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Land cover trajectories and their impact on slope stability in the Ecuadorian Andes

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In Ecuador, as in many tropical mountain regions, the increasing population and institutional reforms have forced numerous people to migrate to steep uplands less favourable to agriculture and highly sensitive to soil erosion. This migration induced rapid land cover change. Mass movements (often called landslides) are also very common in those areas. While various authors have shown that prolonged changes in land cover patterns influence the extent and frequency of mass movements, few studies have realised detailed chronosequential analyses of the impact of land cover change on mass movements. Therefore, it is not clear how fast landscapes respond to rapid land cover change.

The main purpose of this work was to analyse the temporal and spatial response of mass movements to land cover change in the Ecuadorian Andes. We particularly focused on the effect of different land cover trajectories in two steep catchments (of about 25 and 5km^2) with different land cover histories. In the first one, Rio Llavircay catchment, deforestation mainly started in the mid-20th century while deforestation started few decades earlier in Rio Ingapata catchment located just few kilometres upstream.

Landslides localisations and land cover maps were created by interpretation of aerial photographs from 1963, 1973, 1983 and 1995, and by field surveys in 2008, 2009 and 2010. In total, 335 mass movements (reactivation excluded) were identified between 1963 and 2010 in the two catchments. During the same period of time, half of the primary forest (824ha) in Rio Llavircay catchment has been degraded or harvested and all of it (172ha) in Rio Ingapata catchment.

A statistical approach was used to analyse the main factors controlling mass movement occurrences. Due to the small size of the mass movement samples, standard statistical analyses could not be applied. To bypass this difficulty, we developed a statistical approach where we used Monte Carlo simulations to test if the spatial distribution of mass movements was random or dependant of some topographical variables and/or land cover trajectories.

According to the statistical results, topographic factors such as slope and distance to watercourses are significant variables explaining mass movement presence in both catchments. This is well understandable knowing that half the area is covered with slopes of more than 26°. Anthropogenic factors that are linked to recent land cover change have more importance in the catchment that was deforested in the last four decades (Rio Llavircay catchment). Forest conversion to agricultural land significantly explained mass movement presence, as well as the presence of roads and paths. Importantly, we observe no correlation between the degradation of forest and the pattern of mass movements. This suggests that a significant reduction in the density of trees in forests does not lead to a measurable increase in mass movement occurrence. Geophysical testing of soil samples taken in different land cover units will be realized to further investigate this trend.