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Modelling the Effect of Targeted Reforestation in Reducing Shallow Landslide Occurrence, Guabalcón Catchment, Ecuador

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Deforestation of upland areas has been found to increase the incidence of shallow landslides and debris flows, soil erosion and injection of sediment into river systems. Because people rely on the land for their livelihoods, complete reforestation of a river catchment to reduce landsliding is unrealistic. However, it has been proposed that reforestation of only small parts of a catchment, carefully targeted, could produce a disproportionately large reduction in landslide occurrence and sediment yield. The potential for achieving this aim is therefore explored through mathematical modelling. In particular the SHETRAN hydrological, sediment transport and landslide model is applied to the 65.8-km2 Guabalcón catchment in central Ecuador to demonstrate a technique for identifying the areas of a basin most susceptible to shallow landsliding and for quantifying the effects of different vegetation covers on landslide incidence. The model uses a dual resolution approach to represent spatial variability which in this case results in the catchment hydrology being modelled at a 500-m resolution while shallow landslides are modelled at a 10-m resolution. As the catchment rises to an altitude of 4432 m, field data collection is difficult, especially in winter. Soil and vegetation parameters were therefore evaluated on the basis of measurements in the catchment where available and otherwise using regional transpositions as well as data from the literature. Calibration was limited to the hydrological component, using data from the two available stream gauges. For the modelled scenario, landslides were found to be concentrated at a particular region of steeper slopes in the catchment. Simulations were therefore carried out with a range of root cohesion values to represent different vegetation covers in this area. Increasing the root cohesion from 300 to 1500 Pa (representing a change from grass to young trees), causes a two-thirds reduction in the number of landslides. The simulation thus demonstrates the use of a landslide model for identifying the areas of a river catchment which are most susceptible to shallow landsliding and for quantifying the effect of different vegetation covers on landslide incidence. Such models can therefore be proposed as a means of testing and selecting strategies for the targeted reforestation of basins, i.e. of managing those parts of a basin most critical for landslide occurrence. With physically based models such as SHETRAN, useful information can be obtained even on the basis of imperfect data availability but model output should be interpreted carefully in the light of parameter uncertainty.