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Deforestation leads to an increase of young water in the stream of a headwater catchment

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The transport of precipitation water through a catchment to its outlet is influenced by many factors among which are topography, climate, geology and land use to name a few. Knowledge of the exact relationships between these influencing factors and the water transport properties of a catchment can guide water management decisions regarding the quantity and quality of freshwater resources. However, the relationships and their possible interactions are still being investigated in hydrological studies and thus predicting the effects of an e.g., land use change in a certain catchment is still difficult.
Highlighting an often occurring land use change we investigated the effects of partial deforestation on the distribution of water flow times (Transit Time Distribution, TTD) and the percentage of 2 to 3 month old water in the stream (Fraction of Young Water, Fyw). We studied the 38 ha Wüstebach catchment in Germany, a humid spruce-forested headwater catchment, where a partial deforestation happened in August/September 2013. Four years of tracer and meteorological data was available prior to 21% of the catchment being deforested with two-and-a-half years of the same data following the deforestation. The TTD and the time-variable Fyw were modeled in a conceptual modeling approach that split up the hillslope and the riparian zone into unsaturated and saturated storages with different Storage-Age-Selection functions. As a tracer we used the stable isotope of water [U+F064]18O. Auxiliary data such as groundwater level, potential and actual evapotranspiration and detailed soil moisture information was used to constrain the model and help in interpreting results. We found that after the deforestation the TTD indicated an increase in faster flow paths during storm events, indicating that more young water leaves the catchment. Complementary to this the time-variable Fyw showed that before deforestation and during dry periods less young water contributed to runoff, meaning streamwater was more strongly fed by groundwater. During wet periods the percentage of young water increased. After the deforestation only the wet period changed significantly. Now a higher percentage of Fyw could be observed while during dry catchment conditions Fyw did not change markedly. Thus, in conclusion we find that deforestation leads to an increase in the export of young water out of the catchment. This in turn will impact nutrient and pollutant transport, influencing the nutrient balance and the quality of streamwater and the forest ecosystem.