Spatial and Temporal Soil Water Dynamics in a Small, Grazed Southern Piedmont Watershed

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ABSTRACT

Data are required to test models and other representations of soil water at the filed scale. We measured soil water for three years at 12 locations, 6 at mid-slope and 6 at slope bottom, in an 7.7-ha pasture of Cecil sandy loam, near Watkinsville, GA. Measurement depths were: 0-15, 15-30, 30-60, 60-90 and 90-120 cm. The late fall and winter months were periods of recharge, while the spring and summer months were periods of drying. The soil profile was highly responsive to wet and dry conditions, especially in the top 60-cm. Mean soil water varied 10 to 35% in the 0-15, 16 to 32% in the 15-30, 20 to 35% in the 30-60, 25 to 38% in the 0-90, and 30 to 40% in the 90-120 cm depths. The mid-slope locations lost or gained between 10 and 48% more total soil water (mm) than bottom-slope locations in all but the bottom profile. Such soil water dynamics has implications for hydrologic processes such as infiltration and runoff.

INTRODUCTION

Soil water controls major hydrologic processes: partitioning of precipitation into infiltration, runoff and root zone; evapotranspiration because it controls water availability to plants and thus affects the partitioning of latent and sensible heat; transport of chemicals nutrients and pathogen transport.

Soil water is also a key state variable in hydrologic models. Our ability to test spatial performance of models or alternative spatial representations of soil water is limited by lack of suitable spatial data (Beven, 1989; Grayson et al., 1992; Western et al., 1999).

The objective of this research was to instrument a small grazed Southern Piedmont watershed and monitor the spatial and temporal soil water dynamics.

METHODS AND MATERIALS

- The experimental site is a 7.7-ha bermudagrass pasture (W-1) at the USDA-ARS, Watkinsville, GA, located in the Southern Piedmont (Fig. 1, Fig. 2). Slopes vary 3 to 10%. The Soil is a moderately eroded Cecil developed from residual soil material derived from metamorphic and igneous granitic rock.

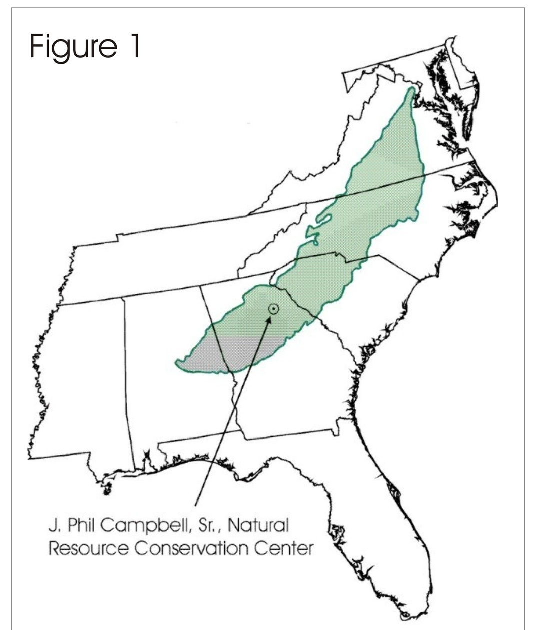
In Feb. 1998, 12 locations were instrumented with the TDR-based MoisturePoint system (model MP-917, ESI, Victoria, British Columbia, Canada). Locations were on three transects at the lower, mid and upper part of the watershed, with one each at mid and bottom slope of the north and south facing slopes (Fig. 3; Table 1).

Reading intervals varied but were often as frequent as two to three time a week, especially in 1998 and 1999. Changes in soil water between two successive dates were computed. A selection of periods of soil water loss and gain were made for further analysis. The total soil water loss and gain in mm was computed for each period and then summed to give the loss and gain in each year and over the three years. The total losses and gains over three years were then analyzed for differences with the General Linear Models of SAS (SAS Institute, 1990). Periods were:

LOSS: 1998 - 10 (7 to 30 d); 1999 - 15 (2 to 26 d); 2000 - 5 (9 to 49 d)
Gain: 1998 - 6 (8 to 35 d); 1999 - 16 (8 to 35 d); 2000 - 4 (9 to 35 d)

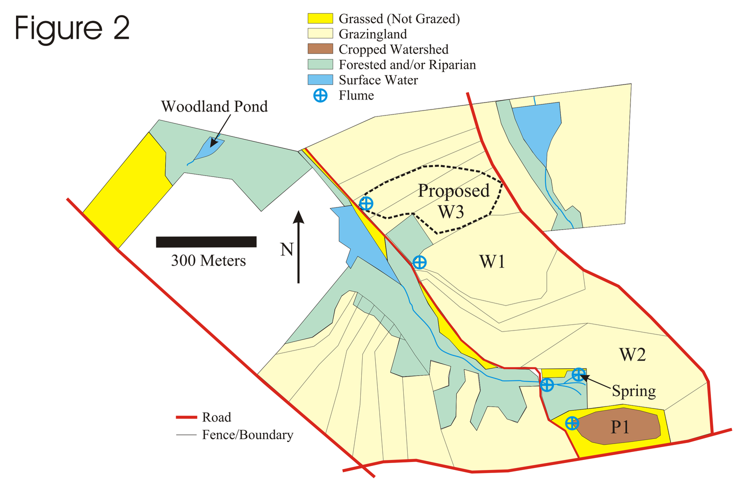
Rainfall was measured (Fig. 4; Fig. 7)

Figure 1



The Southern Piedmont

Figure 2



The 7.72-Ha W1-Watershed nested within the North Unit Research Watershed of the J. Phil Campbell, Sr. Natural Resource Conservation Center in Watkinsville, GA

Figure 3

W1 With Soil Water Measurement Locations

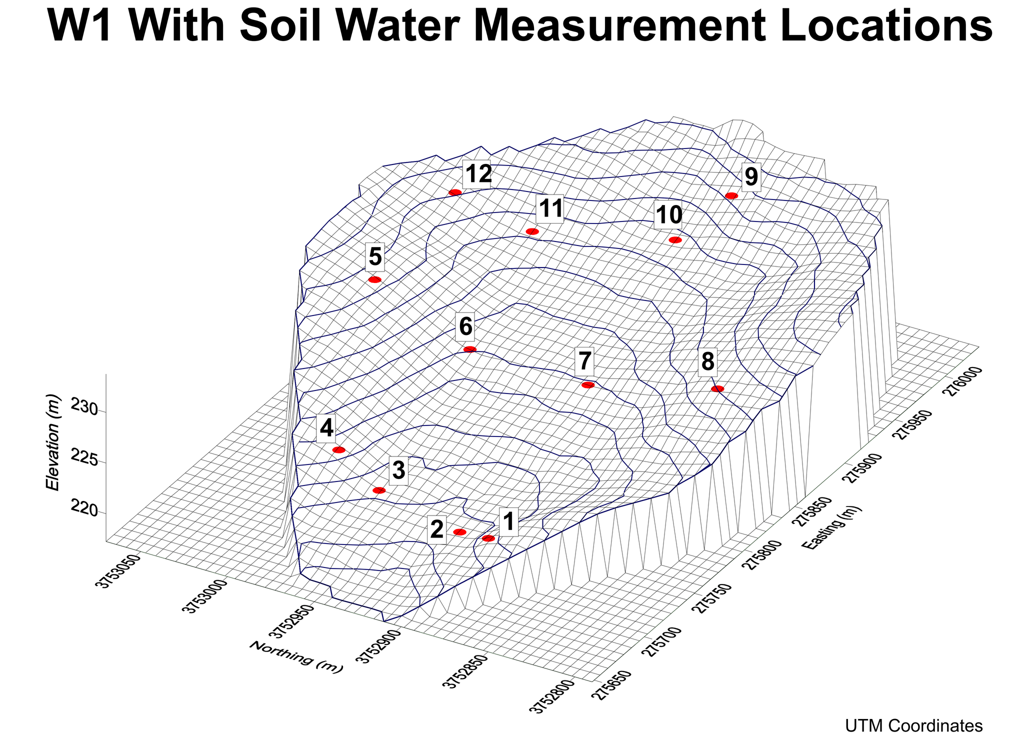
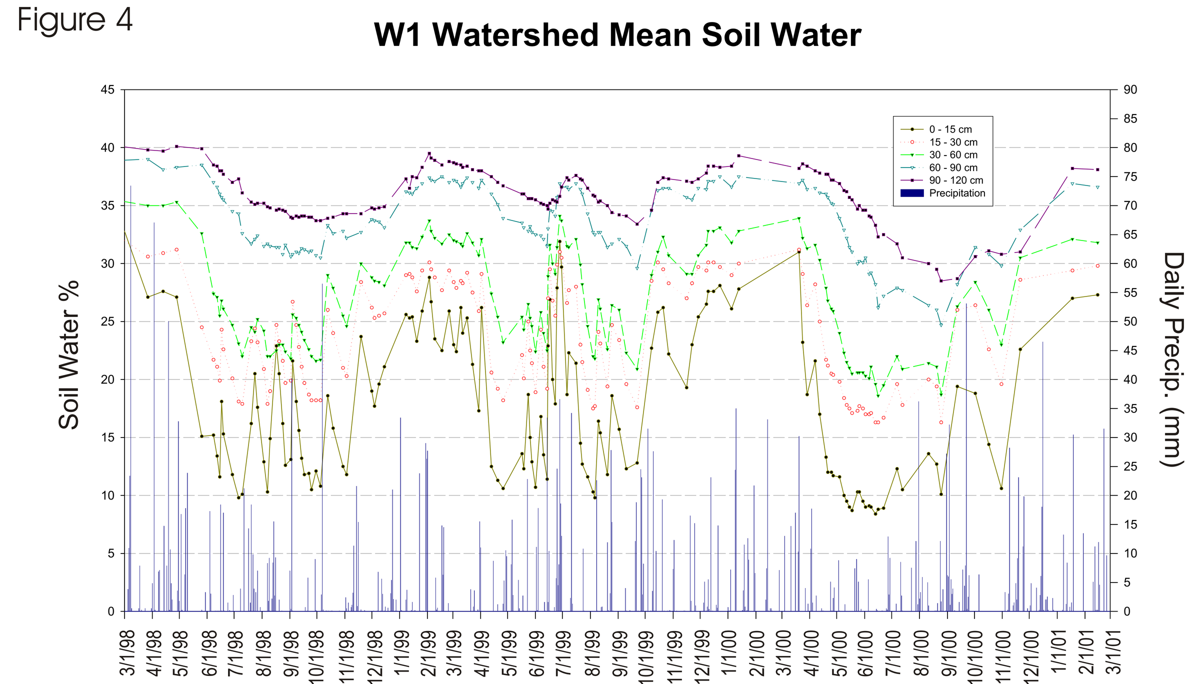
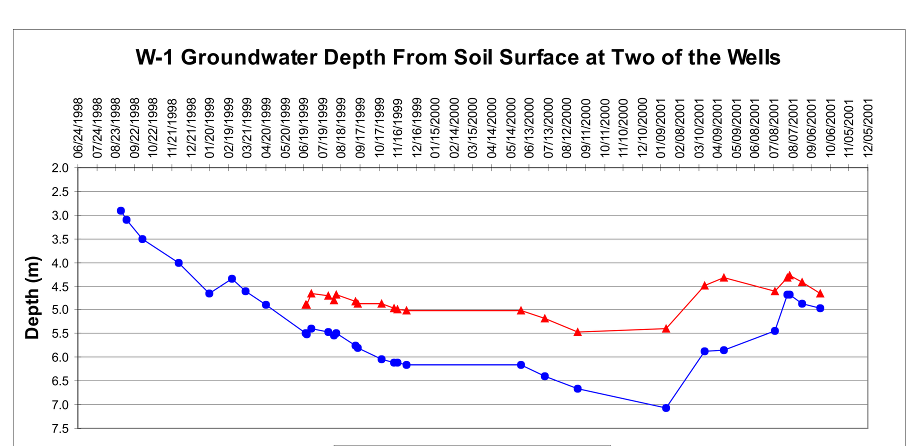
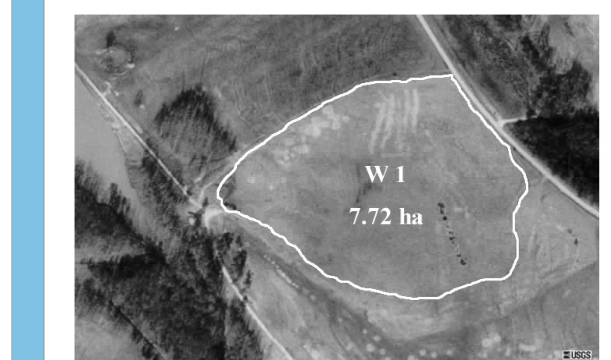


Figure 4







Aerial View of W1 Watershed

The Moisture Point System: ESI MP-917 interface/datalogger, probe connection cable, and 5-segment 1.2m TDR probe.

Technique used to install soil water measuring devices.

Measuring soil water in the field.

W1 V-notch weir and instrument building

Table 1. Location designation used in Fig. 5, 6

TDR Probe Locations	Designation For Fig 5 and 6	Designation Table 2
1, 4, 5, 8, 9, 12	Slope	SL
2, 3, 6, 7, 10, 11	Bottom	BO
1, 8, 9	S-Slope	SLS
4, 5, 12	N-Slope	SLN
2, 7, 10	S-Bottom	BOS
3, 6, 11	N-Bottom	BON
1, 4	Low-Slope	SLL
2, 3	Low-Bottom	BOL
5, 8	Mid-Slope	SLM
6, 7	Mid-Bottom	BOM
9, 12	High-Slope	SLH
10, 11	High-Bottom	BOH

Figure 5a

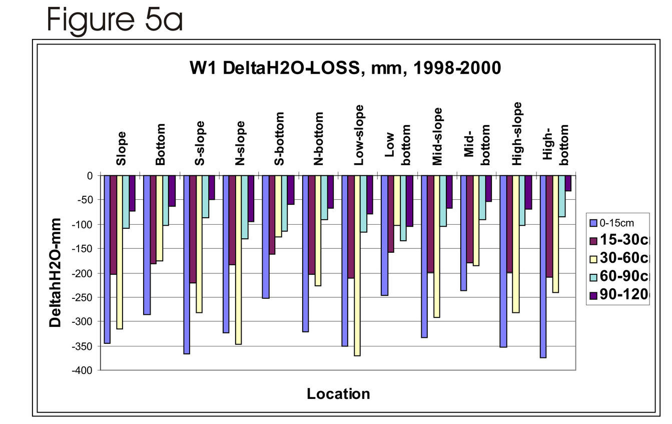


Figure 6a

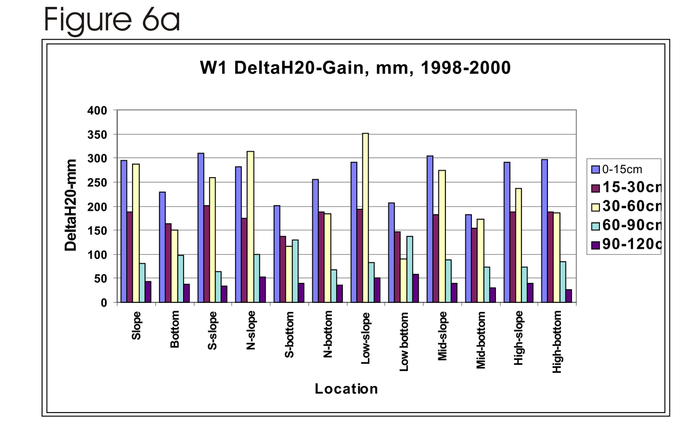


Figure 5b

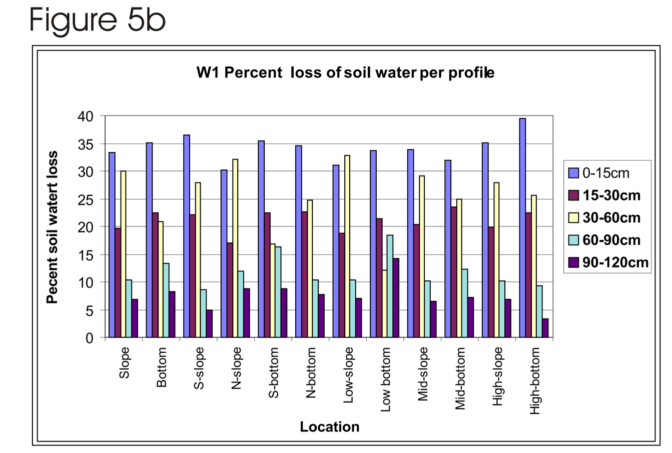


Figure 6b

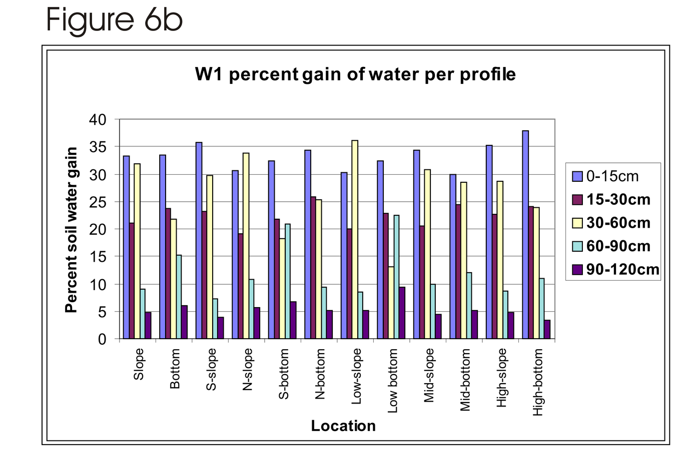
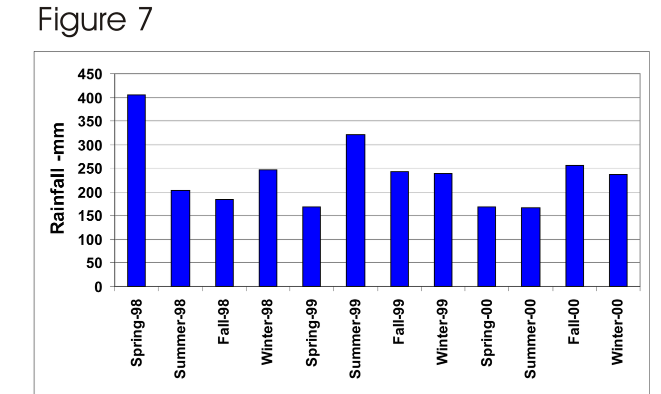
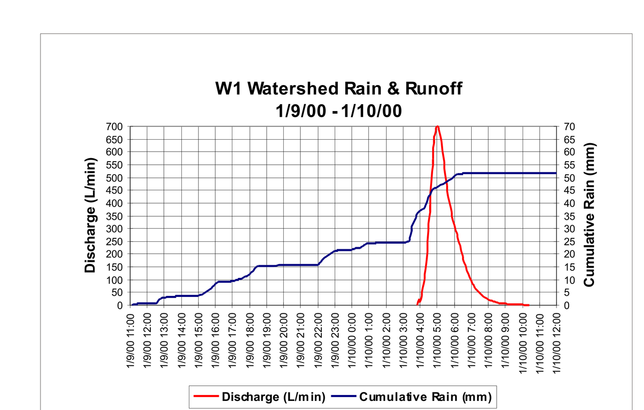


Figure 7





RESULTS

Soil water dynamics

The soil profile was highly responsive to wet and dry climatic condi
4). The response was: 0-15 cm >15-30 cm > 30-60 cm. Belo
losses and gains were less dynamic than the profiles above. Soil
highest in mid to late winter then diminished through spring. Soil
lowest in summer except during periods of recharge by precipitat

Loss of soil water

Mean total soil water loss per profile Fig. 5a. Percentage of tot
profile Fig 5b. Differences for mean loss from the whole profile:
SL > BO (1042 vs 810-mm); SLN > BON or BOS; SLS > BOS;
BON > BOS (908 vs 712-mm); N > S (827 vs 745-mm);
Transect SL and BO differences at the low and mid-elevation only

Differences within profiles : SLS > BOS in the top 2 profiles;
SL > BO, SLN > BON or BOS, and SLS > BOS in the 30-60 cm profil
SLN > SLS, and SLN > BOS in the 60-90 cm profile;
Along transects: BO for low > upper, and medium > upper ele
the 0-15 cm profile; and the low > upper for the 90-120 cm profil

Gain of soil water

Mean total soil water gain per profile Fig. 6a. Percentage of tota
profile Fig 6b. Differences for mean gain from the whole profile:
SL > BO (894 vs677-mm); SLN > BON or BOS; SLS > BOS or BON;
Differences between bottom slopes along transects of low vs u
medium vs upper elevations.

Differences within profiles : SLS > BOS in the top 2 profiles;
SL > BO, SLN > BON or BOS, and SLS > BOS in the 30-60 cm profil
SLN > SLS, and SLN > BOS in the 60-90 cm profile;
Along transects: BO for low > upper, and medium > upper ele
the 0-15 cm profile; and the low > upper for the 90-120 cm profil

CONCLUSIONS

The research showed that soil water in a grazed small typical Southern
watershed was highly dynamic in response to dry and wet climatic c
seasons, and landscape positions. This dynamism occurred primarily in t
cm. Such soil water dynamics has implications for hydrologic process
infiltration and runoff. For example, the three runoff events recorded
research period occurred in winter when soil water content was 25 to 3
10-cm, and 30 to 35% in the 15-60 cm profiles. The generated dat
serve as ground truth data set for evaluating soil water representation
hydrologic models.

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