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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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Root zone storage capacity is a key variable in ecosystems, as it determines the moisture storage available to plants, and therefore the partitioning between runoff and transpiration. Nevertheless, root zone storage capacity is impossible to observe at the catchment scale and also considered to remain constant in time. In this research, we 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.

Three experimental catchments from the forests of HJ Andrews (Oregon, USA) and Hubbard Brook (New Hampshire, USA) were selected that were deforested in the 60's and 80's. In this way, a long record was available to assess the evolution of root zone storage capacity. Root zone storage capacities were estimated with a simple, water-balance based method, which approximated root zone storage capacity by the maximum difference between cumulative rainfall and estimated transpiration. In other words, the maximum moisture deficit was determined and assumed to represent the root zone storage capacity. In addition, four conceptual models (HYPE, HYMOD, FLEX, TUW) were calibrated for consecutive 2-year windows and provided model-based root zone storage capacities for comparison.

After deforestation, a sharp decline followed by a gradual recovery of root zone storage capacities was observed for both calibrated values and water-balance based estimations of root zone storage capacity. It took between 5 and 13 years for the different catchments to recover towards a new equilibrium, as suggested by a trend analysis. A time-dynamic formulation of root zone storage capacity was eventually inserted into one of the models. In this way, improvements were observed after evaluating a set of hydrological signatures, such as rising limb density or peak flows.

This research emphasizes the time-dynamic character of root zone storage capacity, which is strongly affected by deforestation and not a constant parameter. Therefore, time-dynamic formulations of root zone storage can provide improved hydrological predictions in systems under change.