Geophysical Research Abstracts
Vol. 20, EGU2018-14949, 2018
EGU General Assembly 2018


# Effects of land use on storage thresholds for surface runoff generation in Eastern Madagascar

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Threshold relations between runoff and antecedent soil moisture or precipitation are common and indicate that a certain storage has to be filled before significant flowcan occur. However, it remains unclear how these threshold relations are influenced by land use. Land use can affect soil storage dynamics and thus runoff dynamics through changes in evapotranspiration and through changes in soil properties that result in changes in lateral and vertical drainage. Understanding the effects of land use on storage dynamics and runoff thresholds is particularly important in the tropics where land use is both increasingly patchy and changing rapidly.

Here, we compare the thresholds for surface runoff generation for a degraded fire-climax grassland site (DG), a young secondary forest site (YSF; LAI 1.83) and a disturbed forest site that had undergone manual selective logging until ca. 22 years ago (semi-mature forest, SMF; LAI 3.39) in Eastern Madagascar. The sites are located less than 5 km apart and are characterized by clay-rich soils with a low (< 3 mm/hr) saturated hydraulic conductivity below 20-30 cm depth. At each site we installed a climate station and measured surface runoff from two (SMF) or three (YSF and DG) 3 x10 m bounded runoff plots between October 2014 and September 2015. Perched groundwater levels were measured in piezometers installed at 30 cm depth in the centre of each runoff plot. Soil moisture content was measured at 4 depths at each site.

Surface runoff occurred mainly during large rainfall events during the wet season and was much higher for the DG site (11 % of precipitation) than for the two forest sites (2% of precipitation each). Comparison of surface runoff occurrence with water level and soil moisture data indicated that surface runoff occurred only when the top soil layers became saturated because of the slow drainage to the low conductivity deeper soil layers. Indeed surface runoff occurred only when event total precipitation exceeded the antecedent soil moisture deficit in the top 27.5 cm of the soil. A one-parameter box model was fitted to the observed surface runoff and perched groundwater level data. The calibrated linear reservoir constants differed for the three sites. Analyses with the model suggest that if slightly larger rainfall events had occurred during the study period, soil water storage would have been filled more frequently at the YSF and DG sites and there would have been a measurable difference in the amount of surface runoff for the YSF and SMF sites. Our results do not only highlight the need to understand storage dynamics to properly interpret runoff responses but also show how land use affects storage dynamics and storage thresholds.