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

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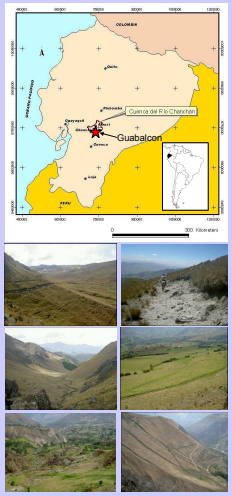
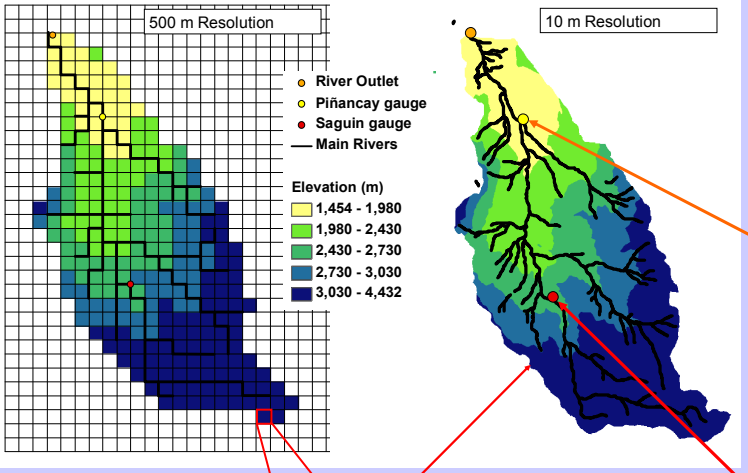
INTRODUCTION

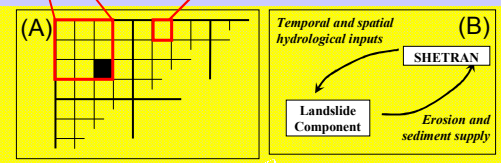
For deforested catchments prone to landslide erosion, it has been suggested that reforestation of only small parts of the catchment, carefully targeted, could produce a disproportionately large reduction in landslide occurrence and sediment yield (Reid & Page, 2002). The SHETRAN hydrological, sediment transport and landslide model is therefore applied to the 65.8-km^2 Guabalcón catchment in central Ecuador to demonstrate a technique for identifying the areas of a catchment most susceptible to shallow landsliding and for quantifying the effects of different vegetation covers on landslide incidence. The Guabalcón catchment has an elevation range of 1370-4420 m, an annual rainfall of 700-1000 mm (higher in El Niño years) and a land cover of mainly grassland, pasture or cultivated land, and is subject to landslides and debris flows.

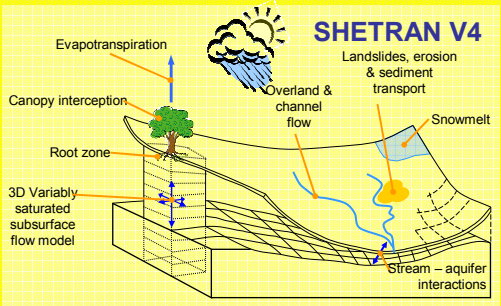




THE SHETRAN LANDSLIDE MODEL

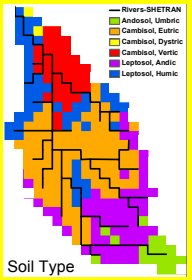
SHETRAN is a physically based, spatially distributed, integrated surface / subsurface modelling system for water flow and sediment transport in river catchments. The landslide component models shallow landslide occurrence and the resulting sediment yield at the catchment scale. A dual resolution scheme uses a topographic index to link the SHETRAN grid resolution (typically 100 m – 2 km), at which the basin hydrology and sediment yield are modelled, to a sub-grid resolution (typically 10 – 20 m), at which landslide occurrence and erosion are modelled (A). Landslide occurrence is determined as a function of the time- and space-varying soil saturation conditions simulated by SHETRAN using infinite-slope, factor-of-safety analysis. The landslide derived sediment is passed to the SHETRAN sediment transport component and routed along the channel system to the catchment outlet (B).

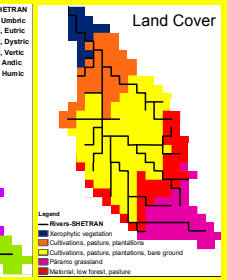




DATA AVAILABILITY

- ❑ 10-m resolution Digital Elevation Model
- ❑ Soil hydraulic property data for limited sites
- ❑ Hourly rainfall for six stations and daily evapotranspiration for three stations
- ❑ Daily mean discharge at Saguin (13.3 km^2) and Piñancay (57.4 km^2)
- ❑ Other model parameters were derived from literature sources, past applications or calibration

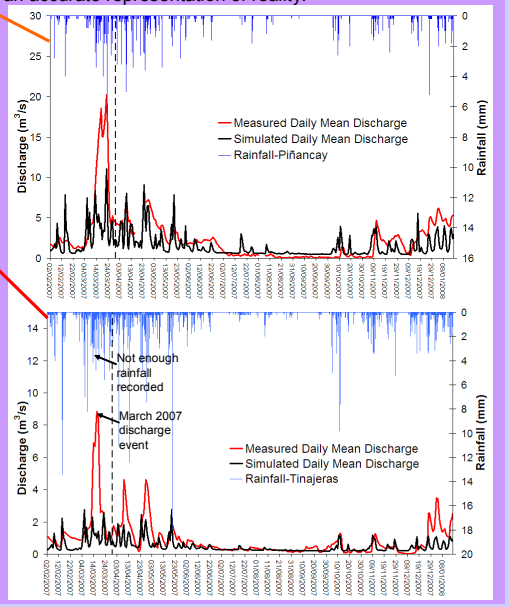




Soils	Soil Depth (m) Top layer	Bottom layer
Andosol (umbric)	0.30	0.70
Cambisol (eutric)	0.25	4.00
Cambisol (vertic & dystric)	0.25	4.00
Leptosol (andic & humic)	0.25	-

CALIBRATION

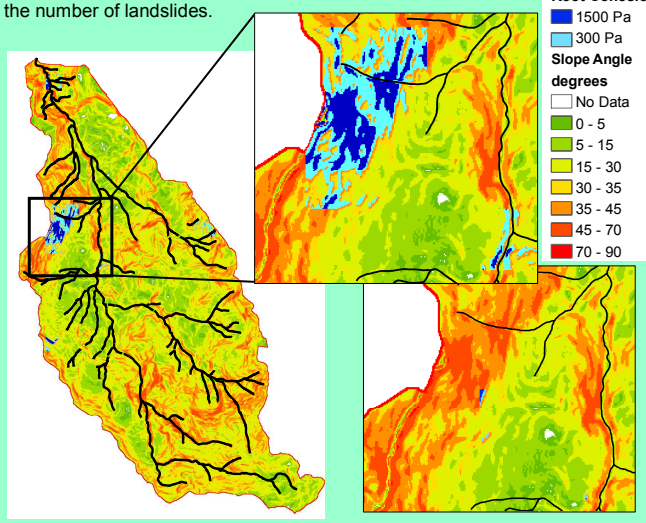
Calibration was carried out for the daily discharge series at the Saguin (13.3 km^2) and Piñancay (57.4 km^2) gauging stations. Because of data limitations (especially for rainfall and soil properties), the calibration is approximate. (See, for example, the inability to model the major hydrograph in March 2007 because of missing rainfall data.) It therefore provides a sufficient technical basis for landslide modelling but the results should be viewed as illustrative rather than an accurate representation of reality.



LANDSLIDE SIMULATION

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.

Root cohesion (Pa)	Number of landslides
300	78
700	56
1000	42
1500	25



CONCLUSION

The simulation demonstrates the use of a physically based, spatially distributed 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. Even with imperfect data availability it is still possible to carry out an initial exploration of the problem area. Such models can therefore be proposed as a means of testing and selecting strategies for the targeted reforestation of basins.

References

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ACKNOWLEDGEMENTS

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