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# Estimating hillslope-scale soil strength for regional landslide forecasting

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Estimating the distribution of soil strength across hillslopes is essential for the forecasting of future landslide hazards. This challenge is particularly difficult as the distribution of soil and plant root properties that control soil strength are difficult to estimate at a hillslope-scale. The distribution of root strength is of particular importance in soil-mantled mountain ranges, where colluvial soils provide little additional cohesion to the soil. We present a novel, new model of hillslope-scale root cohesion that combines empirical relationships of root biomass based on extensive field experimentation with remote sensing of aboveground biomass using airborne LiDAR. Our field experiments show that root biomass, its diameter distribution with depth, and root elastic properties vary systematically along hillslope scale soil moisture gradients. Higher elevation trees on drier noses have proportionally greater belowground biomass than lower elevation plants and those in hollows. Root strengths vary as a function of local soil moisture contents and the average wood density of the species of interest. Allocation ratios of above to belowground biomass also vary systematically with age. Our empirical data show systematic changes in the allocation of aboveground and belowground biomass along age and soil moisture gradients. We combine these topographic functional relationships with measurements of aboveground biomass based on LiDAR-derived canopy heights to map the spatial distribution of root cohesion across the Southern Appalachians. To validate this new model of root reinforcement we coupled the new root cohesion with the shallow landslide model SINMAP and compared our predicted ranges of instability with a landslide inventory collected in the area. The new root cohesion model significantly improves our prediction of root cohesion, reducing the number of false positive results. We show that this new, physiologically based model of root cohesion can be upscaled to produce regional estimates of landslide potential in areas with little empirical data, representing a significant step forward in forecasting future landsliding.