New data on tree growth do not impact forest carbon management

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Much is to be learned from large datasets of observations. Stephenson *et al.*[1] have built a truly remarkable one on growth of individual trees across a range for 403 tropical and temperate species. They conclude from its analysis that the rate of carbon accumulation increases with increasing tree size. However, we respectfully disagree with their use of the absolute growth rate (AGR) either as a growth or carbon accumulation metric, adding that it may even be misleading for forest carbon management which needs to be informed by stand and landscape-level information about all carbon pools, including dead trees, litter and soil. While the new data about individual live trees are informative, they are insufficient to alter decisions about the management of forest carbon.

The authors write: "… 85% of the species had mass growth rates that increased continuously with tree size …, with growth curves closely resembling those in Fig. 2. Thus, our finding of increasing growth not only has broad generality across species, continents and forest biomes (tropical, subtropical and temperate), it appears to hold regardless of competitive environment". Globally this is not exactly true. By taking the logarithm of above ground biomass, the data are transformed in a way that hides the deceleration of growth rate with increasing tree size, as shown in Fig. 1. This deceleration means that 10 *Sequoia sempervirens* trees each with a mass of 1 Mg will grow by 1.4 Mg y^{-1} while a single 10 Mg tree will only grow by 0.38 Mg y^{-1}. Such an outcome is generalizable as growth per unit tree mass, the relative growth rate, is known to decrease with tree size[2].

As to the important issue of carbon, the authors conclude that their observations imply increased carbon capture with increasing tree size. Although the authors are careful to point out later in the text that their results do not contradict the well-known age-related decline in stand productivity, we find it crucial here to emphasize the following points. On a per ground area basis, growth of stands decreases with stand age[3]. Even when large trees dominate the canopy of older stands, they are not only less efficient in their growth (i.e. have a smaller relative growth rate), but they also compete for resources with trees of smaller stature, enhancing their mortality (as noted by the authors) and also causing a decline in their efficiency[4] (as not noted by the authors). It is therefore on a per-area basis at the stand level or even at the landscape level[5] that net biomass increment or carbon capture must be assessed, and, for carbon, the assessment must include all other forest carbon pools. Stand-level measurements show that carbon accumulation slows down as forests get older[6]. Landscape-level measurements show that forest carbon sinks are linked to both growth and removals[7]. Management actions are informed by knowledge about stand and landscape-level dynamics of all carbon pools. The new data on growth rates of live trees, while informative, do not alter our understanding of stand and landscape-level carbon dynamics and therefore do not lead to changes in forest carbon management practices.

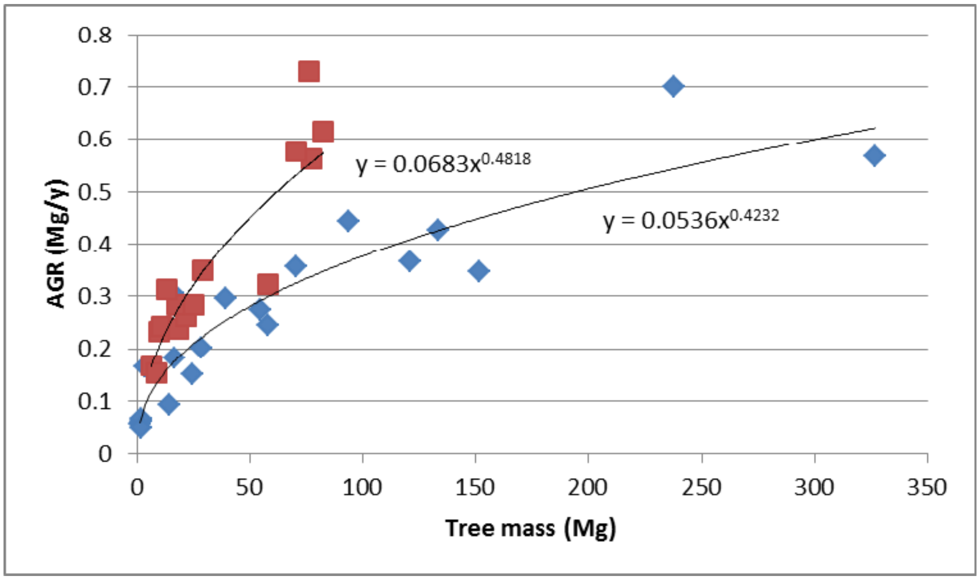

Figure 1: Absolute growth rate (AGR) of *Eucalyptus regnans* (squares) and *Sequoia sempervirens* (lozenges) as a function of tree mass. Data from Stephenson *et al.*[1], their Fig. 3, but replotted on a linear scale. The solid lines are least square fit relationships. According to curve downward concavity, bigger trees are less efficient at putting on mass than smaller trees.

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