reconstruct past climates(**fritts\_tree\_1976?**) or understand how forest productivity may respond to future climate change (Dow *et al.*, in press; e.g., Cabon *et al.*, 2022; Kannenberg *et al.*, 2022). Moreover, as shown by Martínez-Sancho *et al.* (2022), a severe drought might not even register in annual tree-rings if it is short enough that C fixed during the drought [by the less moisture-sensitive process of photosynthesis; (**delpierre\_wood\_2016\_verify?**); Kannenberg *et al.* (2022)] can bolster late-season wood formation and compensate for missed growth during the drought. The implication is that the ability of annual growth rings to capture drought depends on the timing and nature of the drought. *(other implications for tree-ring studies?)*

*(one paragraph discussing models:)* The decoupling of *ANPPwoody* from *GPP* also has important implications for global C cycle models. Most models represent C allocation to *ANPPwoody* as a constant fraction of *GPP* (**ref?**), and thereby effectively assume that long-term C sequestration in woody growth – the main variable of interest for climate change projections – parallels *GPP*. Yet, as reviewed above, this assumption is not accurate and represents an important uncertainty in these models. (Models may project over- or under-predict drought sensitivity, depending on the timing and nature of the drought.) To get models right, we need to understand seasonal patterns of C allocation to woody growth and how they are influenced by climate variation (and change)

We need more studies like Martínez-Sancho *et al.* (2022) – bonus if they also get GPP – to broaden our understanding of how *ANPPwoody* is jointly shaped by climate– both directly and indirectly (through GPP).

*(active vs passive allocation)*

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