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Eco-geomorphic controls on slope stability

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Vegetation controls soil-mantled landscape evolution primarily through growth of roots into soil and rock. Root-soil interactions affect the spatial distribution and rate of shallow landsliding and other hillslope processes. Yet the distribution and tensile strength of roots depends on a number of geomorphically-influenced parameters, including soil moisture. Our field-based study investigated the effects of topography on root distributions, tensile strengths, and cohesion. Systematic differences in plant species distribution and soil properties are found in the hollow-nose topography of soil-mantled landscapes; with hollows containing thick colluvial soils and mesic tree species and noses containing thinner, more differentiated soils and more xeric species. We investigated whether these topographic variations in geomorphic and ecologic properties affected the spatial distribution of root cohesion by measuring the distribution and tensile strength of roots from soil pits dug downslope of fifteen individual trees in the Coweeta Hydrologic Laboratory, North Carolina. Our soil pits were located to capture variance in plant species (10 species total), topographic positions (nose, hollow), and sizes (a range of DBH between 5 cm and 60 cm). Root tensile strengths showed little variance with different species, but showed strong differences as a function of topography, with nose roots stronger than hollow roots. Similarly, within species, root cellulose content was systematically greater in trees on nose positions compared to those in hollows. For all species, roots were concentrated close to the soil surface (at least 70% of biomass occurred within 50 cm of the surface) and variations in this pattern were primarily a function of topographic position. Hollow roots were more evenly distributed in the soil column than those on noses, yet trees located on noses had higher mean root cohesion than those in hollows because of a higher root tensile force. These data provide an empirical basis for the development of simple geomorphic transport laws that explicitly include vegetation.