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Age, allocation, and availability of nonstructural carbohydrates in red maple

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Nonstructural carbohydrates (NSC) are the primary products of photosynthesis, composed mostly of sugars and starch. Recent studies show that NSC pools in mature trees can be quite large and on average a decade old. Thus, NSC pools integrate years of carbon assimilation and represent significant ecological memory at the whole plant and ecosystem level. However, we know very little about how older stored NSC versus newly assimilated NSC are used to support growth and metabolism, or how available older NSC are to trees during stress or following disturbance. To better understand these potential lags in NSC allocation, we studied mature red maple (Acer rubrum) trees in New England temperate forests. Applying the radiocarbon (14C) "bomb spike" approach, we estimated the age of carbon in stemwood NSC, ring cellulose, bole respiration, and stump sprouts regenerated following harvesting. These measurements allowed us to compare the NSC used for metabolic demands, annual growth, and the NSC available for regrowth following disturbance to the NSC actually present in the stemwood. Finally, tree ring widths were analyzed to determine the annual autocorrelation in radial wood increment.

We found that the mean age of stemwood sugars was 9.8 $\pm$ 5 y. The age of NSC used to support metabolism (bole respiration) was much younger than the mean age of stemwood sugars, indicating preferential use of more recently assimilated NSC. In the spring before leaves emerged, bole respiration was between 1-2 y, whereas it was composed of newly assimilated NSC in the late summer. The ring cellulose 14C age was on average 0.8 y older than direct ring counts (within error of 14C measurement) which may or may not indicate a stored NSC contribution. Tree ring width analyses indicate strong autocorrelation between ring growth in one year and in the following year, in agreement with ring cellulose 14C ages. However, autocorrelation weakened over the following 10 years, consistent with the measured mean age of the NSC pool. The stump sprouts were formed from NSC 1-17 y old, (mean 5.8 $\pm$ 5 y), with older trees using older NSC to produce stump sprouts, indicating that some of the older NSC reserves are available to the tree for use following major disturbance. These results highlight the importance of ecological memory in NSC pools for understanding tree carbon allocation and overall ecosystem carbon balance.