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The long-term hydrological effect of forest stands on the stability of slopes

T.A. Bogaard (1), W Meng (1), and L.P.H. van Beek (2)

(1) Delft University of Technology, Water resources Section, Delft, Netherlands (t.a.bogaard@tudelft.nl, w.meng@tudelft.nl), (2) Utrecht University, department Physical geography, Utrecht, The Netherlands (r.vanbeek@uu.nl)

Forest is widely known to improve slope stability as a result of mechanical and hydrological effects. While the mechanics underlying the stabilizing process of root reinforcement are well understood and quantified, the influence of forest on the occurrence of critical hydrological conditions in terms of suction or pore pressure remains uncertain. Due to seasonal and inter-annual fluctuations, the stabilizing influence of evaporation and transpiration is difficult to isolate from the overall noise of the hydrological signal. More long-term effects of forest stands on soil development are highly variable and thus difficult to observe and quantify. Often these effects are ambivalent, having potentially a stabilizing or destabilizing influence on a slope under particular conditions (e.g., more structured soils leading to both rapid infiltration and drainage). Consequently, it can be postulated that forests will hydrologically influence the magnitude-frequency distribution of landsliding, not only at the stand level but also on a regional scale through the groundwater system.

The overall aim of this research is to understand and quantify the stabilizing hydrological effect of forests on potentially unstable slopes. To this end, we focus on the changes in the magnitude-frequency distribution of landsliding that arise as a result of variations in evapotranspiration losses over the life cycle of stands. Temporal variations in evapotranspiration comprise first of all the interception that can account for an important amount of evaporation from a forest, and that changes with seasonal and annual variations in the interception capacity of the canopy and forest floor. Transpiration also represents an important loss that varies over the various growth stages of a forest stand.

Based on a literature review of water consumption by tree species and water balance studies of forested catchments we defined the potential transpiration for different growth stages. This information we used in a spatially distributed, physical-based, dynamical model to simulate the hydrology and resulting stability for a catchment on a daily scale.

The results can be used to identify end members of the hydrological influence of forests on slope stability and the typical variations in stability associated with the various growth stages. They indicate that the influence of forest stand age on the water consumption can be significant and has clear consequences for the antecedent soil moisture condition within a slope and thus on the potential for slope destabilization. The outcome should help to understand the long-term impact of vegetation on slope hydrology and define sustainable and reliable management strategies at the scale of forest stands.

Keywords: slope stability, hydrology, vegetation, long-tem effect