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Reconciling the multiple impacts of land use change on soil carbon, nitrogen, phosphorus and sulphur cycles

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Predicted changes in land use in mountain ecosystems due to agricultural and climatic pressure have the potential to change the abiotic controls of soil organic matter storage (i.e. temperature, and humidity). Yet an integrated assessment of the impact of land use change on site abiotic varibles (temperature, humidity) and its relation to the molecular composition of carbon (C), nitrogen (N), sulphur (S) and phosphorus (P) is lacking. In this study, we used a natural land use gradient (forest [F], degraded forest [DF] and alpine pasture [AP]) within the Karwendel mountain range as a model system to analyse the C, N,S and P dynamics. At these sites, we measured climatic variables (air temperature and humidity and soil temperature at three depths) through a whole year and determined significant changes in soil temperature after conversion to alpine pasture. Soils were sampled at the organic and mineral horizons of each site and thereafter analysed for its C, N, S and P total concentrations, pH and sugar and amino sugars content. Thereafter, the molecular composition of C,N,S and P in the soils was analysed combining synchrotron-based X-ray absorption near edge structure (XANES) spectroscopy and liquid state ^{31}P-NMR spectroscopy. Our results show that although forest to alpine pasture conversion led to losses of C no changes of N, P or S concentrations where observed. These analyses show that with conversion to alpine pasture the SOM changes to a more decomposed state (increase of Alkyl:O-Alkyl ratio), which is accompanied by an increase of Amidic and Pyrrolic-N and an increase of sulfate-S. Moreover, the nominal oxidation state (NOS) of each analysed element, calculated from the spectral data shows a decrease, which might be due to higher decomposition rates in alpine pasture. This shows that molecular changes in C,N,S and P occur after land use change in the topsoil, and are majorly depended on the soil temperature. Moreover, this indicates changes that soil microorganisms were affected by land use change, which will be explored further by aminosugar analysis and PLFA. Our results show the rapid molecular changes of soil C,N,S and P after to land use.