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Interannual and seasonal dynamics, and the age, of nonstructural carbohydrate pools in the stemwood of temperate trees across a climatic gradient in the Northeastern US

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Like all plants, forest trees accumulate and store non-structural carbohydrates (NSC) as resources to be used in the future. This can be viewed as a bet-hedging strategy, providing reserves that the tree can draw on in times of stress—e.g., following disturbance, disease, or extreme climatic events. In the context of climate change, understanding factors influencing the availability of these stored NSC compounds to support growth and metabolism is essential for predicting the resilience of forests to environmental stress factors. We conducted this study to investigate the role of these stored NSC pools in the context of ecosystem C balance at time scales from days to years. At quarterly intervals over a three-year period, we monitored stemwood total NSC concentrations of the dominant tree species of New England. Work was conducted at three sites along a climatic gradient: an oak-dominated transition hardwood forest (Harvard Forest), a maple-beech-birch northern hardwood forest (Bartlett Experimental Forest), and a spruce-fir forest (Howland Forest). We observed large differences among species both in NSC concentrations, and in how the NSC pool is partitioned to different compounds (starch, sucrose, glucose, fructose, raffinose, and stachyose). Within a species, however, seasonal dynamics were remarkably similar across sites. We used the bomb radiocarbon (14C) spike to estimate the average age of the sugars and starches in the NSC pool in a subset of nine maple trees from each site. We found that the age of sugars ranged from 1–24 y and starches from 1–31 y. The ages of sugar and starch pools were highly correlated across all sites, and there was no significant difference in the mean age of the two pools, which was $\sim$11 y. Using a one-pool representation of NSC reserves (similar to the standard approach used in several existing forest C models) our model FöBAAR (FOrest Biomass, Allocation, Assimilation and Respiration) failed to reproduce the seasonal NSC dynamics we observed, and also predicted a much shorter NSC mean residence time (< 2 y). We will discuss how these estimates of NSC pool size and age will be valuable for testing and improving the representation of carbon allocation processes in tree growth and ecosystem carbon cycling models.