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Nutrient limitation in soils and trees of a treeline ecotone in Rolwaling Himal, Nepal

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At a global scale, tree growth and thus the position of natural alpine treelines is limited by low temperatures. At landscape and local scales, however, the treeline position depends on multiple interactions of influencing factors and mechanisms. The aim of our research is to understand local scale effects of soil properties and nutrient cycling on tree growth limitation, and their interactions with other abiotic and biotic factors, in a near-natural alpine treeline ecotone of Rolwaling Himal, Nepal.

In total 48 plots (20 m x 20 m) were investigated. Three north-facing slopes were separated in four different altitudinal zones with the characteristic vegetation of tree species Rhododendron campanulatum, Abies spectabilis, Betula utilis, Sorbus microphylla and Acer spec. We collected 151 soil horizon samples (Ah, Ae, Bh, Bs), 146 litter layer samples (L), and 146 decomposition layer samples (Of) in 2013, as well as 251 leaves from standing biomass (SB) in 2013 and 2014. All samples were analysed for exchangeable cations or nutrient concentrations of C, N, P, K, Mg, Ca, Mn, Fe and Al. Soil moisture, soil and surface air temperatures were measured by 34 installed sensors. Precipitation and air temperatures were measured by three climate stations.

The main pedogenic process is leaching of dissolved organic carbon, aluminium and iron from topsoil to subsoil. Soil types are classified as podzols with generally low nutrient concentrations. Soil acidity is extremely high and humus quality of mineral soils is poor. Our results indicate multilateral interactions and a great spatial variability of essential nutrients within the treeline ecotone. Both, soil nutrients and leave macronutrient concentrations of nitrogen (N), magnesium (Mg), potassium (K) decrease significantly with elevation in the treeline ecotone. Besides, phosphorus (P) foliar concentrations decrease significantly with elevation. Based on regression analyses, low soil temperatures and malnutrition most likely affect tree growth in high altitudes. Thus, we assume a high influence of soil properties and nutrient supply on the position of alpine treeline at a local scale. In addition, a manganese (Mn) excess in foliage of woody species was determined above treeline. With the help of multivariate statistical approaches, potential determining factors of treeline position could be quantified.