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INVESTIGATIONS IN EROSION CONTROL AND THE RECLAMATION OF ERODED LAND
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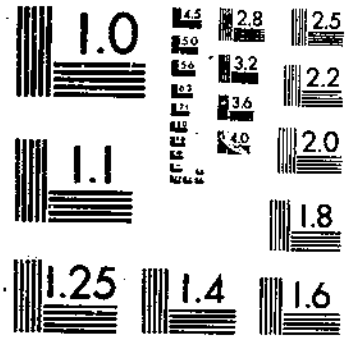

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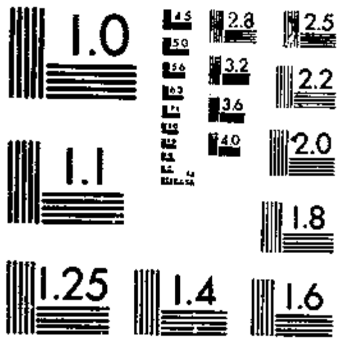

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TECHNICAL BULLETIN No. 973, April 1949

Investigations In Erosion Control and the Reclamation of Eroded Land at the Upper Mississippi Valley Conservation Experiment Station Near La Crosse, Wis. 1933-43

By
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Soil Conservation Service

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, WASHINGTON, D. C.

IN COOPERATION WITH THE
WISCONSIN COLLEGE OF AGRICULTURE

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FOREWORD

The Nation's soil conservation program, begun little more than a dozen years ago, was dedicated to the permanent security and welfare of all our citizens. In war it demonstrated its capacity for service to the country as a powerful weapon in the hands of thousands of American farmers. On the home front it helped them wage the year-round battle for the necessarily monumental production of foods, fibers, fats, and oils.

The modern methods of land use, soil protection, and water conservation are designed to maintain and improve the vital natural resources on which our agriculture is founded. These same measures hold our soil and conserve our water for today and for tomorrow. As an average across the country, they have also increased the yields of all the principal crops by 20 percent or more per acre. This is being accomplished on thousands of farms with savings of time, labor, fuel, power, and other production facilities.

However, we still do not have enough good land left under cultivation in the United States to meet our present needs, unless we use every means at our disposal to increase yields and to protect the soil while we are doing so. Even then, we may have to bring some new land into cultivation by irrigation or by drainage.

These considerations put a premium on knowledge—that special kind of knowledge that will enable farmers to increase production without so impoverishing their land that it cannot produce the even greater crops that the postwar needs of hungry peoples require.

This knowledge, supplementing the training and experience of American farmers as a group, points the way to a successful agriculture upon which America and a great deal of the world depend, today and tomorrow.

This bulletin contains much especially significant knowledge, as it has been developed through study and research in the important agricultural region served by the conservation experiment station at La Crosse, Wis. Crop yields are being notably increased in this region by conservation farming methods. This bulletin describes the methods farmers may use to increase crop production without abusing their land.

Briefly, it is a report of technical advances in conservation farming during 10 years, showing not only the methods used, but also the basic factors involved. They are here set down, and they are authenticated by figures, plates, tables, and other data.

Any soil and water conservation technician working in the Upper Mississippi Valley region has in his copy of this bulletin a handy guide for determining degrees of slope for terrace channels, the expectancy of protection to be derived from various kinds of cover crops, the amount of water likely to be conserved from the average rains for crop use under various tillage treatments, and similar factors. Other reports provide like data for the guidance of technicians in other important farming regions.

These reports in the hands of soil technicians who work with farmers will be the means of putting into effect on the land more rapidly and more effectively than ever before the essential measures to increase production and to maintain a permanently prosperous agriculture.

H. H. BENNETT,
Chief, Soil Conservation Service.

UNITED STATES
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

Investigations in Erosion Control and Reclamation of Eroded Land at the Upper Mississippi Valley Conservation Experiment Station, Near La Crosse, Wis., 1933-43[1]

By O. E. HAYS, *project supervisor*, A. G. McCALL, *senior soil conservationist*, and F. G. BELL, *chief, Erosion Control Practices Division, Research, Soil Conservation Service*[2]

The United States Department of Agriculture, Soil Conservation Service, in Cooperation with the Wisconsin College of Agriculture

CONTENTS

[1]Submitted for publication May 1946.

[2]Members of the Station staff who contributed to the planning and development of the research program are: R. H. Davis, G. E. Ryerson, F. L. Hardisty, V. J. Palmer, H. B. Atkinson, C. E. Bay, V. J. Kilmer, S. J. Mech, C. J. Krumm, J. C. Trieloff, B. A. Myers, and A. R. Grunewald. Noble Clark, R. J. Muckenhirn, H. L. Ahlgren, and others of the University of Wisconsin have contributed generously to the development of plans for the studies herein reported.

SUMMARY

The Upper Mississippi Valley Soil Conservation Experiment Station, near La Crosse, Wis., was established in 1931 as a cooperative research project between the United States Department of Agriculture and The Wisconsin College of Agriculture. Studies are conducted to obtain information on the basic factors affecting soil and water losses and their control in this important agricultural area. The area includes the unglaciated soils in southwestern Wisconsin, southeastern Minnesota, northeastern Iowa, and northwestern Illinois. Dairying is the dominant type of agriculture in most of the area.

The average annual precipitation at La Crosse is 31 inches. The winter precipitation is largely in the form of snow, the thawing of which does not usually result in high soil loss unless accompanied by rain. Intense thunder showers are experienced during the growing season. Four or five intense storms a year may result in as much as 90 percent of the total annual soil loss.

Surveys show that nearly 50 percent of the cropland has lost more than one-half of its surface soil. Not much land has been abandoned, but areas have been retired from cultivation and seeded down to pasture as a result of erosion. Present high losses emphasize the importance of establishing control measures rapidly on all sloping farms in the area. Otherwise, all of the surface soil will be lost in a relatively short period.

The yield of crops is greatly influenced by the depth of surface soil. This has been shown by plot and field studies at the station. Areas under uniform treatment show that the yield of corn is about 70 percent as much on a severely eroded as on a moderately eroded soil, of grain 60 percent and of hay 90 percent. The severely eroded soil lost 1.7 times as much of the precipitation in runoff as the moderately eroded soil. The soil loss was 1.5 times as much on a severely eroded area. The plots were planted to a 5-year rotation of corn, grain, and 3 years of hay, and received good fertilizer treatments. These results were obtained on moderately deep and uniform Fayette silt loam. On the more shallow soils such as the Dubuque silt loam, the loss of surface soil would probably be even more critical.

The control plot studies show that cover is one of the most important factors affecting soil and water losses. A dense growth of bluegrass or timber protected from fire and grazing will prevent erosion. It will also produce a soil condition capable of absorbing most of the precipitation, even during the most intense storms. In general, the soil and water loss will vary according to the density of crop. The less dense the cover, the higher the losses.

A 3-year rotation of corn, grain, and hay reduced soil losses to less than one-third of the losses from land planted annually to corn. But

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FIGURE 1

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it did not give adequate control on a 16-percent slope of Fayette silt loam. The loss from corn in rotation was about one-half that from corn following corn.

Organic matter added to the soil in the form of green manure and barnyard manure will greatly reduce soil losses, depending on the amount added and on the length of time required for the material to decompose. In general, carbonaceous material has been found to have more lasting effects than nitrogenous material. Corn following alfalfa-timothy sod, which was rather grassy, resulted in much lower soil losses than corn following 1-year clover-timothy hay.

Strip cropping with 2 or more years of hay has been found to control erosion effectively if the slope is not too long. A 17-percent slope of 270-foot length was cropped to a 6-year rotation of corn, grain, and 4 years of hay, with strips about 50 feet in width. Strip cropping in this instance reduced soil losses to one-half of that measured from a similar watershed that was contoured with a filter strip and planted to the same rotation. The average loss from the strip-cropped area was about 2.5 tons per acre for the growing season. On fields that are strip cropped, it has been found that if the drainage length is greater than 300 feet the soil losses from the lower strips are excessive. The width of strip required to obtain adequate erosion control will depend upon steepness of slope, length of slope, crop rotation, soil type, and method of cultivation.

Terraces with 7-foot vertical spacing and a maximum 3-inch grade per 100 feet in channel have not given adequate control of erosion on 10-percent slopes where the rotation included only 1 year of hay. A rotation with 2 years of hay would be necessary under these conditions. In a 6-year rotation of corn, grain, and 4 years of hay, the soil loss from a terrace with a maximum 6-inch grade per 100 feet has been one-fourth that from a contoured watershed in the same rotation. Sufficient channel capacity can be maintained by leaving a dead furrow in the channel and by back furrowing on the ridge once in the rotation that includes 2 or more years of hay.

Soil and water losses are low from pasture land that is productive and well managed. Soil losses have been found to be low from all pasture lands except those that are overgrazed or on which runoff from cropland concentrated and caused gullies. In the latter case, terraces should be used to divert runoff water.

Runoff from a timbered area, even in the most intense storms, was prevented by protecting the area from grazing. Soil and water losses from timber land have been found to be low. Grazed timber had less than half the carrying capacity of a similar cleared area.

Lysimeter studies show that the loss of water and nutrients by percolation from a Fayette silt loam is low. The amount of loss decreases with the density of cover.

THE AREA

The unglaciated area of the Upper Mississippi Valley Region includes some 12 million acres in southwestern Wisconsin, southeastern Minnesota, northeastern Iowa, and northwestern Illinois (fig. 1, in envelope, p. 3, cover). The topography ranges from steep, short slopes with narrow ridges and valleys in the bluff portion (fig. 2), to the more gently rolling long slopes with broad ridges and valleys on the lands extending beyond the bluff portion. The bluffs frequently have slopes of 50 to 60 percent with ridges extending from 300 to 500 feet above the floor of the valley. Slopes of 30 percent are not uncommonly cultivated.

The soils of the Upper Mississippi Valley area belong to the general Gray-Brown Podzolic group. The underlying rock is largely limestone and sandstone. Most of the area has been covered with a mantle of loess. The thickness of the mantle varies, having a tendency to be

FIGURE 2.—Air view showing topography of Upper Mississippi Valley Area.

thicker nearer the Mississippi River. The dominant vegetation has been the oak-hickory association. This type of vegetation has tended to return more of the humus to the soil resulting in a less acid surface soil than in the true Podzols. Under virgin conditions, the soils in the area are neutral or only slightly acid. The Fayette series is the major series in the problem area.

The Fayette silt loam is very high in silt content. A mechanical analysis of a profile located near the control plots on the Station shows that there is over 70 percent silt to a depth of 8 inches and over 65 percent silt to a depth of 44 inches. This soil, which is low in colloidal content and high in silt, has a low degree of aggregation; therefore, the soil is easily dispersed by rain. As a result, high soil losses occur when the soil is not protected by dense vegetation.

There was little land cultivated until about 1850. Farming at first consisted principally of the production of spring wheat. The practice was to crop an area of land successively to spring grain until the crop yield became too low to pay for cultivation. The only aim was to secure the largest crop for the smallest outlay of capital without regard for the future. At first the soil was so productive that it was not considered economical to apply barnyard manure or to rotate crops. Yields declined rather rapidly under this system of continuous grain. By 1880 there was a trend toward a more diversified type of agriculture with dairy farming definitely on the increase. With the change to dairy farming came the need for hay. Red clover became a popular crop in the area.

It is apparent that during the 20 to 30 years of wheat farming the soil was rapidly depleted in fertility and undoubtedly the losses by erosion were high. Washing away of loose soil by spring rains, years of short crops, low prices, and the ills that follow one-crop farming led to a change from wheat farming to dairying.

Fortunately for the agriculture of the area, dairy farming was adopted along with the use of barnyard manure and rotations. At the present time dairying is the predominant type of farming except in the southern part. In that section corn and hogs make up a greater part of the farm income.

Although erosion has not resulted in the abandonment of large areas, there are fields or portions of fields which, due to severe erosion, have been removed from cultivation and seeded down for pasture. Muckenhirn and Zeasman[3] found in 1940 that about 33 percent of the cropland in Wisconsin had lost an average furrow slice or more of soil, that 25 percent of the pasture land had lost a similar amount of soil. This amounts to more than 7 million acres of Wisconsin farm land that have lost approximately one plow depth of topsoil. They report that the loss was much higher in the southwestern part of the State. There they found that over 60 percent of the cropland has lost one plow depth or more of soil. In Winona County (*2*)[4] in southeastern Minnesota, a detailed erosion survey showed that of the cropland 21 percent has lost more than 50 percent of the surface soil. In Iowa, a similar survey (*6*) conducted in the Farmersburg area, in the northeastern part of the State, showed that 30 percent of the cropland has lost 50 percent or more of the surface soil.

[3] MUCKENHIRN, R. J., and ZEASMAN, O. R. SOIL EROSION SURVEY OF WISCONSIN. Wis. Univ. Spec. Bul., 24 pp., illus. [Processed.]

[4] Italic numbers in parentheses refer to Literature Cited, p. 87.

The results of these studies should apply fairly well to the general problem area. Although erosion has not progressed to the extent that it has in some sections of the United States, it has removed and is continuing to remove surface soil at a rapid rate. Control measures, if applied in the near future, will save these soils from further rapid loss and avoid the cost of a general reclamation program.

METEOROLOGICAL RECORDS

Daily meteorological records of precipitation and temperature have been obtained. Most of the erosion in this area is caused by water. Occurrence and intensities of precipitation are, therefore, important to the study of the conservation problem. Temperature is important in that the ground is frozen for about 4 months each year, during which time soil losses are extremely low.

PRECIPITATION

Precipitation was measured by means of recording snow and rain gages and standard Weather Bureau gages. The three factors of rainfall that have been found to be most important in affecting erosion control are amount of precipitation, intensity of precipitation, and season of occurrence. The average annual precipitation for the 11-year period was 32.61 inches. This is 1.65 inches above the 70-year average measured by the United States Weather Bureau at La Crosse, Wis. During the 11-year period covered by this report the annual precipitation varied from a minimum of 23.17 inches in 1943 to a maximum amount of 44.10 inches in 1938.

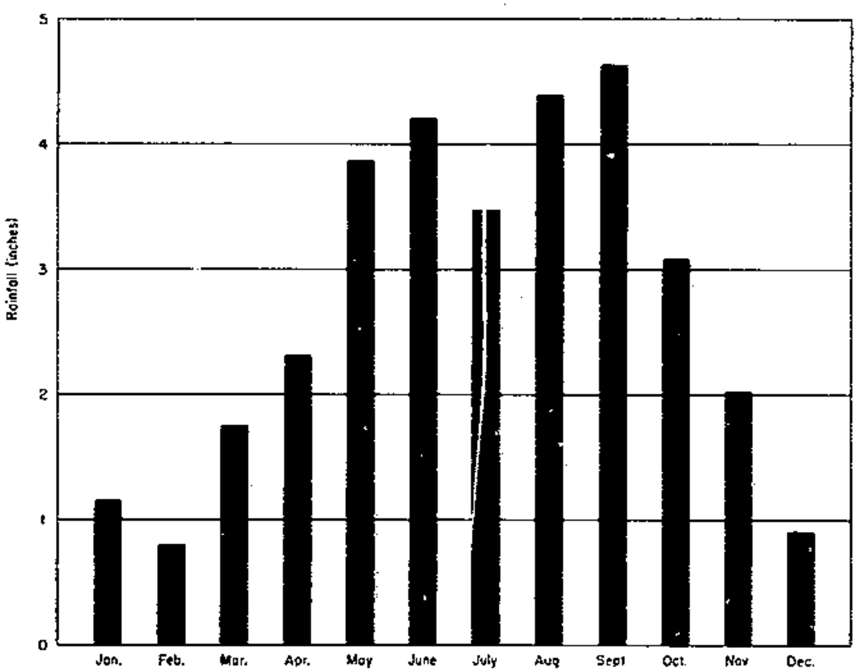

FIGURE 3.—Chart showing 11-year average rainfall by months at Upper Mississippi Valley Conservation Experiment Station, La Crosse, Wis.

FIGURE 4

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The average monthly rainfall at the Station is shown in figure 3. It will be noted that the distribution of rainfall by months through the growing season is good. In some seasons the yield of one or two crops may be greatly reduced by a short dry period occurring at a critical time in the development of that crop, but generally good crop yields occur every year.

RUNOFF AND EROSION FACTORS

The amount of runoff and erosion that is caused by a given rain will depend on the total amount of rainfall and the intensity of the rainfall. In order to determine the relative importance of intensity and amount of precipitation, data by storms from fallow and corn plots were analyzed. Factors were developed that include the total amount of precipitation, the 5-minute intensity in inches per hour, and the 30-minute intensity in inches per hour. In figure 4 (in envelope, p. 3, cover) the average intensities for 5-, 15-, and 30-minute periods of precipitation are shown for every month of the growing season. By use of these factors, storms can be grouped or classified according to the amounts of runoff and erosion that would be expected.

The formula for the erosion factor is as follows: 2½ times the total amount of precipitation in inches plus 8½ times the 30-minute intensity in inches per hour minus the 5-minute intensity in inches per hour.

The formula for the runoff factor is as follows: 7 times the total amount of precipitation plus 5 times the 30-minute intensity in inches per hour minus the 5-minute intensity in inches per hour.

Dr. Henry Hopp, Soil Conservationist at the Washington office, determined the correlation of these factors with soil and water losses. His data are shown in table 1. A very satisfactory correlation with soil and water losses was obtained by the use of these factors.

TABLE 1. *Efficiency of predicting erosion and runoff from storms by means of meteorological measurements*

Factor	Formula[1]	Correlation between predicted losses and actual losses on—	
		Fallow	Corn
Erosion	$2\frac{1}{2}A + 8\frac{1}{2}B - C$	0.94	0.84
Runoff	$7A + 5B - C$	.92	.87

[1]A = Amount of precipitation; B = maximum 30-minute intensity; C = maximum 5-minute intensity.

In this report most of the data are divided into three groups by use of the erosion and runoff factors as follows:

Group:	Factor: *Erosion*	Factor: *Runoff*
Low	0–7	0–5
Moderate	7–11	5–11
High	11	11

For the period 1940–43 there was an average of 4 storms a year in the high group, 7 storms a year in the moderate group, and 63 storms a year in the low group. This classification of storms resulted in the distribution of soil and water losses shown in table 2. Four storms a year result in 95 percent of the soil loss and 84 percent of the runoff from cornland. Conservation practices to be effective must be designed to control runoff and erosion during these storms if effective conservation is to be accomplished.

TABLE 2.—*Soil and water loss by storm groups*

Crop	Total soil loss			Total runoff		
	High	Moderate	Low	High	Moderate	Low
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Corn	95	2	3	84	16	0
Grain	74	12	14	64	24	12
Hay	88	7	5	81	15	4

TEMPERATURE

Daily readings were made of maximum and minimum air temperatures. Temperature has an effect on soil and water losses, primarily due to type of precipitation and condition of soil. Most of the winter precipitation is in the form of snow. Occasionally a rain of low intensity is experienced. The soil is usually frozen for most of the period from December 1 to April 1. During this period soil losses have been low, with the exception of one storm when rain fell on soil that was thawed on the surface to a depth of 3 to 4 inches.

Maximum, minimum, and mean air temperatures are shown in table 3. More detailed data are given in table 19, Appendix.

TABLE 3.—*Maximum, minimum, and mean air temperatures by months at La Crosse, 1933–43*

Month	Mean [1]	Highest	Lowest	Average	
				Maximum	Minimum
	°F.	*°F.*	*°F.*	*°F.*	*°F.*
January	18	50	−32	40	−20
February	19	47	−24	41	−15
March	32	75	−17	64	3
April	48	85	8	76	19
May	61	104	28	86	33
June	69	94	40	89	44
July	75	105	49	95	52
August	72	98	40	92	47
September	63	94	24	86	34
October	51	83	14	77	23
November	35	74	−2	62	7
December	23	55	−19	46	−11

[1] Weather Bureau, La Crosse, Wis.

THE SOIL AND WATER CONSERVATION EXPERIMENT STATION

LOCATION AND DESCRIPTION

The Upper Mississippi Valley Soil Conservation Experiment Station is located near La Crosse, Wis., about 5 miles east of the Minnesota-

Wisconsin line (fig. 5). The farm of 160 acres was purchased by the State of Wisconsin in 1931. It constituted one of the group of 10 experiment stations established on farms representative of large problem areas of eroding soils in various parts of the country. Its establishment was authorized by the Buchanan amendment to the Agricultural Appropriation Bill (7) for the fiscal year 1930, appropriating $160,000 for soil-erosion investigations. The topography is typical of ridge farms located in the bluff portion of the Upper Mississippi Valley unglaciated area. The ridges are narrow, breaking off rather abruptly to steep slopes. Slopes as steep as 25 percent were under cultivation. Open and wooded pasture slopes as steep as 40 percent were being grazed. About 70 of the 160 acres of land were at one time under cultivation.

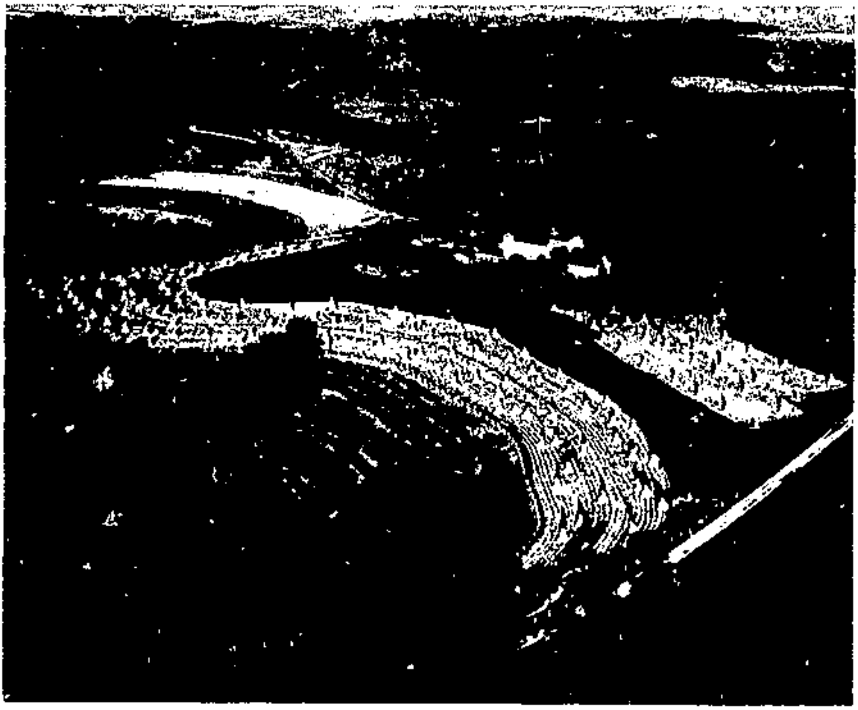

FIGURE 5.—Air view of the Upper Mississippi Valley Soil Conservation Experiment Station. [Photo by James N. Meyer.]

SOILS

The principal soil types on the Station are Fayette silt loam and Dubuque silt loam. The Fayette silt loam was formerly classified as Knox silt loam and Clinton silt loam. It has been developed from loessial material deposited at various depths. The maximum depth is about 6 feet, the average 4½ feet. The Dubuque silt loam has only a thin mantle of loessial material over soil residual from limestone. The depth of loessial material may be as much as 24 inches. The two soils have surface soils that are high in silt content and erode very easily. Both the Fayette and the Dubuque soils are low in organic-matter content and require the addition of 2 to 3 tons of lime to the acre for legume production. A soil and erosion map, shown in figure 6 (in envelope, p. 3, cover), was made of the Station in 1934. It will be noted that much of the cultivated land is severely eroded.

Agricultural History of the Station

It has been difficult to obtain a very accurate record of the agricultural history of the Station farm. The farmer from whom it was purchased stated that, in general, he had followed a rotation of corn, grain, and hay on the cultivated fields. Tillage and planting operations were done parallel to roads and fences; as a result, much of the cultivation was not on the contour. A map of the Station and the experimental areas are shown in figure 7 (in envelope, p. 3, cover).

The fields on which experiments were set up had probably been under cultivation 70 to 75 years at the time the Station was established. The farm was first cropped to grain and potatoes. In the late eighties there was a change to dairy farming. In 1932, at the time the Station began to function, the land was unproductive. Indications were that the farmer had not used good cultural practices and that as a result the soil was run-down and in low productive condition. The hay on the fields was composed largely of quack grass. Soil tests showed that the cultivated fields were acid, requiring 2 to 3 tons of lime per acre, and were low in phosphorus and potassium.

In 1940 additional land was rented from Mr. Hubert Hundt near Coon Valley, Wis. (fig. 8). Fifteen acres of Fayette silt loam soil are included in this tract. This farm is located outside of the steep bluff portion in the more gently rolling section of the area. The leased tract is moderately eroded and has uniform slopes that average 11 percent in grade and 300 feet in length.

Winter Erosion

During the winter period, November 1 to April 15, the ground is normally frozen. Most of the precipitation during the winter is in the form of snow. However, there may be some light rains in November and the first part of April. Usually, these rains do not cause high soil losses unless they fall on a soil that is thawed only for a few inches. Under these conditions there is nearly 100-percent runoff and the unfrozen soil, if unprotected by crop cover, is easily carried by the runoff even though the intensity of the storm is not high.

Detailed data for the control plots and watersheds are given in tables 20 and 30, Appendix, showing the soil and water losses by winter and growing season. Figure 9 shows the losses by seasons from the 3-year rotation on the control plots. The losses from corn for the entire year averaged 53 tons per acre, of which less than 2 tons were lost during the winter period. On land planted to grain, about one-third of the year's total loss of 30 tons took place during the winter period and two-thirds during the growing season. The winter soil loss averaged only 3 tons per acre of the total annual loss of 52 tons per acre on the cultivated watershed for a 5-year period.

The soil loss during the winter is low and the difficulties of obtaining accurate data are many. Unequal distribution of snowdrifts, resulting in more precipitation on some areas than others, causes more than the

FIGURE 6

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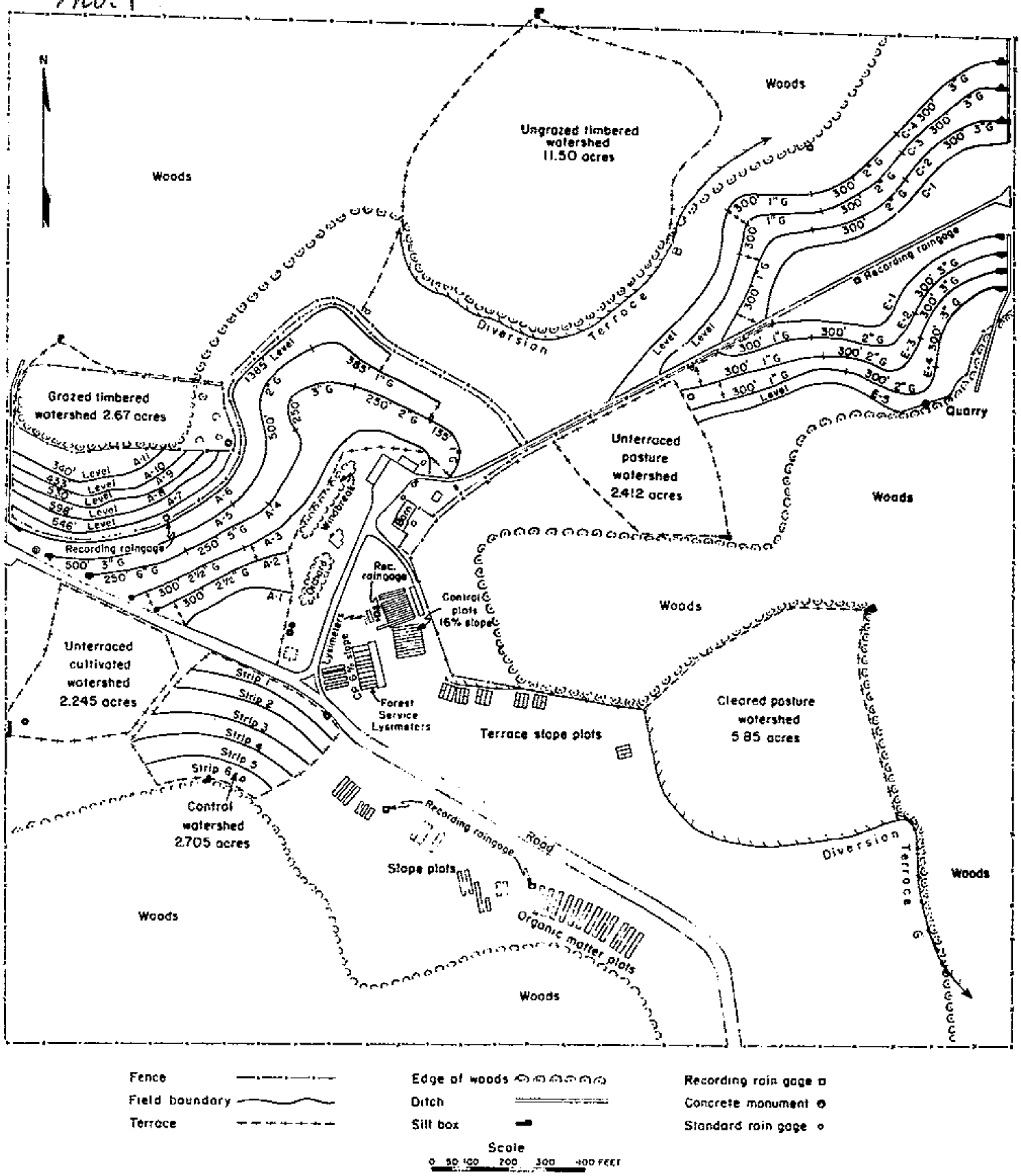

FIGURE 7.—Map of the Upper Mississippi Valley Conservation Experiment Station showing fields and experimental areas.

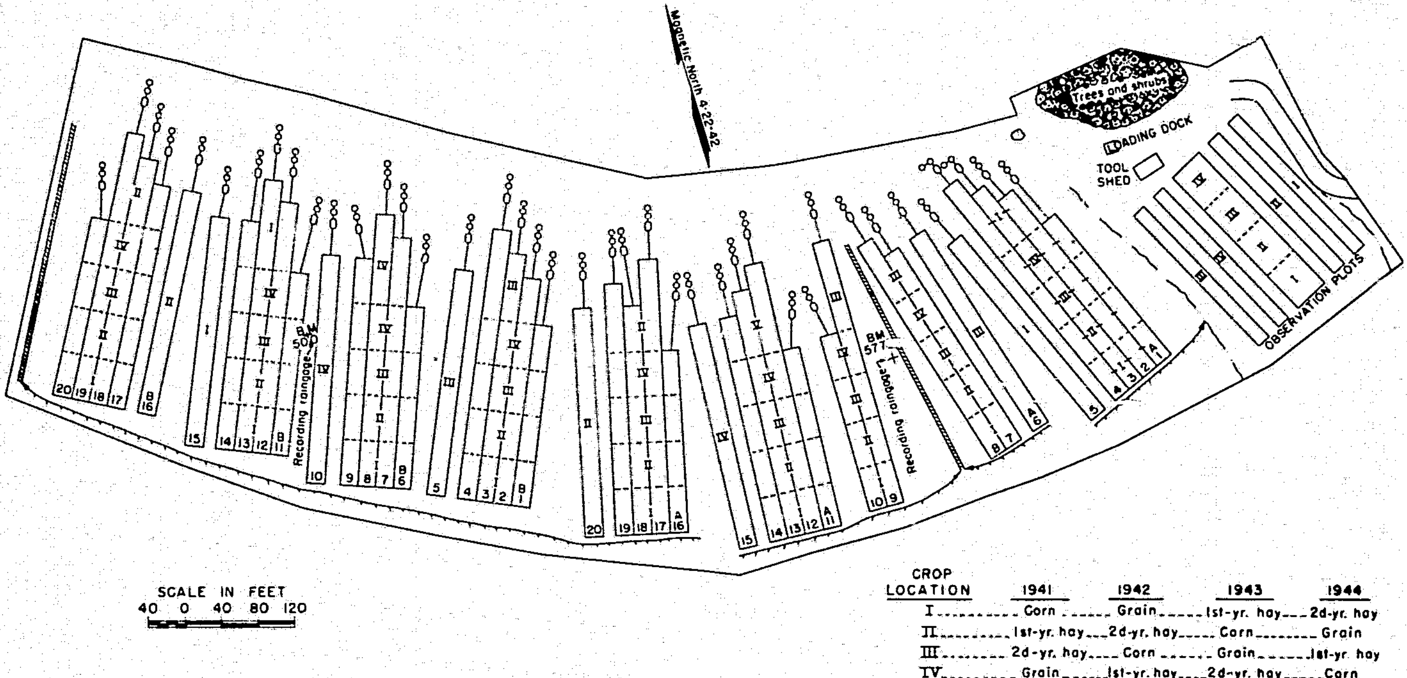

FIGURE 8.—Map showing plan of the Hundt Farm Experiment and crop location during 4-year rotation.

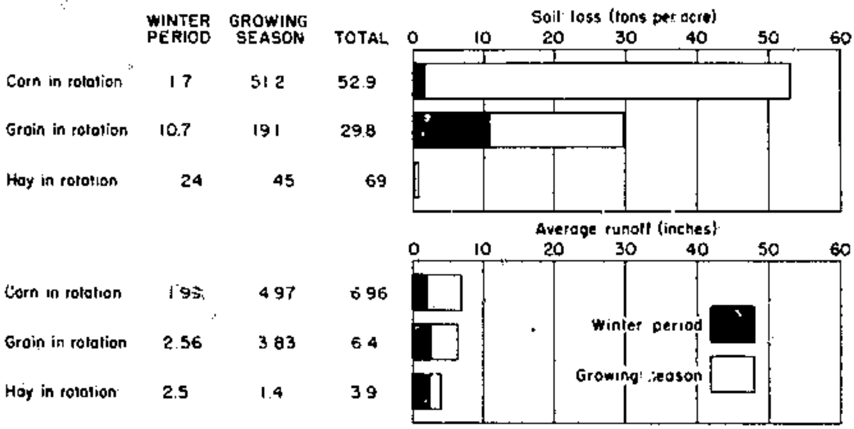

FIGURE 9.—Effect of season on soil and water losses.

usual variation between replicates and treatments. The runoff also changes to ice in the metal flumes and divisors, resulting in an inaccurate measurement of losses. This has made it extremely difficult to obtain reliable records.

In this report soil and water data are given for the growing season only, except in a few tables where both winter and growing season losses are shown.

FACTORS AFFECTING FROST PENETRATION AND THAWING

Studies were made in pasture, plowed land, hay land, and protected timber to determine the effect of cover and depth of snow on frost penetration. A summary of results of these studies (*1*) shows that soil covered with a good growth of timber, protected from grazing and fire so that there is a good covering of leaf litter on the ground, will not freeze deeply. In such a timbered area the snow depth is fairly uniform. The snow and the leaf litter afford good insulation to the soil. The maximum frost penetration in timber was 5 inches as compared with 10 inches in a good pasture having a similar slope and exposure.

Vegetation will protect the soil to an extent depending upon its height and density. Under general field and pasture conditions the effect of vegetation on frost penetration is more dependent upon its ability to trap and hold the snow cover than on the insulation afforded by the vegetation. Normally, the depth of snow is less variable in vegetated fields than in plowed fields. It has been observed in the fall that an area covered with a fair amount of vegetation will not freeze as soon under moderately cold temperatures as a plowed field when there is no snow on either. Maximum frost penetration on hay during some years has been as much as on plowed land.

Snow cover seems to be the most important factor affecting frost penetration during low temperatures. Measurements were made on a terraced field to determine the effect of snow depth on frost penetration. On the terrace ridge the snow cover was the thinnest and frost penetration the greatest (fig. 10). During the winter of 1937 the maximum depth of snow measured on the ridge was 5.5 inches and the maximum frost penetration 24.8 inches.

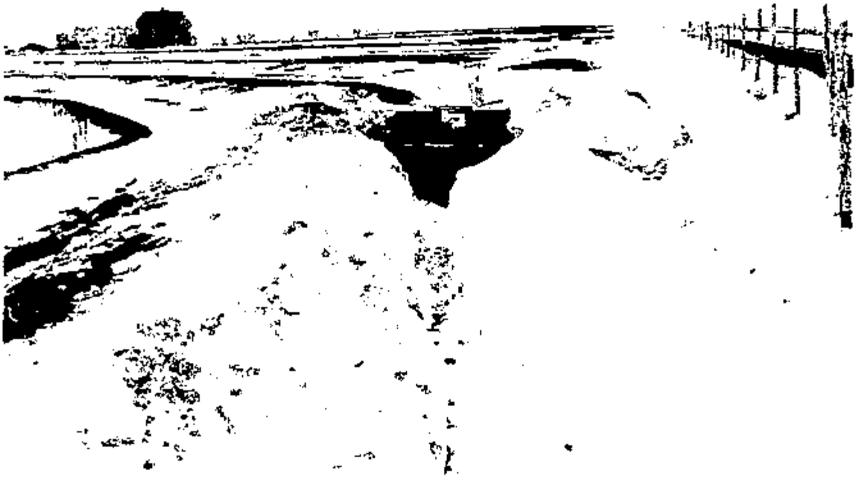

FIGURE 10.—View of "A" terraces showing variations in depth of snow cover.

The maximum depth of snow in the channel was 18 inches and the maximum frost penetration 3.8 inches. Assuming that variation in depth of surface soil was not a factor influencing frost penetration, the depth of snow cover during the season resulted in a variation in frost penetration of 24 inches. In another study various depths of snow were applied to a soil that was frozen to a depth varying from 7 to 10 inches. The depths of snow used were 0, 6, 12, and 24 inches. Snow was placed on frozen soil early in January 1940. The frost penetration on the 0 depth or bare plot continued to increase until there were 22 inches of frost. The 6 inches of snow cover gave some protection, but allowed frost to penetrate to a depth of 12 inches. The 12- and 24-inch depth of snow cover gave sufficient protection against the temperatures experienced to prevent further penetration of frost. In fact, under these depths of snow there was a slow reduction in the depth of frost. In 1940, the year in which these measurements were made, the minimum temperature for January at the station was −23° F. and for February, −13° F. The average minimums for the months were 3° F. and +12° F. for January and February, respectively. The temperatures experienced that winter were about average.

The thawing of the soil in the spring is influenced by exposure and vegetation. A south-facing slope can be expected to be free of snow and frost before a north-facing slope. It will thaw slowly with most of the melting snow infiltrating. Usually, during the first thaws that occur on a south-facing slope, the sun is not sufficiently high to cause much thawing on north-facing slopes. As a result these slopes do not thaw until the temperatures are much higher. This will cause more of the snow to be lost as runoff which will result in more soil loss on the north-facing slopes.

Vegetation, such as grass and hay, will protect the soil from thawing so that more of the snow is lost as runoff than from plowed fields. The plowed soil thaws rapidly when free of snow and is capable of storing and absorbing water in amount dependent upon the roughness of the surface and the moisture content of the soil.

GENERAL INVESTIGATIONAL PROCEDURE

Experiments were conducted to obtain information on the basic factors affecting soil and water conservation. These factors are: Type and density of vegetation, percent slope, length of slope, characteristics of precipitation, and soil type and condition of soil. In addition to these studies, measurements were made on terraced and strip-cropped land to determine the best design of these control practices for conditions common to this problem area. Data obtained consisted of measurements of soil and water losses, yield of crop, and general observations. Water losses are reported in surface inches and as percent of precipitation. Soil losses are reported in tons per acre.

Measuring equipment varied, depending upon the size of plot. On the control plots and lysimeters, metal tanks of sufficient capacity to hold all of the runoff expected from one rain were used. These tanks had a capacity of 3.5 surface inches of runoff which is about 50 percent of 7.23 inches, the maximum amount of rainfall ever recorded during a 24-hour period by the Weather Bureau at La Crosse.

Plots larger than 1/100th acre and less than ½ acre are equipped with a silt tank, multislot divisors, and aliquot tanks (fig. 11). As the runoff suspension passes through the silt tanks, a portion of the silt is deposited

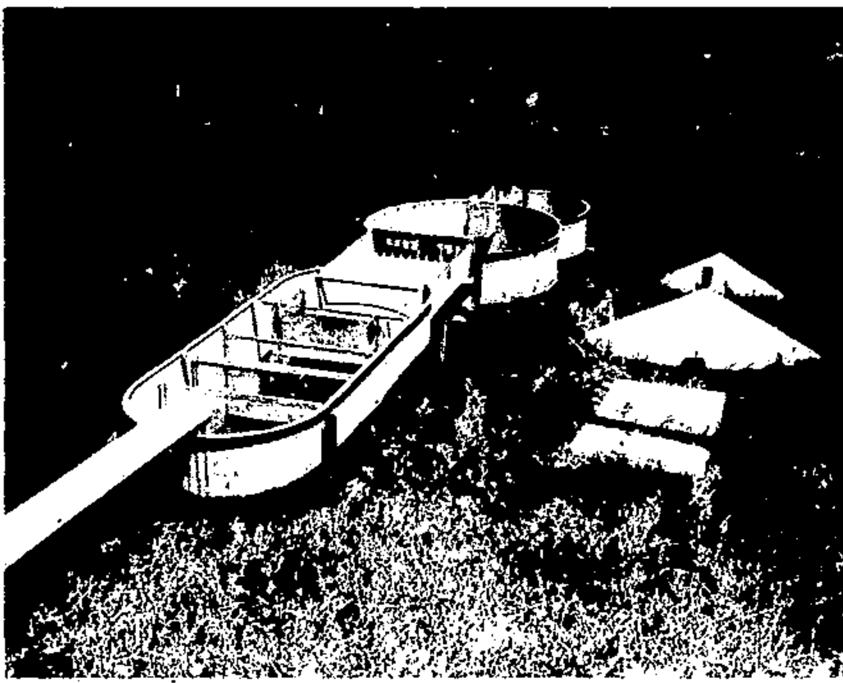

FIGURE 11.—Plot-measuring equipment: Silt-tank multislot divisors and aliquot tanks.

and the trash is screened. When the capacity of the silt tank is exceeded, the screened suspension flows through a multislot divisor in which one slot is connected to an aliquot tank. Therefore, most of the runoff is wasted and only a relatively small portion collected in the aliquot tank for soil and water determinations.

Watersheds and terraces have measuring equipment arranged so that the runoff suspension passes through a calibrated flume to which is attached a water-stage recorder with which a hydrograph of the runoff is obtained. The runoff is then collected in a large silt box where some of the soil is deposited. The silt box is constructed so that the end of the box is a weir, over which most of the runoff flows when the capacity of the silt box is exceeded. A Ramser silt sampler is attached to the side of the box by means of which an aliquot of the runoff is obtained.

Runoff was measured or weighed after each thaw and rain which produced a measurable amount of runoff. The sampling procedure varied with the type of measuring equipment and the size of the area. The runoff in the silt box was measured, the suspension thoroughly agitated, and an aliquot obtained for sampling as the box was drained. The runoff in the aliquot tanks was stirred, pumped through a divisor by which a continuous sample was obtained, and collected in a large tank mounted on a scale. Each tank was measured or weighed, and sampled separately. Triplicate quart samples were obtained from each tank for dry-soil content determination.

Control Plots

A series of 11 plots known as "control plots" was established in 1932 and measurements were begun in 1933 (fig. 12, *A* and *B*). These plots are located on a 16-percent slope of Fayette silt loam soil with northern exposure. All the plots were 6 feet wide and 72.6 feet long except plots 1 and 2. Plot 1 was 36.3 feet long, and plot 2, 145.2 feet. The site on which this experiment was located had been cropped for 70 or more years at the time the study was started. It, however, was not as severely eroded as the rest of the farm. There were about 8 inches of surface soil on the plots at the time the experiment was established.

In 1933, plots 12, 13, and 14 were established on a 30-percent slope. Measurements were discontinued in 1939. Plots 15 and 16 were established in 1936 on a 16-percent slope. Plots 17 and 18 were established in 1939 on a 16-percent slope in connection with the study of degree of erosion. During the same year, plots 19, 20, 21, and 22 were established on a 6-percent slope. All the plots established after 1932 were 6 feet wide and 72.6 feet long. Data from these plots are given in table 20, Appendix.

Plot treatments during 1932–38 were as follows: Plots 1, 2, 3, and 11 were planted to corn each year. Plot 11 was desurfaced by removing the 8 inches of surface soil manually. Plot 4 was planted to grain annually. Plots 5, 6, and 7 were planted to a 3-year rotation of corn, grain, and clover-timothy hay. Plots 8 and 9 were fallowed, being cultivated with a hoe sufficiently to control weeds. Plot 9 received an annual application of 5 tons per acre of barnyard manure. Plot 10 was covered with bluegrass sod and not mowed or grazed during the years 1932–38.

Bluegrass sod gave very good control; only 5.5 percent of the precipitation was lost as runoff. This removed only 0.1 ton of soil per acre per year. Most of this loss occurred during the winter period. Table 20 gives detailed data from this experiment by plots. It will be noted that of the average annual runoff of 1.87 inches from bluegrass only 0.03 inch was lost during the growing season. It was found that more

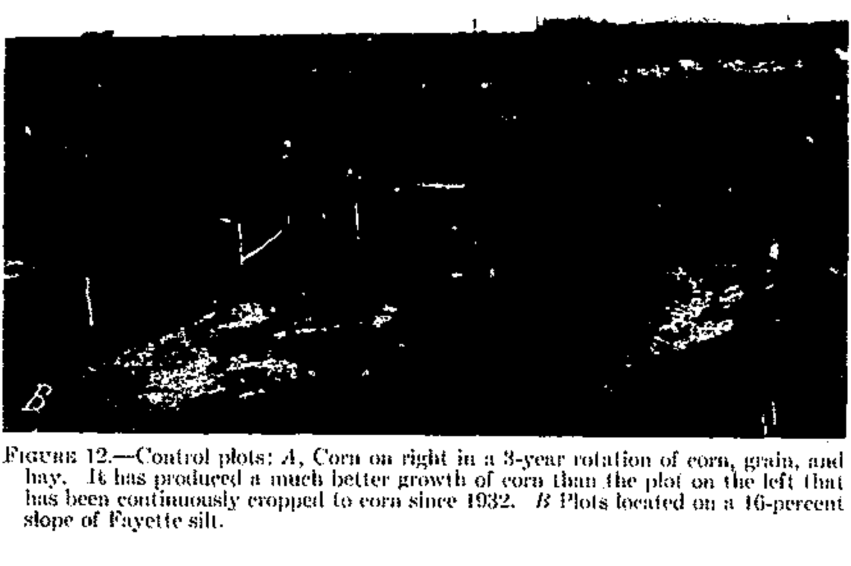

FIGURE 12.—Control plots: *A*, Corn on right in a 3-year rotation of corn, grain, and hay. It has produced a much better growth of corn than the plot on the left that has been continuously cropped to corn since 1932. *B* Plots located on a 16-percent slope of Fayette silt.

runoff occurs from grass land in the winter than from plowed land. This is due to the fact that the soil when frozen under a good dense growth of grass thaws out slowly. Thus, very little of the melting snow is absorbed, whereas plowed land when free of snow will thaw rather rapidly and absorb a considerable amount of precipitation. In the summer this condition is reversed. The grass plot then allows practically no runoff, whereas plowed areas allow high amounts of runoff.

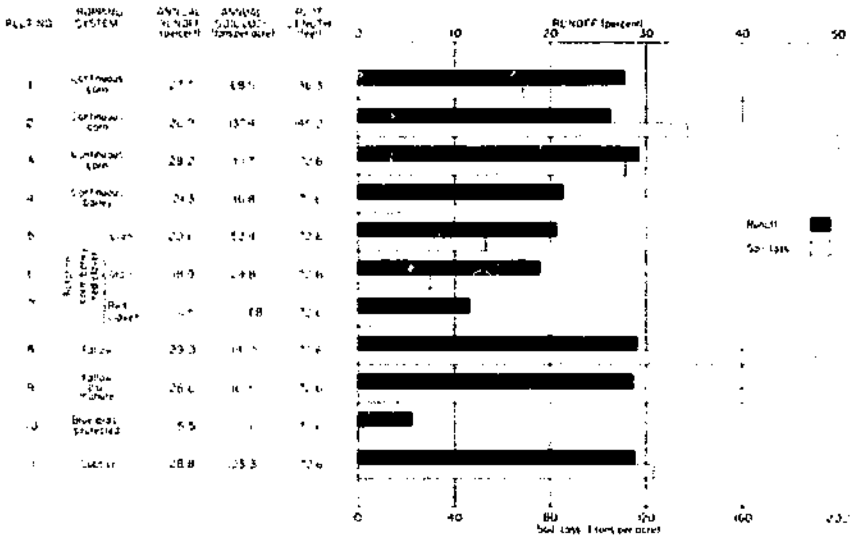

FIGURE 13.—Annual soil and water losses from control plots, 1933-38.

Figure 13 shows the annual soil and water loss by cropping system for the period 1933-38 inclusive. The highest soil loss occurred on plot 8, which was fallow throughout the 6-year period. The average annual soil loss was 191 tons per acre, which is equivalent to about 1⅓ inches of soil. The application of 5 tons of manure per acre annually on fallow was effective in reducing soil losses by about 30 tons per acre.

The effect of vegetation on soil loss depends upon the density of the vegetation, the length of time the soil is protected, and whether or not protection is available when the intense storms occur. Crop rotation is an important factor in controlling erosion, because losses are not only low when the area is growing hay but losses from the clean-tilled crop following hay are reduced by the incorporation of raw organic matter into the soil.

Corn in rotation lost an average of 53 tons of soil per acre following clover-timothy hay. This was less than one-half the loss from continuous corn of about 112 tons per acre. This difference in loss can be largely attributed to the better structure of the soil following hay and to the raw organic matter incorporated into the soil.

The soil loss from grain in rotation with corn has been just about double that of continuous grain. More organic matter is incorporated into the soil grown to continuous grain than in soil in grain following corn.

The average annual soil loss from a 3-year rotation of corn, grain, and clover-timothy hay without the application of barnyard manure was 27.8 tons per acre. This loss is considered to be excessive, inasmuch as one inch of soil would be removed in about 5 years. Table 21 shows soil and water losses by crops for the growing season, April 16 to October 31. The rains are divided into three groups—high-factor, moderate-factor, and low-factor rains. It has been found that on the average 5 out of 59 storms resulted in about 90 percent of the soil lost from corn in rotation.

Figures 14 and 15 show total soil and water losses for corn, grain, and hay for each month during the period, April to October. The runoff from corn following hay is low during April and May. During this period the soil is rough and of good structure; it is capable of storing considerable water on the surface and the intake of water is high. As the season progresses the land is worked and corn is planted by the latter part of May. At this time much of the rough cloddy structure is

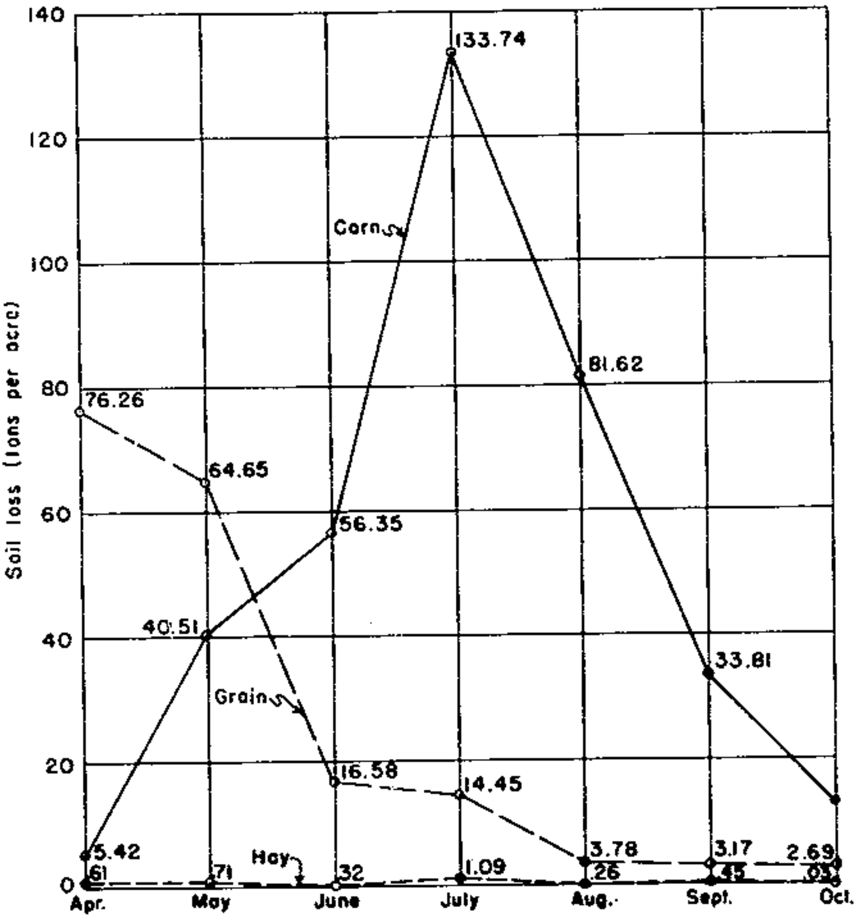

FIGURE 14.—Soil loss by months for corn, grain, and hay, 1933-38, in a 3-year rotation.

destroyed or greatly reduced. The largest amounts of runoff occur in July, August, and September with the runoff peak in August.

For grain following corn the land is also fall spaded, but there is insufficient raw organic matter in the soil. The clods are, therefore, broken down to a considerable extent by alternate freezing and thawing in early spring. Even before the grain land is tilled, runoff is more than from cornland. Grain is usually planted during the last two weeks in

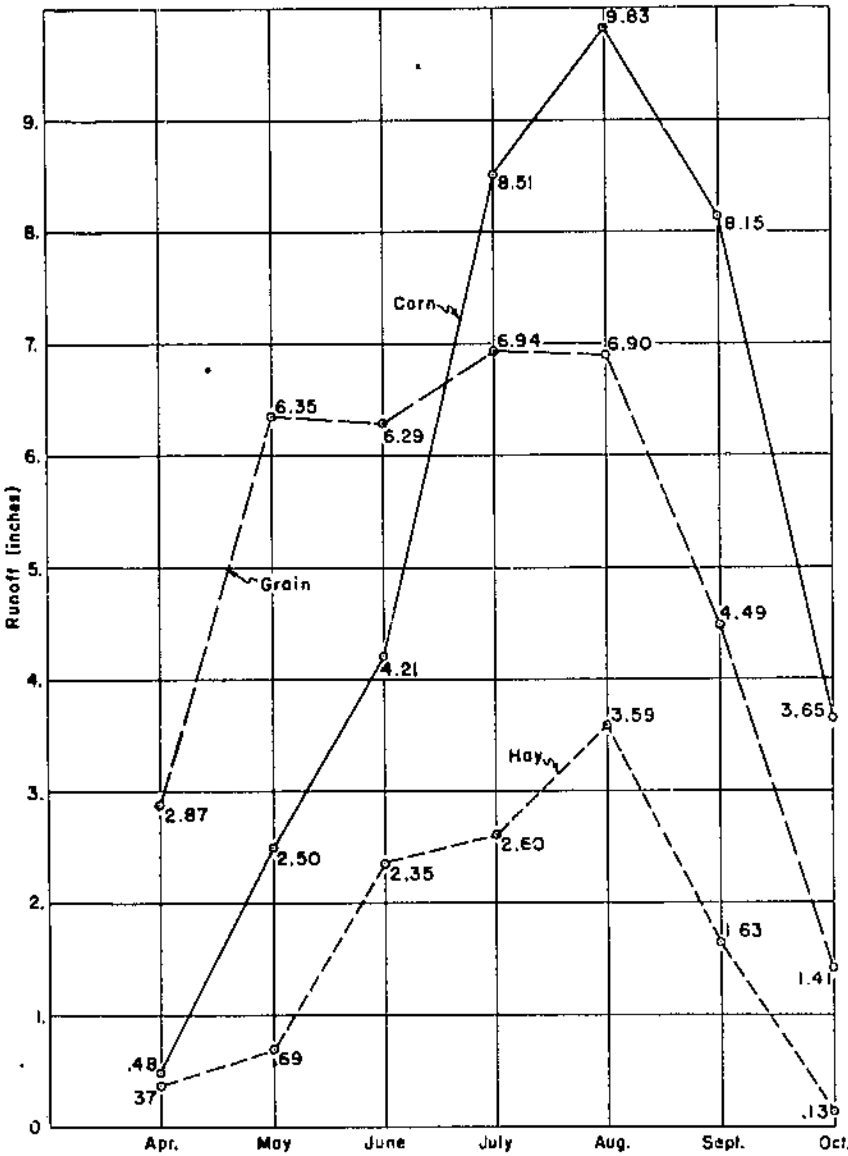

FIGURE 15.—Total runoff by months for corn, grain, and hay, 1933-38, in a 3-year rotation.

April. At that time a fine, firm seedbed is prepared for the legume seeds. This produces a condition that is conducive to high amounts of runoff. Runoff is high from grain throughout the season or until the legumes begin to reduce runoff, which does not normally occur until early fall.

Runoff from hay is relatively low throughout the season; however, the curve for hay land follows a somewhat similar pattern to that of corn and grain.

In general, the soil loss curve for corn follows a pattern similar to that of runoff from corn, except that the soil loss reaches a peak in July instead of August. Soil loss from corn reaches a peak in July because a large number of intense storms occur in July when the corn is being cultivated and is too short to give good canopy interception. In August the corn has been laid by, runoff channels have been established, and weeds start to protect the soil, all of which tends to reduce soil loss.

Soil loss from grain is high during April and May. Any storms of moderate or high intensity will cause high soil losses from grain until it is 8 or 10 inches tall. Thereafter, soil losses can be expected to be relatively low.

The soil loss from hay has been low each month. Rains occurring immediately after the crop has been removed have not resulted in high losses.

Degree of Erosion

Control plots 3 and 11 are used to compare soil and water losses from surface and subsoil plots. In 1932, plot number 11 was desurfaced by the removal of 8 inches of surface soil. Plot number 3 was not given special treatment. Each plot was planted to corn on the contour each year during the period 1932–38. Detailed data are given in table 24. The desurfaced plot lost on the average 117 tons per acre per year and the surface soil plot 99 tons. Throughout the experiment both plots lost soil very rapidly; however, during the first 2 years the desurfaced plot lost 45 percent more soil than the surface-soil plot. During the last 4 years, the subsoil plot lost only 2 percent more soil than the surface-soil plot. At the end of 2 years of corn the raw organic matter had become decomposed and the surface plot had become badly eroded so that there was not much difference in the erodibility of the 2 plots.

By 1938 the fallow and the continuous corn control plots had become severely eroded, having lost all but 2 to 3 inches of the surface soil. However, the plots in rotation and continuous grain during the same period of treatment had lost one-half as much soil or had about 5 to 6 inches of surface soil remaining, which was considered as moderately eroded. By including 2 plots from the moisture series, which were in the same treatment as the control plots, a degree-of-erosion experiment was established in 1939 which included 10 plots. There are 5 plots on severely eroded soil and 5 on moderately eroded soil. The plots have received phosphorus and potash on grain in amounts based on soil tests to maintain a level of fertility of 50 pounds of available phosphorus per acre and of 150 pounds of available potassium per acre. Lime was applied on corn to maintain a soil pH of 6.5. Eight tons per acre of barnyard manure was applied on corn. All crops were planted on the contour and cultural treatments were as similar to field operations as is possible with small plots.

With the phosphorus, potassium, and pH held uniform the principal difference between the two degrees of erosion is in organic-matter and nitrogen content of the soil. The moderately eroded plots in 1939 had an average nitrogen content of 0.108 percent for the 0- 6-inch depth and the severely eroded plots 0.053 percent. The organic-matter content of the moderately eroded soil of 0- 7-inch depth was 1.7 percent, whereas that of the severely eroded soil was 0.82 percent.

Four years of data are reported for this experiment. These data are shown in table 22 and figure 16. Regardless of crop, the severely eroded plots lost more runoff than the moderately eroded plots. The eroded soil became more compact resulting in lower infiltration and higher runoff. The severely eroded areas averaged 3.1 inches of runoff for corn, grain, and hay, whereas the moderately eroded averaged 1.8 inches for the same crops. The soil loss on severely eroded soil was only slightly more than from moderately eroded soil when planted to corn, even though runoff was about 0.6 inches more per year. The soil loss from land planted to grain was higher than the loss from the

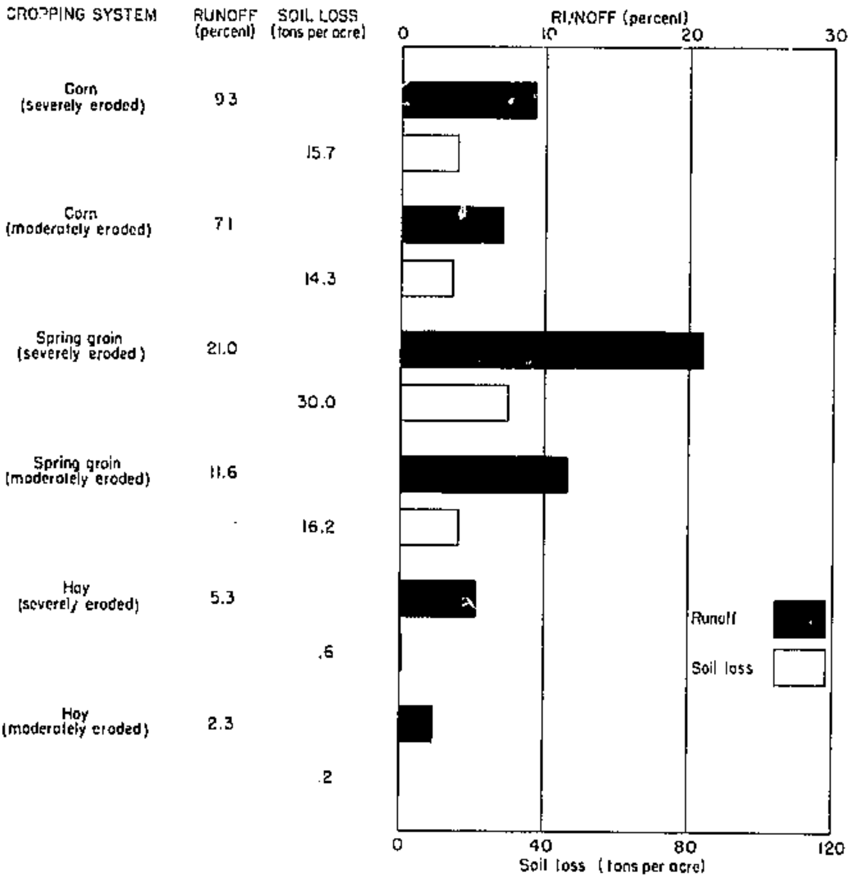

FIGURE 16.—Average annual soil and water loss from moderately and severely eroded plots, 1940-43.

land planted to corn, regardless of degree of erosion. This reduction of erosion on cornland is due to the conditioning of the soil in the longer rotation; that is, the soil structure is better and there is much more raw organic matter incorporated into the soil when hay is plowed under than when corn stubble is plowed under. Grain on severely eroded soil allowed about 1.8 times as much soil loss as grain on a moderately eroded soil. This is due to the fact that when grain follows corn the raw organic matter incorporated from the hay has been decomposed so that degree of erosion can then exert its maximum influence on soil and water losses. The soil loss from hay was low regardless of degree of erosion.

Yield of crop was lower on the severely eroded areas for all crops. Corn yielded 70 percent, grain 55 percent, and hay 92 percent as much on severely eroded as on moderately eroded soil. Yield of hay was not as much influenced as the yield of corn and grain by the loss of surface soil.

In field trials conducted in 1943 on farms in Minnesota and Wisconsin yield of crop was determined on various degrees of erosion within a field.[5 6] Data recorded in these trials (table 4) are in good agreement with those obtained from the small plots at the station. In the studies conducted under farm conditions there was a wide variation in cropping and fertilizing practices between farms. Degree of erosion, however, was found to be a primary factor affecting yield of crop. Yield of crop is less on the eroded soil because the eroded soil contains less organic matter, less nitrogen, and therefore has more runoff.

TABLE 4.—*Effect of degree of erosion on yield of crop, as shown by bushels per acre in field trials of 1943*

Crop	State	Farms	Slightly eroded fields	Moderately eroded fields	Severely eroded fields
		Number	*Bushels*	*Bushels*	*Bushels*
Corn	Wisconsin	8	80	67	60
Grain	do	11	65	59	43
Grain	Minnesota	5	36	30	23

ORGANIC MATTER

Maintaining a soil in high organic matter content is important not only for maximum yields of crop but for controlling soil and water losses. Too frequently, the farmer follows a practice of removing all crop growth that can be utilized for feed. By removing two or three crops of hay and by pasturing the aftermath, full advantage is not taken of the benefits to be gained from a hay crop in adding soil fertility and controlling erosion. Part of the advantage of rotation of crops is the effect that the organic matter has on soil structure and its binding effect on the soil when plowed under.

Within the original control plot experiment there were two fallowed plots. These plots were worked with a hoe to simulate disking and with such frequency as to keep the weeds under control. Barnyard

[5] HAYS, O. E., and MUCKENHIRN, R. J. THE EFFECT OF DEPTHS OF SURFACE SOIL AND CONTOURING ON CROP YIELDS, 7 pp., 1943. [Processed.]

[6] HAYS, O. E., AND ROST, C. O. THE EFFECT OF DEPTH OF SURFACE SOIL AND CONTOURING ON CROP YIELDS IN MINNESOTA, 6 pp., 1943. [Processed.]

manure was applied to one plot each spring at a rate equivalent to 5 tons per acre. The other plot received no treatment other than cultivation.

The soil losses from these plots were extremely high, over 1 inch a year. The plot which received the annual dressing of barnyard manure lost 28 tons per acre per year less soil or about 85 percent as much as the plot which received no manure. Detailed data on this experiment are given in table 25, Appendix. The effect of manure on fallowed soil is mostly mechanical. The organic matter keeps the soil open and partly covers it, thus reducing runoff and decreasing the erosive action of moving water.

Barnyard manure applied to corn on severely eroded soil with 3 inches of surface soil remaining resulted in a slightly greater increase in protection against erosion than when applied to a fallowed soil. One year's data show that barnyard manure plowed under reduced soil losses from 80 to 63 tons per acre and that barnyard manure, surface-applied, reduced soil losses to about the same extent as barnyard manure plowed under, or 65 tons per acre. Thus, the application of 8 tons per acre of barnyard manure resulted in a reduction in loss of 21 percent. Barnyard manure plowed under in the fall reduced the fall and spring losses below those from plots on which manure was not applied. Spring surface-applied barnyard manure reduced the losses after application below those from the plots on which it was applied in the fall. However, for the year there was not much difference in the loss reduction resulting from time or type of application. The effect of time of application of barnyard manure on soil loss will depend upon when intense storms are experienced. Fall application will give more protection from fall and early spring rains and thaws, whereas spring applications will give most protection during the early summer months.

Green manure, which consisted of the alfalfa-timothy hay produced

TABLE 5.—*Soil and water losses and crop yields on eroded soil receiving various organic-matter treatments*[1]

Treatment	Runoff from—		Soil loss per acre from—		Yield per acre from—	
	Corn	Grain	Corn	Grain	Corn	Grain
	Inches	*Inches*	*Tons*	*Tons*	*Bushels*	*Bushels*
No treatment	7.23	0.78	80.10	3.26	66.1	28.0
Barnyard manure fall applied before corn	5.97	.76	63.68	1.08	75.1	33.4
Green manure plowed under fall before corn	5.64	.94	53.62	2.12	69.6	27.6
Barnyard manure applied at corn planting	6.37	1.12	65.44	4.83	72.2	31.4
Green manure plowed under in fall plus barnyard manure applied at corn planting	5.64	.40	57.80	1.56	72.1	24.4
Green manure fall-applied tilled with sweeps	4.23	.40	20.22	.69	53.7	18.1

[1]Plots 72 feet in length are located on a 16-percent slope of Fayette silt loam.

after the first crop of hay was removed, effected a greater reduction of soil loss when plowed under than the application of 8 tons of barnyard manure. Soil loss from plots receiving both barnyard manure and green manure was higher than from green manure alone but less than from barnyard manure alone. It would be expected that the combination of the two manures would result in the greatest reduction of soil loss. This occurred on one plot but on its duplicate the soil loss was much higher than from either treatment alone. The lowest losses occurred on plots worked with the sweeps which left all or most of the green manure on the surface. The losses by treatment and crop are shown in table 5 and table 26, Appendix.

The corn stubble was plowed on all plots except numbers 7 and 12. These two plots were worked with the sweeps. Seeding of grain was uniform within this experiment. Plots on which barnyard manure was surface-applied on corn had the highest soil loss when planted to grain. Barnyard manure plowed under and green manure applied on cornland reduced the soil losses from grain land the following year.

Yields of the crop were highest on plots receiving barnyard manure. Where the barnyard manure was plowed under, the yield was slightly higher than where it was surface-applied. The lowest yield occurred on plots worked with the sweeps.

Subsurface Tillage

In the discussion on organic matter it was pointed out that the lowest soil and water losses on cornland occurred on plots on which sweeps were used for subsurface tillage. It was also shown that yield of crop was less than for other treatments. For the last 4 years strips in fields have been worked with sweeps in seedbed preparation for corn in place of plowing. It has proved very difficult to reduce the stand of grass in the second- or third-year hay enough to keep it from competing too severely with corn for moisture and plant nutrients. In lifting the sod only slightly, as is done with the sweeps, it has been found that, under favorable moisture conditions, the grass keeps right on growing.

It is believed that there is little place for subsurface tillage for corn in this problem area, especially where hay is left down more than 1 year and quack grass is a problem. On soils not infested with quack grass good yields of grain can be obtained by disking. This will leave all or most of the corn residue on the surface. This residue is fairly effective in reducing soil and water losses. Studies made at the station have shown that where the old pasture sod is tilled with a field cultivator in such a way that most of the organic residue is left on or near the surface, soil losses will be very low. This is the case even though intense storms occur before the seeding is sufficiently well established to give adequate protection.

Crop Rotation

The practice of crop rotation, including 1 year or more of hay, is basic to a good soil conservation program. The protection given by a rotation will depend on the type and density of the hay crop grown and the amount of the growth returned to the soil when the hay crop is plowed under.

Most of the experiments during the first 6 years of the La Crosse station's existence were on crops in a 3-year rotation or in continuous cropping. The effect of a 3-year rotation as compared with continuous corn and grain is shown in figure 17. Corn in rotation caused a loss of one-half as much soil as continuous corn. Grain in rotation following corn caused a loss of twice as much soil as continuous grain. The loss for the 6-year period, 1933–38, averaged 28 tons per acre for the three crops in rotation.

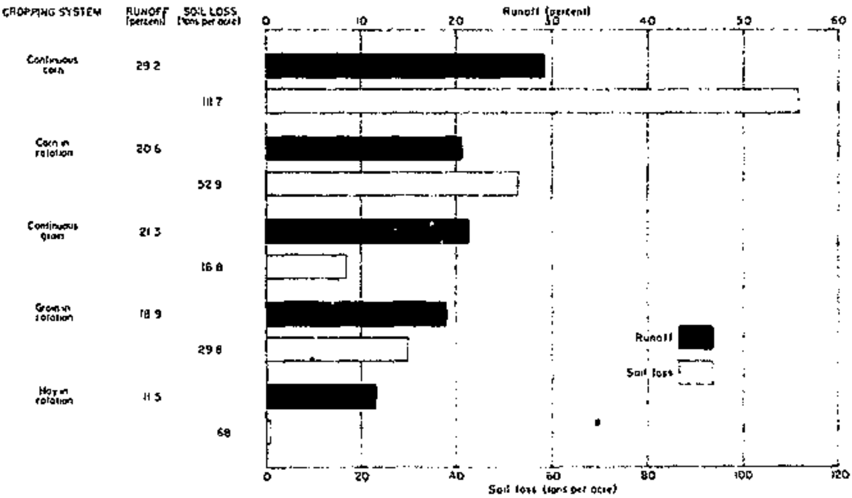

FIGURE 17.—Effect of rotation on soil and water loss, 1933–38.

In addition to these data, measurements had been made by 1941 on various sequences of crops including a year or two of data in each case. This information was assembled in a bulletin, Cropping Systems That Help Control Erosion (*3*). It presents and discusses tables that show the effect of crop sequence, percent of slope, and length of slope or soil and water losses.

The following tabulation from that bulletin shows the effect of crop sequence on soil losses from plots 72.6 feet long located on a 16-percent slope. It gives the computed soil losses under various cropping systems.

Cropping system	*Average soil loss—Tons per acre per year*
Corn annually	89
Corn, barley, (sweetclover)	33
Corn, barley, and hay	22
Corn, barley, hay, hay	13
Corn, barley, hay, hay, hay	8
Corn, barley, hay, hay, hay, hay	7

It will be seen that the data in figure 17 for a system in which corn is grown annually and for the 3-year rotation system are not the same as the data given in the preceding tabulation. The data in the tabulation are for a longer period, 1932–40, and include 2 years, 1939 and 1940, when the soil losses were low. The data used in figure 17 are for the period 1933–38. These data were used because some of the treatments were changed in 1939. The relative effect of rotation, however, is similar regardless of the period used.

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Data obtained since 1940 do not differ materially from those reported by Hays and Clark (*8*). For example, the computed soil loss from a 5-year rotation was 8 tons per acre. The soil loss for a 5-year rotation for the period 1941–43 averaged 7.4 tons per acre.

More studies are needed to determine exactly the relationship of rotation, percent of slope, and length of slope. Information on the relationship of these factors to soil loss is essential to the development of good conservation plans.

Length of Slope

As the length of slope increases, the velocity of the runoff becomes higher. This is caused by the concentration of water in rills and gullies which results in increased carrying power and higher soil losses. The studies at the station on the effect of length of slope are not too conclusive because no uniform slopes are available for such a study. Experiments, therefore, have of necessity been limited to the shorter lengths of slope.

The effect of length of slope has been studied in three experiments. In one, three control plots—36.3 feet, 72.6 feet, and 145.2 feet, respectively, in length were planted to corn on the contour. The plots are 6 feet wide which tends to restrict runoff to sheet flow. Data from this study for the period 1933–38 are included in detail in table 23, Appendix. The 36-foot length of plot lost two-thirds as much soil per unit area as the 73-foot length of plot and one-half as much as the 145-foot length of plot.

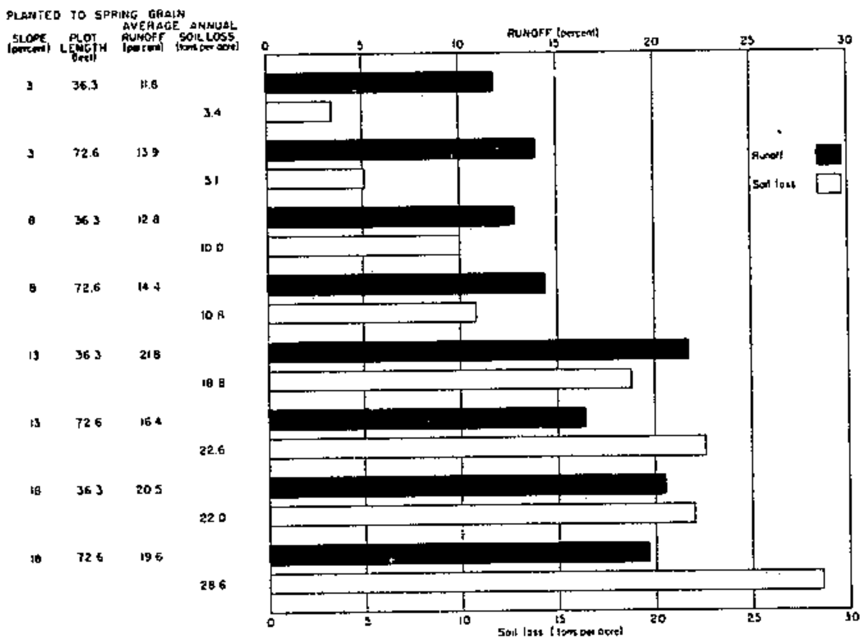

FIGURE 18.—Average annual soil and water loss from plots with 2 lengths of slope and various percents of slope, 1939–43.

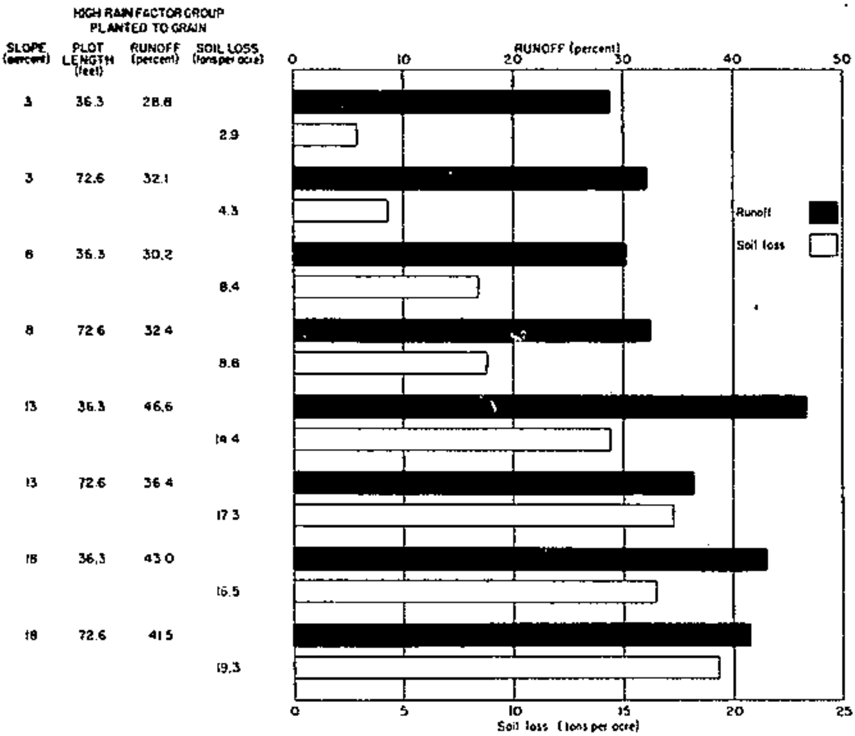

FIGURE 19.—Soil and water losses from plots with various lengths and percents of slopes during high rain-factor group storms, 1939–43.

Runoff is not greatly affected by length of slope; there is, however, a tendency for the percent of runoff to be higher on the shorter length of slope. The soil loss is increased with the length of slope.

In the control-plot experiment corn was grown continuously. Under this severe treatment the plots became badly eroded during the course of the experiment. In another experiment two lengths of plot, 73 and 36 feet, were planted to a 3-year rotation of corn, grain, and clover-timothy hay. Detailed data are given in table 37. The plots were 20 feet wide and were located on a 19-percent slope. Table 6 summarizes the results of this experiment.

TABLE 6.—*Effect of crops on soil loss caused by length of slope*

Crop	Soil loss per acre from slope length of—		Ratio
	72.6 feet	36.3 feet	
	Tons	*Tons*	
Corn	64 1	47.1	1.4
Barley	31.8	20.6	1.5
Hay	2.4	1.2	2.0

It will be seen that the soil loss is higher from each crop when planted on the longer slope. The greatest percentage increase was on hay. This increase occurred largely during years when hay followed a year of severe soil loss from grain. Rills would be washed in the longer grain plots which would result in poorer stands of hay the following year.

In the percent-slope study two lengths of plots are located on each slope. All plots are in triplicate and are planted to grain with the slope. The two lengths under study are 36.3 and 72.6 feet. In table 7 the soil losses are shown by percent of slope and length of slope for the period 1939-43.

TABLE 7.—*The effect of percent slope on soil loss by length of slope*

Percent slope	Soil loss per acre from slope length of—		Ratio
	72.6 feet	36.3 feet	
	Tons	*Tons*	
3	5.11	3.41	1.50
8	10.80	9.98	1.08
13	22.56	18.81	1.20
18	28.62	21.97	1.30

There was a higher soil loss from the longer slope than from the shorter slope regardless of percent of slope. There seems to be no definite relationship between length of slope and percent of slope.

The relationship of slope lengths to soil and water loss from various percent slopes is shown in figures 18 and 19.

PERCENT OF SLOPE

In order to study the effect of percent of slope on soil and water losses, plots were established on four slopes located in a 5-acre field on which soil is quite uniform. The soil is moderately eroded with 6 to 7 inches of surface soil remaining. Plots were established on the following slopes: 3, 8, 13, and 18 percent. The slopes are fairly uniform throughout the experiment with the exception of slope 13 on which the upper part is less steep than the lower part. All plots are 14 feet wide. Within each slope group there are 6 plots, 3 that are 36.3 feet long and 3 that are 72.6 feet long. All plots during the period reported were planted to grain with the slope, in order to eliminate the variable effect of contouring, since it was assumed that the contour furrows would be more effective on the less steep slopes. Detailed data are included in table 27, Appendix. Figure 18 shows the soil and water losses by slope for the growing season.

As an average for all storms, it will be seen that the percent of runoff increases slightly as the slope becomes steeper. In figure 19 are included data from storms in the high-rain factor group. For the 73-foot length of slope the amount of runoff is about the same from each slope except for that of the 18-percent. The 3-percent slope lost 32 percent of the precipitation, the 8-percent 32, the 13-percent 36, and the 18-percent slope lost 42 percent. From individual highly intense storms, slope had no effect on amount of runoff. For example, a very hard storm was experienced on June 7, 1940, from which the 3-percent plots lost 1.24 inches, the 8-percent plots lost 1.22 inches, the 13-percent plots lost 1.18 inches, and the 18-percent plots lost 1.26 inches. Surface runoff is precipitation in excess of infiltration and surface storage. During the most intense storms surface storage is so greatly exceeded that it has very little effect on resulting runoff.

Soil losses in each case are higher from the steeper slopes regardless of intensity of precipitation, although most of the soil loss occurs during the high-rain factor storms. The soil loss from the 3-percent slope has averaged 5.1 tons per acre for the growing season; that from the 8-percent slope has averaged 10.8 tons per acre; that from the 13-percent slope has averaged 22.6 tons per acre; and the 18-percent slope has lost 28.6 tons per acre. These losses are for the 72.6-foot plots. The increase in soil loss as the slope becomes steeper is the result largely of the increase in velocity of runoff water. It is not due to an increase in volume of runoff. Tests made of velocity of flow on the plots immediately following rains that cause runoff show that for an increase in slope of 5 percent, there is an increase in velocity of about 8 feet per minute.

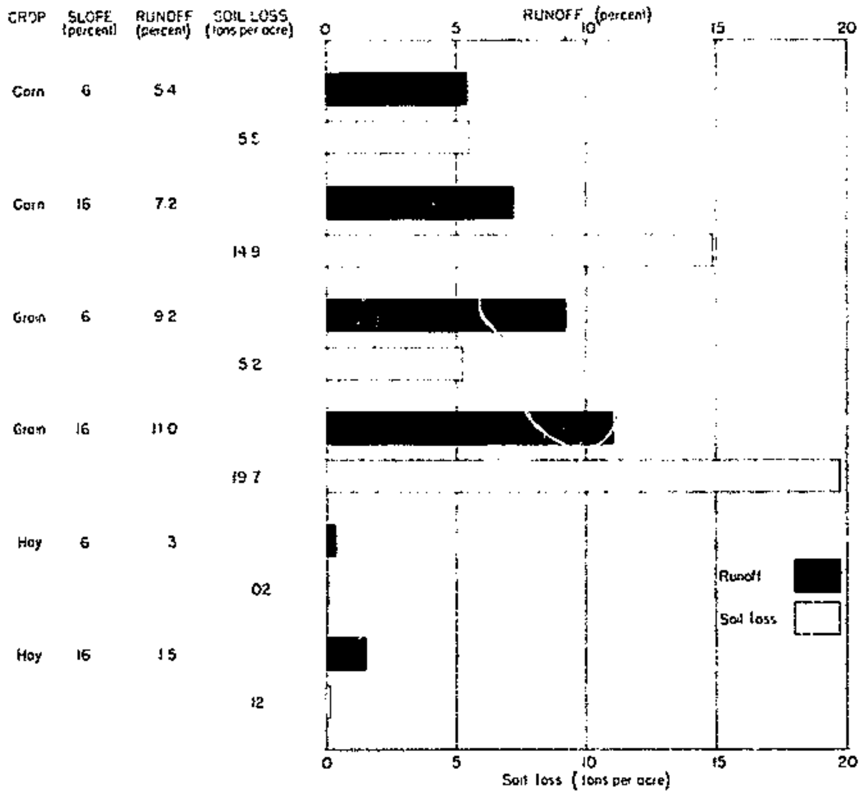

FIGURE 20.—Effect of percent of slope on soil and water losses from various slopes, 1941–43.

In the control-plot experiment corn, grain, and hay are grown in rotation on a 6-percent and 16-percent slope. The plots with 6-percent slope are planted to a 4-year rotation of corn, grain, and 2 years of hay, and the plots with 16-percent slopes are planted to a 5-year rotation of corn, grain, and 3 years of hay. The hay on each slope is alfalfa-timothy. The losses from corn probably are influenced by the variation in length of hay stand, but it can be assumed that the losses from grain would not be greatly influenced.

The data for the 3-year period, 1941–43, are shown in figure 20. These data support those obtained from the more complete percent slope experiment. Runoff from the 6-percent slope planted to corn was 5.4 percent of the precipitation as compared with 7.2 percent from a 16-percent slope. Runoff from spring grain was 9.2 percent from a 6-percent slope and 11 percent from a 16-percent slope. That is, there was only an increase of 2 percent in runoff from corn and grain on the 16-percent as compared with the 6-percent slope. Soil losses were influenced to a greater extent than runoff. The loss from land planted to corn was 5.5 tons per acre on the 6-percent and 14.9 tons per acre on the 16-percent slope. The soil loss from land planted to grain was 5.2 tons on the 6-percent slope and 19.7 tons on the 16-percent slope. For an increase in slope of 10 percent the runoff increased 2 percent and the soil loss 14 tons per acre from corn and grain.

Although the losses from hay were low from both slopes, slope had a greater proportionate effect on soil and water losses from hay than from corn and grain. An examination of data from individual storms shows that the total amount of runoff during the very intense storms is not greatly affected by slope with the exception of the plots devoted to hay.

Contouring

Contouring will result in increased yields, but under field conditions does not give sufficient control of runoff to insure adequate erosion control. In field trials conducted in Minnesota[7] in 1943, it was found that on 12 farms contoured corn yielded an average of 82 bushels per acre; adjacent plots, planted and tilled with the slope, yielded 72 bushels per acre, an increase of 14 percent in favor of contouring. In Wisconsin,[8] similar studies conducted on 16 farms in 1943 showed that contoured corn yielded 86.5 bushels per acre and corn planted with the slope, 82.4 bushels—a 5-percent increase in yield due to contouring. These data substantiate those obtained at the station over a 4-year period. There it was found that during 3 of the 4 years contoured corn yielded more than corn planted with the slope. The contoured plots yielded 4.7 bushels or about 7 percent more per acre.

Soil losses from contouring on the unterraced, cultivated watershed have been excessive when that area was planted to a 3-year rotation. The average annual loss was 56 tons per acre. This watershed is 420 feet long and located on a 15-percent slope. Three contour lines are used in order that all rows shall be as nearly on the contour as possible. Corn is surface planted so that prior to the first cultivation there is not much ridging. During the process of cultivation the ridges are effective

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[7] Hays, O. E., and Rost, C. O. THE EFFECT OF DEPTH OF SURFACE SOIL AND CONTOURING ON CROP YIELDS IN MINNESOTA, 6 pp., 1943. [Processed.]

[8] Hays, O. E., and Muckenhirn, R. J. THE EFFECT OF DEPTHS OF SURFACE SOIL AND CONTOURING ON CROP YIELDS, 7 pp., 1943. [Processed.

in holding excess precipitation during storms of moderate and low intensities; but, during storms of high intensity the capacity of these small ridges and furrows is soon exceeded and high runoff occurs.

Contouring alone gives adequate protection during the less intense storms, but will be of little benefit during the intense storms. Under field conditions, difficulty has been experienced in keeping the rows on the contour, particularly where the topography is uneven. Rows that are off contour usually will carry the runoff for a short distance, then the small furrows will overtop and allow the runoff to flow down to rows that are on the contour. This runoff added to that held by the contour furrows soon exceeds the capacity of the furrows and they overflow. The concentration of the runoff water on a long slope protected only by contouring will result in high soil losses.

Grass waterways are needed on contoured fields to prevent gullying where runoff water concentrates. These waterways frequently have to be placed so closely together that a sizable portion of the field is taken up by them.

WATERSHED STUDIES

To study contouring, contour strip cropping, and terracing, three watersheds were established on which each practice was used.

The unterraced, cultivated watershed was established in 1932. Before that time, the upper two-thirds of this area had been under cultivation for a number of years and the lower one-third had been in hay. The area of this watershed when established was 4.13 acres. In March 1934, it was reduced to 2.33 acres and in April 1938, 0.09 acre was removed from the watershed. This reduced the drainage area to 2.24 acres.

The watershed is V-shaped with a short concentrating trough at the bottom. The drainage of the upper two-thirds of the area is uninterrupted sheet flow; the water concentrates into eight field gullies on the lower one-third of the area. The average slope of the watershed is 15 percent with a maximum of 25 percent. The maximum length of slope is 420 feet.

This watershed is being farmed on the contour without strip cropping or terracing. It was cultivated to a 3-year rotation of corn, small grain, and hay, starting in 1932 with corn. The watershed had become so badly gullied by the fall of 1937 that it was decided to seed the lower one-third to hay. During 1938 and 1939 this lower one-third of the area had a dense stand of hay while the rest of the watershed was in corn and grain, respectively. Numerous small sod-hump dams and sod-bag dams were constructed to help stabilize the field gullies. Starting in 1939 this watershed has been in a 6-year rotation of corn, grain, and 4 years of hay.

The contour strip-cropped watershed was established in 1937. This watershed is approximately rectangular in shape, having an average slope of 17 percent and a length of slope of 270 feet. Drainage is by sheet flow and it is collected by metal-lined concentrating troughs located at the bottom of the watershed.

At first this watershed was divided on the contour into two segments. The upper one was strip cropped to a 3-year rotation of corn, grain, and hay. The lower segment was in alfalfa-timothy hay.

Starting in 1940, the watershed was divided into 6 strips representing each year of a 6-year rotation of corn, grain, and 4 years of hay.

For a terraced watershed the drainage area of one cultivated terrace was used, namely Terrace A-4. The drainage area is 2.21 acres, the average land slope is 10 percent and the terrace is 1385 feet in length. Starting in 1932, it was farmed to a 3-year rotation of corn, grain, and hay. In 1939, the rotation was changed to a 6-year rotation of corn, grain, and 4 years of hay, to conform to the other two watersheds.

The plan for the strip-cropped watershed was to have the bottom strip in the same crop as the terraced and the contour watersheds. As this plan called for all crops on strips in the strip-cropped watersheds, it was impossible to change the crop sequence within 1 year without having most of the watershed open. Therefore, there was a divergence in crop sequence on the bottom strip as compared with the other watersheds until all were in hay in 1940. Tables 8 and 9 show the cropping system followed on the three watersheds.

TABLE 8.—*Cropping systems for various watersheds*

Year	Unterraced cultivated watershed	Strip-cropped lower strip watershed	Terraced A-4 watershed
1938	Corn	Hay	Corn.
1939	Grain	Corn	Grain
1940	Hay	Grain	Hay.
1941	do	Hay	Do.
1942	do	do	Do.
1943	do	do	Do.

TABLE 9.—*Cropping systems for the strip-cropped watershed*

Strip	1938	1939	1940	1941	1942	1943
Strip 1	Hay	Hay	Corn	Grain	Hay	Hay.
2	do	do	Hay	Hay	Corn	Grain.
3	Corn	Grain	Grain	do	Hay	Hay.
4	Grain	Hay	Hay	do	do	Corn.
5	Hay	do	do	Corn	Grain	Hay.
6[1]	do	Corn	Grain	Hay	Hay	Do.

[1]Lower strip of strip-cropped watershed.

The results obtained are recorded in table 29, Appendix. The average percent of runoff from the three watersheds for the period 1937-43, figure 21, shows that the terraced watershed had 1.5 times more runoff than the other two watersheds. The soil loss as measured at the outlet end of the terrace is about one-fourth as much as from the contoured watershed and about one-half that from the strip-cropped watershed. The peak rates of runoff from individual storms for the three watersheds are listed in table 10.

The average trend of the peak rates of runoff for the three watersheds indicates that for the same storm the terrace watershed has the lowest peak, the strip-cropped watershed next, and the unterraced, cultivated watershed produces the highest peak rate. The apparent inconsistencies in table 10 are probably due to unavoidable variables, such as crop

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TABLE 10.—*Data from major storms on rainfall, runoff, and peak rates from terraced, strip-cropped, and contoured watersheds*

Storm	Total rainfall			Runoff as percent of rainfall			Peak rate of runoff per hour		
	Terrace	Strip cropped	Contour	Terrace	Strip cropped	Contour	Terrace	Strip cropped	Contour
	Inches	*Inches*	*Inches*	*Percent*	*Percent*	*Percent*	*Inches*	*Inches*	*Inches*
June 19–20, 1937	2.12	1.97	2.00	57.74	36.60	58.05	1.486	2.931	4.135
July 5, 1938	1.56	1.64	1.70	53.03	53.53	42.50	1.384	1.998	1.943
July 21, 1938	1.80	1.74	1.78	14.09	47.64	38.76	.836	5.510	5.697
Aug. 20–21, 1939	5.00	5.20	5.51	53.43	12.83	19.69	.663	.361	.464
Aug. 16, 1940	1.43	1.38	1.46	61.05	29.56	42.66	1.288	1.924	2.169
Sept. 15–16, 1941	2.54	2.51	2.11	30.55	41.08	26.97	.373	2.589	1.772
June 28–29, 1942	3.75	3.62	3.62	13.55	14.25	4.00	.187	.935	.247

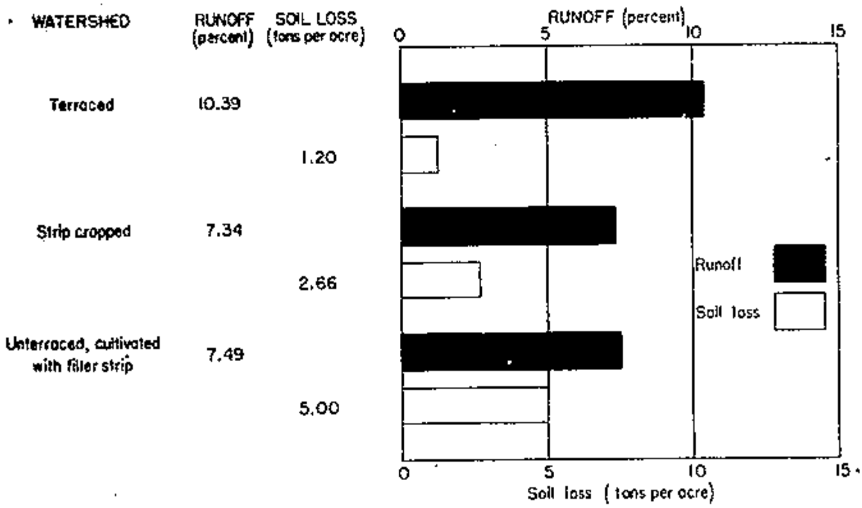

FIGURE 21.—Soil and water losses under different treatments from various watersheds, 1937 to 1943.

condition and time of farming operations that would affect the results.

Precipitation, water loss, and soil loss, by winter season and growing season, on a cultivated watershed, a pasture watershed, and a cultivated terrace are shown in table 11. A more complete record of these watersheds is shown in table 30, Appendix. A detailed compilation of rainfall and runoff data for 1932–38 was issued in 1939.[9] It will be noted from table 11 that the average annual soil loss during the winter season from the unterraced, cultivated watershed was only 6.5 percent

TABLE 11.—*Average annual summary of precipitation, runoff, and erosion by winter season and growing season on a cultivated watershed, pasture watershed, and cultivated terrace, 1934–38*

Treatment	Precipitation			Water loss			Soil loss		
	Winter period	Growing season	Total	Winter period	Growing season	Total	Winter period	Growing season	Total
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Tons*	*Tons*	*Tons*
Unterraced cultivated watershed	7.72	26.35	34.07	1.19	4.54	5.72	3.37	48.29	51.65
Unterraced pasture watershed	7.72	26.35	34.07	.51	1.67	2.18	.01	.41	.42
Terrace A-5	7.72	26.35	34.07	1.72	4.90	6.62	.46	7.49	7.95

[9] HAYS, O. E., and ATKINSON, H. B. HYDROLOGIC STUDIES; COMPILATION OF RAINFALL AND RUNOFF FROM THE WATERSHEDS OF THE UPPER MISSISSIPPI VALLEY CONSERVATION EXPERIMENT STATION, LA CROSSE, WISCONSIN, 1932–38. SCS-TP-20. 1939. [Processed.]

of total average annual soil loss and for the cultivated terrace it was only 5.8 percent.

On examination of table 36 of the Appendix, it will be noted that for terrace A-4, on the average, four intense storms per growing season produce 87 percent of the total soil loss.

The unterraced pasture watershed was established in 1932. The upper two-fifths of the area before 1932 was part of a cultivated field; the remainder had been in pasture for a number of years. The area of this watershed when established was 2.71 acres. At that time there was an old road that divided the upper and lower parts of the area. This road had a tendency to act as a partial terrace.

During the fall of 1934, a small diversion was constructed across the upper part of this watershed that reduced the drainage area to 2.41 acres. The removal of the old road from the watershed was started in April 1936 and finished in June 1936. The old-road location was fenced for a short period to keep the stock off.

The watershed is V-shaped and has a concrete concentrating trough at the bottom. The land slope ranges from 20 to 32 percent. The average is 24 percent. The maximum length of slope is 420 feet.

Table 12 shows the runoff and soil loss from the unterraced pasture watershed and a pastured terrace for the period 1933-37. Table 31, Appendix, shows a more complete record of these watersheds. There are several factors affecting these data. Two of the more important are the proximity of the underlying rock and the raw back slopes of the terrace which existed during the course of this experiment. A more detailed discussion of the E-3 terrace will be found under the subject of terrace studies.

TABLE 12.—*Runoff and soil loss from an unterraced pasture watershed and a pastured terrace by classified groups of rains, 1933–37*

Rainfall group	Runoff as percent of rainfall		Soil loss per acre	
	Unterraced pasture watershed	Pastured terrace	Unterraced pasture watershed	Pastured terrace
	Percent	*Percent*	*Tons*	*Tons*
Annual	4.62	8.99	0.47	0.30
High-rain factor	13.46	22.84	.40	.21
Moderate-rain factor	2.64	7.63	.06	.05
Low-rain factor	.31	.61	.01	.04

Even though the pastured terrace had these raw back slopes, table 12 shows the ratio of soil loss from the pastured terrace to that of the unterraced pasture watershed to be 0.64. The average annual soil loss from the unterraced pastured watershed for the high-rain-factor storms was only 0.40 tons. Terraces in pastures are not recommended unless the pasture lies above cropland or in case a pasture becomes gullied from overgrazing or as a result of being subjected to high amounts of runoff from cultivated fields. Terraces may be used in such cases to divert runoff from the gullies so that they can be seeded and vegetation established. A good stand of grasses reduces water loss and the soil loss will be negligible.

In order to study some of the effects of cover and character of land use upon runoff and soil loss, the United States Forest Service established 3 small watersheds under various cover and land use conditions in addition to the watersheds previously mentioned.[10]

Two of the tracts, one timbered (watershed A) and one cleared of timber in 1932 (watershed G), are grazed. The third tract (watershed B) which is well-forested with second-growth hardwoods is maintained in a fully protected condition. In each case, a diversion ditch has been built around the upper margin of the watershed so that only the precipitation which actually falls within its boundaries enters into the runoff calculations. The watersheds A, B, and G have drainage areas of 2.67 acres, 11.5 acres, and 5.85 acres, respectively; the average channel gradients of A-17, B-27, and G-26 percent. The maximum gradient of A is 28, B, 50, and G, 35 percent. The common exposure is north in all cases.

At the time these watershed experiments were started in 1932, 24 percent (2.78 acres) of tract B was occupied by a heavily sodded, nearly treeless strip along the upper rim of the watershed. This open land was seeded with walnut, red oak, and hickory in 1933, but these young seedlings have had little influence on the runoff. A part (estimated at 35 percent) of watershed A is also poorly timbered. A part of this open area was likewise seeded with oak, hickory, and walnut in 1933.

Table 13 shows the runoff and soil loss from five small watersheds with various cover conditions by classified groups of rains. Table 32, Ap-

TABLE 13.—*Runoff and soil loss from small watersheds with various cover conditions by classified groups of rains, 1935–41*

Watershed	Runoff as percent of rainfall by storm groups				Soil loss per acre by storm groups			
	Annual	High	Moderate	Low	Annual	High	Moderate	Low
	Percent	*Percent*	*Percent*	*Percent*	*Tons*	*Tons*	*Tons*	*Tons*
Watershed A, pastured woodland	1.16	3.37	0.15	------	0.14	0.14	------	------
Watershed B(1), protected woodland	(1)	------	------	------	------	------	------	------
Watershed G, cleared pasture	.35	.93	.45	------	.05	.05	------	------
Unterraced pasture watershed [2]	4.65	13.86	1.05	------	------	------	------	------
Strip-cropped watershed[2]	7.34	20.85	2.73	0.23	2.66	2.23	0.28	0.15
Unterraced cultivated watershed [2 3]	7.49	19.09	3.75	1.37	5.00	3.76	.59	.65
Cultivated terrace A-4 [2]	10.39	27.33	5.58	1.09	1.20	.91	.23	.06

[1] 0.02 inches of runoff in 1935.
[2] Period 1937-43.
[3] Filter strip at bottom of watershed, 1937-41.

[10] SCHOLZ, H. F. SUMMARY OF EROSION RESEARCH CARRIED ON BY THE UNITED STATES FOREST SERVICE IN THE UNGLACIATED REGION OF WISCONSIN. 1935. [Unpublished.]

pendix, gives a more complete record of these watersheds. From the standpoint of controlling runoff and soil loss, protected woodland is the best land use. No runoff or soil loss has occurred on this watershed since 1936, and only small amounts from 1932–35. For the cleared-pasture watershed, 0.35 percent of the rainfall was lost as runoff; for the pastured woodland, 1.16 percent; for the unterraced pasture watershed, 4.65 percent; for the unterraced cultivated watershed, 7.49 percent; for the strip-cropped watershed, 7.34 percent; and for a cultivated terrace, 10.39 percent.

The average annual soil loss for the growing season has been very low for those watersheds that are not in cultivation. The terrace had an average annual soil loss of 1.2 tons per acre, the strip-cropped watershed, 2.66 tons per acre, and the unterraced cultivated watershed, 5 tons per acre. These watersheds are in a 6-year rotation of corn, grain, and 4 years of hay.

Following the clear cutting of watershed G in 1932, the organic debris left on the watershed gradually disappeared and the condition of the sod improved steadily. During this same period, however, there was not a parallel improvement of the grass cover on watershed A and the continued grazing reduced the density and quality further. Pasture records are available for the 7-year period 1933–39. These show that watershed G produced on the average 128 cow pasture days; watershed A, 62 cow pasture days; and the unterraced pasture watershed, 82 cow pasture days per acre.

These data would indicate that one cannot have both woodland and good pasture on the same area of land. If additional pasture is needed, a sufficient amount of the woods should be cleared to meet this need and the remaining woodland protected. If the soil is productive, a properly managed open pasture will allow only low soil and water losses even on the very steep slopes.

As pointed out previously, the upper part of the unterraced pastured watershed prior to 1932 was in cultivated crops and severely eroded, while the lower part was severely grazed. These previous conditions of land use reflect themselves in the runoff figures. For the unterraced pastured watershed, 4.65 percent of the rainfall resulted in runoff (table 13) as compared with 0.35 percent for the cleared pasture watershed. Soil losses for these same watersheds were low, almost negligible, in both cases.

TERRACE STUDIES

The terrace studies can be divided into three major experiments. First, terraces with different variable grades on cultivated land, designated as terrace A-4, A-5, and A-6; second, variable-grade terraces with different vertical spacing on cultivated land, designated as C-2, C-3, and C-4; and third, variable-grade terraces with different vertical spacing on pasture land, designated as E-2, E-3, and E-4.

Terrace A-4 has grades as follows: 250 feet with grades of 6 inches, 5 inches, 4 inches, 3 inches, 2 inches, and the last 135 feet with 1 inch grade per 100 feet. Terrace A-5 has intervals of 500 feet with grades of 3 inches, and 2 inches, and 385 feet of 1-inch grades per 100 feet. Terrace A-6 is a level terrace with one end open.

Terrace Grade

Table 33, Appendix, shows that there is not much difference in total runoff between terrace A-4, with a maximum grade of 6 inches fall per 100 feet and terrace A-5, with a maximum grade of 3 inches fall per 100 feet. Terrace A-6, the level terrace, conserves a much greater proportion of soil and water; however, level terraces cannot be recommended on Fayette silt loam and soils of similar infiltration rate. Some difficulty was encountered in maintaining sufficient channel capacities. Numerous ponds were formed in the channel caused by silt fans and this tended to drown out some of the vegetation. These wet spots also caused some delay and hindrance to the operation of farm machinery.

Soil losses from the terraces are correlated with the steepness of grade of the channel. Terrace A-4 with a maximum 6-inch fall had an average annual soil loss of 5.35 tons per acre; A-5, with a maximum 3-inch fall had 4.85 tons per acre soil loss; and A-6, the level terrace with one end open had 1.42 tons per acre soil loss. The runoff from the 3 terraces ranged as follows: A-4 had 3.79 inches, A-5, 3.81 inches, and A-6, 2.42 inches. Soil losses are higher where the grade of the terrace is steeper as a result of the higher velocities in the terrace channels.

Table 15 gives the peak rates of discharge, the total volume of runoff, and soil losses for 3 selected storms for each year of the rotation. Terrace A-4, which has the steepest grade, produced the highest peaks and when the watershed was in corn or grain produced the highest soil loss. From the data presented it appears that terrace grades on cultivated Fayette silt loam and similar soils should not exceed 3 to 4 inches fall per 100 feet if maximum amounts of soil and water are to be retained and if the terraces are to be satisfactory from the standpoint of maintenance, workability, and crop growth.

Terrace Spacing

Two terrace-spacing experiments, one on the cultivated C terraces and the other on the E pasture terraces, were established in 1932.

Table 14, and tables 33, 34, and 35, Appendix, show the results of these experiments.

The results, as shown in table 14, for cultivated terraces cropped to a 3-year rotation, indicate that there is still need for more information on vertical interval. Terrace C-2 with a vertical interval of 5 feet on a 10-percent slope had an average annual water loss of 19.38 percent and a soil loss of 8.67 tons per acre. Terrace C-3 with a 7-foot vertical interval on a 15-percent slope had a water loss of 17.90 percent and 8.62 tons per acre soil loss. Terrace C-4, with a 9-foot vertical interval on a 17-percent slope had 15.65 percent water loss and 5.16 tons per acre soil loss.

The average annual summary, table 14, for the vertical-interval experiment for pasture terraces shows the same trends. Terrace E-2 with the smallest vertical interval on a 15-percent slope had the greatest percent of runoff, 10.18 percent; terrace E-3 with a 9-foot vertical interval on a 19-percent slope had 8.99 percent runoff and terrace E-4 with an 11-foot vertical interval on a 21-percent slope had 7.76 percent runoff.

TABLE 14.—*Average annual soil and water losses from terraces with different vertical intervals and grades for croplands and pasture*

Experiment and terrace No.	Grade (fall per 100 feet)	Vertical interval	Length	Average land slope	Average length slope	Average annual rainfall	Runoff	Runoff in percent of rainfall	Soil loss per acre
	Inches	*Feet*	*Feet*	*Percent*	*Feet*	*Inches*	*Inches*	*Percent*	*Tons*
Variable grade, cultivated terraces in a 3-year rotation, 1933–40:									
A–4	1 to 6	7	1,385	10	70.0	24.24	3.79	15.64	5.35
A–5	1 to 3	7	1,385	12	58.5	24.24	3.81	15.72	4.85
A–6	0	7	1,385	13	54.0	24.24	2.42	9.98	1.42
Vertical spacing, cultivated terraces in a 3-year rotation, 1933–37:									
C–2	1 to 3	5	850	10	50.0	23.58	4.57	19.38	8.67
C–3	1 to 3	7	850	15	46.5	23.58	4.22	17.90	8.62
C–4	1 to 3	9	850	17	53.0	23.58	3.69	15.65	5.16
Vertical spacing, for pasture terraces, 1933–37:									
E–2	1 to 3	7	850	15	46.5	23.58	2.40	10.18	.38
E–3	1 to 3	9	850	19	47.5	23.58	2.12	8.99	.30
E–4	1 to 3	11	850	21	52.5	23.58	1.83	7.76	.41

These terraces are located on land which has a convex slope. The terraces with the greatest vertical interval are located below and on steeper slopes than those with the lesser vertical interval. Therefore, the increase in vertical interval of 4 feet did not result in much difference in horizontal interval. With two factors, percent of slope and vertical interval, influencing the data, it is impossible to determine the influence of either. Therefore, measurements on the two vertical interval studies were discontinued in 1937.

As stated previously, the E terraces were built on a soil that was very shallow. There is considerable variation in the actual grades of the terrace channels and these grades also varied considerably from the correct theoretical grades as specified at the time of the installation of the experiment. The proximity of the underlying rock and the raw back slopes and channel slopes are factors that have affected the data. Even under these conditions, the low soil losses from the pasture terraces bring out an important point; namely, spacings for pasture terraces should be governed by the amount of runoff, available channel capacities, and grades of the terrace channels and not by the amount of soil loss. The soil loss from all pasture experiments has been small.

The data from the C terrace show quite conclusively that sheet erosion must be reduced to minimum if the terrace system is to be most effective. Soil losses from terraces as shown under the conditions of this experiment are too large. To obtain adequate control of erosion under these soil and slope conditions, a rotation including two or more years of hay would be needed.

The effects on the terraces of three major storms that occurred in 1935–37, are shown in table 15.

TABLE 15.—*Effect of three major storms on the A terraces in 1935–37*

Date of storm	Terrace No.	Rainfall	Peak rate of runoff	Total runoff	Soil loss per acre	Crop
		Inches	*In. hour*	*Inches*	*Tons*	
Aug. 5–6, 1935	A-4	2.55	2.446	1.703	3.16	Corn.
	A-5	2.55	2.014	1.774	2.93	Do.
	A-6	2.55	1.286	.739	1.06	Do.
May 1, 1936	A-4	1.73	1.268	.737	5.08	Grain.
	A-5	1.73	.978	.830	4.84	Do.
	A-6	1.73	.328	.482	1.13	Do.
June 19–20, 1937	A-4	2.12	1.486	1.224	.15	Hay
	A-5	2.12	1.178	1.163	.25	Do.
	A-6	2.12	.577	.715	.16	Do.

DIVERSION TERRACES

Two diversion terraces were constructed at the station in 1932. One was built above watershed B, the protected woodland area, in order to divert the runoff from 5.5 acres of cropland. The other was built above watershed G, the cleared pasture area, and it diverts runoff from 7.85 acres of cropland.

Diversion terrace B has a grade of 1.2 percent and diversion terrace G has a grade of 0.83 percent. After construction, the diversion terraces were seeded down and a 10-foot filter strip was left above the terrace and the bottom of the lower cultivated strip.

The area above the diversion terrace has been cropped to a 5-year rotation. Both terraces have remained satisfactory under these conditions. Diversion terrace B has scoured to some extent near the outlet, but this was due to the lack of vegetation in the channel. No appreciable amount of silting in the channels has been noticed.

Terrace Maintenance

The terraces were built in 1932 by a terracing grader with an 8-foot blade. All maintenance necessary since construction has been accomplished with the plow. No regrading was done.

When the capacity of the terraces became reduced to such an extent as to require an increase in capacity to avoid overtopping, the dead furrow was left in the channel and the back furrow on the ridge. When it was not necessary to increase the capacity of the terrace a back furrow was left at the top of the slope and a dead furrow at the bottom of the watershed. This practice works best with the use of the two-way plow. The plowing and other farm operations were made parallel to the ridges. The results obtained from surveys and observations indicate that terraces have to be maintained if they are to remain effective as silt is deposited in the channel and the effective height of the ridge is gradually reduced by tillage.

Corn has been planted with the row on the crest of the ridge. It was thought that by this procedure cultivation would tend to maintain or increase the height of the ridge. That is, the normal procedure in cultivation is to adjust the shovels so that during the second and third cultivation, soil is thrown toward the row. In order to determine the effect of this practice on height of ridge, 2 profiles were run in 1935. The first one was made soon after the corn was planted and the second one soon after the corn was removed in the fall. A comparison of these profiles was desired to show the effect of cultivation and erosion during the season on the height of the ridge. Measurements were made at 50-foot intervals, carefully measured from the flume with a steel tape. The average difference between the 27 locations on the 2 dates was only 0.02 of a foot, the elevation being slightly lower in the fall.

When the two channel profiles were compared, the average difference showed an increase in elevation of better than 0.10 foot. In combining the two changes, the average effective height was lowered by almost 2 inches in one growing season. The maximum loss of effective height at one station was 0.40 foot. Similar profiles were run in 1938 when this area was again in corn. This year the average effective height was lowered by 0.21 foot.

In 1936, when the area was in grain, profiles were run after the grain was seeded and again in the fall. The average difference of the two channel profiles showed an increase of 0.17 foot and the average difference of the two ridge profiles showed a decrease of 0.03 foot. The combined loss in effective height was 0.20 foot. No farming operations entered into this reduction in effective height when the area was in grain. This reduction was primarily caused by siltation of the channel.

The general practice used in terrace maintenance at the station was to backfurrow on the terrace ridge and at the same time leave the dead furrow in the channel. This was done at the time the corn ground was being plowed for grain, for a deeper furrow could then be used. By

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doing this once during a rotation, enough height can be added to carry sufficient channel capacities through the rotation.

The number of intense rains occurring, soil type, rotations used, and type of farming equipment used are factors which will affect the amount and kind of maintenance required to keep terraces in a good working condition.

Terrace Outlets and Waterways

The data presented for the terrace studies conducted at the station show that outlets or waterways properly designed to handle a large volume of runoff water are an essential part of a terrace system in this area.

From a storm occurring August 5-6, 1935, maximum rates of runoff for terraces A-4 and A-5 were 5.44 and 3.91 cubic feet per second respectively. Another storm on July 21, 1938 produced maximum rates of runoff of 12.9, 15.0, and 4.50 cubic feet per second from the contoured watershed, strip-cropped watershed, and a pastured watershed, respectively. These high rates of discharge from terraces, contouring, strip cropping, and pastures indicate very conclusively the need for a good water disposal system regardless of the practice or land use.

Sod waterways are the most suitable type of terrace outlet. They are the most economical to construct and can be easily maintained by the farmer. In exceptional cases where large volumes of water with high velocities must be handled, some type of hard surfaced channel or series of drop structures must be used.

To study further the use of bluegrass as a protective lining, a sod outlet was established below the flume of the strip-cropped watershed. Part of this outlet was used as a test section. This section was 25 feet long and had a slope of 18.27 percent. It had a 3-foot bottom width and 2 to 1 side slopes. The channel was fertilized and sodded, and a good dense sod was established. The channel was clipped with a mower in order to maintain a uniform height of grass throughout the experiment.

From two observations during runoff periods, velocities of 8.32 and 8.78 feet per second were obtained when the peak flows were 3.41 and 5.86 cubic feet per second, respectively. Although the sod outlet was in place in 1938, when the July 21 storm produced a maximum peak flow of 15.0 cubic feet per second from the strip-cropped watershed, no record is available of the velocity or depth of flow for this discharge. The bluegrass has withstood these flows without damage. A sod waterway built and maintained under these conditions could be designed to carry velocities from 10 to 12 feet per second.

In 1941, R. J. Muckenhirn and V. J. Kilmer tried various methods of protecting 25-foot sections of channels on a 20-percent slope during the time the new seeding in the channels were being established. Runoff from a terrace was allowed to flow down the channels throughout the season after seeding. There was no damage where the channels were protected by straw mulch and woven wire, by a burlap cover, or by sodding. The straw mulch proved most practical because it allowed the grass to grow better than burlap and involved much less work than sodding. Where the channels were merely seeded without giving them protection of any kind, they were badly washed out and converted into ditches.

TABLE 15.—*Details and cost data of hard-surfaced outlet channels built in 1935*[1]

Channel No.	Type	Slope	Capacity	Length	Surface area	Materials used	Total cost	Cost per linear foot	Cost per square foot area	Proportion of total cost: Labor	Proportion of total cost: Materials	Proportion of total cost: Design and supervision
		Percent	*Cubic foot per second*	*Feet*	*Square foot*		*Dollars*	*Dollars*	*Dollars*	*Percent*	*Percent*	*Percent*
1	Tar and crushed rock	19.0	18.0	76.0	342	Type E highway tar,[2] /No. 2 crushed limestone, chips, cement, sand, and gravel.[3]	47.00	0.62	0.137	35.1	50.0	14.9
2	Sheet-metal flume	22.2	20.0	96.0		20-gage galvanized sheet iron, 2 × 4's, wood posts, cement, sand gravel, and reinforcing iron.[3]	115.46	1.20		42.2	50.8	7.0
3	Creosoted wood flume	29.0	21.0	106.0		Pressure creosoted 2-inch lumber, machine bolts, and lag screws.	112.30	1.50		21.4	74.1	4.5

[1] No. 1 finished, Sept. 14; No. 2, Sept. 13; No. 3, Oct. 21.
[2] 0.366 gallons of tar per square foot used.
[3] Cost data include cost of reinforced-concrete header at entrance. Cost of header $30, of which 51 percent was for labor, 39 percent for material, and 10 percent for supervision.

When the quantity and velocity of water is higher than sod allows, some type of hard surface channel or a series of drop structures is required. In this region of severe climatic conditions, rubble-masonry flumes, and thin-shelled concrete flumes without reinforcement are not durable. Reinforced concrete, if properly constructed, provides a satisfactory permanent channel, but the high cost and the technical construction details involved, prohibit its use.

Three different types of linings other than reinforced concrete were constructed at the station: One of tar and rock, one of galvanized sheet iron, and the third of creosoted lumber. Table 16 lists the design and cost figures for the different materials.

Observations of the various types of mechanical channels and consideration of the comparative cost of each, show that channels lined with bituminous materials and crushed rock or gravel are the most satisfactory, principally because they are relatively simple to construct. They require materials that are not inaccessible to the farmer and not too expensive. They are easily maintained by the addition of small amounts of bitumen and rock.

STRIP CROPPING

Strip cropping has been under observation at the Station since 1932. Measurement of losses from a strip-cropping system have been made since 1937. The degree of control obtained by this practice will depend to a large extent upon ability to obtain and maintain good stands of legumes and grasses. With alternate strips of crops, such as corn and grain, and control crops such as alfalfa-grass hay, the runoff water picks up soil from the grain and corn strips in amounts depending upon velocity of flow and will deposit a part or most of the soil load in the hay strip depending upon the effectiveness of the hay in reducing the velocity of flow of runoff.

Among the factors influencing the ultimate loss from a field are the length of slope, the width of strip, length of rotation, position of the erodible strips, soil type, degree of erosion, and type of cultivation. After a field has been worked for a number of years in a contour strip-cropping system, runoff is more directly down the slope. This results in less concentration of water and a reduction in the need for waterways. However, this means that as the system becomes older, more water is flowing across the lower parts of the slope. Thus, if the slope is over 300 to 400 feet long, the lower strips will have excessive soil loss during intense storms.

The wider the strip the higher the soil losses. However, it has not been found practical to reduce the width of strip below 50 feet. The exact width of strip needed to obtain adequate control of erosion will depend not only upon the percent of slope but the length of slope and the rotation. Observations would indicate that with the general practice of increasing the numbers of years of hay as the slope becomes steeper, the following widths of strips will give adequate control on a moderately eroded Fayette silt loam with surface-planted corn on slopes up to 300 feet long on which there is no runoff from other areas: 3–6 percent slope, 100 feet width; 6–10 percent slope, 78 feet width; and 10–16 percent slope, 50 feet width.

The length of rotation is important in a strip-cropping program. A 3-year rotation with only 1 year of hay is ineffective because two-thirds of the area is open a part of the time each year. A 4-year rotation with 2 years of hay works well on a 2-crop system in which alternate strips are in corn and hay or grain and hay. However, if all crops are represented in a field once in 4 years, corn and grain will be in adjacent strips. This will make a rather wide area open to erosion. The 5- and 6-year rotations with 3 and 4 years of hay are necessary on long slopes of more than 10 percent. The exact rotation to be used will depend upon the erosion hazard and the ability of the farmer to maintain the hay crop. It has been observed that, in general, better erosion control has been obtained on farms on which both of these factors were taken into consideration than where just the erosion hazard was considered.

The position of crop is something about which not much can be done. Nevertheless it must be recognized that the farther down the slope the location of the cultivated crop, the higher will be the soil loss. The runoff from the erodible strip and the runoff from hay, corn, or grain strips above will flow across the lower strips. If corn and grain are grown in the same field, grain should be located below corn. Grain land allows high amounts of runoff throughout most of the season. If this runoff flows down across unprotected cornland very high soil losses can be expected.

A filter strip at the bottom of the field will reduce the amount of soil being removed from the field. Actually, however, this results largely in a change in location of area of deposition. The effect of a filter strip on soil losses is shown in table 17, which contains data from the unterraced, cultivated watershed for a period during which the entire area was planted to one crop and for a period during which the lower 130 feet was in hay serving as a filter strip.

TABLE 17.—*Effect of a filter strip on soil loss*

Treatment and year	Crop	Soil loss per acre	
		Unterraced cultivated watershed	Control plot
Entire length in one crop:		*Tons*	*Tons*
1933	Grain	18.2	3.8
1934	Hay	16.0	.5
1935	Corn	91.7	96.2
1936	Grain	99.8	51.0
Average		56.4	37.9
Lower 130 feet in hay filter strip:			
1937	Hay	14.7	.6
1938	Corn	19.3	70.8
Average		17.0	35.7

The unterraced, cultivated watershed and the control plot used in this comparison were both contoured and planted to a 3-year rotation. The watershed had an average slope of 15 percent and the control plot 16 percent. The watershed had a length of 420 feet, and the control plot 73 feet. Before the filter strip was established the watershed lost about 1.5 times as much soil per acre annually as the small plot. After the filter strip was established on the lower part of the watershed, the loss from the small plot was twice as much as from the watershed.

It is probable that the upper part of the watershed was still losing soil at a rate in excess of that from the control plot, but a large part of this soil was deposited in the hay filter strip.

During 1937–43, the unterraced cultivated watershed and the strip-cropped watershed were in the rotation of corn, grain, and 4 years of hay. Detailed data are contained in table 29, Appendix. The soil loss from the contoured watershed was twice that from the contoured strip-cropped watershed even though there was a 130-foot filter strip on the bottom of the contoured watershed. The major loss for the period occurred in 1938 when the contoured watershed was in corn. Assuming that the same relationship would exist between the small plot and the watershed in 1938 as in 1935 one would have expected a soil loss of 68 tons from the contoured watershed or approximately 50 tons per acre more than was actually measured with the filter strip at the bottom. This calculated 68 tons of loss for corn in 1938 would result in an average loss of 12 tons per acre from the contoured watershed, which would be about 4 times that from the strip-cropped watershed.

In a large strip-cropping experiment located on the Hundt farm there are 32 strip-cropped plots and 8 contoured plots in a 4-year rotation of corn, grain, and 2 years of hay. These plots are located on an 11-percent slope. The plots are 20 feet wide and vary in length from 200 to 300 feet, depending upon the width of the bottom strip. All contoured plots are 250 feet in length. The design of the experiment is such that within each block of 5 plots the same crop is planted on the fifth or bottom strip and on the contour plot. The crop on the fifth strip varies by blocks and each crop is represented in duplicate. The position of the crop on the upper four strips is uniform for all strip-cropped plots. Within each block there are three widths of strip on the bottom strip—50, 75, and 100 feet. In table 18 are summarized the data showing the soil and water losses from contouring and from strip cropping. Detailed data are contained in table 28, Appendix. Data from the two most intense storms are not included as the measuring equipment failed because of the excess amount of trash washed from the corn plots.

TABLE 18.—*Soil and water losses from contoured and strip-cropped plots*

Crop	Contoured		Strip cropped	
	Water loss	Soil loss per acre	Water loss	Soil loss per acre
	Inches	*Tons*	*Inches*	*Tons*
Corn	1.2	6.4	1.2	3.4
Grain	1.8	1.2	1.4	.5
First-year hay	1.4	.1	1.5	.2
Second-year hay	.8	.1	1.0	.2
Average	1.3	2.0	1.3	1.1

It will be seen that strip cropping during the establishment period reduced the soil losses by 50 percent and that runoff was about the same for the two practices. These first 3 years of data indicate the control that could be expected soon after a field was changed from contouring to strip cropping. It would be expected from an examination of the data by storm intensities that if the two intense storms had been properly measured there would have been more advantage to strip cropping than is shown in table 18. The data indicate that even during the most intense storms a good crop of hay 50 feet in width will filter out 80 percent of the soil washed from a corn or grain strip.

In a strip-cropping system, soil is picked up by runoff water in the corn or grain strip. The amount of erosion then depends upon the width of open strip. A portion of the soil load is deposited in the hay strip, depending upon the density of the hay and the width of the hay strip. Preliminary indications from this experiment would show that the soil loss is less as the strip width is decreased from 100 to 50 feet when corn or grain is grown on the lower strip; that the loss from the area is less as the width of hay strip increases from 50 to 100 feet when hay is on the lower strip. A 50- to 75-foot width of strip could be expected to give satisfactory control on a 250-foot length of Fayette silt loam on an 11-percent slope when cropped to a 4-year rotation of corn, grain, and 2 years of alfalfa-timothy hay.

LYSIMETERS

Lysimeters were used to determine amounts of water and nutrients lost under various crops grown on the Fayette silt loam. The lysimeters consist of 6 metal cylinders containing Fayette silt loam profile monoliths 36 inches in diameter and 44 inches deep. The monoliths were encased by forcing the cylinders downward into the soil, after which they were lifted and set upon pans partially filled with gravel. The method of construction of this type of lysimeter has been fully described by Musgrave (*5*). Losses were measured from corn, fallow, and clover-timothy hay. When there is a growing crop on the land there is normally very little percolate. The precipitation is lost largely by runoff or taken up by the roots of plants. The results from corn and fallow have been published (*4*).

The amount of water lost by percolation on a 10-percent slope is less than 4 percent of the annual precipitation on fallowed lysimeter plots, and less than 1 percent on lysimeter plots cropped to corn. When the surface was maintained at approximately a zero slope, the loss of water by percolate from fallowed lysimeter plots was 9 percent of the precipitation when runoff was permitted and 20 percent when runoff was prevented.

The plant nutrients determined in the percolate, when arranged in order of decreasing amount of loss by leaching, were as follows: Calcium, magnesium, sulphur, potassium, and phosphorous. The amount of nutrients lost by leaching was low when the soil was cropped. The highest losses were measured on plots that were fallowed and from which no runoff was permitted. The losses of calcium and magnesium under these conditions could be replaced with the application of 1½ tons of dolomitic limestone once in 10 years. Potassium and phosphorous losses were negligible. Losses of nitrogen were not determined on percolate from lysimeter plots cropped to corn, but it is assumed that they would not be high, inasmuch as the total amount of percolate from Fayette silt loam is low.

In 1943, all six lysimeter plots were seeded to a red clover-timothy hay mixture. The surfaces of the lysimeters were maintained at approximately a zero slope as during 1941 and 1942 when all lysimeters were fallowed. Approximately 2 percent of the precipitation was lost as percolate when the lysimeter plots were growing hay as compared with 9 percent of the precipitation when fallowed. Measurement made on percolate obtained during 1943 with the lysimeters cropped to clover-timothy hay showed that the amount of soluble nitrogen removed from the soil by leaching was 2.75 pounds per acre. It would be assumed that the loss of nitrogen from crops like corn and grain would be considerably higher due to the fact that they have much shorter growing seasons and for a part of the year the land is fallow.

APPLICATION OF STATION DATA TO EROSION CONTROL IN THE PROBLEM AREA

No control measure has been developed for this problem area that will prevent the loss of soil from a cultivated sloping field. As long as the soil is not protected by dense-growing vegetation, there is soil movement whenever a rain or thaw results in runoff. Soil losses are greatly reduced by the application of mechanical and vegetative control measures, but even with these controls on the land the loss of soil from sloping fields is continuing. To reduce soil losses to an extent necessary for a permanent agriculture, fields on slopes in excess of 15 percent will have to be seeded down to hay or pasture and not planted to grain or corn. The hay can be reestablished by renovation in such a way that the organic residue is left on the surface. This will largely prevent runoff until the vegetation has been reestablished. This means that some farms in the problem area will have to change to a grassland type of agriculture. This will require changes in livestock so as to consume large amounts of forage.

Most of the soil loss occurs during a few very intense storms during a year. In the development of an erosion-control program in the Upper Mississippi Valley area, the farm planner should take into consideration precipitation records. Data are available over long periods of time at nearby Weather Bureau stations. These show periods of excessive precipitation. Crop and cultural practices can be adjusted to protect the soil better during intense storms. As much as 90 percent of the annual soil loss may occur during 4 or 5 intense storms. These storms may be experienced at any time during the growing season within any single year. Study of the data recorded for several years, however, reveals a definite trend toward concentration during certain months. At La Crosse there is a concentration of moderate-intensity storms during May and June when spring grain land is vulnerable. There is also a concentration of high-intensity storms during the period June 15 to September 15 which causes high losses from corn land.

A control practice to be effective must be capable of maintaining soil loss at a minimum during intense storms. Fortunately, during these critical periods, alfalfa-brome grass, alfalfa-timothy, and red clover-timothy hay give excellent protection. A good dense hay crop not only protects the soil from erosion but greatly increases the amount of water that can be absorbed by the soil.

Seedbed Preparation

Most recommendations for seedbed preparation prior to the establishment of soil conservation research work were based on studies made on evel or nearly level land where erosion was not an important problem.

Therefore, the need for leaving the soil in as cloddy a condition as is consistent with good crop yields was not recognized. On sloping land it is important that the soil be tilled with machines that will control weeds and yet leave the soil in a rough, cloddy condition. The disk and the cultipacker should not be used, at least on the heavy sloping soils. Observations at the station would indicate that good yields can be obtained by the use of the field cultivator or spring-tooth in place of the disk. The spring-tooth or field cultivator lifts the soil and, if properly operated, will leave the roots of weeds on the surface where they will dry out and also produce a trashy surface condition that will increase infiltration and decrease runoff. Lifting the roots to the surface is a very effective method of controlling weeds, such as quack grass, that spread by means of rhizomes. The disk has been found to cut these underground stems off but not materially to reduce their ability to produce new plants except for those few which may be turned over on top of the soil and thereby be exposed to drying. The cultipacker, when used following the seeding of grain, will result in a better stand of legumes only if there is a dry seedbed and if no rains are experienced in the 2-week period immediately following seeding. During the past 10 years legumes have been seeded with and without the packer.

The experience of the Station has been that as good a stand of legume is obtained without the cultipacker as with it. It has also been observed that if a rain occurs before the grain has made sufficient growth to protect the soil, land on which the cultipacker has been used will erode more severely than land on which it has not been used.

In seedbed preparation for cornland, the same general principles apply. That is, the more rough the seedbed that is consistent with the production of a good crop, the lower will be the soil loss and the longer will high yields be maintained. Unless manure high in straw content is used as a top dressing, the field cultivator will work very satisfactorily in preparing a seedbed for the corn. This will leave much of the organic matter on the surface and maintain the desired rough, cloddy structure.

Plowing should be done as late in the fall as possible in order to have the soil protected by vegetation during the early fall rains. Early plowed land is compacted by the fall rains; as a result high fall and spring losses result even though a good growth of hay is plowed under. After plowing, the land should not be tilled in the fall. The practice of disking or spring-toothing land immediately after plowing greatly reduces the surface storage capacity, allows the soil to become compacted by rain, and results in high runoff.

The two-way plow, when used to turn soil uphill, has been found to be the best type of plow for hillside plowing. Furrows turned uphill have been found capable of holding much more water than furrows turned downhill. The land is left more open and rough so that both surface storage and infiltration are higher on land turned uphill. Dead furrows, which are frequently the cause of serious gully erosion, are located at the bottom of the plowed field instead of at the middle or top, as is the case where the conventional plow is used. Turning soil uphill actually moves a furrow slice against the direction of erosion, whereas all soil turned downhill actually speeds the movement of topsoil from the field.

The use of the two-way plow works very well in both strip cropping and terracing. In strip cropping the dead furrow is left at the bottom of the plowed strip. If the furrow is slightly off contour, as is frequently the case under field conditions, any concentration of runoff water by the dead furrow will flow onto a hay strip where little damage will result. In plowing terraced land with the two-way plow, the dead furrow can be left in the channel and the backfurrow on the ridge at such times as it is desired to increase the capacity of the terrace, or the backfurrow can be left at the top of the field and the dead furrow at the bottom if there is sufficient capacity in the terraces.

Crop Rotations

Rotation of crops including 2 or more years of hay is essential to the control of erosion on sloping fields. The higher the percentage of hay in the rotation, the lower the soil losses. The number of years that the land is protected by a dense growing crop is important. Not only are losses low during the time that the soil is protected by that crop, but losses are also reduced from a clean-tilled crop following the plowing under of a hay crop. The amount of reduction in losses resulting from plowing down a hay crop will depend upon the type of crop and amount of surface growth plowed under. It has been observed that soil losses are less from corn following an old alfalfa-timothy or alfalfa-brome field than from clover-timothy. This is thought to be due to the fact that the grass makes up a higher proportion of the mixture in an old alfalfa-grass field than in a clover-timothy field. This is especially evident if the clover-timothy stand is left for only 1 year as in the usual practice.

The soil loss from corn in a 3-year rotation has been about one-half of that from corn grown continuously. The soil loss from a 3-year rotation of corn, grain, and clover-timothy hay on a 16-percent slope has averaged 28 tons per acre. Although this is a marked reduction from the loss from continuous corn, it is still much too high. Rotations with 4 or more years of hay will be required to maintain losses at the desired minimum.

Where the longer rotations are used, and barnyard manure is applied to corn, it has been found that soil losses are as high and in some cases higher from grain than from cornland. The relative loss from cornland and grainland will depend upon when the intense storms occur within a year. Hard spring rains will cause high soil losses from grain and usually will not result in much soil loss from fall-plowed hay land. Hard rains occurring in mid summer will result in high soil losses from corn. At that time grainland, on the other hand, will usually be sufficiently well protected that the soil losses will be low. The runoff from grain during these intense summer rains frequently exceeds the amount of runoff from corn.

Contouring

Contouring, even with a good rotation including 3 or 4 years of hay, cannot be expected to give adequate control on the Fayette silt loam where slopes are steep and fairly long. The amount of storage capacity furnished by rows that are on the exact contour is not sufficient to hold all of the rain that is falling during the intense storms. When the capacity is exceeded, the furrows break over, the stored water drains out and exceedingly high soil losses will result on the longer slopes. It has also been found almost impossible to plant all of the rows on the exact contour in a field. The general practice has been to establish new contour lines at points where it was felt that the rows varied too much from the contour. It has been observed that the point rows and other off-contour rows carry the runoff water for a short distance until it reaches a place where the capacity of the small furrows is exceeded. This runoff then flows down to the contour rows, making them overtop and become ineffective.

Strip Cropping

Contour strip cropping with a good rotation, including 2 to 4 years of hay, is probably one of the best control measures that can be adapted to the cultivated fields of this area. For strip cropping to work properly and accomplish an adequate degree of control, its limitations should be recognized. Strip cropping does not reduce the effective length of slope. During the most intense storms, runoff can be expected from hay as well as corn and grain strips. Therefore, in fields in this area with slopes that average 10 to 12 percent, strips that are receiving runoff from watersheds more than 250 to 300 feet long will have high soil losses when the lower strips are in corn or grain. Terraces must be used to reduce the length of long slopes.

The control given land against erosion by strip cropping is dependent upon the success of obtaining and maintaining good stands of grass and legumes. It is as important to teach the farmer how to increase his chances of obtaining a good seeding and how to safeguard against having most of the field open in case of a seeding failure as it is to lay out the contour strip-cropping program on his land. In case a seeding is poor and it is questionable whether it should be left, plowing should be delayed until spring. At that time, choice can be made between plowing the old hay and planting it to corn or leaving the old hay, plowing up the new seeding, and reseeding to grain and legume. In some cases, the land can be worked up thoroughly after the grain is removed, if it can be determined at that time that the stand of legume will not be sufficiently good to leave. The field cultivator has been used with good success for seedbed preparation following grain. It is best to work the land sufficiently to kill all vegetation; otherwise, that which is left will severely compete with the new seedlings.

Summer seedings of legume and grass should be made before the middle of August so that the new plants will become well enough established to withstand the winter. Not much success has been obtained in attempts to thicken stands of old hay where thin patches have been worked up and reseeded, nor have spring seedings on frozen ground shown much promise. The most reliable method is to work the land thoroughly enough to kill all existing vegetation, then reseed.

A strip-cropping system properly designed and followed with good success in obtaining and maintaining stands of legumes will give good erosion control if the slope length is not excessive. On a strip-cropped watershed located on a 17-percent slope with a slope length of 270 feet, the annual soil loss has averaged less than 3 tons per acre for a 7-year period. This is considered as good control for these conditions.

Terraces

Terraces cropped to a rotation, including 2 or more years of hay, will provide the best control for erosion on cultivated land. Terraces definitely reduce the length of slope. They remove surplus water from the field, thereby protecting the area below the terrace. A 4-year rotation of corn, grain, and 2 years of hay will give adequate control when used with terraces on a 10- to 12-percent slope.

Terraces located on a 15-percent slope have been maintained at sufficient capacity by backfurrowing on the ridge and leaving the dead furrow in the channel once in the rotation. A terrace of about 1400 feet in length with a maximum 3-inch grade per 100 feet and vertical interval of 7 feet was found to have enough capacity to handle the runoff if the ridge height was maintained at a minimum of 12 inches. In general, terraces in pasture land have not been of sufficient benefit to justify the cost of construction. On the shallow soils frequently found in pastures, it is very difficult to establish a stand of grass in the channel and on the inslope. If there is sufficient field water flowing across a pasture to cause gullies, a terrace should be built at the top of the pasture area to divert this water to an established outlet, or, if located above cultivated fields, a terrace can be used to advantage to divert runoff in order to protect the field.

Some difficulty has been experienced with terraces overtopping during thaw periods. If the terraces are not protected by vegetation, serious damage may result, as the runoff water will often thaw the soil, causing a gully on the ridge which will greatly reduce the capacity of the terrace. An ordinary plow may be used to open up a channel so that the water can flow to the outlet end. Usually this furrow is enough to take care of the runoff unless the thawing is very rapid.

Pasture and Woodland

For maximum pasture production, an area should not be in both timber and pasture. For maximum runoff protection, a wooded area should be protected from grazing. So, in general, pasture and woods should not be mixed. Very good pasture production has been obtained on slopes up to 30 percent as long as there is good productive soil and the pastures are not overgrazed. Under these conditions the runoff will also be fairly low. From a production and a conservation standpoint, it seems best to have open pasture of sufficient acreage and quality available to meet the forage requirements of the livestock that will be carried on the farm. The main thing to consider is that the soil should be productive—slope is not thought to be too important a factor.

APPENDIX

In order to avoid an excess of tabular material throughout the text, the data of the individual tables necessary for deriving the summary tables and figures used in the text have been placed in the Appendix as tables 19 to 36.

The data presented in the Appendix give specific records of the results of experimentation for the period of this report that have practical value and interest for technicians engaged in the development of conservation programs and practices.

TABLE 19.—*Maximum and minimum temperatures by months and by years at soil conservation experiment station La Crosse, Wis., 1934–43*

Year	January High	January Low	January Mean High	January Mean Low	February High	February Low	February Mean High	February Mean Low	March High	March Low	March Mean High	March Mean Low
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1934	----	----	----	----	----	----	----	----	----	----	----	----
1935	38	−31	20	2	38	−5	25	16	60	12	46	24
1936	36	−32	14	−2	44	−24	12	−8	67	0	38	22
1937	35	−17	20	−3	43	−17	23	−4	51	4	34	20
1938	45	−14	21	8	44	−13	31	16	75	6	46	24
1939	50	−8	30	14	43	−16	24	2	75	0	40	18
1940	30	−23	14	−3	30	−13	28	12	50	−2	31	19
1941	39	−6	26	10	38	−20	25	6	58	−12	34	17
1942	50	−25	24	10	34	−14	24	9	64	19	42	26
1943	42	−25	22	−5	47	−16	30	5	74	−17	35	10
Average	40	−20	21	3	41	−15	25	6	64	3	38	20

Year	April High	April Low	April Mean High	April Mean Low	May High	May Low	May Mean High	May Mean Low	June High	June Low	June Mean High	June Mean Low
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1934	81	26	60	39	104	42	79	51	94	50	83	59
1935	75	18	51	34	76	28	60	43	84	40	70	54
1936	71	8	49	30	87	34	73	53	86	45	75	55
1937	71	26	51	37	80	33	68	49	90	40	74	59
1938	77	18	54	37	78	33	64	48	91	46	74	57
1939	85	14	51	32	86	34	72	51	87	47	75	60
1940	72	15	52	32	85	28	64	44	89	47	77	57
1941	78	29	61	42	83	32	72	50	89	42	76	58
1942	81	22	61	39	85	32	64	44	84	42	77	54
1943	72	18	54	30	88	32	63	40	92	45	80	58
Average	76	19	54	35	86	33	68	47	89	44	76	57

Year	July High	July Low	July Mean High	July Mean Low	August High	August Low	August Mean High	August Mean Low	September High	September Low	September Mean High	September Mean Low
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1934	100	52	85	58	94	40	79	54	78	32	66	44
1935	94	58	85	60	88	42	79	60	85	34	70	51
1936	105	55	90	66	98	50	85	63	87	39	72	55
1937	94	49	85	64	97	50	85	65	94	34	72	51
1938	87	53	80	62	89	54	80	62	85	41	69	52
1939	95	52	82	64	87	51	77	61	93	33	72	55
1940	96	49	83	64	92	44	75	58	88	35	72	53
1941	95	50	81	60	93	46	78	59	85	34	71	52
1942	91	49	79	59	92	43	79	58	84	24	68	50
1943	92	40	83	60	89	48	80	58	85	34	66	43
Average	95	52	83	62	92	47	80	60	86	34	70	51

Year	October High	October Low	October Mean High	October Mean Low	November High	November Low	November Mean High	November Mean Low	December High	December Low	December Mean High	December Mean Low	Annual High	Annual Low
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1934	80	26	61	38	58	20	43	30	36	−18	23	8	104	−18
1935	78	22	58	39	54	7	36	21	55	−14	26	10	94	−31
1936	71	17	54	36	60	7	38	21	53	−15	31	15	105	−32
1937	78	21	53	37	62	0	37	23	38	−2	26	10	97	−17
1936	81	28	64	46	74	1	43	26	39	−12	27	13	91	−14
1939	83	24	56	42	65	10	28	44	52	−7	35	22	95	−16
1940	75	33	64	44	63	−2	31	19	47	−19	30	15	96	−23
1941	70	20	58	41	68	9	40	28	53	−4	36	19	95	−20
1942	78	14	50	34	63	4	42	23	33	−9	23	7	91	−25
1943	77	25	61	38	50	3	37	21	49	−11	35	12	92	−25
Average	77	23	59	39	62	7	39	26	46	−11	29	13	-----	-----

TABLE 20.—*Annual summary of rainfall, runoff, and soil loss by winter period and growing season on the control plots*

CONTROL PLOT 1, 16-PERCENT SLOPE, 36.3-FOOT LENGTH[1]

Year	Winter cover	Crop and treatment	Precipitation			Water loss			Soil loss per acre		
			Winter period	Growing season	Total	Winter period	Growing season	Total	Winter period	Growing season	Total
			Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Tons*	*Tons*	*Tons*
1933	Fall-spaded corn stubble	Corn	11.26	21.23	32.49	4.46	1.90	6.36	8.35	17.32	25.67
1934	do	do	3.88	24.96	28.84	.72	5.89	6.61	.37	42.42	42.79
1935	do	do	13.71	29.74	43.45	.36	9.07	9.43	.07	108.44	108.51
1936	do	do	6.17	20.77	26.94	5.21	4.90	10.11	12.90	56.84	69.74
1937	do	do	6.53	21.20	27.73	2.81	2.75	5.56	.24	55.72	55.96
1938	do	do	8.31	35.09	43.40	3.98	14.26	18.24	1.32	106.82	108.14
Average			8.31	25.50	33.81	2.92	6.46	9.38	3.88	64.59	68.47
1939	do	Spring grain-lime, phosphorous, and potash.	7.08	18.87	25.95	3.95	4.35	8.30	3.47	6.01	9.48
1940	Alfalfa-timothy seeding	First-year hay	6.25	21.99	28.24	3.24	1.84	5.08	2.39	.79	3.18
1941	Alfalfa-timothy hay	Second-year hay	8.19	32.76	40.95	2.55	1.29	3.84	.04	.26	.30
1942	do	Third-year hay	5.82	31.03	36.85	.59	.44	1.03	.03	.04	.07
1943	do	Fourth-year hay	8.06	18.36	26.42	1.91	.01	1.92	.05	------	.05
Average			7.08	24.60	31.68	2.45	1.59	4.04	1.20	1.42	2.62

CONTROL PLOT 2, 16-PERCENT SLOPE, 145.2-FOOT LENGTH[1]

Year	Winter cover	Crop and treatment	Precipitation: Winter period	Precipitation: Growing season	Precipitation: Total	Water loss: Winter period	Water loss: Growing season	Water loss: Total	Soil loss: Winter period	Soil loss: Growing season	Soil loss: Total
1933	Fall-spaded corn stubble	Corn	11.26	21.23	32.49	3.28	1.69	4.97	24.53	43.73	68.26
1934	do	do	3.88	24.96	28.84	.55	5.67	6.22	1.91	83.06	84.97
1935	do	do	13.71	29.74	43.45	.15	8.13	8.28	.08	147.04	147.12
1936	do	do	6.17	20.77	26.94	4.65	4.93	9.58	35.39	126.83	162.22
1937	do	do	6.53	21.20	27.73	3.16	3.30	6.46	14.89	135.75	150.64
1938	do	do	8.31	35.09	43.40	4.66	14.42	19.08	6.07	205.15	211.22
Average			8.31	25.50	33.81	2.74	6.36	9.10	13.81	123.59	137.40
1939	do	Spring grain-lime, phosphorous, and potash.	7.08	18.87	25.95	2.11	4.76	6.87	1.31	7.85	9.16
1940	Alfalfa-timothy seeding	First-year hay	6.25	21.99	28.24	2.35	3.81	6.16	3.77	1.50	5.27
1941	Alfalfa-timothy hay	Second-year hay	8.19	32.76	40.95	3.97	2.20	6.17	.05	.24	.29
1942	Fall-spaded hay	Corn-manure and lime	5.82	31.03	36.85	.20	1.15	1.35	.16	3.46	3.62
1943	Fall-spaded corn stubble	Spring grain-phosphorous and potash.	8.06	18.36	26.42	.64	.42	1.06	.56	.55	1.11
Average			7.08	24.60	31.68	1.85	2.47	4.32	1.17	2.72	3.89

CONTROL PLOT 3, 16-PERCENT SLOPE, 72.6-FOOT LENGTH

1933	Fall-spaded corn stubble	Corn	11.26	21.23	32.49	4.41	2.04	6.45	27.03	32.80	59.83
1934	do	do	3.88	24.96	28.84	.38	6.43	6.81	.96	61.56	62.52
1935	do	do	13.71	29.74	43.45	.20	8.60	8.80	.05	141.44	141.49
1936	do	do	6.17	20.77	26.94	6.70	5.15	11.85	33.81	102.25	136.06
1937	do	do	6.53	21.20	27.73	3.62	2.97	6.59	6.92	102.94	109.86
1938	do	do	8.31	35.09	43.40	5.34	13.37	18.71	5.00	155.25	160.25
Average			8.31	25.50	33.81	3.44	6.43	9.87	12.30	99.37	111.67
1939	do	Spring grain-lime, phosphorous, and potash.	7.08	18.87	25.95	2.22	3.91	6.13	1.60	10.12	11.72
1940	Alfalfa-timothy seeding	First-year hay	6.25	21.99	28.24	3.23	3.01	6.24	2.20	.92	3.12
1941	Fall-spaded hay	Corn-lime and manure	8.19	32.76	40.95	2.46	5.56	8.02	.36	36.07	36.43
1942	Fall-spaded corn stubble	Spring grain-phosphorous and potash.	5.82	31.03	36.85	1.35	4.80	6.15	7.42	16.35	23.77
1943	Alfalfa-timothy seeding	First-year hay	8.06	18.36	26.42	.87	.11	.98	.05	.02	.07
Average			7.08	24.60	31.68	2.02	3.48	5.50	2.32	12.70	15.02

CONTROL PLOT 4, 16-PERCENT SLOPE, 72.6-FOOT LENGTH

1933	Fall-spaded grain stubble	Spring grain	11.26	21.23	32.49	4.06	1.68	5.74	9.76	2.24	12.00
1934	do	do	3.88	24.96	28.84	.67	4.21	4.88	.06	17.18	17.24
1935	do	do	13.71	29.74	43.45	.17	6.17	6.34		13.10	13.10
1936	do	do	6.17	20.77	26.94	2.26	4.90	7.16	.30	29.81	30.11
1937	do	do	6.53	21.20	27.73	1.83	3.70	5.53	.64	5.02	5.66
1938	do	do	8.31	35.09	43.40	2.66	10.83	13.49	.98	21.44	22.42
Average			8.31	25.50	33.81	1.94	5.25	7.19	1.96	14.80	16.76
1939	do	Corn-lime and manure	7.08	18.87	25.95	1.46	2.62	4.08	.31	4.94	5.25
1940	Fall-spaded corn stubble	Spring grain-phosphorous and potash.	6.25	21.99	28.24	.24	2.97	3.21	.89	5.87	6.76
1941	Alfalfa-timothy seeding	First-year hay	8.19	32.76	40.95	3.49	1.28	4.77	.33	.61	.94
1942	Alfalfa-timothy hay	Second-year hay	5.82	31.03	36.85	1.60	.36	1.96	.73	.19	.92
1943	do	Third-year hay	8.06	18.36	26.42	.17	.01	.18	.01		.01
Average			7.08	24.60	31.68	1.39	1.45	2.84	.45	2.32	2.77

See footnotes at end of table.

TABLE 20.—*Annual summary of rainfall, runoff, and soil loss by winter period and growing season on the control plots*—Continued

CONTROL PLOT 5, 16-PERCENT SLOPE, 72.6-FOOT LENGTH

Year	Winter cover	Crop and treatment	Precipitation			Water loss			Soil loss per acre		
			Winter period	Growing season	Total	Winter period	Growing season	Total	Winter period	Growing season	Total
			Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Tons*	*Tons*	*Tons*
1933	Fall-spaded corn stubble	Spring grain	11.26	21.23	32.49	4.01	1.66	5.67	25.02	3.81	28.83
1934	Clover-timothy seeding	Hay	3.88	24.96	28.84	1.40	1.39	2.79		.47	.47
1935	Fall-spaded hay	Corn-lime	13.71	29.74	43.45	.15	7.79	7.94		96.18	96.18
1936	Fall-spaded corn stubble	Spring grain	6.17	20.77	26.94	6.29	5.02	11.31	34.61	51.01	85.62
1937	Clover-timothy seeding	Hay	6.53	21.20	27.73	2.23	2.03	4.26	.48	.57	1.05
1938	Fall-spaded hay	Corn	8.31	35.09	43.40	3.41	10.40	13.81	.26	70.85	71.11
Average			8.31	25.50	33.81	2.92	4.72	7.64	10.06	37.15	47.21
1939	Fall-spaded corn stubble	Spring grain-lime, phosphorous, and potash.	7.08	18.87	25.95	2.09	3.66	5.75	2.15	4.39	6.54
1940	Alfalfa-timothy seeding	First-year hay	6.25	21.99	28.24	3.40	1.05	4.45	.61	.16	.77
1941	Alfalfa-timothy hay	Second-year hay	8.19	32.76	40.95	3.37	.83	4.20	.04	.19	.23
1942	do.	Third-year hay	5.82	31.03	36.85	1.97	.76	2.73	.17	.15	.32
1943	Fall-spaded hay	Corn-lime and manure	8.06	18.36	26.42	.15	.07	.22	.10	.09	.19
Average			7.08	24.60	31.68	2.20	1.27	3.47	.61	1.00	1.61

CONTROL PLOT 6, 16-PERCENT SLOPE, 72.6-FOOT LENGTH

Year	Winter cover	Crop and treatment	Precipitation: Winter period	Precipitation: Growing season	Precipitation: Total	Water loss: Winter period	Water loss: Growing season	Water loss: Total	Soil loss per acre: Winter period	Soil loss per acre: Growing season	Soil loss per acre: Total
1933	Fall-spaded grain stubble	Corn	11.26	21.23	32.49	2.79	1.71	4.50	9.26	24.90	34.16
1934	Fall-spaded corn stubble	Spring grain	3.88	24.96	28.84	.76	3.78	4.54	.65	21.25	21.90
1935	Clover-timothy seeding	Hay-lime	13.71	29.74	43.45	.15	1.93	2.08		.27	.27
1936	Fall-spaded hay	Corn	6.17	20.77	26.94	3.60	3.43	7.03	.74	43.83	44.57
1937	Fall-spaded corn stubble	Spring grain	6.53	21.20	27.73	1.70	2.58	4.28	1.16	2.88	4.04
1938	Clover-timothy hay	Hay	8.31	35.09	43.40	3.60	2.63	6.23	.37	1.11	1.48
Average			8.31	25.50	33.81	2.10	2.68	4.78	2.03	15.71	17.74
1939	Fall-spaded hay	Spring grain phosphorous and potash.	7.08	18.87	25.95	1.45	2.06	3.51	.17	1.70	1.87
1940	Alfalfa-timothy seeding	First-year hay	6.25	21.99	28.24	3.17	.33	3.50	.86	.07	.93
1941	Fall-spaded hay	Corn-lime and manure	8.19	32.76	40.95	2.07	4.27	6.34	.27	35.11	35.38
1942	Fall-spaded corn stubble	Spring grain phosphorous and potash.	5.82	31.03	36.85	2.72	2.93	5.65	12.41	15.04	27.45
1943	Alfalfa-timothy seeding	First-year hay	8.06	18.36	26.42	.21	.03	.24	.01	.01	.02
Average			7.08	24.60	31.68	1.92	1.92	3.84	2.74	10.39	13.13

CONTROL PLOT 7, 16-PERCENT SLOPE, 72.6-FOOT LENGTH

1933	Clover-timothy seeding	Hay	11.26	21.23	32.49	3.90	0.13	4.03	0.46	0.15	0.61
1934	Fall-spaded hay	Corn	3.88	24.96	28.84	.43	4.39	4.82	.02	29.76	29.78
1935	Fall-spaded corn	Spring grain-lime	13.71	29.74	43.45	.10	4.59	4.69		12.61	12.61
1936	Clover-timothy seeding	Hay	6.17	20.77	26.94	3.67	.27	3.94	.10	.13	.23
1937	Fall-spaded hay	Corn	6.53	21.20	27.73	1.55	2.10	3.65	.15	41.71	41.86
1938	Fall-spaded corn stubble	Spring grain	8.31	35.09	43.40	2.53	5.35	7.88	2.92	23.08	26.00
Average			8.31	25.50	33.81	2.03	2.80	4.83	.61	17.91	18.52
1939	Clover-timothy seeding	Spring grain-lime	7.08	18.87	25.95	1.75	.73	2.48	.07	.13	.20
1940	Alfalfa-timothy seeding	First-year hay	6.25	21.99	28.24	1.12	.04	1.16	.27		.27
1941	Alfalfa-timothy hay	Second-year hay	8.19	32.76	40.95	1.53	.25	1.78		.11	.11
1942	Fall-spaded hay	Corn	5.82	31.03	36.85	.68	1.55	2.23	2.17	9.62	11.79
1943	Fall-spaded corn stubble	Spring grain	8.06	18.36	26.42	.29	.04	.33	.14	.13	.27
Average			7.08	24.60	31.68	1.07	.52	1.59	.53	2.00	2.53

CONTROL PLOT 8, 16-PERCENT SLOPE, 72.6-FOOT LENGTH

1933	Fall-spaded	Fallow—hoed to control weeds	11.26	21.23	32.49	4.51	1.41	5.92	33.34	18.27	51.61
1934	do	do	3.88	24.96	28.84	.87	7.13	8.00	.92	178.60	179.52
1935	do	do	13.71	29.74	43.45	.26	8.18	8.44	.98	220.49	221.47
1936	do	do	6.17	20.77	26.94	5.91	5.70	11.61	31.48	176.53	208.01
1937	do	do	6.53	21.20	27.73	3.80	3.65	7.45	1.57	162.61	164.18
1938	do	do	8.31	35.09	43.40	4.81	12.72	17.53	10.53	310.43	320.96
Average			8.31	25.50	33.81	3.36	6.46	9.82	13.14	177.82	190.96
1939	do	Spring grain-lime, phosphorous, and potash.	7.08	18.87	25.95	1.32	3.22	4.54	.91	3.29	4.20
1940	Alfalfa-timothy seeding	First-year hay	6.25	21.99	28.24	2.17	1.95	4.12	1.56	.44	2.00
1941	Alfalfa-timothy hay	Second-year hay	8.19	32.76	40.95	3.10	1.19	4.29	.02	.38	.40
1942	do	Third-year hay	5.82	31.03	36.85	.76	.94	1.70	.09	.24	.33
1943	Fall-spaded hay	Corn	8.06	18.36	26.42	.40	.13	.53	.18	.18	.36
Average			7.08	24.60	31.68	1.55	1.49	3.04	.55	.91	1.46

TABLE 20.—*Annual summary of rainfall, runoff, and soil loss by winter period and growing season on the control plots*—Continued

CONTROL PLOT 9, 16-PERCENT SLOPE, 72.6-FOOT LENGTH

Year	Winter cover	Crop and treatment	Precipitation			Water loss			Soil loss per acre		
			Winter period	Growing season	Total	Winter period	Growing season	Total	Winter period	Growing season	Total
			Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Tons*	*Tons*	*Tons*
1933	Fall-spaded	Fallow[2] plus manure[3]	11.26	21.23	32.49	4.52	1.48	6.00	14.90	21.40	36.30
1934	do	do[2 3]	3.88	24.96	28.84	1.25	7.16	8.41	1.28	168.17	168.45
1935	do	do[2 3]	13.71	29.74	43.45	.45	8.41	8.86	1.74	203.61	205.35
1936	do	do[2 3]	6.17	20.77	26.94	5.28	5.32	10.60	39.72	129.02	168.74
1937	do	do[2 3]	6.53	21.20	27.73	3.62	3.56	7.18	4.16	132.13	136.29
1938	do	do[2 3]	8.31	35.09	43.40	4.91	12.02	16.93	10.02	243.64	253.66
Average			8.31	25.50	33.81	3.34	6.32	9.66	11.80	149.66	161.46
1939	Fall-spaded fallow	Corn lime and manure	7.08	18.87	25.95	2.26	3.32	5.58	.85	11.59	12.44
1940	Fall-spaded corn stubble	Spring grain–phosphorous and potash.	6.25	21.99	28.24	.73	5.11	5.84	5.43	29.93	35.36
1941	Alfalfa-timothy seeding	First-year hay	8.19	32.76	40.95	3.47	1.72	5.19	.06	.85	.91
1942	Alfalfa-timothy hay	Second-year hay	5.82	31.03	36.85	.47	.33	.80	.08	.07	.15
1943	do	Third-year hay	8.06	18.36	26.42	.40	.04	.44	----	----	----
Average			7.08	24.60	31.68	1.47	2.10	3.57	1.28	8.49	9.77

CONTROL PLOT 10, 16-PERCENT SLOPE, 72.6-FOOT LENGTH

Year	Winter cover	Crop and treatment	Precipitation: Winter period	Precipitation: Growing season	Precipitation: Total	Water loss: Winter period	Water loss: Growing season	Water loss: Total	Soil loss per acre: Winter period	Soil loss per acre: Growing season	Soil loss per acre: Total
1933	Mixed grass	Bluegrass—protected	11.26	21.23	32.49	1.87	----	1.87	----	----	----
1934	do	do	3.88	24.96	28.84	1.80	0.11	1.91	0.02	0.04	0.06
1935	do	do	13.71	29.74	43.45	.09	----	.09	----	----	----
1936	do	do	6.17	20.77	26.94	3.16	----	3.16	.17	.01	.18
1937	do	do	6.53	21.20	27.73	2.03	.01	2.04	.14	.01	.15
1938	do	do	8.31	35.09	43.40	2.11	.03	2.14	.16	----	.16
Average			8.31	25.50	33.81	1.84	.03	1.87	.08	.01	.09
1939	do	Bluegrass—clipped	7.08	18.87	25.95	.95	.02	.97	.04	.04	.08
1940	do	do	6.25	21.99	28.24	.23	----	.23	----	----	----
1941	do	do	8.19	32.76	40.95	1.15	.04	1.19	.01	.01	.02
1942	do	do	5.82	31.03	36.85	.17	.03	.20	----	----	----
1943	do	do	8.06	18.36	26.42	1.87	.01	1.88	.02	----	.02
Average			7.08	24.60	31.68	.87	.02	.89	.01	.01	.02

CONTROL PLOT 11, 16-PERCENT SLOPE, 72.6-FOOT LENGTH

1933	Fall-spaded corn stubble	Corn—subsoil[4]	11.26	21.23	32.49	6.66	3.32	9.98	28.57	57.02	85.59
1934	do	do[4]	3.88	24.96	28.84	1.43	7.90	9.33	2.76	87.72	90.48
1935	do	do[4]	13.71	29.74	43.45	.25	8.43	8.68	.17	147.13	147.30
1936	do	do[4]	6.17	20.77	26.94	2.79	5.02	7.81	4.54	106.75	111.29
1937	do	do[4]	6.53	21.20	27.73	.47	3.27	3.74	.07	116.06	116.13
1938	do	do[4]	8.31	35.09	43.40	4.41	14.45	18.86	3.29	185.48	188.77
Average			8.31	25.50	33.81	2.67	7.06	9.73	6.57	116.69	123.26

CONTROL PLOT 12, 30-PERCENT SLOPE, 72.6-FOOT LENGTH

1933	Mixed grass	Bluegrass—protected	11.26	21.23	32.49	1.71	0.87	2.58		0.02	0.02
1934	do	do	3.88	24.96	28.84	2.08	1.47	3.55	0.01	.36	.37
1935	do	do	13.71	29.74	43.45	.62	.91	1.53	.04		.04
1936	do	do	6.17	20.77	26.94	2.89	.19	3.08		.01	.01
1937	do	do	6.53	21.20	27.73	.12	.01	.13			
1938	do	do	8.31	35.09	43.40	.07	.24	.31			
Average			8.31	25.50	33.81	1.25	.62	1.87	.01	.06	.07

CONTROL PLOT 13, 30-PERCENT SLOPE, 72.6-FOOT LENGTH

1933	Mixed grass	Bluegrass—clipped	11.26	21.23	32.49	1.46	1.64	3.10		0.04	0.04
1934	do	do	3.88	24.96	28.84	2.25	3.21	5.46	0.01	.81	.82
1935	do	do	13.71	29.74	43.45	.92	1.40	2.32	.07	.06	.13
1936	do	do	6.17	20.77	26.94	1.90	.78	2.68		.09	.09
1937	do	do	6.53	21.20	27.73	.24	.44	.68	.01	.03	.04
1938	do	do	8.31	35.09	43.40	2.69	.93	3.62	.07	.36	.43
Average			8.31	25.50	33.81	1.58	1.40	2.98	.03	.23	.26

CONTROL PLOT 14, 30-PERCENT SLOPE, 72.6-FOOT LENGTH

1934	Fall-spaded corn stubble	Corn	3.88	24.96	28.84	0.16	5.61	5.77	0.03	47.73	47.76
1935	do	do	13.71	29.74	43.45	.35	7.75	8.10	.10	114.51	114.61
1936	do	do	6.17	20.77	26.94	.46	4.28	4.74	.29	105.53	105.82
1937	do	do	6.53	21.20	27.73	.37	2.84	3.21	.01	141.37	141.38
1938	do	do	8.31	35.09	43.40	4.47	11.51	15.98	18.67	219.33	238.00
Average			7.72	26.35	34.07	1.16	6.40	7.56	3.82	125.69	129.51

TABLE 20.—*Annual summary of rainfall, runoff, and soil loss by winter period and growing season on the control plots*—Continued

Year	Winter cover	Crop and treatment	Precipitation			Water loss			Soil loss per acre		
			Winter period	Growing season	Total	Winter period	Growing season	Total	Winter period	Growing season	Total
			Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Tons*	*Tons*	*Tons*
		CONTROL PLOT 15, 16-PERCENT SLOPE, 72.6-FOOT LENGTH									
1937	Fall-spaded soybeans	Soybeans	6.53	21.20	27.73	3.81	3.34	7.15	0.27	62.85	63.12
1938	do	Corn	8.31	35.09	43.40	2.45	8.28	10.73	1.71	110.03	111.74
1939	Fall-spaded corn stubble	Winter-grain—phosphorous and potash.	7.08	18.87	25.95	4.12	2.96	7.08	.62	2.37	2.99
1940	Clover-timothy seeding	First-year hay	6.25	21.99	28.24	2.20	2.33	4.53	5.66	1.43	7.09
1941	Fall-spaded hay	Corn—lime and manure	8.19	32.76	40.95	2.53	6.25	8.78	.29	70.84	71.13
1942	Fall-spaded corn stubble	Winter-grain—phosphorous and potash.	5.82	31.03	36.85	2.89	3.09	5.98	3.07	2.24	5.31
1943	Clover-timothy seeding	First-year hay	8.06	18.36	26.42	1.18	.07	1.25	.02		.02
Average 1939–43			7.08	24.60	31.68	2.58	2.94	5.52	1.93	15.38	17.31
		CONTROL PLOT 16, 16-PERCENT SLOPE, 72.6-FOOT LENGTH									
1937	Alfalfa-timothy hay	Old hay	6.53	21.20	27.73	2.57	0.18	2.75	0.06	0.03	0.09
1938	Fall-spaded hay	Corn	8.31	35.09	43.40	2.91	6.02	8.93	.17	47.16	47.33
1939	Fall-spaded corn stubble	Spring-grain—phosphorous and potash.	7.08	18.87	25.95	2.18	2.21	4.39	.94	1.45	2.39
1940	Clover-timothy seeding	First-year hay	6.25	21.99	28.24	2.13	.36	2.49	1.33	.14	1.47
1941	Fall-spaded hay	Corn	8.19	32.76	40.95	1.74	5.10	6.84	.14	36.65	36.79
1942	Fall-spaded corn stubble	Spring-grain	5.82	31.03	36.85	1.70	4.35	6.05	14.08	29.18	43.26
1943	Clover-timothy seeding	First-year hay	8.06	18.36	26.42	1.94	.01	1.95	.02		.02
Average 1939–43			7.08	24.60	31.68	1.94	2.41	4.35	3.30	13.48	16.78
		CONTROL PLOT 17, 16-PERCENT SLOPE, 72.6-FOOT LENGTH									
1940	Fall-spaded grain stubble	Corn—lime and manure	6.25	21.99	28.24	0.42	1.53	1.95	2.26	12.43	14.69
1941	Fall-spaded corn stubble	Spring-grain—phosphorous and potash.	8.19	32.76	40.95	2.75	6.07	8.82	1.03	43.92	44.95
1942	Alfalfa-timothy seeding	First-year hay	5.82	31.03	36.85	1.62	.62	2.24	.32	.11	.43
1943	Alfalfa-timothy hay	Second-year hay	8.06	18.36	26.42	2.07	.08	2.15	.06	.02	.08
Average			7.08	26.04	33.12	1.72	2.08	3.80	.92	14.12	15.04

		CONTROL PLOT 18, 16-PERCENT SLOPE, 72.6-FOOT LENGTH									
1940	Fall-spaded grain stubble	Corn—lime and manure	6.25	21.99	28.24	0.99	2.90	3.89	13.46	23.32	36.78
1941	Fall-spaded corn stubble	Spring-grain—phosphorous and potash.	8.19	32.76	40.95	3.70	11.59	15.29	1.23	73.19	74.42
1942	Alfalfa-timothy seeding	First-year hay	5.82	31.03	36.85	.92	.76	1.68	.30	.46	.76
1943	Alfalfa-timothy hay	Second-year hay	8.06	18.36	26.42	2.02	.07	2.09	.06	.02	.08
Average			7.08	26.04	33.12	1.91	3.83	5.74	3.76	24.25	28.01
		CONTROL PLOT 19, 6-PERCENT SLOPE, 72.6-FOOT LENGTH									
1940	Grain seeded in corn stubble	Winter-grain—phosphorous and potash.	6.25	21.99	28.24	2.02	2.23	4.25	2.38	1.35	3.73
1941	Fall-spaded grain stubble	Corn—lime and manure	8.19	32.76	40.95	2.45	4.33	6.78	.26	16.38	16.64
1942	Fall-spaded corn stubble	Spring-grain—phosphorous and potash.	5.82	31.03	36.85	2.61	2.51	5.12	3.40	4.05	7.45
1943	Alfalfa-timothy seeding	First-year hay	8.06	18.36	26.42	3.77	.02	3.79	.04	-------	.04
Average			7.08	26.04	33.12	2.71	2.27	4.98	1.52	5.44	6.96
		CONTROL PLOT 20, 6-PERCENT SLOPE, 72.6-FOOT LENGTH									
1940	Fall-spaded corn stubble	Spring-grain—phosphorous and potash.	6.25	21.99	28.24	1.18	1.89	3.07	2.21	1.71	3.92
1941	Alfalfa-timothy seeding	First-year hay	8.19	32.76	40.95	3.56	.16	3.72	.06	.03	.09
1942	Alfalfa-timothy hay	Second-year hay	5.82	31.03	36.85	2.35	.09	2.44	.12	.01	.13
1943	Fall-spaded hay	Corn—lime and manure	8.06	18.36	26.42	1.33	.02	1.35	.04	-------	.04
Average			7.08	26.04	33.12	2.10	.54	2.64	.61	.44	1.05
		CONTROL PLOT 21, 6-PERCENT SLOPE, 72.6-FOOT LENGTH									
1940	Grain seeded in corn stubble	Winter-grain—phosphorous and potash.	6.25	21.99	28.24	1.66	2.10	3.76	2.08	1.27	3.35
1941	Alfalfa-timothy hay	First-year hay	8.19	32.76	40.95	2.79	.04	2.83	.02	.02	.04
1942	Fall-spaded hay	Corn—lime and manure	5.82	31.03	36.85	.71	.05	.76	.21	.15	.36
1943	Fall-spaded corn stubble	Spring-grain—phosphorous and potash.	8.06	18.36	26.42	.62	.02	.64	.03	-------	.03
Average			7.08	26.04	33.12	1.44	.55	1.99	.58	.36	.94

TABLE 20.—*Annual summary of rainfall, runoff, and soil loss by winter period and growing season on the control plots*—Continued

CONTROL PLOT 22, 6-PERCENT SLOPE, 72.6-FOOT LENGTH

Year	Winter cover	Crop and treatment	Precipitation			Water loss			Soil loss per acre		
			Winter period	Growing season	Total	Winter period	Growing season	Total	Winter period	Growing season	Total
			Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Tons*	*Tons*	*Tons*
1940	Fall-spaded corn stubble	Corn—lime and manure	6.25	21.99	28.24	0.88	1.13	2.01	1.15	1.92	3.07
1941	do	Spring-grain—phosphorous and potash.	8.19	32.76	40.95	2.50	5.01	7.51	.30	11.67	11.97
1942	Alfalfa-timothy seeding	First-year hay	5.82	31.03	36.85	3.14	.31	3.45	.22	.06	.28
1943	Alfalfa-timothy hay	Second-year hay	8.06	18.36	26.42	2.20	.01	2.21	.04	----	.04
Average			7.08	26.04	33.12	2.18	1.62	3.80	.43	3.41	3.84

[1] Slope length of 72.6 feet from 1939 on.
[2] Hoed to control weeds.
[3] 5 tons per acre.
[4] 8 inches of surface soil were removed from this plot in 1932.

TABLE 21—*Rainfall and soil and water losses from control plots under various kinds of vegetation and from a cultivated fallow plot, by classified groups of rains*[1], *1933-38*[2]

Rainfall group and plot No.	Vegetative cover	Rains				Amount of rainfall		Water loss				Soil loss per acre	
		1938[3]		Average		1938	Average	Amount		Percent of rainfall		1938	Average
		Total	Causing runoff	Total	Causing runoff			1938	Average	1938	Average		
		Number	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
Annual:[1]													
10	Blue grass, unclipped	98	3	59	1	35.09	25.50	0.03	0.02	0.08	0.08	----	0.01
8	Fallow	98	27	59	15	----	----	12.72	6.47	36.25	25.38	310.43	177.82
3	Corn annually	98	30	59	16	----	----	13.37	6.43	38.10	25.22	155.22	99.38
4	Grain annually	98	32	59	18	----	----	10.83	5.25	30.86	20.59	21.44	14.80
5, 6, 7	Corn in rotation	98	23	59	13	----	----	10.40	4.97	29.64	19.49	70.85	51.20
5, 6, 7	Barley in rotation	98	26	59	16	----	----	5.35	3.83	15.25	15.02	23.08	19.11
5, 6, 7	Clover-timothy hay in rotation	98	20	59	9	----	----	2.63	1.40	7.50	5.49	1.11	.43

High-factor rains:													
10	Blue grass, unclipped	8	3	5	1	14.95	8.00	.03	.02	.20	.25	----	.01
8	Fallow	8	8	5	4	----	----	8.91	4.29	59.60	53.63	265.92	154.16
3	Corn annually	8	8	5	5	----	----	9.94	4.41	66.49	55.13	125.82	85.87
4	Grain annually	8	8	5	5	----	----	8.34	3.74	55.78	46.75	14.84	10.60
5, 6, 7	Corn in rotation	8	8	5	5	----	----	8.32	3.65	55.65	45.62	57.26	44.67
5, 6, 7	Barley in rotation	8	8	5	5	----	----	3.74	2.62	25.02	32.75	15.25	14.07
5, 6, 7	Clover-timothy hay in rotation	8	8	5	4	----	----	2.36	1.21	15.79	15.13	1.06	.33
Moderate-factor rains:													
10	Blue grass, unclipped	8	0	6	0	6.01	6.94	----	----	----	----	----	----
8	Fallow	8	7	6	5	----	----	2.35	1.62	39.10	23.34	23.90	16.55
3	Corn annually	8	8	6	5	----	----	1.70	1.53	28.29	22.05	19.48	10.91
4	Grain annually	8	8	6	6	----	----	1.63	1.17	27.12	16.86	.89	1.61
5, 6, 7	Corn in rotation	8	6	6	4	----	----	1.09	1.03	18.14	14.84	11.72	5.70
5, 6, 7	Barley in rotation	8	7	6	6	----	----	1.31	1.00	21.80	14.41	.26	2.08
5, 6, 7	Clover-timothy hay in rotation	8	8	6	3	----	----	.22	.14	3.66	2.02	.02	.02
Low-factor rains:													
10	Blue grass, unclipped	82	0	48	0	14.13	10.56	----	----	----	----	----	----
8	Fallow	82	12	48	6	----	----	1.46	.56	10.33	5.30	20.61	7.11
3	Corn annually	82	14	48	6	----	----	1.73	.49	12.24	4.64	9.86	2.60
4	Grain annually	82	16	48	7	----	----	.86	.34	6.09	3.31	5.71	2.59
5, 6, 7	Corn in rotation	82	9	48	4	----	----	.99	.29	7.01	2.75	1.87	.83
5, 6, 7	Barley in rotation	82	11	48	5	----	----	.30	.21	2.12	1.99	7.57	2.96
5, 6, 7	Clover-timothy hay in rotation	82	4	48	2	----	----	.05	.05	.35	.47	.03	.08

[1] Runoff—storms are divided into 3 groups by use of the runoff factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 5 to 11, and the low group includes storms with factors of less than 5. Erosion—storms are divided into 3 groups by use of the erosion factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 7 to 11, and the low group includes storms with factors of less than 7.

[2] Data are for the period, Apr. 16 to Oct. 31, only.

[3] Year of highest soil loss for period covered by this table.

TABLE 22.—*Rainfall and soil and water losses from severely eroded and moderately eroded control plots by classified groups of rains,[1] 1940–43[2]*

Rainfall group, degree of erosion, and crop	Rains				Amount of rainfall		Water loss				Soil loss per acre	
	1941[3]		Average		1941	Average	Amount		Percent of rainfall		1941	Average
	Total	Causing runoff	Total	Causing runoff	Total	Total	1941	Average	1941	Average		
	Number	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
Annual:												
Severely eroded, corn	75	15	74	9	32.76	26.04	5.56	2.43	16.97	9.33	36.01	15.70
Moderately eroded, corn	75	12	74	8	32.76	26.04	4.28	1.86	13.06	7.14	35.12	14.27
Severely eroded, spring grain	75	26	74	18	32.76	26.04	11.59	5.47	35.38	21.01	73.19	29.95
Moderately eroded, spring grain	75	21	74	15	32.76	26.04	6.07	3.02	18.53	11.60	43.92	16.24
Severely eroded, hay	75	11	74	11	32.76	26.04	1.72	1.37	5.25	5.26	.85	.57
Moderately eroded, hay	75	10	74	7	32.76	26.04	1.28	.61	3.91	2.34	.61	.20
High-factor rains:												
Severely eroded, corn	7	7	4	4	15.10	8.58	4.90	2.04	32.45	23.78	34.98	14.94
Moderately eroded, corn	7	7	4	4	15.10	8.58	3.93	1.65	26.03	19.35	34.40	13.44
Severely eroded, spring grain	7	7	4	4	15.10	8.58	7.85	3.49	51.99	40.68	60.14	22.21
Moderately eroded, spring grain	7	7	4	4	15.10	8.58	4.53	2.12	30.00	24.71	41.57	11.87
Severely eroded, hay	7	7	4	4	15.10	8.58	1.58	1.11	10.46	12.94	.83	.50
Moderately eroded, hay	7	7	4	4	15.10	8.58	1.22	.56	8.08	6.53	.60	.19
Moderate-factor rains:												
Severely eroded, corn	9	6	7	4	6.05	5.10	.62	.38	10.25	7.45	.39	.35
Moderately eroded, corn	9	4	7	3	6.05	5.10	.33	.19	5.45	3.73	.34	.13
Severely eroded, spring grain	9	9	7	6	6.05	5.10	2.09	1.34	34.55	26.27	8.19	3.57
Moderately eroded, spring grain	9	7	7	6	6.05	5.10	.77	.59	12.73	11.57	1.23	2.88
Severely eroded, hay	9	3	7	4	6.05	5.10	.12	.21	1.98	4.12	--------	.04
Moderately eroded, hay	9	2	7	2	6.05	5.10	.05	.04	.83	.78	--------	.01
Low-factor rains:												
Severely eroded, corn	59	2	63	1	11.61	12.36	.04	.01	.34	.08	.70	.41
Moderately eroded, corn	59	1	63	1	11.61	12.36	.02	.02	.17	.16	.38	.70
Severely eroded, spring grain	59	10	63	8	11.61	12.36	1.65	.64	14.21	5.18	4.86	4.17
Moderately eroded, spring grain	59	7	63	5	11.61	12.36	.77	.31	6.63	2.51	1.12	1.49
Severely eroded, hay	59	1	63	3	11.61	12.36	.02	.05	.17	.41	.02	.03
Moderately eroded, hay	59	1	63	1	11.61	12.36	.01	.01	.09	.08	.01	--------

[1] Runoff—storms are divided into 3 groups by use of the runoff factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 5 to 11, and the low group includes storms with factors of less than 5. Erosion—storms are divided into 3 groups by use of the erosion factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 7 to 11, and the low group includes storms with factors of less than 7.

[2] Data are for the period, Apr. 16 to Oct. 31, only.

[3] Year of highest soil loss for period covered by this table.

TABLE 23.—*Rainfall and soil and water losses from control plots of various lengths, by classified groups of rains,*[1] *1933–38*[2]

[Corn grown annually]

Rainfall group and plot No.	Length of slope	Rains: 1938[3]: Total	Rains: 1938[3]: Causing runoff	Rains: Average: Total	Rains: Average: Causing runoff	Amount of rainfall: 1938: Total	Amount of rainfall: Average: Total	Water loss: Amount: 1938	Water loss: Amount: Average	Water loss: Percent of rainfall: 1938	Water loss: Percent of rainfall: Average	Soil loss per acre: 1938	Soil loss per acre: Average
		Number	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
Annual:													
1	36.3 feet	98	31	59	16	35.09	25.50	14.26	6.46	40.64	25.33	106.82	64.59
3	72.6 feet	98	30	59	16			13.37	6.43	38.10	25.22	155.22	99.38
2	145.2 feet	98	31	59	16			14.42	6.36	41.09	24.94	205.15	123.58
High-factor rains:													
1	36.3 feet	8	8	5	5	14.95	8.00	9.75	4.29	65.22	53.63	80.11	54.84
3	72.6 feet	8	8	5	5			9.94	4.41	66.49	55.13	125.88	85.87
2	145.2 feet	8	8	5	5			9.81	4.18	65.62	52.25	155.71	106.26
Moderate-factor rains:													
1	36.3 feet	8	8	6	5	6.01	6.94	2.46	1.64	40.93	23.63	17.42	7.69
3	72.6 feet	8	8	6	5			1.70	1.53	28.29	22.05	19.48	10.91
2	145.2 feet	8	8	6	5			2.68	1.61	44.59	23.20	21.78	11.04
Low-factor rains:													
1	36.3 feet	82	15	48	6	14.13	10.56	2.05	.53	14.51	5.02	9.29	2.06
3	72.6 feet	82	14	48	6			1.73	.49	12.24	4.64	9.86	2.60
2	145.2 feet	82	15	48	6			1.93	.57	13.66	5.40	27.66	6.28

[1] Runoff—storms are divided into 3 groups by use of the runoff factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 5 to 11, and the low group includes storms with factors of less than 5. Erosion—storms are divided into 3 groups by use of the erosion factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 7 to 11, and the low group includes storms with factors of less than 7.

[2] Data are for the period, Apr. 16 to Oct. 31, only.

[3] Year of highest soil loss for period covered by this table.

TABLE 24.—*Rainfall and soil and water losses from surface-soil and subsoil control plots planted to corn, by classified groups of rains,*[1] *1933–38*[2]

Rainfall group and plot No.	Crop and surface	Rains: 1938[3] Total	Rains: 1938[3] Causing runoff	Rains: Average Total	Rains: Average Causing runoff	Amount of rainfall: 1938 Total	Amount of rainfall: Average Total	Water loss: Amount 1938	Water loss: Amount Average	Water loss: Percent of rainfall 1938	Water loss: Percent of rainfall Average	Soil loss per acre: 1938	Soil loss per acre: Average
		Number	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
Annual:													
3	Corn annually—surface soil	98	30	59	16	35.09	25.50	13.37	6.43	38.10	25.22	155.22	99.38
11	Corn annually—subsoil	98	31	59	16			14.45	7.07	41.18	27.72	185.48	116.69
High-factor rains:													
3	Corn annually—surface soil	8	8	5	5	14.95	8.00	9.94	4.41	66.49	55.12	125.88	85.87
11	Corn annually—subsoil	8	8	5	5			10.42	4.56	69.70	57.00	153.36	96.60
Moderate-factor rains:													
3	Corn annually—surface soil	8	8	6	5	6.01	6.94	1.70	1.53	28.29	22.05	19.48	10.91
11	Corn annually—subsoil	8	8	6	5			2.15	1.84	35.77	26.51	17.90	14.17
Low-factor rains:													
3	Corn annually—surface soil	82	14	48	6	14.13	10.56	1.73	.49	12.24	4.64	9.86	2.60
11	Corn annually—subsoil	82	15	48	6			1.88	.67	13.30	6.34	14.22	5.92

[1] Runoff—storms are divided into 3 groups by use of the runoff factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 5 to 11, and the low group includes storms with factors of less than 5. Erosion—storms are divided into 3 groups by use of the erosion factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 7 to 11, and the low group includes storms with factors of less than 7.

[2] Data are for the period, Apr. 16 to Oct. 31, only.

[3] Year of highest soil loss for period covered by this table.

TABLE 25.—*Rainfall and soil and water losses from a fallow plot which received barnyard manure and a fallow plot without manure, by classified groups of rains,*[1] *1933–38*[2]

Rainfall group and plot No.	Organic matter treatment	Rains				Amount of rainfall		Water loss				Soil loss per acre	
		1938[3]		Average		1938	Average	Amount		Percent of rainfall		1938	Average
		Total	Causing runoff	Total	Causing runoff	Total	Total	1938	Average	1938	Average		
		Number	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
Annual:													
8	Fallow	98	27	59	15	35.09	25.50	12.72	6.47	36.25	25.38	310.43	177.82
9	Fallow plus 5 tons manure	98	26	59	15			12.02	6.32	34.25	24.78	243.64	149.83
High-factor rains:													
8	Fallow	9	8	5	4	14.95	8.00	8.91	4.29	59.60	53.63	265.92	154.16
9	Fallow plus 5 tons manure	9	8	5	4			8.43	4.31	56.39	53.88	207.91	128.94
Moderate-factor rains:													
8	Fallow	8	7	6	5	6.01	6.94	2.35	1.62	39.10	23.34	23.90	16.55
9	Fallow plus 5 tons manure	8	6	6	5			2.06	1.51	34.28	21.76	23.80	16.65
Low-factor rains:													
8	Fallow	81	12	48	6	14.13	10.56	1.46	.56	10.33	5.30	20.61	7.11
9	Fallow plus 5 tons manure	81	12	48	6			1.53	.50	10.83	4.73	11.93	4.24

[1] Runoff—storms are divided into 3 groups by use of the runoff factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 5 to 11, and the low group includes storms with factors of less than 5.
Erosion—storms are divided into 3 groups by use of the erosion factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 7 to 11, and the low group includes storms with factors of less than 7.

[2] Data are for the period, Apr. 16 to Oct. 31, only.

[3] Year of highest soil loss for period covered by this table.

TABLE 26.—*Rainfall and soil and water losses and crop yields from various organic-matter treatments on severely eroded soil, by classified groups of rains,*[1] *1941–43*[2]

Rainfall group and treatment[3]	Plot No.	Rains						Amount of rainfall			Water loss						Soil loss per acre			Yield per acre	
		Hay 1941[4]		Corn 1942		Spring-grain 1943					Amount			Percent of rainfall							
		Total	Causing runoff	Total	Causing runoff	Total	Causing runoff	Hay 1941	Corn 1942	Spring grain 1943	Hay 1941	Corn 1942	Spring grain 1943	Hay 1941	Corn 1942	Spring grain 1943	Hay 1941	Corn 1942	Spring grain 1943	Corn 1942	Spring grain 1943
		No.	*No.*	*No.*	*No.*	*No.*	*No.*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Percent*	*Tons*	*Tons*	*Tons*	*Bushels*	*Bushels*
Annual:[4]																					
No treatment—fall plowed	1	34	5	80	22	67	7	16.86	31.03	18.36	0.92	6.45	0.64	5.46	20.79	3.48	0.39	72.06	2.27	65.7	29.6
	9	34	5	80	22	67	8	------	------	------	1.29	8.02	.92	7.65	25.84	5.01	.23	88.15	4.26	66.5	26.5
8 tons per acre barnyard manure plowed under in fall preceding corn	2	34	5	80	20	67	6	------	------	------	1.16	6.00	.40	6.88	19.34	2.18	.34	56.83	.41	75.7	38.9
	6	34	5	80	18	67	8	------	------	------	.80	5.94	1.13	4.74	19.14	6.15	.23	70.52	1.75	74.5	28.0
Green manure plowed under in fall preceding corn	3	34	6	80	18	67	8	------	------	------	1.80	4.96	.74	10.68	15.98	4.03	.27	40.87	1.22	70.2	27.3
	5	34	3	80	23	67	9	------	------	------	.66	6.33	1.14	3.91	20.40	6.21	.09	66.37	3.03	69.1	28.0
8 tons per acre barnyard manure disked into fall-plowed land immediately preceding corn planting	4	34	6	80	21	67	9	------	------	------	1.00	6.31	1.09	5.93	20.34	5.94	.19	68.49	3.52	70.1	34.0
	10	34	6	80	22	67	10	------	------	------	1.08	6.43	1.14	6.40	20.72	6.21	.27	62.39	6.14	74.3	28.9
Green manure plowed under in fall preceding corn; 8 tons per acre barnyard manure disked into fall-plowed land immediately preceding corn planting	8	34	5	80	12	67	5	------	------	------	1.62	4.81	.26	9.61	15.50	1.42	.09	31.04	.14	65.1	27.6
	11	34	4	80	21	67	6	------	------	------	.43	6.46	.55	2.55	20.82	3.00	.07	84.56	2.99	79.1	21.2
Green manure worked with sweeps in fall preceding corn; cultivated with sweeps	7	34	6	80	17	67	6	------	------	------	1.01	5.84	.64	5.99	18.82	3.48	.19	32.29	1.18	53.8	21.6
	12	34	3	80	14	67	4	------	------	------	.59	2.63	.16	3.50	8.48	.87	.55	8.16	.20	53.6	14.7
High-rain factor:																					
No treatment—fall plowed	1	3	3	6	6	1	1	7.36	10.43	1.21	.88	4.31	.17	11.96	41.32	14.05	.34	53.67	.12	------	------
	9	3	2	6	6	1	1	------	------	------	1.22	5.35	.17	16.58	51.29	14.05	.19	57.92	.24	------	------
8 tons per acre barnyard manure plowed under in fall preceding corn	2	3	3	6	5	1	1	------	------	------	1.10	4.45	.11	14.94	42.66	9.09	.30	43.93	.06	------	------
	6	3	2	6	6	1	1	------	------	------	.76	4.27	.17	10.33	40.94	14.05	.20	54.89	.13	------	------
Green manure plowed under in fall preceding corn	3	3	3	6	6	1	1	------	------	------	1.73	3.51	.17	23.50	33.65	14.05	.24	29.37	.15	------	------
	5	3	2	6	6	1	1	------	------	------	.63	4.51	.20	8.56	43.24	16.53	.06	50.44	.20	------	------
8 tons per acre barnyard manure disked into fall-plowed land immediately preceding corn planting	4	3	3	6	6	1	1	------	------	------	.92	4.33	.25	12.50	41.51	20.66	.15	48.32	.29	------	------
	10	3	3	6	6	1	1	------	------	------	1.01	4.58	.20	13.72	43.91	16.53	.23	45.28	.40	------	------

Green manure plowed under in fall preceding corn; 8 tons per acre barnyard manure disked into fall-plowed land immediately preceding corn planting	8	3	3	6	6	1	1	------	------	------	1.58	3.31	.09	21.47	31.74	7.44	.08	21.03	.03	------	------
	11	3	2	6	6	1	1	------	------	------	.39	4.15	.10	5.30	39.79	8.26	.05	53.13	.06	------	------
Green manure worked with sweeps in fall preceding corn; cultivated with sweeps	7	3	3	6	5	1	1	------	------	------	.85	3.67	.18	11.55	35.19	14.88	.10	22.73	.09	------	------
	12	3	2	6	4	1	1	------	------	------	.56	1.76	.05	7.61	16.87	4.13	.54	5.86	.01	------	------
Moderate-rain factor:																					
No treatment, fall plowed	1	6	2	9	8	6	5	5.04	7.85	4.90	.04	1.38	.46	.79	17.58	9.39	.05	8.40	2.15	------	------
	9	6	3	9	8	6	5	------	------	------	.07	1.79	.70	1.39	22.80	14.28	.04	16.57	4.02	------	------
8 tons per acre barnyard manure plowed under in fall preceding corn	2	6	2	9	7	6	5	------	------	------	.06	.86	.29	1.19	10.96	5.12	.04	4.38	.35	------	------
	6	6	3	9	5	6	5	------	------	------	.04	.90	.92	.79	11.46	18.78	.03	4.71	1.62	------	------
Green manure plowed under in fall preceding corn	3	6	3	9	7	6	5	------	------	------	.07	.84	.54	1.39	10.70	11.02	.03	3.92	1.07	------	------
	5	6	1	9	9	6	5	------	------	------	.03	1.02	.87	.60	12.99	17.76	.03	5.88	2.83	------	------
8 tons per acre barnyard manure disked into fall-plowed land immediately preceding corn planting	4	6	3	9	8	6	5	------	------	------	.08	1.19	.77	1.59	15.16	13.71	.04	10.81	3.32	------	------
	10	6	3	9	8	6	5	------	------	------	.07	1.12	.87	1.39	14.27	17.76	.04	8.81	5.72	------	------
Green manure plowed under in fall preceding corn; 8 tons per acre barnyard manure disked into fall-plowed land immediately preceding corn planting	8	6	2	9	3	6	4	------	------	------	.04	.94	.17	.79	11.97	3.47	.01	3.85	.11	------	------
	11	6	2	9	6	6	5	------	------	------	.04	1.44	.45	.79	18.34	9.18	.02	22.03	2.93	------	------
Green manure worked with sweeps in fall preceding corn; cultivated with sweeps	7	6	3	9	6	6	5	------	------	------	.16	1.55	.46	3.17	19.74	9.39	.09	3.04	1.09	------	------
	12	6	1	9	5	6	3	------	------	------	.03	.52	.11	.60	6.62	2.24	.01	.76	.19	------	------
Low-rain factor:																					
No treatment—fall plowed	1	25	------	65	8	60	1	4.46	12.75	12.25	------	.76	.01	------	5.96	.08	------	9.99		------	------
	9	25	------	65	8	60	2	------	------	------	------	.88	.05	------	6.90	.41	------	13.66	------	------	------
8 tons per acre barnyard manure plowed under in fall preceding corn	2	25	------	65	8	60	------	------	------	------	------	.69	------	------	5.41	------	------	8.52	------	------	------
	6	25	------	65	7	60	2	------	------	------	------	.77	.04	------	6.04	.35	------	10.92	------	------	------
Green manure plowed under in fall preceding corn	3	25	------	65	5	60	2	------	------	------	------	.61	.03	------	4.78	.24	------	7.58	------	------	------
	5	25	------	65	8	60	3	------	------	------	------	.80	.07	------	6.27	.57	------	10.65	------	------	------
8 tons per acre barnyard manure disked into fall-plowed land immediately preceding corn planting	4	25	------	65	7	60	3	------	------	------	------	.79	.07	------	6.20	.57	------	9.56	------	------	------
	10	25	------	65	8	60	4	------	------	------		.73	.07	------	5.72	.57	------	8.30	.02	------	------
Green manure plowed under in fall preceding corn; 8 tons per acre barnyard manure disked into fall-plowed land immediately preceding corn planting	8	25	------	65	3	60	------	------	------	------	------	.56	------	------	4.30	------	------	6.16	------	------	------
	11	25	------	65	9	60	------	------	------	------	------	.87	------	------	6.82	------	------	9.40	------	------	------

TABLE 26.—*Rainfall and soil and water losses and crop yields from various organic-matter treatments on severely eroded soil, by classified groups of rains,[1] 1941-43[2]*—Continued

Rainfall group and treatment[3]	Plot No.	Rains: Hay 1940[4] Total	Rains: Hay 1940[4] Causing runoff	Rains: Corn 1942 Total	Rains: Corn 1942 Causing runoff	Rains: Spring-grain 1943 Total	Rains: Spring-grain 1943 Causing runoff	Amount of rainfall: Hay 1941	Amount of rainfall: Corn 1942	Amount of rainfall: Spring grain 1943	Water loss amount: Hay 1941	Water loss amount: Corn 1942	Water loss amount: Spring grain 1943	Water loss percent of rainfall: Hay 1941	Water loss percent of rainfall: Corn 1942	Water loss percent of rainfall: Spring grain 1943	Soil loss per acre: Hay 1941	Soil loss per acre: Corn 1942	Soil loss per acre: Spring grain 1943	Yield per acre: Corn 1942	Yield per acre: Spring grain 1943
		No.	*No.*	*No.*	*No.*	*No.*	*No.*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Percent*	*Tons*	*Tons*	*Tons*	*Bushels*	*Bushels*
Green manure worked with sweeps in fall preceding corn; cultivated with sweeps	7	25	-----	65	6	60	-----	-----	-----	-----	-----	.62	-----	-----	4.86	-----	-----	6.52	-----	-----	-----
	12	25	-----	65	5	60	-----	-----	-----	-----	-----	.35	-----	-----	2.74	-----	-----	1.54	-----	-----	-----

[1] High-rain factor group includes all rains with a rain factor of 10 or more; moderate-rain factor group includes all rains with a rain factor of 5 and less than 10; low-rain factor group includes all rains with a rain factor of less than 5.

[2] Data are for the period, Apr. 16 to Oct. 31, only.

[3] Green manure consisted of the growth of hay produced after the first crop of hay was removed from plots 3, 5, 7, 8, 11, and 12. On Oct. 28, 1941, when all plots were plowed with the exception of plots 7 and 12, which were worked with sweeps, plots 3, 5, 7, 8, 11, and 12 had an average of 1.36 tons per acre of dry organic residue on the surface as compared with 0.76 tons per acre on plots 1, 2, 4, 6, 9, and 10. All plots were plowed in the fall of 1942, for grain, except 7 and 12, which were worked with the sweeps. In the spring of 1943, all plots were fertilized before grain planting and legume seeding with commercial fertilizer to a uniform fertility level.

[4] For 1941, Aug. 3 to Oct. 31, only. The second cut of hay was removed from plots 1, 2, 4, 6, 9, and 10 on Aug. 2.

TABLE 27.—*Rainfall and soil and water losses from plots with two lengths of slope located on various percents of slope, planted to spring grain, by classified groups of rains,[1] 1939-43[2]*

3-PERCENT SLOPE

Rainfall group and plot No.	Length of slope	Rains: 1941[3] Total	Rains: 1941[3] Causing runoff	Rains: Average Total	Rains: Average Causing runoff	Amount of rainfall: 1941	Amount of rainfall: Average	Water loss amount: 1941	Water loss amount: Average	Water loss percent of rainfall: 1941	Water loss percent of rainfall: Average	Soil loss per acre: 1941	Soil loss per acre: Average
	Feet	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
Annual:[3]													
3-S-1	36.3	75	21	71	12	32.76	24.60	7.17	2.98	21.89	12.11	15.13	3.87
3-S-2	36.3	75	17	71	10			5.70	2.46	17.40	10.00	9.81	2.58
3-S-3	36.3	75	20	71	13			8.09	3.28	24.69	13.33	14.10	3.78
Average	-----	75	19	71	12	-----	-----	6.99	2.91	21.34	11.83	13.02	3.41

3-L-1	72.6	75	21	71	12			8.07	3.29	24.63	13.37	22.10	5.10
3-L-2	72.6	75	22	71	13			9.12	3.48	27.84	14.15	22.77	5.35
3-L-3	72.6	75	22	71	12			8.75	3.48	26.71	14.15	20.74	4.84
Average		75	22	71	12			8.65	3.42	26.40	13.90	21.87	5.11
High-factor rains:													
3-S-1	36.3	7	7	4	3	13.67	6.95	5.14	2.04	37.60	20.35	14.71	3.39
3-S-2	36.3	7	6	4	3			4.51	1.80	32.99	25.90	9.60	2.22
3-S-3	36.3	7	7	4	3			5.62	2.20	41.11	31.65	13.50	3.22
Average		7	7	4	3			5.09	2.01	37.23	28.92	12.61	2.94
3-L-1	72.6	7	7	4	4			5.17	2.11	37.82	30.36	20.46	4.37
3-L-2	72.6	7	7	4	4			6.03	2.23	44.11	32.09	20.65	4.42
3-L-3	72.6	7	7	4	4			5.77	2.28	42.21	32.80	19.07	4.11
Average		7	7	4	4			5.66	2.21	41.40	31.80	20.06	4.30
Moderate-factor rains:													
3-S-1	36.3	9	7	7	5	7.75	6.21	1.05	0.69	13.55	11.11	.13	.32
3-S-2	36.3	9	6	7	4			.72	.53	9.20	8.53	.06	.26
3-S-3	36.3	9	6	7	5			1.23	.78	15.87	12.56	.20	.37
Average		9	6	7	5			1.00	.67	12.90	10.79	.13	.32
3-L-1	72.6	9	7	7	5			1.39	.82	17.94	13.20	.68	.44
3-L-2	72.6	9	8	7	5			1.53	.83	19.74	13.36	.90	.52
3-L-3	72.6	9	8	7	5			1.42	.83	18.32	13.36	.69	.40
Average		9	8	7	5			1.45	.83	18.71	13.36	.76	.45
Low-factor rains:													
3-S-1	36.3	59	7	60	4	11.34	11.44	.98	.25	8.64	2.18	.29	.16
3-S-2	36.3	59	5	60	3			.47	.13	4.14	1.14	.15	.10
3-S-3	36.3	59	7	60	4			1.24	.30	10.93	2.62	.40	.19
Average		59	6	60	4			.90	.23	7.94	2.01	.28	.15
3-L-1	72.6	59	7	60	3			1.51	.36	13.32	3.15	0.96	.35
3-L-2	72.6	59	7	60	4			1.56	.42	13.76	3.67	1.22	.41
3-L-3	72.6	59	7	60	3			1.56	.37	13.76	3.23	.98	.33
Average		59	7	60	3			1.54	.38	13.58	3.32	1.05	.36

TABLE 27.—*Rainfall and soil and water losses from plots with two lengths of slope located on various percents of slope, planted to spring grain, by classified groups of rains,*[1] *1939–43*[2]—Continued

8-PERCENT SLOPE

Rainfall group and plot No.	Length of slope	Rains: 1941[3] Total	Rains: 1941[3] Causing runoff	Rains: Average Total	Rains: Average Causing runoff	Amount of rainfall: 1941	Amount of rainfall: Average	Water loss: Amount 1941	Water loss: Amount Average	Water loss: Percent of rainfall 1941	Water loss: Percent of rainfall Average	Soil loss per acre: 1941	Soil loss per acre: Average
	Feet	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
Annual:[4]													
S-S-1	36.3	75	22	71	14	32.76	24.60	6.62	3.36	20.21	13.66	40.86	10.34
S-S-2	36.3	75	22	71	13			5.86	2.91	17.89	11.83	40.37	9.86
S-S-3	36.3	75	21	71	13			6.05	3.19	18.47	12.97	39.40	9.72
Average		75	22	71	13			6.17	3.15	18.83	12.80	40.21	9.98
S-L-1	72.6	75	24	71	16			9.00	4.11	27.47	16.71	45.19	11.20
S-L-2	72.6	75	23	71	15			8.01	3.49	24.45	14.19	43.56	10.52
S-L-3	72.6	75	23	71	14			6.96	3.00	21.24	12.20	44.01	10.69
Average		75	23	71	15			8.00	3.53	24.42	14.35	44.25	10.80
High-factor rains:													
S-S-1	36.3	7	7	4	4	13.67	6.95	4.93	2.15	36.06	30.94	38.63	8.52
S-S-2	36.3	7	7	4	4			4.51	1.95	32.99	28.06	38.50	8.48
S-S-3	36.3	7	7	4	4			4.70	2.16	34.38	31.08	37.55	8.22
Average		7	7	4	4			4.71	2.09	34.46	30.07	38.22	8.41
S-L-1	72.6	7	7	4	4			6.21	2.58	45.43	37.12	40.07	8.97
S-L-2	72.6	7	7	4	4			5.65	2.18	41.33	31.37	39.18	8.57
S-L-3	72.6	7	7	4	4			5.08	1.94	37.16	27.91	40.52	8.77
Average		7	7	4	4			5.65	2.23	41.33	32.09	39.92	8.77
Moderate-factor rains:													
S-S-1	36.3	9	7	7	5	7.75	6.21	.98	.91	12.64	14.65	.80	1.08
S-S-2	36.3	9	7	7	5			.78	.75	10.06	12.08	.56	.82
S-S-3	36.3	9	6	7	5			.78	.79	10.06	12.72	.61	.84
Average		9	7	7	5			.84	.81	10.84	13.04	.66	.91
S-L-1	72.6	9	9	7	6			1.39	1.05	17.94	16.91	2.07	1.14
S-L-2	72.6	9	8	7	6			1.23	.91	15.87	14.65	2.02	1.08
S-L-3	72.6	9	8	7	5			1.02	.77	13.16	12.40	1.39	1.06
Average		9	8	7	6			1.22	.91	15.74	14.65	1.83	1.09

Low-factor rains:													
8-S-1	36.3	59	8	60	5	11.34	11.44	.71	.30	6.26	2.62	1.43	.74
8-S-2	36.3	59	8	60	4			.57	.21	5.03	1.84	1.31	.56
8-S-3	36.3	59	8	60	4			.57	.24	5.03	2.10	1.24	.66
Average		59	8	60	4			.62	.25	5.47	2.18	1.33	.66
8-L-1	72.6	59	8	60	6			1.40	.48	12.34	4.20	3.05	1.09
8-L-2	72.6	59	8	60	5			1.13	.40	9.96	3.50	2.36	.87
8-L-3	72.6	59	8	60	5			.86	.29	7.58	2.53	2.10	.86
Average		59	8	60	5			1.13	.39	9.96	3.41	2.50	.94
13-PERCENT SLOPE													
Annual:[3]													
13-S-1	36.3	75	24	71	17	32.76	24.60	9.36	5.17	28.57	21.02	65.68	18.30
13-S-2	36.3	75	24	71	17			9.37	5.25	28.60	21.34	69.78	20.47
13-S-3	36.3	75	24	71	16			10.61	5.62	32.39	22.84	64.18	17.65
Average		75	24	71	17			9.78	5.35	29.85	21.75	66.54	18.81
13-L-1	72.6	75	24	71	17			8.30	4.13	25.34	16.79	85.11	22.93
13-L-2	72.6	75	24	71	17			8.22	4.03	25.09	16.38	81.97	22.27
13-L-3	72.6	75	24	71	16			8.08	3.94	24.66	16.02	79.15	22.49
Average		75	24	71	17			8.20	4.03	25.03	16.38	82.08	22.56
High-factor rains:													
13-S-1	36.3	7	7	4	4	13.67	6.95	6.28	3.11	45.94	44.75	57.73	14.05
13-S-2	36.3	7	7	4	4			6.31	3.20	46.16	46.04	61.15	15.88
13-S-3	36.3	7	7	4	4			7.28	3.43	53.26	49.35	54.71	13.83
Average		7	7	4	4			6.62	3.25	48.43	46.76	57.86	14.59
13-L-1	72.6	7	7	4	4			5.84	2.62	42.72	37.70	76.41	17.85
13-L-2	72.6	7	7	4	4			5.67	2.43	41.48	34.96	73.77	17.20
13-L-3	72.6	7	7	4	4			5.72	2.49	41.84	35.83	70.71	16.88
Average		7	7	4	4			5.74	2.51	41.99	36.12	73.63	17.31
Moderate-factor rains:													
13-S-1	36.3	9	9	7	6	7.75	6.21	1.56	1.39	20.13	22.38	2.98	2.11
13-S-2	36.3	9	9	7	6			1.55	1.36	20.00	21.90	3.27	2.21
13-S-3	36.3	9	9	7	6			1.61	1.46	20.77	23.51	3.54	1.82
Average		9	9	7	6			1.58	1.40	20.39	22.54	3.26	2.05
13-L-1	72.6	9	9	7	6			1.27	1.06	16.39	17.07	3.50	3.06
13-L-2	72.6	9	9	7	6			1.31	1.09	16.90	17.55	3.23	2.99
13-L-3	72.6	9	9	7	6			1.21	1.00	15.61	16.10	3.42	3.54
Average		9	9	7	6			1.27	1.05	16.39	16.91	3.38	3.20

TABLE 27.—*Rainfall and soil and water losses from plots with two lengths of slope located on various percents of slope, planted to spring grain, by classified groups of rains,[1] 1939–43[2]*—Continued

Rainfall group and plot No.	Length of slope	Rains				Amount of rainfall		Water loss				Soil loss per acre	
		1941[3]		Average		1941	Average	Amount		Percent of rainfall		1941	Average
		Total	Causing runoff	Total	Causing runoff			1941	Average	1941	Average		
	Feet	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
Low-factor rains:													
13-S-1	36.3	59	8	60	7	11.34	11.44	1.52	.67	13.40	5.86	4.97	2.14
13-S-2	36.3	59	8	60	7			1.51	.69	13.32	6.03	5.36	2.38
13-S-3	36.3	59	8	60	6			1.72	.73	15.17	6.38	5.93	2.00
Average		59	8	60	7			1.58	.70	13.93	6.12	5.42	2.17
13-L-1	72.6	59	8	60	7			1.19	.45	10.49	3.93	5.20	2.02
13-L-2	72.6	59	8	60	7			1.24	.51	10.93	4.46	4.97	2.08
13-L-3	72.6	59	8	60	6			1.15	.45	10.14	3.93	5.02	2.07
Average		59	8	60	7			1.19	.47	10.49	4.11	5.07	2.05
18-PERCENT SLOPE													
Annual:[3]													
18-S-1	36.3	75	24	71	18	32.76	24.60	9.75	5.58	29.76	22.68	91.60	27.53
18-S-2	36.3	75	24	71	16			8.85	4.98	27.01	20.24	71.87	19.68
18-S-3	36.3	75	24	71	16			8.16	4.55	24.91	18.50	68.25	18.71
Average		75	24	71	17			8.92	5.04	27.23	20.49	77.24	21.97
18-L-1	72.6	75	24	71	17			9.38	5.04	28.63	20.49	90.43	30.33
18-L-2	72.6	75	24	71	17			8.83	4.75	26.95	19.31	82.90	27.97
18-L-3	72.6	75	24	71	16			8.67	4.69	26.46	19.06	82.04	27.63
Average		75	24	71	17			8.96	4.83	27.35	19.63	85.12	28.63

High-factor rains:													
18-S-1	36.3	7	7	4	4	13.67	6.95	6.42	3.19	46.96	45.90	79.85	19.96
18-S-2	36.3	7	7	4	4	------	------	6.04	3.02	44.18	43.45	64.72	15.32
18-S-3	36.3	7	7	4	4	------	------	5.45	2.74	39.87	39.42	61.14	14.62
Average	------	7	7	4	4	------	------	5.97	2.98	43.67	42.88	68.57	16.63
18-L-1	72.6	7	7	4	4	------	------	6.25	2.98	45.72	42.88	76.28	20.48
18-L-2	72.6	7	7	4	4	------	------	5.99	2.85	43.82	41.01	71.75	19.09
18-L-3	72.6	7	7	4	4	------	------	6.00	2.85	43.89	41.01	72.46	18.89
Average	------	7	7	4	4	------	------	6.08	2.89	44.48	41.58	73.48	19.48
Moderate-factor rains:													
18-S-1	36.3	9	8	7	7	7.75	6.21	1.68	1.68	21.68	27.05	5.03	4.61
18-S-2	36.3	9	8	7	6	------	------	1.45	1.42	18.71	22.87	2.73	2.45
18-S-3	36.3	9	8	7	6	------	------	1.36	1.29	17.55	20.77	2.89	1.94
Average	------	9	8	7	6	------	------	1.50	1.47	19.35	23.67	3.55	3.00
18-L-1	72.6	9	8	7	6	------	------	1.68	1.43	21.68	23.03	6.77	6.34
18-L-2	72.6	9	8	7	6	------	------	1.48	1.34	19.10	21.58	5.15	5.78
18-L-3	72.6	9	8	7	6	------	------	1.38	1.30	17.81	20.93	4.58	5.98
Average	------	9	8	7	6	------	------	1.51	1.35	19.48	21.74	5.50	6.03
Low-factor rains:													
18-S-1	36.3	59	9	60	7	11.34	11.44	1.65	.71	14.55	6.21	6.72	2.96
18-S-2	36.3	59	9	60	6	------	------	1.36	.54	11.99	4.72	4.42	1.91
18-S-3	36.3	59	9	60	6	------	------	1.35	.52	11.90	4.54	4.22	2.15
Average	------	59	9	60	6	------	------	1.45	.59	12.79	5.16	5.12	2.34
18-L-1	72.6	59	9	60	7	------	------	1.45	.63	12.79	5.51	7.43	3.51
18-L-2	72.6	59	9	60	7	------	------	1.36	.56	11.99	4.90	6.00	3.10
18-L-3	72.6	59	9	60	6	------	------	1.29	.58	11.38	5.07	5.00	2.76
Average	------	59	9	60	7	------	------	1.37	.59	12.08	5.16	6.14	3.12

[1]Runoff—storms are divided into 3 groups by use of the runoff factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 5 to 11, and the low group includes storms with factors of less than 5. Erosion—storms are divided into 3 groups by use of the erosion factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 7 to 11, and the low group includes storms with factors of less than 7.

[2]Data are for the period of Apr. 16 to Oct. 31, only.

[3]Year of highest soil loss for period covered by this table.

TABLE 28.—*Rainfall and soil and water losses from contoured and strip-cropped plots on the Hundt farm*[1]

[Total rainfall: 1941, 31.43 inches; 1942, 27.16 inches; 1943, 18.64 inches]

Crop and treatment and plot	Rains						Water loss						Soil loss per acre		
	1941		1942		1943		Amount			Percent of rainfall			1941	1942	1943
	Total	Causing runoff	Total	Causing runoff	Total	Causing runoff	1941	1942	1943	1941	1942	1943			
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Percent*	*Tons*	*Tons*	*Tons*
Corn—contour:															
A	75	15	70	10	68	3	2.20	1.59	0.26	7.00	5.89	1.43	8.71	3.28	0.97
B	75	13	70	10	68	2	1.73	1.41	.22	5.51	5.22	1.21	16.80	8.07	.43
Average	75	14	70	10	68	2	1.96	1.50	.24	6.24	5.56	1.32	12.76	5.68	.70
Corn—strip crop:[2]															
A	75	14	70	14	68	3	2.00	1.52	.12	6.36	5.63	.66	5.94	1.31	.07
B	75	12	70	16	68	3	1.62	1.59	.10	5.16	5.89	.55	9.38	3.64	.12
Average	75	13	70	15	68	3	1.81	1.56	.11	5.76	5.78	.60	7.66	2.48	.10
Barley—contour:															
A	75	18	70	21	68	3	2.60	2.66	.10	8.27	9.85	.55	.63	4.33	.03
B	75	20	70	15	68	5	3.41	1.85	.31	10.85	6.85	1.70	1.36	.90	.14
Average	75	19	70	18	68	4	3.00	2.25	.20	9.55	8.33	1.10	1.00	2.62	.08
Barley—strip crop:															
A	75	18	70	22	68	5	1.55	1.82	.15	4.93	6.74	.82	.26	.55	.03
B	75	20	70	10	68	4	3.46	1.26	.25	11.01	4.67	1.37	1.53	.29	.12
Average	75	19	70	16	68	4	2.50	1.54	.20	7.96	5.70	1.10	.90	.42	.08
1st-year hay—contour:[3]															
A	75	20	70	8	68	------	2.17	1.21	------	6.91	4.48	------	.39	.03	------
B	75	17	70	8	68	------	2.74	1.94	------	8.72	7.18	------	.30	.05	------
Average	75	18	70	8	68	------	2.46	1.58	------	7.83	5.85	------	.34	.04	------
1st-year hay—strip crop:[3]															
A	75	20	70	8	68	2	2.73	1.13	.02	8.69	4.18	.11	.65	.03	------
B	75	20	70	8	68	------	3.62	1.37	------	11.52	5.07	------	.54	.17	------
Average	75	20	70	8	68	1	3.18	1.25	.01	10.12	4.63	.05	.60	.10	------
2nd-year hay—contour:															
A	75	13	70	7	68	2	1.33	.55	.02	4.23	2.04	.11	.18	.01	------
B	75	20	70	3	68	1	2.26	.49	.01	7.19	1.81	.05	.30	.01	------
Average	75	16	70	5	68	2	1.80	.52	.02	5.73	1.92	.11	.24	.01	------
2nd-year hay—strip crop:															
A	75	14	70	8	68	------	1.81	.88	------	5.76	3.26	------	.27	.04	------
B	75	20	70	9	68	1	2.58	.99	.01	8.21	3.67	.05	.62	.10	------
Average	75	17	70	8	68	------	2.20	.94	------	7.00	3.48	------	.44	.07	------

[1] Data are for the period, Apr. 16 to Oct. 31.
[2] All plots planted to a 4-year rotation. Crop shown for strip cropping is the crop on the bottom strip.
[3] 1941—hay was actually fall-seeded grain, spring-seeded legume.
1942—hay was all first-year hay.

TABLE 29.—*Rainfall and runoff and soil loss from contoured,*[1,2] *terraced,*[3] *and strip-cropped*[4] *watersheds, 1933–43*[5]

Year	Rains on land—						Amount of rainfall on land	Water loss						Soil loss per acre on land—		
	Contoured		Terraced		Strip cropped			Amount			Percent of rainfall			Con-toured	Ter-raced	Strip cropped
	Total	Causing runoff	Total	Causing runoff	Total	Causing runoff		Con-toured	Ter-raced	Strip cropped	Con-toured	Ter-raced	Strip cropped			
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Percent*	*Tons*	*Tons*	*Tons*
1933	49	14	49	12	--------	--------	21.23	1.55	1.59	--------	7.30	7.49	--------	18.18	1.07	--------
1934	41	15	41	12	--------	--------	24.96	3.86	3.41	--------	15.46	13.66	--------	15.99	3.72	--------
1935	63	19	63	17	--------	--------	29.74	5.58	7.36	--------	18.76	24.75	--------	91.69	16.70	--------
1936	49	13	49	10	--------	--------	20.77	4.60	4.50	--------	22.15	21.66	--------	99.78	13.08	--------
Average 1933–36	50	15	50	13	--------	--------	24.18	3.90	4.22	--------	16.13	19.03	--------	56.41	8.64	--------
1937	52	13	52	13	52	3	21.20	2.96	2.65	.99	13.96	12.50	4.67	14.67	.19	2.39
1938	98	19	98	20	98	20	35.09	5.68	6.10	6.41	16.19	17.38	18.27	19.31	7.84	9.18
1939	55	2	55	3	55	1	18.87	1.10	2.73	.67	5.83	14.47	3.55	.21	.25	.35
1940	75	5	75	7	75	5	21.99	.86	1.94	.75	3.91	8.82	3.41	.22	--------	.49
1941	75	10	75	10	75	15	32.76	1.51	3.10	2.63	4.61	9.46	8.03	.36	.08	5.78
1942	80	5	80	9	80	13	31.03	1.30	2.12	1.70	4.19	6.83	5.48	.20	.05	.47
1943	67	--------	67	1	67	--------	18.36	--------	.01	--------	--------	.05	--------	--------	--------	--------
Average 1937–43[2]	72	8	72	9	72	8	25.61	1.92	2.66	1.88	7.49	10.39	7.34	5.00	1.20	2.66

[1]Contoured watershed: Area–2.24 acres; slope–15 percent; crops were grown as follows: 1933–spring grain; 1934–clover-timothy hay; 1935–corn; 1936–spring grain; 1937–clover-timothy hay (the lower one-third of watershed was so badly gullied that sod-hump dams were constructed); 1938–upper two-thirds, corn, lower one-third, hay; 1939–upper two-thirds, spring grain, lower one-third, hay; 1940–41–42–43–entire area in alfalfa-timothy hay.

[2]Filter strip added 1937.

[3]Terraced watershed A-4: Area–2.21 acres; slope–10 percent; crops were grown as follows: 1933–spring grain; 1934–clover-timothy hay; 1935–corn; 1936–spring grain; 1937–clover-timothy hay; 1938–corn; 1939–spring grain; 1940–41–42–43–alfalfa-timothy hay.

[4]Strip-cropped watershed: Area–2.70 acres; slope–17 percent; cropped to a 6-year rotation; crops were grown as follows on the bottom strip: 1937–alfalfa-timothy hay; 1938–alfalfa-timothy; 1939–corn; 1940–grain; 1941–42–43–alfalfa-timothy hay.

[5]Data are for the period, Apr. 16 to Oct. 31.

TABLE 30.—*Annual summary of rainfall, runoff, and soil loss, by winter period and growing season, on a cultivated watershed, a pastured watershed, and a cultivated terrace, 1934–38*

Watershed and year	Winter cover	Crop	Precipitation			Water loss			Soil loss per acre		
			Winter period	Growing season	Totals	Winter period	Growing season	Totals	Winter period	Growing season	Totals
			Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Tons*	*Tons*	*Tons*
Unterraced cultivated watershed:											
1934	Clover-timothy seeding	Hay	3.88	24.96	28.84	0.26	3.86	4.12	0.26	15.99	16.25
1935	Fall-plowed hay	Corn	13.71	29.74	43.45	.64	5.58	6.22	.22	91.69	91.91
1936	Fall-plowed corn stubble	Spring-grain	6.17	20.77	26.94	2.25	4.60	6.85	15.78	99.78	115.56
1937	Clover-timothy seeding	Hay	6.53	21.20	27.73	2.14	2.96	5.10	.14	14.67	14.81
1938	Upper two-thirds fall-plowed hay-lower one-third hay	Upper two-thirds corn-lower one-third hay	8.31	35.09	43.40	.65	5.68	6.33	.43	19.31	19.74
Average			7.72	26.35	34.07	1.19	4.54	5.72	3.37	48.29	51.65
Unterraced pasture watershed:											
1934	Grass	Pasture	3.88	24.96	28.84	.06	2.12	2.18	.02	1.63	1.65
1935	do	do	13.71	29.74	43.45	.01	1.30	1.31		.14	.14
1936	do	do	6.17	20.77	26.94	2.16	.93	3.09	.01	.15	.16
1937	do	do	6.53	21.20	27.73	.10	.66	.77		.03	.03
1938	do	do	8.31	35.09	43.40	.22	3.34	3.56		.11	.11
Average			7.72	26.35	34.07	.51	1.67	2.18	.01	.41	.42
Terrace A-5:											
1934	Clover-timothy seeding	Hay	3.88	24.96	28.84	.05	3.06	3.11	.02	2.13	2.15
1935	Fall-plowed hay	Corn	13.71	29.74	43.45	1.39	6.84	8.23	.46	14.00	14.46
1936	Fall-plowed corn stubble	Grain	6.17	20.77	26.94	4.26	4.64	8.90	1.56	12.22	13.78
1937	Clover-timothy seeding	Hay	6.53	21.20	27.73	1.92	2.47	4.39	.04	.39	.43
1938	Fall-plowed hay	Corn	8.31	35.09	43.40	.97	7.51	8.48	.21	8.71	8.92
Average			7.72	26.35	34.07	1.72	4.90	6.62	.46	7.49	7.95

TABLE 31—*Rainfall and runoff and soil loss from unterraced pastured watershed and pastured terrace by classified groups of rains,[1] 1933-37[2]*

Rainfall group,[1] watershed, or terrace No.	Size of area	Land slope	Rains				Amount of rainfall		Water loss				Soil loss per acre	
			1935[3]		Average		1935	Average	Amount		Percent of rainfall		1935	Average
			Total	Causing runoff	Total	Causing runoff			1935	Average	1935	Average		
	Acres	*Percent*	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
Annual:														
Unterraced pasture watershed	2.412	24	63	8	51	8	29.74	23.58	1.30	1.09	4.37	4.62	0.14	0.47
Pasture terrace E-3	1.011	19	63	12	51	9	29.74	23.58	3.04	2.12	10.22	8.99	.19	.30
High-factor rains:														
Unterraced pasture watershed	2.412	24	4	3	4	4	8.01	6.61	1.22	.89	15.23	13.46	.12	.40
Pasture terrace E-3	1.011	19	4	4	4	4	8.01	6.61	2.23	1.51	27.84	22.84	.14	.21
Moderate-factor rains:														
Unterraced pasture watershed	2.412	24	12	4	6	3	12.37	7.21	.08	.19	.65	2.64	.02	.06
Pasture terrace E-3	1.011	19	12	8	6	4	12.37	7.21	.81	.55	6.55	7.63	.04	.05
Low-factor rains:														
Unterraced pasture watershed	2.412	24	47	1	41	1	9.36	9.76	--------	.03	--------	.31	--------	.01
Pasture terrace E-3	1.011	19	47	0	41	1	9.36	9.76	--------	.06	--------	.61	.01	.04

[1]Runoff—storms are divided into 3 groups by use of the runoff factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 5 to 11, and the low group includes storms with factors of less than 5. Erosion—storms are divided into 3 groups by use of the erosion factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 7 to 11, and the low group includes storms with factors of less than 7.

[2]Data are for the period, April 16 to Oct. 31, only.

[3]Year of highest soil loss for period covered by this table.

TABLE 32.—*Rainfall and runoff and soil loss from small watersheds with various cover conditions by classified groups of rains,[1] 1935–41[2]*

Rainfall group and watershed	Size of area	Land slope	Rains: 1935[4] Total	Rains: 1935[4] Causing runoff	Rains: Average Total	Rains: Average Causing runoff	Amount of rainfall: 1935	Amount of rainfall: Average	Water loss: Amount 1935	Water loss: Amount Average	Water loss: Percent of rainfall 1935	Water loss: Percent of rainfall Average	Soil loss[3] per acre: 1935	Soil loss[3] per acre: Average
	Acres	*Percent*	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
Annual:														
Watershed A, pastured woodland[5]	2.67	17	63	6	67	3	29.74	25.77	1.06	0.30	3.56	1.16	0.79	0.14
Watershed B, protected woodland[5]	11.50	27	63	1	67	—	—	—	.02	—	.07	—	.01	—
Watershed G, cleared pasture[5]	5.85	26	63	6	67	2	—	—	.38	.09	1.28	.35	.30	.05
Unterraced pasture watershed	2.412	24	63	8	67	7	—	—	1.30	1.18	4.37	4.58	.14	.10
Unterraced cultivated watershed	2.245	15	63	19	67	11	—	—	5.58	3.03	18.76	11.76	91.69	32.28
High-factor rains:														
Watershed A, pastured woodland	2.67	17	4	4	5	3	8.01	8.60	1.01	.29	12.61	3.37	.78	.14
Watershed B, protected woodland	11.50	27	4	1	5	—	—	—	.02	—	.25	—	.01	—
Watershed G, cleared pasture	5.85	26	4	4	5	2	—	—	.34	.08	4.24	.93	.28	.05
Unterraced pasture watershed	2.412	24	4	4	5	5	—	—	1.22	1.10	15.23	12.79	.12	.10
Unterraced cultivated watershed	2.245	15	4	4	5	5	—	—	3.17	2.02	39.58	23.49	78.75	27.96
Moderate-factor rains:														
Watershed A, pastured woodland[5]	2.67	17	12	2	7	—	12.37	6.66	.05	.01	.40	.15	.01	—
Watershed B, protected woodland[5]	11.50	27	12	—	7	—	—	—	—	—	—	—	—	—
Watershed G, cleared pasture[5]	5.85	26	12	2	7	—	—	—	.04	.01	.32	.15	.02	—
Unterraced pasture watershed	2.412	24	12	4	7	—	—	—	.08	.07	.65	1.05	.02	—
Unterraced cultivated watershed	2.245	15	12	11	7	3	—	—	2.09	.79	16.90	11.86	11.35	3.44
Low-factor rains:														
Watershed A, pastured woodland	2.67	17	47	—	55	—	9.36	10.51	—	—	—	—	—	—
Watershed B, protected woodland	11.50	27	47	—	55	—	—	—	—	—	—	—	—	—
Watershed G, cleared pasture	5.85	26	47	—	55	—	—	—	—	—	—	—	—	—
Unterraced pasture watershed	2.412	24	47	—	55	—	—	—	—	—	—	—	—	—
Unterraced cultivated watershed	2.245	15	47	4	55	—	—	—	.32	.22	3.42	2.09	1.59	.88

[1] Runoff—storms are divided into 3 groups by use of the runoff factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 5 to 11, and the low group includes storms with factors of less than 5. Erosion—storms are divided into three groups by use of the erosion factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 7 to 11, and the low group includes storms with factors of less than 7.

[2] Data are for the period of Apr. 16 to Oct. 31, only.

[3] Soil loss measurements discontinued in 1938.

[4] Year of highest soil loss for period covered by this table.

[5] Data from watershed A, B, and G obtained by the Forest Service.

TABLE 33.—*Rainfall and runoff and soil loss from terraces of variable grade by classified groups of rains*[1] *for the 8-year period, 1933–40*[2]

Rainfall group, terrace No., and vertical interval	Size of area	Land slope	Rains: 1935[3]: Total	Rains: 1935[3]: Causing runoff	Rains: Average: Total	Rains: Average: Causing runoff	Amount of rainfall: 1935	Amount of rainfall: Average	Water loss: Amount: 1935	Water loss: Amount: Average	Water loss: Percent of rainfall: 1935	Water loss: Percent of rainfall: Average	Soil loss per acre: 1935	Soil loss per acre: Average
	Acres	*Percent*	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
Annual:														
A-4, 1 to 6 inches	2,206	10	63	17	60	10	29.74	24.24	7.36	3.79	24.75	15.64	16.70	5.35
A-5, 1 to 3 inches	1.885	12	63	17	60	13	29.74	24.24	6.84	3.81	23.00	15.72	14.00	4.85
A-6, level	1.632	13	63	17	60	11	29.74	24.24	3.67	2.42	12.34	9.98	3.60	1.42
High-factor rains:														
A-4, 1 to 6 inches	2,206	10	4	4	4	4	8.01	7.47	5.09	2.77	63.54	37.08	15.61	4.62
A-5, 1 to 3 inches	1.885	12	4	4	4	4	8.01	7.47	4.94	2.76	61.67	36.95	13.29	4.16
A-6, level	1.632	13	4	4	4	4	8.01	7.47	2.65	1.89	33.08	25.30	3.44	1.28
Moderate-factor rains:														
A-4, 1 to 6 inches	2.206	10	12	11	6	4	12.37	6.51	2.04	.81	16.49	12.44	.87	.57
A-5, 1 to 3 inches	1.885	12	12	11	6	5	12.37	6.51	1.73	.84	13.98	12.90	.56	.57
A-6, level	1,632	13	12	11	6	4	12.37	6.51	.94	.39	7.60	5.99	.13	.13
Low-factor rains:														
A-4, 1 to 6 inches	2.206	10	47	2	50	2	9.36	10.26	.23	.21	2.46	2.05	.22	.16
A-5, 1 to 3 inches	1,885	12	47	2	50	4	9.36	10.26	.17	.21	1.82	2.05	.15	.12
A-6, level	1,632	13	47	2	50	3	9.36	10.26	.08	.14	.85	1.36	.03	.01

[1] Runoff-storms are divided into 3 groups by use of the runoff factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 5 to 11, and the low group includes storms with factors of less than 5. Erosion-storms are divided into 3 groups by use of the erosion factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 7 to 11, and the low group includes storms with factors of less than 7.

[2] Data are for the period, Apr. 16 to Oct. 31, only.

[3] Year of highest soil loss for period covered by this table.

TABLE 34.—*Rainfall and runoff from terraces with the same variable grade but different vertical intervals on pasture land by classified groups of rains*[1] *for the 5-year period, 1938–42*[2]

Rainfall group, terrace No., and vertical interval	Size of area	Land slope	Rains				Amount of rainfall		Water loss			
			1941[3]		Average		1941	Average	Amount		Percent of rainfall	
			Total	Causing runoff	Total	Causing runoff			1941	Average	1941	Average
	Acres	*Percent*	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*
Annual:												
E–2, 7-foot	0.929	15	75	12	76	9	32.76	27.95	3.23	3.24	9.86	11.59
E–3, 9-foot	1.011	19	75	11	76	10	32.76	27.95	4.06	3.78	12.39	13.52
C–3, 7-foot	1.101	15	75	11	76	8	32.76	27.95	2.99	3.14	9.13	11.23
C–4, 9-foot	1.075	17	75	11	76	8	32.76	27.95	2.98	3.05	9.10	10.91
High-factor rains:												
E–2, 7-foot	.929	15	7	7	5	5	13.67	9.93	2.79	2.84	20.41	28.60
E–3, 9-foot	1.011	19	7	7	5	5	13.67	9.93	3.44	3.20	25.16	32.22
C–3, 7-foot	1.101	15	7	7	5	5	13.67	9.93	2.71	2.85	19.82	28.70
C–4, 9-foot	1.075	17	7	7	5	5	13.67	9.93	2.62	2.72	19.17	27.39
Moderate-factor rains:												
E–2, 7-foot	.929	15	9	3	7	2	7.75	6.43	.42	.31	5.42	4.82
E–3, 9-foot	1.011	19	9	3	7	3	7.75	6.43	.58	.44	7.48	6.84
C–3, 7-foot	1.101	15	9	3	7	2	7.75	6.43	.27	.22	3.48	3.42
C–4, 9-foot	1.075	17	9	3	7	2	7.75	6.43	.33	.28	4.26	4.35
Low-factor rains:												
E–2, 7-foot	.929	15	59	1	64	2	11.34	11.59	.02	.09	.18	.78
E–3, 9-foot	1.011	19	59	1	64	2	11.34	11.59	.04	.14	.35	1.21
C–3, 7-foot	1.101	15	59	1	64	1	11.34	11.59	.01	.07	.09	.60
C–4, 9-foot	1.075	17	59	1	64	1	11.34	11.59	.03	.05	.26	.43

[1] Runoff-storms are divided into 3 groups by use of the runoff factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 5 to 11, and the low group includes storms with factors of less than 5. Erosion-storms are divided into 3 groups by use of the erosion factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 7 to 11, and the low group includes storms with factors of less than 7.

[2] Data are for the period, Apr. 16 to Oct. 31, only.

[3] Year of highest soil loss for period covered by this table.

TABLE 35.—*Rainfall and runoff and soil loss from terraces with the same variable grade but different vertical intervals on cropland by classified groups of rains[1] for the 5-year period, 1933–37[2]*

Rainfall group, terrace No., and vertical interval	Size of area	Land slope	Rains				Amount of rainfall		Water loss				Soil loss per acre	
			1935[3]		Average		1935	Average	Amount		Percent of rainfall		1935	Average
			Total	Causing runoff	Total	Causing runoff			1935	Average	1935	Average		
	Acres	*Percent*	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
Annual:														
C–2, 5-foot	1.007	10	63	18	51	19	29.74	23.58	9.26	4.57	31.14	19.38	17.67	8.67
C–3, 7-foot	1.101	15	63	17	51	19	29.74	23.58	9.13	4.22	30.70	17.90	23.38	8.62
C–4, 9-foot	1.075	17	63	16	51	19	29.74	23.58	6.87	3.69	23.10	15.65	13.47	5.16
High-factor rains:														
C–2, 5-foot	1.007	10	4	4	4	4	8.01	6.61	5.87	2.85	73.28	43.12	15.09	7.65
C–3, 7-foot	1.101	15	4	4	4	4	8.01	6.61	6.27	2.84	78.28	42.96	21.09	7.70
C–4, 9-foot	1.075	17	4	4	4	4	8.01	6.61	4.61	2.27	57.55	34.34	11.55	4.33
Moderate-factor rains:														
C–2, 5-foot	1.007	10	12	11	7	7	12.37	7.21	3.10	1.41	25.06	19.56	2.39	.93
C–3, 7-foot	1.101	15	12	11	7	7	12.37	7.21	2.72	1.13	21.99	15.67	2.08	.82
C–4, 9-foot	1.075	17	12	10	7	7	12.37	7.21	2.00	1.15	16.17	15.95	1.78	.71
Low-factor rains:														
C–2, 5-foot	1.007	10	47	3	40	8	9.36	9.76	.29	.31	3.10	3.18	.19	.09
C–3, 7-foot	1.101	15	47	2	40	8	9.36	9.76	.14	.25	1.50	2.56	.21	.10
C–4, 9-foot	1.075	17	47	2	40	8	9.36	9.76	.26	.27	2.78	2.77	.14	.12

[1] Runoff–storms are divided into 3 groups by use of the runoff factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 5 to 11, and the low group includes storms with factors of less than 5. Erosion–storms are divided into 3 groups by use of the erosion factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 7 to 11, and the low group includes storms with factors of less than 7.

[2] Data are for the period, Apr. 16 to Oct. 31, only.

[3] Year of highest soil loss for period covered by this table.

TABLE 36.—*Rainfall and runoff and soil loss from terraces with the same variable grade but different vertical intervals on pasture land by classified groups of rains*[1] *for the 5-year period, 1933–37*[2]

Rainfall group, terrace No., and vertical interval	Size of area	Land slope	Rains: 1935[3] Total	Rains: 1935[3] Causing runoff	Rains: Average Total	Rains: Average Causing runoff	Amount of rainfall: 1935	Amount of rainfall: Average	Water loss: Amount 1935	Water loss: Amount Average	Water loss: Percent of rainfall 1935	Water loss: Percent of rainfall Average	Soil loss per acre: 1935	Soil loss per acre: Average
	Acres	*Percent*	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
Annual:[3]														
E–2, 7-foot	0.929	15	63	15	51	12	29.74	23.58	5.17	2.40	17.38	10.18	0.21	0.38
E–3, 9-foot	1.011	19	63	12	51	9	29.74	23.58	3.04	2.12	10.22	8.99	.19	.30
E–4, 11-foot	1.036	21	63	12	51	10	29.74	23.58	2.70	1.83	9.08	7.76	.34	.41
High-factor rains:														
E–2, 7-foot	.929	15	4	4	4	4	8.01	6.61	3.50	1.69	43.70	25.57	.18	.33
E–3, 9-foot	1.011	19	4	4	4	4	8.01	6.61	2.23	1.51	27.84	22.84	.14	.21
E–4, 11-foot	1.036	21	4	4	4	4	8.01	6.61	2.01	1.33	25.09	20.12	.31	.30
Moderate-factor rains:														
E–2, 7-foot	.929	15	12	10	7	5	12.37	7.21	1.64	.61	13.26	8.46	.03	.03
E–3, 9-foot	1.011	19	12	8	7	4	12.37	7.21	.81	.55	6.55	7.63	.04	.05
E–4, 11-foot	1.036	21	12	8	7	4	12.37	7.21	.69	.42	5.58	5.82	.03	.04
Low-factor rains:														
E–2, 7-foot	.929	15	47	1	40	3	9.36	9.76	.03	.10	.32	1.02	------	.02
E–3, 9-foot	1.011	19	47	0	40	1	9.36	9.76	------	.06	------	.61	.01	.09
E–4, 11-foot	1.036	21	47	0	40	2	9.36	9.76	------	.08	------	.82	------	.07

[1] Runoff-storms are divided into 3 groups by use of the runoff factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 5 to 11, and the low group includes storms with factors of less than 5. Erosion-storms are divided into 3 groups by use of the erosion factor as follows: The high group includes storms with factors of 11 or more, the moderate group includes storms with factors of from 7 to 11, and the low group includes storms with factors of less than 7.

[2] Data are for the period, Apr. 16 to Oct. 31, only.

[3] Year of highest soil loss for period covered by this table.

TABLE 37.—*Rainfall and soil and water losses from plots of various lengths with and without berm,*[1] *1935–38*[2]

CLOVER-TIMOTHY HAY IN ROTATION

[Rainfall amounts: 1938, 35.09 inches; average, 26.70 inches]

Plot length and treatment	Rains				Water loss				Soil loss per acre	
	1938[3]		Average		Amount		Percent of rainfall		1938	Average
	Total	Causing runoff	Total	Causing runoff	1938	Average	1938	Average		
	Number	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
72.6-foot plot:										
With berm	98	15	66	10	3.23	1.90	9.20	7.12	2.07	1.05
With berm	98	18	66	15	6.75	3.84	19.24	14.38	2.45	2.60
Without berm	98	13	66	9	2.70	2.48	7.69	9.29	1.77	1.27
Without berm	98	21	66	15	10.66	5.23	30.38	19.59	7.06	4.81
Average	98	17	66	12	5.83	3.36	16.61	12.58	3.34	2.43
36.3-foot plot:										
With berm	98	13	66	9	2.83	2.08	8.06	7.79	.78	.88
With berm	98	17	66	12	7.38	4.06	21.03	15.20	3.61	1.47
Without berm	98	13	66	11	4.06	2.55	11.57	9.55	1.82	.99
Without berm	98	17	66	14	4.69	3.31	13.36	12.40	1.37	1.64
Average	98	15	66	12	4.75	3.00	13.54	11.24	1.89	1.24
BARLEY IN ROTATION										
72.6-foot plot:										
With berm	98	19	66	16	5.37	5.36	15.30	20.07	35.98	28.90
With berm	98	25	66	18	11.96	7.94	34.08	29.74	40.15	35.07
Without berm	98	18	66	14	4.47	4.95	12.74	18.54	20.02	26.53
Without berm	98	27	66	19	9.29	7.20	26.47	26.97	35.22	36.59
Average	98	22	66	17	7.77	6.36	22.14	23.82	32.84	31.77
36.3-foot plot:										
With berm	98	17	66	15	4.90	4.93	13.96	18.46	7.29	16.35
With berm	98	24	66	18	11.89	7.86	33.88	29.44	19.75	19.85
Without berm	98	19	66	15	5.85	5.56	16.67	20.82	21.49	22.80
Without berm	98	24	66	18	10.69	7.38	30.46	27.64	30.16	23.28
Average	98	21	66	17	8.34	6.43	23.77	24.08	19.67	20.57

TABLE 37.—*Rainfall and soil and water losses from plots of various lengths with and without berm,*[1] *1935–38*[2]—Continued

CORN IN ROTATION

Plot length and treatment	Rains				Water loss				Soil loss per acre	
	1938[3]		Average		Amount		Percent of rainfall		1938	Average
	Total	Causing runoff	Total	Causing runoff	1938	Average	1938	Average		
	Number	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Percent*	*Percent*	*Tons*	*Tons*
72.6-foot plot:										
With berm	98	24	66	15	12.61	6.37	35.94	23.86	115.89	60.56
With berm	98	23	66	15	11.17	6.39	31.83	23.93	104.78	61.57
Without berm	98	22	66	15	12.88	6.62	36.70	24.79	132.73	66.62
Without berm	98	23	66	15	10.39	6.27	29.61	23.48	108.47	67.70
Average	98	23	66	15	11.77	6.41	33.54	24.01	115.47	64.11
36.3-foot plot:										
With berm	98	24	66	15	10.71	5.68	30.52	21.27	91.65	45.92
With berm	98	23	66	15	9.73	5.49	27.73	20.56	62.53	38.13
Without berm	98	24	66	16	12.02	6.62	34.25	24.79	97.75	55.55
Without berm	98	24	66	16	10.63	5.87	30.29	21.98	85.14	48.85
Average	98	24	66	16	10.77	5.91	30.69	22.13	84.27	47.11

[1] The berm was a terrace ridge constructed so that the crest of the ridge defined the upper plot boundary.
[2] Data are for the period, Apr. 16 to Oct. 31, only.
[3] Year of highest soil loss for the period covered by this table.

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INVESTIGATIONS IN EROSION CONTROL AND THE RECLAMATION OF ERODED LAND
HAYS, O E ; MCCALL, A G ; BELL, F G 2 OF 2

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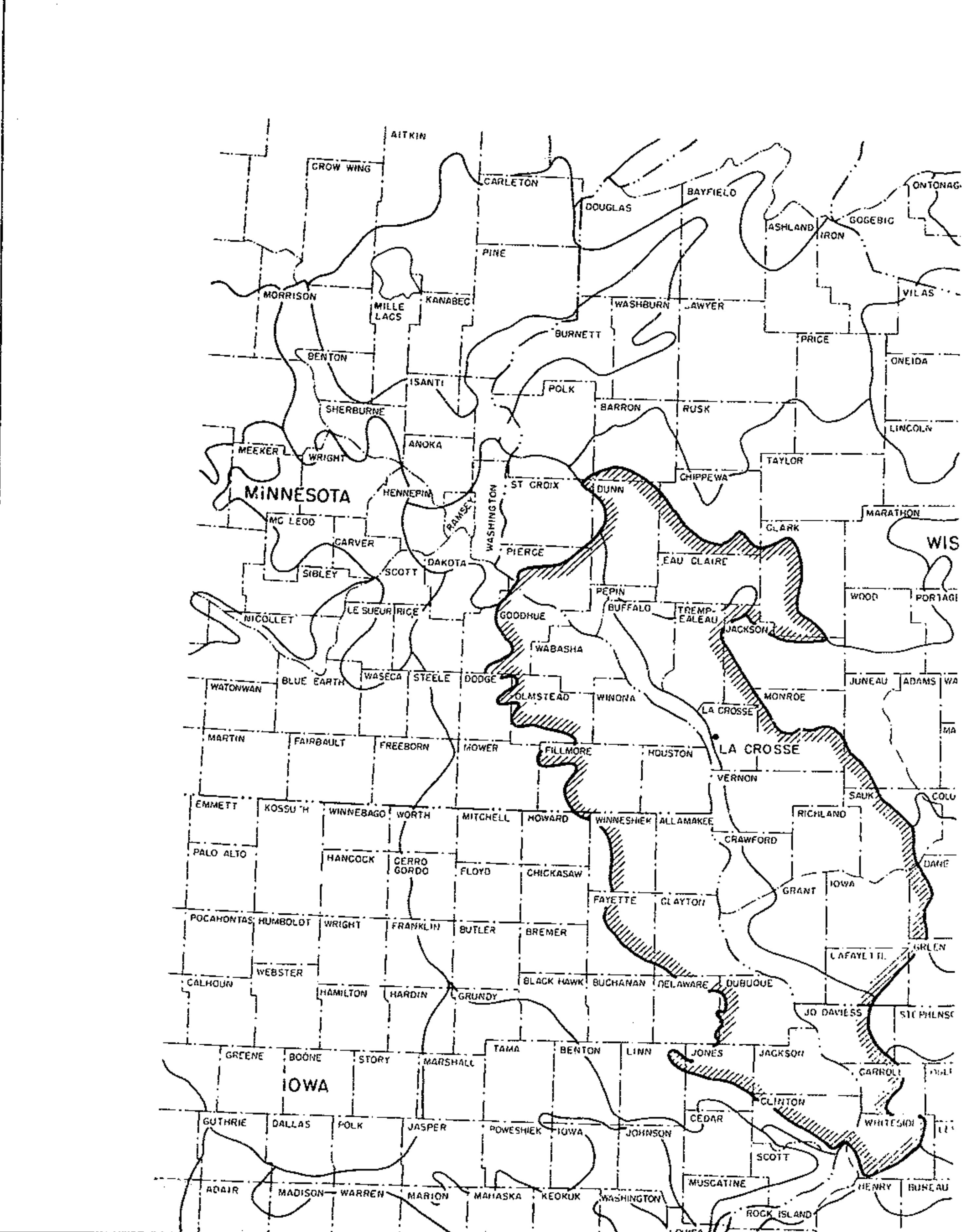

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WASHBURN
SAWYER
VILAS
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EAU CLAIRE
SIBLEY
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PEPIN
WOOD
PORTAGE
NICOLLET
LE SUEUR
RICE
GOODHUE
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TREMP-EALEAU
JACKSON
WABASHA
WATONWAN
BLUE EARTH
WASECA
STEELE
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MONROE
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FREEBORN
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VERNON
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KOSSUTH
WINNEBAGO
WORTH
MITCHELL
HOWARD
WINNESHIEK
ALLAMAKEE
RICHLAND
PALO ALTO
HANCOCK
CERRO GORDO
FLOYD
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BUCHANAN
DELAWARE
DUBUQUE
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BOONE
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CLINTON
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POLK
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CEDAR
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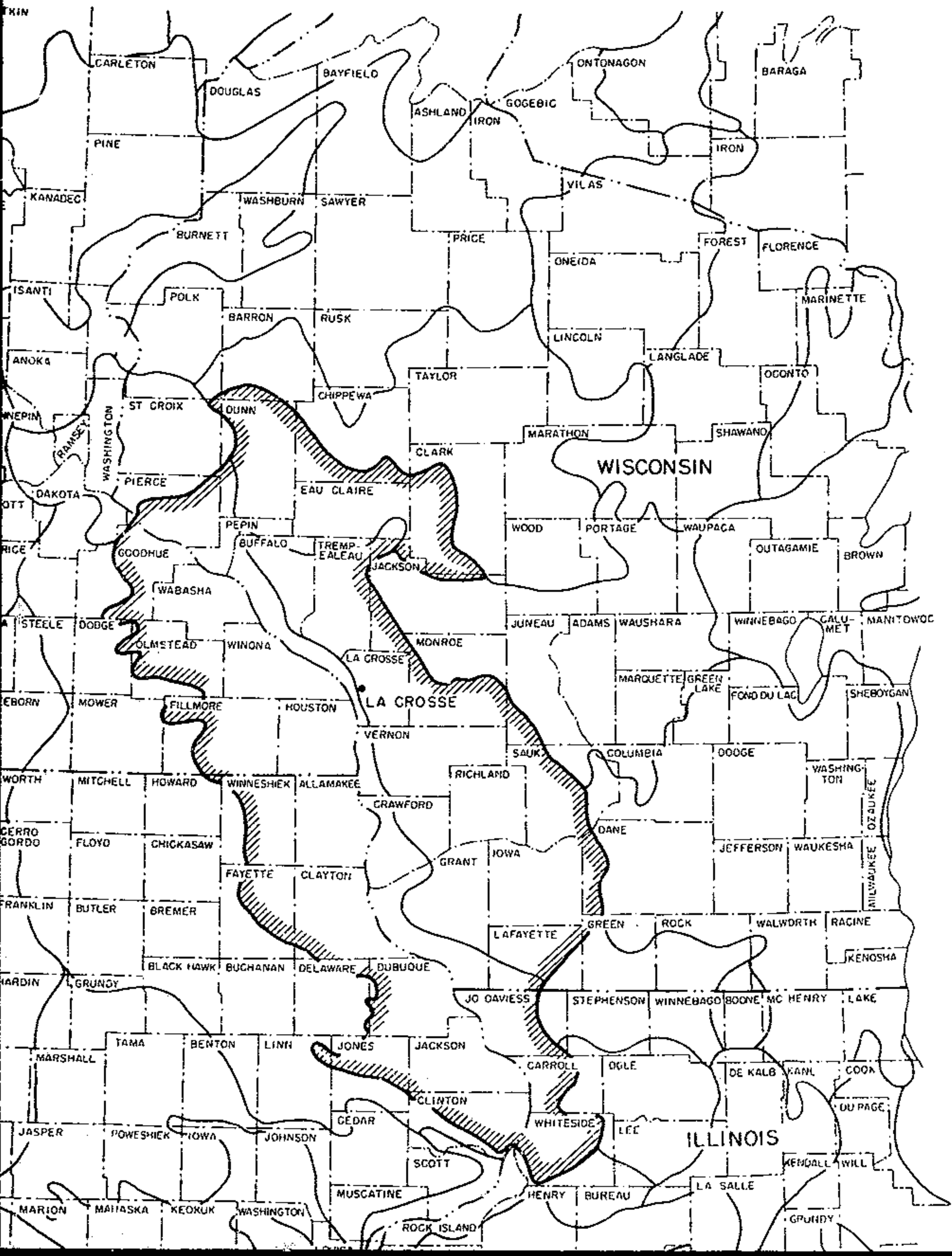
BUREAU
ROCK ISLAND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KANADEC
WASHBURN
SAWYER
VILAS
PRICE
FOREST
FLORENCE
BURNETT
ONEIDA
ISANTI
POLK
BARRON
RUSK
MARINETTE
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LANGLADE
ANOKA
TAYLOR
OCONTO
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WAUPACA
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GOODHUE
BUFFALO
TREMP-EALEAU
JACKSON
WABASHA
STEELE
DODGE
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ADAMS
WAUSHARA
WINNEBAGO
CALU-MET
MANITOWOC
OLMSTEAD
WINONA
MONROE
LA CROSSE
MARQUETTE
GREEN LAKE
FOND DU LAC
SHEBOYGAN
MOWER
FILLMORE
HOUSTON
VERNON
SAUK
COLUMBIA
DODGE
WASHING-TON
OZAUKEE
MITCHELL
HOWARD
WINNESHIEK
ALLAMAKEE
RICHLAND
CRAWFORD
CERRO GORDO
FLOYD
CHICKASAW
DANE
JEFFERSON
WAUKESHA
MILWAUKEE
GRANT
IOWA
FAYETTE
CLAYTON
FRANKLIN
BUTLER
BREMER
LAFAYETTE
GREEN
ROCK
WALWORTH
RACINE
KENOSHA
BLACK HAWK
BUCHANAN
DELAWARE
DUBUQUE
GRUNDY
JO DAVIESS
STEPHENSON
WINNEBAGO
BOONE
MC HENRY
LAKE
TAMA
BENTON
LINN
JONES
JACKSON
MARSHALL
CARROLL
OGLE
DE KALB
COOK
CLINTON
DU PAGE
CEDAR
WHITESIDE
LEE
JASPER
POWESHIEK
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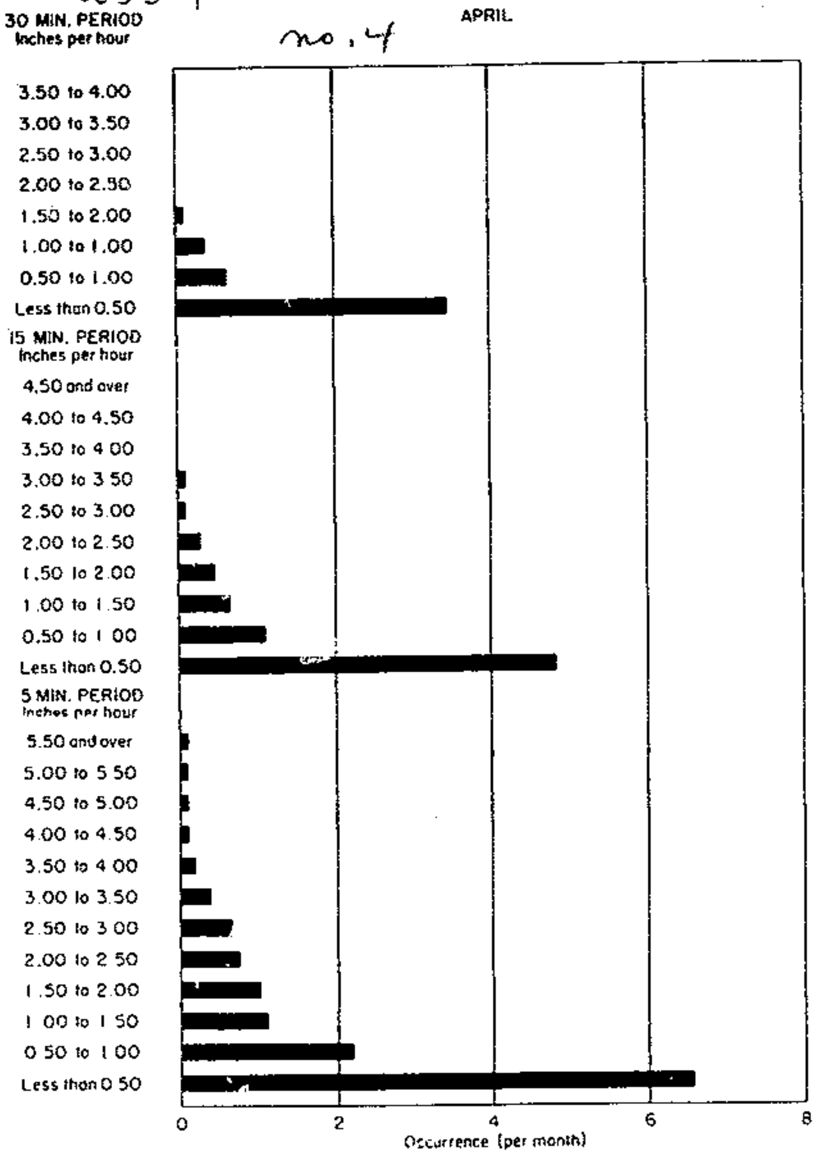
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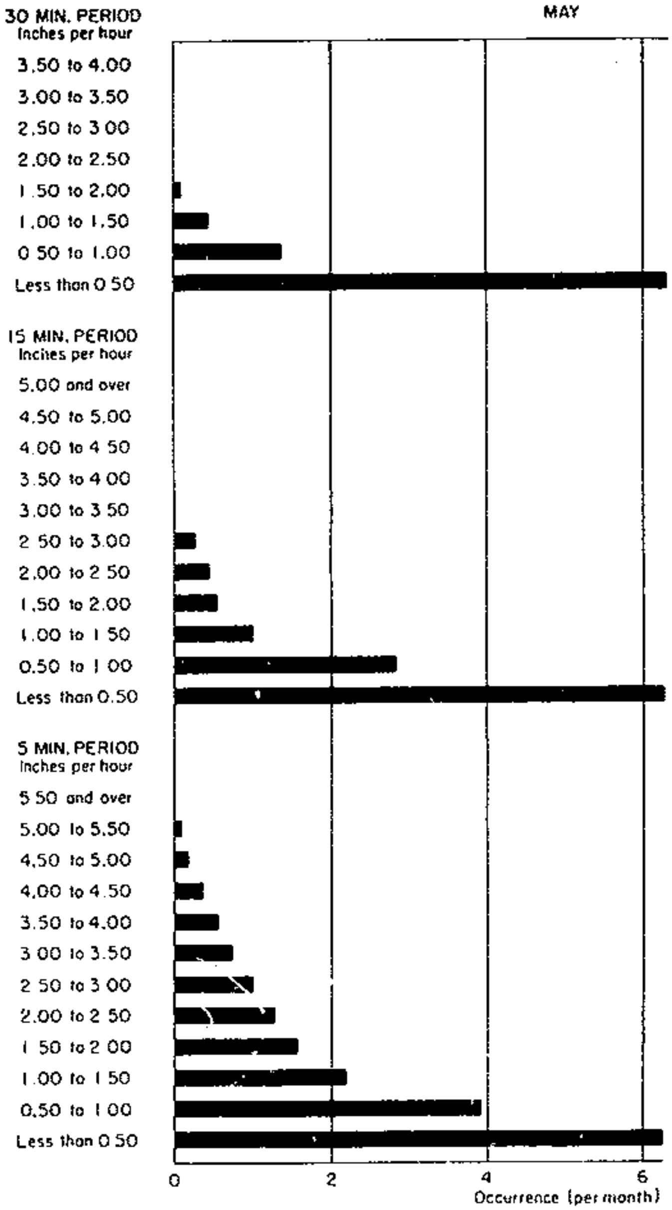
2.00 to 2.50
1.50 to 2.00
1.00 to 1.00
0.50 to 1.00
Less than 0.50
15 MIN. PERIOD
Inches per hour
4.50 and over
4.00 to 4.50
3.50 to 4.00
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
1.50 to 2.00
1.00 to 1.50
0.50 to 1.00
Less than 0.50
5 MIN. PERIOD
Inches per hour
5.50 and over
5.00 to 5.50
4.50 to 5.00
4.00 to 4.50
3.50 to 4.00
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
1.50 to 2.00
1.00 to 1.50
0.50 to 1.00
Less than 0.50
0
2
4
6
8
Occurrence (per month)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2.00 to 2.50
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1.00 to 1.50
0.50 to 1.00
Less than 0.50
15 MIN. PERIOD
Inches per hour
5.00 and over
4.50 to 5.00
4.00 to 4.50
3.50 to 4.00
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
1.50 to 2.00
1.00 to 1.50
0.50 to 1.00
Less than 0.50
5 MIN. PERIOD
Inches per hour
5.50 and over
5.00 to 5.50
4.50 to 5.00
4.00 to 4.50
3.50 to 4.00
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
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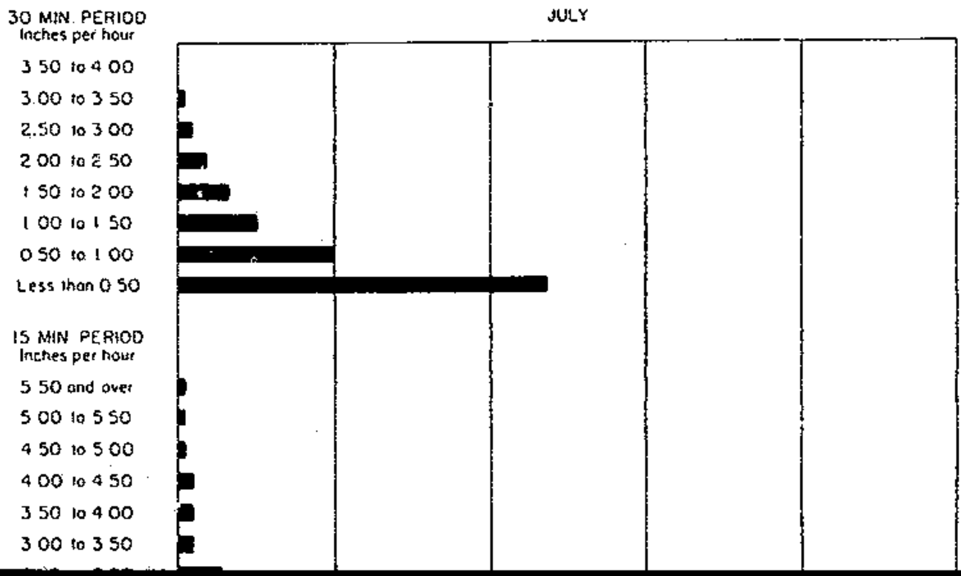
0.50 to 1.00
Less than 0.50
0
2
4
6
Occurrence (per month)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Inches per hour
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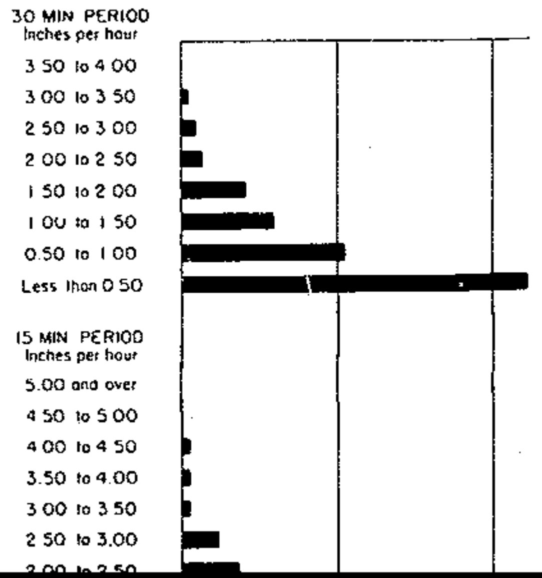
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
1.50 to 2.00
1.00 to 1.50
0.50 to 1.00
Less than 0.50
15 MIN. PERIOD
Inches per hour
5.50 and over
5.00 to 5.50
4.50 to 5.00
4.00 to 4.50
3.50 to 4.00
3.00 to 3.50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Inches per hour
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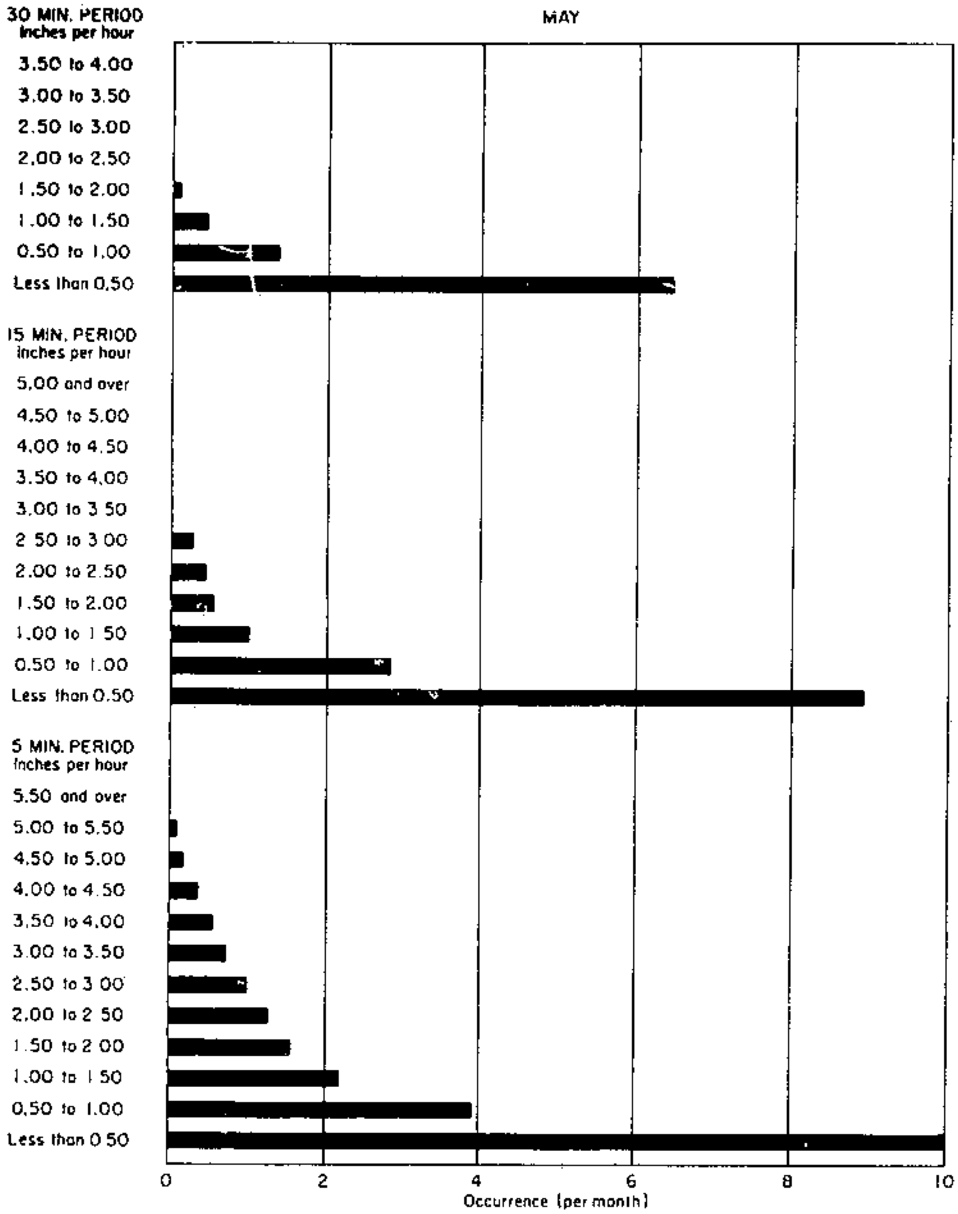
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
1.50 to 2.00
1.00 to 1.50
0.50 to 1.00
Less than 0.50
15 MIN. PERIOD
Inches per hour
5.00 and over
4.50 to 5.00
4.00 to 4.50
3.50 to 4.00
3.00 to 3.50
2.50 to 3.00


MAY
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Inches per hour
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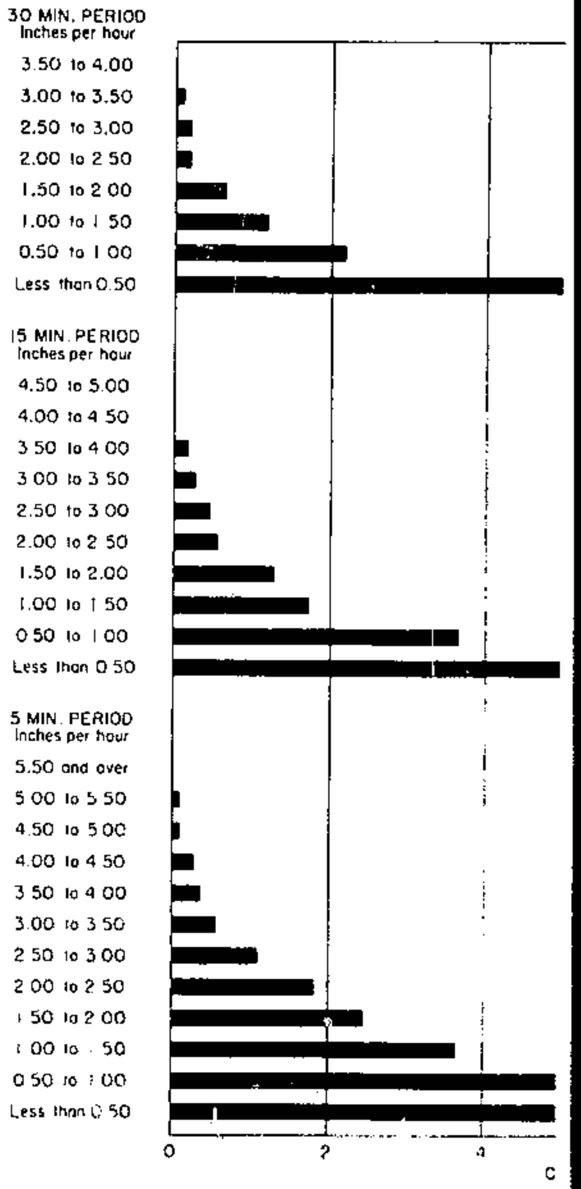
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
1.50 to 2.00
1.00 to 1.50
0.50 to 1.00
Less than 0.50
15 MIN. PERIOD
Inches per hour
5.00 and over
4.50 to 5.00
4.00 to 4.50
3.50 to 4.00
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
1.50 to 2.00
1.00 to 1.50
0.50 to 1.00
Less than 0.50
5 MIN. PERIOD
Inches per hour
5.50 and over
5.00 to 5.50
4.50 to 5.00
4.00 to 4.50
3.50 to 4.00
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
1.50 to 2.00
1.00 to 1.50
0.50 to 1.00
Less than 0.50
0
2
4
6
8
10
Occurrence (per month)


30 MIN. PERIOD
Inches per hour
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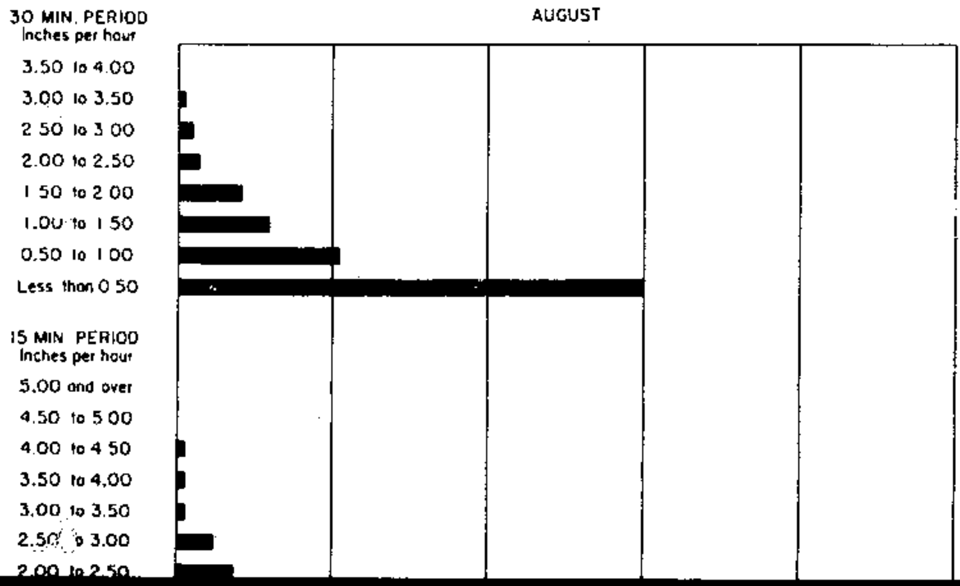
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
1.50 to 2.00
1.00 to 1.50
0.50 to 1.00
Less than 0.50
15 MIN. PERIOD
Inches per hour
4.50 to 5.00
4.00 to 4.50
3.50 to 4.00
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
1.50 to 2.00
1.00 to 1.50
0.50 to 1.00
Less than 0.50
5 MIN. PERIOD
Inches per hour
5.50 and over
5.00 to 5.50
4.50 to 5.00
4.00 to 4.50
3.50 to 4.00
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
0
2
4


AUGUST
30 MIN. PERIOD
Inches per hour
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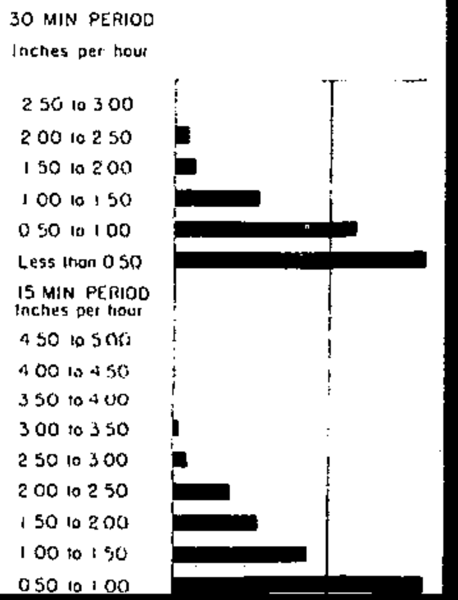
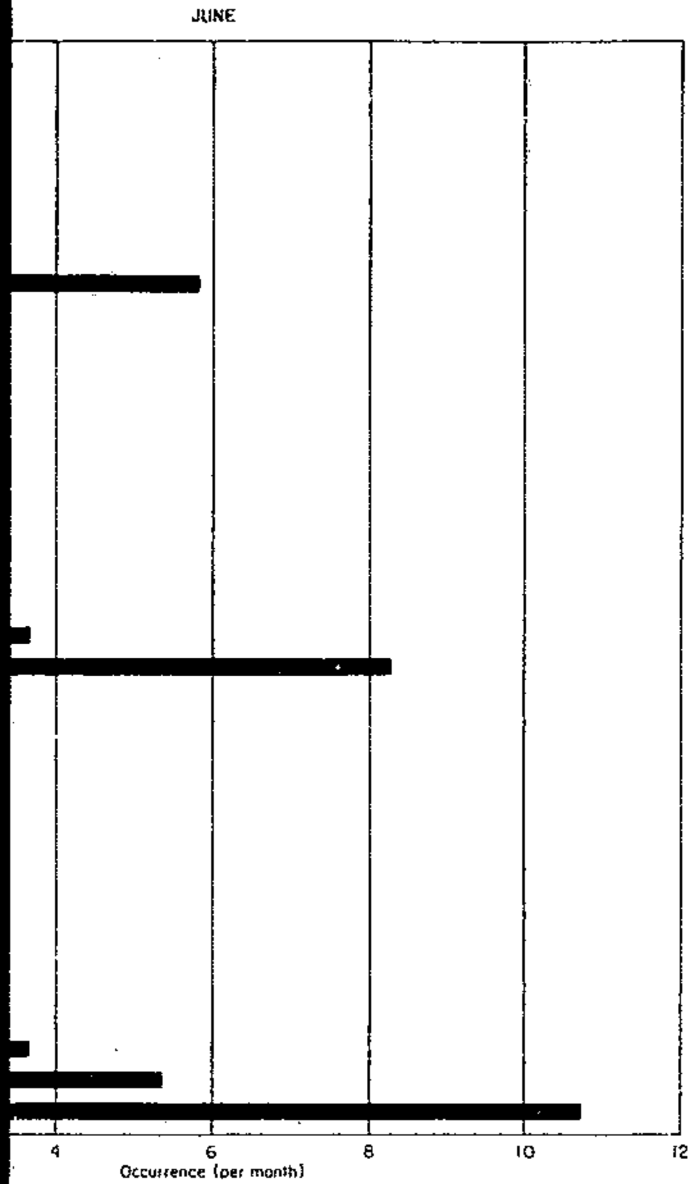
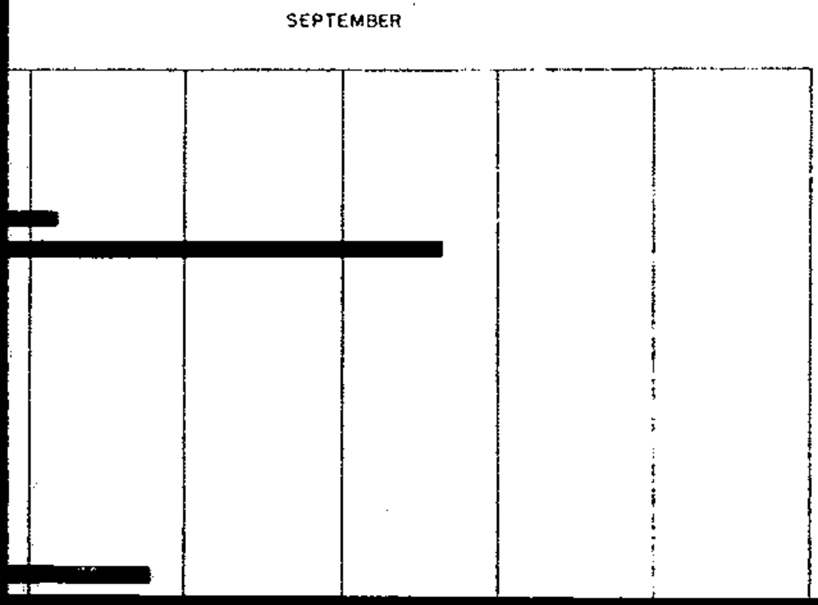
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
1.50 to 2.00
1.00 to 1.50
0.50 to 1.00
Less than 0.50
15 MIN. PERIOD
Inches per hour
5.00 and over
4.50 to 5.00
4.00 to 4.50
3.50 to 4.00
3.00 to 3.50


30 MIN PERIOD
Inches per hour
2.50 to 3.00
2.00 to 2.50
1.50 to 2.00
1.00 to 1.50
0.50 to 1.00
Less than 0.50
15 MIN PERIOD
Inches per hour
4.50 to 5.00
4.00 to 4.50
3.50 to 4.00
3.00 to 3.50
2.50 to 3.00
2.00 to 2.50
1.50 to 2.00
1.00 to 1.50
0.50 to 1.00


JUNE
4
6
8
10
12
Occurrence (per month)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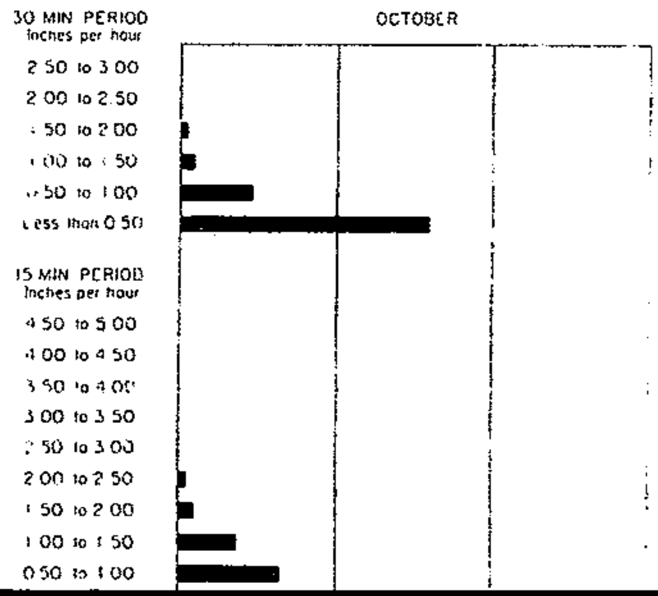
30 MIN PERIOD
Inches per hour
2 50 to 3 00
2 00 to 2 50
0 50 to 1 00
OCTOBER
15 MIN PERIOD
Inches per hour
4 50 to 5 00
4 00 to 4 50
3 00 to 3 50
2 00 to 2 50
1 00 to 1 50

SS
DD-F
Du-8
D-F
CL-6
C
CL-4
A
CL-8
B
CL-4
CL-4
C
Du-7
CC
CL-6
C
CL-8
B


SS
DD-F


SS
DD-F
Du-10
D-F
Du-8
C-
Du-5
CC-
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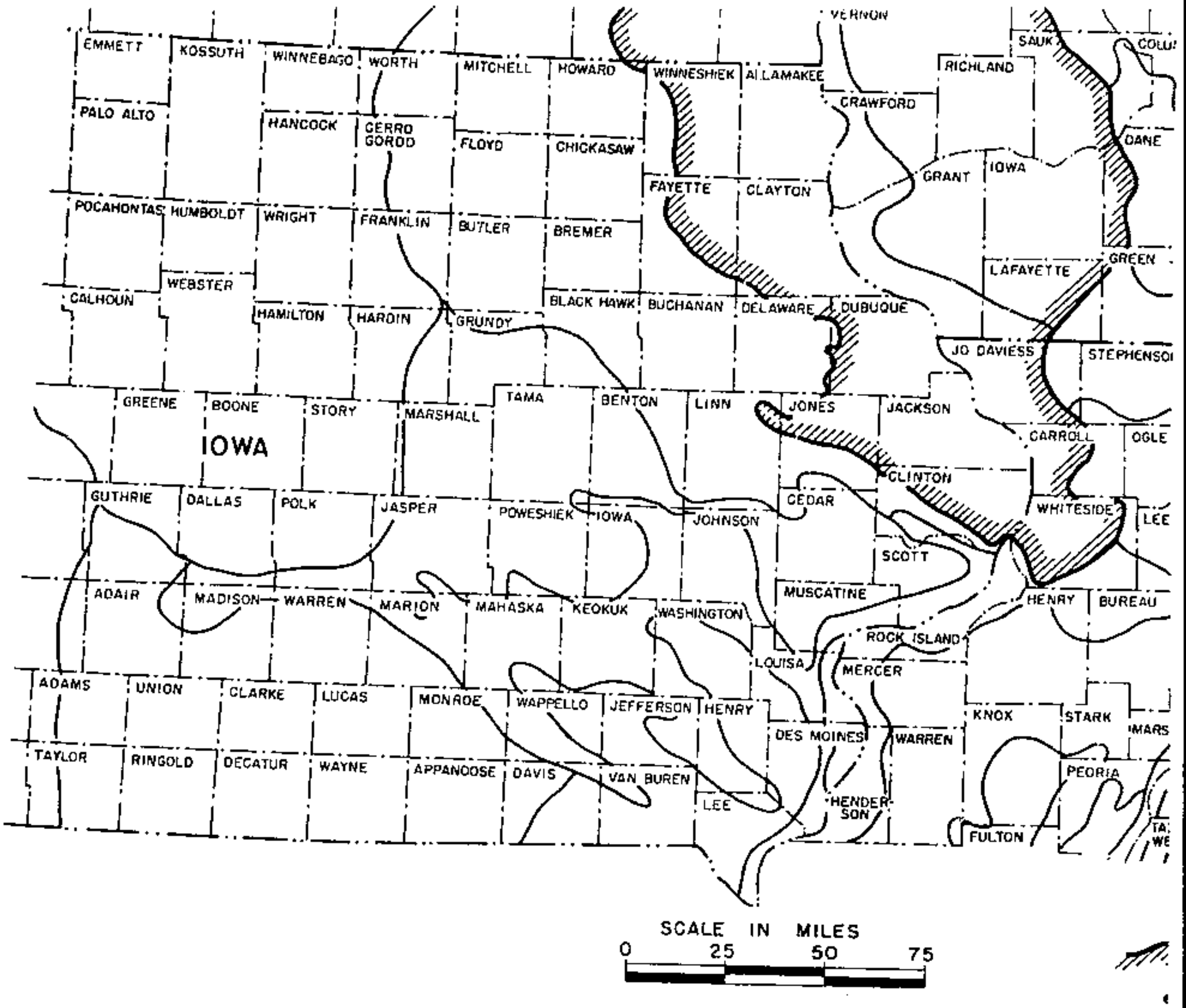
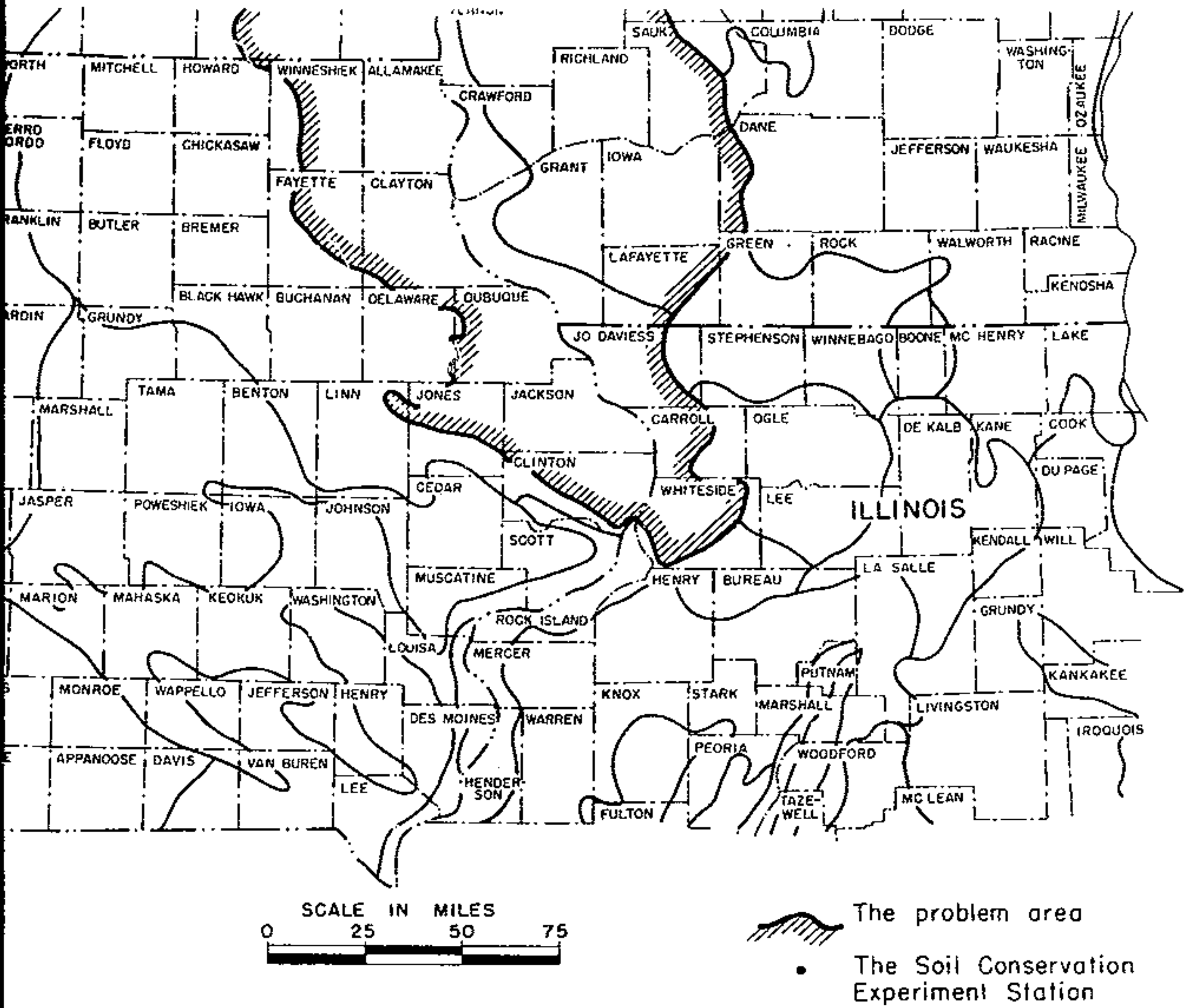


FIGURE 1.—Location map of the Upper Mississippi Valley area, showing location of the Soil Conservation Experim



Upper Mississippi Valley area, showing location of the Soil Conservation Experiment Station near La Crosse, Wis.

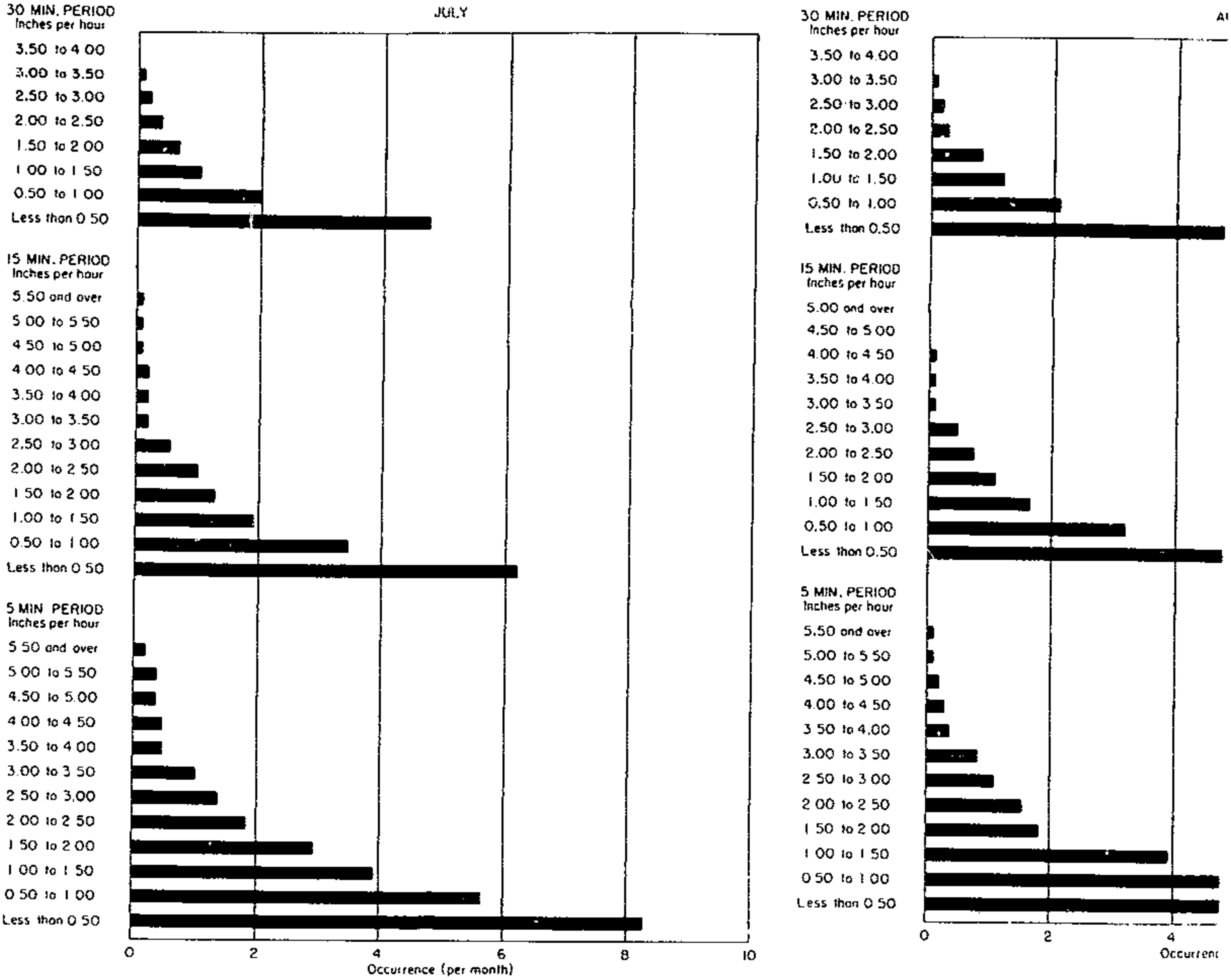


FIGURE 4.—Average intensities for 5-,

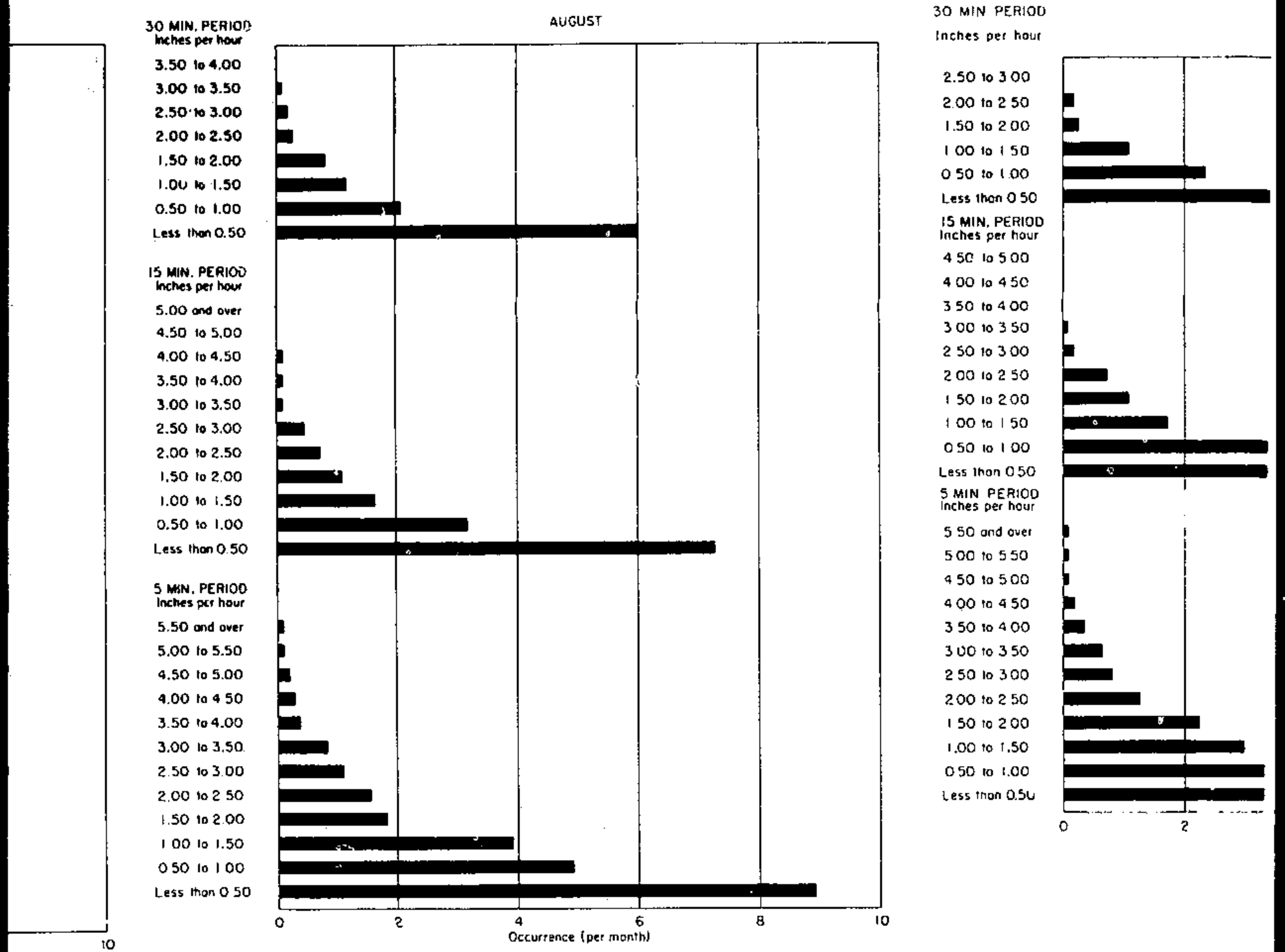
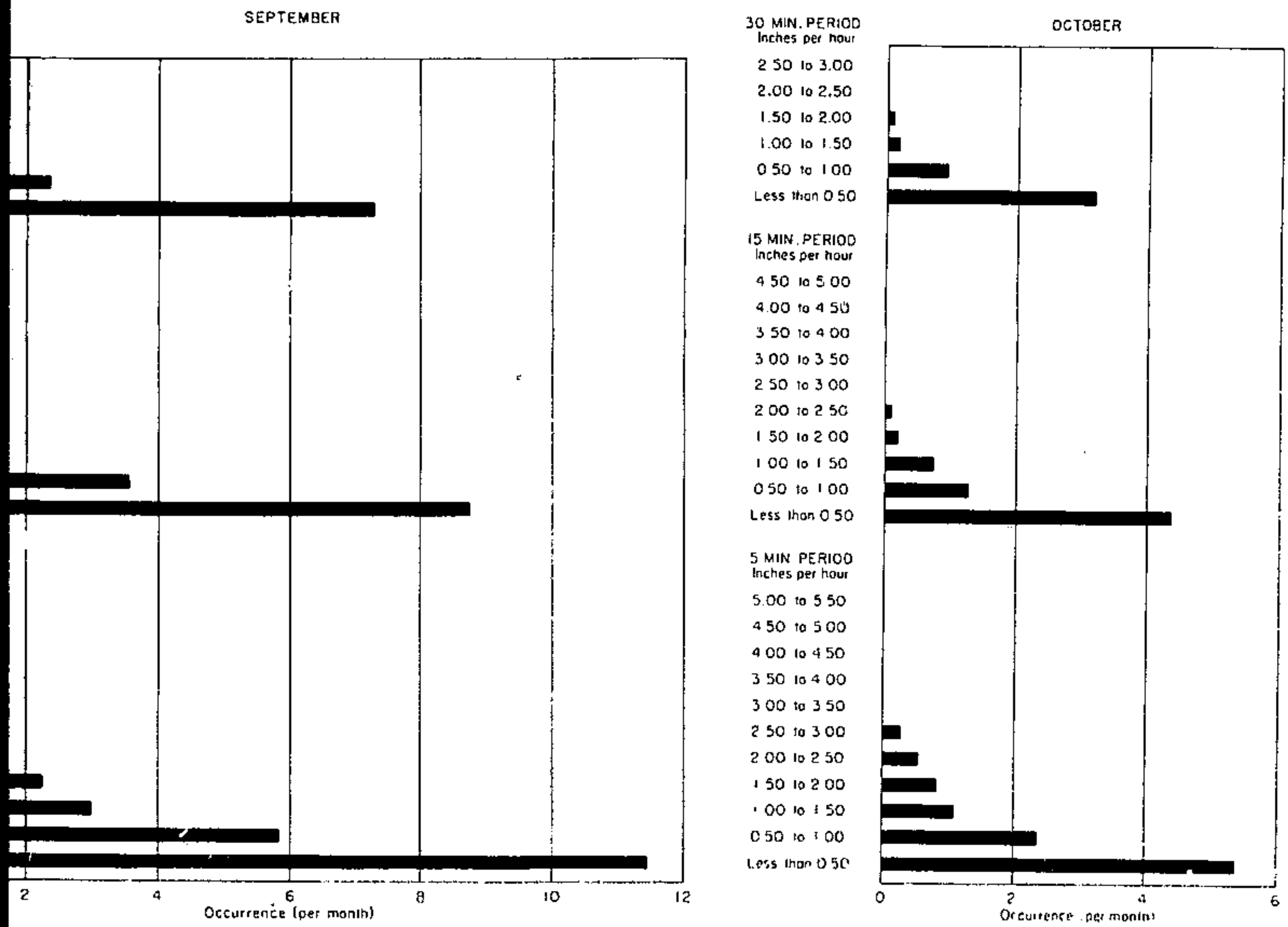


FIGURE 4.—Average intensities for 5-, 15-, and 30-minute periods of precipitation for each month of the growing season, 19



g season, 1933–43, La Crosse, Wis.

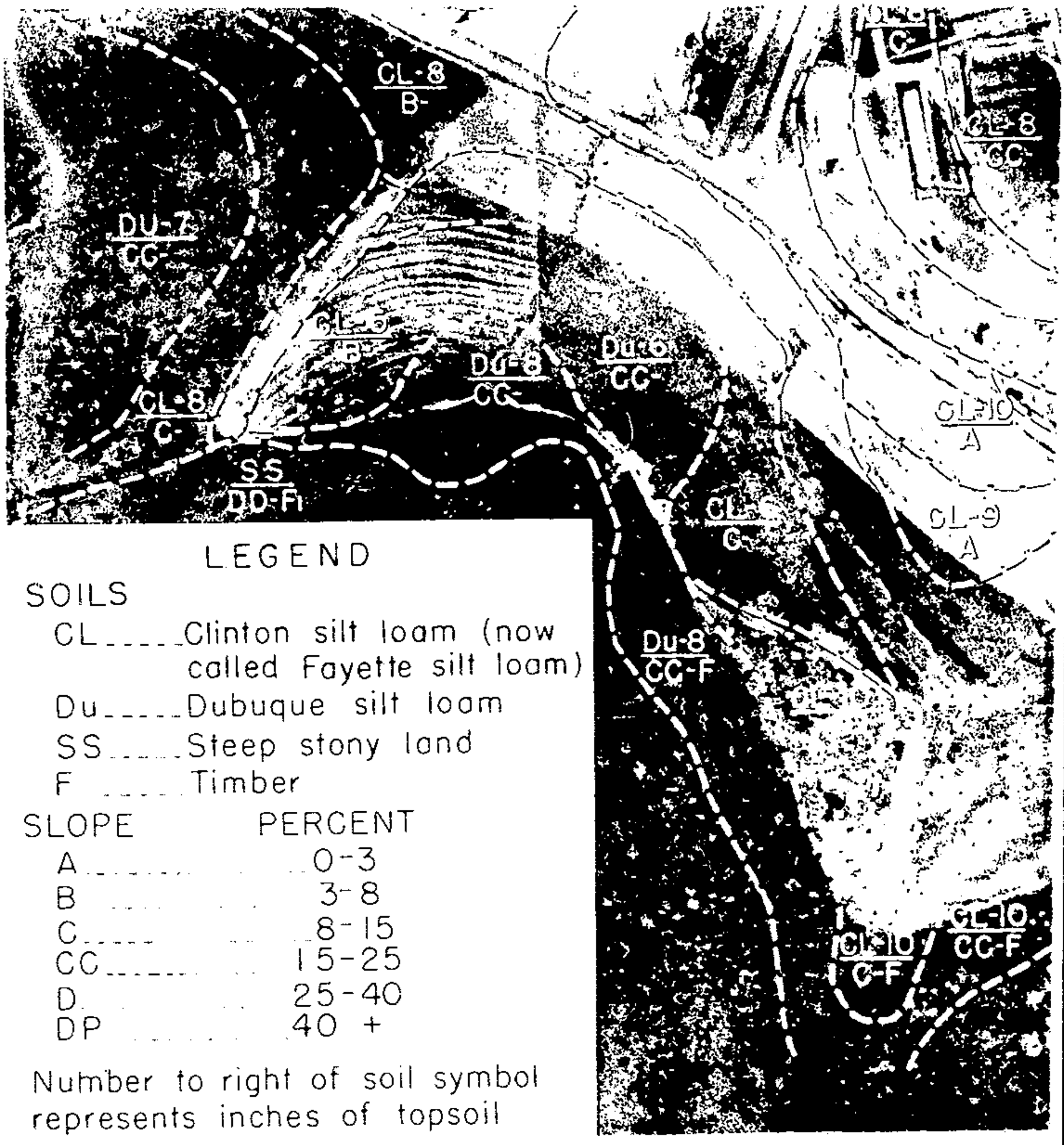


Figure 6.—Soil erosion survey map

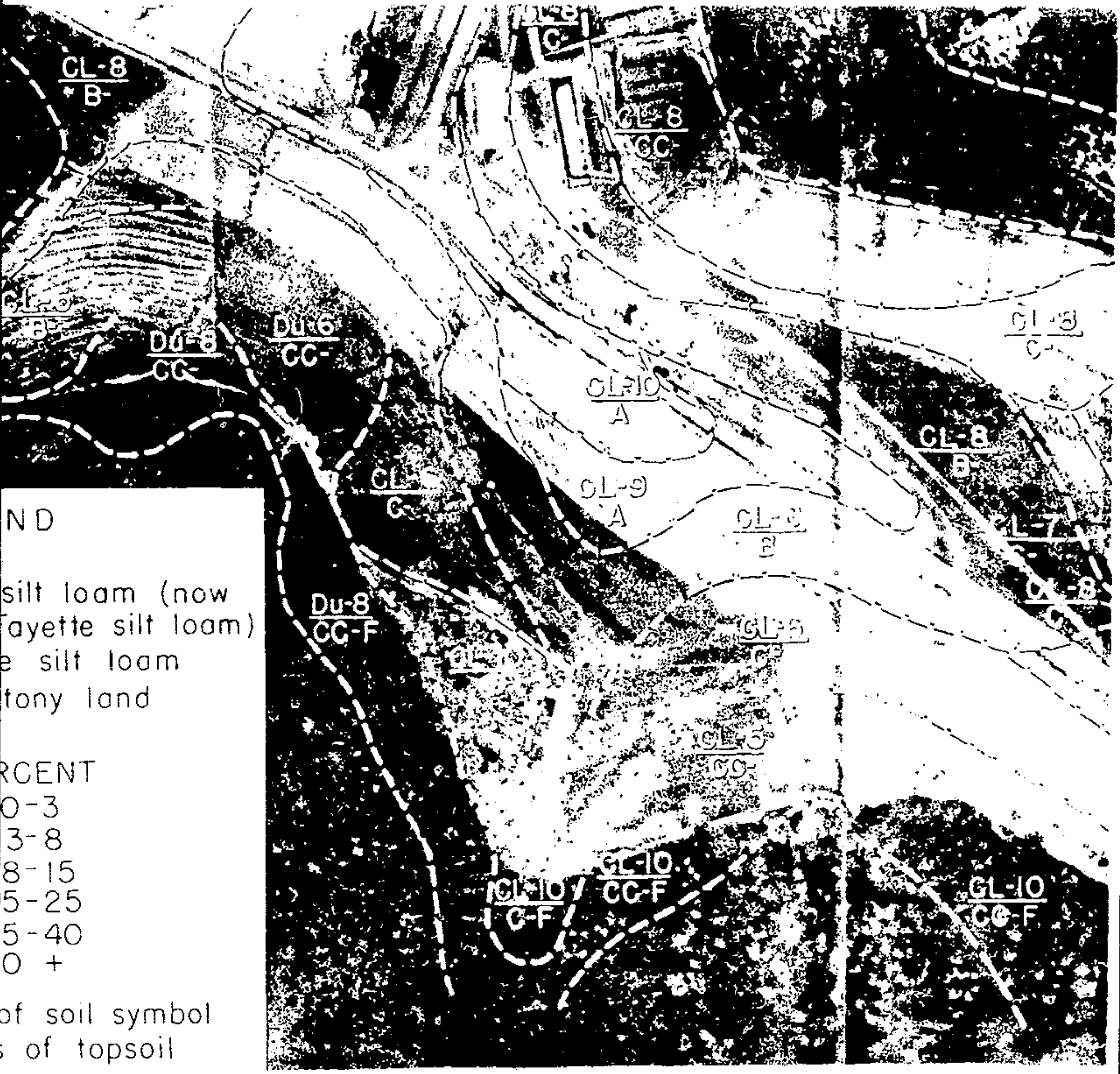


FIGURE 6.—Soil erosion survey map [illegible] slope [illegible]

S
CL-8
D
CL-10
DC
CL-10
CL-8
A

END