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Stoichiometry and climatic stress drive respiration and nutrient dynamics of beech litter decomposition

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Little is known about how the variance in resources in terms of carbon (C), nitrogen (N), phosphorus (P) ratios affects respiration and nutrient dynamics. To elucidate how resource quantity and stoichiometry affect the decomposition process of beech (Fagus sylvatica) litter a terrestrial microcosm experiment was conducted. Our aim was to follow changes of beech litter stoichiometry and biogeochemical processes, and to quantify element losses as affected by temperature and moisture extremes. In addition to gaseous element losses (CO2) we examined the release of nutrients prone to leaching and the importance of environmental controls. We addressed mechanisms and pathways of carbon, nitrogen and phosphorus losses.

In our experiment sterilised dried leaves were inoculated with a litter-soil suspension from a beech forest in order to ensure similar starting conditions. Beech litter from different Austrian sites covering C:N ratios from 45 to 66 and C:P ratios from 652 to 1467 were incubated at 15°C for six months. The water content was adjusted to 60% at regular intervals to keep the moisture constant. To monitor transient and persistent influences of environmental stress, the microcosms were subject to extreme changes in temperature (+30°C and -20°C) and moisture (draught) after an incubation time of three months.

Litter stoichiometries (C:N, C:P) turned out to be strong predictors for respiration, and nitrogen, and phosphorous losses. (i) Litter with narrow litter C:nutrient ratios decomposed faster than litter with wider litter C:nutrient ratios; and therefore showed higher respiration rates. (ii) Increased nutrient losses as leachates were observed for high quality leaf litter i.e. inorganic nitrogen losses for sites with narrow litter C:N ratios and phosphate was released more quickly in sites with narrow C:P ratios.

There was a strong functional response of the microbial community to environmental extremes. Respiration increased upon temperature extremes, especially in the litter with highest C:P ratio. A persistent effect of temperature extremes on NH4 and NO3 concentrations was observed for three months after stress application. However, the effect on PO4 concentrations was only transient. Environmental conditions had a strong affect on nutrient losses but only a minor affect on microbial carbon Cmic and microbial nitrogen Nmic. The impact of environmental stress (heat or freezing) on microbes in terms of Cmic, Nmic and C:Nmic was strongest in sites with narrow litter C:N ratios. Our results indicate a similar stoichiometric demand of microbes, with temporal changes which results in differences in nutrient cycling on substrates with different C:N:P ratios.