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Three-dimensional and temporal distributions of soil water repellency in eucalyptus forests, Portugal: impact on hydrological response.

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It is well known that soil water repellency can influence the hydrological response of small patches of soil, but there is a major research gap concerning its impact at hillslope and catchment scales. This study reports on an extensive programme of repellency measurements and a series of rainfall simulations to investigate the three-dimensional and temporal dynamics of soil water repellency. Repellency was assessed on eight occasions over a 16-month period in four different *Eucalyptus globulus* plantations of different ages in Portugal. Within each plantation, measurements were made using the %Ethanol method at three depths (surface, 10 cm and 20 cm) at (i) 60 evenly spaced points on a meso-scale grid (10 m $\times$ 18 m), and (ii) 36 evenly spaced points on a micro-scale grid (0.6 m x 0.6 m). The $>$9000 repellency measurements were each paired with a measurement of soil moisture and leaf litter depth. Daily rainfall data are available from a nearby weather station. A separate experiment assessed the small plot scale hydrological responses of a repellent soil and a simulated wettable soil to storm intensity rainfall, using simulated rainfall and wetting agents. Of the results from these two investigations, this paper focuses on those that have particular significance for the ability of repellency to enhance slope hydrological response.

The rainfall simulation experiments showed that repellency caused a marked increase in overland flow generation relative to the wettable soils; for example, sixteen-fold increases were recorded on unburnt, litter-covered soils. Some spatially-discontinuous wetting of the top 15 mm of repellent soil was observed following the 30-minute simulated storms, indicating at least a temporary breakdown in repellency. This was, however, insufficient to cause a measurable decrease in overland flow generation. In addition, the eucalyptus litter layer demonstrated a considerable moisture storage capacity.

The extensive measurements of *in-situ* repellency showed that contiguous or near-contiguous repellency was found at the longest-established site and a recently burnt site but not at younger sites where eucalypts were mid-way or less through their commercial harvesting cycle. The contiguous or near-contiguous repellency was only found following dry, late-summer conditions; the longer established and burnt sites were found to be entirely wettable following the wet winter period. After the first autumn storms, the *spatial frequency* of repellency (i.e. the percentage of repellent grid points) remained relatively high at some sites (88%), suggesting that more rainfall might be required for soils to become entirely wettable. Where repellency was spatially discontinuous at the meso-scale, it had a fragmented spatial distribution whereas the vertical distribution suggested a series of wettable soil columns of increasing diameter with depth spanning the surface and subsurface layers, within an otherwise repellent matrix. The implications of these results for repellency to enhance the slope and catchment hydrological response are discussed.