

**Evaluation of the Soil Water Infiltration and
Movement model for assessing the effects of
grazing intensity on the soil water balance.**

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by

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Abstract

There is an increasing concern that grazing animals cause soil structural damage. The pressures exerted by grazing animals are comparable to agricultural vehicles and, when soil conditions are conducive, can result in soil compaction. Compaction causes changes to soil physical properties which lead to changes in soil hydraulic properties affecting water entry, storage and movement within the soil.

The aim of this study was to examine the effects of grazing on the soil water balance of a gleyed podzolic soil. The soil hydraulic properties, namely, the moisture characteristic and hydraulic conductivity function were measured, under a grazed and ungrazed pasture. The Soil Water Infiltration and Movement (SWIM) model was used to examine the consequences of changed hydraulic properties under grazing on the soil water balance. An evaluation was made of SWIM's ability to predict soil drainage.

The study was carried out on a long term grazing trial near Armidale, NSW. The trial was set up in 1958. The two plots used in the experiments were an ungrazed plot and an adjacent plot that was stocked at 10 DSE per ha, situated on a gleyed podzolic soil type. The surface hydraulic properties were determined by both field and laboratory methods at three depths: above, within and below a compacted zone as indicated from soil strength measurements by Lemin (1992). The moisture characteristic was measured by the pressure plate method and unsaturated hydraulic conductivity was measured in the field using a negative head disc permeameter. Although there were no significant differences in the moisture characteristic between the two grazing treatments at 5-9 cm or 20-24 cm, surface infiltration was significantly higher in the ungrazed treatment compared to the grazed treatment. Differences in macroporosity and pore continuity at the soil surface could account for the higher infiltration rate. The treatment difference at the soil surface was for infiltration rates measured at tensions of 20 mm and 10 mm tension. The results suggest that the ungrazed plot has a greater number of pores that are greater than 1.5 mm in diameter and/or the pores are better connected.

The subsoil moisture characteristic was measured using the pressure plate method and saturated hydraulic conductivity using a well permeameter. The B horizon held more water than the A horizon over the potential range -5 kPa to -1500 kPa. The B horizon has a high clay content resulting in a predominance of fine pores that require large suctions (low potentials) for water to drain. Saturated hydraulic conductivity decreased with depth, again as a result of increasing clay content.

To evaluate the drainage component of SWIM soil hydraulic properties were measured *in situ*. SWIM's drainage prediction was evaluated by comparing measured water content and drainage in the field with SWIM simulated output. SWIM uses the equations of Campbell (1974, 1985) to define soil hydraulic properties used to solve Richards' equation describing one dimensional vertical flow. The inputs required for Campbell's equations are saturated hydraulic conductivity, air-entry potential, the slope of the best fit line relating water content to matric potential on a log-log scale (b) and saturated hydraulic conductivity. These inputs were determined from the *in situ* and laboratory moisture characteristic data and *in situ* hydraulic conductivity measurements.

A drainage plot was set up with a neutron probe access tube placed in the centre of the plot with several tensiometers placed at selected depths around the tube. The plot was isolated from any lateral water movement into or out of the plot by placing plastic sheets down each side of the plot. A tent-like structure was erected over the plot to prevent any wetting by rainfall and once the plot was saturated with rain water, a thick mulch and plastic sheet was placed over the surface to prevent evapotranspiration. *In situ* volumetric water content and matric potential were monitored as the drainage plot dried. The soil water flux (q) was calculated from water content data at different depths and different times and hydraulic gradients (I) were calculated from the matric potential data. Given q and I , the hydraulic conductivity function was calculated by rearranging Darcy's law. Drainage was also calculated at different depths over time.

Only small differences were found between measured and simulated water content profiles and drainage over time, indicating that SWIM provides reliable estimates of drainage. It was concluded that the process of water movement is well described by the SWIM model, which simulates water movement through numerical solution of Richards' equation.

SWIM was also used to examine the consequences of changed hydrological properties under grazing on the soil water balance. Infiltration was decreased under grazing resulting in increased runoff. The effects of different rainfall intensity, initial matric potential and surface detention were also examined. The output from SWIM showed that a stocking rate of 10 DSE per ha did not degrade soil structure enough to induce runoff until at least 43 mm of rain fell in one hour. However, runoff was much greater in the grazed plot compared with the ungrazed plot.

Difficulties in obtaining a reasonable estimation of infiltration with a disc permeameter were encountered. The infiltration rate measured with the disc permeameter was much

higher than that measured with a drip infiltrometer. The differences are due to the different wetting mechanisms.

Simulation modelling also identified two runoff mechanisms occurring in the gleyed podzolic soil: Hortonian flow and saturated excess runoff. Hortonian flow occurs when the surface hydraulic conductivity is less than the rainfall intensity, resulting in runoff when the profile is not saturated. This mechanism was expected to occur with a 1 in 20 year storm whose rainfall intensity was at least 43 mm/hr. Saturated excess runoff is likely at least 1 in 10 years. It results from the low hydraulic conductivity of the B horizon which restricts downward movement of water draining through the A horizon, thus causing the A horizon to saturate. The B horizon therefore controls the infiltration rate. To improve infiltration and water availability to the pasture, the hydraulic properties of the B horizon need to be improved through production of vigorously growing, deep rooted perennial pasture that will create biopores and increase faunal activity.

One aspect of water movement not modelled by SWIM is lateral water flow. Water ponding on top of the B horizon is likely due to the low hydraulic conductivity of the B horizon compared with the A horizon. This ponded water could move laterally, particularly on a slope.

Increasing initial matric potential reduced infiltration due to the reduction in air-filled porosity with increasing water content. An increase in surface detention increased infiltration due to ponding of water at the surface in depressions and thus allowing more time to infiltrate.

A sensitivity analysis found SWIM output to be most sensitive to the soil input parameters, namely, initial matric potential, saturated water content air-entry potential, b and saturated hydraulic conductivity. These properties determine the accuracy of SWIM predictions and need to be measured accurately if SWIM is to describe soil hydrology well. Spatial variation in soil hydraulic properties has important implications for models such as SWIM. To improve the use of SWIM a greater understanding of the spatial variation of the soil properties in the study area is necessary.

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