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Interflow in Claypan Soils[1]

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Abstract. Storm runoff amounts from drainage areas of several square miles have often been estimated by direct application of runoff data from small plots and single-cover watersheds. Data presented here attest to the existence of gains from interflow or quick-return flow on midwest claypan soils under conditions of high antecedent soil moisture. Lesser storm periods with low antecedent moisture conditions show transmission losses on these same areas. For these reasons, weighted plot runoff cannot be accepted as a true representation of watershed runoff. Further evidence of interflow and its evaluation was obtained in 1963 on small irrigated plots at the University of Missouri Experiment Station Farm near McCredie, Missouri. These studies will be continued for another year or two.

INTRODUCTION

There is evidence that not all the flow measured as runoff from plots or watersheds on claypan prairie soils is surface flow. Runoff measured at a gaging station may include water that enters the soil upslope and returns as interflow downslope.

The claypan prairies and associated soil types were developed from loess over glacial till and residuum from limestones. These soils have moisture-impeding layers at depths of 10–25 inches. When they are protected by a good vegetative cover, they will absorb precipitation rather rapidly until the surface layer approaches saturation; additional precipitation will then result in high runoff. The claypan soils are quite extensive in southern Illinois, Missouri, and eastern Kansas.

Variations in runoff between plot and watershed, as illustrated by data presented here, may be a particular characteristic of claypan soils. An awareness of the magnitude of these variations will caution the hydrologist on the limitations of his data and aid him in its interpretation.

[1] Contribution from the Corn Belt Branch, Soil and Water Conservation Research Division, Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the Illinois and Missouri Agricultural Experiment Stations.

Definitions. The terms used are defined as follows.

1. Runoff: All flow that passes over the weir or through the measuring flume, including surface runoff and any interflow or quick return flow. Runoff expressed as inches over the drainage area.
2. Surface runoff: That part of the precipitation that reaches the stream channel or gaging station by flowing continually over the surface of the ground.
3. Interflow: That part of the precipitation that infiltrates into the soil, moves through the permeable surface layer, and returns to the surface above the gaging station.
4. Transmission losses: Infiltration of surface runoff into the watershed or streambed material en route to the gaging station.
5. Antecedent precipitation index (API): An empirical measure of the effect of precipitation falling a given number of days prior to the date selected (see equation 1).
6. Equal infiltration potential (EIP): Refers to those areas of the watershed that have similar infiltration characteristics.
7. Recession: That part of the falling limb of the hydrograph after the point of inflection.

Data presented here, indicating the presence of interflow, are the results of two years of in-

(over)

tensive study of 6- by 12-foot rectangular plots and two small watersheds of 27 and 50 acres near Edwardsville, Illinois; and an 8-year record from continuous corn plots 90 and 420 feet long, and from selected storms on a 420-foot-long pasture plot on the University of Missouri Experiment Station near McCredie.

EDWARDSVILLE, ILLINOIS, WATERSHEDS AND PLOTS

Description of areas. Three small watersheds were established near Edwardsville, Illinois, in March 1938 and discontinued in December 1955. The soils on these areas, because of their low infiltration rates, have many periods of runoff each year that can be directly attributed to a particular period of precipitation. Data from these areas afford an excellent opportunity for comparisons between plot runoff and watershed runoff. From 1940 to 1943 a detailed infiltration study was conducted on two of the areas, designated as W-1 (a 27.2-acre cultivated area) and W-2 (a 50-acre pasture area).

Watershed W-1 is fan-shaped, with a range in elevation of 20 feet, and more than two-thirds of the area has slopes of less than 1%. This watershed was all in alfalfa hay during the period 1940–1944.

Watershed W-2 is oval-shaped and has a length of about 1½ times its width. The difference in elevation between the divide and the runoff station is 39 feet. The upper third of the area has an average slope of 1.5%, and the third near the waterways has 12% slopes. The entire watershed was in bluegrass and lespedeza pasture during the study period.

From May 1940 to July 1941 an intensive infiltrometer survey was made on these two watersheds to determine the variability in infiltration [*Sharp et al.*, 1949]. Water was applied by sprinklers on 6- by 12-foot plots at 54 widely scattered locations. The results of these studies on plots having different cover densities, topsoil depths, soil temperatures, slopes, and soil moisture content at the start of the infiltrometer run showed that only three of these characteristics were significantly related to infiltration. These characteristics were cover density, soil depth, and soil moisture content. Figure 1 shows the areas of equal infiltration potential (EIP) and the location of the 6- by 12-foot plots selected for study with natural rainfall.

Based on the above infiltrometer survey, four 6- by 12-foot semipermanent plots on watershed W-1 and five plots on watershed W-2 were selected in July 1941 and instrumented for the measurement of rainfall and runoff. Each of these semipermanent plots represented an EIP area different in some characteristic from the rest of the watershed. Records of runoff from natural rainfall were obtained from these plots simultaneously with the watershed runoff records from July 1941 to June 1943. Slopes, topsoil depths, cover type and density, and EIP areas, expressed as a per cent of the total watershed area, are given below.

Plot No.	Slope, %	Depth of Topsoil, in.	Vegetal Cover	Cover Density, %	EIP Area, %
		Watershed W-1			
61	11.15	5	Alfalfa	15	12.06
62	0.35	14	Alfalfa	15	47.32
63	2.40	15	Alfalfa	20	19.63
64	3.55	12	Alfalfa	12	20.99
					100.00
		Watershed W-2			
65	1.05	18	Lespedeza	50	25.68
66	11.56	4	Lespedeza	20	19.83
67	1.47	15	Bluegrass	45	13.28
68	0.65	18	Bluegrass	100	24.32
69	10.63	8	Bluegrass	98	16.89
					100.00

Basic data. Precipitation during the period 1938–1947 was measured with one recording gage located near the weir on W-1 and two recording gages on W-2. An additional recording gage was located at each of the semipermanent plots during the latter part of the infiltration study from July 1941 to June 1943.

Runoff from the watersheds was measured with laboratory-calibrated concrete V-notch, broad-crested weirs equipped with water stage recorders. Runoff from the 6- by 12-foot plots was measured in two 29.7-inch-diameter tanks installed in tandem, equipped with water stage recorders and a small float wheel, so that each traverse across the 5-inch-wide chart represented a change in stage of 6 inches. Each tank had a total capacity of 3 inches of runoff and was equipped with a hook gage, so that the

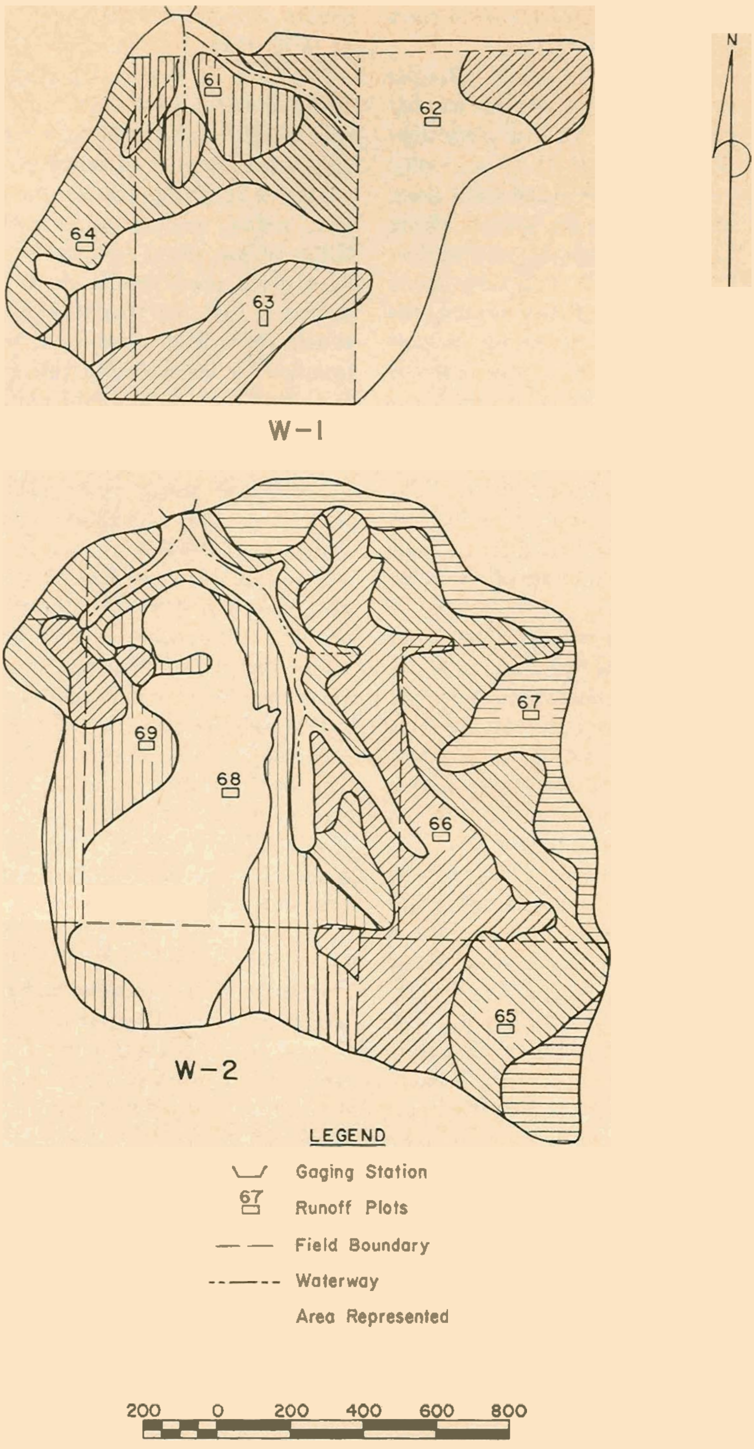

Fig. 1. Map of Edwardsville, Illinois, watersheds.

depths could be read to the nearest 0.001 foot, as a check against the recorder chart.

Relation of plot to watershed runoff. Results of the studies on runoff from natural rainfall on the semipermanent 6- by 12-foot plots were summarized in SCS TP-81 [*Sharp et al.*, 1949]. Table 1 shows plot and watershed data from W-1. Some of these data are for periods within a storm when there was a lapse in precipitation that made subdivision possible. This table shows that, for more than half of the storms, the total plot runoff, weighted according to percentage of area represented, was more than the measured watershed runoff. These reductions in measured runoff at the weir amounted to as much as 50% of the weighted average; they could be considered transmission losses. The sum of all 24 loss values in storms for the two years of record on W-1 was over 2 inches (Table 1) or 10% of the weighted plot runoff for these storms.

The plots varied in their relative amounts of runoff according to antecedent soil moisture conditions. Under low-antecedent moisture, the flattest plot (number 62) usually had the least runoff. Total runoff from plot 61 for the first year through June 1942 was more than double the total runoff from plot 63; but for the last year, July 1942 to June 1943, it was only 75% as much. As the soils approached saturation, the flat plots frequently showed runoff exceeding the runoff for steeper plots. This tendency for a reversal in behavior is well illustrated in Table 1. The point of reversal is undoubtedly influenced by the depth of topsoil. Plot 61, with a slope of 11.15%, had less runoff than any other plot for about half of the storms. Perhaps one reason for this phenomenon is that the flat plots absorbed a greater portion of high intensity rainfalls and thus became saturated sooner than the steep plots.

Table 2 shows individual plot and watershed runoff data from watershed W-2. One-third of the storms produced more runoff from the watershed than from any individual plot. Plot 66 had about 4 times as much total runoff as plot 67 (under average antecedent moisture) from October 1941 through May 1942, but it had only 12% more from November 1942 through June 1943 when soil moisture was high. Plot 66, which was the steepest and had the least depth of topsoil and the lowest cover density, produced more runoff than any of the plots for three-fourths of the storm periods.

Since use of weighted plot data as shown in Table 2 would result in an underestimation of watershed runoff by 27%, interflow was probably a sizeable part of runoff on watershed W-2.

Figure 2, giving the accumulated precipitation, runoff, and errors of estimation for the entire period, shows that use of plot data would have given good results on W-1. For the few storms in 1941, the weighted plot and watershed runoff from W-2 agree very well, showing no interflow or losses during this period. The 1942 and 1943 plot data would underestimate total runoff on W-2 each year by more than 2.5 inches. The waterways on W-2 are more pronounced and deeply entrenched than those on W-1, and they probably intercepted larger amounts of interflow.

Figure 3 shows precipitation, plot runoff, and watershed runoff for the storm of June 6, 1943, on W-2. Base flow at the beginning of this storm was 0.0003 inch per hour, and 30 hours after the end of rainfall the flow rate was still 0.0005 inch per hour. Runoff from the watershed exceeded the weighted plot runoff by 0.28 inch. The hydrograph for this storm was separated into its component parts following the method developed by *Barnes* [1939]. This separation suggests that about 20% of the difference was base flow and the remaining 80% was interflow.

MCCREDIE, MISSOURI, PLOTS

Records of precipitation and runoff have been collected at the Midwest Claypan Experiment Station near McCredie, Missouri, on plots 10.5 feet wide by 90 feet long and 103.7 feet wide by 420 feet long under various cover and cultural conditions. These plots are on Mexico silt loam and have reasonably uniform slopes of about 3%. Plot borders of sheet metal were imbedded into the soil to a depth of 8 inches, and the downstream cutoffs did not penetrate to the claypan layer. Thus the metal borders were not the cause of interflow returning to the surface above the measuring flume.

Comparison of runoff from plots of different lengths in continuous corn, under full fertility treatment, is shown in Table 3. Runoff from the 420-foot plots was more than double the runoff from the 90-foot plots for the eight years 1955 to 1962. Two-thirds of this difference oc-

TABLE 1. Watershed and Plot Runoff Data by Storm Periods for Watershed W-1, Edwardsville, Illinois

Date	Mean Precipitation, in.	Antecedent Moisture,* %	Runoff, in. Plot 62 (0.35)†	Plot 63 (2.40)	Plot 64 (3.55)	Plot 61 (11.15)	Wtd. Average	Measured W-1	Difference§
1941									
July 9	1.02	9	0.07	0.12	0.26	0.47	0.17*e*¶	0.06‡	+0.11
10	1.30	9	.43	.32	.62	.81	.49*e*	.25‡	+.24
Sept. 2	1.70	10	.23	.31	.65	.79	.40	.25	+.15
2	0.68	10	.06	.14	.29	.42	.17	.14	+.03
Oct. 17	1.29	19	.05	.10	.12	.60	.14	.19	−.05
22	.50	24	.03	.07	.06	.33	.08	.09	−.01
22	.45	24	.06	.17	.10	.39	.13	.15	−.02
22	.26	24	.03	.12	.09	.24	.09	.10	−.01
30–31	1.97	25	.08	.09	.56	.81	.27	.39	−.12
Nov. 5–6	2.00	25	1.21	.78	1.12	.83	1.06*e*	.75‡	+.31
1942									
April 8	0.66	22	0.54	0.01	0.07	0.01	0.27	0.20	+0.07
June 13	1.13	20	.14	.05	.08	.34	.13	.14	−.01
21	1.34	20	.34	.25	.49	.52	.38	.31	+.07
26	1.70	22	.75*e*	.67	1.02	.82	.80	.83	−.03
July 8–9	3.98	24	2.50*e*	2.93	2.32	2.29	2.52	2.53	−.01
9–10	.86	28–30*e*	.76	.66	.67	.58	.70	.67	+.03
12	.47	28	.01	.03	.03	.05	.02	.07	−.05
Aug. 6	1.16	22	.13	.22	.23	.24	.18	.22	−.04
7	.82	23	.22	.25	.22	.43	.25	.24	+.01
Oct. 29–30	2.03	19	.02	0	0	.24	.04	.08	−.04
Nov. 17	.83	22	.23	.14	.39	.53	.28	.31	−.03
22	.98	23	.84	.12	.40	.53	.57	.50	+.07
Dec. 27	2.29	23	2.22	2.32	2.07	1.17	2.08	1.84	+.24
1943									
Feb. 3	0.63	27	0.07	0.54	0.49	0.28	0.28	0.29	−0.01
Mar. 16	.82	28	.74	.74	.83	.10	.68	.48	+.20
19	.54	28	.48	.51	.60	.19	.48	.38	+.10
May 7	1.21	26	.64	.17	.18	.16	.39	.24	+.15
8	.36	27	.22	.25	.04	.01	.16	.08	+.08
10	.41	28–30	.34*e*	.31*e*	.29	.07	.29	.20	+.09
10	.27		.22	.25*e*	.28	0	.21	.18	+.03
10–11	.43		.45	.45*e*	.50	.28	.44	.40	+.04
11	.20	Soil moisture	.16	.18*e*	.19	.03	.15	.15	0
15	.28	data says	.22	.23*e*	.25	.13	.22	.22	0
15–16	.25	'Water stand-	.13	.15*e*	.16	0	.12	.14	−.02
16	.37	ing on sur-	.17*e*	.18*e*	.20	.11	.17	.19	−.02
17	.58	face of entire	.58	.53*e*	.51	.46	.54	.52	+.02
17	1.23	project May	1.15*e*	1.15*e*	1.17	1.16	1.16	1.17	−.01
17	.54	11–18.'	.50	.50*e*	.52	.49	.50	.46	+.04
17	.99		1.01	.92*e*	.93	.88	.96	.91	+.05
17–18	1.39		1.34	1.33*e*	1.34	1.29	1.33	1.27‡	+.06
19	.60		.51	.48*e*	.45	.15	.45	.48	−.03
June 6	1.22	27	.92	.88	.51	.59	.79	.74*e*	+.05
10	.91	27	.48	.61	.42	.28	.47	.40	+.07

* Per cent of dry weight at depth interval 15–19 inches.
† Figures in parentheses represent land slope.
‡ Watershed runoff less than for any plot.
§ Plus sign shows weighted plot runoff too high due to transmission losses. Minus sign shows weighted plot runoff too low due to gains from interflow.
¶ *e*, estimated, due to leakage or plugged channels.

TABLE 2. Watershed and Plot Runoff Data by Storm Periods, Watershed W-2, Edwardsville, Illinois

Date	Mean Precipitation, in.	Antecedent Moisture,* %	Runoff, in.							
			Plot 68 (0.65)†	Plot 65 (1.05)	Plot 67 (1.47)	Plot 69 (10.63)	Plot 66 (11.56)	Wtd. Average	Measured W-2	Difference§
1941										
Oct. 9	0.61	18	0.03	0.08	0.12	0.30	0.45	0.18	0.13	+0.05
17	1.26	20	.01	.10	.11	.39	.89	.29	.30	−.01
22	.56	24	.08	.15	.19	.29	.55	.24	.20	+.04
22	.52	24	.08	.16	.21	.37	.45	.24	.24	0
22	.27	24	.01	.07	.04	.16	.26	.10	.10	0
31	1.31	25	.29	.18	.04	.26	.93	.35	.50	−.15
Nov. 5–6	1.96	26	1.73	1.56	.57	.51	1.27	1.24	1.04	+.20
1942										
Mar. 7–8	0.62	23	0.20	0.21	0.02	0.07	0.06	0.13	0.24‡	−0.11
April 7	.58	20	0	0	0	.03	.11	.03	.13‡	−.10
8	.66	20	.06*e*¶	.11	.03	.09	.21	.10	.33‡	−.23
9	.15	21	.10*e*	.14*e*	0	.04	.14	.09	.14‡	−.05
May 5–6	1.08	21	0	.05	.05	.12	.30	.10	.18	−.08
15	.99	21	0	0	0	.04	.15	.04	.13	−.09
June 13	1.16	20	0	.22	.36	.39	.59	.29	.35	−.06
21	1.71	21	.24	.32	.69	.84	.94	.56	.75	−.19
26	1.74	22	.78	.52	.62	.80	.98	.74	1.07‡	−.33
July 8	.73	22	0	0	.03	.14	.16	.06	.10	−.04
8	3.29	24	1.80	2.08	1.89	2.29	2.58	2.12	2.35	−.23
9	.70	26	.37	.14	.05	.19	.29	.22	.35	−.13
9	.23	26	.05	0	0	.03	.01	.02	.11‡	−.09
9–10	.79	26	.58	.34	.56	.52	.48	.49	.66‡	−.17
14	.58	25	.01	0	0	.05	.13	.04	.16‡	−.12
21	.71	24	0	0	.06	.20	.31	.10	.11	−.01
Aug. 6	1.10	20	.14	.34	.33	.52	.74	.40	.41	−.01
7	.82	21	.11	.19	.24	.40	.54	.28	.36	−.08
Nov. 5	.96	20	0	0	0	.05	.20	.05	.12	−.07
17	.78	22	0	.16	.17	.46	.67	.27	.28	−.01
22	1.04	23	.02	.05	.01	.25	.59	.18	.40	−.22
Dec. 27	2.40	24	1.04	2.23*e*	1.63	1.03	.95	1.40	1.82	−.42
1943										
Feb. 3	0.64	26	0.00	0.05*e*	0.01	0.04	0.08	0.04	0.19‡	−0.15
Mar. 16	.49	27	.10	.36	.17	.20	.18	.21	.30	−.09
16	.35	28	.26	.36	.32	.26	.31	.30	.31	−.01
19	.53	28	.26	.42	.39	.31	.39	.35	.41	−.06
May 7	1.21	24	.01	.44	.19	.46	.51	.32	.55‡	−.23
8	.31	25	.02	.03	0	.05	.10	.04	.12‡	−.08
10	.43	26	.13*e*	.10	.15*e*	.18	.26	.16	.25	−.09
10	.28	27	.08*e*	.12	.10*e*	.04	.19	.11	.22‡	−.11
10–11	.42	27–30	.19*e*	.37*e*	.27*e*	.27	.40	.30	.40‡	−.10
11	.20		.09*e*	.16	.02*e*	.06	.15	.11	.17‡	−.06
15	.33		.05*e*	.26	.19*e*	.18	.28	.19	.22	−.03
15–16	.23		.03	.18	.07*e*	.02	.14	.09	.17	−.08
16	.35		.02	.17	.16*e*	.12	.26	.14	.21	−.07
17	.51		.30	.52	.33*e*	.34	.45	.40	.49	−.09
17	1.26		1.07	1.17	1.05*e*	1.01	1.25	1.12	1.21	−.09
17	.57		.40	.55	.39*e*	.36	.55	.46	.53	−.07
17	.96		.83	.92	.80*e*	.82	.92	.87	.94‡	−.07
17–18	1.61		1.26	1.49	1.20*e*	1.21	1.59	1.37	1.56	−.19
19	.60		.13	.47	.28*e*	.23	.51	.33	.54‡	−.21
June 5	.86	25	0	.07	0	.02	.24	.07	.15	−.08
6	1.48	26	.39	.66	.64	.84	.92	.67	.93‡	−.26
10	.74	27	.12*e*	.37	.23	.18	.40	.26	.33	−.07

* Per cent of dry weight at depth of 18 to 22 inches.

† Figures in parentheses represent land slopes.

‡ Watershed runoff higher than on any of the plots.

§ Plus sign shows weighted plot runoff too high due to transmission losses. Minus sign shows weighted plot runoff too low due to gains from interflow.

¶ *e*, partially estimated.

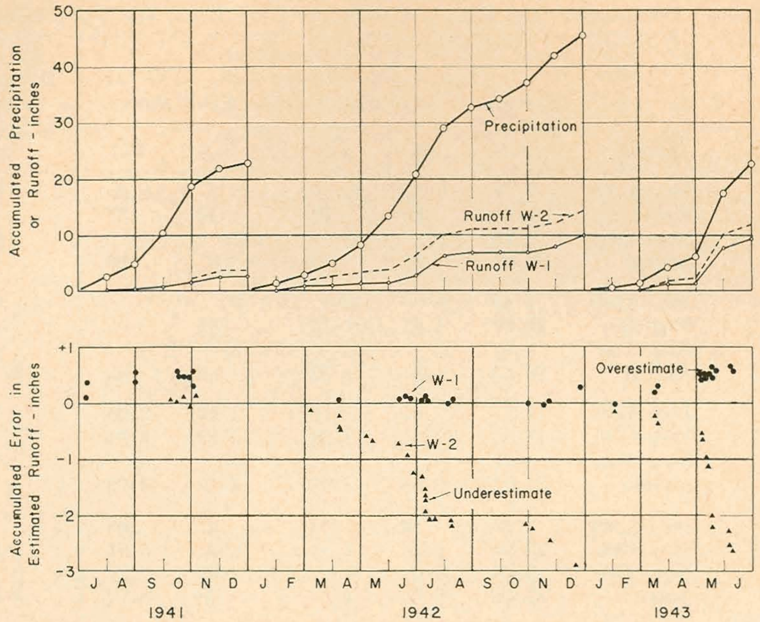

Fig. 2. Precipitation, runoff, and errors in estimating watershed runoff from weighted plot runoff, Edwardsville, Illinois, watersheds.

curred during the dormant season from November through April. Only in 1958 and 1961, the two wettest years, was there any marked increase in runoff from the longer plots during the growing season.

The only other year showing high summer runoff was 1957, when all four of these corn plots produced about the same amount of runoff. Nearly all of this 1957 summer runoff resulted from an intense rainfall totaling 4.25 inches on June 29–30. This storm was preceded by less than 1 inch of precipitation in the previous three weeks; thus the more than 2 inches that infiltrated during this storm did not

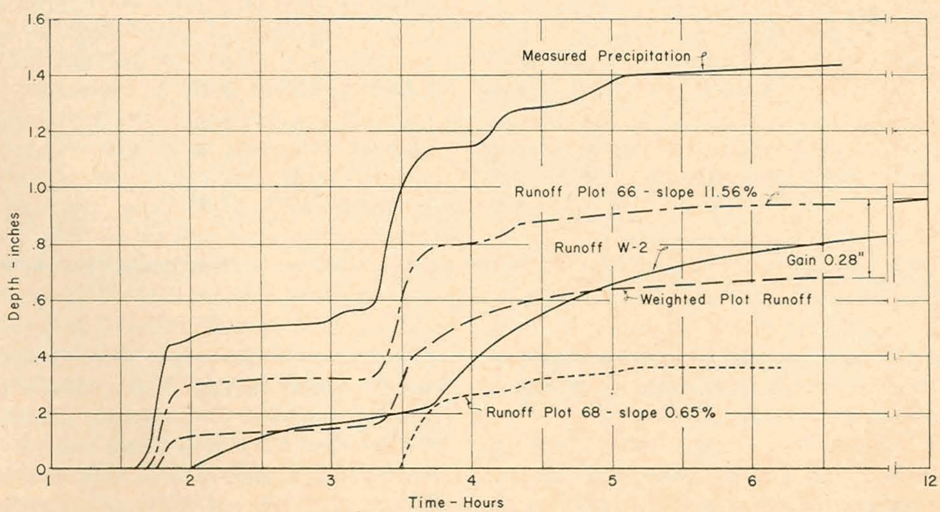

Fig. 3. Precipitation, plot, and watershed runoff for June 6, 1943, Edwardsville, Illinois, watershed W-2.

TABLE 3. Precipitation and Runoff, Continuous Corn Plots, McCredie, Missouri

Year	Season	Precipitation, in.	Runoff, in. 90-ft Plots* #6	90-ft Plots* #22	420-ft Plots† P-2	420-ft Plots† P-3	Average Differences between Long and Short, in.
1955	Jan.–April	9.38	0.27	0.44	0.57	0.22	0.04
	May–Oct.	21.90	.30	.12	.30	.38	.13
	Nov.–Dec.	0.79	0	0	0	0	0
	Annual	32.07	.57	.56	.87	.60	.17
1956	Jan.–April	4.41	0	0	0	0	0
	May–Oct.	20.01	1.31	1.72	.35	.93	−.87
	Nov.–Dec.	4.41	0	0	0	0	0
	Annual	28.83	1.31	1.72	.35	.93	−.87
1957	Jan.–April	11.67	.67	.70	2.29	2.54	1.73
	May–Oct.	17.83	2.01	2.28	2.23	2.24	.09
	Nov.–Dec.	4.77	0	0	0	0	0
	Annual	34.27	2.68	2.98	4.52	4.78	1.82
1958	Jan.–April	7.95	.10	.03	.97	.63	.73
	May–Oct.	25.90	2.23	1.84	3.22	3.04	1.10
	Nov.–Dec.	3.44	0	0	.09	.10	.10
	Annual	37.29	2.33	1.87	4.28	3.77	1.93
1959	Jan.–April	9.01	2.03	2.14	2.87	2.72	0.71
	May–Oct.	21.33	.89	.92	1.08	.72	0
	Nov.–Dec.	1.55	0	0	.06	.04	.05
	Annual	31.89	2.92	3.06	4.01	3.48	0.76
1960	Jan.–April	8.66	.01	.18	3.33	3.08	3.11
	May–Oct.	16.16	.09	.06	.43	.34	.31
	Nov.–Dec.	3.33	0	0	.01	0	0
	Annual	28.15	.10	.24	3.77	3.42	3.42
1961	Jan.–April	10.43	.32	.53	2.92	1.83	1.95
	May–Oct.	26.42	2.15	1.89	5.22	4.22	2.70
	Nov.–Dec.	4.45	.23	.09	1.16	.97	.90
	Annual	41.30	2.70	2.51	9.30	7.02	5.55
1962	Jan.–April	7.53	1.24	1.51	3.12	3.70	2.04
	May–Oct.	16.04	0	0	0	0	0
	Nov.–Dec.	1.78	0	0	0	0	0
	Annual	25.35	1.24	1.51	3.12	3.70	2.04
8-Year Average, 1955–1962	Jan.–April	8.63	.58	.69	2.01	1.84	1.28
	May–Oct.	20.70	1.12	1.10	1.60	1.48	.43
	Nov.–Dec.	3.07	.03	.01	.17	.14	.14
	Annual	32.40	1.73	1.80	3.78	3.46	1.85

* Plots 6 and 22 farmed up and down slope.

† Plot P-3 farmed on the contour. Plot P-2 farmed on the contour 1955–1958; up and down slope 1959–to 1962.

completely fill the soil profile above the claypan. With the soil profile unsaturated there was no excess moisture to cause interflow.

For May through October 1956, there was a reversal of the general trend, and the long plots had less than half as much runoff as the short plots. Nearly all runoff in the summer of 1956 resulted from 8.70 inches of precipitation in two and one-half weeks in July. Precipitation from November through June totaled only 11.4 inches as compared with a normal precipitation of more than 22 inches. There was no runoff from these plots during these eight months, and the soil moisture was fairly well depleted by July. This low soil moisture caused some of the surface runoff from the upper end of the long

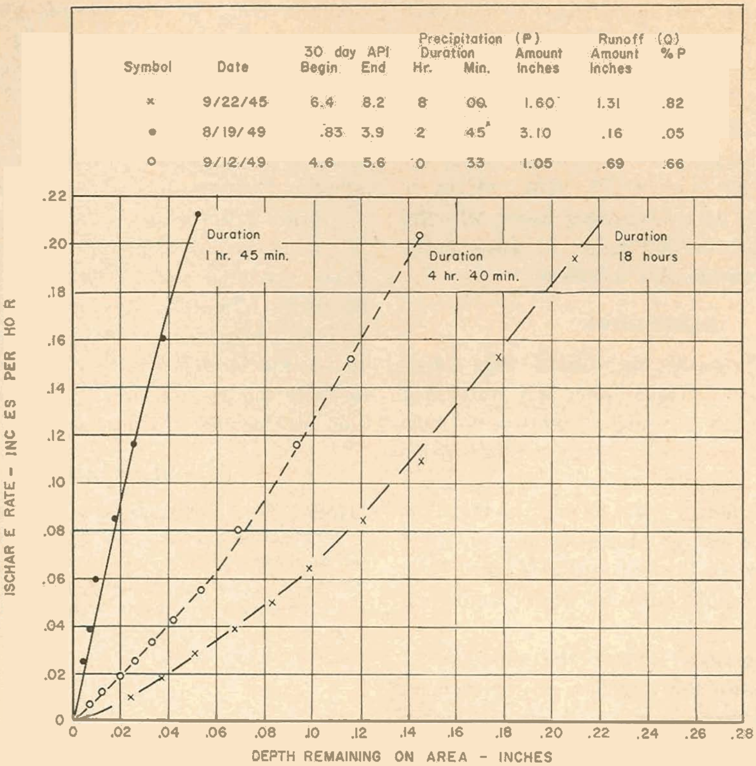

Fig. 4. Recession volume curves for McCredie, Missouri, pasture plot 7 under different antecedent moisture conditions.

plots to infiltrate before reaching the gaging station.

The effect of direction of farming on runoff is shown by comparison of plots P-2 and P-3. Plot P-3 was formed on the contour for the entire eight years; P-2 was contour-farmed the first four years, then farmed up and down slope. For the first four years there was very little difference in total runoff from these two plots. The last four years show 20.20 inches from P-2 and 17.62 inches from P-3, with most of the difference coming in the wet year 1961.

Because of the presence of transmission losses or gains from interflow there is no one standard recession or depletion curve for this soil type. If a recession could be established that had neither losses nor gains the volume between this and any other recession would be a direct measure of such losses or gains. The larger the interflow contribution to runoff the longer will be the recession time.

Figure 4 shows the depth and duration of runoff remaining under the falling limb of the hydrograph on 420-foot pasture plot 7 for three summer storms with different antecedent moisture conditions. In this figure the depth remaining on the area is the amount of runoff, after a specified rate on the recession, that will eventually pass through the gaging station. The antecedent precipitation index (API) is used to indicate soil moisture conditions at the time of the storm.

$$API = P_0 + P_1k + P_2k^2 + P_3k^3 \cdots P_nk^n$$

where P_0 refers to precipitation within the 24 hours prior to the storm; P_1, P_2, P_3 indicate precipitation 1, 2, 3 days prior to the storm; n denotes the number of days used to establish the index (in this case 30); and k is a constant depending on soil type (0.95 used for claypan areas). The remaining depths are all subsequent to the point of inflection on the falling limb of the hydrograph.

For the storm of August 19, 1949, the indicated storage depth at a discharge rate of 0.20 inch per hour amounted to 0.05 inch and runoff continued only 1 hour and 45 minutes. In contrast the September 22, 1945, storm had a depth of 0.21 inch and a duration of 18 hours after the same discharge rate. The small depth remaining for the August 19, 1949, storm is probably caused by transmission losses, whereas the greater depth on September 22, 1945, probably includes considerable interflow.

CONCLUSIONS

Analysis of Edwardsville, Illinois, data shows that the relation between plot and watershed runoff depends on antecedent moisture condition of the soil. Data from different plot lengths at McCredie, Missouri, generally show higher runoff from the longer plots during the dormant season. Summer storms of high intensity, short duration, or low antecedent moisture show little difference in runoff between short and long plots.

These comparisons suggest the existence of transmission losses and interflow on the claypan soils. If these losses or gains can be evaluated quantitatively, it may become possible to estimate runoff from watersheds by applying correction factors to plot runoff. Such correction factors will probably need to take into account the duration and amount of precipitation, antecedent moisture conditions, and physiographic features of the watershed.

Studies initiated on former pasture plot P-7 of the Missouri Experiment Station in 1963 have provided some additional information. Sprinkler irrigation was used to accelerate this research, instead of waiting for natural rainfall to produce a saturated soil profile. The results of these studies are being prepared for publication in a sequel to this report.

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