EROSION STUDIES IN BURNED FOREST SITES OF GEORGIA

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INTRODUCTION

Soil erosion from disturbed forestlands is of great concern to forest managers, soil scientists and hydrologists. The problem arises not only from detrimental effects of erosion on soil productivity but also by the adverse effects on water quality.

Site preparation techniques such as burning, root raking and disking are most frequent causes of disturbance to forestlands. Burning is a common practice used to control understory hardwood, reduce fuel hazards, improve wildlife habitat and prepare seedbeds and sites for planting (Van Lear 1985). Burning, however, can increase the erosion rate by two different mechanisms. First, by destroying the surface litter layer and possibly the underlying fibrous root layer, the mineral soil is exposed and the forces resisting erosion are reduced. Second, burning can decrease the infiltration rate by creating a hydrophobic (non-wettable) condition (DeBano 1981), thus, surface runoff will increase and that increases the driving forces for erosion.

Reliable and consistent data on the rate of runoff and sediment production from burned forest sites is not available in the South. This research is presented with two main objectives: (1) to assess the rate of erosion and runoff from a burned forest site in the Georgia Piedmont and how it changes with time for different levels of slope steepness, rainfall intensity, and antecedent moisture conditions, and (2) to present data on observations of the hydrophobicity (non wettability) phenomenon and discuss its significance on runoff and erosion production.

METHODS

The study was conducted at the University of Georgia, Whitehall Forest located in the southern Piedmont region, between July 1989-July 1990. The soil is shallow with a sandy clay loam texture in the surface 50 cm. A fibrous layer of fine roots, typical of hardwood forests, with a thickness varying between 1 to 3 cm covered the mineral soil in an undisturbed condition.

Three sites with average slopes of 10, 20, and 30 percent were selected in a mixed pine-hardwood stand. On each site, two pairs of 1x5 m uniform slope plots were located. Each pair corresponded to one intensity for application of simulated rain. Trees were cut and removed without mechanical intrusion. Slash was removed, kiln dried and replaced on each site and burned prior to plot setup. Following the burning and before the application of the first simulation rain event, a pair of 1x5 m plots with 15-cm metal sidewalls were established on each of the two locations within each slope class. Since runoff and sediment production from natural sites are low, no control plot was used in this study.

Two simulated rainfall intensities, 71.1 mm/hr and 101.6 mm/hr were used. The oscillating nozzle rainfall simulator used for this study had the nozzle spacing, water supply and recirculating system of the Purdue-type simulator (Foster et al. 1982), with the nozzle opening at the axis of oscillation (the Kentucky-type of Moor and others, 1983). A Veejet 80150 nozzle (Spraying System Company) was used for rainfall application. The nozzle pressure was 41 KPa and the fall height was 3 m. A network of 20 sprinklers spaced 1.52 m apart applied rain uniformly on each pair of plots. The frame supporting the sprinklers was wide enough to permit setup of the two 1x5 m plots with a buffer zone of 50 cm between them.

Initial soil moisture conditions were created by using three rainfall application runs, dry, wet and very wet runs. The first rainfall application to plots was carried out when the soil was relatively dry. The wet run was applied about 24 hours after the dry run, when the soil was relatively wet, and the very wet run started about 30 minutes after the end of the wet run. Runoff samples were collected manually in 1000 ml bottles over timed intervals to define the runoff hydrograph. All samples were oven dried and weighed to determine sediment loss.

Effects of temporal changes in surface conditions, particularly the root mat and the residual forest floor, on runoff and erosion rate were studied by repeating the experiment four times (July 24-August 21, August 22-September 8, November 7-25, in 1989, and July 16-26, 1990). Due to time limitations and based on the analysis of results of the first three trials, the fourth trial was conducted only for the high intensity rainfall plots. All vegetative regrowth was prevented during the entire study period by repeated application of Glyphosate as needed.

SUMMARY OF RESULTS AND DISCUSSIONS

Runoff. The total depth of runoff per 30-minute run per plot throughout the period of experiment ranged from a maximum of 5.97 mm or about 12 percent of applied rain (for steep slope high intensity plot, third trial, dry run) to a minimum of a 0.02 mm (for low slope high intensity plot, trial 2, very wet run). The mean depth of runoff per 30 minute period for high intensity rainfall runs was 1.11 mm compared with 0.78 mm for low intensity rainfall runs. These runoff values are about 2 percent of the depth of their respective applied rain. Thus, it was observed that the runoff production potential of these burned sites is generally low.

Temporal variation of runoff during the period July 89 to July 90 and variation of runoff with slope steepness is presented in Table 1. The lack of significant difference in runoff depth between trial 3 and trial 4 indicates that gradual changes in the thickness and spatial coverage of residual root mat during the period Nov. 89 to July 90 was not appreciable enough to increase runoff. For high intensity rainfall runs it is shown that increasing the slope steepness from 10 to 30 percent increased runoff nearly four-fold. There are no significant differences in mean runoff among slope classes for low intensity runs.

Table 1. Influence of Time since Burning (Trial), Slope, Antecedent Moisture (Run), and Rainfall Intensity on Runoff from Simulated Rainfall.

All Slopes and Runs		All Trials and Runs		All Trials and Slopes	
Trial	Mean Run-off	Slope	Mean Run-off	Run	Mean Run-off
	mm	%	mm		mm
High intensity rainfall runs					
1	0.82b*	10	0.51b	1	1.47a
2	0.62b	20	0.87b	2	0.88b
3	1.55a	30	1.96a	3	0.99b
4	1.46a				
Low intensity rainfall runs					
1	0.52b	10	0.80a	1	0.94a
2	0.60b	20	0.79a	2	0.67a
3	1.16a	30	0.76a	3	0.74a

*Means with the same letter are not significantly different at 0.05

Table 1 also indicates the effect of antecedent moisture condition on runoff. For low intensity rainfall, there is no significant difference in runoff depth of the three runs (dry, wet, very wet); however, mean runoff from run 1 was significantly greater than runs 2 and 3, when high intensity rainfall runs were considered.

The fact that dry runs produced significantly higher depth of runoff than wet and very wet runs deserves more detailed explanation. Figure 1 presents the hydrographs of runoff for the three runs on steep slope high intensity rain, plot 2, trials 1-4. It can be observed that during the dry run (run 1), the runoff hydrograph of trial 1 rises sharply to a peak over 20 mm/hr at about 4 minutes into the run and then the hydrograph recedes gradually to a value about 2 mm/hr at the end. During the wet and very wet runs (runs 2 and 3), the runoff hydrograph did not show similar peaks and the runoff rates are constantly low. This observation is contrary to the generally known increase in runoff with increasing soil moisture content and is explained by temporary hydrophobic conditions at the surface of plots due to dry organic material covering the mineral soil.

Similar peaks can be observed in the dry run hydrographs of the same plot in other trials except that peaks had different magnitudes, although the time to peaks were the same. Differences in the magnitude of the peaks in the hydrographs of dry runs for the four trials is explained by the differences in dryness of the plot surface at the beginning of dry runs in the four trials.

Sediment. The total weight of sediment per 30-min. run per plot throughout the period of experiment ranged from a maximum of 189.7 g (high slope high intensity plot, third trial, dry run) to a minimum of 3.0 g (low slope low intensity plot, first trial, dry run). The mean weight of sediment production for high intensity rainfall runs was 30.24 g per plot or about 60 Kg/Ha compared with 21.04 g per plot or 42 Kg/Ha for low intensity rainfall runs. Thus, the erosion rate from plots in burned mixed pine hardwood site is low. Variation of sediment production with time, slope and moisture conditions are shown in Table 2.

Suspended sediment concentration and sediment transport rate for the steep slope high intensity rainfall runs of trial three is presented in Fig.2. The sediment concentration peak is about 8 g/l and sediment transport rate is over 3.5 t/ha/hr at the beginning of dry run, gradually dropping to less than 1 g/l and 1 t/ha/hr near the end of dry run and continuing at about the same lower rate into wet and very wet runs. This observation is explained by the higher infiltration rates and lower runoff volumes with time after rainfall starts.

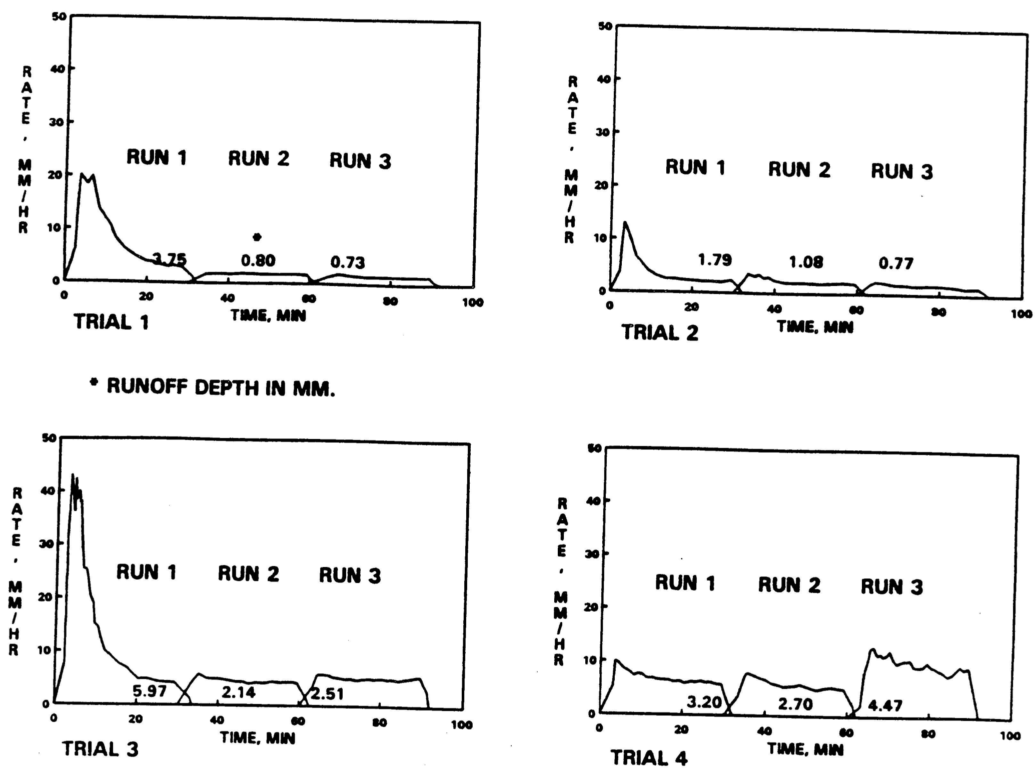

Figure 1. Hydrographs of High Slope (30%) High Intensity Rain Runs, Plot 2, Trials 1-4.

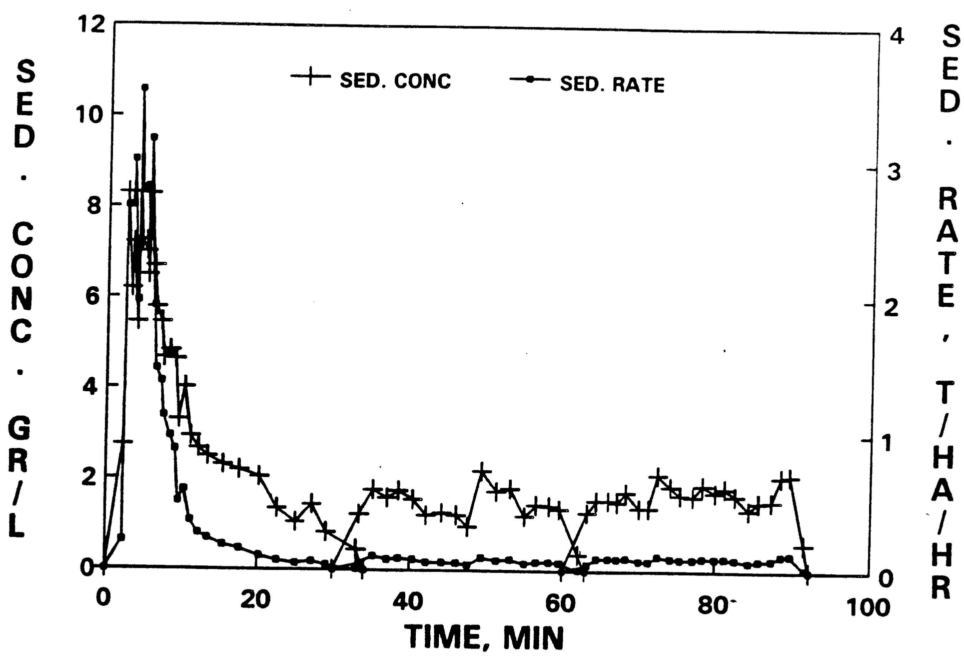

Figure 2. Sedigraph of High Slope (30%) High Intensity Rain Runs, Plot 2, Trial 3.

Table 2. Influence of Time since Burning (Trial), Slope, Antecedent Moisture (Run), and Rainfall Intensity on Sediment Production from Simulated Rainfall.

All Slopes and Runs		All Trials and Runs		All Trials and Slopes	
Trial	Mean Sediment	Slope	Mean Sediment	Run	Mean Sediment
	g	%	g		g
High intensity rainfall runs					
1	24.21ba*	10	15.96b	1	40.08a
2	19.80b	20	26.31b	2	27.21ab
3	37.34a	30	48.48a	3	23.45b
4	39.63a				
High and low intensity rainfall runs combined					
1	23.97ba	10	16.46b	1	31.86a
2	18.72b	20	30.44a	2	22.24b
3	29.57a	30	25.34ba	3	18.13b

*Means with the same letter are not significantly different at 0.05

CONCLUSIONS

This study indicated that runoff and sediment production from 1x5 m plots on burned mixed pine hardwood sites with slope steepness as high as 30 percent and intensity as high as 100 mm/hr is low. Temporal changes in surface conditions during a period of one year was not sufficient to result in significant differences in runoff and sediment production over time. Runoff and sediment production were most closely related to slope and rainfall intensity factor. Relatively high runoff and sediment production values occurred during dry runs on steep slopes at high (100 mm/hr) intensity. This was due to temporary non-wettable condition of the dry organic material covering the surface of mineral soil.

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