CARBON DYNAMICS

Tree growth in sync

Global synchrony in tree growth shows a recent rapid rise tied to increasing temperature synchrony, which might alter global carbon sink dynamics.

Lara M. Kueppers

Tree rings, representing the annual growth of trees recorded over their lifetime, are an essential ecological archive best known for extending temperature records back thousands of years. However, tree rings also tell us about trees themselves. Writing in *Nature Ecology & Evolution*, Manzanedo et al.[1] used global tree ring records from the International Tree Ring Data Bank (ITRDB) to analyse patterns in tree growth over the last 1,000 years. They report that global synchrony in tree growth between populations was low and remarkably stable over most of that period, but has risen sharply in the last half century. That is, high growth years (and low growth years) have been more 'in sync' across sites in recent decades than in the last millennium (Fig. 1).

Notably, Manzanedo et al. find that the observed recent increase in tree growth synchrony is best explained by temperature, which shows a recent rapid rise in global synchrony as well. This relationship with temperature is perhaps not surprising because tree ring chronologies in the ITRDB probably more closely track large-scale climate factors than trees in general since trees that are insensitive to climate variables are underrepresented in the database. Nevertheless, trees near ITRDB trees are expected to exhibit similar, if less pronounced, sensitivities to climate variation.

Cleverly, Manzanedo et al. evaluated changes in the absolute value of correlations in tree growth between sites, allowing stronger positive and stronger negative correlations to contribute to the trend in global growth synchrony. Why might this be valuable? Take, for example, boreal trees, whose growth is generally limited by low temperatures. Stronger positive correlations between boreal sites might be expected as northern latitudes rapidly warm, lengthening growing seasons in many sites. But consider also Mediterranean trees, whose growth is generally limited by water availability. A relatively warm year in both locales is likely to increase growth in the boreal but decrease growth in the Mediterranean sites, while a cool year would do the opposite, creating a negative correlation between boreal and Mediterranean sites[2]. Stronger positive and stronger negative correlations have a coherent global explanation even though the proximal local mechanisms differ.

Trees account for a large fraction of the current global carbon sink, pulling from the atmosphere at least 20% of the CO_2 that humans emit[3]. Tree growth synchrony is relevant to this sink: if tree growth is not synchronized and is varying randomly with respect to location, the strength of the carbon sink depends, in part, on the sum of distinct growth variations across thousands of locations and is very hard to predict. But if tree growth is synchronized globally, and we can identify common factors driving the growth fluctuations, we are better able to understand and predict how ongoing global changes alter the sink strength.

Given that the increase in growth synchrony mirrors increased temperature synchrony, and that temperature synchrony is projected to increase further[4], should we then expect larger swings in global forest carbon sink strength as trees sync with global temperature? The answer depends on whether correlations between diverse sites are increasingly positive. While the increased tree growth synchrony appears to be driven largely by stronger positive correlations, there are hints that this may have reversed in the most recent periods of the record. If stronger negative correlations emerge, strong growth in one region could offset weak growth in another in any given year, evening out the overall carbon sink variability. The answer also depends on whether proximal mechanisms, such as longer growing seasons, enhanced water stress, or changing forest age, driving the recent uptick in synchrony persist. As high elevation and high latitude trees are no longer temperature limited, local factors could become more important, diminishing growth synchrony[5]. But most importantly, the answer depends on the degree to which the increased synchrony among ITRDB trees is representative of all trees globally.

Fig. 1 | Growth synchrony. Using tree ring chronologies from thousands of tree populations, such as these from Tennessee and Kentucky, United States, in the International Tree Ring Data Bank, Manzanedo et al.[1] report that global synchrony in tree growth has rapidly increased in recent decades. Credit: Neil Pederson.

If co-occurring, less sensitive trees do not share the increased growth synchrony, the relevance of the finding for forests and the global carbon cycle is more limited. Further, the ITRDB archive lacks records from the wet tropics, where many trees do not produce recognizable rings, and where the terrestrial carbon sink has been strongest but may be weakening[6].

There are numerous opportunities to build on the Manzanedo et al. analysis to better understand the global pattern of tree growth synchrony and its implications for the terrestrial carbon sink. High and low elevation trees seem to have similar recent trends in growth synchrony, but what about gymnosperms versus angiosperms, which may respond differently to rising CO_2[7], or trees in old versus younger forests or rooted in more fertile versus nutrient-depleted soils? Within and across regions it would be valuable to know how positive and negative correlations may be changing, the distances over which synchrony is strongest, and the proximal mechanisms by which temperature variation contributes to growth variation. Perhaps most important would be to expand the analysis to include more tropical sites. Methods for extracting historical records of growth variation there are still challenging and not yet widely employed, but have yielded valuable data from selected sites and species[8].

A further important question is whether the global rise in tree growth synchrony extends to plant and animal population sizes. Recent results suggest that it may, but perhaps not in all cases[9]. For example, an increase in synchrony between North American breeding bird populations has been observed and, as in the case of tree growth reported by Manzanedo et al., attributed to increased temperature synchrony[10]. The oscillations in the global upward climb in temperature brought on by human CO_2 emissions appear to be synchronizing important parts of the biosphere, with as yet unknown consequences. ❐

Lara M. Kueppers ✉
Energy and Resources Group, UC Berkeley and Climate and Ecosystem Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA.
✉*e-mail: lmkueppers@berkeley.edu*

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Competing interests

The author declares no competing interests.