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Fate of leaf-litter N in forest and grassland along a pedo-climatic gradient in south-western Siberia: an in situ ^{15}N-labelling experiment

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The suitability of Siberia for agriculture is expected to increase in the next decades due to strong and rapid climatic changes, but little is known on the environmental drivers of soil fertility there, especially nitrogen (N). Plant-available N is mainly derived from litter decomposition. South-western (SW) Siberia is located on the transition between several bioclimatic zones that are predicted to shift and extend along with climate change (steppe, forest-steppe, sub-taiga). The soils of this region are formed on a common loess deposit but they are submitted to different climatic conditions and vegetation cover. In the south of the region, typically in steppe/forest-steppe, soil freezes over winter because of a relatively shallow snow-pack, and water shortages are frequent in summer. In the north, typically in sub-taiga, the soil is barely frozen in winter due to a thick snow-pack and sufficient soil moisture in summer.

In this study, we characterized the dynamics of leaf litter decomposition and the transfer of N from leaf litter to the soil and back to plants. Four sites were chosen along a climate gradient (temperature, precipitation and snow depth). At each site, we applied ^{15}N-labelled leaf litter on the soil surface in experimental plots in an aspen (Populus tremula L.) forest and in a grassland. Twice a year during three years, we tracked the ^{15}N derived from the decomposing labelled-litter in the organic layers, in the first 15 cm of the soil, and in above-ground vegetation. Soil temperature and moisture were monitored at a daily timestep over three years and soil water budgets were simulated (BILJOU model, Granier et al. 1999).

We observed contrasting patterns in the fate of litter-derived ^{15}N between bioclimatic zones. Over three years, along with faster decay rates, the release of leaf litter-N was faster in sub-taiga than in forest-steppe. As such, higher quantities of ^{15}N were transferred into the soil in sub-taiga. The transfer was also deeper there, which might be related to a more intense drainage because of higher snow levels, as inferred from soil water budget modelling. Interestingly, this higher drainage seems to induce only a small loss of N from the system. Such retention could result from soil physico-chemical properties (higher fine silt and oxides contents) enhancing soil organic matter stabilization, and/or by the immobilization of N in microbial metabolites.

We observed differing N dynamics between forest and grassland that can be related to the different chemical composition of initial litter (tree leaves vs. grasses) and plant–soil interactions. In general, N was retained in the first centimeters of the mineral soil in grassland while the transfer was deeper in the forest soils. As fine root exploration is denser in grassland topsoil than in forest topsoil, we infer that an efficient uptake of N by grasses in the first soil layers limits N migration down the profile. It is also possible that grasses are active earlier in the season than trees and understorey species, i.e. at snow-melt when drainage is the most intense.