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Something old, something new: Why models need a multi-pool representation of storage reserves

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We know surprisingly little about processes regulating the allocation of photosynthetic assimilates to growth, storage, and other metabolic functions. Storage of nonstructural carbon (NSC, principally sugars and starch) is critically important for woody plants, because these reserves enable sessile, long-lived organisms to tolerate biotic and abiotic stress, including pests, disturbance, and drought. But, critical questions about the size and turnover of these reserves remain unanswered. Labeling studies have generally shown rapid use of new (labeled) NSC and inferred fast mixing between old and new NSC, both of which suggest quick turnover of storage reserves. However, recent studies have shown that some of the reserves stored in stem and root tissue are not only a decade old, but also still available to support new tissue growth following catastrophic disturbance.

We characterized the distribution of NSC in the stemwood, branches, and roots of two temperate trees, and we used the continuous label offered by the radiocarbon (14C) bomb spike to estimate the mean age of NSC in different tissues of two temperate trees. NSC in branches and outermost stemwood growth rings had the 14C signature of the current growing season. However, NSC in older above- and below-ground tissues was enriched in 14C, indicating that it was produced from older assimilates. Radial patterns of 14C in stemwood NSC showed strong mixing of NSC across the youngest growth rings, with limited "mixing in" of younger NSC to older rings. Sugars in the outermost 5 growth rings, accounting for two-thirds of the stemwood pool, had a mean age < 1 y, whereas sugars in older growth rings had a mean age > 5 y. Thus, there is not a single, well-mixed "storage pool," and indeed "young" and "old" storage compounds appear to be physically isolated from each other.

We will discuss the implications of these results for improving model representation of NSC storage and consumption by forest trees. We will suggest that there are conceptual similarities between modeling NSC pools and modeling soil C pools. We will propose future directions for modeling NSCs and also identify key questions that still need to be answered with new experimental work.