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Soil erosion and biodiversity – Effects of ecological variables on throughfall kinetic energy for different spatial scales

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To combat soil erosion is a prominent and most important ecosystem service of forests. Yet, little is known about the mechanistic relation of this ecosystem service to biodiversity. We hypothesize that the underlying processes in forests can be explained by (i) mechanisms that alter rainfall properties and (ii) those that change forest floor properties. The present study concentrates on the alteration of rainfall properties by vegetation canopies in a subtropical forest ecosystem in SE-China. The research approach consists of investigations in established forest stands complemented by measurements in a plantation-like experiment.

On the level of whole forest stands we relate forest succession, specific species, forest stand variables and species richness as a measure of biodiversity to throughfall kinetic energy (KE) (plot size=900m^2). Effects of plant architectural traits, species identity and stand density on throughfall KE were studied more in detail on a smaller spatial scale (plot size=1m^2) and related to changes in throughfall KE.

On the forest stand level we could identify effects of tree canopy structure (height, leaf area index), diversity (rarefied species number) and functional trait identity (proportion of needle leafed species). Throughfall KE increases with canopy height, biodiversity and an interaction between canopy height and rainfall amount where both factors reinforce each other. It decreases with increasing proportion of needle leafed species within a plot and an increasing LAI.

In subtropical broad-leaved forests throughfall KE is largely controlled by forest structure, traits and the number of the species present in the canopy. High coverage and a low total height keeps throughfall KE low in younger plots whereas canopy gaps and a higher total height enlarge the values of throughfall KE in older plots.

The variability of throughfall KE is controlled by rainfall intensity and biodiversity which counteract against each other. The variability of throughfall KE is highest in highly diverse plots when the intensity of a given rainfall event is low.

For the smaller spatial scale results show that rainfall KE per area was reduced by 59% below the canopy of the studied saplings (height < 1.2m). We found a significant effect of sapling density on throughfall KE. The main cause for this circumstance is the relation between free throughfall and release throughfall. As free throughfall possesses a far higher KE than release throughfall originating from saplings, a lower density results in a higher total throughfall KE. Moreover we could show that the influence of density on throughfall KE decreases with increasing sapling height due to lateral growth and canopy closure of the saplings.

Throughfall KE was significantly different between sapling species. We attribute this to species-specific differences in crown architectural traits. These traits influence throughfall KE contrarily and interact with each other. Depending on its magnitude, one crown trait can possibly superimpose contrary effects of others on throughfall KE.

For established forests the influence of rainfall properties on throughfall KE is stronger than expected. Interestingly the influence of stand height on throughfall KE depends on the amount of rainfall. Biodiversity, as a measure of dissimilarity, increases the spatial heterogeneity of throughfall KE within a forest stand.

At the smaller spatial scale we can state that the ecosystem function of erosion control is being activated gradually. The velocity of crown development is supposed to be the most important factor for this circumstance. Moreover, at this temporal and spatial scale, specific single species are supposed perform better in stabilizing ecosystems threatened by erosion than species mixtures.