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Carbon allocation, source-sink relations and plant growth: do we need to revise our carbon centric concepts?

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Since the discovery that plants 'eat air' 215 years ago, carbon supply was considered the largely unquestioned top driver of plant growth. The ease at which CO_2 uptake (C source activity) can be measured, and the elegant algorithms that describe the responses of photosynthesis to light, temperature and CO_2 concentration, explain why carbon driven growth and productivity became the starting point of all process based vegetation models. Most of these models, nowadays adopt other environmental drivers, such as nutrient availability, as modulating co-controls, but the carbon priority is retained. Yet, if we believe in the basic rules of stoichometry of all life, there is an inevitable need of 25-30 elements other then carbon, oxygen and hydrogen to build a healthy plant body. Plants compete for most of these elements, and their availability (except for N) is finite per unit land area. Hence, by pure plausibility, it is a highly unlikely situation that carbon plays the rate limiting role of growth under natural conditions, except in deep shade or on exceptionally fertile soils. Furthermore, water shortage and low temperature, both act directly upon tissue formation (meristems) long before photosynthetic limitations come into play. Hence, plants will incorporate C only to the extent other environmental drivers permit. In the case of nutrients and mature ecosystems, this sink control of plant growth may be masked in the short term by a tight, almost closed nutrient cycle or by widening the C to other element ratio. Because source and sink activity must match in the long term, it is not possible to identify the hierarchy of growth controls without manipulating the environment. Dry matter allocation to C rich structures and reserves may provide some stoichimetric leeway or periodic escapes from the more fundamental, long-term environmental controls of growth and productivity. I will explain why carbon centric explanations of growth are limited or arrive at plausible answers for the wrong reason. Suggested reading: Fatichi, Leuzinger, Körner (2013) Moving beyond photosynthesis: from carbon source to sink-driven vegetation modeling. New Phytologist. Körner C (2013) Growth controls photosynthesis – mostly. Nova Acta Leopoldina 391:273-283.