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Using a Multiproxy Tree Ring Approach to Examine the Effects of Environmental Change on Eastern U.S. Forests

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The continued capacity of terrestrial forest ecosystems to sequester carbon (C) emissions is critical to mitigating future climate change. Increases in atmospheric CO_2 stimulate forest productivity, thereby enhancing carbon storage; however, these responses are often modulated by changes in temperature or precipitation, as well as by acid pollution. It is, therefore, critical to understand how each of these factors contribute to the long-term growth and physiological changes of trees, and the extent, and nature of any interactive effects. To address this, we examined long-term tree growth, physiological parameters reconstructed from tree ring C isotope chronologies (Δ13C), and nitrogen cycling dynamics developed from tree ring δ15N of northern red oak (Quercus rubra), tulip poplar (Liriodendron tulipifera), red spruce (Picea rubens Sarg.), and eastern red cedar (Juniperus virginiana), four of the most abundant and ecologically important tree species in the northeastern U.S.

We collected $\sim$250 increment cores across nine sites spanning 230 km in the central Appalachian Mountains from which we developed chronologies of basal area increment (BAI), seasonally-integrated photosynthesis (A), stomatal conductance (gc), and intrinsic water use efficiency (iWUE), over the past 75 years. We examined the relationships between tree growth, δ15N, and underlying physiology derived from Δ13C, as well as their relationships to environmental factors. We then used linear mixed effects models to quantitatively investigate the contribution, and potential interactions, of environmental factors (atmospheric CO_2, acid pollution, climatic water balance, and temperature) with changes in growth and reconstructed physiology of these tree species. Overall, results indicate differential enhancement and sensitivity of BAI, A, gc, and iWUE to increasing atmospheric CO_2, with responses modulated by environmental factors such as acid pollution and climate. These results point to the complex environmental influences over the growth and physiology of these tree species, and the need to begin to incorporate acid pollution into process-based models.