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Nitrogen isotopes from trees exposed to acidifying emissions – Archives for changes in the forest N cycle?

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Globally increasing anthropogenic airborne emissions of reactive nitrogen (N) generate several environmental issues that require investigating how N deposition modifies the N cycle in various compartments of the Earth surface. Several natural archives may help understanding the global distribution and impacts of these emissions. In this sense, the isotopic N (δ^{15}N) trends in nitrate from ice cores and total N from North American lake sediments characterized by low primary productivity indicate a general depletion of δ^{15}N ratios in anthropogenic N accumulated through the last century. Such results suggest either complex atmospheric processes changing the signal of deposited N or anthropogenic sources with generally low δ^{15}N signals. What can the tree-ring records reveal about this question? Although several studies have attempted to address past and current perturbations in the forest N cycle due to anthropogenic emissions, most of them were of local scale or based on short series. The development of this environmental indicator however would benefit from examining, at the regional scale, the relationships of long tree-ring series with soil N biogeochemical processes. Here we explore these links for spruce trees from boreal stands of the oil-sands region in northern Alberta, and mixed forest stands of the coal-fired power plants region in central Alberta, Canada. We characterize the tree-ring δ^{15}N trends and intrinsic water use efficiency (iWUE), the N modification rates and bacterial and fungal communities of soil samples directly associated with the selected trees. The tree-ring δ^{15}N series show increasing and decreasing trends with time, independently of the nature and δ^{15}N signals of the sources (coal-fired power plants or oil sands mining). Combined with the soil microbiome results, they suggest that local soil conditions, including specifically soil pH and bacterial and fungal communities, which are mostly responsible for N-cycling in soils, influence tree-ring δ^{15}N responses to anthropogenic emissions. Overall, spruce tree-ring δ^{15}N series may record changes in the forest-N cycle, but their interpretation requires understanding key soil biogeochemical processes. These results support previous suggestions that natural archives do not record directly the δ^{15}N signal of anthropogenic N sources (emissions). Equally important, not only atmospheric processes may control the isotopic characteristics of N cumulating in terrestrial settings, but soil processes may also modify the δ^{15}N ratios of N prior to its accumulation in lake sediments or its assimilation by trees.