Drivers of radial growth and carbon isotope discrimination of bur oak (Quercus macrocarpa Michx.) across continental gradients in precipitation, vapor pressure deficit and irradiance

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Tree-ring characteristics including stable isotope composition are commonly used to reconstruct climate variables and establish mechanisms that underlie oscillations in modes of climate variability. However, divergence from the assumption of a single, primary biophysical control over these tree-ring variables may reduce the accuracy of climate reconstructions or obscure true oscillatory patterns. Here we examine patterns of ring-width indices (RWI) and carbon stable isotope discrimination signals (Δ13C) from tree-rings of bur oak (Quercus macrocarpa Michx.) within and beyond its current bioclimatic envelope to identify the conditions under which a switch may occur in the environmental controls on these paleoclimate proxies. Our results indicate that for modern bur oaks, controls on both RWI and Δ 13C differed substantially across the range of this species. At the center and western edge of the range, RWI was controlled by both atmospheric drought and soil water deficits, whereas at the northern and wettest site the influence of these variables was weak. Across tree-rings from each site, leaf internal to atmospheric vapor pressure difference (VPD) was the primary control on tree-ring Δ13C. The scaling of Δ13C with VPD was much closer to previously reported canopy-level eddy flux measurements than our own leaf gas exchange measurements on bur oaks. Among sites, photosynthetically active radiation (PAR) was a secondary influence on Δ13C. In combination, VPD and PAR closely predicted Δ13C among sites ($r^2=0.81$, $P=0.039$). Correlations between RWI and Δ13C differed in strength and direction among sites and scaled with VPD or the average fraction of precipitation that was transpired. We therefore propose that the strength and direction of correlations between RWI and Δ13C can be used to more reliably infer past wetness or aridity from paleo wood by determining the degree to which tree carbon gain and growth has been more limited by moisture or irradiance over decadal or greater timescales.