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Impacts of fast vs. slow permafrost thaw on nitrogen and phosphorus availability in a subarctic palsa mire

Oriol Grau (1,2), Olga Margalef (1,2), Hans Joosten (3), Pere Roc Fernández (1,2), Ellen Dorrepaal (4), Frida Keuper (5), Andreas Richter (6), Jordi Sardans (1,2), Josep Peñuelas (1,2)

(1) CREAF, Center for Ecological Research and Forestry Application, 08193 Cerdanyola del Vallès, Catalonia, Spain (grau.oriol@gmail.com), (2) CSIC, Global Ecology Unit, CREAF-CSIC-UAB, 08193 Cerdanyola del Vallès, Catalonia, Spain, (3) Department of Peatland Studies and Palaeoecology, Institute of Botany and Landscape Ecology, Greifswald University, Partner in the Greifswald Mire Centre, Greifswald, Germany, (4) Department of Ecology and Environmental Science, Climate Impacts Research Centre, Umea University, Abisko, Sweden, (5) INRA, French National Institute for Agriculture Research, Department of Environment and Agronomy, Paris, France, (6) Department of Microbiology and Ecosystem Science, Division of Terrestrial Ecosystem Research, University of Vienna, Austria

Subarctic permafrost peatlands are particularly sensitive to climate warming. The progressive degradation of permafrost in these ecosystems promotes the decomposition of old organic matter in deep soil layers and re-activates the cycling of C and nutrients. Several studies reported that thawing of permafrost in subarctic peatlands increases nitrogen (N) availability for plants and microbes, ecosystem productivity as well as CH4 and CO_2 emissions. Very little is known, however, about phosphorus (P) availability after permafrost degradation and about possible changes of C:N:P ratios in soil and vegetation. In June 2018 we collected soil samples from several palsas (peat mounds with a permafrost core) at Stordalen (Abisko, 68ºN, Sweden). We sampled at four different depths: two above the active layer (5-10 and 40-45 cm) and two in the permafrost (70-75 and 95-100 cm). We incubated the samples at 0.1 °C (thaw front temperature) and 10.5 °C (summer rooting zone soil temperature) over 120 days, similar to the length of the growing season. These two temperatures simulated slow vs. fast thawing of permafrost, which are associated with a deepening of the active layer or with a complete disappearance of the permafrost, respectively. We determined total C, N and P, available P, Hedley P and available N from pre-incubation and incubated samples. The availability of P was highest near the surface of the palsa in pre-incubation samples, and lower at deeper layers; the N:P ratio was consistently higher at deeper layers. The samples exposed to 10.5°C showed a very significant increase in N and P availability and a decrease in N:P ratio. Our results indicate that in intact, oligotrophic palsa the relative availability of P might be higher than that of N, whereas the opposite may apply after permafrost thawing. Such shift in relative nutrient availability is crucial to understand changes in stoichiometry in the soil and vegetation, in ecosystem productivity, C fixation and ecosystem functioning when palsas in subarctic mires collapse by permafrost thaw.