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Dynamic hydrophobicity-driven hydrological behaviour of different woodland types within a peri-urban catchment mosaic in Portugal: field evidence and planning implications

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Land-use in peri-urban catchments tends to be dynamic and fragmented, presenting opportunities for planning land-use mosaics designed to reduce adverse hydrological and water quality impacts associated with urbanization. Forest cover within such catchments potentially provides ecosystem services associated with its regulation of the water cycle, but its effectiveness will vary with woodland species and the spatial distribution and management of woodland patches. Forest cover is usually associated with permeable soils, thereby generating little overland flow and providing potential sinks for overland flow from upslope urban land. The situation, however, is more complex in Mediterranean (and other seasonally dry) environments, where hydrophobic soil conditions (which can enhance overland flow responses) are differentially associated with forest species types and are to varying degrees subject to change with season and weather. Little is known, however, about hydrophobicity dynamics in different woodland types within land-use mosaics in such environments. Yet understanding spatiotemporal variation of hydrophobicity is essential in inferring the role that forest patches may play in breaking or enhancing flow generation and connectivity within peri-urban catchments, particularly in the intense storm events that typically occur after the dry season and tend to trigger floods in Mediterranean urban areas. This paper explores evidence from field experiments of spatiotemporal hydrophobicity change during and following simulated rainstorms in oak and eucalyptus woodland types, in conjunction with seasonal changes in hydrophobicity and hydrological response, in the peri-urban Ribeira dos Covões catchment (6 km2) on the outskirts of the actively expanding city of Coimbra, central Portugal. The field experiments involved measuring hydrophobicity (surface and at 5 cm depth)using the WDPT technique at daily intervals before and after standardized simulated rainstorms applied to 32 mini-plots (0.25 m2 area; 16 in oak woodland, 16 in a Eucalyptus globulus plantation). Half the miniplots had litter left intact and half had the litter cover removed prior to the simulated rainfalls. In the field experiments, marked contrasts were found between the miniplots on the two woodland types, with greater severity, faster recovery and reduced local spatial variability of hydrophobicity in the eucalyptus terrain. Overland flow responses in the simulated rainstorms were also measured, with significantly greater overland flow recorded in the eucalyptus miniplots. Their faster recovery would also mean that eucalyptus terrain will be more often in a spatially contiguous hydrophobic (and hence overland flow generating) condition than is the case for oak woodland. The results therefore suggest that patches of semi-natural oak forest are significantly more effective than eucalyptus stands in promoting infiltration and reducing overland flow responses in rainstorms – and also in acting as sinks for overland flow from upslope urban land. Authorities concerned with catchment management and urban planning should try to incorporate strategically-placed semi-natural forest patches (residual or planted) in any development proposal not only to enhance rainfall infiltration but also to provide potential sinks for upslope runoff. This would potentially both reduce not only downstream peak streamflows and flood risk, but enhance downstream water quality by filtering pollutants in urban runoff.