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Editorial

Growth and Allocation of Woody Biomass in Forest Trees Based on Environmental Conditions

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Terrestrial ecosystems, and forests in particular, are important components of land processes because of their key role in reducing atmospheric greenhouse gas concentrations by storing a large amount of carbon in tree biomass and soils. Increasing attention is being paid to forestland area, which accounts for 30% of the total land surface and acts as the main C store in the Earth system. In their life cycle, plants uptake, process, allocate (i.e., the distribution of net primary production among the different plant organs), and remobilize the product of photosynthesis. The relative amount of above- and below-ground biomass partitioned among leaves, branches, stems, roots, non-structural pools, and reproductive tissues is a good indicator for forest productivity and reflects the material flow, the health, the wood quality, and the plant's survival strategies. How plants share their labile products across their compartments is not fixed, rather is influenced by plant size and likely varies over time, among species and growth environments, and is affected by natural and anthropogenic disturbances (e.g., forest management). Accordingly, the whole allocation process would be constrained under strong natural selection. Our understanding of the mechanisms governing these processes is, however, still patchy, with some processes and their responses to the environmental conditions much more well understood than others. Getting a qualitative/quantitative insight into the impact that the above-mentioned factors have on tree growth and above- and below-ground biomass allocation is essential both for understanding plant ecology and evolution and for developing environmental policies and forest management practices to cope with climate change. In this regard, new insights for Amazonian forests come from the modeling work of De Faria et al. [1], who quantified the loss in above-ground biomass and the changes in recovery time (i.e., the time required for a forest to return to its former or usual condition following a disturbance) of forests affected by droughts, wildfire, and their combination. Their findings provide a valuable gaze and alarming prevision on the impacts that climate change will likely have on the Amazonian regions housing more than half of the world's remaining rainforests in the world. However, even European forests are likely to face an increasing number of extreme events in the future. The work of Schäfer et al. [2] analyzed the effect of drought and mixture of forest composition in a mature temperate forest of Norway spruce (*Picea abies* (L.) Karst.) and European beech (*Fagus sylvatica* L.) located in southern Germany. They reported differential allocation of tree biomass related to the drought condition period, where trees prioritized the stem growth at the beginning of the growing season, and root growth during the remaining growing season. Interestingly, spruces exhibited less tree water deficit than beech trees, while mixture seems to enhance the water supply of spruce trees, which should increase the stability of this species in a time of climatic warming. Similarly, but in a Mediterranean context, Ogaya and Peñuelas [3] studied the growth and the allocation in a Mediterranean holm oak (*Quercus ilex* L.) forest experimentally exposed to partial rainfall exclusion during 21 consecutive years in the Prades holm oak forest, in Catalonia, NE Spain. The authors aimed to study the effects of the expected decrease in water availability in the Mediterranean in the following decades and found that allocation in woody structures and total above-ground biomass were correlated with annual rainfall, whereas canopy allocation and the ratio of wood/canopy allocation were not dependent on rainfall. Their results highlight that water deficits characterized by lower soil moisture and higher atmospheric aridity are leading to several changes in the ecosystem functioning of the Mediterranean forests, causing a strong decrease in the capacity of these forests to mitigate climate change because of the high decrease in wood growth and suggesting that progressive substitution of the species most sensitive to water scarcity by other species more adapted to drought is expected, transforming the current Mediterranean forest. In the context of climate change, the effect of increasing temperature on tree phenology and growth, even including biomass partitioning, is also the focus of the work of Mura and colleagues [4]. Mura et al. analyzed, under field conditions in managed Norway spruce plots regenerating after clearcuts in central Norway, whether the trees growing at different elevations invest similarly in their various organs. They found that different local environmental conditions affect both the growth rate and phenology but the biomass partitioning among different parts of the tree remains essentially unchanged, giving support to the hypothesis that maintaining specific allometric trajectories is fundamental for tree functioning. High temperatures in warm months were also found to be a key environmental factor for the net primary productivity (NPP) in *Pinus massoniana* (Lamb.), a major planted tree species in southern China due to its important role in the development of forestry both for economic and ecological benefit. Huang et al. [5] established a large biomass database for *P. massoniana* including stems, branches, leaves roots, above-ground organs, and entire tree, thanks to published literature, to find out potential geographical trends in NPP for each tree compartment and their influencing factors in carbon allocation. Huang et al. found that the NPP of tree components showed no clear relationships with longitude and elevation, but a statistically significant inverse relationship with latitude, but with different sensitivities to environmental conditions, mostly temperature, and stand variables. Temperature and precipitation are also the focus for the transcontinental work of Usoltsev et al. [6] based on a database of 413 sample plots for stand biomass, ranging from France to Japan to southern China, for the genus *Populus* spp, which is overall the most widely cultivated fast-growing tree species in the middle latitude plain. They found significant changes in the structure of the forest stand biomass (stems, above- and below-ground biomass). However, while a positive and statistically significant relationship with winter temperature emerged for all components of the biomass, a less clear relationship with the precipitation was found. Poplar plantations are also the focus of the work led by Zhang and colleagues [7]. The authors, based on a field trial established in 2007 in Sihong forest farm, Jiangsu Province (China), in order to understand the response of growth, biomass production, carbon storage, planting spacing, and their interaction, they destructively harvested 24 sample trees for biomass measurements and stem analyses. Not surprisingly, they found that biomass production and carbon storage for the single tree of three clones was enhanced as planting spacing increased, with carbon concentration decreasing from stem to leaves. With these data, Zhang et al. established a Chapman–Richards empirical model for predicting tree volume growth for Chinese poplar clones. With the aim to quantify total tree biomass and its allocation to components in common aspen (*Populus tremula* L.), at both the tree and stand levels, in the forested mountainous area in central Slovakia, Konôpka et al. [8] measured, through destructive sampling, leaves, branches, stem, and roots. By these measurements, the authors derived allometric biomass models with stem base diameter as an independent variable for individual tree components. Moreover, biomass stock of the woody parts and foliage, as well as the leaf area index, were modeled using mean stand diameter as an independent variable, showing that foliage contribution to total tree biomass decreased with tree size.

Ritchie et al.'s [9] work evaluate the tree growth and total above-ground productivity (even including shrubs) of a twelve-year-old ponderosa pine (*Pinus ponderosa* (Lawson and C. Lawson)) plantation under three separate treatments representing a range of management intensities in the southern Cascade Range in northeastern California subjected to wildfire events. The authors found a significant effect of the manual grubbing release from shrub competition on tree growth when compared with the no release control and that the total above-ground biomass or carbon was only marginally influenced because shrub biomass dominated both sets of plots in this young plantation. Their results show that a broader tradeoff for controlling competing shrubs between using herbicides and grubbing or other means should be evaluated if biomass production or carbon sequestration is one of the goals of prevention or for a post-fire reforestation program.

A novel approach, aiming at comparing structural carbon allocation to tree growth and to the climate in a dendrochronological analysis, is presented in Ivanusic et al. [10] for hybrid white spruce (*Picea glauca* (Moench) × *engelmannii* (Parry)) grown in British Columbia, Canada. With this new approach, the authors found significant differences between the percent structural carbon of wood in individual natural and planted stands. Some significant relationships were found between percent carbon, ring widths, early wood, late wood, and the cell wall thickness and density values. Carbon accumulation in planted stands and natural stands was found in some cases to correlate with increasing temperatures where warmer late-season conditions appear to enhance growth and carbon accumulation in these sites.

The below-ground biomass, especially fine roots, and the relationship with forest structure in a mature European beech forest in central Italy is the core of the analyses presented by D'Andrea et al. [11]. The authors investigated the spatial variability of fine root production, soil CO_2 efflux, forest structural traits, and their reciprocal interactions and found, unexpectedly, that, in the year of study (2007–2008), fine root production resulted in the main component of NPP explaining about 70% of the spatial variability of soil respiration. The authors also found that fine root production was strictly driven by leaf area index and soil water content, suggesting close interactions between forest structure and functional forest characteristics to optimize carbon source–sink relationships.

Migolet and colleagues [12] implemented local and regional methods for estimating palm biomass in a mature plantation, using destructive sampling in the Congo Basin (West Equatorial Africa). Using data from eighteen 35-year-old oil palms in a plantation located in Makouké, central Gabon, they derived allometric equations for estimating stem, leaf, and total above-ground biomass. With a comparison with existing allometric models for oil palms generated elsewhere, the authors showed that their site-level model was a better predictor.

The current Special Issue groups a selection of works representing the most recent advances and insights linking growth and carbon allocation with, among others, environmental forcing, forest structure, and potential wood supply, including soil characteristics. We hope that new further research and scientific questions may come about in the near future by reading this collection of papers. We would like to thank the authors for their invaluable efforts and also the reviewers and the editorial board who helped us in significantly improving the quality of each of the published papers.

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