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Land-use change impacts on hydrologic soil properties and implications for overland-flow in a periurban Mediterranean catchment

Carla S.S. Ferreira (1,2), Tammo S. Steenhuis (3), Rory P.D. Walsh (4), Daniel Soares (2), António J.D. Ferreira (2), and Celeste O.A. Coelho (1)

(1) CESAM, Department of Environment and Planning, University of Aveiro, Aveiro, Portugal, (2) CERNAS, Coimbra Polytechnic Agriculture School, Bencanta, Coimbra, Portugal, (3) Department of Biological and Environmental Engineering, Cornell University, Ithaca, NY, USA, (4) Department of Geography, Swansea University, Swansea, UK

Global urbanization affects land-use, soil properties and runoff generation and has implications on flow connectivity in the landscape. Understanding how various forms of the urban mosaic affects the landscape functioning is still a challenge. The aim of our research is to: 1) understand spatio-temporal variability of soil hydrological properties of land-uses in a periurban Mediterranean environment and the impacts on runoff processes; 2) assess the impacts of urbanizing mosaic features of periurban areas on flow connectivity and streamflow response. The study is carried out in a Portuguese typical urbanizing environment, the Ribeira dos Covões (6 km2 catchment). In the last 50 years, the catchment has changed from being rural into urban. By 2009, although still dominated by forest (66%), the catchment urban areas (30%) exhibited a distinctive pattern involving sets of gardens and walls, with derelict land in between properties.

The study combines field surveys and hydrological monitoring to assess spatio-temporal dynamics of land-use contributions to surface hydrology. Over a one year period, nine monitoring campaigns were carried out to assess the variability of water-repellency, soil moisture and water infiltration in different land-use categories. In 2010 fall, nine 8mx2m runoff plots were installed in the forest areas, as well as a continuous-recording network that includes three rain-gauges and nine water-level recorders. This network provides continuous data on hydrological response to rainfall at the catchment outlet and in eight sub-catchments.

The results revealed high spatio-temporal variability in soil hydrological properties with significant differences between land-uses. In summer, soil hydrophobicity is widespread and most severe in forest areas, resulting in very low soil-matrix infiltration and thereby promoting Hortonian overland-flow. In wet periods, water-repellency almost vanished, with infiltration rates at forest sites increasing to12mm/h. In contrast, in agricultural and urban areas, the increased soil moisture promotes saturation-excess overland-flow in valley and other low-slope areas where the regional groundwater table intersects the surface. Despite extreme hydrophobicity during the summer, plot runoff coefficients did not exceed 20%, indicating that most storm rainfall, particularly in the limestone part of the catchment infiltrated via structural cracks and root-holes through the hydrophobic matrix to the groundwater system. Land-use patches, soil properties and geological features, form a mosaic of different runoff source areas. Runoff not necessarily reaches the stream channel network because overland-flow often infiltrate in mosaic units that favour infiltration.

We argue that knowledge of the spatial distribution and temporal dynamics of runoff response and flow connectivity in the urban mosaic is important to understand streamflow regimes and flood risk, and should be considered by managers and decision-makers, to support water management and urban planning. For example paving over the infiltration zones will result in flooding downstream that easily could have been avoided by proper planning that takes into account the functioning of the landscape.