

Runoff Generation from Water Repellent Soils with High Spatial and Temporal Variability in Infiltration Capacity

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EXTENDED ABSTRACT

Sheridan et al. (2007) reported that infiltration-excess runoff ratios of up to 60% were observed during 100 mm h⁻¹ rainfall simulation on water repellent macroporous, clay loam forest soils in a SE Australian Eucalypt forest. At the same time, ponded ring infiltrometer measurements showed conductivities in the order of 100's of mm h⁻¹. The aim of this research is to test the hypothesis that these unusual results are due to strong water repellence resulting in very high spatial variability in conductivity, with a large proportion of soil surface area having zero to very low conductivity, punctuated by small areas of extremely high conductivity.

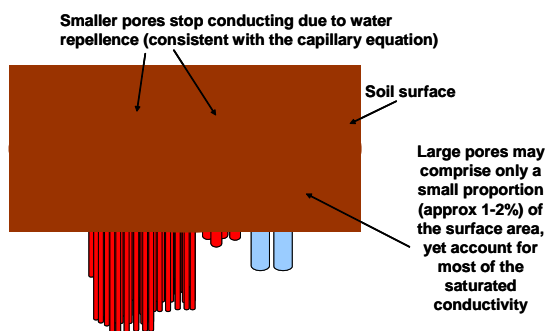


Figure 1. An illustration of how water repellence may lead to large runoff producing areas punctuated by small areas of very high conductivity.

Pore size distributions of intact soil cores were quantified at high soil water potentials (0-50cm water) using a tension table, while the relative contribution of these pore size classes to total conductivity were measured using tension infiltrometers in the field, also at water potentials close to zero. The results were used to generate a randomly arranged grid of relative conductivity with correct distribution properties for numerical

simulations of runoff generation under 100 mm h⁻¹ rainfall. These random grids of relative conductivity were then modified to prevent water entry to pores less than a critical diameter, based on the capillary equation and laboratory measurement of the soil-water contact angle of the water repellent soil. These modelled runoff values were compared to measured runoff from field 1.5 m wide rainfall simulation plots at 100 mm h⁻¹ intensity and plot lengths between 0.1-2.0m.

The results showed that:

- Under non-water repellent conditions only a small fringe adjacent to the plot outlet contributes runoff to the plot exit;
- Both the runoff rate and the average connected length (with the plot outlet) are very sensitive to the selected contact angle;
- 20% runoff can be generated even when the infiltration capacity (127 mm h⁻¹) is higher than the rainfall rate (100 mm h⁻¹), if the contact angle is assumed to be 94°.

When the laboratory measured contact angle of 90.3° is used in the runoff model, runoff generation is increased only slightly in summer and the modelled results do not support the experimental hypothesis. However if it is assumed that the field soil-water contact angle increases to 94° in summer, then the results support the hypothesis that the observed spatial and temporal patterns of infiltration and runoff generation can be attributed to seasonal changes in water repellence. Several technical and theoretical issues may have bearing on the conclusions drawn from this paper.

The results have implications for infiltration-excess runoff estimation from areas with highly spatially variable conductivity, as are commonly found in forested environments, particularly where water repellence also occurs.

