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Reduction in lumen area increases the amount of δ18O exchange with source water during cellulose synthesis

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Fine-scale sampling of secondary growth, isotopic composition and wood anatomical features has enabled the study of intra-seasonal tree growth dynamics in response to environmental and ecophysiological processes, and this fine-scale sampling approach has led to a re-examination of our fundamental understanding of how environmental factors are recorded in $\delta^{18}O$ of cellulose ($\delta^{18}O_{cell}$). High resolution xylem anatomical analyses, such as wood density, lumen area (LA), cell wall thickness (CWT), and blue intensity have also been used to understand tree response to climate. However, linking wood anatomical traits with their isotopic signature has not yet been explored, but can provide new insights on the interpretation of the $\delta^{18}O_{cell}$ through time. In this study, we test the response of wood anatomical features in *Pinus ponderosa* and *Pseudotsuga menziesii*, including cell-wall thickness (CWT) and lumen area (LA), along with the oxygen isotopic composition of α-cellulose ($\delta^{18}O_{cell}$) to shifts in relative humidity (RH) in two treatments: one from high to low RH and the second one from Low to high RH. We observed a significant decrease in LA and a small increase in CWT within the experimental growing season in both RH treatments. The measured $\delta^{18}O_{cell}$ along the tree ring was also responsive to RH variations in both treatments. However, estimated $\delta^{18}O_{cell}$ did not agree with measured $\delta^{18}O_{cell}$ when the proportion of exchangeable oxygen during cellulose synthesis (P_{ex}) was kept constant. We found that modeled $\delta^{18}O_{cell}$ agreed with measured $\delta^{18}O_{cell}$ only when P_{ex} increased through the ring formation; we also found that P_{ex} linearly decreased with an increase in standardized LA. Based on this varying P_{ex} within an annual ring, we propose a targeted sampling strategy for different hydroclimate signals: earlier season cellulose (larger LA) is a better recorder of relative humidity while late season cellulose (smaller LA) is a better recorder of source water.