RUNOFF AND SOIL LOSS FROM PASTURED LOESS SOILS IN NORTH MISSISSIPPI [1/]

by

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INTRODUCTION

Runoff and erosion studies were initiated in 1957 on pastured areas at the North Mississippi Branch Experiment Station, Holly Springs, Mississippi. These studies were part of an extensive field research program to establish the erosion potential of various soil-cover complexes in the loessial soils of the southeastern United States. After approximately 6½ years of continuous operation these investigations were discontinued at the end of the 1963 calendar year. This paper gives a summary of the data and a discussion of the influence of several management features and topographical characteristics on runoff and erosion.

THE STUDY AREA

The studies were conducted on eight 0.05-acre plots and one 3-acre watershed. Soils in the experimental and surrounding areas have been derived from loess deposits with some outcropping of underlying Coastal Plains material in the small watershed. Physical characteristics and type of management for each experimental area are shown in Table 1. Figure 1 shows the relative locations and topography of the plots and watershed.

1/ A contribution from the USDA Sedimentation Laboratory, Southern Branch, Soil and Water Conservation Research Division, Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the Mississippi Agricultural Experiment Station and the University of Mississippi.

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Table 1.--Physical characteristics of experimental areas

Plot nos.	Type of management	Slope (percent)	Length of slope (feet)	Width (feet)	Area (acres)	Soil type
1 & 5	Improved	10	72.6	30	0.05	Providence silt loam
2 & 6	Improved	5	72.6	30	0.05	Grenada silt loam
3 & 7	Poor	10	72.6	30	0.05	Providence silt loam
4 & 8	Poor	5	72.6	30	0.05	Grenada silt loam
WP-4	Poor	9.2 1/	250.0 1/	525 1/	3.01	2/

1/ Average watershed dimensions.

2/ Soil types as follows: 17 percent Grenada silt loam; 45 percent Providence silt loam; 38 percent Ruston fine sandy loam.

Land Management

Management, in this report, is defined as the control of grazing, fertilization, seeding, and clipping for weed control. "Improved Management" areas were seeded at the beginning of the experiment and subsequently as necessary to maintain good stands of Dallis grass (Paspalum dilatatum) and Kobe lespedeza (Lespedeza striata). They were fertilized annually as recommended by the North Mississippi Branch Experiment Station agronomist. Grazing was controlled to provide vegetation at least 4 inches high throughout the growing season.

"Poor Management" areas were not seeded although reasonably good stands of Dallis grass and lespedeza were present at the beginning of the experiment. Generally, the height of vegetation did not exceed 2 inches during the growing season as these areas were overgrazed continuously and no fertilizer was applied during the entire course of the experiment. Both poor and improved areas were clipped as needed to control weeds.

Instrumentation

A recording-type raingage was centrally located in the experimental area for precipitation measurements (see Figure 1). All plots were equipped with small H-flumes and Coshocton-type wheel samplers for measuring and sampling runoff (see Figure 2). A slightly different arrangement, consisting of a modified Parshall flume, silt box, and slot samplers, was used on the watershed (see Figure 3). Total precipitation and runoff were obtained from each experimental area for each storm. Total soil loss was also obtained for the plots for each storm but soil loss measurements for the watershed were obtained only on a monthly basis.

Precipitation

Average annual precipitation for the 64-year period 1899-1963 at the North Mississippi Branch Experiment Station was 52.34 inches. Annual precipitation during the period of the investigations ranged from 37.23 to 58.71 inches. This represents a relatively wide range in values as 58.71 inches was exceeded only fourteen times during 64 years of records at the Experiment Station, and less than 37.23 inches of rainfall occurred only once during the same period.

RESULTS AND DISCUSSIONS

Data collection began in November 1957. Since both the poor and improved management areas had received the same seed and fertilizer treatments prior to the initiation of the research project, soil-cover conditions at the beginning of the experiment were approximately the same. Consequently, conditions during the early part of the experiment were not representative of the two management levels and data collected during the first 14 months were not used in the analysis of the results. During this adjustment period the improved management plots were adding ground cover as a result of grazing control and additional fertilization. Conversely, cover on the poor management areas was deteriorating.

Annual precipitation, runoff and soil loss from each experimental area, are listed in Table 2. The plot data shown are average values for two replicate plots. Whereas both annual runoff and soil loss usually increased as annual precipitation increased, the mean concentration of sediment in the runoff remained about the same.

Soil losses from the experimental areas, even those under poor management, were very small, ranging from 0.14 ton/acre/year for the 10-percent slope improved management plots to 2.32 tons/acre/year for the watershed. Comparatively higher soil losses from the watershed were attributed to rilling and small gullies that developed on the steeper slopes as vegetative cover deteriorated, particularly during the latter years of the experiment. Soil losses from both plots and watershed were relatively insignificant when compared to losses of 43 tons/acre/year from cultivated fields in the vicinity.1/

Average annual runoff ranged from 9.01 inches on 5-percent slope improved management plots to 17.9 inches on 10-percent slope poor management plots. Monthly precipitation and runoff were fairly evenly distributed throughout the year as shown by the accumulative curves in Figure 4. Average monthly rainfall ranged from 2.12 inches in September to 5.19 inches in February during the period of record. The runoff curves are similar in shape, with the improved management 5- and 10-percent slope curves having almost identical values. The percentage of annual rainfall measured as runoff (percent runoff) ranged from 10 percent from the 5-percent slope improved management plots to 51 percent from the 10-percent slope poor management plots.

1/ Ursic, S. J., and Dendy, F. E., Sediment Yields from Small Watersheds Under Various Land Uses and Forest Covers. Proc. Federal Inter-Agency Sedimentation Conference, USDA Misc. Pub. 970, 1963.

Table 2.--Annual rainfall, runoff and soil loss data from experimental pasture areas 1959-1963

Year	Rain-fall (inches)	10% Improved Mgt. (1 & 5)				10% Poor Mgt. (3 & 7)				5% Improved Mgt. (2 & 6)				5% Poor Mgt. (4 & 8)				3-Acre Watershed (WP-4)			
		Runoff (inches)	Runoff (percent)	Soil Loss (Tons/Acre)	Tons/A./Inch	Runoff (inches)	Runoff (percent)	Soil Loss (Tons/Acre)	Tons/A./Inch	Runoff (inches)	Runoff (percent)	Soil Loss (Tons/Acre)	Tons/A./Inch	Runoff (inches)	Runoff (percent)	Soil Loss (Tons/Acre)	Tons/A./Inch	Runoff (inches)	Runoff (percent)	Soil Loss (Tons/Acre)	Tons/A./Inch
1959	48.50	7.15	15	.16	.02	15.17	31	1.10	.07	6.84	14	.24	.04	10.30	21	.38	.04	13.34	28	1.19	.09
1960	45.28	6.48	14	.14	.02	14.46	32	.62	.04	7.40	16	.16	.02	9.36	21	.26	.03	12.86	28	1.60	.12
1961	58.71	18.60	32	.23	.01	30.05	51	.90	.03	17.54	30	.21	.01	20.07	34	.33	.02	23.37	40	2.03	.09
1962	47.01	10.36	22	.12	.01	19.98	42	.52	.03	9.46	20	.08	.01	14.89	32	.27	.02	17.99	38	3.47	.19
1963	37.23	4.24	11	.06	.01	9.83	26	.33	.03	3.80	10	.04	.01	5.58	15	.11	.02	8.61	23	3.30	.38
5-Yr. Avg.	47.34	9.37	19	.14	.01	17.90	36	.69	.04	9.01	18	.15	.02	12.04	25	.27	.03	15.23	31	2.32	.17

Although soil loss occurred in each month of the year it was not as evenly distributed as rainfall and runoff (Figure 5). On the average, approximately 60 percent of the yearly total occurred during the months of March, April, May and June. Rainfall and runoff during this period were approximately 37 percent and 40 percent, respectively, of the annual total. Again the accumulative curves for improved management 5- and 10-percent slope plots have almost identical values.

The Effect of Vegetative Cover

Forage production from the improved management pasture plots, ranging from 2.33 to 3.47 tons/acre/year, was approximately three times as great as that from the poorly managed areas. This additional forage provided excellent ground cover which was quite effective in reducing both surface runoff and soil loss. Average surface runoff reductions of 25 percent and 48 percent on the 5- and 10-percent slope plots, respectively, were apparently due to better vegetative cover on the improved management plots. Smaller but significant reductions in annual soil loss are also attributed to better cover on the improved management plots.

The Effect of Slope

The effect of slope on runoff and soil loss was almost completely obliterated by better cover on the improved management plots. This is readily apparent from the accumulative curves in Figures 4 and 5. When the quantity of ground cover is reduced, the influence of slope becomes more evident as shown by the curves for the 5- and 10-percent slope poor management plots. Average annual runoff for the 5-percent slope poor management plots was only 67 percent of that for the 10-percent slope plots for the period of record. Although insignificant quantitatively, there were also corresponding differences in soil loss attributable to slope on the poor management plots (Figure 5).

The Effect of Antecedent Soil Moisture

Although known to exert considerable influence on the quantity of runoff and possibly soil loss, the effect of soil moisture cannot be detected from monthly totals (Table 2). The effect of antecedent moisture is best illustrated by single

rainfall events occurring when other variables were relatively constant. Two such events with approximately the same amount of rainfall, 0.83 and 0.85 inch, and approximately the same erosion index values, 1488 and 1369 units, were selected. (The erosion index is a measure of the ability of rainfall to cause erosion, and is determined by multiplying the maximum 30 minute intensity of the storm by the kinetic energy of rainfall.) 2/ These storms occurred during mid-summer, July 25, 1962 and August 5, 1960, and vegetative cover was approximately the same for both events. Antecedent moisture conditions were relatively wet prior to the August 5 storm when compared to conditions prior to the July 25 storm. Runoff and soil loss data for these two storms are listed in Table 3. Although other factors may have been involved, significant reductions in runoff rates, illustrated graphically in Figures 6 and 7, and volumes, tabulated in Table 2, are attributed primarily to antecedent moisture conditions.

SUMMARY

Erosion experiments on loess soils in northern Mississippi show that soil losses from pasture areas are relatively insignificant. Average annual losses for a 5-year period ranged from 0.14 ton/acre for 5-percent slope improved management plots to 2.32 tons/acre on a 3-acre poor management watershed. Average annual runoff ranged from 9.01 inches on 5-percent slope improved management plots to 17.9 inches on 10-percent slope poor management plots. Although both cover and land slope are shown to influence runoff and soil loss, the excellent ground cover provided by vegetation on improved management plots almost obliterated the effect of slope between slopes of 5 and 10 percent. Antecedent soil moisture is shown to influence runoff rates and amounts significantly on a storm basis.

2/ Wischmeier, W. H., and Smith, D. D., Rainfall Energy and Its Relationship to Soil Loss, Trans. American Geophysical Union, Vol. 39, No. 2, April 1958.

Table 3.--Runoff and soil loss from 0.05-acre pasture plots for two comparable rainstorms with different antecedent conditions

Slope	Management	Rainfall = 0.85 in. WET ANTECEDENT SOIL MOISTURE CONDITIONS			Rainfall = 0.83 in. DRY ANTECEDENT SOIL MOISTURE CONDITIONS		
		Runoff (inches)	Runoff (percent)	Soil Loss (Tons/A.)	Runoff (inches)	Runoff (percent)	Soil Loss (Tons/A.)
5%	Poor	0.59	69	0.006	0.07	8	0
10%	Poor	0.62	73	0.007	0.18	22	0.01
10%	Improved	0.34	40	0.001	0.01	1	0

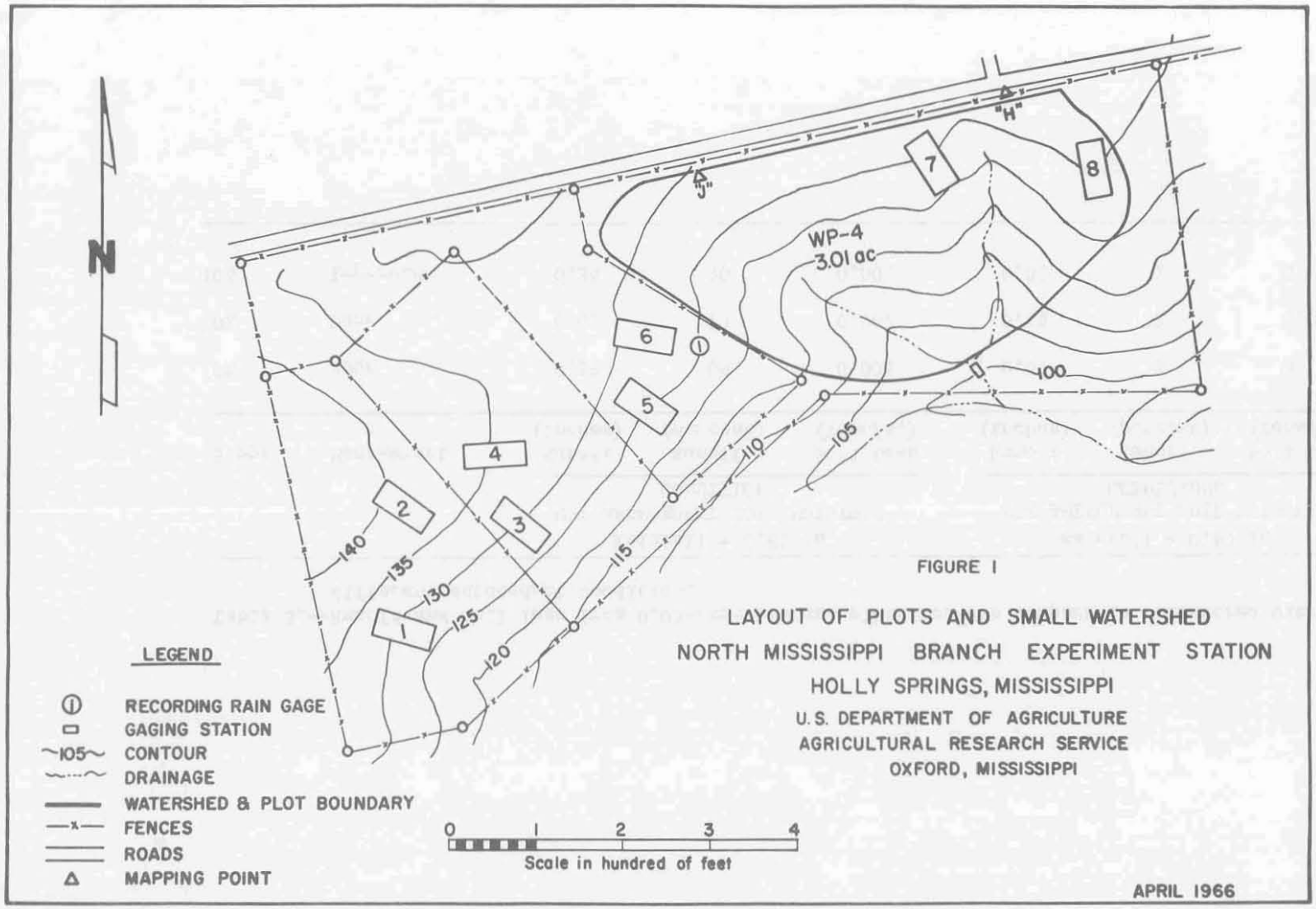

FIGURE 1

LAYOUT OF PLOTS AND SMALL WATERSHED
NORTH MISSISSIPPI BRANCH EXPERIMENT STATION
HOLLY SPRINGS, MISSISSIPPI
U.S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
OXFORD, MISSISSIPPI

APRIL 1966

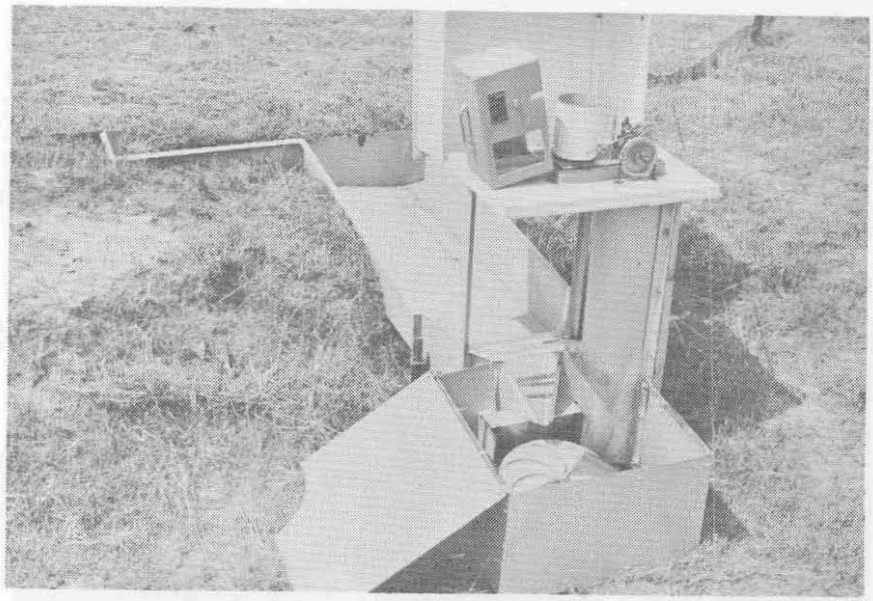

Figure 2 - Plot instrumentation included H-flume, water stage recorder and Coshocton-Type wheel sampler.

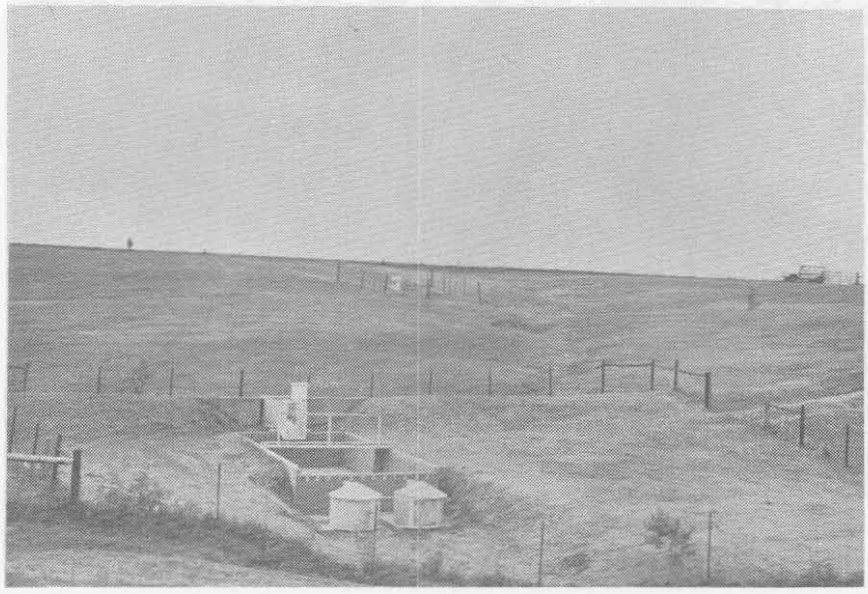

Figure 3 - Watershed instrumentation included modified Parshall flume, water stage recorder, silt box, slot sampler, and sample collection tanks.

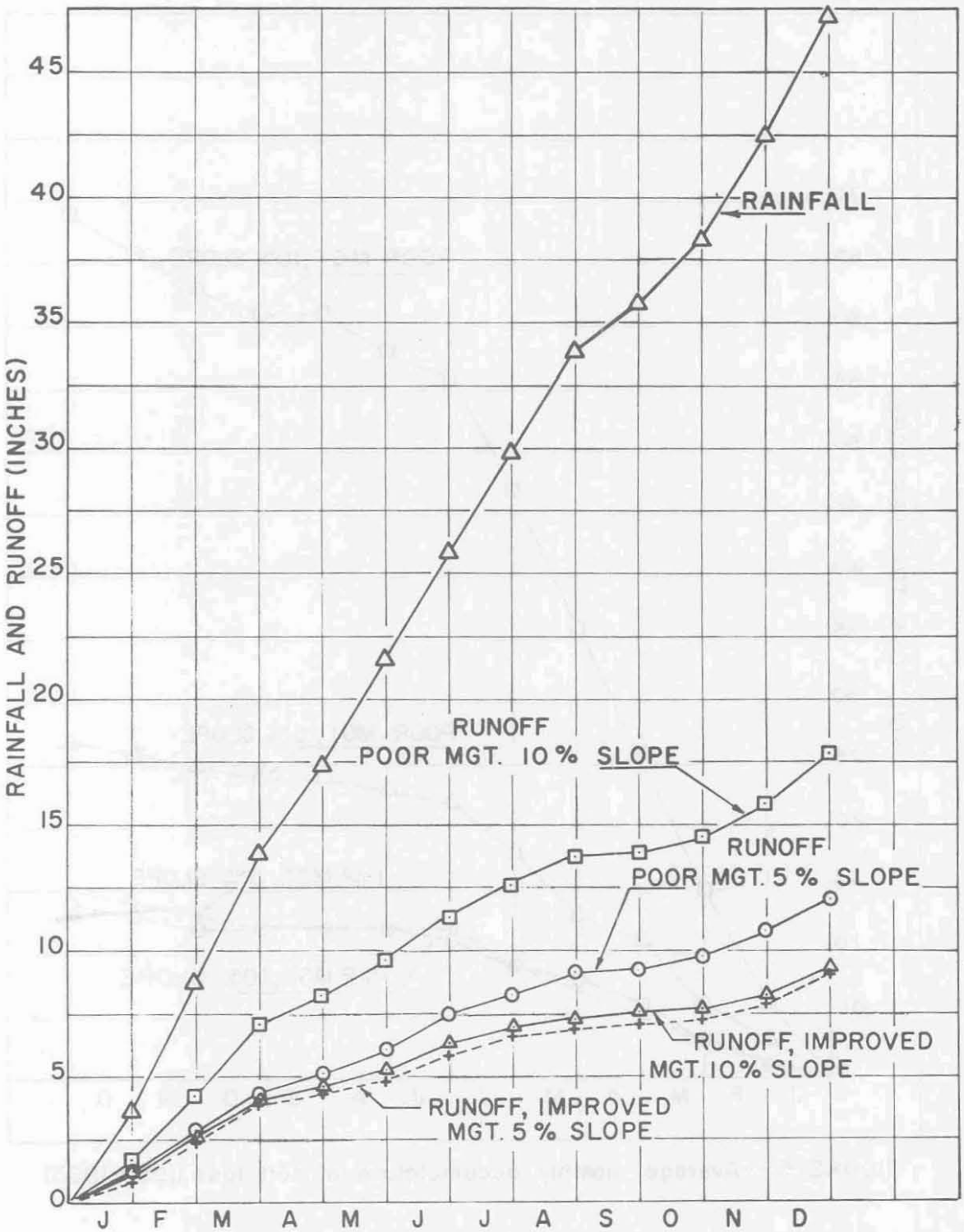

FIGURE 4.--Average monthly accumulation of rainfall and runoff.(1959-1963)

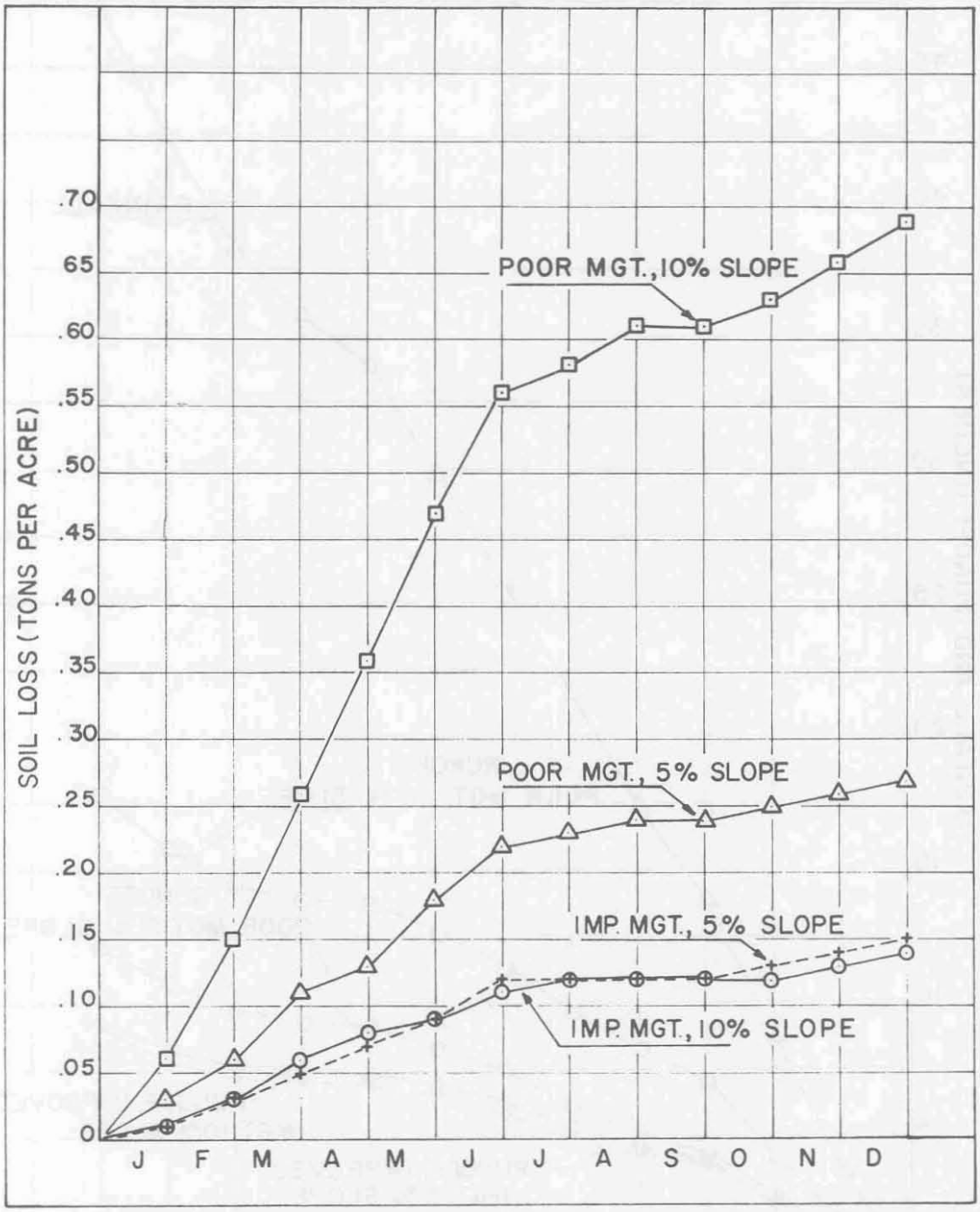

FIGURE 5.--Average monthly accumulation of soil loss (1959-1963)

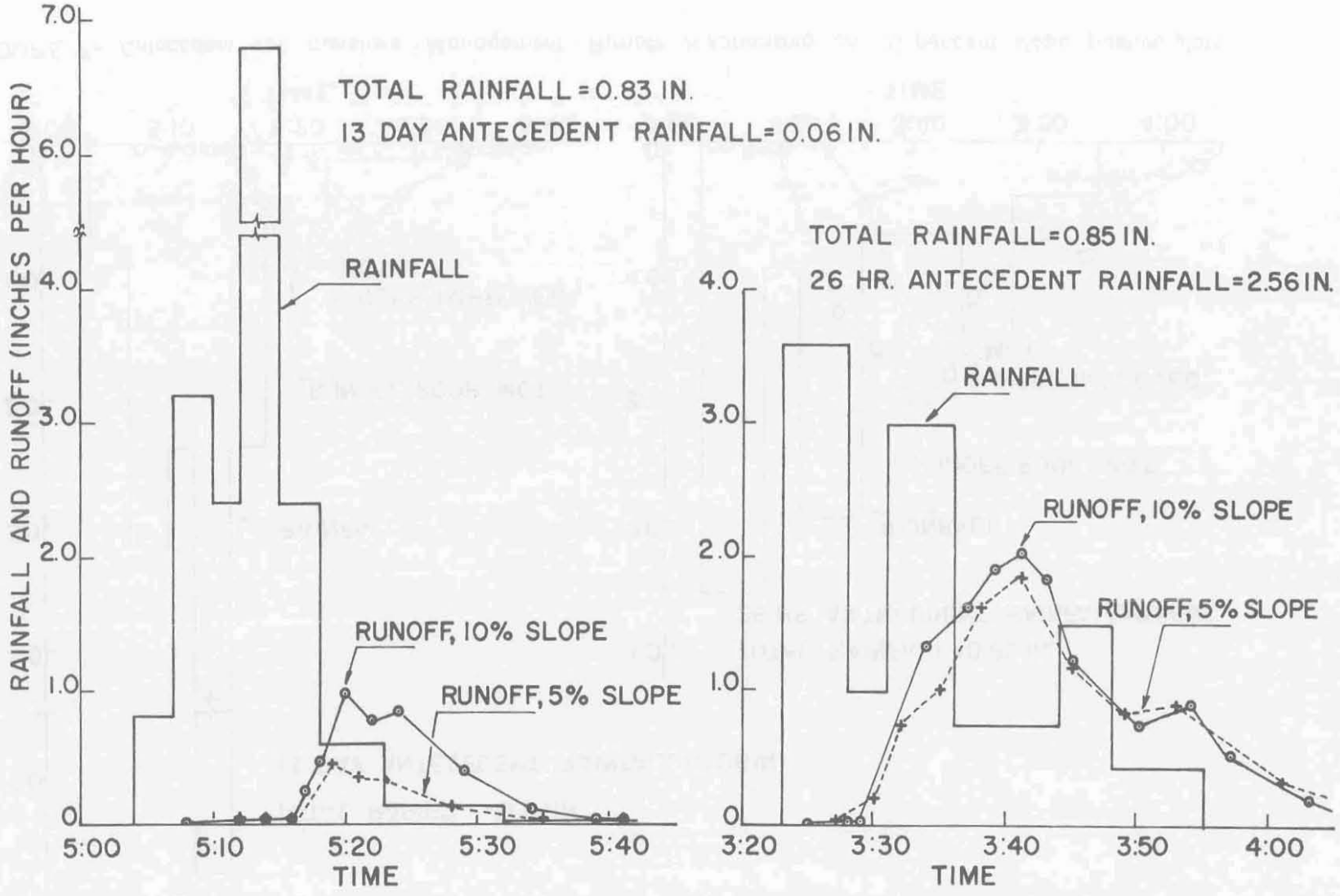

FIGURE 6.-- Antecedent soil moisture - Slope - Runoff relationships on poor management pasture plots.

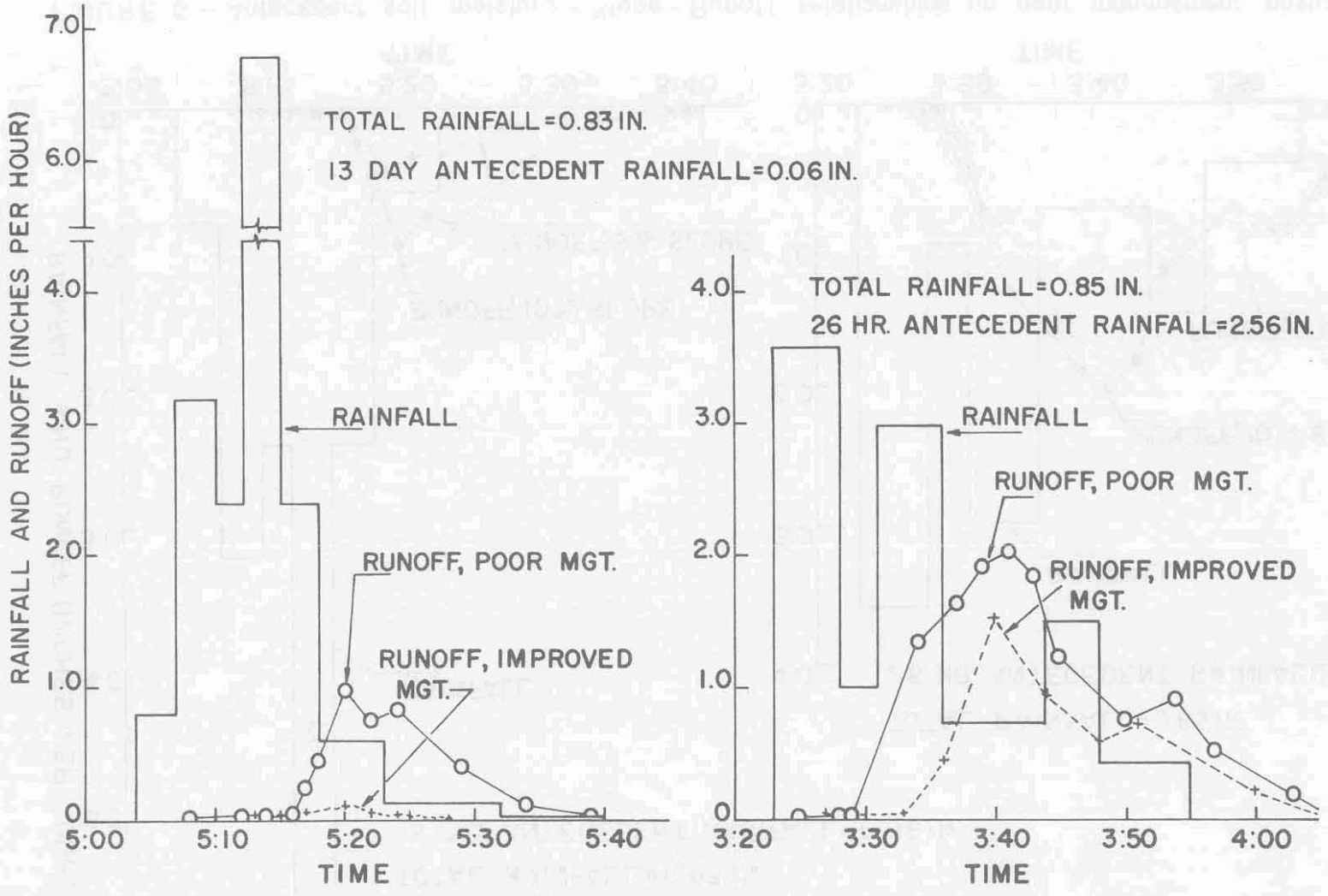

FIGURE 7.-- Antecedent soil moisture - Management - Runoff Relationship on 10 percent slope pasture plots.