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Pollution and Climate Effects on Tree-Ring Nitrogen Isotopes

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BACKGROUND

Monitoring of nitrous oxide concentration only started during the last 30 years in North America, but anthropogenic atmospheric nitrogen has been significantly emitted over the last 150 years. Can geochemical characteristics of tree rings be used to infer past changes in the nitrogen cycle of temperate regions? To address this question we use nitrogen stable isotopes in 125 years-long ring series from beech specimens (*Fagus grandifolia*) of the Georgian Bay Islands National Park (eastern Ontario), and pine (*Pinus strobus*) and beech trees of the Arboretum Morgan near Montreal (western Quebec). To evaluate the reliability of the N stable isotopes in wood treated for removal of soluble materials, we tested both tree species from the Montreal area. The reproducibility from tree to tree was excellent for both pine and beech trees, the isotopic trends were strongly concordant, and they were not influenced by the heartwood-sapwood transition zone. The coherence of changes of the isotopic series observed for the two species suggests that their tree-ring N isotopic values can serve as environmental indicator.

RESULTS AND INTERPRETATION

In Montreal and Georgian Bay, the N isotopes show strong and similar parallel agreement (Gleichlaufigkeit test) with the climatic parameters. So in fact, the short-term isotopic fluctuations correlate directly with summer precipitation and inversely with summer and spring temperature. A long-term decreasing isotope trend in Montreal indicates progressive changes in soil chemistry after 1951. A pedochemical change is also inferred for the Georgian Bay site on the basis of a positive N isotopic trend initiated after 1971. At both sites, the long-term δ^{15}N series correlate with a proxy for NOx emissions (Pearson correlation), and carbon-isotope ring series suggest that the same trees have been impacted by phytotoxic pollutants (Savard et al., 2009a). We propose that the contrasted long-term nitrogen-isotope changes of Montreal and Georgian Bay reflect deposition of NOx emissions from cars and coal-power plants, with higher proportions from coal burning in Georgian Bay (Savard et al., 2009b). This interpretation is conceivable because recent monitoring indicates that coal-power plant NO_x emissions play an important role in the annual N budget in Ontario, but they are negligible on the Quebec side.

CONCLUSION

Interpretations of long tree-ring N isotopic series in terms of effects generated by airborne N-species have been previously advocated. Here we further propose that the contrasted isotopic trends obtained for wood samples from two regions reflect different regional anthropogenic N deposition combined with variations of climatic conditions. This research suggests that nitrogen tree-ring series may record both regional climatic conditions and anthropogenic perturbations of the N cycle.

REFERENCES

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