Old carbon in the rainforest understory: complementary evidence from inventories and growth-ring patterns.

Most of the organic carbon comprised in land cover exists as wood and highest concentrations are found in tropical moist forests. These quantities and the relevance of this element for the global climate justify extensive research on the carbon dynamics of forests and those in tropical rainforests in particular. Key factors like tree recruitment, growth and mortality are typically quantified through subsequent inventories of intact forest plots. The question arises whether growth-ring studies could add complementary information on the carbon cycle.

We measured trees in a semi-deciduous rainforest in the western Congo Basin forest belt, both in 5 permanent samples plots of 1 ha (surveyed in 2009, 2016 and 2017) and along a phenological trail that consisted of $$$ trees (annual tree measurements from 1948-$$$ and more recently during 2013-2014 on $$$ rediscovered trees). In 2013 and 2014 we were able to take wood samples from $$$ trees alongside the trail that showed traces of ingrown nails, originating from tree labeling in 1948. This offers unique opportunities for a cambial wounding experiment spanning 66 years.

Tree increments could be exactly dated through the ingrown nails. Many trees showed patterns of growth rings, but very often these appear are indistinct or non-periodical. Only a limited number of individuals from a few species showed annual growth rings and cross dating was not successful. Bomb peak dating was not feasible on a number of trees large enough to measure carbon uptake by a community that consists of many different species and size classes.

Treatment of census data typically involves correction protocols of the raw measurements, e.g. often trees show a zero, a negative or a very small increment.

We used the number of rings formed between 1948 and 2014 in order test a correction protocol. We estimated total tree age and compared this reference age with tree ages inferred from tree size and annual increment (dividing final DBH by the annual DBH growth during the period 1948-2014).

Tree age inferred from DBH growth produced fairly well age estimations except for trees older than 200 years from which the ages are both under- and overestimated.

Census data made clear that DBH data from $$$ trees on a total of $$$ measured trees needed to be corrected. To avoid unrealistic age estimations the reference ages inferred from the ring counts was used to choose a relevant correction protocol.

Plot-level mean tree ages and mean carbon ages where significantly higher in the understory (tree age 260, tree-level mean carbon age 73) and the emergent trees (tree age 220 and tree-level mean carbon age 66 compared to intermediates classes.

Understory trees grow slowly and non-periodically, but they store more than half of the stand-level aboveground carbon, they contribute more to net uptake and they outlive most of the canopy trees. Understory trees maintain a stable carbon pool, while carbon in larger trees is subject to faster turnover.

The major role of growth-ring analysis in a context of undisturbed forests is avoiding unrealistic tree ages in correction protocols of census data. When forests are disturbed, either logged or degraded by overuse, growth-ring studies need to be considered in analysis of past and ongoing carbon sequestration processes.