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The Effect of Slope on Soil Erosion

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Soil erosion is a process that is affected by rainfall, vegetative cover, slope of land and soil conditions. Much investigational effort has been expended to determine the relative importance of the various factors concerned. The Missouri Agricultural Experiment Station began an investigation in 1917 in order to determine the influence of systems of cropping and methods of culture on surface runoff and soil erosion. The results of the first six years of this investigation were published in 1923[1]. The results after fourteen years were published in 1932[2]. The effects of different crops and cropping systems, collectively considered as cover, are now generally understood.

An investigation was begun in 1925 by F. L. Duley and M. F. Miller in order to determine the effects of length and degree of slopes on soil erosion. The project was operated for 11 years, and then discontinued because of other uses of the land. This report gives the results of this investigation.

A number of soil erosion experiment stations have been established since 1930 by the Federal Soil Conservation Service[3] and Missouri College of Agriculture. The effect of slope on soil erosion has been investigated at most of these stations. As a consequence there is now available a mass of data and information from which it is possible to evaluate the effect of various slope factors on soil erosion and water runoff. The results obtained at these stations are in general agreement, in so far as the erosion conditions are comparable, with those reported here as more distinctly applicable to the glacial soils so extensively developed in northern Missouri and adjacent states.

Plan of the Investigation

The plan of the investigation was modeled in general after that of the earlier work at the Missouri station. Eight elongated plots, arranged in pairs, as given in Fig. 1, were placed so as to extend up and down a uniform slope. The plots were six feet wide,

[1]Erosion and Surface Runoff Under Different Soil Conditions. Missouri Agricultural Experiment Station Research Bulletin 63, 1923.

[2]The Influence of Systems of Cropping and Methods of Culture on Surface Runoff and Soil Erosion. Missouri Agricultural Experiment Station Research Bulletin 177, 1932.

[3]Annual reports (unpublished) U. S. Soil Conservation Experiment Stations in Missouri.
Bethany Station, established 1930.
McCredie Station, established 1939.

and of three lengths, namely, 60, 90, and 150 feet. The area of the plots varied according to the length, 1/120, 1/80, and 1/48 acre, respectively. The plots were separated by sheet iron strips, which were about 18 inches wide and set into the soil about 12 inches. The catchment basin at the lower end of each plot was a square concrete tank, and of such size as to hold all runoff water from a heavy rain.

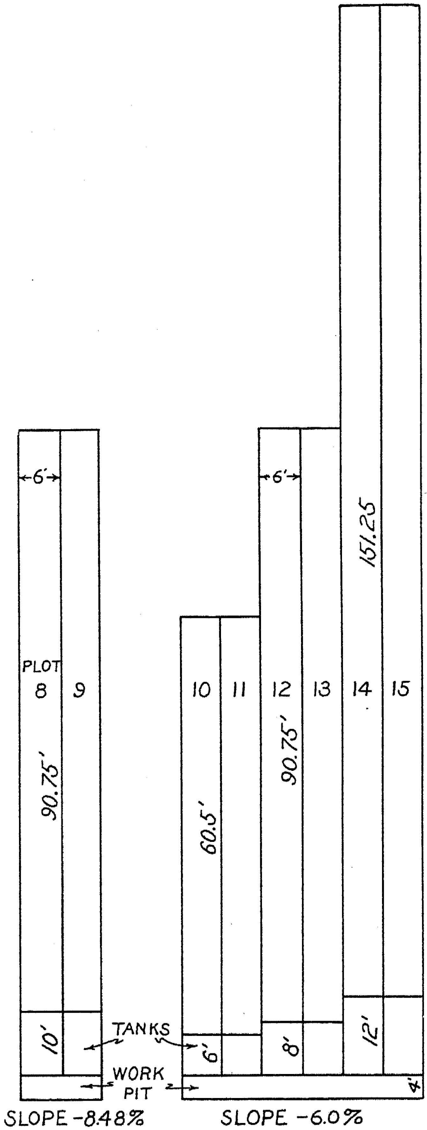

Fig. 1.—Arrangement of Plots.

The plots were located in an open field area with a northern exposure. The land had previously been farmed, but had not been fertilized or limed. The six plots with lengths 60, 90, and 150 feet had a slope or gradient, of 6 per cent. Two additional plots 90 feet in length, were included because they had a steeper slope of 8.48 per cent. The latter were located about 50 feet east of the former. At the beginning of the experiment the surface of all plots was leveled to a uniform grade. This required some removal and slight filling, but did not modify the general condition of the soil.

The soil type, a light colored phase of Shelby loam, is simlar to that used in the earlier investigation. The surface soil is a gray-brown loam about 12 inches in depth. In a textural classification it will rate as a silt loam, although it contains very fine sand. The subsoil is a gray-brown changing to a yellow-brown, plastic, sandy clay. It is not compact, but is slowly permeable. The structure of the top soil is moderately granular, but tends to form clods easily, and compact at the surface. In general, the soil at this location is lighter in color and lower in productivity than is characteristic of the Shelby loam in northwestern Missouri. It erodes easily which is attributed to the loamy texture and also to the tendency of the soil to shrink and swell under different moisture conditions. The content of organic matter in the surface soil is about 2 per cent. A part of the surface soil had been removed by erosion previous to the establishment of this experiment.

Two cropping systems were used—continuous corn, and a three year rotation of corn, wheat and clover (Table 1*). These systems were the same as those used on some of the plots in the earlier erosion investigation. The continuous growing of corn is an extreme condition of cropping, and the soil and water losses obtained under this crop were naturally higher than is characteristic under average farming practices. On the other hand, the losses under the corn, wheat, clover system were rather low. All cultural practices were such as prevail in general farming. Land for corn was prepared in April, and planted in early May. Spading the ground was always to a uniform depth of 7 inches. Level cultivation, three or four times, was practiced. Wheat was sown about October 1. Red clover failed frequently, but usually the ground was covered with an equivalent stand of wild grasses and lespedeza. This grass cover developed quickly after the wheat was removed. It is assumed that its effect on erosion was the same as that of clover. No fertilizer was applied to any of the plots.

Climatological Record

The climate in the region of Columbia is temperately warm, moderately humid. It is continental in type as indicated by the wide fluctuations in temperature and rainfall. The weather conditions during the time of this experiment are recorded in Tables 2 and 3. It should be noted that the temperature and rainfall varied widely from the normal during different seasons and years.

Temperature

Temperature as a factor in soil erosion is of minor importance. In some winters the ground was frozen for several months. The depth of freezing rarely extended below 8 to 10 inches, and the soil generally thawed slowly because of the north exposure. Slow thawing of deep frozen ground caused the surface soil to creep or flow. Such mass movement, although infrequent, was of signi-

*All tables are collected in the Appendix, Pages 20 to 25.

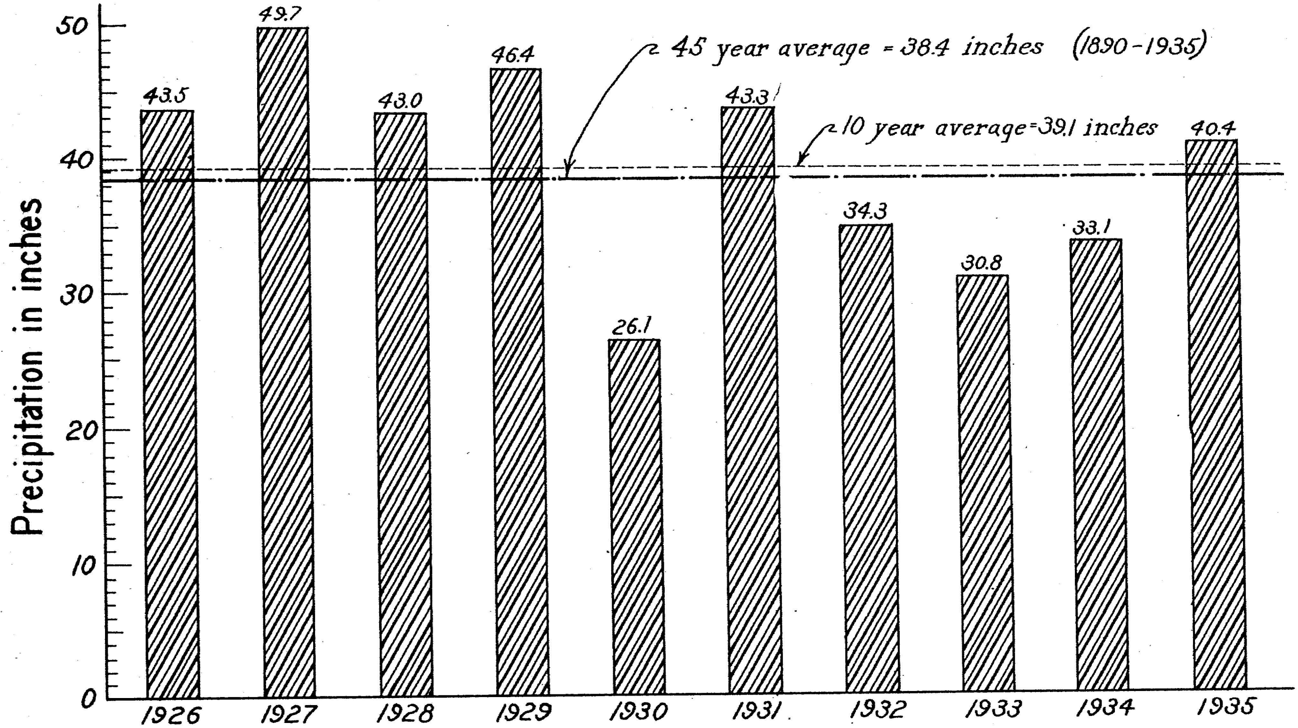

Fig. 2.—Precipitation for each year and the averages for the ten years under investigation and the 45 years 1890-1935.

ficance in increasing erosion, especially at the lower end of the plots. It occurred mainly in late winter when the soil was saturated with water.

Precipitation

Runoff and soil erosion are related to the amount, intensity and time of rainfall. During 6 years of the investigation the rainfall was above the normal (Figure 2). Two of these years had the highest soil and water losses. The number of torrential rains of one inch or over varied from 5 in 1930 and 1933 to 15 in 1927. The frequency of such rains has a closer relation to runoff and erosion than the total annual rainfall. The highest monthly rainfalls occurred in June, May and September (Figure 3 and Table

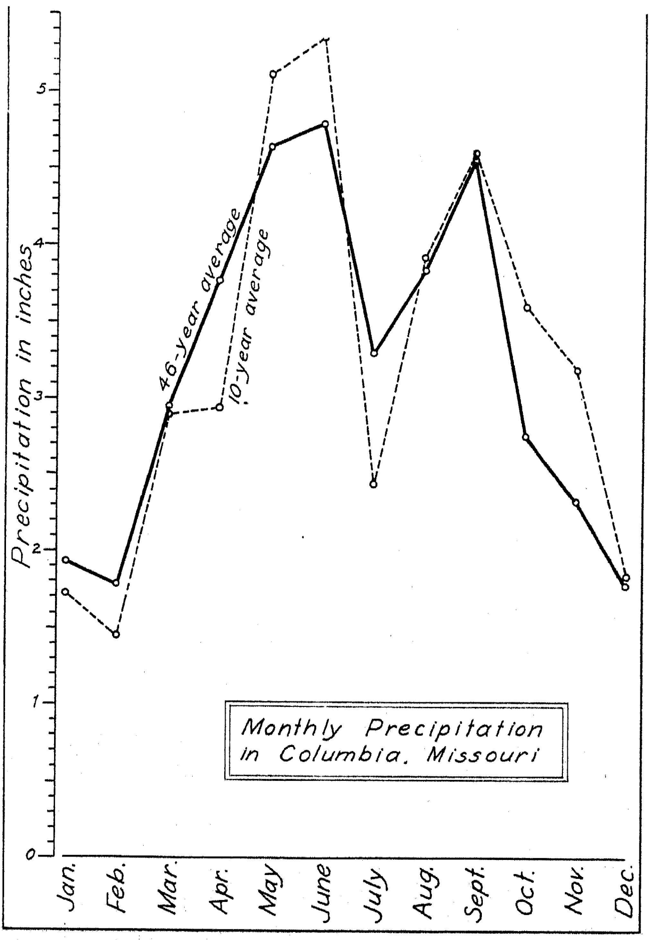

Fig. 3.—Mean monthly precipitation during the ten years of the investigation as compared with the average of 46 years.

4). Soil erosion, also, was largest in these months. The summer months of both 1927 and 1928 were characterized by high rainfall. In June, 1928 the precipitation was more than 14 inches. The entire year 1930 was characterized by low rainfall, which totaled only 26.16 inches. The wide deviation in precipitation from the average annual rainfall is indicated in Table 5.

Runoff Losses

Various conditions of slope, cover and soil have a marked effect on the amount of water running off the surface of the soil. Tables 6 and 7 show the average monthly and annual runoff on different slopes for the period of the investigation. Runoff decreases with

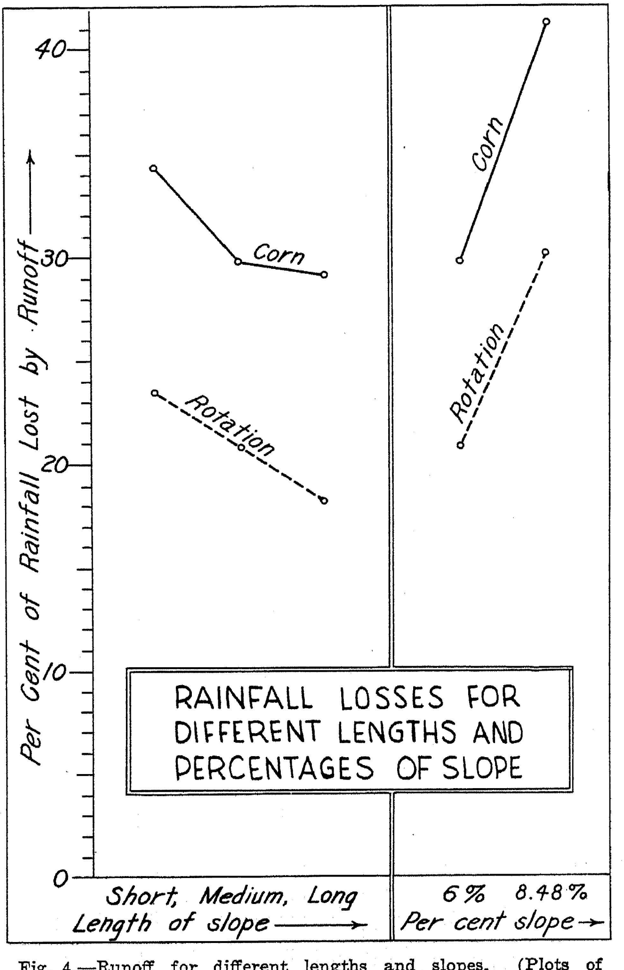

Fig. 4.—Runoff for different lengths and slopes. (Plots of different lengths had a slope of 6 per cent, plots of different slopes had a length of 90 feet.)

length of slope but increases with steepness of slope. On long slopes and slopes of low gradient water has more time to be absorbed into the soil. The marked effect of vegetation or cover is indicated in Figure 4. Runoff from land in continuous corn is approximately 50 per cent greater than from land that has a rotation of crops.

A comparison of runoff by months indicates that the water loss is greatest in the months of highest rainfall—June, May and September (Figure 5). Observations at Columbia,* and else-

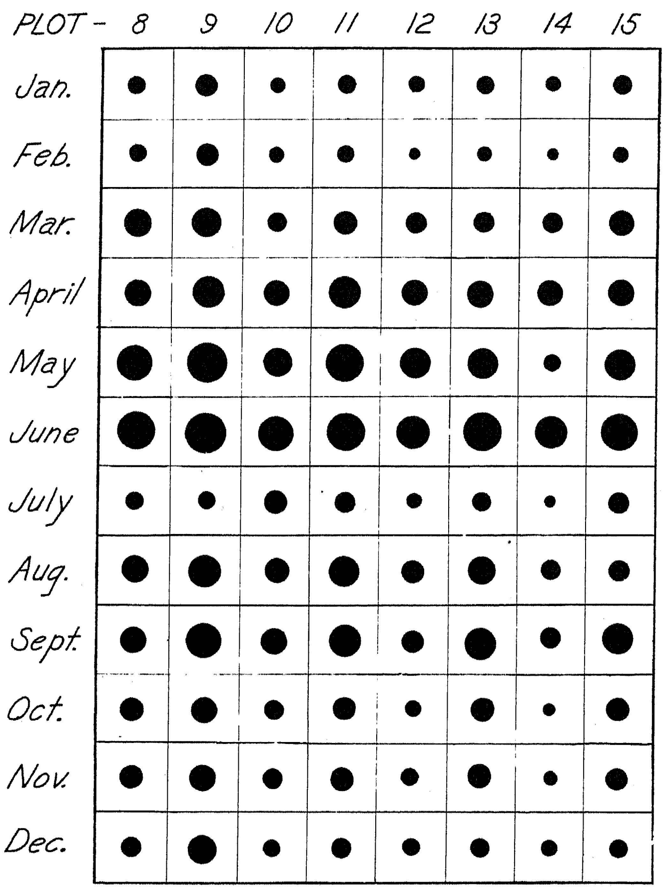

Fig. 5.—Relative magnitudes of runoff for each of the different plots by months.

where indicate that the per cent of runoff is highest in seasons of frequent rainfall, when the soil is moist or saturated. Such conditions generally prevail in May and June. The wide variation in

*Missouri Agricultural Experiment Station Research Bulletin 280.

per cent of runoff for different years is evidence that the amount and intensity of rainfall are more important than length of slope, Tables 8 and 9. Differences in degree of slope have more effect on runoff than differences in length of slope. This is illustrated in the following table. Data from plots with same cropping system—corn, wheat, and clover.

Length of slope	Per cent runoff	Degree of slope	Per cent runoff
60 ft.	23.4	3.68%	13.8*
90	20.7	6.00	20.7
120	18.1	8.48	30.0

*Missouri Agricultural Experiment Station Research Bulletin 280.

Erosion

The results of this investigation have been duplicated by experimental studies elsewhere, and show that soil erosion increases with increase in length and degree of slope. This relationship is most apparent under conditions of poor cover. Under continuous corn the soil losses ranged from 43 tons per acre for the short slope to 72 tons for the long slope. These losses were from 300 to 600 per cent greater than the losses from the corresponding slopes under a rotation cropping system. These differences are graphically indicated in Figure 6.

The results indicate that under a good cropping system, length of slope is relatively unimportant. However, if long slopes are frequently used for cultivated crops, such as corn, then shortening the slopes by means of terraces or other devices becomes increasingly important. Under continuous corn, an increase of 30 feet in slope length, resulted in an increased soil loss of about 14 tons per acre. A noticeable effect of erosion on long slopes was the tendency for some of the eroded soil to accumulate at the lower end of the slope. This tendency may possibly be attributed to the greater soil load or higher density of the water and its slower movement as it reaches the lower part of the slope. The accumulation of soils on the lower part of long, gentle slopes is a common observation on gently rolling land.

An increase of 2 per cent in steepness of slope, that is from 6 to 8 per cent, more than doubled the soil losses for both systems of cropping used in this investigation. The results emphasize again the effect of cover on soil erosion. The Shelby soils are noted for their erodibility even on gentle relief. The growing of intertilled crops generally results in rapid soil deterioration. A cropping system largely based on grass is best adapted to this type of land.

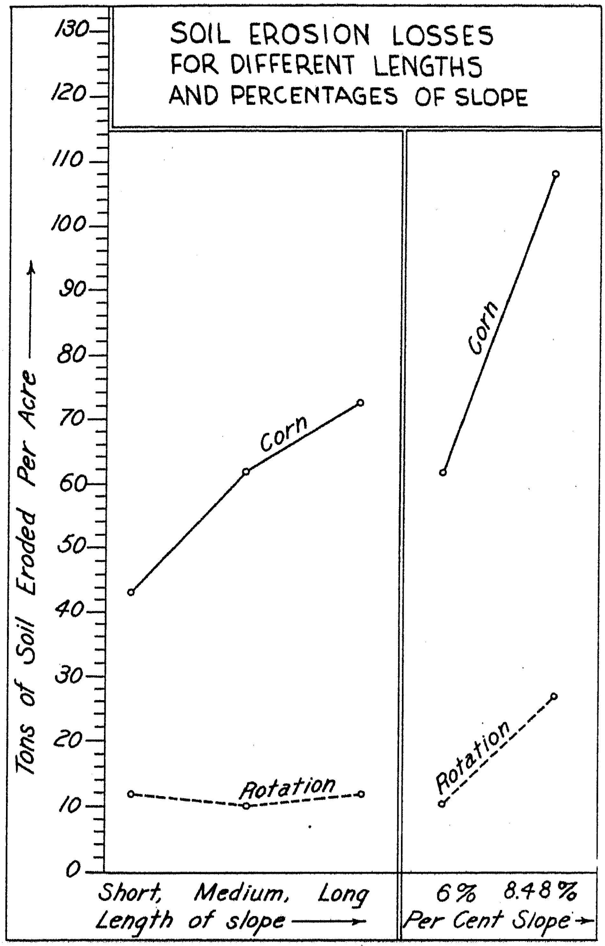

Fig. 6.—Erosion for different lengths and slopes. (Plots of different lengths had a slope of 6 per cent, plots of different slopes had a length of 90 feet.)

The following table shows soil erosion from plots in corn, when grown in different cropping systems. Comparisons are average for the years 1926, 1929, 1932, and 1935 when all plots were in corn.

EFFECT OF CROPPING SYSTEM ON SOIL LOSS BY EROSION.

Slope	Corn in rotation	Continuous corn
6%	18.1 tons/acre	51.5 tons/acre
8	37.2	94.1

The relative monthly erosion shows some striking contrasts. The month of June is consistently high. It also is the month of highest rainfall, and of most frequent torrential rains. The erosion from the continuous corn plots is especially high. At this season the corn does not cover the surface, the surface soil is generally loose from cultivation, and heavy torrential rains have maximum effect. Another peak period in erosion is during August. This also is a period of torrential and heavy rains. In general, the majority of erosion occurs from May to September, which corresponds to the season of highest rainfall. These relationships are indicated in Tables 10 and 11, and Figure 7.

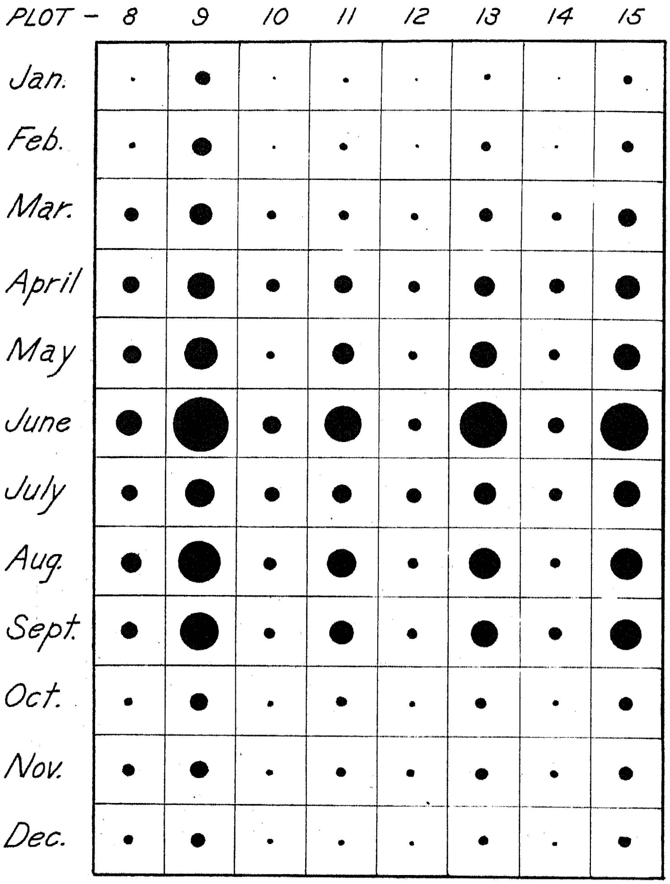

Fig. 7.—Relative magnitudes of erosion for each of the different plots by months. (Plots with odd numbers were in corn ontinuously.)

The wide annual fluctuations in rainfall and erosion are made evident by comparing the results for 1927, a wet year, (49.7 inches) with 1930, a year of low rainfall (26.16 inches). In both years the rotation plots were in wheat. Soil losses ranged from 24 to 32 tons per acre in 1927, to approximately one ton per acre in 1930. Under continuous corn the soil losses in 1927 were approximately ten times greater than in 1930. In both years most of the rain came in the spring months. The number of rains causing runoff in 1927 was 24, while in 1930 the number was 10. The total of all rains causing runoff in 1927 was 31.4 inches, and in 1930 it was 15.7 inches.

Discussion

The results of this investigation indicate that cover, or the cropping system, is the most important factor affecting runoff and erosion (Table 12). Regardless of the degree or length of slope, and the time or intensity of the rain, soil and water losses were lowest whenever the ground was covered with vegetation. Degree of slope and the amount and intensity of the rainfall also have profound effects on erosion, but these factors are variable and their influence is greatly modified by the density of the cover. Vegetation is relatively more effective in retarding erosion than in reducing the runoff. This is graphically shown in Figures 8 to 11, and Tables 13 and 14.

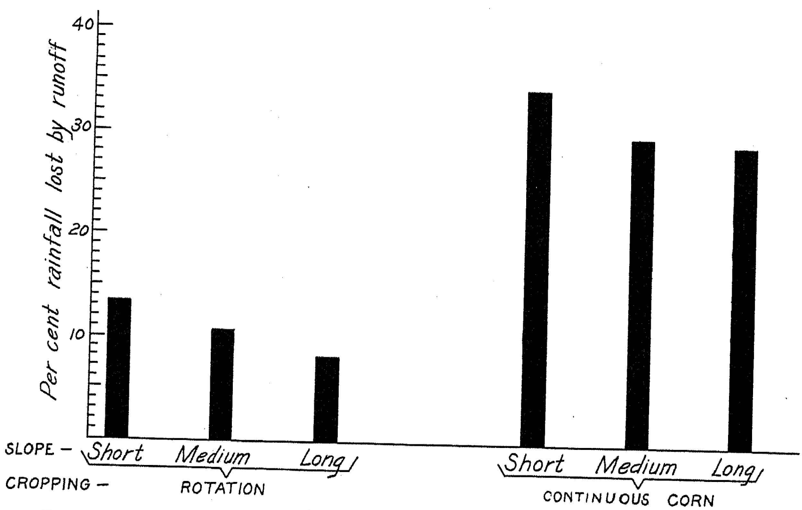

Fig. 8.—Per cent runoff for different cropping systems on different lengths of slope, but the same degree of slope, 6 per cent.

Length of slope is probably the least significant of the factors affecting runoff and erosion. This is again most apparent under conditions of good cover (Tables 15 and 16). Length of slope is readily modified under erosion control practices. Terraces, con-

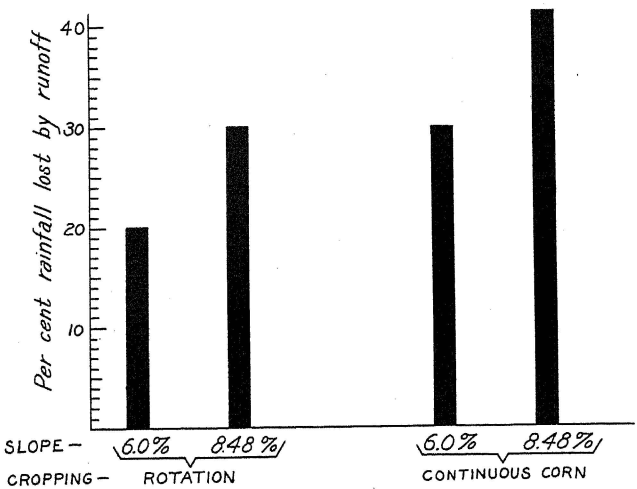

Fig. 9.—Per cent runoff for different cropping systems on different degrees of slope, with the same length of slope, 90 feet.

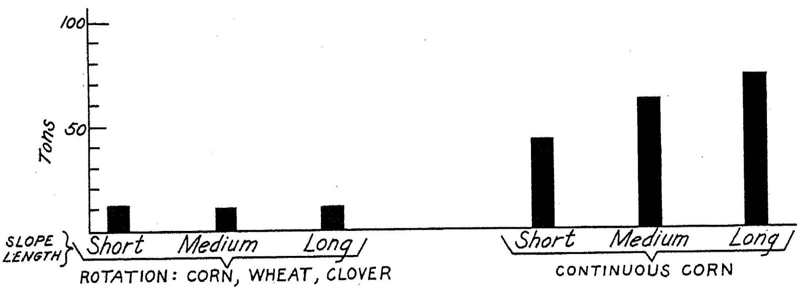

Fig. 10.—Soil losses for different cropping systems on different lengths of slope but of the same degree of slope, 6 per cent.

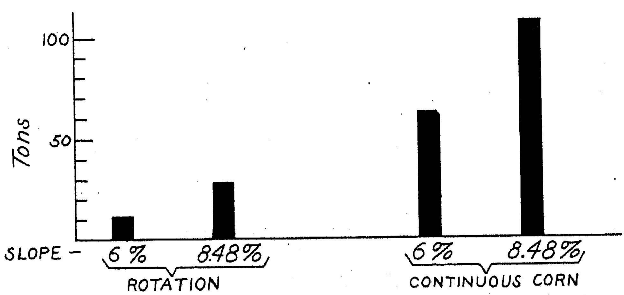

Fig. 11.—Soil losses for different cropping systems on different degrees of slope, with the same length of slope, 90 feet.

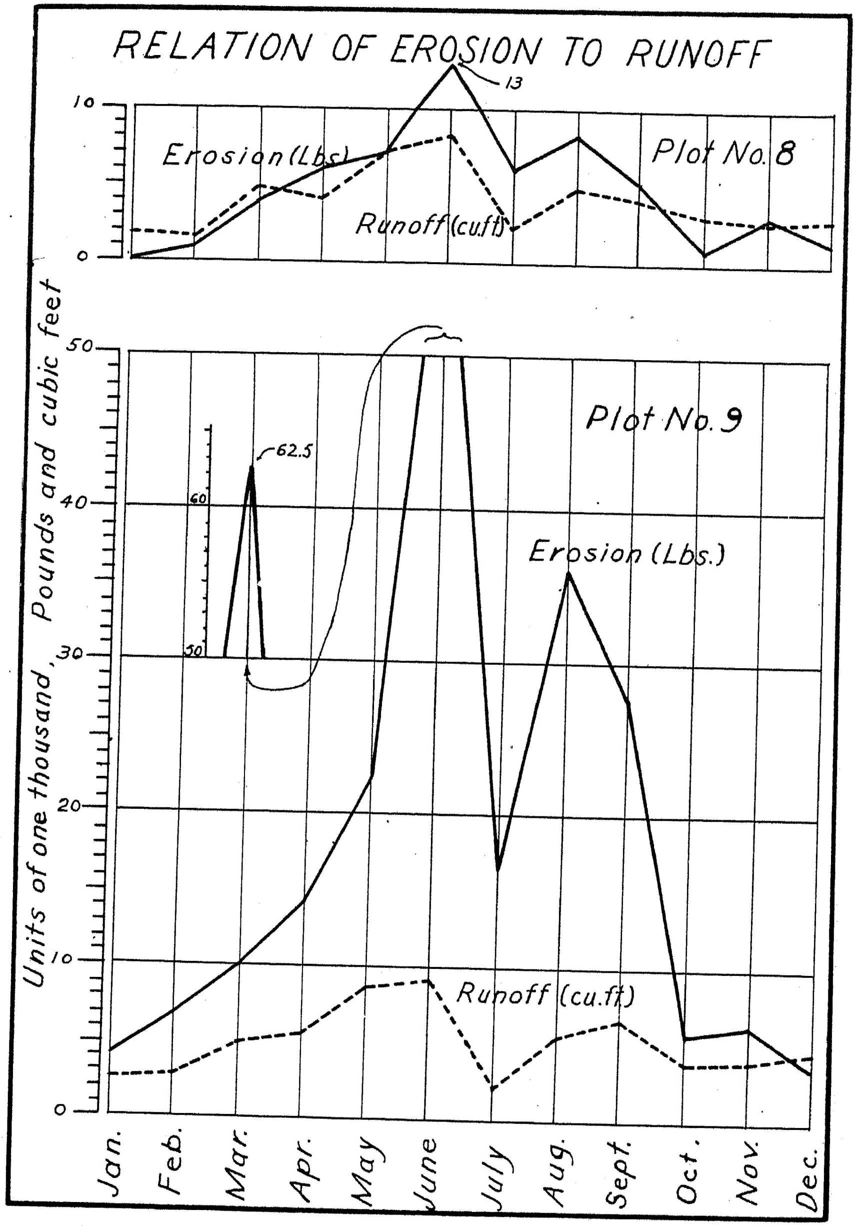

Fig. 12.—Mean monthly erosion and runoff for plots 8 (rotation) and 9 (continuous corn) with slope of 8.48 per cent and length of 90 feet.

tour and strip cropping all have the effect of shortening the slope.

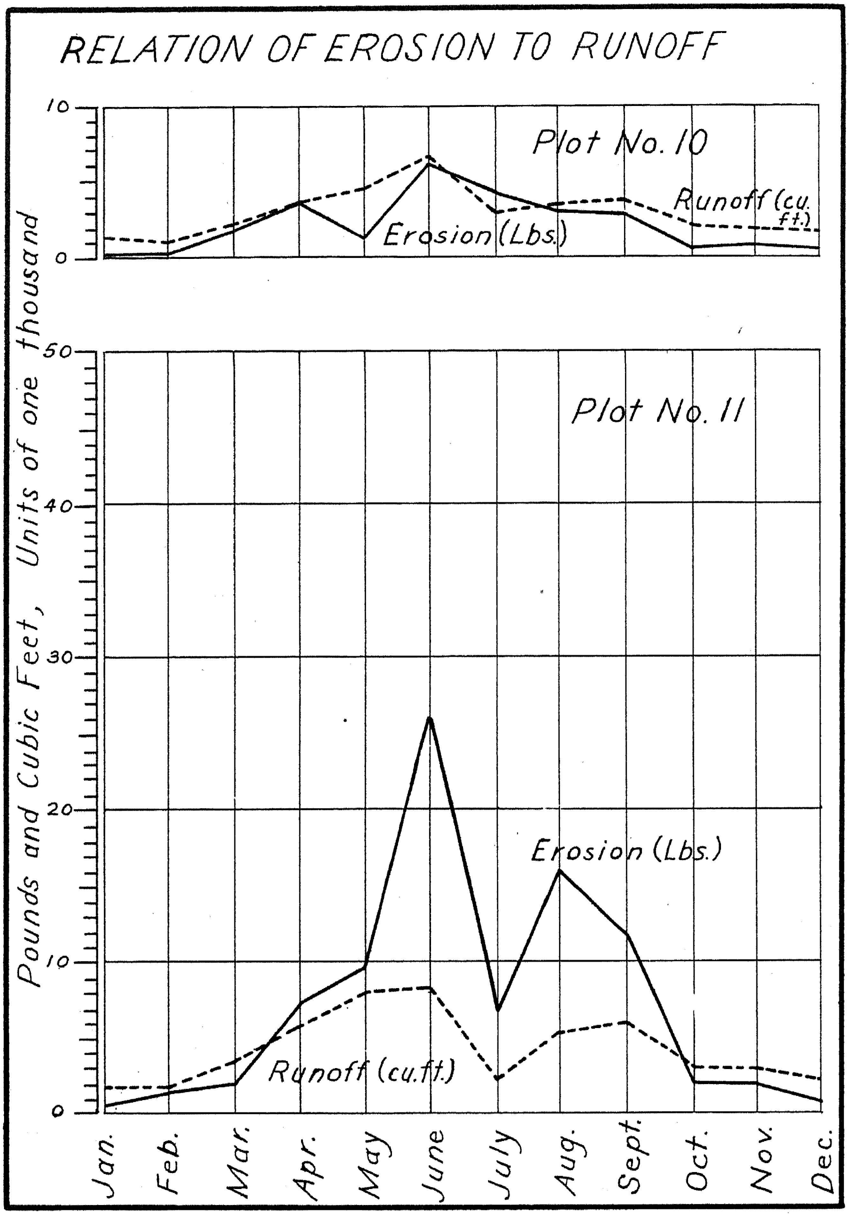

Fig. 13.—Mean monthly erosion and runoff for plots 10 (rotation) and 11 (continuous corn) with slope of 6 per cent and length of 60 feet.

The erosion on all the plots during the time of the investigation caused significant change in the surface soil. This was most

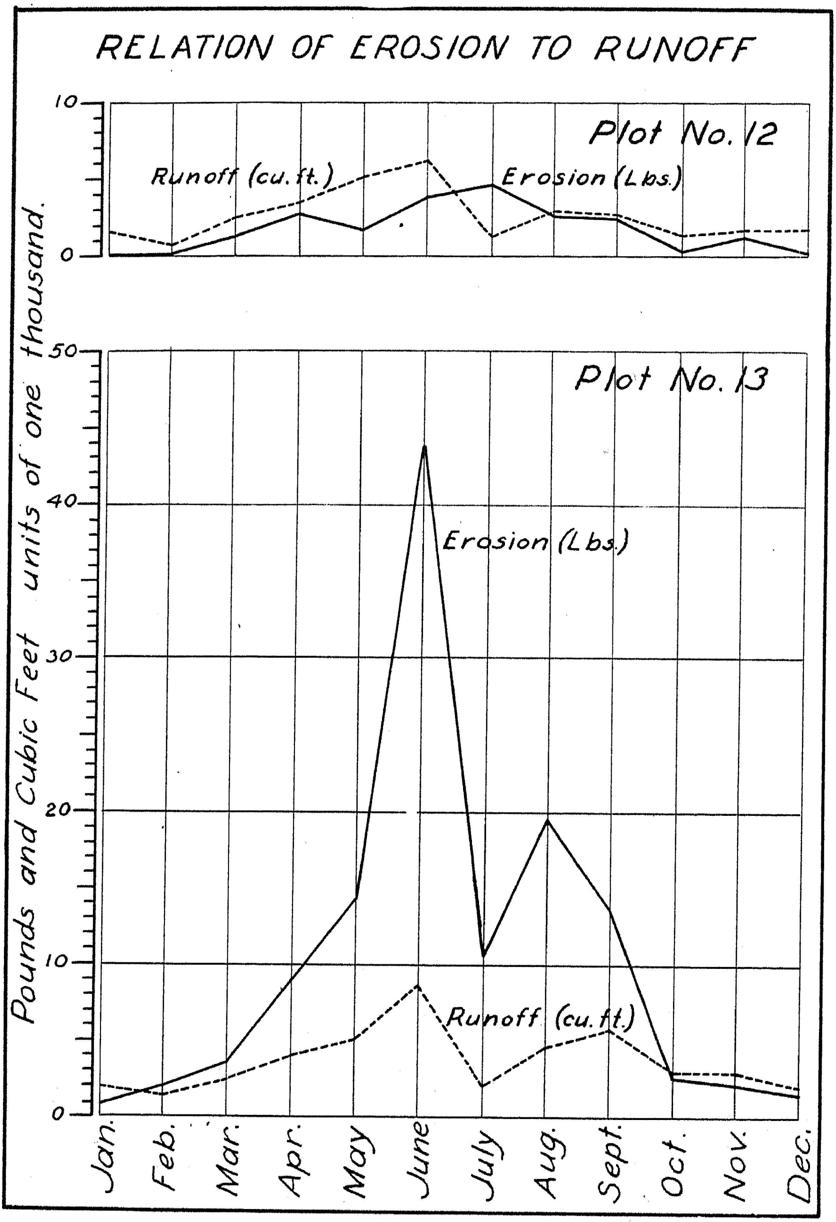

Fig. 14.—Mean monthly erosion and runoff for plots 12 (rotation) and 13 (continuous corn) with slope of 6 per cent and length of 90 feet.

apparent on the plots in continuous corn. Here the surface soil became shallower. There was an accumulation of sand at the surface because of the removal of the finer soil material. The poor structure was manifested by a tendency of the soil to acquire a smooth, hard surface after rains. A slower penetration and a greater runoff might be expected from such changes in the soil condition. A deterioration in tilth is always associated with erosion. As the surface soil becomes shallower a portion of the subsurface becomes included in the topsoil. Such modification is most apparent in shallow soils, and when the subsoil contains a high per cent of clay. While it cannot be concluded from the data that runoff and erosion were at a greater rate during the latter years of the investigations, there was a tendency for gullies to form. This was most pronounced on the most severely eroded plots. When the gullies cut into the subsoil, as was the case on the steeper plots 8 and 9, there was a tendency for them to recur at the same places, even when the soil had been cultivated and leveled.

The effectiveness of vegetation in reducing runoff and erosion indicates that the type of farming and the kind of rotation are of great importance in planning for soil erosion control. The cropping system must be adjusted to the slope of the land. On the 8.48 per cent slope the three year crop rotation used in this investigation permitted more erosion than is permissible for soil maintenance. An average annual soil loss of 10 or more tons per acre, or the removal of 7 inches of soil in approximately 80 to 90 years, means eventual deterioration even if fertility in the form of fertilizer and manure is added (Table 17). Soil fertility improvement or even maintenance is possible only under approximately stable conditions as to erosion. This is in agreement with observations on farms throughout the glacial soil region. A basic principle of crop rotations then should be that the ratio of sod or grass crops to intertilled crops should increase as the slope of the land and the length of the slope increase.

Under the conditions of this experiment an increase in slope from 6 to 8.48 per cent caused an increase of about 35 per cent in runoff and an increase of approximately 100 per cent in soil erosion. The more rapid increase in erosion over runoff with increase in per cent or slope, is in accord with field observations. The ratio of erosion to runoff becomes even wider if the per cent of slope is accompanied by an increase in the length of slope. In general, any change in length or per cent of slope, or in vegetation cover, has a relatively greater effect on erosion than on runoff. Any condition of slope or cover that tends to hasten the rate of runoff results in an increased rate of erosion.

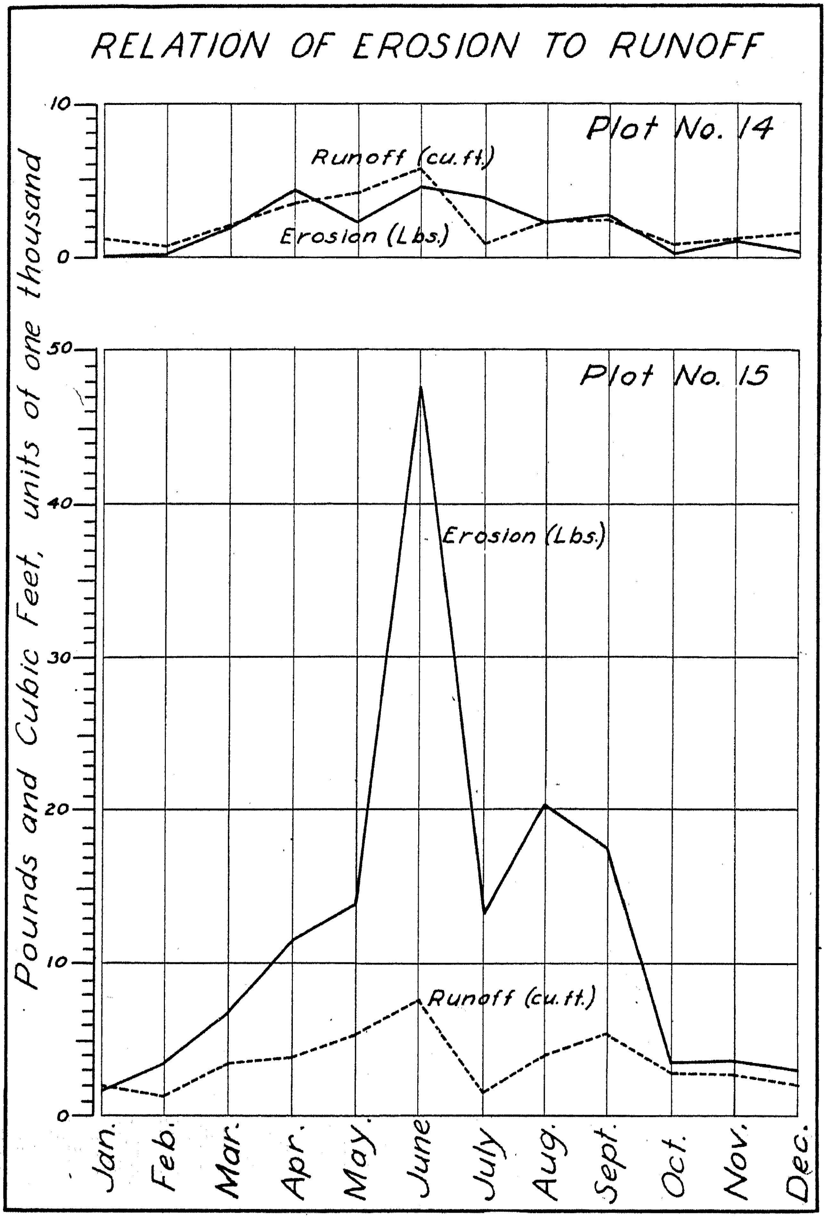

Fig. 15.—Mean monthly erosion and runoff for plots 14 (rotation) and 15 (continuous corn) with a slope of 6 per cent and a length of 150 feet.

APPENDIX

The following tables give quantitative information on the various factors—rainfall, cover, slope—that affect runoff and erosion. Tables 2 to 5 indicate the climatic conditions. Tables 6 to 15 compare the effectiveness of each of the erosion factors. All data are on an acre area basis. Table 17 is essentially a summary of the experiment.

TABLE 1. CROP ON EACH PLOT FOR EACH YEAR OF THE EXPERIMENT

	Plot							
Year	8	9	10	11	12	13	14	15
1926	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn
1927	Wheat	"	Wheat	"	Wheat	"	Wheat	"
1928	Clover	"	Clover	"	Clover	"	Clover	"
1929	Corn	"	Corn	"	Corn	"	Corn	"
1930	Wheat	"	Wheat	"	Wheat	"	Wheat	"
1931	Clover	"	Clover	"	Clover	"	Clover	"
1932	Corn	"	Corn	"	Corn	"	Corn	"
1933	Wheat	"	Wheat	"	Wheat	"	Wheat	"
1934	Clover	"	Clover	"	Clover	"	Clover	"
1935	Corn	"	Corn	"	Corn	"	Corn	"

TABLE 2. MONTHLY AND ANNUAL MEAN TEMPERATURES - 1926-1935

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1926	32.6	38.7	37.8	48.3	67.0	70.0	77.2	76.2	68.5	55.9	39.4	32.2	53.6
1927	30.0	40.0	46.0	56.8	63.2	69.5	74.8	70.0	70.9	60.6	46.0	29.2	54.8
1928	32.8	36.4	46.0	51.2	65.7	66.6	77.2	75.8	63.8	60.8	44.5	36.2	54.8
1929	23.5	25.4	48.5	57.5	61.0	71.2	77.8	76.6	66.9	57.4	38.1	34.4	53.3
1930	20.4	44.2	42.8	59.9	64.2	72.0	81.1	78.4	70.6	55.2	46.0	34.2	55.8
1931	36.1	41.0	38.4	54.7	60.4	78.0	81.0	75.0	75.2	62.0	52.8	43.4	58.2
1932	36.2	42.6	37.0	57.4	66.3	75.1	79.1	77.0	67.1	55.2	39.1	31.4	55.3
1933	42.1	31.6	44.0	54.4	65.4	78.0	79.7	75.3	74.4	55.8	44.8	38.0	57.0
1934	35.6	31.5	39.8	56.3	68.8	80.4	86.8	80.1	65.2	61.0	48.8	31.0	57.1
1935	32.3	36.8	50.1	52.1	59.9	69.6	80.6	77.6	68.8	56.5	41.2	30.6	54.7
Mean	32.3	36.8	43.0	54.9	64.2	73.0	79.5	76.2	69.1	58.0	44.1	34.1	55.4

TABLE 3. PRECIPITATION (INCHES) FOR EACH MONTH DURING THE TEN YEARS OF THE EXPERIMENT

Month	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	10 yr. Avg.	46 yr. Avg.
January	1.43	1.75	0.94	2.09	4.41	.28	1.79	1.87	0.93	1.74	1.72	1.94
February	2.04	0.57	2.10	1.03	1.82	3.19	1.01	0.97	1.06	0.85	1.16	1.79
March	2.43	7.65	0.69	4.05	1.03	2.97	1.16	3.27	2.91	2.88	2.9	2.96
April	4.96	5.17	2.89	5.74	1.55	1.42	2.04	1.72	1.28	2.66	2.94	3.77
May	2.87	6.68	1.74	11.98	2.88	6.45	1.67	7.30	1.35	8.19	5.11	4.64
June	2.91	6.11	14.86	7.49	3.10	1.30	6.28	2.18	3.56	5.72	5.35	4.79
July	4.15	3.07	3.72	1.49	.50	2.53	3.39	1.02	.67	3.89	2.44	3.29
August	5.07	5.01	3.22	.40	2.18	8.86	6.44	2.86	4.94	.27	3.92	3.83
September	10.00	2.38	3.33	3.06	3.39	6.69	2.15	3.92	8.31	2.77	4.6	4.56
October	3.72	5.08	2.86	6.96	2.57	3.15	2.36	2.97	2.57	3.81	3.6	2.76
November	2.38	4.29	4.68	1.23	2.25	3.94	1.27	.80	4.40	6.71	3.19	2.32
December	1.60	1.94	2.04	.88	.48	2.52	4.81	1.94	1.19	.97	1.84	1.78
Total	43.56	49.7	43.07	46.4	26.16	43.3	34.37	30.82	33.17	40.46	39.1	38.43

TABLE 4. FREQUENCY AND OCCURRENCE OF RAINS OF ONE INCH OR OVER IN 24 HOURS, BY MONTHS AND YEARS

Month	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	Total
January					1						1
February	1		1		1	1					4
March		3		1		1		1			6
April	1	2	1	2			1				7
May		2		2		2		1		3	10
June		3	5	2	1		3	1	1	2	18
July	2		1				1			2	6
August	2	2				3	3		1		11
Sept.	3		1			2	1	2	2	1	12
October		2		2	1						5
November		1	1		1	1	1		3	1	9
December						1	1				2
Total	9	15	10	9	5	11	11	5	7	9	

TABLE 5. PRECIPITATION (INCHES) AND DEVIATION FROM AVERAGE DURING EACH YEAR OF THE EXPERIMENT

Year	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935
Annual Precipitation	43.56	49.70	43.07	46.40	26.16	43.30	34.37	30.82	33.17	40.46 in.
Deviation from 10 year avg.*	+ 4.46	+10.6	+ 3.97	+ 7.3	-12.94	+ 4.2	- 4.73	- 8.28	- 5.93	+ 1.36
Deviation from 46 year avg.**	+ 5.13	+11.27	+ 4.64	+ 7.97	-12.27	+ 4.87	- 4.06	- 7.61	- 5.26	+ 2.03

* 10 year average = 39.10"
** 46 year average = 38.43"

TABLE 6. RUNOFF AS CUBIC FEET PER ACRE PER MONTH FOR THE DIFFERENT PLOTS

	Plot							
Month	8	9	10	11	12	13	14	15
January	1762.0	2660.2	1313.8	1842.7	1430.6	1963.2	1189.0	2008.1
February	1653.4	2747.7	1148.5	1673.4	737.3	1347.2	774.9	1379.8
March	4634.9	4968.9	2157.8	3085.1	2548.2	2434.6	2322.0	3486.3
April	3958.1	5767.5	3561.2	5661.6	3560.1	3999.0	3555.3	3876.6
May	6925.0	8750.6	4415.9	8033.9	5249.0	5042.5	4245.7	5316.0
June	8180.4	9230.0	6674.0	8196.7	6231.6	8525.9	5845.7	7591.9
July	1725.4	1995.9	3037.9	2304.5	1355.0	2060.8	927.0	1617.9
August	4395.4	5715.2	3264.8	5272.7	2955.6	4581.6	2392.1	3961.5
September	3872.4	6757.6	3882.8	6002.1	2688.1	5797.2	2544.8	5410.0
October	2706.5	3726.3	2267.3	3068.6	1438.5	2945.2	978.1	2854.3
November	2550.7	3840.2	2240.4	3055.3	1753.6	2900.2	1290.7	2697.9
December	2502.8	4478.4	1692.0	2321.6	1835.1	2045.4	1492.7	1983.3
Average	4495.7	6063.8	3565.6	5051.8	3180.0	4364.2	2755.8	4218.3

TABLE 7. RUNOFF AS CUBIC FEET PER ACRE PER ANNUM FOR THE DIFFERENT PLOTS

	Plots							
Year	8	9	10	11	12	13	14	15
1926	46726	62876	85228	65937	44060	50960	39685	43638
1927	85947	87048	73756	66543	74744	62991	66002	57166
1928	46887	76540	50768	68606	34621	66293	28661	55342
1929	48456	92289	36991	85585	47428	41607	35981	44052
1930	12249	32096	10729	17756	10445	17377	8544	16615
1931	44237	62194	24524	42798	27913	42278	29495	46166
1932	40852	54681	28280	36003	30702	40218	23295	37622
1933	37280	39218	15336	31904	16872	30325	14329	31121
1934	16160	29260	961	26329	244	24796	600	21399
1935	69964	69814	29701	63372	30796	60396	29652	69288
Avg.	44876	60602	35627	50483	31783	43742	27725	42241

TABLE 8. RUNOFF AS PER CENT OF RAINFALL PER ANNUM FOR THE DIFFERENT PLOTS

		Plot							
Year	Precip.	8	9	10	11	12	13	14	15
1926	43.56	29.8	40.1	53.9	41.7	28.1	32.5	25.1	27.6
1927	49.70	46.8	47.4	40.9	36.9	40.7	34.3	36.6	31.7
1928	43.07	30.2	49.3	33.3	45.0	22.3	42.7	18.8	36.3
1929	46.40	28.3	53.9	22.0	50.9	27.7	24.3	21.4	26.2
1930	26.16	12.9	33.8	11.3	18.7	11.0	18.3	9.0	17.5
1931	43.30	27.1	38.1	15.3	26.7	17.1	25.9	18.4	28.8
1932	34.37	32.2	43.1	22.7	28.9	24.2	31.7	18.7	30.2
1933	30.82	32.7	34.4	13.7	28.5	14.8	26.6	12.8	27.8
1934	33.17	13.2	23.9	.8	21.9	.2	20.4	.5	17.8
1935	40.46	46.8	46.7	20.2	43.1	20.6	40.4	20.2	47.2
Average	39.1	30.0	41.1	23.4	34.2	20.7	29.7	18.1	29.1

TABLE 9. NUMBER OF RAINS PER ANNUM CAUSING RUNOFF

Year	Total rainfall (inches)	Amount of rainfall causing erosion (inches)	Number of rains causing runoff	Number of rains 1-2 inches and over in 24 hours	Number of rains 2 inches or over in 24 hours
1926	43.56	29.6 *	29	8	1
1927	49.70	31.39*	24	13	3
1928	43.07	27.67*	19	5	5
1929	46.4	30.92*	17	6	3
1930	26.16	15.76	10	5	0
1931	43.3	32.24	20	8	3
1932	34.37	22.42	19	9	2
1933	30.82	17.14	21	5	0
1934	33.17	20.64	13	4	3
1935	40.46	31.37	23	8	1
Avg.	39.1	25.9	19.5	7.1	2.1

* By computation

TABLE 10. EROSION AS POUNDS PER ACRE PER MONTH

	Plots							
Month	8	9	10	11	12	13	14	15
January	169	3,900	65	597	58	801	50	1,649
February	791	7,120	131	1,296	141	1,967	154	3,406
March	3,719	10,037	1,675	2,073	1,253	3,525	1,930	6,854
April	5,828	14,203	3,524	7,197	2,809	8,965	4,397	11,453
May	6,985	22,411	1,324	9.808	1,629	14,202	2,229	13,781
June	13,207	62,376	5,934	25,996	3,921	43,692	4,713	47,534
July	5,694	16,563	4,219	6,991	4,653	10,501	3,889	13,220
August	8,220	35,872	2,966	16,155	2,610	19,658	2,279	20,370
September	5,154	28,957	2,891	11,770	2,493	13,717	2,817	17,460
October	620	5,891	269	2,028	315	2,640	312	3,545
November	2,875	6,571	642	1,929	1,223	2,974	1,122	3,577
December	1,196	3,676	425	834	189	1,347	289	2,839

TABLE 11. EROSION PER MONTH AS PER CENT OF THE ANNUAL TOTAL FOR THE DIFFERENT PLOTS. AVERAGE FOR 1926-1936

	Plots							
Month	8	9	10	11	12	13	14	15
January	.3	1.8	.3	.6	.3	.6	.2	1.1
February	1.4	3.2	.5	1.5	.7	1.6	.6	2.2
March	6.8	4.6	6.9	2.4	5.9	2.9	7.9	4.7
April	10.7	6.6	14.6	8.3	13.2	7.2	18.2	7.9
May	12.9	10.4	5.5	11.3	7.6	11.5	9.3	9.5
June	24.2	28.8	24.7	29.9	18.4	35.2	19.6	32.8
July	10.5	7.6	17.6	8.6	21.8	8.5	16.1	9.1
August	15.1	16.7	12.3	18.6	12.3	15.8	9.4	14.0
September	9.5	12.9	12.0	13.5	11.7	11.1	11.6	12.0
October	1.1	2.6	1.3	2.2	1.5	2.1	1.3	2.4
November	5.3	3.1	2.6	2.2	5.7	2.4	4.6	2.5
December	2.2	1.7	1.7	.9	.9	1.1	1.2	1.8

TABLE 12. EROSION TONS PER ACRE PER ANNUM FOR THE DIFFERENT PLOTS

		Plots							
Year	Precip.	8	9	10	11	12	13	14	15
1926	43.56	26.7	91.7	28.9	27.6	24.4	48.2	30.5	71.9
1927	49.70	65.9	160.7	32.4	49.9	24.2	81.6	30.6	85.9
1928	43.07	4.4	251.8	12.9	98.7	2.5	162.6	1.5	184.3
1929	46.40	18.0	108.8	7.6	49.0	9.2	56.1	15.5	66.2
1930	26.16	4.7	24.8	.62	4.5	1.2	7.9	1.2	8.4
1931	43.30	.9	102.1	1.4	55.8	1.0	69.1	.98	77.3
1932	34.37	75.4	85.0	30.0	37.1	30.3	52.0	28.2	77.7
1933	30.82	32.3	71.7	1.5	29.0	4.3	41.8	5.4	44.1
1934	33.17	15.3	94.5	.2	45.5	.77	50.5	.09	58.6
1935	40.46	28.7	91.2	4.6	36.1	8.5	50.1	7.0	53.1
Avg. per year	39.1	27.2	108.23	12.0	43.3	10.6	62.0	12.1	72.7

TABLE 13. RUNOFF AS PER CENT OF RAINFALL FOR THE DIFFERENT PLOTS GROUPED ACCORDING TO CROPS. (PLOTS WITH ODD NUMBER WERE IN CORN CONTINUOUSLY.)

Crop	Year	Rotation Plot 8	Cont. corn 9	Rotation 10	Cont. corn 11	Rotation 12	Cont. corn 13	Rotation 14	Cont. corn 15
	1926	29.8	40.1	53.9	41.7	28.1	32.5	25.1	27.6
Rotation plots	1929	28.3	53.9	22.0	50.9	27.7	24.3	21.4	26.2
in corn	1932	32.2	43.1	22.7	28.9	24.2	31.7	18.7	30.2
	1935	46.8	46.7	20.2	43.1	20.6	40.4	20.2	47.2
Average		34.3	45.95	29.70	41.15	25.15	32.25	21.35	32.80
	1927	46.8	47.4	40.9	36.9	40.7	34.3	36.6	31.7
Rotation plots	1930	12.9	33.8	11.3	18.7	11.0	18.3	9.0	17.5
in wheat	1933	32.7	34.4	13.7	28.5	14.8	26.6	12.8	27.8
Average		30.8	38.53	21.97	28.03	22.2	26.4	19.47	25.7
	1928	30.2	49.3	33.3	45.0	22.3	42.7	18.8	36.3
Rotation plots	1931	27.1	38.1	15.3	26.7	17.1	25.9	18.4	28.8
in clover	1934	13.2	23.9	.8	21.9	.2	20.4	.5	17.8
Average		25.5	37.1	16.47	31.2	13.2	29.66	12.57	27.63

TABLE 14. EROSION AS TONS PER ACRE PER ANNUM FOR THE DIFFERENT PLOTS GROUPED ACCORDING TO DIFFERENT CROPS

Crop	Year	Rotation Plot 8	Cont. corn 9	Rotation 10	Cont. corn 11	Rotation 12	Cont. corn 13	Rotation 14	Cont. corn 15
	1926	26.7	91.7	28.9	27.6	24.4	48.2	30.5	71.9
Rotation plots	1929	18.0	108.8	7.6	49.0	9.2	56.1	15.5	66.2
in corn	1932	75.4	75.4	30.0	37.1	30.3	52.0	28.2	77.7
	1935	28.7	91.2	4.6	36.1	8.5	50.1	7.0	53.1
Average		37.2	91.8	17.8	37.4	18.1	51.6	20.3	67.2
	1927	65.9	160.7	32.4	49.9	24.2	81.6	30.6	85.9
Rotation plots	1930	4.7	24.8	.62	4.5	1.2	7.9	1.2	8.4
in wheat	1933	32.3	71.7	1.5	29.0	4.3	41.8	5.4	44.1
Average		34.3	85.7	11.51	27.8	9.9	43.8	12.4	46.1
	1928	4.4	251.8	12.9	98.7	2.5	162.6	1.5	184.3
Rotation plots	1931	.9	102.1	1.4	55.8	1.0	69.1	.98	77.3
in clover	1934	15.3	94.5	.2	45.5	.77	50.5	.09	58.6
Average		6.9	149.5	4.83	66.7	1.42	94.1	.86	106.7

TABLE 15. RUNOFF AS PER CENT OF RAINFALL FOR DIFFERENT DEGREES OF SLOPE, 90 FEET LONG

		Slope 3.68%		Slope 6.0%		Slope 8.48%	
		Pl. 6	Pl. 7	Pl. 12	Pl. 13	Pl. 8	Pl. 9
Year	Rainfall	Rot.	Cont. C.	Rot.	Cont. C.	Rot.	Cont. C.
1926	43.56	16.3%	32.4	28.1	32.5	29.8	40.1
1927	49.70	29.5	38.9	40.7	34.3	46.8	47.7
1928	43.07	20.7	36.1	22.3	42.7	36.2	49.3
1929	46.40	14.0	43.6	27.7	24.3	28.3	53.9
1930	26.16	5.7	15.7	11.0	18.3	12.9	33.8
1931	43.30	5.7	22.4	17.1	25.9	27.1	38.1
Avg.	42.03	15.3	31.5	24.48	29.66	30.18	43.76

EROSION AS TONS PER ACRE PER ANNUM FOR DIFFERENT DEGREES OF SLOPE, 90 FEET LONG

	Slope 3.68%		Slope 6.0%		Slope 8.48%	
Year	Pl. 6	Pl. 7	Pl. 12	Pl. 13	Pl. 8	Pl. 9
1926	4.9	20.8	24.4	48.2	26.7	91.7
1927	10.7	28.4	24.2	81.6	65.9	160.7
1928	4.9	38.1	2.5	162.6	4.4	251.8
1929	4.1	23.0	9.2	56.1	18.0	108.8
1930	1.1	2.3	1.2	7.9	4.7	24.8
1931	1.8	22.4	1.0	69.1	.9	102.1
Average	4.58	22.6	10.4	70.88	20.1	123.3

TABLE 16. RUNOFF AS CUBIC FEET PER ACRE PER ANNUM PER POUND OF SOIL ERODED

	Plot							
Year	8	9	10	11	12	13	14	15
1926	.88	.34	1.47	1.2	.9	.53	.65	.30
1927	.65	.25	1.14	.66	1.54	.39	1.1	.33
1928	.53	.15	1.95	.35	7.0	.20	9.8	.15
1929	1.30	.42	2.43	.87	2.57	.37	1.2	.33
1930	1.30	.64	8.9	2.0	4.2	1.1	3.6	.93
1931	22.40	.30	8.5	.38	13.6	.31	15.0	.30
1932	.27	.32	.47	.48	.52	.38	.41	.24
1933	.58	.28	4.9	.55	1.9	.36	1.32	.35
1934	.53	.15	2.54	.29	.19	.25	3.47	.18
1935	1.20	.38	3.21	.87	1.8	2.1	.47	.65
Avg.	2.96	.32	3.55	.76	3.42	.60	3.70	.38

TABLE 17. RUNOFF AND EROSION PER ACRE DURING TEN YEARS

	8.48%		6% slope					
	90 ft. long		60 ft. long		90 ft. long		150 ft. long	
	Rotation	Continuous corn	Rotation	Continuous corn	Rotation	Continuous corn	Rotation	Continuous corn
	Plot 8	9	10	11	12	13	14	15
Average number tons soil eroded per acre annually	27.2	107.4	12.0	43.3	10.6	62.0	12.1	72.7
Surface inches of soil eroded annually	.189	.700	.083	.291	.073	.411	.084	.500
Average number cubic feet runoff per acre annually	44,920	60,640	35,640	50,520	31,784	43,760	27,662	42,288
Average per cent runoff annually	30.0	41.1	23.4	34.2	20.7	29.7	18.1	29.1
Cubic feet runoff required to erode one pound soil	3.26	.35	3.91	.84	3.76	.66	4.07	.41
Number of years to erode 7 inches soil	37	10	84	24	95	17	83	14