

Global change impacts on tree-ring growth detected by stable isotope analysis.

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Global change influences the growth patterns of forest trees in a complex way, whereby many factors are altered simultaneously, including climate, atmospheric CO₂ concentrations and nitrogen availability. Accordingly, determining the degree to which each of these factors influences tree growth presents a big challenge which, however, must be met in order to reliably estimate future forest response to global change. The combined analysis of different stable isotope ratios in wood has the potential to improve our knowledge of tree response to past environmental changes. Tree-rings constitute an annual archive of organic matter and isotopes that contains not only climatic, but other environmental information (McCarroll and Loader 2004). The isotope ratios of carbon and oxygen reveal physiological responses of the trees and may therefore be used to reconstruct changes in growth conditions caused by human influence, especially that of increasing CO₂. In particular, the carbon isotope ratio in leaves or in the stem reflects the conditions during photosynthesis when the organic matter was formed. The increasing levels of CO₂ in the past two centuries have influenced the balance of stomatal versus biochemical limitation of photosynthesis, altering the water-use efficiency at the leaf level, the water used per unit carbon gain. This signal can be detected in the carbon isotope ratio of tree-rings (Saurer et al. 2004). Results from various sites around the globe show that the water-use efficiency in general has been increasing over the last two centuries. We investigated tree-ring chronologies from Switzerland, covering a wide range of site conditions and tree species: these show that the reconstructed water-use efficiency increased by 30%-50% since the start of the industrialization in the 19th century. This increase was similar for conifers and deciduous trees, and did not strongly depend on altitude and soil moisture availability. Our results are in the upper range of the increase of water-use efficiency observed in other parts of the world ranging from 0 to 50%. Further, we show that the information on evaporative enrichment contained in the oxygen isotope signal of the tree-rings helps to better determine the cause of the wide-spread increase in water-use efficiency. We use a combined carbon-oxygen isotope model to determine whether the increase might have been due to reduced stomatal conductance or increased photosynthesis.

REFERENCES

McCarroll, D. & Loader, N.J. (2004): Stable isotopes in tree rings. *Quaternary Science Reviews* 23: 771-801.

Saurer, M., Siegwolf, R.T.W. & Schweingruber, F.H. (2004): Carbon isotope discrimination indicates improving water-use efficiency of trees in northern Eurasia over the last 100 years. *Global Change Biology* 10: 2109-2120.