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Effects of soil fertility and topography on tree growth in subtropical forest ecosystems

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This study investigates the effects of soil fertility and topography on tree growth in a forest biodiversity and ecosystem functioning experiment. The main objective was to examine whether topography controls small-scale differences of soil fertility expressed in soil texture, soil pH, soil organic carbon (SOC), N, cation exchange capacity (CEC), base saturation, Na, K, Mg, Ca, Fe and Mn in a hilly forest area in subtropical China. Geomorphometric terrain analyses were carried out at a spatial resolution of 5 m $\times$ 5 m. Soil samples of different depth increments and data on tree growth were collected from a total of 566 plots (667 m2 each). All plots were classified into geomorphological units. Analyses of variance and linear regressions were applied to all terrain, soil fertility and tree growth attributes.

In general, limited soil formation and relatively small differences in stable soil properties suggest that soil erosion has truncated the soils to a large extent over the whole area of the experiment. This explains the concurrently increasing CEC and SOC stocks downslope, in hollows and in valleys. However, colluvial carbon-rich sediments are missing widely due to the convexity of the footslopes caused by uplift and removal of eroded sediments by adjacent waterways. The results showed that soil fertility is mainly influenced by topography. Monte-Carlo flow accumulation (MCCA), curvature, slope and aspect significantly affected soil fertility. Furthermore, soil fertility attributes were affected by the different geomorphological positions of the experimental sites with ridge and spur positions showing lower exchangeable base cation contents due to leaching. This geomorphological effect of soil fertility is most pronounced in the topsoil and decreases when considering the subsoil down to 50 cm depth. Few soil fertility attributes affect tree height after 1-2 years of growth, among which C stocks proved to be most important while pHKCl and CEC only played minor roles. Nevertheless, soil acidity and a high proportion of Al on the exchange complex affected tree height even after only 1-2 years growth. Hence, our study showed that forest nutrition is coupled to a recycling of litter nutrients and does not only depend on subsequent supply of nutrients from the mineral soil. Besides soil fertility, topography affected tree height. We found that especially MCCA as indicator of water availability affected tree growth at small-scale as well as aspect.
Overall, our synthesis showed that topographic heterogeneity lead to ecological gradients across geomorphological positions. In this respect, small-scale soil-plant interactions in a young forest can serve as a driver for the future development of vegetation and biodiversity control on soil fertility. In addition, it shows that terrain attributes should be accounted for in ecological research.