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The evolution of root zone moisture storage capacities after deforestation: a step towards hydrological predictions under change?

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The moisture storage available to vegetation is a key parameter in the hydrological functioning of ecosystems. This parameter, the root zone storage capacity, determines the partitioning between runoff and transpiration, but is impossible to observe at the catchment scale. In this research, data from the experimental forests of HJ Andrews (Oregon, USA) and Hubbard Brook (New Hampshire, USA) was used to test the hypotheses that: (1) the root zone storage capacity significantly changes after deforestation, (2) changes in the root zone storage capacity can to a large extent explain post-treatment changes to the hydrological regimes and that (3) a time-dynamic formulation of the root zone storage can improve the performance of a hydrological model.

At first, root zone storage capacities were estimated based on a simple, water-balance based method. Briefly, the maximum difference between cumulative rainfall and estimated transpiration was determined, which could be considered a proxy for root zone storage capacity. These values were compared with root zone storage capacities obtained from four conceptual models (HYPE, HYMOD, FLEX, TUW), calibrated for consecutive 2-year windows.

Both methods showed a sharp decline in root zone storage capacity after deforestation, which was followed by a gradual recovery signal. It was found in a trend analysis that these recovery periods took between 5 and 13 years for the different catchments. Eventually, one of the models was adjusted to allow for a time-dynamic formulation of root zone storage capacity. This adjusted model showed improvements in model performance as evaluated by 28 hydrological signatures, such as rising limb density or peak flows.

Thus, this research clearly shows the time-dynamic character of a crucial parameter, which is often considered to remain constant in time. Root zone storage capacities are strongly affected by deforestation, leading to changes in hydrological regimes, and time-dynamic formulations of root zone storage are therefore necessary in systems under change.