Transition of soil sustainability in granite watersheds through artificial deforestation: quantifying acceleration of hillslope erosion in the Tanakami Mountains, central Japan

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Destabilization of soil layer on hillslopes by deforestation accelerate sediment discharge, resulting in an irreversible state transition of watersheds. This study established a model of soil development on steep hillslopes incorporating effects of surface protection by organic materials and tree-root reinforcement of soil to quantify human impact on soil coverage. We selected two typical watersheds under contrasting soil and vegetation conditions for model application, and then conducted filed survey, topographic analysis, cosmogenic nuclide analysis for model parameterization. Natural-state watershed is mantled by cohesive soil (c = 4.1 kPa, ϕ = 31.5˚) and covered with mixed forest of broad-leaf trees and conifer stands, while transition-state watershed is mostly saprolite-exposed and thinly covered by cohesion-less sand (c = 1.9 kPa, ϕ = 34.6˚). Each property of soil indicates that the changes of weathering process by state-transition appear as the difference in cohesive strength and grain-size. Tree roots produce an additional cohesive strength via fiber reinforcement, promoting stability of bulk soil in a natural-state watershed. Based on the in-situ measurement of reinforcement and distribution of tree roots, the calculated additional cohesive strength reaches 10^1 kPa at the surface and gradually decreases with soil depth. Stability analysis for the modeled soil mantle in these contrasting watersheds suggested that the changes of the properties of soils as well as disappearance of vegetation cover and the tree-roots regulate the sustainability of soil layer on a hillslope. In this presentation, we also demonstrate a strategy for validation of the transition process of hillslope denudation via ^{10}Be depth-profiling for lowland deposits forming raised-bed rivers.

Keywords: human impact, soil sustainability, tree roots, terrestrial cosmogenic nuclide, raised-bed river

