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Modeling nonstructural carbohydrate reserve dynamics in forest trees

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Understanding the factors influencing the availability of nonstructural carbohydrate (NSC) reserves is essential for predicting the resilience of forests to climate change and environmental stress. However, carbon allocation processes remain poorly understood and many models either ignore NSC reserves, or use simple and untested representations of NSC allocation and pool dynamics.

Using model-data fusion techniques, we combined a parsimonious model of forest ecosystem carbon cycling with novel field sampling and laboratory analyses of NSCs. Simulations were conducted for an evergreen conifer forest and a deciduous broadleaf forest in New England. We used radiocarbon methods based on the 14C “bomb spike” to estimate the age of NSC reserves, and used this to constrain the mean residence time of modeled NSCs. We used additional data, including tower-measured fluxes of CO_2, soil and biomass carbon stocks, woody biomass increment, and leaf area index and litterfall, to further constrain the model’s parameters and initial conditions.

Incorporation of fast- and slow-cycling NSC pools improved the ability of the model to reproduce the measured interannual variability in woody biomass increment. We show how model performance varies according to model structure and total pool size, and we use novel diagnostic criteria, based on autocorrelation statistics of annual biomass growth, to evaluate the model’s ability to correctly represent lags and memory effects.