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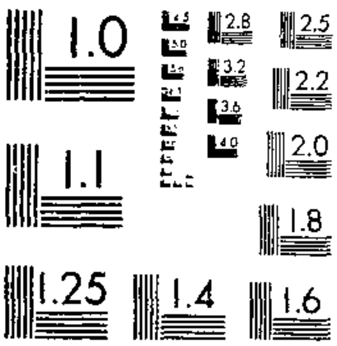

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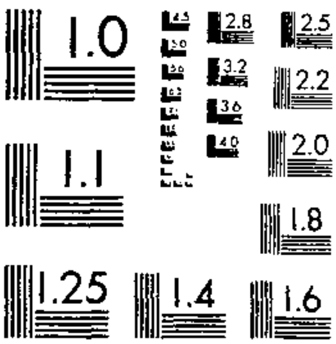

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**UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.**

Investigations in Erosion Control and Reclamation of Eroded Land at the Northwest Appalachian Conservation Experiment Station, Zanesville, Ohio, 1934-42[1]

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The United States Department of Agriculture, Soil Conservation Service, in Cooperation with the Ohio Agricultural Experiment Station

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SUMMARY AND APPLICATION OF FINDINGS TO LAND USE IN THE PROBLEM AREA

The Soil Conservation Experiment Station near Zanesville, Muskingum County, Ohio, was established in 1932 to investigate soil and water conservation problems in the northwest Appalachian area.

The topography of this area is mostly hilly. The soils, derived largely from sandstone and shale, belong to the large group of Gray-Brown Podzolic soils. In general, they are acid. The land was originally in forests which were cut and burned by the early settlers. General farming came to be the prevailing agriculture soon after settlement. This type of agriculture has caused rapid soil depletion and erosion.

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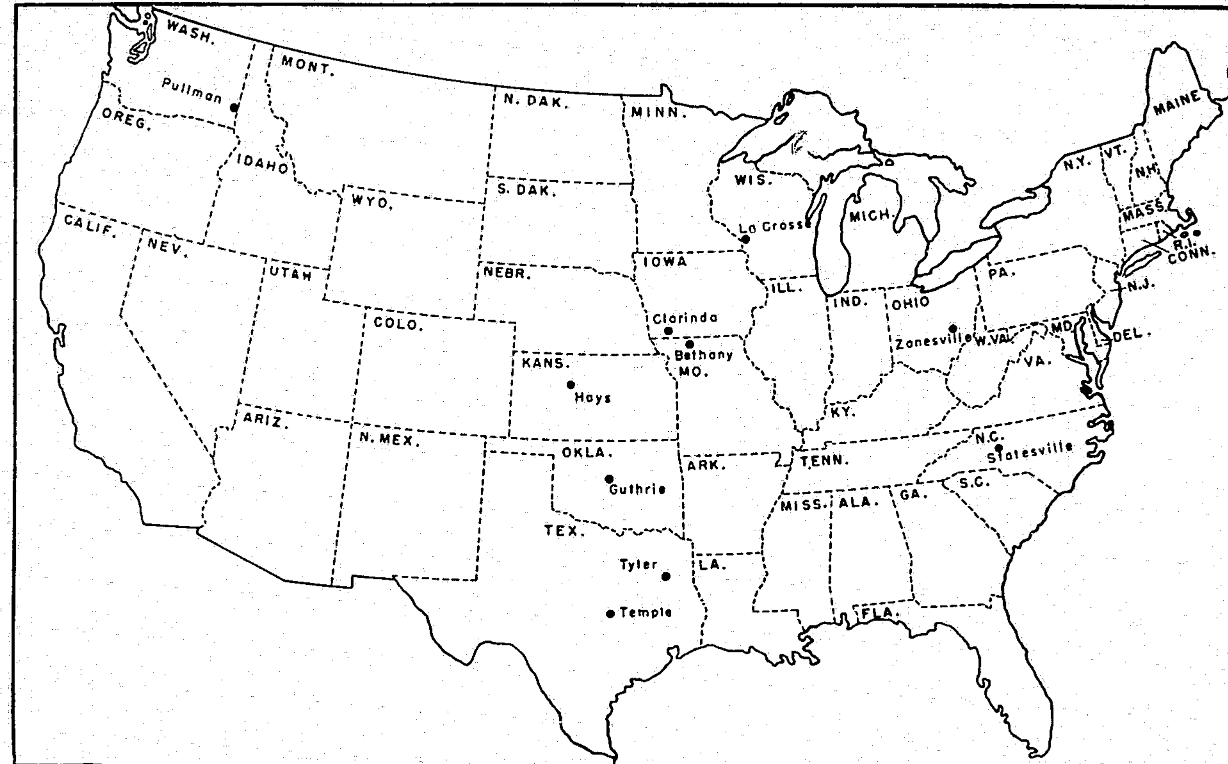
[1] Submitted for publication August 1944.

[2] The early work at this station was supervised by S. W. Phillips, soil scientist, Bureau of Chemistry and Soils, and F. E. Hardisty, associate agricultural engineer, Bureau of Agricultural Engineering. Following the death of Mr. Phillips in January 1933, E. B. Deeter, assistant soil scientist, was in charge until October 1934. At that time, Mr. Deeter was succeeded by J. M. Snyder, soil scientist, and Mr. Hardisty by V. D. Young, associate agricultural engineer. In February 1936, Mr. Snyder was succeeded by H. L. Borst, soil conservationist, and Mr. Young was followed in August 1937 by Russell Woodburn. From October 1935 to August 1937, E. A. Carleton was a member of the staff. Mr. Woodburn left the station in February 1941. In December 1942 F. A. Post joined the station staff.



Map of the United States showing location of 10 soil conservation experiment stations.

Although, in the area as a whole, agriculture is still carried on, there are several comparatively large tracts which have been given over to reforestation and many individual farms have been abandoned. Within the last decade or two the acreages of corn and grain crops have been reduced. Dairying is an important enterprise in much of the area.

Investigations of climatic, hydrologic, topographic, and soil factors causing and affecting soil erosion and water loss and of various erosion-control and water-conserving practices, together with related studies of vegetation, have been made during the 9-year period covered by this report, 1934–42.

The findings of the station bear out the evidence presented by erosion surveys that the sloping soils of the area undergo severe erosion when devoted to "old style" general farming in which intertilled crops have a prominent place. The results of the investigations at the station also point the way to agricultural practices which not only will aid in conserving the soil resources of the problem area but at the same time, if adopted generally, will add significantly to the Nation's food supply.

In general, the type of agriculture indicated is one in which grasses and legumes play a major role. On hill-land farms the growing of crops should be restricted insofar as possible to those areas best suited by topography to their production—to fairly level bottom lands and the gentler slopes. The remainder of the farms, in fact the most of the acreage, should be devoted to pastures, pasture meadows, and woodland. In the broad, comparatively level valleys, attention should be directed chiefly to agronomic problems rather than toward erosion control.

The cropping of hill lands should be carried on only with all feasible practices for erosion control. Emphasis should be shifted from erosion-control practices in the narrow sense to a broader, more inclusive program designed to conserve productive capacity of soils in the fullest sense of the term. Calcium, phosphorus, and potassium must be supplied liberally in manures or commercial forms. Grass and legumes, particularly, require an adequate supply of these mineral elements. A sound fertility program is fundamental to the conservation of the soil. The rotations should include 2 years or more of sod crops. Meadows should be seeded with long-lived, deep-rooted legumes. Strip cropping, fortified by diversions and terraces where necessary, should be practiced.

Dairying and sheep raising are now important farm enterprises. Small beef herds will fit well into the picture. The changing of the present "exercise lot" type of unimproved native pasture to one producing all-summer herbage of high protein value by methods developed at this station, would be a potent force in the present food-production program. Reclaiming a comparatively few hundred of the thousands of acres of virtually idle land, now growing broomsedge (*Andropogon virginicus*) and poverty (oat) grass (*Danthonia spicata*) by this station's "trash mulch" method of seeding alfalfa-grass mixtures on such land, would add in no small way to the supplies of meat, milk, and butter.

Not only should attention be directed to a more comprehensive soil-conserving program for cultivated lands, but emphasis should be shifted from crop acres to what is now considered noncropland—potential grassland. Not only does a grass or legume vegetation control erosion effectively and conserve water for the replenishment of ground water, but it is efficacious in rebuilding the dynamic organic-matter reserves of the soil and in restoring a desirable structure to the soil. The potential grassland of the area should be recognized as being fully as important, with respect to income possibilities, as the cropland and should, in general, receive more attention because it has been so neglected in the past. In short, "grass" should be looked upon and treated as a crop.

At present the noncultivated land of the problem area falls into three categories—pastures, woodland, and idle land. To these should be added some acres now cultivated that should be "retired." To utilize those areas suitable for grass profitably, requires a combination of the three "l's"—lime, legumes, and livestock. Areas too steep or too gullied for the use of machinery should be devoted to woods.

The use of a minimum of cultivated land and long rotations, including deep-rooted legumes, in connection with strip cropping, terraces, and diversions—all known soil and water conserving practices; the devoting of the large acreages to improved grassland to be utilized for grazing and forage; the returning to forest of those areas unsuited to farming—these are the bases for a permanent agriculture for the region.

The following is a brief summary of the findings of the station upon which the preceding recommendations are based:

The practice of strip cropping materially reduced erosion. A 4-year rotation strip cropping system was more effective than a 3-year system. Strips 35 feet wide lost slightly less soil than 70-foot strips.

Terracing proved an effective means of controlling erosion. Neither level nor closed terraces were satisfactory, because of the relatively impervious nature of the soil. A channel gradient of 6 inches per 100 feet of length caused excessive scouring, whereas grades of from 2 to 3 inches per 100 feet were satisfactory.

Winter erosion from bare corn stubble land was about 7 tons greater than from land in wheat, whereas runoff was about twice as great from the former.

Losses of plant nutrients were computed for the soil and water losses of plots in fertilized and unfertilized corn and on contoured and noncontoured plots. In general, these nutrient losses were governed by the soil losses and totaled more than the amounts removed by the crop.

Slope studies showed that erosion increased with length of slope and that erosion per acre was increased nearly 20 percent when the slope length was doubled. Runoff had a tendency to decrease slightly with increased length of slope. Erosion from cultivated land increased rapidly with an increase in steepness of slope. There was evidence that the erosion-slope relationship is exponential, but neither runoff percentages nor rates were affected materially by steepness of slope.

Records from the bare, hard, fallow plot show that May, June, July, and August are the months of most serious erosion—71 percent of the annual average soil loss and 62 percent of the runoff occurred in this period. June is the month of greatest erosion, and August the month of greatest runoff. Increased intensity of summer rainfall, rather than a greater amount of rainfall, was deemed responsible for the high erosion losses.

The amount of runoff and erosion from cultivated land has varied with the crop, cropping practices, soil surface condition, and numerous other factors. A plot planted to corn continuously without fertilizer for the 9 years on a 12-percent slope lost, as an average, slightly more than 99 tons per acre or approximately two-thirds surface inch of soil each year. During the 9 years of record the corn yield of this plot decreased from 60 bushels per acre to 1.6 bushels and the percentage of organic matter from 2.5 to 0.5. The use of standard fertilizer application to a similar plot reduced erosion approximately 14 percent. Plots where corn followed 2 years of meadow in a rotation (without fertilizer) lost 46 tons of soil per acre annually, or less than half as much as plots where corn was grown continuously. It was found that plowing under good sods does not completely control erosion, and apparently the control value of plowed-under sod disappeared after the first year.

Rotation meadow plots suffered negligible soil losses and the runoff was similar to that from permanent grassland. Second-year meadow plots lost less water than first-year meadow, indicating an improvement in infiltration characteristics as the soil remained in sod. Annual soil losses from plots in rotation wheat followed by meadow was about 12 tons per acre while the average rotation losses were 7.7 inches of runoff and 13.4 tons of soil. During the 9 years of the rotation experiment, corn yields decreased from 54+ to 25 bushels per acre and the organic-matter content of the plots decreased from 2.12 to 1.53 percent.

Rain-simulator studies of the effect of plant residues used as mulches and incorporated in the soil, and the effect of soil surface condition on erosion, runoff, and infiltration, reported in previous publications (*9*, *10*),[3] showed that straw incorporated into the soil beneath the surface had little or no effect on erosion or infiltration; cultivated Muskingum soil "sealed" rapidly under the impact of rainfall, resulting in low infiltration, and in high runoff and attendant erosion. Straw mulch placed on a sealed surface prevented erosion but did not curtail runoff. Straw mulch placed on a cultivated or "open" surface promoted rapid infiltration and controlled erosion. Straw mulch supported 1 inch above the soil on hardware cloth had nearly the same effect as straw on the surface, showing that the raindrop impact is an important factor in the erosion process.

In a study of seasonal infiltration, it was found that infiltration on a site covered with permanent bluegrass fluctuated markedly during the year—it was high in the summer months and low during the late fall and winter months.

Runoff and erosion were greater from unfertilized, overgrazed pasture plots than from fertilized plots. Judiciously grazed fertilized plots lost less water than those grazed more closely.

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[3] Italic numbers in parentheses refer to Literature Cited, p. 94.

The effect of vegetation on erosion and runoff is shown by records from the control plots, pasture plots, and three watersheds. Grass virtually controls erosion and conserves a large percentage of the precipitation. Annual average runoff from an ungrazed, mowed, 1/100-acre plot was slightly less than 5 percent of the precipitation. From one-half acre grazed plots and from a 3½-acre pasture watershed, it was approximately 14 percent. Soil losses from these areas ranged from negligible amounts to a maximum of about 300 pounds per acre each year.

Records from three watersheds devoted to cultivation, pasture, and woods showed that both grassland and woodland (ungrazed) lose negligible amounts of soil and conserve much of the rainfall; the pasture lost about 14 percent of the precipitation, and the woodland only 3.2 percent. Erosion losses from the cultivated watershed varied much with the crop. Little erosion occurred during the meadow years, but appreciable soil loss took place from the land in wheat, and serious erosion was recorded for the years when corn occupied the land.

Moisture studies of soils under grass, woods, and corn showed that the moisture content of such soils increased during the late fall and winter months, reaching a maximum in February or March, and decreased from this time to amounts approaching the wilting point in September or October.

Experiments having for their objective the establishment of desirable vegetation on eroded rundown land have been carried on at the station since its establishment. Early in 1936 a trial seeding of alfalfa was made on a badly eroded field, half of which was bare and the remainder covered by a sparse growth of poverty grass and briars. Needed calcium and phosphorus were supplied by liberal applications of lime and fertilizer. The results from the seeding were so promising that several similar plantings have been made during subsequent years. The field used in 1937 was similar to the one treated in 1936 and had been in pasture for more than 20 years. The five areas used in 1940, 1941, and 1942 had been abandoned for more than 10 years. Three cuttings of hay have been made on all of these areas each year since their establishment. First cuttings each year have been mixed hay, but the second and third crops have been almost straight alfalfa. With the exception of one year (1941), the yields have equalled or exceeded those from the rotation meadows on the experimental farm.

In addition to the trials at the Zanesville Station, similar seedings were made at the Experimental Watershed Project near Coshocton, Ohio, and at the Ohio Agricultural Experiment Station at Wooster, Ohio, both of which were successful. Under this trashy-fallow method of seeding alfalfa the land is protected from the destructive forces of rainfall by leaving the soil covered with a blanket of organic material, thus promoting infiltration and decreasing runoff and erosion hazards. Seeding the meadow direct without the conventional small grain eliminates competition by the so-called nurse crop frequently used in the establishment of a new alfalfa seeding.

INTRODUCTION

This publication is 1 of a series of 10 reports designed to cover the first decade of experimental work at each of the 10 original soil erosion experiment stations established with funds appropriated by the Congress and carried in the appropriations for the United States Department of Agriculture.

On December 18, 1928, the Buchanan Amendment to the Agricultural Appropriation Bill for the fiscal year 1930, appropriating $160,000 for soil-erosion investigations, was adopted by the House of Representatives. The language of the amendment was as follows:

> Soil-erosion investigations: To enable the Secretary of Agriculture to make investigations not otherwise provided for, of the causes of soil erosion and the possibility of increasing the absorption of rainfall by the soil in the United States, and to devise means to be employed in the preservation of soil, the prevention or control of destructive erosion and the conservation of rainfall by terracing or other means, independently or in cooperation with other branches of the Government, State agencies, counties, farm organizations, associations of businessmen, individuals, $160,000 of which amount $40,000 shall be immediately available.

Plans were developed for the establishment of experimental work on lands representative of large problem areas of eroding land in various parts of the country. Eventually, 10 experiment stations were organized to serve the areas (*2, 3, 4, 5*).

In April 1935 the Soil Conservation Act was passed by which the Federal Government was definitely committed to the policy of soil and water conservation and provision was made for the establishment of the Soil Conservation Service in the Department of Agriculture. The stations, at this time, became an integral part of the research activities of the Soil Conservation Service.

The research program of the stations was designed to investigate the causes of erosion and to determine the most effective and practical methods of checking and controlling soil and water losses from the agricultural lands of the areas. This included experiments with various types of vegetative cover, soil treatments, cultural and cropping systems to determine their comparative effectiveness in preventing erosion, studies of the performances of terraces and check dams of different designs in removing runoff without injury to soil and crops, attempts to reclaim and revegetate eroded land, and the keeping of meteorological records.

The research program of the Soil and Water Conservation Experiment Station near Zanesville, Ohio, was established to obtain information on the causes and effects of erosion and to develop measures for its control in the Northwestern Appalachian problem area.

The station, since its establishment, has been working under a cooperative agreement with the Ohio Agricultural Experiment Station.

The principal work to date has included studies of the effect on soil and water losses of such factors as vegetative cover, length and degree of slope, slope characteristics, crop rotations, strip-cropping practices, and terracing—including grade, spacing, and length—and the revegetation of eroded land.

These studies have served as a basis for the development of an erosion-control program applicable to this area, and some may continue to furnish useful information for future improvement of erosion-control methods. Findings of the station have been adopted and

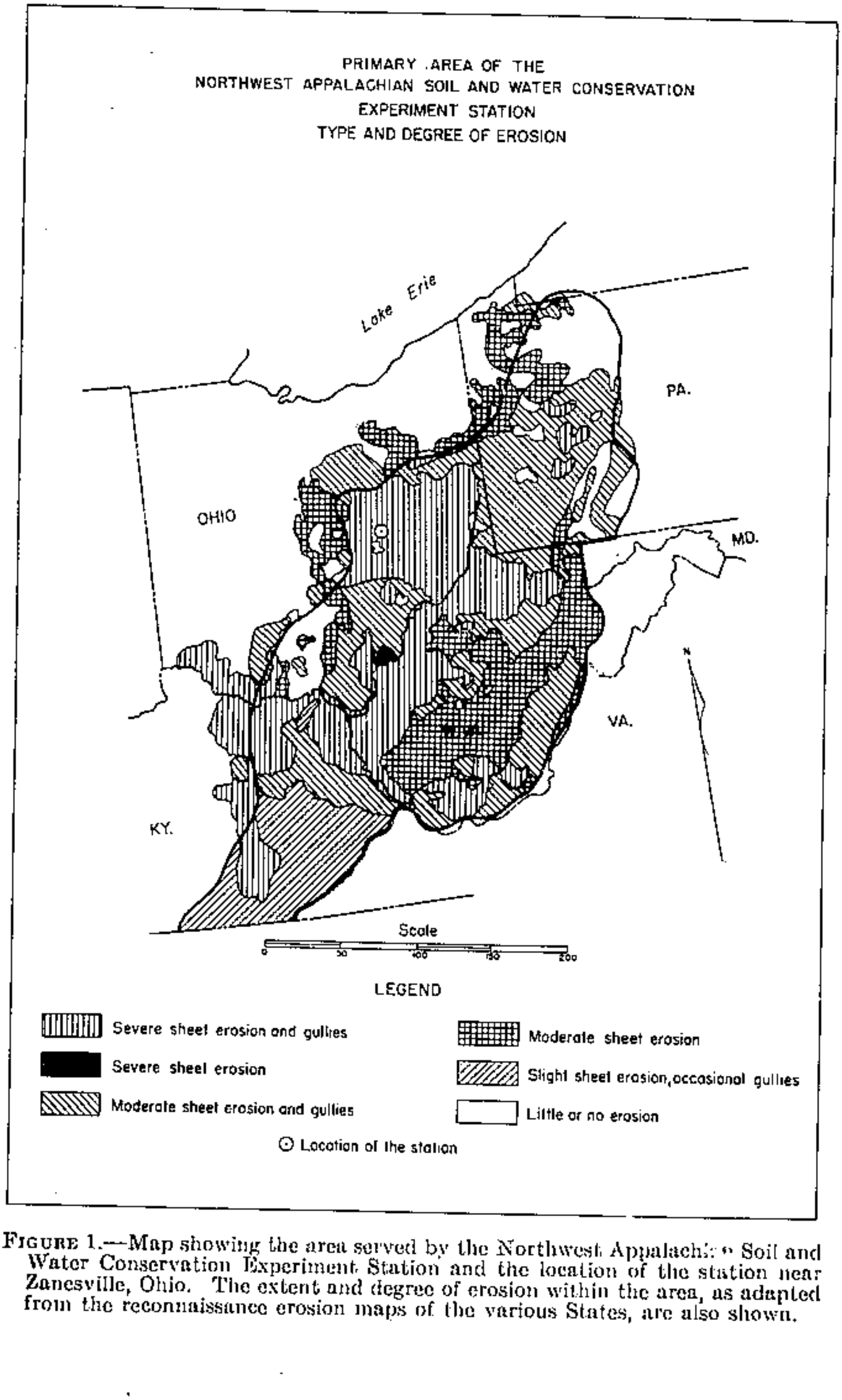

FIGURE 1.—Map showing the area served by the Northwest Appalachian Soil and Water Conservation Experiment Station and the location of the station near Zanesville, Ohio. The extent and degree of erosion within the area, as adapted from the reconnaissance erosion maps of the various States, are also shown.

modified to fit special conditions existing in other parts of the area. Methods of establishing and improving the protective cover meadows and pastures, the effectiveness of certain soil conserving and soil-improving crops, and the most desirable terrace characteristics for the area are examples of the types of information obtained during the time the station has been in operation. Practices such as strip cropping, contour tillage, and other conservation measures have been tested to determine the conditions under which they are most effective when applied to the soils of this region.

THE PROBLEM AREA

Location and extent.—The station was established to serve, primarily a problem area known as the Northwest Appalachian Plateau. This area roughly embraces about one-third of Ohio paralleling the Ohio River on the southeast, eastern Kentucky, nearly all of western West Virginia, the western one-fourth of Pennsylvania, and a small part of southwestern New York (fig. 1).

With the progress of the work has come an appreciation that basic findings, at least, may apply to a rather wide range of soils and conditions so that a secondary area served by the station may extend well beyond (particularly westward) the boundaries of the area shown in figure 1.

Topography.—Most of the problem area is uneven in relief and is best described as hilly and in some sections even mountainous. (See figs. 2 and 3). There are occasional broad valleys, and many narrower ones, particularly in Ohio and western Pennsylvania. On the majority of farms, however, level or even gently sloping land is at a minimum or lacking. A large part of the cultivated land is on slopes ranging from 10 to 40 or more percent.

Soils and vegetation.—The soils are derived mainly from sandstone and shale. They are immature and belong to the large group of Gray-Brown Podzolic soils. In various sections of the area there are outcrops of limestone, which are usually interbedded with sandstone and shale and vary considerably in thickness.

The sandstones and shales are mostly gray to yellow, and on disintegration produce grayish-brown or brownish-yellow soils. The most important soils produced from this material are of the Muskingum, Dekalb, Gilpin, Wellston, and Zanesville series. Red sandstone, shales, and clay shales also come to the surface at various places over the problem area and produce the Upshur and Meigs series of soils. All the sandstone and shale soils are acid. The Brook series and associated soils are derived from the parent material containing limestone.

Most of the area lies in the hardwood belt, where oak, chestnut, chestnut oak, and tulip poplar once predominated. A portion of the area extends into the northeastern hardwood belt.

Extent and degree of erosion.—Because of the relative steepness of the topography of the area and the formerly widespread practice of utilizing hillsides for the production of corn and wheat, the soil has been eroded to a serious degree. Severe sheet erosion with frequent gullies occurs over southeastern Ohio and western West Virginia. Parts of some of the counties of Ohio have been damaged by gullying to such an extent that agriculture has been abandoned. The extent and degree of erosion in the primary area are shown in figure 1. Typical views of sheet and gully erosion are shown in figures 4 and 5.

FIGURE 2.—Typical topography near Zanesville, Ohio.

FIGURE 3.—Typical topography of eroded and gullied land near the station

Agriculture.—The agriculture of the area dates back over 100 years. In some sections agriculture has been abandoned because the topography is unfavorable and the soil has been depleted by unwise cropping and erosion. The chief agricultural income is from livestock, and usually only enough land is cultivated to produce feed for the livestock carried. Sheep and small dairy herds are common. In the past a greater proportion of the land of the Ohio farms was devoted to general farming, especially to wheat raising. In places where there is considerable bottom land, general farming still prevails.

Climate.—The annual rainfall ranges from about 34 inches in northeastern Ohio to approximately 48 inches in southern West Virginia.

Mean annual temperature ranges from less than 48° F. in the northern part of the area to over 55° F. in the southern part. At

FIGURE 4.—Sheet erosion and finger gullies in Coshocton County, Ohio.

FIGURE 5.—Gully erosion in Muskingum County, Ohio.

Zanesville the mean annual temperature has averaged about 51° F. for a long period. Maximum temperatures range from about 90° to 110° F. Minimum temperatures vary a great deal in the southern part of the area depending upon the altitude. In northeastern Ohio and western New York the temperature sometimes reaches 30° F. below zero. The length of the growing season, or the time from the last killing frost of spring to the first frost in the fall, has ranged, over a period of 27 years, from approximately 135 days in the northern part of the area to 185 days in the southern part. At Zanesville the growing season has been about 155 days.

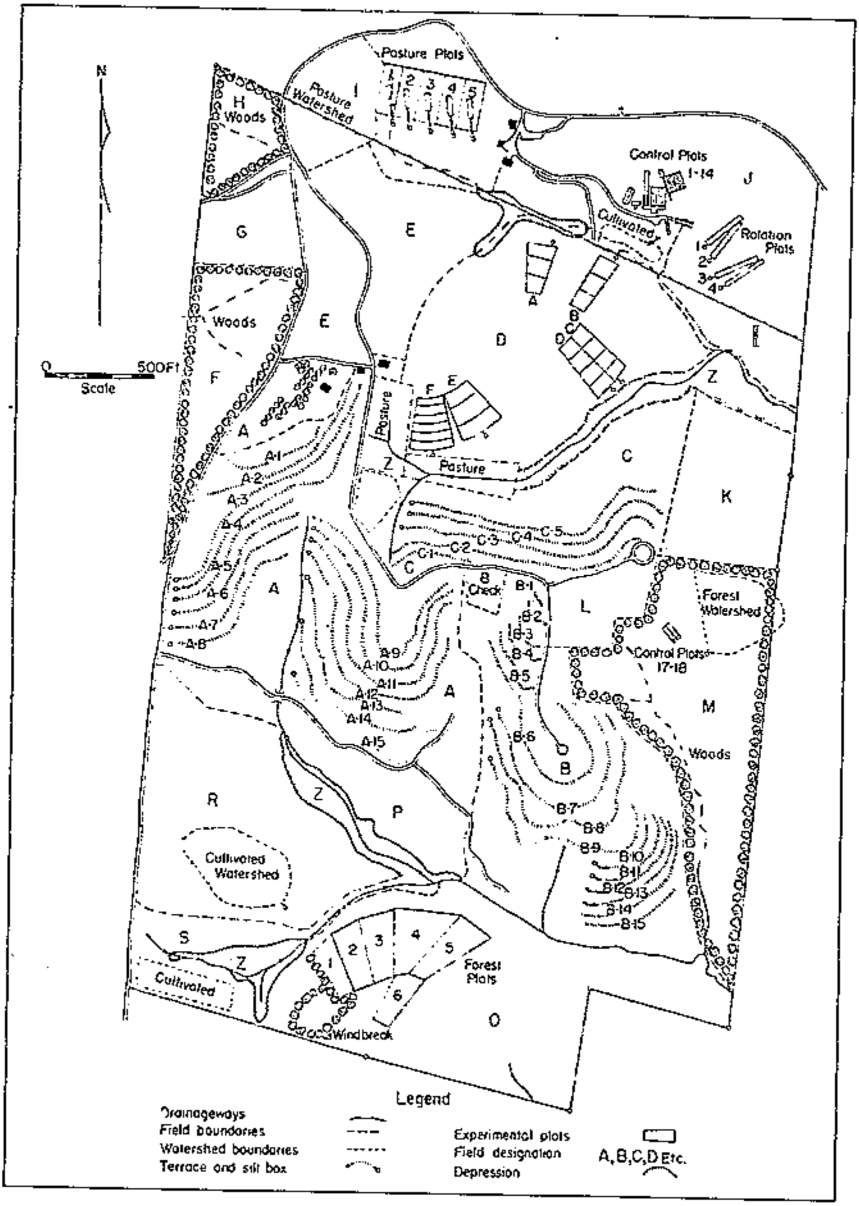

FIGURE 6.—Map of the Northwest Appalachian Soil and Water Conservation Experiment Station, showing location of the fields and experimental areas as of 1936.

THE CONSERVATION EXPERIMENT STATION

Location and history.—The soil and water conservation experiment station consists of approximately 250 acres of land lying along the upper end of Timber Run, a small tributary of the Licking River, which flows into the Muskingum River at Zanesville, Ohio. The station is approximately 6½ miles west of Zanesville and 1½ miles north of U. S. Highway No. 40. Its location within the area is shown in the map of figure 1. The land was acquired in the summer of 1932 by the Ohio Agricultural Experiment Station and construction was started that fall. The control plots and most of the terrace were installed by the first of July 1933. Figure 6 presents a map of the station showing the locations of the fields and experimental areas as of 1936, figure 7 shows the control plots.

FIGURE 7.—General view of north part of the station with control plots in the foreground.

Soils and topography.—The predominating soils of the station are Muskingum loam and Muskingum silt loam. These types and the related series as they occur in the problem area are described in the Soil Survey Report for Muskingum County (*32*). In some places, the subsoil is of slightly heavier texture than that of the typical Muskingum series. Paschall and Laughry [4] described the deep or mature phase of the Muskingum silt loam on the station farm as follows:

0 to 6 or 8 inches	Brown to grayish-brown silt loam.
8 to 10 inches	Grayish-yellow to grayish-brown silt loam.
10 to 24 inches	Bright yellow, almost buff, heavy silt loam to clay loam. Contains a few rock fragments.
24 to 32 inches	Yellowish-brown silt loam to sandy silt loam. Contains numerous rock fragments.

Second in importance on the station tract is Eifort silt loam. This soil resembles the Muskingum on the surface but differs from Muskingum in that it has a gray fire-clay stratum from about 18 to 36

[4] PASCHALL, A. H., and LAUGHRY, F. G. Unpublished report of a special survey made by the Ohio Agricultural Experiment Station to serve as a basis for laying out experiments.

inches. Below 36 inches, fine clay or sandstone and shale may occur. Other soil series of the station are the Lickdale, Adkins, Philo, and Brook. The Brook soil is derived from limestone and occurs on only a small area.

The topography of the station on which these soils are located is hilly and ranges in elevation from about 880 to 1,040 feet above sea level, with slopes varying from about 5 percent to 25 percent or more.

PURPOSE AND PLAN OF EXPERIMENTS

The investigations which have been conducted fall into two main categories: (1) Studies having to do with what might be termed basic factors affecting soil and water conservation, and (2) the application of these basic findings to conservation practices and the field evaluation of such practices.

In the first category are studies of precipitation, its seasonal distribution, intensity characteristics and frequency of erosive storms; the effect of topographic factors such as degree of slope and length of slope; the influence of various crops and different land use on erosion and runoff; and the infiltration of water into the soil. Under the second category are experiments dealing with the application of these studies to contour cultivation, strip cropping, rotation, terracing, and other agronomic practices.

Basic Investigations

Rainfall studies.—The seasonal distribution of rains of various intensities has been studied in relation to the erosion and runoff they have produced. Such studies point out the vulnerable periods of the year. Investigations of the potency of raindrop impact as compared to overland flow produced by rains have been made with a rain simulator.

Control plot studies.—Control plots 1 to 15 were established in 1933. Plots 16 to 21, duplicates of plots 3, 4, 5, 6, 7, and 8, were started in 1938 but official records were not initiated until January 1, 1940. Total runoff and soil losses from these plots are caught in tanks and measured. Two control plots were installed in the woods but were discontinued when found to be faulty.

Plots 1, 2, and 3 were installed to study the effect of length of slope on erosion and runoff. Plots 3, 14, and 15 constitute a degree-of-slope comparison. Plots 4, 5, 6, and 7 are devoted to an evaluation of the efficiency of a 4-year rotation of corn, wheat, and 2 years of meadow, in relation to soil and water losses. On plots 9, 10, and 11 the effect of native wild grasses and bluegrass on erosion losses is compared. Plot 13 has reflected the effect of fertilizing corn, while on plots 8 and 12 the effect of the desurfacing and removal of topsoil has been studied.

The lay-out and cropping of these plots is shown in table 36, Appendix. The plot house and some of the plots are shown in figure 8.

Watershed studies.—Three watersheds, one in timber, one in pasture, and one cultivated (3-year rotation of corn, wheat, meadow) have furnished data on the effect of land use on erosion losses. Table 37, Appendix, gives the physical data on these areas.

Infiltration studies.—Infiltration studies have been conducted over a period of more than 2 years, including times when the soil was frozen.

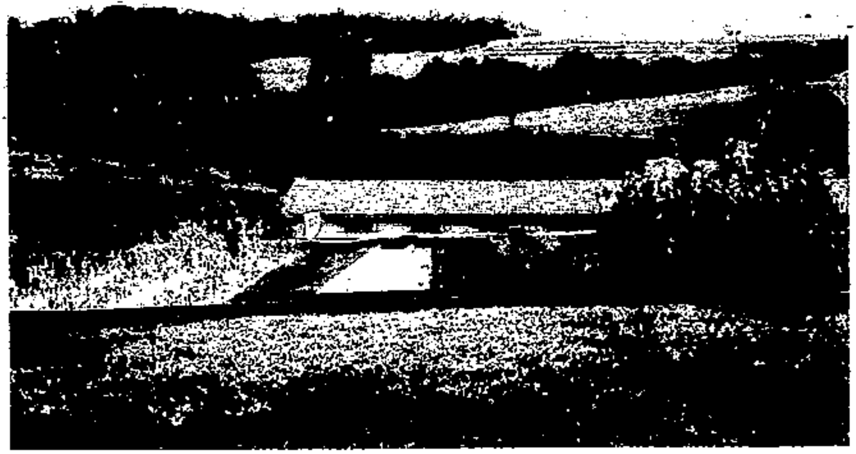

FIGURE 8.—View of some of the control plots.

Rain-simulator experiments.—Rain-simulator studies have been made to determine the effect of such factors as degree of slope, surface condition, mulching, incorporation of organic matter, different methods of seedbed preparation to utilize crop residues to the best advantage, and the protective effect of different vegetative covers.

APPLICATION STUDIES

Experiments dealing with the application of basic findings to control measures have included: (1) A comparison of 3- and 4-year rotation strip-cropping systems, areas A, B, C, and D; (2) a width-of-strip comparison, areas E and F; (3) a comparison of terraces of different lengths, A–4, A–5, A–6, A–7, A–11, and A–12; (4) a comparison of terrace grades, A–4 to A–12; (5) the effect of terracing pasture land, B–7 to B–11; (6) a study of terrace spacing, C–3, C–4, and C–5; and (7) a study of the effect of crop cover on terrace effectiveness, A–13, A–14, and A–15. Physical data on all these areas are recorded in tables 38 and 39, Appendix.

Contour cultivation has been evaluated on temporary rain-simulator plots and on the semipermanent plots 22 to 25.

The effect of the fertility level and degree of grazing on soil and water losses has been measured for 2 years on pasture plots I to V, in field I.

Extensive studies involving the revegetation of eroded land without plowing and by sowing to alfalfa have been conducted in fields D, E, A, and R.

INVESTIGATIONS AND RESULTS

METEOROLOGICAL RECORDS

In a humid climate such as Ohio has, rainfall is the chief cause of soil erosion. A knowledge of the amount and the seasonal occurrence and character of the rainfall, therefore, is an advantage in designing and evaluating soil-conserving practices.

The average annual precipitation at the station for the 9-year period of this report was 38.02 inches. This agrees closely with the 55-year average of 38.23 inches at Wooster. (See table 1 and fig. 9.) During 4 of the 9 years, precipitation exceeded 40 inches. In 1934 it was only 24.64 inches and in 1941, 30.27 inches.

Seasonal distribution.—The monthly rainfall averages for the 9-year period were not widely different from those of the long-time record except for June, July, and August. The rainfall in June exceeded the long-time average for that month in 7 years of the 9-year period. The average excess was 1.35 inches. July, normally the high-rainfall month, was below the long-time average 7 years of the 9, with an average deficiency of 0.96 inch. There were 9 months during the 9 years when precipitation was less than 1 inch. Highest monthly

TABLE 1.—*Average monthly rainfall at Northwest Appalachian Conservation Experiment Station, Zanesville, Ohio, 1934–42,*[1] *and the 55-year average for Wooster, Ohio*[2]

Month	1934	1935	1936	1937	1938	1939	1940	1941	1942	9-year average	55-year average
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
January	1.57	1.78	1.66	10.17	1.54	2.52	1.22	2.12	1.18	2.64	3.11
February	.34	1.90	2.32	1.23	2.80	4.89	3.17	.36	2.34	2.15	2.42
March	1.80	3.29	3.07	1.72	5.06	3.27	3.10	.64	3.62	2.84	3.43
April	1.34	1.82	3.46	2.72	3.68	4.58	7.72	.99	2.94	3.24	3.03
May	.91	5.51	1.98	4.55	6.42	.96	5.09	2.98	4.13	3.62	3.70
June	4.10	4.55	1.37	6.85	4.64	9.76	6.04	3.80	5.32	5.20	3.97
July	1.03	3.53	6.09	2.84	2.38	3.90	1.78	5.28	3.21	3.34	4.01
August	6.00	8.22	4.80	3.63	3.80	4.57	4.02	4.65	2.32	4.68	3.60
September	4.30	2.79	2.76	1.53	4.62	2.38	2.16	2.01	3.89	2.94	3.19
October	.67	1.86	5.59	3.57	.59	3.56	1.84	3.98	1.94	2.62	2.52
November	1.28	3.25	3.45	1.13	2.97	.88	3.76	1.82	2.96	2.39	2.63
December	1.30	2.41	2.49	3.66	1.42	1.38	2.58	1.64	4.35	2.36	2.62
Total for year	24.64	41.27	39.13	43.60	39.82	42.65	42.48	30.27	38.20		

[1] From records of the station gages.
[2] From records for period 1888–1937, shown in Ohio Agr. Expt. Sta. Bul. 445, Wooster, Ohio, and Ohio Bimonthly Bulletin issued by the Ohio station for May–June, 1940; March–April, 1941; March–April, 1942; and May–June, 1943.

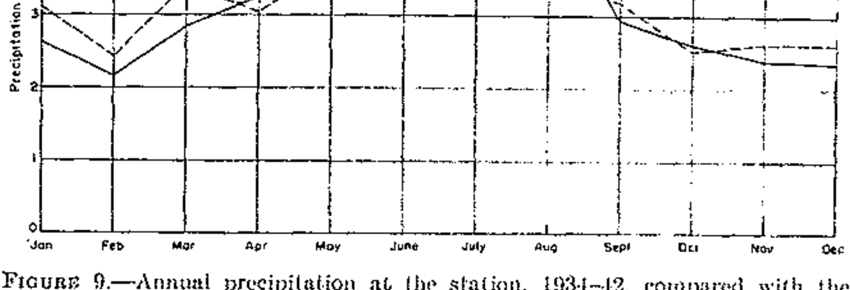

FIGURE 9.—Annual precipitation at the station, 1934–42, compared with the 55-year average at Wooster, Ohio.

rainfall occurred once in January, once in May, three times in June, twice in July, and twice in August.

Expected frequency amounts and intensities of rainfall for this location, based on Yarnell's work (*33*), are given in table 2, and rains for the period which exceeded these frequencies are shown in table 3. The 2-year expected frequency for a 5-minute period was exceeded three times; the 5-year, once; the 10-year, three times; the 25-year, once; the 50-year, once; and the 100-year, once. From an inspection of table 3 it would appear that Yarnell's figures are too conservative as applied to this area. Since rainstorms are often of a local nature, it may be that as records from more closely spaced gages become available, certain intensities will be recorded more frequently than in the past.

TABLE 2.—*Expected frequency of various amounts and intensities of rainfall in the area in which the station is located* [1]

AMOUNT

Frequency period [2]	5 minutes	10 minutes	15 minutes	30 minutes	1 hour	2 hours
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
2 years	0.40	0.65	0.78	1.05	1.30	1.40
5 years	.47	.76	.96	1.30	1.65	1.95
10 years	.52	.92	1.14	1.60	2.05	2.40
25 years	.55	1.01	1.26	1.83	2.40	2.85
50 years	.60	1.06	1.42	2.10	2.75	3.30
100 years	.63	1.16	1.53	2.25	3.05	3.60

INTENSITY PER HOUR

Frequency period [2]	5 minutes	10 minutes	15 minutes	30 minutes	1 hour	2 hours
2 years	4.80	3.90	3.12	2.10	1.30	0.70
5 years	5.64	4.56	3.84	2.60	1.65	.98
10 years	6.24	5.52	4.56	3.20	2.05	1.20
25 years	6.60	6.06	5.04	3.66	2.40	1.43
50 years	7.20	6.36	5.68	4.20	2.75	1.65
100 years	7.56	6.96	6.12	4.50	3.05	1.40

[1] Data compiled from Yarnell (*33*).
[2] The frequency period represents the time during which a rain is expected to occur once.

TABLE 3.—*Number of rains at the station that exceeded expected intensities during short periods, 1934–42*

Frequency period	Rains exceeding expected intensities during periods of—			
	5 minutes	10 minutes	15 minutes	30 minutes
	Number	*Number*	*Number*	*Number*
2 years	3	2	6	6
5 years	1			1
10 years	3	3	2	1
25 years	1			1
50 years	1			
100 years	1	1	1	

Temperature records.—Temperatures for the period 1934 to 1942 were in line with long-time averages. Winter temperature varied from a low of 18° F. below zero to about 70° above zero; summer temperatures, from 44° to 103° F. Daily average minimum temperatures ranged from 16° to 63° F. and maximum temperatures from 36° to 86° F. (See table 4.)

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TABLE 4.—*Temperature data, Zanesville, Ohio, 1934–42*

Month	Temperatures			
	Highest	Lowest	Daily average	
			Maximum	Minimum
	°F.	°F.	°F.	°F.
January	66	−18	39	20
February	68	−12	36	16
March	82	−1	48	27
April	86	19	60	37
May	92	26	72	43
June	97	41	78	50
July	103	47	86	63
August	97	44	83	62
September	96	28	78	53
October	88	24	66	42
November	80	12	51	32
December	72	−6	40	23

CONTROL PLOTS

The arrangement, treatment, and characteristics of the control plots at the station are given in table 36, Appendix, and the soil and water losses are shown in figure 10.

The differences in soil and water losses from the plots with different vegetative cover are outstanding. Plots planted to corn each year lost approximately ⅜-inch surface soil annually while those in grass cover had a negligible soil loss and very low runoff. The losses from these plots are discussed in detail in connection with the various studies involved.

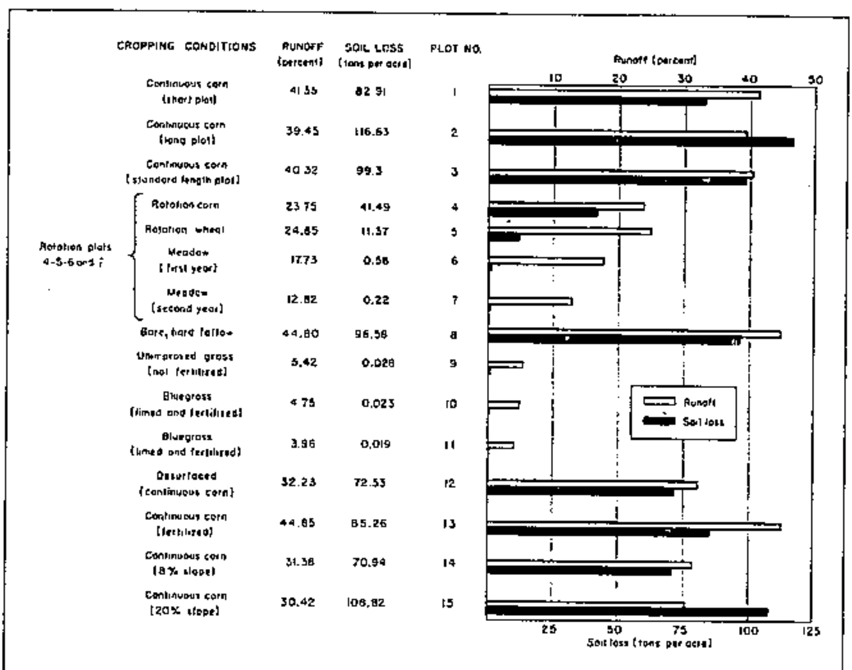

FIGURE 10.—Average annual soil and water losses from the control plots, 1934–42.

Rainfall characteristics in relation to runoff and erosion.—A study of the relation of the characteristics and seasonal distribution of rainfall to erosion and runoff was made using the data from the bare, hard, fallow control plots 8 and 21 (fig. 11). (The latter was used in place of plot 8 for 1942.) A preliminary report of this study has been published (*8*). The rainfall at the plots is given in table 5.

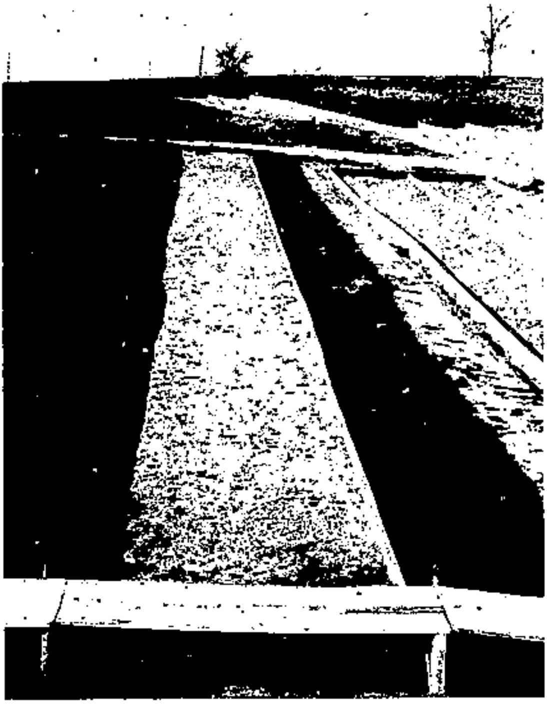

FIGURE 11.—Control plot No. 8, bare, hard, fallow surface, used in study of rainfall-erosion relationships.

In all 813 rains were recorded during the 9-year period, or an average of about 90 each year. Of these approximately 390, or less than 50 percent, produced runoff. From this number, 183 rains, about 22 percent of the total number, each of which caused erosion of 0.5 ton per acre or more, were selected for the rainfall-erosion study. In the following discussion, these are referred to as erosive rains. These rains are classified into monthly soil-loss groups in table 6 and into monthly intensity groups in table 7. Relationships between rainfall characteristics and runoff and erosion are shown in figure 12.

TABLE 5.—*Average monthly rainfall as recorded by gages at control plots, 1934–42*

Month	1934	1935	1936	1937	1938	1939	1940	1941	1942	9-year average
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
January	1.63	1.74	1.98	10.29	1.57	2.67	1.25	2.15	1.27	2.73
February	.31	2.07	2.34	1.28	2.76	5.13	3.45	.45	2.32	2.23
March	3.27	3.24	3.50	1.80	5.08	3.30	3.16	.71	4.10	3.13
April	1.37	1.90	3.50	2.71	3.77	4.64	8.04	1.01	2.48	3.27
May	.94	5.67	1.92	4.50	0.61	.95	5.11	3.01	4.20	3.06
June	4.18	4.84	1.42	6.83	4.72	9.72	6.15	3.81	5.33	5.23
July	1.16	3.60	6.38	2.90	2.43	3.05	1.67	5.69	3.25	3.45
August	6.25	8.86	4.95	3.54	3.85	4.46	4.03	4.72	2.43	4.79
September	4.28	2.87	2.81	1.62	4.63	2.39	2.29	2.15	3.02	3.00
October	.68	1.84	5.59	3.51	.57	3.53	1.83	4.10	2.01	2.63
November	1.21	3.23	3.62	1.12	3.19	.00	3.73	1.79	3.01	2.42
December	1.30	2.58	2.39	3.63	1.39	1.53	2.55	1.62	4.32	2.37

TABLE 6.—*Monthly distribution of runoff and soil losses as related to rainfall characteristics, 9-year average, 1934–42*

Month or item	Rains causing soil loss per acre amounting to—								Rainfall				Runoff—erosive rains		Soil loss and percentage of annual erosion from erosive rains	
	0.50–.99 tons	1.00–2.49 tons	2.50–4.99 tons	5.00–7.49 tons	7.50–9.99 tons	10.00–14.99 tons	15.00–19.99 tons	20.00 tons or more	Erosive rains [1]	Average amount: All rains	Average amount: Erosive rains	5-minute average maximum—erosive rains				
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Inches per hour*	*Inches*	*Percent*	*Tons*	*Percent*
January	1	2	0	2	0	0	0	0	5	2.73	0.78	0.81	0.52	66.7	1.57	1.64
February	3	0	1	1	0	0	0	0	5	2.23	.41	1.10	.19	46.3	1.26	1.31
March	0	8	1	0	0	0	1	0	10	3.13	.80	1.33	.55	61.8	3.59	3.74
April	4	4	2	4	0	0	0	0	14	3.27	1.68	.94	1.16	69.0	4.37	4.55
May	5	8	6	1	0	1	2	0	23	3.66	2.47	1.92	1.27	51.4	9.85	10.25
June	3	9	6	9	5	5	1	1	39	5.23	4.30	2.65	2.60	60.5	27.31	28.40
July	5	8	3	1	1	3	2	1	24	3.45	2.46	2.73	1.55	63.0	15.87	16.51
August	1	8	6	12	3	1	0	1	32	4.79	4.35	2.59	2.93	67.4	19.05	19.82
September	2	4	3	0	2	1	2	0	14	3.00	1.90	2.91	1.34	70.5	8.71	9.06
October	1	1	4	2	0	0	0	0	8	2.63	1.26	1.74	.79	62.7	3.04	3.17
November	5	2	1	0	0	0	0	0	8	2.42	.76	1.06	.50	65.8	1.04	1.09
December	0	0	1	0	0	0	0	0	1	2.37	.07	2.16	.04	57.1	.11	.46
Total	30	54	34	32	11	11	8	3	183	38.91	21.33		13.44	63.0	95.77	
Percentage of total erosive rainfall in each class	8.0	15.1	16.2	27.4	8.2	9.9	10.1	5.1								
Average intensity (5-minute average maximum in inches per hour) for each class	1.00	1.44	1.88	2.58	3.71	4.60	4.78	4.84								
Percentage of runoff for each class	52.5	51.0	59.3	67.4	69.6	71.3	71.7	87.2								
Percentage of soil loss caused by each class	2.4	9.3	14.4	22.9	11.0	15.4	15.9	8.7								
Average rainfall per rain (inches)	.61	.66	.98	1.54	1.30	1.54	2.14	2.36								
Average soil loss per rain (tons per acre)	.70	1.49	3.66	6.19	8.69	12.13	17.13	24.91								
Average runoff per rain (inches per acre)	.32	.34	.58	1.04	.90	1.10	1.53	2.06								

[1] An erosive rain is one which causes soil loss of 0.50 ton or more per acre.

TABLE 7.—*Monthly distribution of 183 erosive rains and related data*

Month or item	Rains with 5-minute average maximum intensity of—								Number of rains		Average monthly rainfall in the 183 rains
	0.00–0.99 inches per hour	1.00–1.99 inches per hour	2.00–2.99 inches per hour	3.00–3.99 inches per hour	4.00–4.99 inches per hour	5.00–5.99 inches per hour	6.00–6.99 inches per hour	9.00–10.00 inches per hour	Total	3.00 inches per hour or over	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*			*Inches*
January	3	2							5		0.78
February	3	1	1						5		.41
March	5	3	1	1					10	1	.89
April	11	1	1	1					14	1	1.68
May	6	10	4	1	1		1		23	3	2.47
June	1	15	8	7	6	2			39	15	4.30
July	2	10	5	3	1	1	1	1	24	7	2.46
August	1	10	12	5	3		1		32	9	4.35
September	1	4	3	1	2	1	2		14	6	1.90
October	3	1	4						8		1.26
November	4	4							8		.76
December			1						1		.07
Total	40	61	40	19	13	4	5	1	183	42	
Average annual rainfall in each class (inches)	4.56	5.25	4.25	3.01	2.80	.51	.71	.24			21.33
Percentage of rainfall in each class	21.38	24.61	19.92	14.11	13.13	2.39	3.33	1.13			
Percentage of soil loss caused by each class	7.04	17.01	22.05	17.29	20.83	6.80	6.75	2.24			
Percentage of runoff caused by each class	19.73	22.38	20.37	14.42	14.36	3.25	4.05	1.43			
Average rainfall per rain (inches)	1.03	.77	.96	1.43	1.94	1.14	1.27	2.18			1.05
Average soil loss per rain (tons per acre)	1.52	2.41	4.77	7.87	13.86	11.70	11.07	19.40			4.73
Average runoff per rain (inches per acre)	.60	.44	.62	.92	1.34	.98	.98	1.73			.66

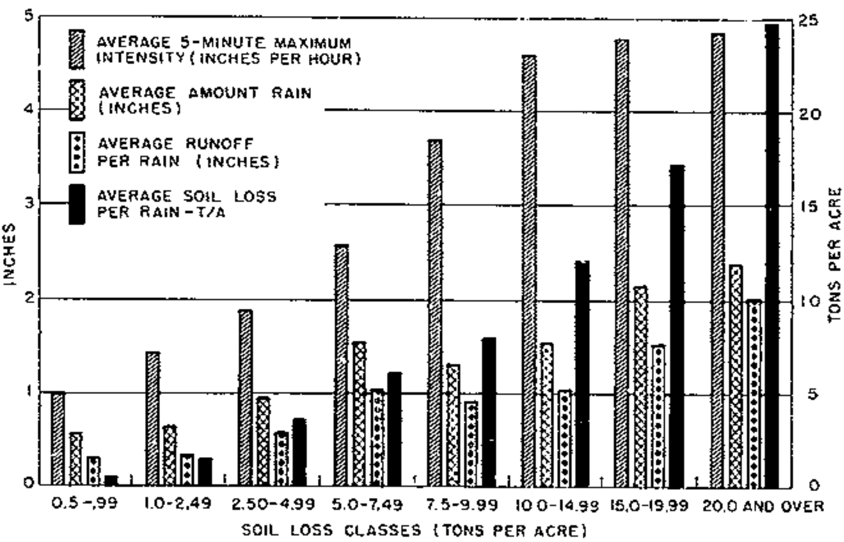

FIGURE 12.—Relation of rainfall characteristics to runoff and erosion for 183 erosive rains.

The 183 rains included slightly less than 55 percent of all rainfall but caused approximately 96 percent of the erosion from the plots. Only 65 rains, about 7 each year, caused a soil loss of 5 tons or more each and were responsible for nearly three-fourths of all erosion. The 65 rains included slightly over 60 percent of the erosive rainfall and caused slightly more than 38 percent of the runoff.

A little more than 50 percent of the erosion was caused by 33 rains (less than 4 each year) in soil-loss classes of 7.5 tons per acre or above. The 2.5- to 5.0-tons-per-acre class had the largest number of rains, but the 5.0- to 7.5-ton class accounted for the largest percentage of rainfall of any class.

As the rainfall increased from class to class, the percentage of runoff also increased. Erosion, however, increased at a rate out of all proportion to the increase in rainfall. This fact indicates the effect of the intensity of rainfall on erosion. This relationship is shown in figure 13 and discussed more fully in the following paragraphs.

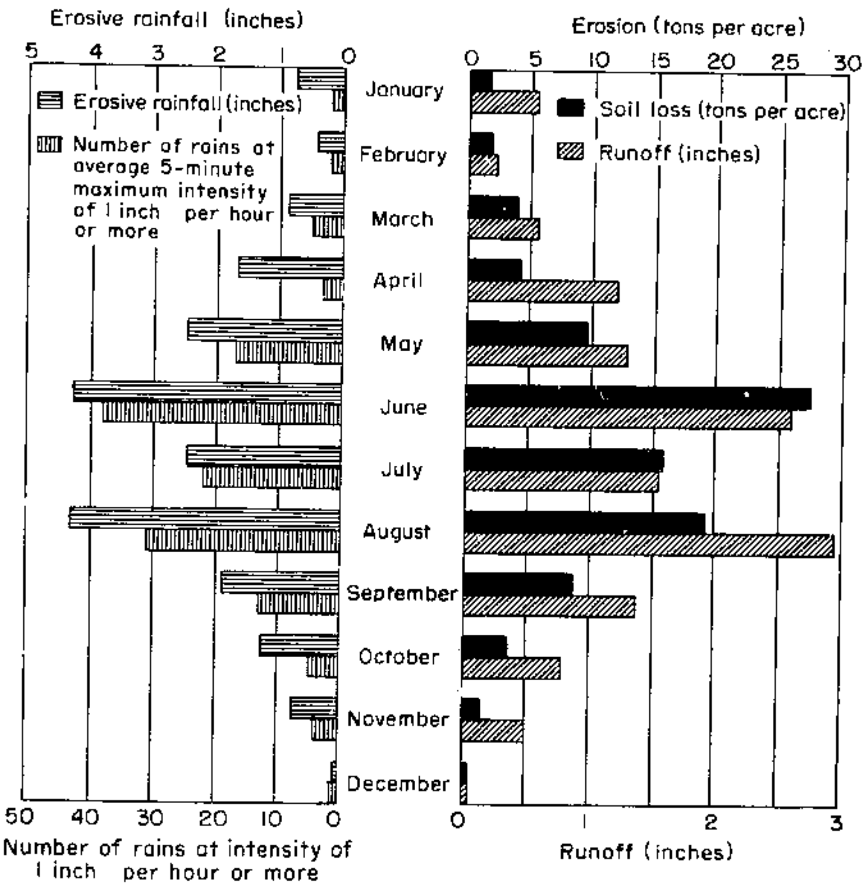

FIGURE 13.—Monthly distribution of erosive rains and resulting erosion and runoff.

Seasonal distribution of erosive rains.—Erosive rainfall increased sharply to a high during the summer months (fig. 13). With one exception, all rains which caused a 7.5-ton-per-acre soil loss or more came in the months of May to September. The greatest number of erosive rains occurred during May, June, July, and August, June being the high month and August a close second. Sixty-two percent of the erosive rainfall occurred in these 4 months and caused 75 percent of the erosion and 62 percent of the runoff. As previously mentioned, the long-time precipitation record for the vicinity shows July to have had the highest monthly rainfall. For the period of this report, July total rainfall has been lower than that of June or August and it may be assumed that the July erosive rainfall also has been less.

Some relationships of intensity of rainfall and erosion and runoff are presented in table 7. It is of interest that the monthly classification of rains by intensity groups in this table resembles the monthly distribution of the same rains grouped on a soil-loss basis in table 6. About 46 percent of the erosive rainfall occurred with an average 5-minute maximum intensity of less than 2 inches per hour. This rainfall caused only 24 percent of the total erosion and 42 percent of the runoff. Only about 34 percent of the erosive rainfall (5 rains each year) with an average maximum intensity of 3 inches per hour or over caused 54 percent of the erosion losses and 38 percent of the runoff. Twenty-three rains of 4 inches per hour or more average 5-minute maximum intensity (approximately 2½ each year) caused over 35 percent of the erosion.

The class causing the greatest percentage of the erosion was the 2- to 3-inches-per-hour intensity class.

The class with the greatest number of erosive rains (61) was the 1- to 2-inches-per-hour intensity class. This class also had the highest amount of rainfall and runoff. The bulk of the erosion was caused by rains varying from 2 to 5 inches per hour. As the intensities increased above the 1- to 2-inches-per-hour rate, the number of rains and the total rainfall in each class decreased rapidly; the amount of each rain showed a generally increasing trend, and soil loss increased still more rapidly, indicating the marked influence of increasing intensities.

The study shows that the period of greatest rainfall intensity and consequently of the most serious erosion is the period when corn or other intertilled crops occupy the land. Further, it shows that control practices must be designed to furnish protection during rains of high intensity for these crops.

The effect of length of slope on erosion and runoff.—It is well established that soil losses increase with increase in the length of slope and that the runoff shows a slight decrease as the length increases.

A summary of 9 years of soil and water losses from control plots 1, 2, and 3 is given in table 8. Detailed data are contained in tables 41 and 42, Appendix. These plots are on a 12-percent slope and are 36.3, 72.6, and 145.2 feet in length, respectively, and 6 feet wide. (See table 36, Appendix, and fig. 14). The soil is Muskingum silt loam and the plots have been planted to corn each year. In the planting and cultivation, care has been taken not to introduce differences in surface condition or other variables that would affect the comparison of losses from the plots.

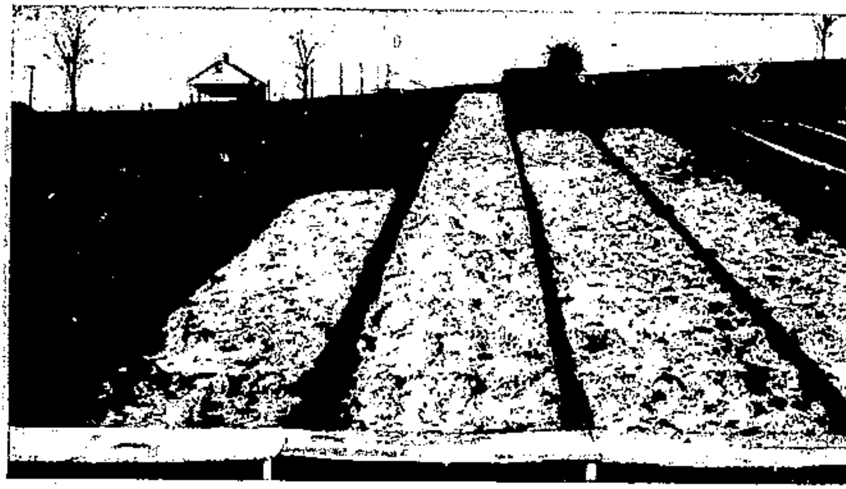

FIGURE 14.—Control plots 1, 2, and 3 used in a study of the effect of the length of slope on erosion and runoff.

From table 8 it will be seen that, for the period of record, the soil losses average 82.9 tons per acre from the short plot, 99.3 tons from the plot of standard length, and 116.6 from the long plot. The relationship between soil loss and length of slope is illustrated in figure 15. Logarithmic plotting of the soil losses shows that they are proportional to the 1.23 power of the slope length. Doubling the slope length has, on an average, multiplied the loss per plot by approximately 2.38. Erosion losses are usually reported in tons per acre, however. Doubling slope length has increased the acre loss by approximately 19 percent. This would seem to be a conservative figure as compared to the findings of other experiment stations.

Zingg (*34*), using the data from length-of-slope studies at Clarinda, Iowa; Bethany, Mo.; Tyler, Tex.; Guthrie, Okla.; and LaCrosse, Wis., concluded that erosion was proportional to the 1.60 power of

TABLE 8.—*Annual soil and water losses from control plots of different lengths, planted to corn each year without fertilizer*

Year	Rainfall	Plot 1, short		Plot 3, standard		Plot 2, long		Ratios [1] of—	
		Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Short to standard	Standard to long
	Inches	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*		
1934	26.58	8.20	28.71	9.00	36.17	6.78	31.70	2.5	1.8
1935	42.44	16.14	75.77	15.28	83.07	14.95	89.27	2.2	2.2
1936	40.40	20.94	106.72	21.62	100.37	20.07	122.55	1.9	2.4
1937	43.74	15.17	78.47	18.82	88.22	18.27	122.71	2.2	2.8
1938	40.57	18.35	91.29	16.37	118.65	15.91	151.98	2.6	2.6
1939	43.16	20.21	104.50	18.31	132.34	17.34	147.16	2.5	2.2
1940	43.26	20.01	76.84	18.63	103.07	18.80	107.43	2.7	2.1
1941	31.27	10.41	100.77	10.79	131.49	9.26	144.25	2.6	2.2
1942	38.61	14.35	83.10	12.40	100.32	16.76	132.67	2.4	2.6
9-yr. average	38.91	16.09	82.91	15.69	99.30	15.35	116.63	2.41	2.35
Pounds soil loss per plot			829		1,986		4,665		

[1] Calculated on basis of pounds per plot.

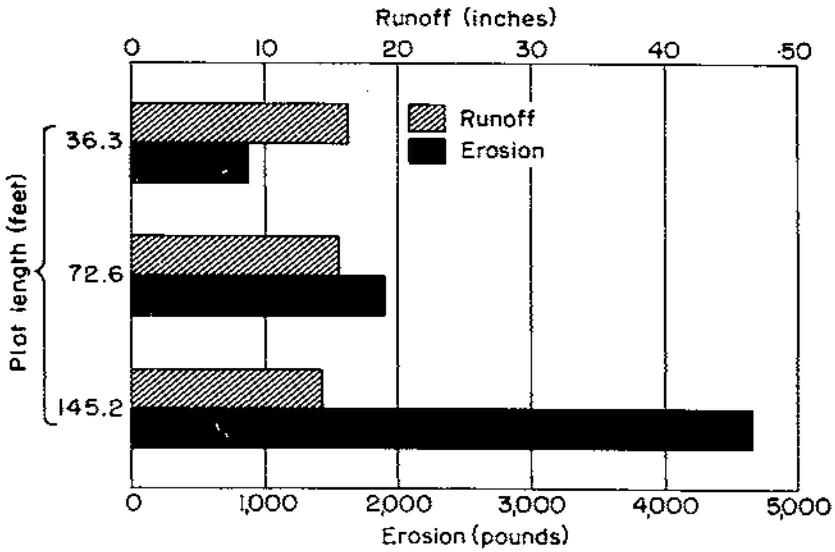

FIGURE 15.—The effect of length of slope on soil and water losses.

the slope length. Doubling the length of slope multiplied the soil loss in pounds per plot by 3.03.

Although the average runoff figures show a slight decrease in runoff with increase in slope length, the data for the Zanesville plots are not consistent in this respect. Musgrave and Norton (*29*) report a consistent decrease in runoff accompanying an increase in slope length.

The effect of degree of slope on erosion and runoff.—Control plots 3, 14, and 15 on 12-, 8-, and 20-percent slopes, respectively, were established to study the relationship between degree of slope and erosion and runoff. They were planted to corn each year and treated in the same manner as the plots on which the length-of-slope study was made. Annual soil and water losses for the degree-of-slope study are recorded in table 9. Detailed results are shown in tables 41 and 42, Appendix.

TABLE 9.—*Runoff and soil loss from control plots of different slopes, planted annually to corn without fertilizer*

Year	Plot 14, 8-percent slope		Plot 3, 12-percent slope		Plot 15, 20-percent slope [1]	
	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss
	Inches	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*
1934	6.60	31.39	9.00	36.17	5.25	29.10
1935	12.73	72.48	15.28	83.97	9.62	67.56
1936	13.90	79.06	21.62	100.37	12.91	126.32
1937	12.94	66.09	18.82	88.22	20.42	109.67
1938	11.64	78.02	16.37	118.65	12.28	139.73
1939	14.78	87.47	18.31	132.34	13.96	142.82
1940	15.72	63.14	18.63	103.07	13.80	88.19
1941	8.98	78.74	10.79	131.49	9.58	155.44
1942	12.59	82.06	12.40	100.32	10.83	120.33
9-year average	12.21	70.94	15.69	99.30	....	....

[1] Data for plot 15 are not directly comparable with those of plots 3 and 14 because of known abnormal ground-water conditions under the plot.

TABLE 10.—*Annual runoff and soil loss from plots receiving different treatments for 9-year period, 1934–42*

Year	Rainfall	Plot 3, Continuous corn		Plot 8, bare, fallow		Plot 21, bare, fallow		Plot 12, desurfaced		Plot 9, wild grasses		Plot 10, bluegrass		Plot 11, blue gras	
		Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss
	Inches	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*
1934	26.58	9.00	36.17	11.69	41.32			8.72	75.62	1.30	0.046	1.14	0.079	0.76	0.067
1935	42.44	15.28	83.07	17.67	68.10			14.24	97.35	2.73	.023	1.98	.020	1.93	.019
1936	40.40	21.62	100.37	24.06	97.74			19.22	105.02	3.60	.028	3.99	.022	2.96	.017
1937	43.74	18.82	88.22	18.46	108.85			14.42	56.35	3.67	.026	3.73	.025	2.22	.020
1938	40.57	16.37	118.65	17.61	139.24			11.92	65.72	.64	.002	.53	.002	.64	.001
1939	43.17	18.31	132.34	18.26	139.29			12.37	73.64	2.61	.033	1.80	.015	2.72	.020
1940	43.26	18.63	103.06	19.90	83.52	18.94	94.33	11.84	51.26	3.26	.048	2.53	.032	2.10	.016
1941	31.27	10.79	131.49	12.91	117.31	11.94	127.15	9.68	76.94	.35	.018	.30	.008	.39	.010
1942	38.64	12.40	100.32	16.28	73.81	16.08	106.82	10.47	50.88	.80	.033	.68	.017	.12	.002
9-yr. average	38.90	15.69	99.30	17.43	96.58	[1] 15.65	109.44	12.54	72.53	2.11	.028	1.85	.023	1.54	.019

[1] 3-year average.

The data for plot 15 have not been averaged because of a discovery that subsurface drainage under this plot was such as to vitiate the results obtained.

As a 9-year average, the 8-percent slope lost 12.2 inches as runoff and 70.9 tons per acre of soil as compared with losses of 15.7 inches of runoff and 99.3 tons of soil from the steeper slope. Other degree-of-slope studies are discussed in a subsequent section of this report.

The effect of vegetation, degree of erosion and surface condition on erosion and runoff.—From table 10 and figure 16 the remarkable

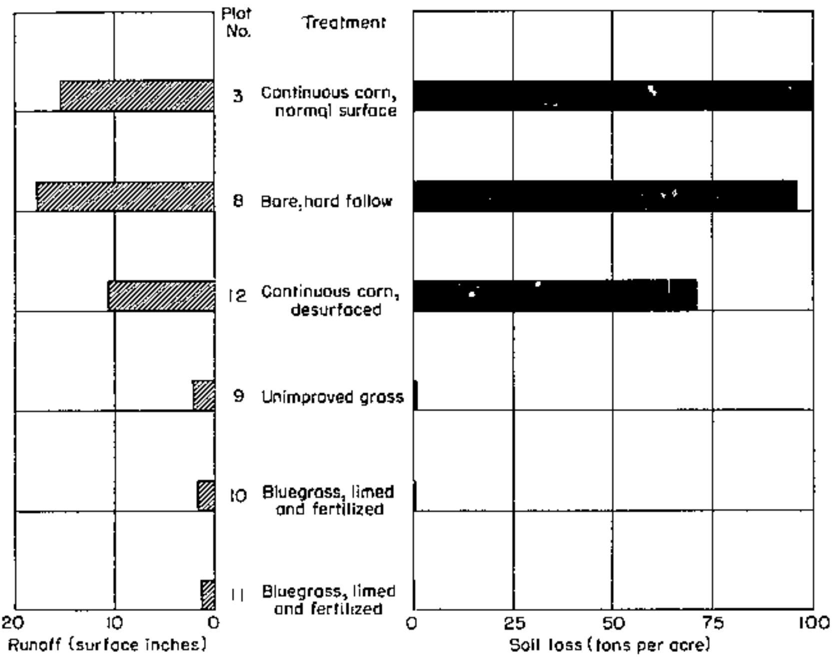

FIGURE 16.—Effect of crop and soil treatment on runoff and soil losses.

effectiveness of grass in holding soil and water is at once apparent, as erosion from the 3 grass plots (fig. 17) was negligible while the bare and the cropped plots lost amounts varying from about 72 to nearly 110 tons per acre annually.

There appears to be slightly lower runoff from the bluegrass plots than from the unimproved native grass plot, but an examination of the yearly results indicates that this difference has little significance. An examination of individual rain data brings out the fact that in certain intense summer storms the runoff was somewhat greater from the unimproved or native grass. Had these plots been grazed, doubtless both soil and water losses from this plot would have been materially greater than from the bluegrass plots.

It is of interest that the plot in corn each year lost more soil than the bare, hard, fallow plot, in spite of the fact that the corn crop furnished some canopy and root protection.

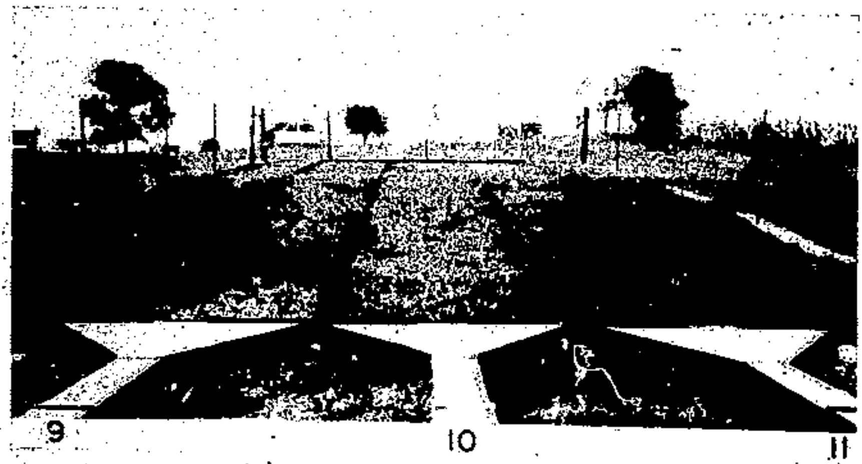

FIGURE 17.—Control plot 9 (left) in native unimproved grass and plots 10 and 11 in bluegrass.

FIGURE 18.—*A*, Corn on the desurfaced (subsoil) plot 12; *B*, corn on normally eroded plot 3. Pictures were taken July 7, 1937.

For the first 3 years of the period, the desurfaced plot lost more soil than the corn plots, whereas, during the last 6 years, erosion from the desurfaced plot was materially less. The formation of an "erosion pavement" on the latter plot (shale particles) may account for part of the reduction in its erosion rate. Observations lead to the belief that a difference in soil structure of the deeper horizon of this plot was also partly responsible for the results recorded. The runoff from the desurfaced plot was consistently less than that from the corn and bare plots.

The relation of depth of topsoil to crop production is shown in figure 18, which affords a comparison of corn on normal soil and on subsoil. Corn was planted each year on the desurfaced plot 12. Ears never developed and the plants grew only to a height of 24–40 inches. The average yield of stover on the plot was 314 pounds. The production of plot 3, normal soil, is discussed in a subsequent section.

Detailed data secured from these plots are to be found in Tables 41, 43, and 44, Appendix.

The effect of a rotation of crops on erosion and runoff.—Results from the rotation plots (limed but not fertilized) are compared with those from a continuous-corn plot in table 11 and figure 19. The annual average water loss from the rotation was 8 surface inches less than from continuous corn. The erosion was only 13.4 tons per acre from the rotation as compared with 99.3 tons from continuous corn. Detailed data for the 9 years are given in tables 41 and 44, Appendix.

As would be expected, the soil and water losses from the plots in the crop rotation are much less than from plots continuously cropped with corn. A good part of this reduction in erosion results from the increase in vegetative cover afforded by the rotation. The rotation plots had fair to good vegetal protection during all but about 7 months of the entire 4-year rotation period. This 7-month period of poor protection occurred from about April 15, when the soil was plowed for corn, until November 1–15, when the wheat following the corn had made sufficient growth to serve as a cover crop.

However, this difference in amount of vegetal cover as compared to continuous corn has not been responsible for all the soil saved by the rotation, since rotation corn has lost less than half the soil continuous corn did. Obviously, the rotation sod crop plowed under for corn helped to reduce both erosion and runoff.

Since calendar-year losses for rotation corn were reduced to some extent by the meadow which preceded the corn, a comparison was made on a growing-season basis to determine the effect of the plowed-under sod on runoff and erosion. This comparison, given in table 12 and in table 45, Appendix, shows that rotation corn lost 47 tons less soil and about 2¼ inches less water than did the continuous corn. The reduced runoff (2.24 inches) may account, theoretically, for the saving of about 14 tons of soil per acre, leaving a saving of about 33 tons to be accounted for otherwise. Doubtless, increased canopy and root growth of the rotation corn brought about some reduction in erosion. Very evidently, however, erosion resistance was built up in the soil by the rotation sod.

TABLE 11.—*Annual runoff and soil loss from plots in a crop rotation and in continuous corn, for the 9-year period, 1934–42*

Year	Rainfall	Plot 3, continuous corn		Plot 13, continuous corn [1]		Plots 4, 5, 6, and 7									
						Rotation corn		Rotation wheat		Rotation meadow (1 year of grass)		Rotation meadow 2 years of grass)		Average	
		Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss
	Inches	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*
1934	26.58	9.0	36.1	10.9	27.2	6.2	13.3	7.3	7.3	2.6	0.07	3.6	0.49	4.9	5.3
1935	42.44	15.3	83.1	17.1	73.9	10.4	41.9	7.5	.32	7.9	.19	5.4	.05	7.8	10.6
1936	40.40	21.6	100.4	19.8	65.1	11.6	54.3	14.7	19.0	11.1	.34	3.9	.16	10.3	18.4
1937	43.74	18.8	88.2	20.1	84.3	9.9	41.9	10.8	5.4	8.6	.41	10.7	.16	10.0	12.0
1938	40.57	16.4	118.6	23.2	107.8	10.9	72.6	8.6	4.0	3.3	.09	2.1	.02	6.2	19.2
1939	43.17	18.3	132.3	23.4	113.3	8.9	33.0	10.9	18.6	9.9	.62	7.0	.16	9.1	13.1
1940	43.26	18.6	103.1	18.1	92.4	11.4	41.8	12.0	13.7	8.7	1.56	10.7	.58	10.7	14.4
1941	31.27	10.8	131.5	11.3	106.3	6.7	48.2	7.4	22.8	.67	.10	.57	.09	3.8	17.8
1942	38.64	12.4	100.3	13.3	97.0	7.3	26.5	7.8	11.1	9.3	1.86	.87	.30	6.3	9.9
9-yr. average	38.90	15.7	99.3	17.4	85.3	9.2	41.5	9.7	11.4	6.9	.58	5.0	.22	7.7	13.4

[1] Fertilized.

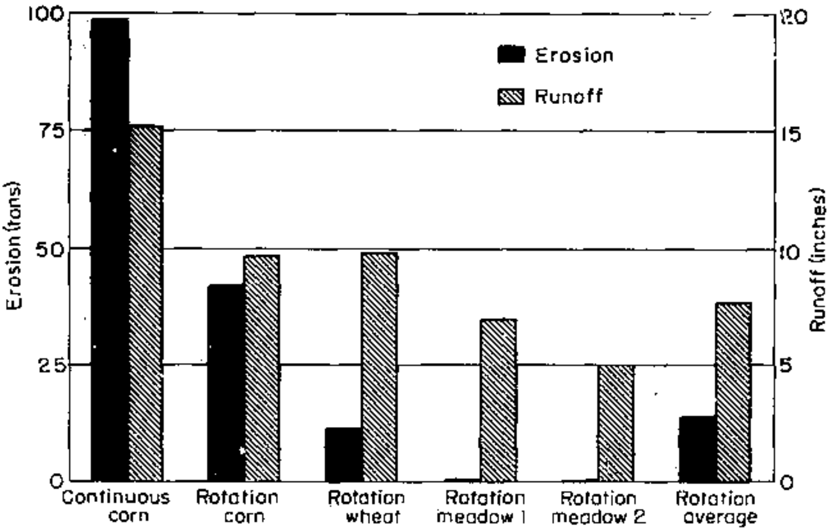

FIGURE 19.—Comparison of annual runoff and erosion from plots in continuous corn and a 4-year rotation.

TABLE 12.—*Comparison of runoff and soil loss from plots in rotation corn and continuous corn for the 5-month corn season*

[9-year average]

Month	Rainfall	Runoff		Erosion		Calculated infiltration [1]	
		Continuous corn	Rotation corn	Continuous corn	Rotation corn	Continuous corn	Rotation corn
	Inches	*Inches*	*Inches*	*Tons*	*Tons*	*Inches*	*Inches*
May	3.66	1.05	0.50	8.10	1.79	2.61	3.16
June	5.23	2.20	1.78	31.06	15.19	3.03	3.45
July	3.45	1.17	.86	20.46	8.00	2.28	2.59
August	4.79	2.57	1.99	19.54	10.66	2.22	2.80
September	3.00	1.43	1.06	7.67	4.21	1.57	1.94
Total	20.13	8.42	6.19	86.83	39.85	11.71	13.94

[1] Total rainfall minus surface runoff.

Evidence that erosion resistance from sod is of short duration was obtained from one of the duplicate control plots in 1939. On the original rotation plots, corn followed the usual 2 years of sod (1937–38). The duplicate plot was in sod in 1937, was spaded and left fallow in 1938, and was planted to corn in 1939. In table 13 and figure 20 soil and water losses from these two plots during the summer and fall are compared with losses from the continuous-corn plot.

Presumably a 1-year-old sod might not offer as much resistance to erosion as the 2-year sod, which fact may account for some of the difference in erosion from the two plots. However, the results indicate that under these conditions the erosion-control value of sod disappears in a comparatively short time.

TABLE 13.—*Comparison of soil and water losses from corn planted following 2 years of sod, 1 year sod and 1 year fallow, and corn grown continuously*

Crop and condition	Water loss	Soil loss
	Inches	*Tons*
Corn following 2 years of sod	6.8	32.2
Corn following 1 year of sod and 1 year of fallow	9.0	107.4
Corn following corn, no sod	11.4	119.3

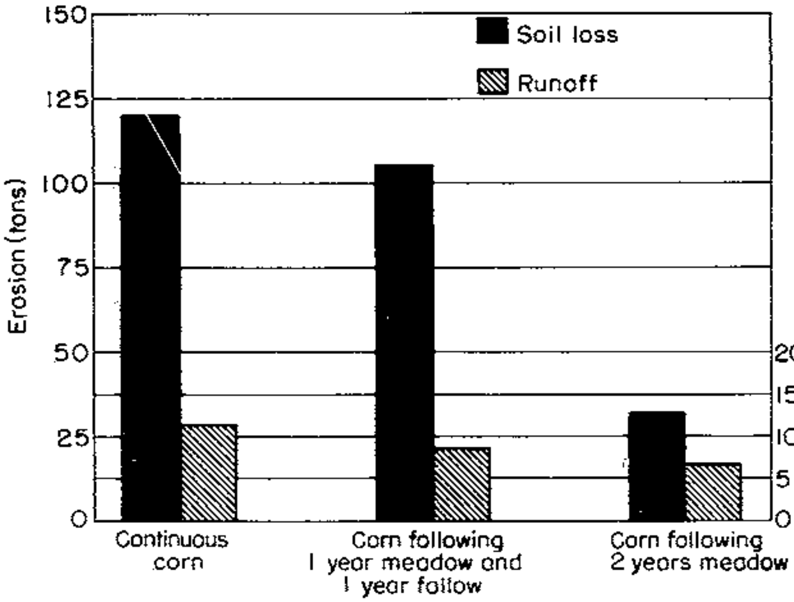

FIGURE 20.—Erosion and runoff from plots planted to continuous corn, to corn following 1 years of sod and 1 year fallow, and to corn following 2 years of sod.

Further studies of sod plowed under for corn.—There is a current opinion that if a sufficiently good sod is turned under for the corn crop, erosion will be negligible.

The rotation control plots indicated that when a 2-year old sod was plowed for corn, erosion was reduced to one-half that from continuous corn but was still more than 40 tons per acre. However, these sods were not the best. The soil was poor and had not been fertilized. To evaluate the effect of better sods on losses from corn and to compare sods of different quality, duplicate 1/250-acre plots were installed in 1941 on a 5-year-old alfalfa-orchard grass sod, on an alfalfa sod of the same age containing some bluegrass, and on timothy sod 2 years old. The slopes were all approximately 15 percent. The alfalfa-orchard grass sod was dense and an examination of it showed that the grass roots were abundant to a depth of 8 to 10 inches. The alfalfa sod contained only a little bluegrass and the timothy sod was rather thin. Mechanical analyses of the soils showed that the alfalfa-orchard grass plots contained somewhat more clay than the other plots.

The runoff and erosion losses from the principal rains of the 1941 corn season are given in table 14. The erosion from the plot where

TABLE 14.—*Comparative effect of plowing under different types of sod on runoff, soil loss, and corn yields for the growing season June, July, and August, 1941*

[Average rainfall—11.97 in.]

Type of sod plowed under for corn	Runoff			Soil loss			Crop yields	
	Plot A	Plot B	Average	Plot A	Plot B	Average	Corn	Stover
	Inches	*Inches*	*Inches*	*Tons*	*Tons*	*Tons*	*Bushels*	*Pounds*
Alfalfa	4.83	4.79	4.81	30.47	29.48	29.97	32.6	4040
Alfalfa-orchard grass	6.29	6.65	6.47	30.64	33.83	32.23	31.7	2685
Timothy	5.02	4.76	4.89	46.23	41.63	43.93	30.9	2185

timothy sod was plowed (approximately 44 tons per acre) was similar to that from the rotation control plots; that from the alfalfa-orchard grass plots was nearly 12 tons per acre less, or 32.2 tons, and that from the lafalfa was 14 tons less or about 30 tons. That runoff as well as erosion was greater from the alfalfa-orchard grass plots than from the alfalfa plots, may have been due to the higher percentage of clay in the soil. The results bring out the fact that while plowing under sods materially reduces losses, it does not satisfactorily control erosion. This is particularly true when the crop residue is completely buried.

Detailed studies at this station of the effect of raindrop impact on erosion and runoff, previously published (*9*) and discussed on page 52, showed that in the absence of a surface mulch of some sort, Muskingum soils crust or seal. Similar findings were reported by Duley (*16*) and Duley and Kelly (*18*, *19*) for other soils. The plots in this test were crusted or sealed by the first rains, since after they had been plowed 6 inches deep, insufficient plant residues remained at the surface o the soil to prevent sealing and the resultant serious runoff and soil loss. The plant residues, when buried by plowing, lose much of their effectiveness in preventing sealing and erosion.

The effect of winter cover on runoff and erosion.—While winter erosion in Ohio is small in comparison with summer losses, some winter protection is desirable, especially on steep slopes. Although no special study was made of the effectiveness of winter cover crops, some idea of the losses from unprotected soil as compared with the losses from soil seeded to wheat can be gained from the data given in table 15 on

TABLE 15.—*Winter losses from plots in winter wheat or corn stubble from October 1 to March 31*

[9-year average]

Cover	Water loss	Soil loss
	Inches	*Tons*
Corn stubble, only	6.0	9.7
Winter wheat	3.3	2.4

winter losses from the continuous-corn plot and from rotation plots in wheat. The continuous-corn plot probably had less protection than the average cornfield, since the plot was usually entirely free of weeds. Only the stubble remained.

On the other hand, the slope was shorter than many in cultivation. The data show that the unprotected corn land lost an average of 7 tons more soil than the wheat land and nearly 3 inches more water during the winter period. Considering both soil and water losses, particularly the latter, the value of winter cover is apparent.

Some relationships between organic matter, crop yields, and erosion when corn is grown continuously.—The number of surface inches removed annually by erosion, annual corn yields, and the percentage of organic matter for plot 3 in continuous corn, unfertilized, are shown graphically in figure 21.

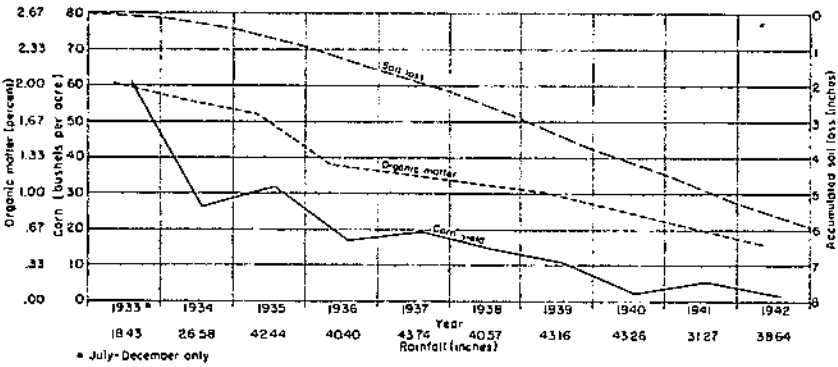

FIGURE 21.—The relation of erosion to organic matter and crop yields, continuous corn plot.

Close relationships between erosion, organic matter, and crop yields are evident. Nearly 6 inches of soil was eroded from the plot during the 9 years.

While plant growth has been influenced noticeably by variations in growing-season rainfall, a general downward trend in yields is apparent. The yield of corn (grain) decreased from a little more than 60 bushels per acre in 1933 to 1.6 bushels in 1942. The loss of organic matter did not keep pace whith the soil loss, possibly because of the annual addition of crop root material and a progressively decreasing loss of the original topsoil as it is mixed with more and more subsoil from year to year.

Doubtless, since the plot was unfertilized, the decrease in crop yields was caused in part by a depletion of the nutrients and organic matter available to the growing crop. However, it would seem that the decrease in yield may be attributed largely to the loss of topsoil and an accompanying removal of organic matter and mineral nutrients.

The effect of fertilizing corn on runoff and erosion.—To study the possible effect on runoff and erosion, of fertilizing corn, plot 13 in continuous corn, fertilized, was carried on in comparison with other continuous-corn control plots which were not fertilized. A summary of soil and water losses resulting from these treatments is given in table 16. More detailed data are shown in tables 41 and 43, Appendix.

The average annual soil loss from the fertilized plot was about 14 tons an acre less than the loss from the unfertilized plot. A rain-by-rain examination of the data for the 9 years indicates that the soil losses from the two plots were rather consistently similar before the crop season started and that the differences in losses occurred during the crop season. It would seem that the greater leaf and stalk growth on the fertilized plot afforded a slightly greater canopy protection and the greater root growth may have tended to hold the soil in place. That the fertilized corn was slightly more vigorous than the unfertilized corn is indicated by the crop yields.

TABLE 16.—*Summary of runoff losses and yields from fertilized and unfertilized corn plots*

[9-year average]

Plot No.	Crop and treatment	Water loss	Soil loss	Acre yields	
				Stover	Grain
		Inches	*Tons*	*Pounds*	*Bushels*
3	Continuous corn, unfertilized	15.7	99.3	1,818	14.5
13	Continuous corn, fertilized [1]	17.4	85.3	2,238	16.4

[1] 150 pounds per acre of 4-10-6 fertilizer applied in the row.

Average water loss was slightly greater from the fertilized plot than from the unfertilized. Unlike the soil loss, this difference in runoff occurred mostly during the noncrop months. It is probable that subsurface conditions made for slightly greater runoff from the fertilized plot during the fall, winter, and spring when the soil was, at times, nearly saturated.

The loss of plant nutrients by erosion.—During the summer of 1940, analyses were made of aliquot samples of the washoff from eight 1/100-acre corn plots, to determine the erosion losses of plant nutrients from Muskingum soil. The findings, which cover a 100-day experimental period, are given in table 17.

The average loss of nitrogen from the two unfertilized plots was 102.7 pounds per acre for the 100-day period, and that from the fertilized plot 104.9 pounds. The phosphorus (P_2O_5) losses averaged 142.6 pounds per acre from the unfertilized plots and 149.4 from the fertilized. Although there was a higher concentration of both nitrogen and phosphorus in the supernatant liquid (containing some soil) from the fertilized plot than from the unfertilized, the percentages of these nutrients in the sediment (sludge) were nearly the same. Nor was there a significantly higher amount of nitrogen and phosphorus per ton of eroded material from the fertilized plot than in the average losses from the unfertilized. In general, losses of nutrients from all of the plots were governed by total soil losses. Contour cultivation used on some of the plots lessened the fertility losses by reducing soil losses.

Nitrogen losses were greater from plots top-dressed with nitrate of soda than from those not top-dressed. On the top-dressed plots, also, contouring reduced the soil loss to less than half and nitrogen

TABLE 17.—*Plant nutrient losses*[1] *in runoff and washoff from experimental plots in Muskingum silt loam*

Treatment and plot No.	Crop and treatment	Loss per acre		Nitrogen losses						Phosphorus losses (P_2O_5)						Potash losses (K_2O)		
				In top-water[2]		In sediment		Total		In top-water[2]		In sediment		Total		In sediment		
		Soil	Runoff	Per 1,000 cubic feet	Per acre	Percent	Per acre	Per acre	Per ton of washoff	Per 1,000 cubic feet	Per acre	Percent	Per acre	Per acre	Per ton of washoff	Percent	Per acre	Per ton of washoff
		Tons	*Cu. ft.*	*Lbs.*	*Lbs.*	*Pct.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Pct.*	*Lbs.*	*Lbs.*	*Lbs.*	*Pct.*	*Lbs.*	*Lbs.*
Control plot:																		
3	Corn annually, unfertilized.	67.3	220.4	0.473	10.42	0.09	115.6	126.0	1.87	0.498	10.97	0.12	154.7	165.7	2.46	1.67	1,327.0	39.49
16	Corn annually, unfertilized.	56.1	201.8	.475	9.58	.08	69.8	79.4	1.42	.762	15.37	.11	104.0	119.4	2.13			
Average 3 and 16	do	61.7	211.1	.474	10.00		92.7	102.7	1.64	.624	13.17		129.4	142.6	2.31			
13	Corn annually, fertilized.	60.3	213.4	.704	15.03	.09	89.9	104.9	1.74	.822	17.54	.13	131.9	149.4	2.48			
Contour-cultivated plot, fertilized:																		
23	Corn, up-and-down slope.	43.8	196.5	.751	14.75	.09	76.9	91.7	2.09	.533	10.47	.12	101.8	112.2	2.56	3.23	1,584.6	64.66
24	Corn, contoured	15.6	124.8	.555	6.93	.10	26.7	33.7	2.16	.633	7.90	.12	30.9	38.8	2.49	2.60	601.2	52.09
25	Corn, contoured plus soybeans in row.	14.9	118.1	.516	6.10	.10	25.8	31.9	2.14	.572	6.75	.14	36.3	43.1	2.89			
Top-dressed (nitrate of soda) plots:																		
26	Corn, up-and-down slope, top-dressed.	41.0	102.5	.524	5.37	.11	40.9	46.3	1.10									
27	Corn, contoured, top-dressed.	19.8	82.5	.531	4.38	.11	19.8	24.2	1.22									

[1] Nitrogen and phosphorus losses for period May 25 to Aug. 30 and potassium losses from May 25 to June 18, 1940.
[2] Supernatant liquid in catchment tanks.

FIGURE 22.—View of the cultivated watershed in corn.

losses to not quite half of those on plots not top-dressed. The loss of nitrogen was slightly higher per ton of soil loss from the contoured plot than from the plot not contoured.

Potassium (K_2O) losses were determined in the heavy sediment from three plots for only a portion of the summer. Losses of this element ranged from 39.5 pounds to 64.7 pounds per ton of soil loss. Assuming the same proportionate losses for the season, the loss from plot 3 would have been 2,654 pounds per acre.

These losses are much higher than those reported by Duley and Miller (*20*) and Miller and Krusekopf (*27*) from plots growing corn annually, but compare fairly well with the losses from plots of bare, cultivated soil when it is considered that the present losses were for a 100-day summer period.

Former workers, including Lipman and Conybeare (*23*), have pointed out that the fertility taken from the soil by erosion is as great as that taken from the soil by crops. In the plots used in this study the fertility losses in runoff were much greater than those caused by cropping, since the corn crop on these plots produced less than a ton per acre.

The percentage of nitrogen in the sediment of the eroded material compares well with analysis of the Muskingum soil of these plots by Middleton, et al. (*26*). The percentage of K_2O is slightly lower than the figure reported by these investigators, and the percentage of P_2O_5 is 2 to 4 times as great as the figure they report.

Effect of Land Use on Runoff and Erosion—Watershed Studies

Early in the history of the station, three watersheds were laid out and equipped with the necessary devices for measuring the runoff and soil losses from each. (See figs. 22, 23, and 24.)

A pasture watershed of about 3.5 acres was located near the northwest corner of the station farm, a cultivated watershed of 2.5 acres near the southwest corner, and a wooded watershed of a little more than 2 acres on the edge of the tract near the center of the eastern

FIGURE 23.—The pasture watershed and measuring device.

FIGURE 24.—A portion of the wooded watershed and measuring device.

boundary (fig. 6). Runoff records were begun in 1933 and the early results have been reported.[5]

The crops on the cultivated watershed and treatment are given in table 37, Appendix. Excellent meadows have been obtained and good sods have been plowed under for the corn crops. No erosion control practices have been used except that planting has been done approximately across the major slope.

Erosion.—Soil loss from the pasture and wooded watersheds has been negligible, whereas that from the cultivated area averaged 17.2 tons annually. (See fig. 25 and table 18). This amount represents about ⅛ of a surface inch. At this rate, 7 inches of topsoil would be removed in 63 years. Obviously, the erosion from the cultivated watershed varied markedly with the crop grown. Figure 26 and

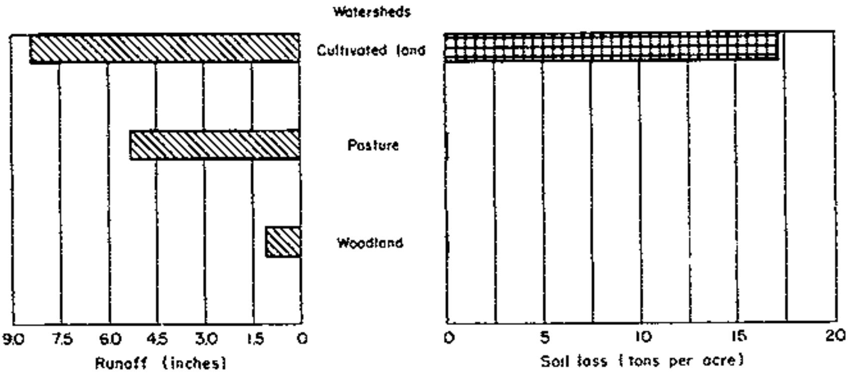

FIGURE 25.—Average soil and water losses from cultivated, pasture, and wooded watersheds.

TABLE 18.—*Comparison of runoff and soil loss from cultivated, pasture, and wooded watersheds for the 9-year period 1934–42*

	Wheat, 1934	Meadow, 1935	Corn, 1936	Wheat, 1937	Meadow, 1938	Corn, 1939	Wheat, 1940	Meadow, 1941	Corn, 1942	9-year average	Percent of total rainfall
Cultivated watershed (2.55 acres):											
Rainfall (inches)	23.87	41.27	38.80	44.49	40.73	43.62	42.50	20.78	37.76	38.09	.....
Runoff (annual inches)	5.27	7.58	11.66	12.81	6.24	10.65	8.89	1.42	6.01	7.84	20.6
Soil loss (tons)	11.64	2.45	72.39	14.00	.55	31.71	3.90	.11	16.93	17.18	.....
Pasture watershed (3.57 acres):											
Rainfall (inches)	23.87	41.27	30.26	45.53	41.05	42.70	43.07	31.32	38.67	38.30	.....
Runoff (annual inches)	1.12	3.82	5.78	9.53	5.83	8.82	7.22	.97	4.34	5.30	13.8
Soil loss (tons)	.16	.09	.13	.15	.06	.21	.04	.04	.03	.10	.....
Wooded watershed (2.23 acres):											
Rainfall (inches)	23.87	41.27	38.21	42.61	39.30	42.20	41.71	20.32	37.67	37.35	.....
Runoff (annual inches)	.01	.80	.55	4.51	.50	1.40	2.62	.01	.33	1.20	3.2
Soil loss (tons)	.01	.01	.01	.04	(1)	.01	.02	(1)	.01	.01	.....

[1] Trace.

[5] BORST, H. L., AND WOODBURN, R. HYDROLOGIC STUDIES—COMPILATION OF RAINFALL AND RUNOFF FROM THE WATERSHEDS OF THE NORTH APPALACHIAN CONSERVATION EXPERIMENT STATION, ZANESVILLE, OHIO—1933-38. U. S. Dept. Agr. SCS-TP-26, 25 pp., illus. 1939. [Processed.]

——. SOIL AND WATER LOSSES FROM THREE AREAS DEVOTED TO DIFFERENT LAND USES—A PRELIMINARY REPORT. Soil Conserv. Serv. in cooperation with Ohio Agr. Expt. Sta., Release No. 1, 9 pp., illus. 1940 [Processed.]

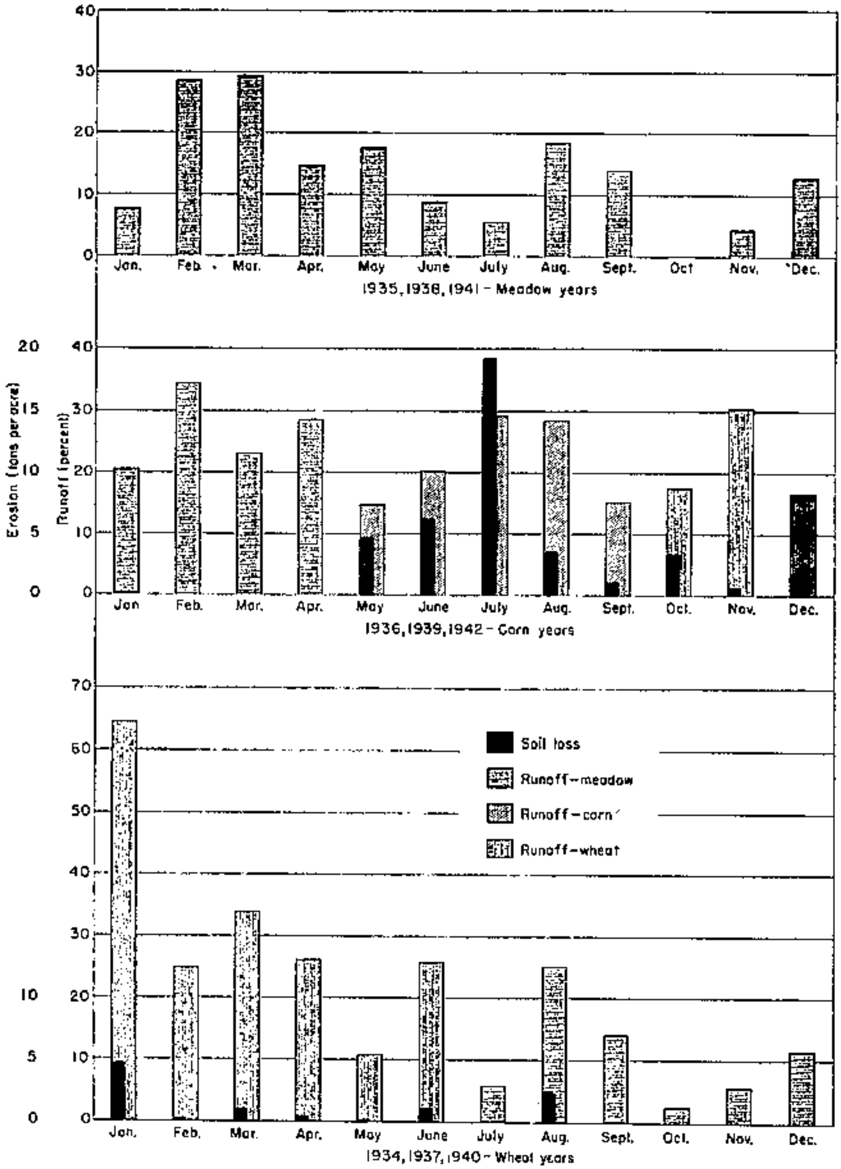

FIGURE 26.—Average monthly distribution of runoff and soil loss from the cultivated watershed for the corn, wheat, and meadow years.

table 19 bring out the fact that most of the loss has occurred during the months when this area was in corn. The average annual loss for this crop (5 months in corn) has been 40 tons per acre, about the same as from the rotation corn plots. It is of interest that most of the erosion during the corn season occurred in July, whereas control-plot losses were greatest in June. This may be accounted for by the fact that this watershed was in corn at the time of the extremely heavy rain of July 4, 1936, which alone produced 40 tons of erosion.

TABLE 19.—*Average monthly runoff from a cultivated watershed for the wheat, meadow, and corn years*[1]

Month	Average of 3 wheat years 1934, 1937, and 1940				Average of 3 meadow years 1935, 1938, and 1941				Average of 3 corn years 1936, 1939, and 1942			
	Rain	Runoff		Soil loss	Rain	Runoff		Soil loss	Rain	Runoff		Soil loss
	Inches	*Inches*	*Percent*	*Tons*	*Inches*	*Inches*	*Percent*	*Tons*	*Inches*	*Inches*	*Percent*	*Tons*
January	4.43	2.86	64.6	4.53	1.81	0.14	7.7	0.01	1.76	0.37	20.5	0.01
February	1.53	.38	24.8	.22	1.61	.46	28.6	.12	3.15	1.08	34.3	.04
March	2.30	.78	33.9	.06	3.00	.88	29.3	.29	3.30	.76	23.0	.18
April	3.85	1.01	26.2	.40	2.17	.32	14.7	.01	3.64	1.04	28.6	.06
May	3.53	.38	10.8	.18	5.05	.80	17.6	.20	2.38	.35	14.7	4.61
June	5.43	1.40	25.8	1.08	4.38	.39	8.9	.08	5.47	1.10	20.1	6.14
July	2.02	.14	6.9	.13	3.75	.21	5.6	.04	4.25	1.24	29.2	19.23
August	4.72	1.19	25.2	2.43	5.53	1.01	18.3	.24	4.14	1.18	28.5	3.52
September	2.61	.37	14.2	.13	3.16	.44	13.9	.03	3.10	.47	15.2	1.06
October	2.05	.05	2.4	([2])	2.21	([2])	0	0	3.74	.66	17.6	3.32
November	2.06	.14	6.8	.01	2.73	.12	4.4	([2])	2.49	.76	30.5	.56
December	2.43	.29	11.5	.01	1.86	.23	12.9	.01	2.63	.43	16.7	1.62
Total	36.96	8.99	24.3	10.14	37.26	5.09	13.7	1.03	40.05	9.44	23.6	40.3

[1] Calendar years.
[2] Trace.

As would be expected, erosion from rotation meadow was negligible. The high soil loss from wheat in January probably would not occur over a longer period of years, as wheat was on the cultivated watershed during the flood period of January 1937, at which time erosion was unusually severe. Overlooking this period, October is shown to be the most erosive period for land seeded to wheat after corn.

Runoff.—The average annual water losses from the 3 areas have been from woods, 1.20 inches or 3.2 percent; pasture, 5.30 inches or 13.8 percent; and cultivated, 7.84 inches or 20.6 percent. Average monthly losses are shown in figure 27.

The effect of land use on water relationships is indicated in figure 27, where probable infiltration, computed as percentage of rainfall, is shown for the three watersheds. The low infiltration rate for January reflects the flood period of 1937, when more than 10 inches of rain fell in 24 days.

On the average, infiltration in the woods equaled rainfall, or very nearly so, during August, September, and October. Runoff occurred during the winter, spring, and early summer. Runoff from the cultivated watershed varied, as did erosion, with the crop grown. The greater runoff from corn and wheat land for comparable seasons of the year is noteworthy.

In general, the runoff from rotation meadow was greater than that from pasture, although in some months the reverse was true. Water losses from wheat were usually higher than from meadow or pasture.

While the average runoff data are of interest from the standpoint of soil and moisture conservation, they hardly apply when consideration is given to the effect of land use on floods. Floods occur when other than average conditions of rainfall and soil moisture prevail. Table 20 lists a number of outstanding rains and storm periods that have occurred during the period of the experiment, some of which have contributed to or have produced serious flood conditions in the Muskingum Valley.

It is evident that the runoff from the three areas has on many occasions differed widely from the annual average figures. The same

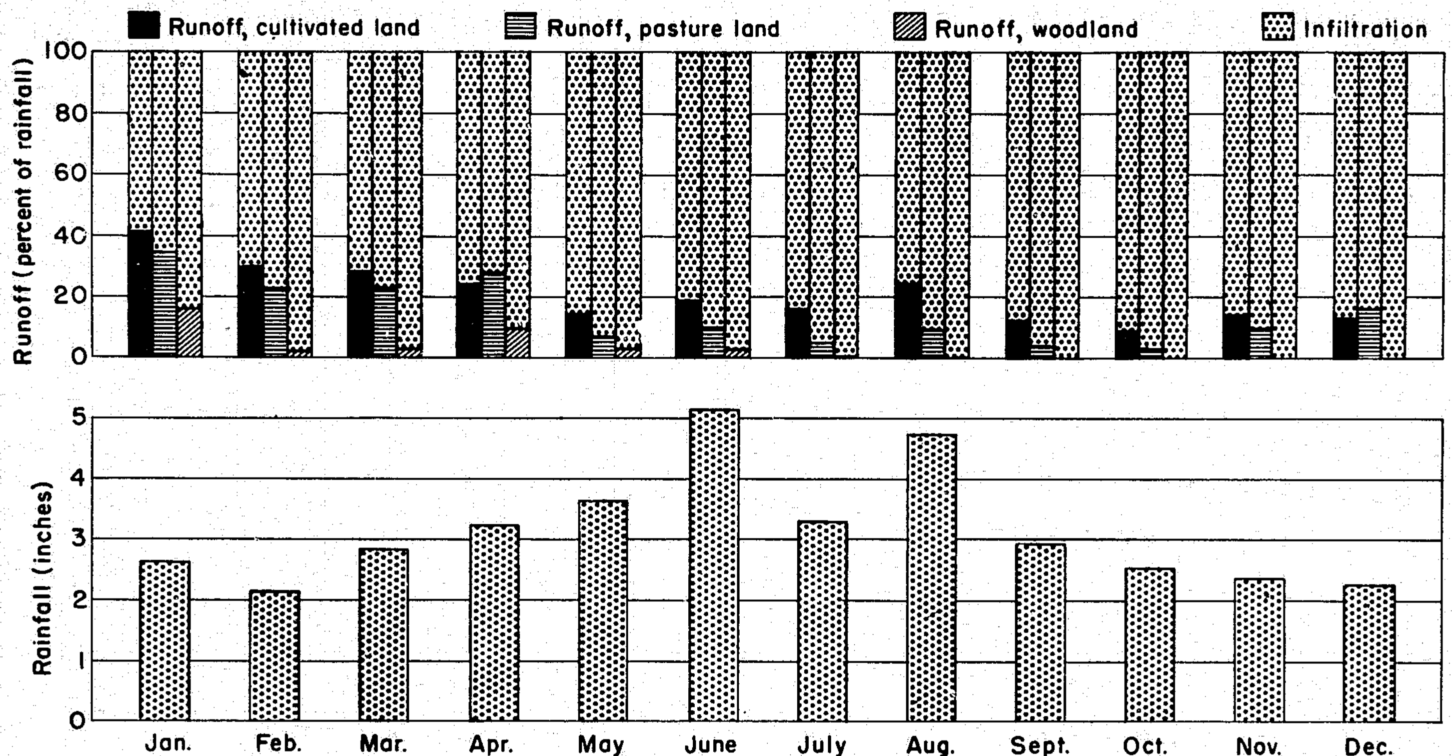

FIGURE 27.—Comparison of runoff and probable infiltration on cultivated, pasture, and wooded watersheds.

factors which produce variations in runoff from areas in different vegetative covers also cause variations in runoff throughout the year. The total amount of water in the soil is important. This depends much on the duration and frequency of the rains. Obviously, if a soil is saturated there will be greater runoff from the land than if the soil is dry and porous. The effects of land use and vegetal cover diminish under under such conditions.

It is of interest that even where two watersheds approached the same runoff, the peak rates of runoff (table 20) differed materially. Peak rates, of course, are obtained for only short periods of time.

TABLE 20.—*Outstanding rainstorms and runoff from the three watersheds, 1934–42*

Date	Rainfall			Runoff			Peak rate runoff		
	Amount	5-minute maximum intensity	Duration	Cultivated land	Pasture	Woods	Cultivated land	Pasture	Woods
	Inches	*Inches per hour*	*Hours*	*Percent*	*Percent*	*Percent*	*Inches per hour*	*Inches per hour*	*Inches per hour*
1934									
Aug. 2	2.14	5.04	4	42.1	1.9	0	2.10	0.20	0
Aug. 15–16	2.92	2.52	14	59.2	6.5	0	2.00	.28	0
1935									
May 5–7	1.67	1.38	24	56.9	28.3	21.0	.67	.35	.07
Aug. 7 [1]	2.53	5.85	9	57.7	39.1	2.0	2.71	1.73	.02
Aug. 10 [1]	1.71	5.00	5	45.6	24.6	2.9	3.89	2.00	.04
1936									
Apr. 2	.98	1.92	3	44.9	50.0	1.0	.59	.45	.01
July 4	1.74	9.36	⅓	74.7	15.5	.6	[2] 11.70	1.55	[3]
1937									
Jan. 2	.29	.24	5	39.9	6.4	0	.11	[3]	0
Jan. 7–8	.30	.24	6½	23.6	5.5	0	.11	[3]	0
Jan. 9–10 [1]	.87	.20	20	71.8	21.5	2.8	.09	.03	[3]
Jan. 14–15 [1]	2.00	1.44	23	62.7	67.1	36.2	.80	.29	.06
Jan. 17–18 [1]	1.00	.24	21	75.4	59.3	16.6	.18	.13	.02
Jan. 20–23 [1]	3.15	1.44	42	85.9	74.6	34.2	1.17	.22	.06
Jan. 24–25 [1]	2.44	1.20	17	94.5	87.6	74.7	.70	.39	.13
Jan. 31	.34	.24	5¼	23.4	18.4	0	.02	.02	0
May 26	1.05	2.64	4	41.0	31.4	1.1	1.35	.57	[3]
June 20–21 [1]	3.46	4.32	11	54.3	49.1	22.1	3.49	1.90	.58
1938									
June 22	1.20	3.12	2	9.1	8.0	.2	.59	.33	0
June 26–27	1.64	2.87	10	20.2	22.1	.5	1.07	1.09	[3]
1939									
Feb. 14–15	1.49	.48	12	44.4	46.6	19.3	.20	.27	.04
Mar. 29–30	1.01	.36	17	19.6	36.3	11.6	.10	.13	.02
June 17–18–19	3.13	3.60	26	20.5	16.7	6.7	1.07	.70	.04
June 22	1.38	2.40	8	52.9	45.1	25.9	1.45	.88	.08
July 4–5	2.12	2.70	3	45.1	46.7	7.1	1.63	1.62	.06
Aug. 12–13	2.08	4.32	2	50.7	42.7	1.4	1.41	1.50	.05
1940									
Apr. 11	1.14	.36	10	19.0	31.2	7.2	.11	.20	.01
Apr. 17–20	4.48	.96	44	55.4	67.1	46.9	.40	.35	.19
May 23–24	1.77	1.56	19¼	10.7	.4	8.7	.21	.02	.01
May 29–31	1.19	.36	11	20.2	9.1	9.2	.09	.03	.01
June 11	.70	3.12	2	30.1	3.5	10.3	.44	.06	.0
June 28	1.15	1.68	2	42.6	24.0	.6	1.62	.82	[3]
1941									
July 18	1.83	5.76	1	19.8	18.8	.3	.18	1.36	[3]
Aug. 30–Sept. 5	2.14	6.24	4	19.1	17.1	.3	1.06	.95	[3]
1942									
Mar. 13–16	2.19	3.48	20	60.0	42.5	9.9	1.13	[4]	.05
Apr. 8–11	1.92	.60	19	54.3	61.4	8.0	.12	.10	.02
May 15	1.52	4.32	7	63.1	3.6	1.1	.98	.16	[3]
June 22	1.62	1.62	3	32.6	16.0	.4	.51	[4]	[3]

[1] Storms producing or contributing to flood condition.
[2] Approximate.
[3] Negligible.
[4] No record.

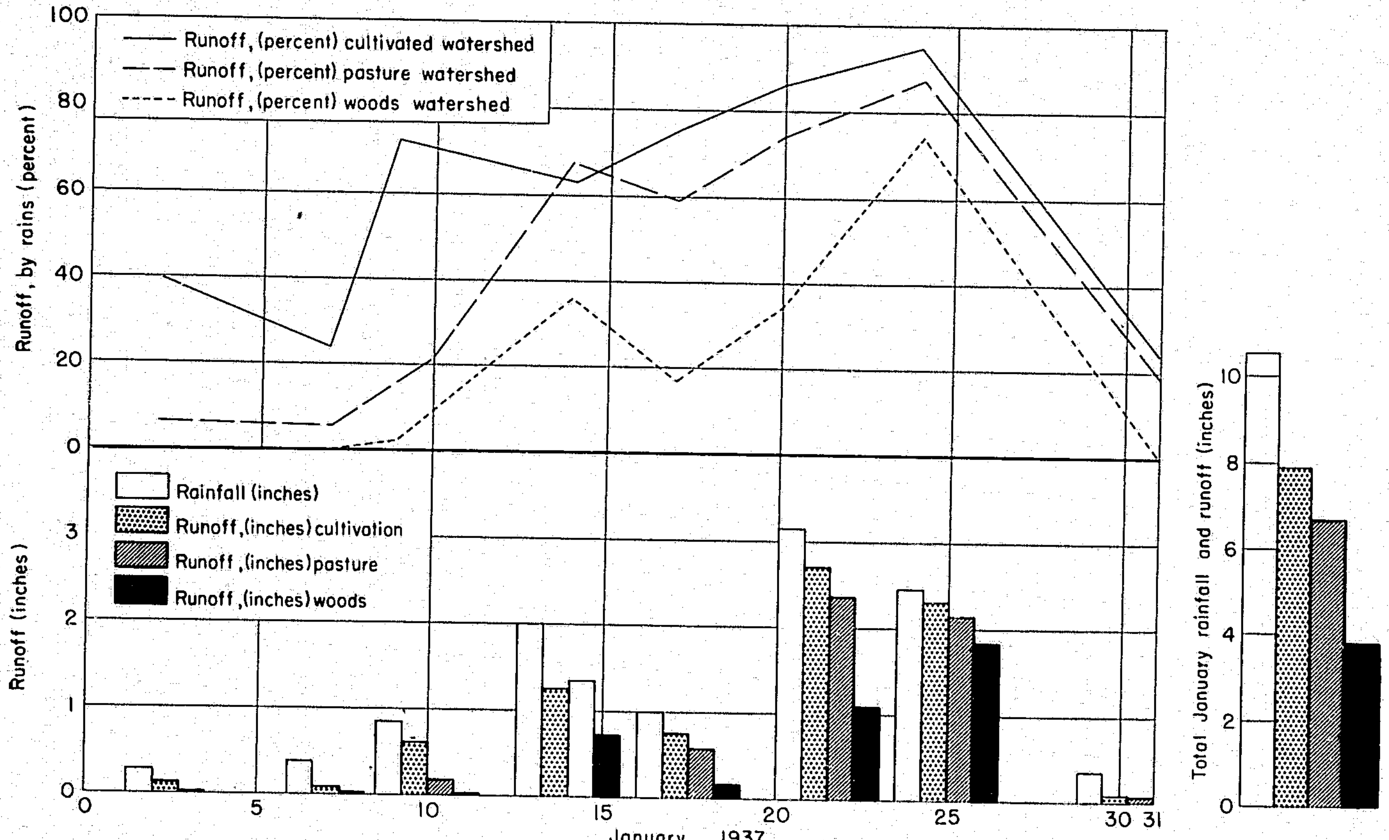

FIGURE 28.—Comparison of runoff from three types of cover during a flood period.

The action of the three watersheds during a flood period is shown by the January 1937 rains in table 20 and 20a and their effect is depicted graphically in figure 28. During the rain of January 9–10, the cultivated watershed in wheat lost about 72 percent of the rainfall; the pasture 21 percent; and the woods 3 percent. The woods runoff increased to 36 percent for the rain of January 14–15 and 34 percent on January 20–23. For the last rain of this period, January 24–25, the woods runoff reached the high amount of 75 percent, while the pasture was 88 percent and the cultivated area about 95 percent. Over 10 inches of total rainfall had been received by January 25. After a 6-day period without rain, the woods runoff again became negligible for a small rain on January 31. During January, the woods retained almost 3 inches more water than the pasture and over 4 inches more than the wheat on the cultivated watershed. Detailed data from these areas are given in table 46, Appendix.

TABLE 20a.—*Surface inches of runoff from three watersheds, January 1937*

	Runoff surface inches			
	Total rainfall	Cultivated	Pasture	Woods
	Inches	*Inches*	*Inches*	*Inches*
Jan. 2	0.29	0.116	0.019	0.000
Jan. 7–8	.39	.092	.021	.000
Jan. 9–10	.87	.625	.187	.024
Jan. 14–15	2.00	1.254	1.342	.724
Jan. 17–18	1.00	.754	.593	.106
Jan. 20–23	3.15	2.706	2.350	1.077
Jan. 24–25	2.44	2.305	2.137	1.823
Jan. 31	.34	.080	.062	.000
Total	10.48	7.932	6.711	3.814

EFFECT OF LAND USE ON SOIL-MOISTURE CONTENT

As a basis for studies of moisture utilization and the importance of water-conserving practices, a study was made of the moisture content of soils under continuous corn, grass, and woods vegetal covers. The areas sampled were on slopes varying from 12 to 14 percent. The grass was a fair stand of bluegrass; the woodland was a good second growth about 30 years old and the soil was covered with leaf litter 2 to 4 inches in depth. The corn plot was one where corn had been grown every year since 1933. From the standpoint of plant utilization of moisture, this plot cannot be considered representative corn land. The average annual production of dry matter in the crop approximated only 1,400 pounds per acre for the 3 years.

The soils were sampled daily in 6-inch profile increments to a depth of 30 inches during most of 1939, 1940, and 1941. Monthly data for three horizons derived from the records obtained are given in inches in table 47, Appendix, and 3-year averages of the moisture content of the three soils are presented in both inches and percentage of moisture on a dry-weight basis in table 21. Because of differences in the volume weight of soils under different conditions, particularly under woods cover, the amount of soil moisture in inches provides a more accurate measure of the quantity of moisture present than does percentage. Some of the more obvious findings of this study are reported here.

TABLE 21.—*Soil-moisture content on dry-weight basis in various horizons under cornland, grassland, and woodland, 3-year average, 1939–41*

Cover and horizon (inches)	Soil moisture											
	January		February		March		April		May		June	
	In.	*Pct.*	*In.*	*Pct.*	*In.*	*Pct.*	*In.*	*Pct.*	*In.*	*Pct.*	*In.*	*Pct.*
Corn:												
0–12	4.38	27.2	4.70	29.1	4.33	26.8	3.83	23.7	2.97	18.4	3.53	21.9
12–18	1.98	[1] 21.7	2.02	[1] 22.1	1.93	21.0	1.99	21.7	1.73	18.9	1.78	19.4
18–30	3.14	[1] 16.0	3.48	[1] 17.8	3.28	16.8	3.15	16.1	3.02	15.4	3.14	16.1
0–30	9.50	......	10.20	......	9.54	......	8.97	......	7.72	......	8.45	......
Grass:												
0–12	4.65	28.8	4.71	29.2	4.74	29.4	4.43	27.5	3.30	20.5	3.87	24.0
12–18	2.26	24.6	2.31	25.2	2.36	25.7	2.31	25.2	1.89	20.6	2.01	21.9
18–30	3.85	19.7	4.23	21.6	4.23	21.6	4.17	21.4	3.77	19.3	3.89	19.9
0–30	10.76	......	11.25	......	11.33	......	10.91	......	8.96	......	9.77	......
Woods:												
0–12	4.14	29.8	4.46	32.0	4.50	32.3	4.30	30.9	3.94	28.3	3.95	28.4
12–18	2.06	21.9	2.23	23.7	2.19	23.3	2.13	22.7	1.97	20.9	1.90	20.3
18–30	3.96	19.6	4.23	20.9	4.44	21.9	4.30	21.3	4.00	19.8	3.99	19.7
0–30	10.16	......	10.92	......	11.13	......	10.73	......	9.91	......	9.84	......

Cover and horizon (inches)	Soil moisture—Continued												
	July		August		September		October		November		December		Average
	In.	*Pct.*	*In.*	*Pct.*	*In.*	*Pct.*	*In.*	*Pct.*	*In.*	*Pct.*	*In.*	*Pct.*	*In.*
Corn:													
0–12	2.69	16.7	2.46	15.2	2.21	13.7	2.48	15.4	3.56	22.1	4.18	25.9	3.44
12–18	1.70	18.5	1.47	16.1	1.46	15.9	1.52	15.0	1.67	18.1	1.89	20.6	1.76
18–30	2.98	15.2	2.92	14.9	2.78	[1] 14.2	2.76	14.1	2.94	15.0	3.09	15.8	3.06
0–30	7.37	......	6.85	......	6.45	......	6.76	......	8.17	......	9.16	......	8.26
Grass:													
0–12	2.96	18.4	2.58	16.0	2.47	15.5	2.83	17.6	4.11	25.4	4.34	26.9	3.75
12–18	1.86	20.3	1.64	17.9	1.72	18.8	1.56	17.0	1.93	21.0	2.10	22.9	2.00
18–30	3.57	18.3	3.44	17.7	3.45	[1] 17.7	3.39	17.3	3.58	18.3	3.86	19.7	3.78
0–30	8.39	......	7.66	......	7.64	......	7.78	......	9.62	......	10.32	......	9.53
Woods:													
0–12	3.02	21.7	2.81	20.2	2.09	15.0	2.28	16.4	3.88	27.8	4.03	29.0	3.62
12–18	1.61	17.2	1.56	16.5	1.32	14.0	1.29	13.7	1.80	19.1	1.98	21.1	1.84
18–30	3.38	16.7	3.15	15.6	3.18	[1] 15.8	3.08	15.2	3.28	16.2	3.61	17.9	3.72
0–30	8.01	......	7.52	......	6.59	......	6.65	......	8.96	......	9.62	......	9.17

[1] 2-year average.

Figure 29 presents a comparison of the moisture in 2 horizons of the soil under the three vegetal covers. The accretion of soil moisture during the winter months and its decrease, in spite of increased precipitation, from the late winter months (February-March) to fall (September-October) is very evident.

From the Chart it will be noted that the greatest seasonal fluctuation occurred in the upper 18 inches of the soils. Seasonal decreases in soil moisture of 3 horizons under the three covers are shown in table 22. Similar fluctuations on closely related soils have been reported by Dreibelbis and Post (*15*).

The corn soil showed the greatest seasonal decrease in the upper 12 inches. In the 12- to 30-inch horizons, moisture under corn decreased the least; under grass, next; and under woods, the most. Annual average soil moisture was consistently lowest under corn. Grass and woods soils were not widely different during the first 7 months of the year. After July, the woods soil moisture decreased in amount considerably more than the moisture under the grass, to as low as corn soil moisture. These data show that in spite of the fact that Ohio is in a humid region, soil moisture reserves built up during the winter are dissipated during the growing season. In fact, soil

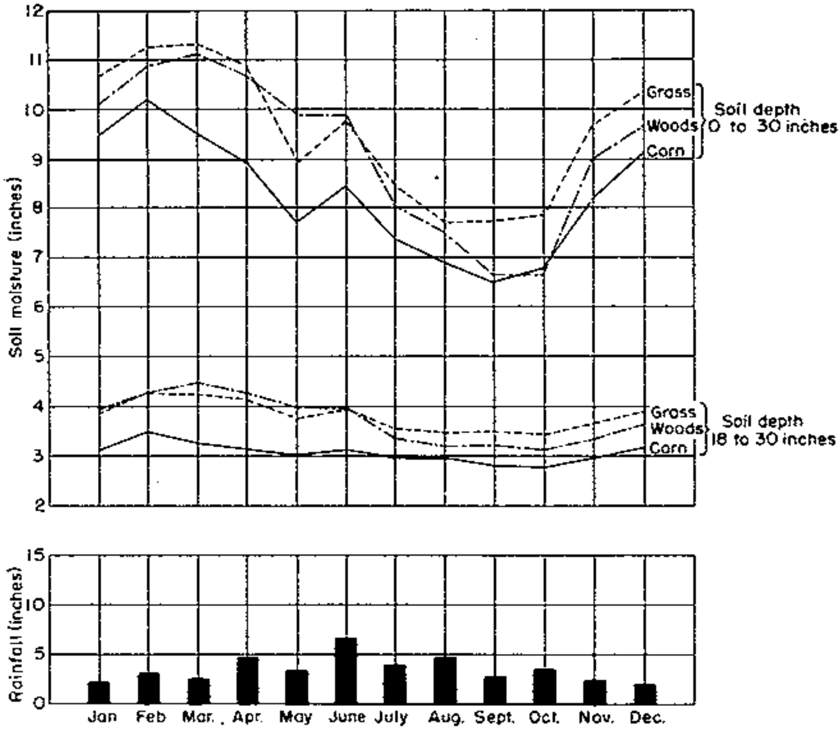

FIGURE 29.—Seasonal fluctuations and relative amounts of soil moisture under cornland, grassland, and woodland; 1939-41.

TABLE 22.—*Seasonal decreases in soil moisture under different vegetal covers, 3-year period*

Soil profiles (inches)	Corn	Grass	Woods
	Inches	*Inches*	*Inches*
0-12	2.49	2.27	2.41
12-18	.56	.80	.94
18-30	.72	.84	1.36
0-30	3.75	3.69	4.54

moisture under corn and woods approached the theoretical wilting point (*1, 24*). Assuming soil moisture lost by percolation under the three covers to be the same, and knowing that evaporation was a minor source of water loss under the thick leaf litter in the woods, it would seem that the woods vegetation drew much more heavily on the soil moisture reserves than did the other types of vegetation.

The consistently lower moisture content of the corn soil is explained by the loss from runoff. Figure 30 presents ratios of probably infiltrated rainfall (precipitation minus runoff) to soil moisture. On this basis, the corn soil retained a greater amount of the moisture which entered the soil than the other 2 soils, which were very similar. This relatively high moisture retention under the corn crop may be explained partially by the comparatively low crop usage indicated by the low

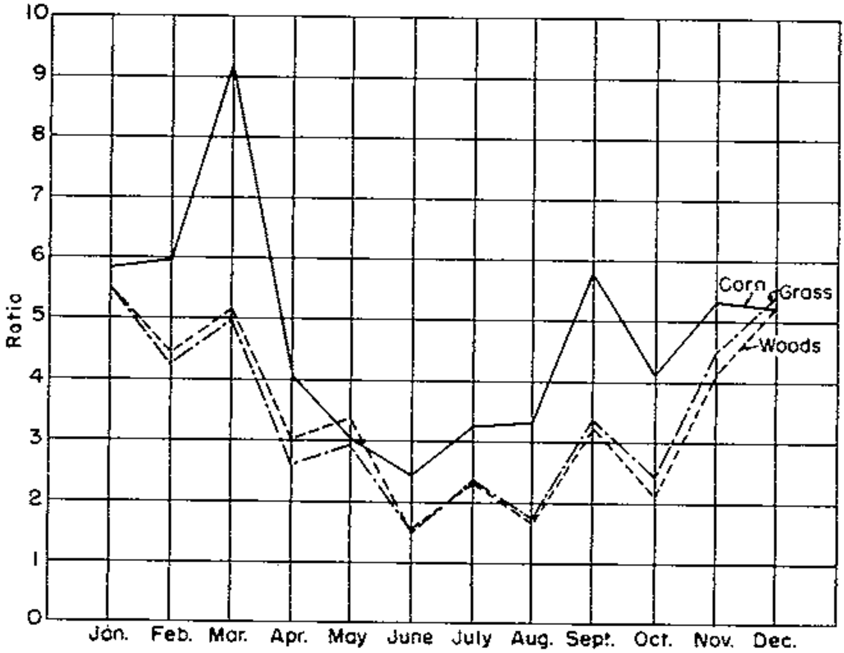

FIGURE 30.—Ratio of rainfall intake to soil moisture in a 30-inch profile for cornland, grassland, and woodland, 1939–41.

yield. The fact that, even with this low moisture usage by the crop, this soil approached the wilting percentage, indicates the need for moisture-conserving practices.

INFILTRATION STUDIES

Many factors are known to affect infiltration, some of which may produce marked changes in the infiltration characteristics of a soil.

From June 1938 to February 1941, a study was conducted of infiltration on Muskingum soil as affected by seasonal or climatic changes.[6]

Sixty seamless 9-inch tubes and other apparatus described by Musgrave (*28*) were used. The tubes were sunk to a depth of 16 inches in a natural bluegrass sod and left in this site throughout the study. Twenty-four additional tubes were sunk late in 1940 for special runs on frozen soil. Records of soil moisture and soil, air, and water temperatures were kept. For the frozen soil study, a record of the depth of the freezing of the soil, was also made. In general, initial runs were made on "dry" (normal moisture content) soil and these were followed by so-called "wet" runs 24 hours later.

During the course of the study, 25 initial and 25 wet runs were made when the ground was not frozen and 11 runs were made on frozen soil. The pertinent data appear in tables 48, 49, and 50, Appendix.

Precise control of variables in a study of this sort is impossible, but trends may be indicated by the data. The study showed, for instance

[6] BORST, H. L., and MUSGRAVE, G. W. SEASONAL CHANGES IN INFILTRATION FOR A SINGLE SITE AND VEGETAL COVER. 10 pp. illus. (Unpublished manuscript, prepared Jan. 1943.)

(fig. 31), that there was a tendency for infiltration rates to be low during the winter-early spring period; to increase during the late spring and midsummer period; and to decrease during the late summer and fall period; and for the soil moisture to decline during the summer. Correlations computed on the data were as follows: High positive correlations between air and soil temperatures and air temperature and infiltration, and a strong negative relationship between soil moisture and infiltration during the initial runs. There was also an inverse relationship between temperature and soil moisture.

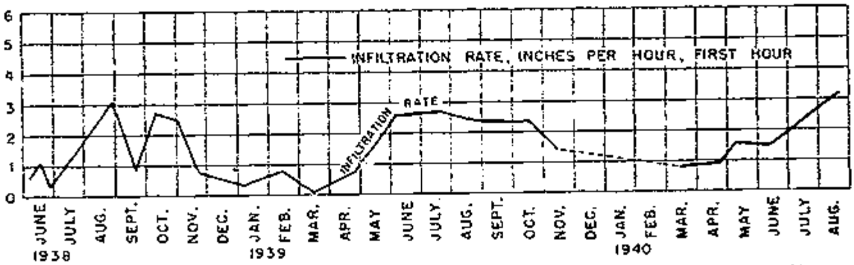

FIGURE 31.—Seasonal fluctuations in infiltration rate. (Broken line indicates winter period during which no measurements were recorded.)

The data from the runs on frozen soil showed no apparent relationship between the temperatures of air, soil, and water used in the study and the infiltration rates. There was, however, a marked relationship between depth of frozen soil and infiltration. It is of interest that some slight infiltration (averaging all tubes) took place when the soil was frozen to a depth of 10 or more inches. Although in some tubes the soil was apparently completely sealed by freezing and no intake of water was registered, in others there was a comparatively rapid intake indicating that cracks or fissures permit infiltration even on frozen soil.

RAIN-SIMULATOR STUDIES

The effect of mulching and surface condition on erosion and runoff.—The effect of soil surface condition, of straw mulches, and of straw incorporated into the soil, on erosion and water infiltration on Muskingum soils, was studied during the summers of 1940 and 1941. These studies, made with the rain simulator, type E (fig. 32), have been reported in previous publications (*9, 10*). The first series of studies led to the conclusion indicated in figure 33.

Wheat straw incorporated in the soil entirely beneath the surface at rates of 2 and 4 tons per acre had little or no effect on runoff and erosion. Muskingum soil crusted or sealed quickly under the impact of simulated rainfall and high runoff and heavy erosion resulted (fig. 34). Application of a straw mulch at the rate of 2 tons per acre to sealed surface increased infiltration only slightly but controlled erosion effectively. Shallow cultivation which broke the surface seal (fig. 35) increased infiltration for a time and reduced erosion somewhat. The application of a 2-ton-per-acre straw mulch to an "open" or cultivated soil surface resulted in a high rate of infiltration and a very low soil loss. Straw mulch of 1 ton per acre controlled erosion nearly as effectively as a 2-ton mulch but was about one-half as effective as the 2-ton rate in controlling runoff. Cornstalks applied at

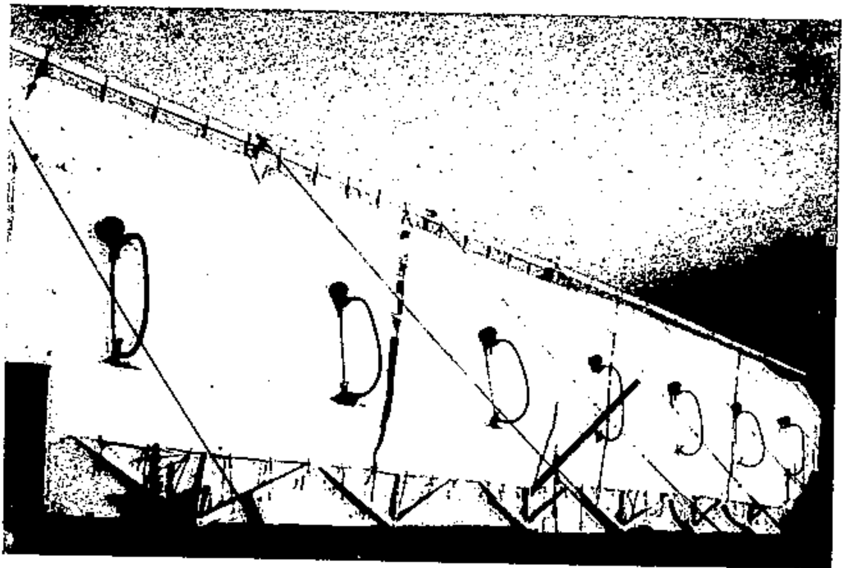

FIGURE 32.—Exterior view of type E rain simulator.

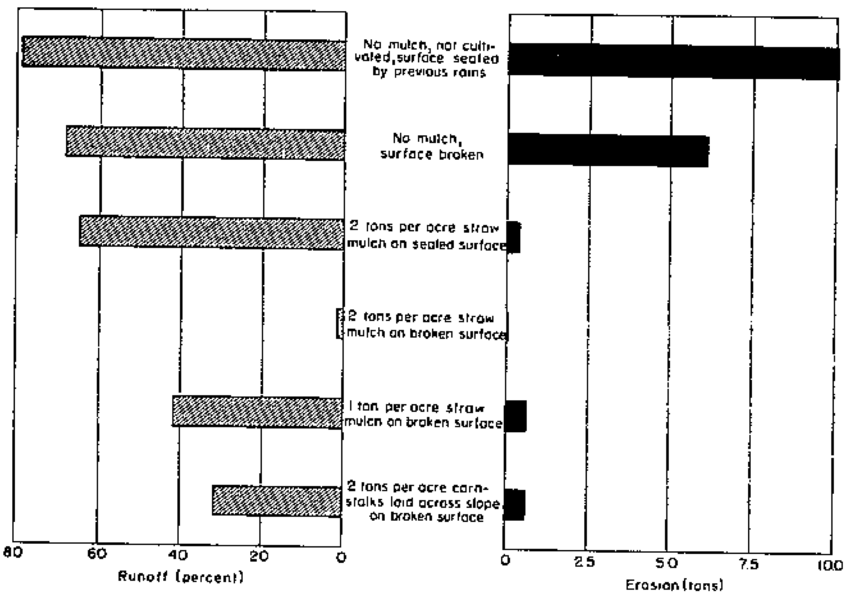

FIGURE 33.—Effect of mulches on sealed and cultivated soils (as indicated by erosion and runoff from 60 minutes of rain applied at 2.20 inches per hour).

2 tons per acre, laid across the slope, were nearly as effective as a 1-ton application of straw in controlling erosion and runoff.

A study was made of the mechanics of the effect of mulching. On the "open" soil surface the mulch prevented sealing and thus maintained a high infiltration rate. Since little runoff resulted, erosion

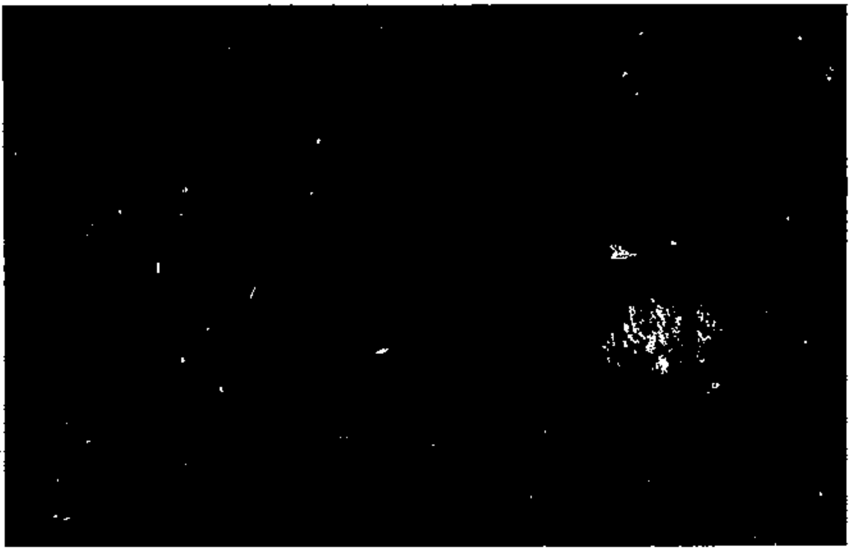

FIGURE 34.—Appearance of Muskingum soil with surface sealed by rainfall A mulch applied to this surface controlled erosion but not runoff.

was negligible. In this instance, obviously, the mulch reduced erosion by nullifying drop impact and preventing soil dispersion and sealing. On the sealed surface, where heavy runoff occurred but erosion was controlled, it was found that the velocity of runoff was reduced somewhat by the mulch. A question remaining unanswered was: Is erosion controlled by reduced runoff velocity, or is protection from

FIGURE 35.—A mulch applied to a broken surface like this effectively controlled erosion and runoff.

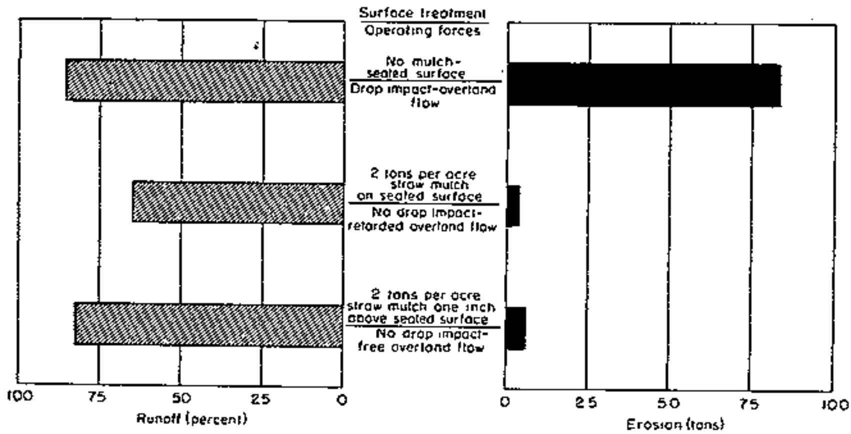

FIGURE 36.—Runoff and erosion from surface-mulched and supported-mulched plots showing the erosive effect of drop impact versus overland flow.

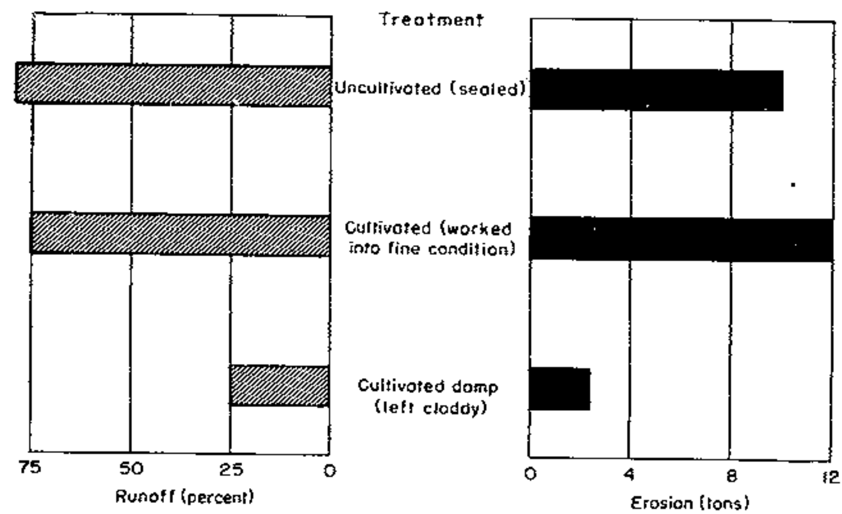

FIGURE 37.—Runoff and erosion as affected by the condition of the soil surface.

raindrop impact still an important function of the mulch? To answer this question, plots were prepared on which a 2-ton-per-acre mulch of straw was supported on hardware cloth 1 inch above the soil surface. With these plots, raindrop impact was obviated but overland flow was unimpeded. The results are shown in figure 36. Although the runoff was somewhat greater from the "supported-mulch" plots, the erosion was only slightly greater than from the surface-mulched plots. This evidence leads to the conclusion that the elimination of drop impact rather than the interference with overland flow was the chief function performed by the mulch. On longer slopes the reduction of velocity of runoff by the mulch probably would be more important than in this study on comparatively short slopes.

Further evidence of the effect of soil surface conditions is presented in figure 37. Plots cultivated and worked into a fine condition lost considerably more soil and water than those worked before the surface was completely dry and left cloddy. This indicated that Muskingum soil in a fine state seals quickly.

The effect of methods of soil preparation on erosion and runoff.—As previously brought out, Muskingum soil, worked down, seals quickly under the impact of rainfall. Surface mulch applied to this soil promoted infiltration and controlled erosion to a remarkable degree. Meadow sod completely buried by "good" plowing, in the rotation and sod-plot studies, was only partially effective in controlling erosion and runoff. To measure the effect on runoff and erosion of different methods of preparing sod for a subsequent cultivated crop, six 1/300-acre plots were installed in the summer of 1941 on orchard grass-alfalfa sod. The slope was 15 percent.

No crop was planted on the plots. They were cultivated 2 inches deep before rains applied at approximately 2.5 inches per hour for 1 hour. The various treatments and the results of water applications to the plots when dry are given in table 23.

TABLE 23.—*Effect of cultural methods on soil losses and infiltration rates*

Treatment	Runoff	Soil loss per plot	Infiltration rate after following intervals of rainfall— 15 minutes	30 minutes
	Percent	*Pounds*	*Inches per hour*	*Inches per hour*
Plowed 6-7 inches deep; sod well covered	61	38.1	1.20	0.81
Plowed 3-4 inches deep; sod partially covered	41	6.8	1.98	1.29
Plowed 6 inches deep; furrow slice on edge	51	7.4	1.72	1.07
Desurfaced 2 inches; plowed 4 inches deep	64	19.1	1.21	.64
Disked	48	1.5	2.50	1.06
Spring-tooth harrowed	34	2.2	2.37	2.33

Figure 38 shows the plant residues left on or near the surface by disking, harrowing, and edge plowing.

Although this test developed no practical substitute for plowing with a moldboard plow, it does bring out the fact that the method of soil preparation, particularly as it affects surface debris, has a marked effect on the infiltration rate and erosion characteristics of Muskingum soil.

RAIN-SIMULATOR SLOPE STUDIES

The effect of slope on soil and water losses.—The principal factors affecting erosion and runoff are degree of steepness of slope, length of slope, amount and intensity of rainfall, soil type and surface condition, and vegetal cover or land use. Knowledge of the influence of each of these factors is helpful in the planning of a more permanent type of agriculture. Special studies of the effect of slope on erosion and runoff were made during 1938, 1939, and 1940, with rain-simulator apparatus. By means of this apparatus it was possible to hold nearly constant such factors as amount and intensity of rain, length of slope, soil moisture content, surface condition, and vegetal cover, so that the factor of steepness of slope could be more nearly isolated.

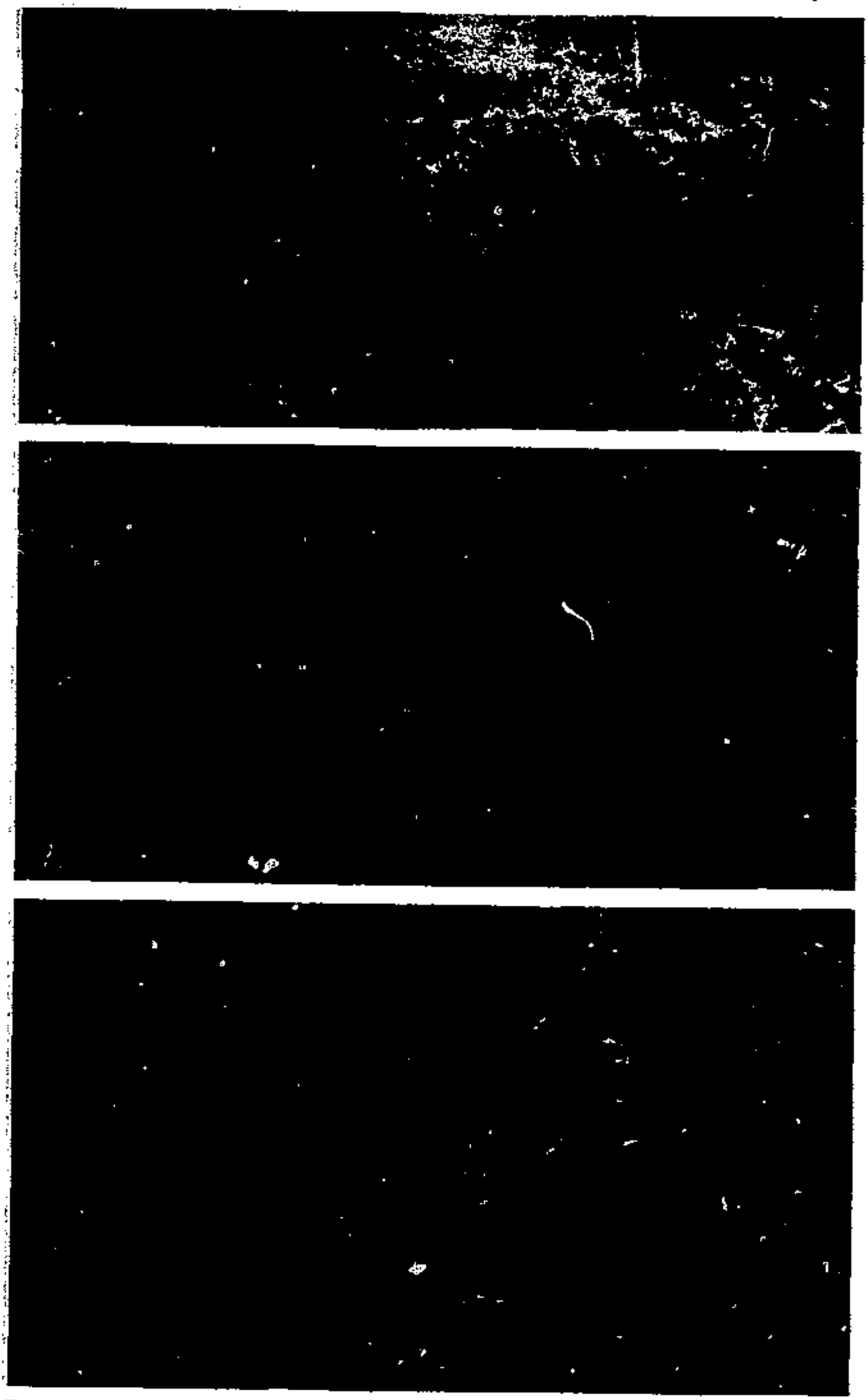

FIGURE 38.—Plant residues left on or near the surface by (*A*) disking, (*B*) using a spring-tooth harrow, and (*C*) plowing plot so that furrow slices were set on edge.

These studies were made on bare soils of the Muskingum series at Zanesville and on the Wooster silt loam at the Ohio Agricultural Experiment Station at Wooster, Ohio. A preliminary report on the first year's work has been made.[7]

Losses for the individual runs on the Wooster soil were much more variable than those from the Muskingum slopes. The former plots were laid out on a field which had been in an alfalfa-timothy sod and remaining root material may have accounted for the variations. The equations for the average values of three groups of runs were as follows:

On dry Wooster soil, 4.5 inches per hour, $E=3.73S^{1.48}$
On wet Wooster soil, 4.5 inches per hour, $E=4.53S^{1.58}$
On wet Wooster soil, 9.25 inches per hour, $E=5.27S^{1.63}$

Zingg (*34*), using data from the work of Duley and Hayes (*17*) and Disecker and Yoder (*14*), reported that soil loss is proportional to the 1.40 power of the slope, a figure not far from the average of the exponents of the equations above. Neal (*30*), working with an artificial soil profile in a greenhouse, concluded that for 1 inch of rain, erosion varied as the 0.7 power of slope. Nichols and Sexton (*31, p. 103*), working with sprinkler plats, reported that: "Erosion varied uniformly with slope up to about 12 percent grade. Above this slope, the rate of erosion increased very rapidly * * *" Disecker and Yoder (*14, p. 49*), using the same plots, both bare and vegetated, reported thus: "Erosion losses from smooth fallow [land] were comparatively high at 5 percent (slope) and * * * increased rather uniformly above this point." Duley and Hayes (*17*) reported that erosion from a bare silty clay loam soil increased at less than a 1:1 relationship on slopes up to about 6 percent and that above this slope value, erosion more than doubled with a doubling of slope.

Subsequent studies at Zanesville were made on plots planted to soybeans and to wheat in order to evaluate the effect, if any, of vegetal cover on slope-erosion-runoff relationships. During the first two seasons, the plots were 1/100 acre, 6 x 72.6 feet in size but in 1940 the wheat plots were reduced to 36.3 feet in length.

Data from the individual runs are given in tables 51 to 54, Appendix.

The slope-soil loss relationship.—In general, soil losses for all the runs on both bare and vegetated plots increased progressively with the increase in slope. Plotted logarithmically, erosion losses from the bare Muskingum soil exhibited straight-line trends, indicating an exponential relationship between soil loss and slope (fig. 39), and trend equations for the curves, fitted by least squares, were as follows:

On dry Muskingum soil E (erosion) $=4.84S^{1.30}$
On wet Muskingum soil $E=8.23S^{1.22}$

The effect of vegetation on the slope-erosion relationship.—Three series of runs were made in July, August, and September of 1939, on the plots planted "solid" on the contour with soybeans. Each series consisted of a run on initially dry soil, at an application rate of 4.5 inches per hour, a run on wet soil at the same intensity, and a third run on wet soil at approximately 9.25 inches per hour. All

[7] Borst, H. L., and Woodburn, R. RAIN SIMULATOR STUDIES OF THE EFFECT OF SLOPE ON EROSION AND RUNOFF—1938. U. S. Dept. Agr. SCS–TP–36. 37 pp., illus. 1940. [Processed.]

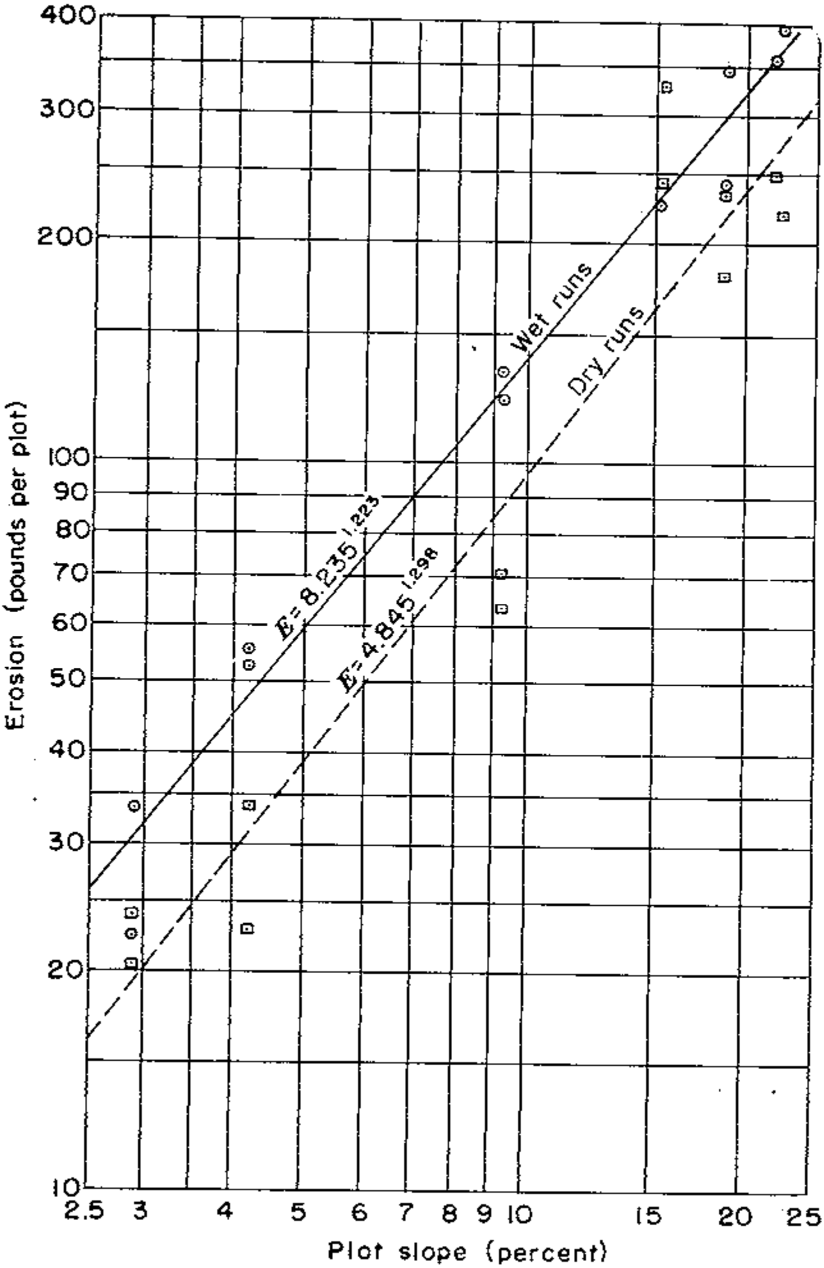

FIGURE 39.—Relationship between plot slope and erosion for 1 inch of rainfall at 4 inches per hour.

applications were 1 surface inch. Four similar series of runs were made on similar plots in wheat in 1940, all after the crop had headed.

An outstanding effect of the vegetal covers was to reduce soil loss to the extent that it was somewhat difficult to evaluate the effect of slope from the small losses. Another noticeable effect of the vegetation was to increase the variability of losses from the various plots. It is of interest that the soil losses decreased markedly as the soybeans matured. (Table 54, Appendix.)

The soil losses from the slopes planted with wheat, when plotted on log-log scale, do not show a close adherence to an exponential trend. While individual-run data from the soybean runs are noticeably variable, an average of all losses from the slopes planted with soybeans does show an exponential trend. Data secured from the study of slopes planted with both kinds of vegetation show that there is a greater tendency for erosion to increase slightly with increase in slope, than is the case with bare-plot slopes. Whether this tendency is significant is problematical. It is a fact, however, that while the vegetal covers in these studies greatly reduced the magnitude of the erosion from the plots, they did not reduce (in fact probably magnified) the erosion-slope ratio.

The effect of slope on the percentage of runoff and infiltration.—The studies of bare-cultivated Muskingum soil showed that there was no relationship between the runoff percentage and degree of slope. Consequently, there was no slope trend for infiltration rates, since the two are related. In general, the infiltration rates for the wet runs were calculated from the equilibrium period of runoff. On the bare, cultivated Wooster slopes, runoff percentages increased rather consistently, though slightly, with slope.

The runoff from the plots planted to wheat was greater than that from the bare-cultivated Muskingum soil; but as in the Muskingum soil experiments, also, there was no apparent relationship between slope and percentage of runoff. The infiltration rates on these plots were variable without any trend.

On the slopes planted to soybeans, there was a trend toward a slight increase in runoff percentage and decrease in infiltration rate accompanying an increase in slope.

Neal (*30*) found no slope-runoff relationship on a plot 16 feet long. Data of Desiker and Yoder (*14*) show no consistent trend toward a slope-percent of runoff relationship. Nichols and Sexton (*31*) report data that show a gradual increase in runoff percentage on slopes above 5 percent. Duley and Kelly (*18*) report a tendency for infiltration to decrease slightly with increase in slope. Duley and Hays (*17*) stated that runoff increased with slopes up to about 3 percent but only slightly with further slope increases. Horton (*22*) states that there is always some increase in runoff with increase in slope.

The studies seem to indicate that while the relation between slope and the percent of runoff may vary with surface and soil conditions the relationship usually is not pronounced.

Effect of slope on rate of runoff.—Runoff rate data for the wet runs on the various slopes are shown in table 24. Variations in rainfall rate have been eliminated by reporting the ratio between rainfall and equilibrium runoff rates. There was no indication of an increased rate of runoff on the bare Muskingum slopes, and only a slight indication of an increased rate on the Wooster soil; but there was a more

TABLE 24.—*Relationship of slope and rate of runoff as affected by soil type, soil surface, and vegetation*

Muskingum soil (bare, uncultivated). Water application rate 4.40 to 4.52 inches per hour		Muskingum soil (bare, cultivated). Water application rate, 3.96 to 4.17 inches per hour		Wooster soil (bare, cultivated). Water application rate, 4.46 to 4.75 inches per hour		Muskingum soil (soybeans). Water application rate 4.50 inches per hour	
Slope (percent)	Runoff-rate ratio [1]	Slope	Runoff-rate ratio [1]	Slope	Runoff-rate ratio [1]	Slope	Runoff-rate ratio [1]
		Percent		*Percent*		*Percent*	
2.9	0.96	2.9	0.89	2.2	0.91	4.2	0.79
8.0	.94	4.2	.86	6.5	.86	9.3	.87
13.2	.95	9.3	.87	10.5	.96	15.3	.94
18.7	.93	15.3	.88	16.2	.95	22.5	.87
		18.7	.88				
		22.2	.88				

[1] Runoff-rate ratio is the ratio of equilibrium rate of runoff to application rate. The use of this ratio permits comparison of runs with different application rates.

definite relationship between runoff and slope on the slopes planted to soybeans, particularly for the runs made when the plants were mature. No rate measurements were made on the wheat plots. The values are what would be expected from the percentage-of-runoff data. If a comparatively greater quantity of runoff leaves a steeper slope than a more gentle one, it is logical that it would do so at a higher rate.

Effect of slope on rate of soil loss as modified by soil type and vegetation.—Curves showing the rate of soil loss from different slopes are shown in figure 40.

On the gentler bare slopes, the rate of soil loss, after an initial rise during the first 2 minutes, was rather constant. On the medium slopes, there was a tendency for the rate to increase slightly during the runs, whereas on the steepest slopes, the rate appears to reach a high point about midway during the runs. The chief effect of the soybeans was a general lowering of the rate of runoff and an indication of a lessening of the rate of soil loss as the run continued.

Discussion of rain-simulator slope studies.—These studies bring out the marked effect slope has upon erosion. It would seem that the slope-erosion relationship, at least for a certain range of slopes, is exponential with the power of slope in percent lying between 1.22 and 1.63. In contrast with soil losses, there was little relationship between soil runoff and slope. It is logical that with long slopes the results would deviate somewhat from the findings of these studies. Infiltration time would become a somewhat greater differential on long hillsides of different slope degrees. The fact that slope has a comparatively minor effect on the percentages of runoff and the water taken into the soil is important in planning moisture-conserving and runoff-disposal practices.

STRIP-CROPPING EXPERIMENTS

In 1936 strip-cropping experiments were inaugurated in field D, where the effect of this practice on erosion and runoff has been investigated for 7 years. For description and location of the areas see figure 6 and table 38, Appendix.

The data from these experiments are given in table 25. Detailed loss data are given in table 55, Appendix.

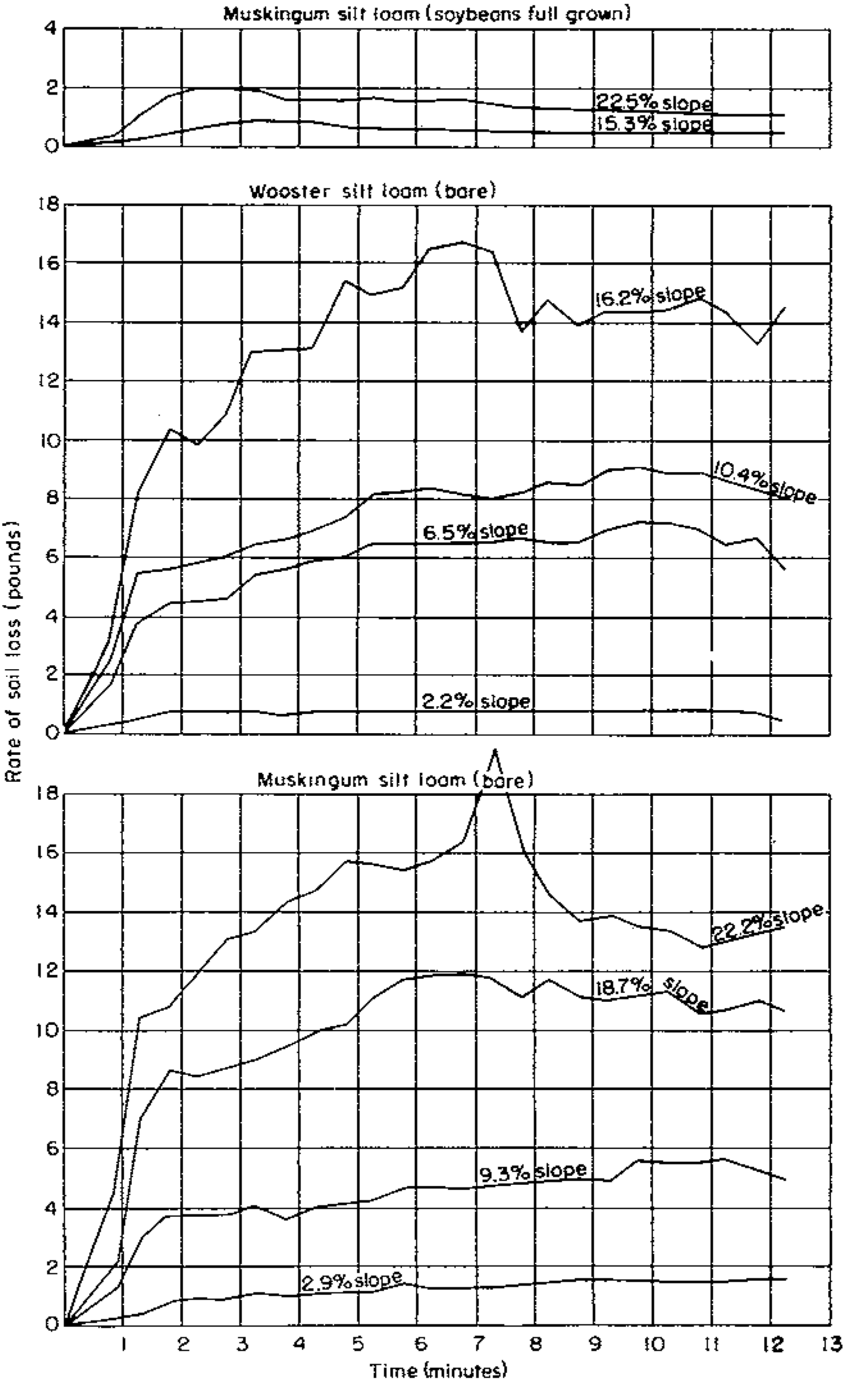

FIGURE 40.—Effect of slope on rate of soil loss.

Comparison of 3- and 4-year rotation strip cropping.—The average losses from the 3-year system were 8.83 inches of water and 7.83 tons of soil per acre, whereas the 4-year system lost 6.82 inches and 4.41 tons, respectively.

There are several reasons for the better erosion control of the 4-year system. A greater proportion of the area was in erosion-resisting meadow (one-sixth more than in the 3-year system). Also, because of the longer rotation, corn and wheat occupied the lower strip less often in the 4-year areas than on the 3-year plots. A still more effective 4-year strip-cropping system is one in which the cultivated strips alternate with the meadow strips. The present experiment has followed this system since 1942.

In the foregoing experiments, the effectiveness of strip-cropping as compared with no strip-cropping can be evaluated only in a general way by comparing soil and water losses from these areas with those from the cultivated watershed, previously discussed, which was planted to a single crop each year.

TABLE 25.—*Runoff and soil loss from strip-cropped areas*

Areas and rotations [1]	Surface runoff								
	1936	1937	1938	1939	1940	1941	1942	Average 5-year	Average 7-year
3-year rotation:	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Field A	6.83	8.03	4.94	10.54	11.54			8.38	
Field B	10.45	8.56	5.31	9.87	12.24			9.29	
Average	8.64	8.30	5.12	10.20	11.89			8.83	
4-year rotation:									
Field C	10.71	10.12	4.89	10.01	11.93	4.77	6.62	9.54	8.44
Field D	6.41	6.73	3.10	7.33	8.54	2.34	1.98	6.42	5.20
Average	8.56	8.42	4.00	8.68	10.24	3.56	4.30	7.98	6.82
3-year rotation:									
Field E, 70-foot strips	8.13	6.49	3.70	8.50	8.89	5.34	6.82	7.14	6.84
Field F, 35-foot strips	8.69	8.16	4.65	10.04	10.01	4.21	6.87	8.49	7.65
	Soil loss per acre								
Areas and rotations [1]	1936	1937	1938	1939	1940	1941	1942	Average 5-year	Average 7-year
3-year rotation:	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Field A	13.62	7.98	7.50	3.68	2.86			7.13	
Field B	18.61	8.55	9.23	3.27	2.97			8.53	
Average	16.12	8.26	8.36	3.48	2.92			7.83	
4-year rotation:									
Field C	12.32	4.60	1.06	10.08	5.29	2.26	.99	6.67	5.23
Field D	4.93	2.96	.64	9.76	4.93	.72	1.19	4.64	3.59
Average	8.62	3.78	.85	9.02	5.11	1.49	1.09	5.66	4.41
3-year rotation:									
Field E, 70-foot strips	8.72	2.14	5.28	2.50	.84	9.78	1.98	3.90	4.46
Field F, 35-foot strips	7.88	2.84	3.44	2.31	1.39	8.70	1.59	3.57	4.02

[1] 3 year rotation of corn, wheat, meadow, with second-year meadow added to make a 4-year system. Fertilizer: 150 lbs. per acre 4–10–6 mixture on corn, 400 lbs. per acre 2–14–4 mixture on wheat.

In order to evaluate more accurately the effectiveness of strip cropping, the 3-year rotation plots in the above experiment were replaced, in 1941, with a replicated series of plots (12 in all) in which each crop occurs twice in each slope position each year and in addition there are 2 areas each of unstripped corn, meadow, and wheat. The arrangement of the treatments is randomized. The unstripped areas are contour planted and tilled.

The soil and water losses from these plots for 1942 are summarized in table 26. Because all three crops occupied all positions on the slope, the data are of interest even though for only 1 year when erosion was less than in other years. The data indicate that breaking the slope into strips significantly reduced erosion.

The width of strip experiment.—In the width-of-strip comparison on areas E and F, for 5 of the 7 years erosion was slightly less from the 35-foot strips than from those 70 feet wide. The 35-foot strips lost only about 0.4 ton less than the 70-foot, whereas the water loss was some 0.8 inch greater from the former. Apparently, under the conditions of this experiment, width of strip is not an important factor. Where a longer slope or steeper one is used for this practice, it would seem logical that the advantage of the narrow strips would be greater. Gerdel and Allen (*21*) have proposed an equation for determining the width of strips under various conditions.

TABLE 26.—*Soil and water losses from strip-cropped and nonstrip-cropped areas compared*

Areas	Surface runoff	Soil loss
	Inches	*Tons*
Strip-cropped	4.25	2.92
Nonstrip-cropped	3.67	5.46

TERRACES IN EROSION CONTROL

Terracing has been shown to be an effective means of reducing erosion. Characteristics of terrace design, namely, grades, lengths, and spacing, need to be evaluated in locations where terraces have not been used. Early in the development of this station, terraces were installed for the purpose of making such evaluation and data were collected on 17 terraces through 1937 and on 3 others through 1942. The physical characteristics and treatment of the various terraces are presented in table 39, Appendix.

Terrace length.—The lengths of the terraces in a field are governed usually by the number and kind of outlets available and by other factors peculiar to the lay-out. In the event, however, that the conditions permit a choice between long and short terraces, information as to comparative soil losses of long and short terraces is useful.

Terraces to study the effect of terrace length on soil and water losses, installed in field A, were designated as A–5, A–6, and A–7. These varied in length from 718 to 762 feet, whereas another series including A–4, A–11, and A–12 were 1,173 to 1,276 feet long. The land slope was about 12 percent. The terraced area was farmed in a 3-year rotation, wheat in 1934, meadow in 1935, corn in 1936, and wheat in 1937.

FIGURE 41.—Level terraces were unsatisfactory on Muskingum soil.

The average soil losses from these terraces, given in table 27, show slightly greater losses from the three long terraces for the 4-year period than from the three short ones. There was, however, some inconsistency in the yearly results and it is doubtful whether the small differences are significant. Of the two variable grade terraces, there was a trend toward less water loss from the longer terrace whereas the runoff from the two uniform-grade and the two level terraces was essentially the same.

It would appear from these data that length of terrace is relatively unimportant in relation to erosion and runoff. Daniel et al. (*13*) report findings which indicate that terraces may be longer on a permeable soil than a compact clay. Musgrave and Norton (*29*) report a trend toward somewhat greater soil and water losses per unit area from shorter terraces than from longer.

Terrace grade.—Soil and water loss data for both long and short terraces with different grades are shown in table 28. Although there are exceptions, these data show that in general, a decrease in soil loss accompanies a decrease in grade. Because of inconsistencies in the annual losses, the loss differences should not be regarded too seriously, however. The 6-inch grade was noticeably too great, as it caused considerable scouring. In 1936, when planted to corn, this terrace lost 23 tons of soil per acre. The level terraces were entirely unsatisfactory, as water stood in them so that the crops were drowned out (fig. 41).

Terrace spacing.—To investigate the effect of different vertical intervals for terraces on erosion and runoff, terraces C–3, C–4, and C–5, with vertical intervals of 10, 8, and 6 feet, respectively, were installed in field C. The land slope was about 15–16 percent and the resulting horizontal spacings were approximately 61, 52, and 40 feet.

The average losses of soil and water, given in table 29, show a slight progressive decrease with decrease in vertical spacing from 10 to 6 feet. The differences in annual losses were not consistent, however.

TABLE 27.—*Runoff and soil loss from terraces of various lengths, 1934–37*

Terrace No.[1]	Length	Grade	Grade interval	Vertical spacing	Runoff 1934	Runoff 1935	Runoff 1936	Runoff 1937	Runoff Average		Soil loss 1934	Soil loss 1935	Soil loss 1936	Soil loss 1937	Soil loss Average
Long group:	*Feet*		*Feet*	*Feet*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
A-11	1,276	3 inches	(2)	7	6.1	14.7	9.5	12.8	10.8	29.3	4.0	8.4	12.2	5.7	7.6
A-4	1,187	Variable, 1, 2, or 3 inches	400	7	4.3	8.4	8.3	13.8	8.7	23.6	2.5	3.1	12.4	4.6	5.6
A-12	1,173	Level		7	8.3	11.0	7.6	12.7	9.9	26.9	3.7	2.3	5.1	5.1	4.0
Average									9.8						5.7
Short group:															
A-7	762	3 inches	(2)	7	7.0	9.0	12.7	14.0	10.7	29.1	3.2	4.8	14.8	4.2	6.8
A-6	747	Variable, 1, 2, or 3 inches	200, 300, 300	7	7.0	11.5	10.3	14.5	10.8	29.3	2.7	3.1	10.6	2.9	4.8
A-5	718	Level		7	5.1	10.3	9.1	15.2	9.9	26.9	2.3	3.5	6.8	2.9	3.9
Average									10.5						5.2
Rainfall					24.64	40.70	38.77	43.09	36.80						

[1] See table 39, Appendix.
[2] Uniform.

TABLE 28.—*Runoff and soil loss from terraces of various grades, 1934–37*

Terrace No.[1]	Grade	Grade interval	Length	Runoff 1934	Runoff 1935	Runoff 1936	Runoff 1937	Runoff Average		Soil loss 1934	Soil loss 1935	Soil loss 1936	Soil loss 1937	Soil loss Average
Long group:		*Feet*	*Feet*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
A-10	6	(2)	1,236	7.4	13.0	12.4	17.3	12.5	34.0	8.3	10.1	22.9	11.1	13.1
A-11	3	(2)	1,276	6.1	14.7	9.5	12.8	10.8	29.3	4.0	8.4	12.2	5.7	7.6
A-4	Variable, 1, 2, or 3 inches	400	1,187	4.3	8.4	8.3	13.8	8.7	23.6	2.5	3.1	12.4	4.6	5.6
A-12	Level		1,173	8.3	11.0	7.6	12.7	9.9	26.9	3.7	2.3	5.1	5.1	4.0
A-3	Variable, 1, 2, 3, 4, 5, or 6 inches	200	1,200	4.9	5.4	7.6	8.1	6.5	17.7	1.4	1.2	9.5	2.5	3.6
Short group:														
A-7	3	(2)	762	7.0	9.0	12.7	14.0	10.7	29.1	3.2	4.8	14.8	4.2	6.8
A-8	Variable, 2, 4, or 6 inches	200, 300, 300	736	5.3	11.2	8.7	13.4	9.6	26.1	4.0	6.5	10.2	4.6	6.3
A-6	Variable, 1, 2, or 3 inches	200, 300, 300	747	7.0	11.5	10.3	14.5	10.8	29.3	2.7	3.1	10.6	2.9	4.8
A-5	Level		718	5.1	10.3	9.1	15.2	9.9	26.9	2.3	3.5	6.8	2.9	3.9
Rainfall				24.64	40.70	38.77	43.09	36.80						

[1] See table 39, Appendix.
[2] Uniform.

As the range in length of slope was small and the horizontal spacing varied only from 61 to 40 feet, greater differences in soil losses from these terraces would not have been expected. These findings are in line with those reported by Daniel et al. (*13*).

TABLE 29.—*Runoff and soil loss from terraces with various vertical spacings, 1934–37*

Terrace No.[1]	Vertical spacing	Horizontal spacing	Grade	Runoff						Soil loss				
				1934	1935	1936	1937	Average		1934	1935	1936	1937	Average
	Ft.	*Ft.*		*In.*	*In.*	*In.*	*In.*	*In.*	*Pct.*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
C-3	10	61	Variable, 1, 2, 3, 4, 5, or 6 inches.	10.2	8.8	15.3	15.8	12.5	34.0	6.1	2.0	16.5	7.9	8.1
C-4	8	52	Variable, 1, 2, 3, 4, 5, or 6 inches.	6.2	10.0	14.0	15.7	11.5	31.2	4.9	1.9	14.2	5.8	6.7
C-5	6	40	Variable, 1, 2, 3, 4, 5, or 6 inches.	3.8	11.2	13.7	13.6	10.6	28.8	6.6	2.2	13.5	3.9	6.5
Rainfall				21.61	40.76	38.77	13.09	36.80						

[1] See table 39, Appendix.

It is a well-established fact, borne out by the results on the length-of-slope control plots at this and other stations, that soil loss decreases with a decrease in length of slope. Within certain limits, the closer the terraces the less will be the erosion. However, spacing terraces close together increases back slope area, construction costs, and tillage difficulties and if terraces are spaced too far apart, maximum benefits will not be derived. Obviously, the best spacing of terraces will depend upon the slope of the land and terrace design. Zingg (*85*) has presented a theoretical equation for the spacing of terraces that takes into consideration the steepness and length of slope.

Terrace losses as affected by rotation crops.—Annual and average losses from three terraces devoted to a 3-year rotation of corn, wheat, and meadow are given in table 30. For description and treatment see table 39, Appendix. All three crops were grown each year, one on each of the terraces. Under this plan the climatic factors were the same for all the crops of the rotation, and the effect of the terraces during a complete rotation as well as the effect of each crop can be evaluated at the end of each year.

The average annual losses for the 9 years (3 rotations) were 3.8 tons of soil per acre and 22.7 percent of the rainfall. The average soil losses from the terraces by crop years, 6.3 tons per acre from corn, 3.4 tons from wheat, and 1.7 tons from meadow, were in the same order as the losses from the rotation control plots with the same types of cover but were considerably less in amount.

The water losses from the terraced areas were 21.6 percent for the corn years, 26.0 percent for the wheat years, and 20.4 percent from the meadow. During the year a particular terrace was in corn, it was also in meadow until plowing time and in wheat in the fall after the corn. The meadow preceding the corn crop doubtless tended to reduce water losses as did, also, the contour planting and cultivation of the corn. The results indicate that these terraces prevented considerable soil movement from the field.

TABLE 30.—*Annual runoff and soil loss from terraces in a 3-year rotation of corn, wheat, meadow, for the 9-year period, 1934–42* [1]

Terrace No. or crop	Runoff 1934	1935	1936	1937	1938	1939	1940	1941	1942	Average	Average
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*
A-13	8.38	11.87	8.90	11.71	11.56	9.82	11.65	5.43	4.34	9.30	21.7
A-14	6.62	11.60	8.86	13.83	5.71	10.02	11.50	2.08	3.51	8.19	21.8
A-15	7.83	8.24	10. 6	9.47	6.80	12.58	9.23	3.04	4.21	8.09	21.5
Average	7.61	10.57	9.41	11.67	8.02	10.81	10.79	3.50	4.02	8.53	22.7
Corn	8.38	8.24	8.86	11.71	6.80	10.02	11.65	3.04	3.51	8.12	21.6
Wheat	6.62	11.87	10.56	13.83	11.56	12.58	11.50	5.43	4.21	9.80	26.0
Meadow	7.83	11.60	8.90	9.47	5.71	9.82	9.23	2.08	4.34	7.66	20.4
Average										8.53	22.7

Terrace No. or crop	Soil loss 1934	1935	1936	1937	1938	1939	1940	1941	1942	Average
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
A-13	8.66	6.91	2.21	10.43	2.06	0.30	1.43	1.24	0.39	3.71
A-14	3.99	4.65	9.26	5.36	.12	5.12	1.58	.89	1.37	3.50
A-15	5.40	13.18	6.10	1.58	6.46	2.78	.70	1.38	.85	4.27
Average	6.02	8.25	5.87	5.79	2.88	2.73	1.14	.90	.87	3.83
Corn	8.66	13.18	9.26	10.43	6.46	5.12	1.43	1.38	1.37	6.33
Wheat	3.99	6.91	6.10	5.36	2.06	2.78	1.58	1.24	.85	3.43
Meadow	5.40	4.65	2.21	1.58	.12	.30	.70	.89	.39	1.72
Average										3.83

[1] 9-year average rainfall, 37.62 inches.

Terraces on pasture land.—Soil loss from a good pasture is usually negligible, but the presence of terraces may curtail soil losses on poor pastures and conserve some water that would otherwise be lost.

The pasture terraces under measurement included B-7 and B-8, with a vertical spacing of 10 feet and 8 feet, respectively, and the same variable grade; B-8 and B-9, with the same spacing but different grades; and B-10 and B-11, short-level terraces. The vegetation was none too good on the area at the beginning of the period but improved rapidly. Table 31 shows the annual and 4-year average losses for these terraces as well as the water losses from an unterraced pasture watershed.

Erosion from terrace B-7 with a 10-foot vertical spacing, though small, was consistently more each year than from B-8 with an 8-foot vertical spacing and is in line with other spacing and length-of-slope results The water loss, which followed a trend similar to that of the soil losses, is not in line with those of similar experiments. Soil and water losses from terraces B-8 and B-9 with variable grades of 1, 2, 3, 4, 5, and 6 inches and 1½, 3, 4½, 6, 7½ and 9 inches, respectively, were nearly the same. The level terraces lost less soil and water than either of the other pairs. Considering the small erosion losses from these terraces and the fact that they would doubtless have been less with better vegetation, the value of terraces for erosion control only on pasture land in this area is questionable. In general, all of the

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TABLE 31.—*Runoff and soil loss from terraced and unterraced pastures, 1934–37*

Terrace or watershed	Grade	Vertical spacing	Length	Runoff 1934	Runoff 1935	Runoff 1936	Runoff 1937	Runoff Average	Runoff Average	Soil loss 1934	Soil loss 1935	Soil loss 1936	Soil loss 1937	Soil loss Average
		Feet	*Feet*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Percent*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Spacing study:														
B 7	Variable, 1, 2, 3, 4, 5, or 6 inches	10	1,118	7.1	6.0	7.2	9.6	7.5	26.1	1.6	0.1	0.1	0.3	1.3
B 8	Variable, 1, 2, 3, 4, 5, or 6 inches	8	1,067	5.2	3.5	4.1	4.2	4.3	14.7	2.0	.3	.3	.1	.7
Average								5.9						1.0
Grade study:														
B 8	Variable, 1, 2, 3, 4, 5, or 6 inches	8	1,067	5.2	3.9	4.1	4.2	4.3	11.7	2.0	.3	.3	.1	.7
B 9	Variable, [illegible] 3, [illegible] 6, 7[illegible] or 9 inches	8	1,098	4.7	3.7	3.9	4.1	4.1	11.1	2.1	.2	.3	.1	.7
Average								4.2						.7
Level terraces:														
B 10	Level	7	101		3.1	3.6	1.6	3.1	7.6		.6	1.0	.1	.6
B 11	Level	7	178		2.7	1.5	2.2	2.3	5.6		.2	.1	.1	.2
Average								2.7						.4
Rainfall				21.61	10.70	38.77	13.09	26.80						
Pasture watershed[1]				1.1	3.8	5.8	9.8	5.1	13.8	.16	.09	.13	.15	.13
Rainfall				21.61	10.73	39.26	15.53	37.04						

[1] See table 39, Appendix.

pasture terraces except B–7 lost somewhat less water than the unterraced pasture watershed. Observations borne out by other work (*12*) lead to the belief that the moisture saved was confined to the channel and nearby soil. The level terraces on this pasture were not objectionable, as they were on the cultivated land, since no damage to the grass resulted from temporary ponding.

Six closed level terraces, B–1 to B–6, were installed near the pasture terraces for observation. Because of the impervious nature of the soil, water stood in these channels for weeks at a time. For this reason, they were considered unsatisfactory and the ends were opened.

Comparison of terraced and unterraced land.—The comparison in table 32 of losses from terrace A–14 (cropped the same as the watershed) with those from the cultivated watershed shows that soil removal from the field was considerably less from the terraced area.

That there was considerable movement of soil down the slope on the interterrace spaces was shown by a channel-silting study made in 1936 and 1937. The water losses were consistently greater from the wheat and meadow crops on the terrace than from these crops on the unterraced area.

Channel silting.—In any measurement of soil and water losses at the outlets of terraces, the total quantity of soil moved from the slopes cannot be determined because some of this soil is deposited in the terrace channels. A number of factors may contribute to such silting, such as catchment by vegetation and deposition as a result of velocities of flow too low to carry the particles of soil.

Although precise measurement of soil stranded in a channel is impossible under field conditions, the amount of silting may be approximated by determining the changes in area of cross section at close intervals along the channel. This method was used to determine the amount of soil deposited in the channels of several terraces in corn for the period June–September, 1936. The results of these measurements are as follows:

TABLE 32.—*Runoff and soil loss from terraced and unterraced watersheds*

Area	Corn years, 1936, 1939, and 1942		Wheat years, 1934, 1937, and 1940		Meadow years, 1935, 1938, and 1941		Average	
	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss
	Inches	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*
Unterraced watershed	9.41	40.34	8.91	10.15	5.08	1.04	7.8	17.2
Terrace A–14	7.46	5.25	10.65	3.01	6.46	1.62	8.2	3.5

In terrace A–3, 7.8 tons of soil were stranded per acre; in A–4, 35.5; in A–5, 49.6; and in A–7, 43.9.

A–13, in corn, showed about 17 tons of stranded soil loss per acre for the same 4-month period in 1937. The silting for terraces A–14 and A–15, in wheat and meadow, was so small that calculations were not made.

Although these determinations are subject to considerable error, they show that measurements of soil losses at terrace outlets do not accurately represent actual soil movement from the slopes between terraces. For this reason, soil losses at terrace outlets are not strictly comparable with soil losses from other experimental areas where a more direct system of measurement is used. Comparisons may be made, however, of the losses of various terraces as measured at the outlets. Soil moves down the interterrace slope regardless of the characteristics of the terrace.

Contour Planting and Interplanting of Other Crops With Corn for Erosion Control

The effect of contour planting of corn, and the interplanting of other crops with corn, on runoff and erosion was investigated in 1939, 1940, and 1941 on plots 22 through 25 in field J. These were 1/100-acre plots (6×72.6 feet) on a 13-percent slope. Preliminary studies conducted with a rain simulator on corn plots after the corn had been laid by had shown that contour planting, if accompanied by ridged cultivation, decidedly reduced runoff and erosion (7).

With the idea that some crop planted in the row with the corn might increase the effectiveness of contouring, small grains and soybeans were used in this manner on two of the plots. Both of the small grains used (winter wheat 1 year and winter rye the other), when planted in the spring, make a quick growth for several weeks and then die. The soybeans were planted about 2 inches apart in the corn rows; the small grain, in a solid row. The contoured plots were compared with one planted up and down the slope with no intercrop. The plots were ridged along the row in cultivating the first 2 years. In 1941 ridging was not done, in order to test more effectively the influence of the interplanted crops. Soil- and water-loss measurements were made only during the summer months. The data from these tests are presented in table 33.

Table 33.—*The effect of contour planting [1] of corn and the interplanting of other crops with corn on runoff and soil loss*

[May to September data]

Year	Rainfall	Corn rows up and down the slope		Contoured corn		Contoured corn, wheat or rye in row		Contoured corn, soybeans in row	
		Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss
	Inches	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*
1939	20.51	7.7	67.1	5.2	16.6	4.5	16.0	5.0	11.6
1940	17.72	6.7	48.8	3.7	15.7	3.9	16.1	3.4	15.0
Average	19.12	7.2	58.0	4.4	16.2	4.2	16.0	4.2	13.2
1941	24.16	11.6	93.7	12.0	100.8	11.4	46.6	11.7	48.3

[1] Contoured rows were ridged in 1939–40, but were not ridged in 1941.

On the average, during the 2 years when the rows were ridged, contour cultivation of corn alone reduced the runoff approximately 40 percent and the erosion about 72 percent as compared with up-and-down-the-slope culture. The interplanted crops did not effect significant saving of either water or soil in these years. In 1941, when the plots were cultivated flat, no advantage was shown for contour planting of corn alone, but the interplanted crops did, under these conditions, reduce erosion by one-half from nearly 100 tons to a little less than 50.

Rain-by-rain examination of the data from these plots shows that little, if any, reduction in runoff and erosion took place until the plots were cultivated sufficiently to produce some ridge. It would seem that contour planting should be accompanied by ridged cultivation, as ridging increases depression storage. From a practical standpoint, most cultivators do ridge to some extent. Just how much ridge is desirable is problematical. Doubtless this will depend on soil types and their relative infiltration rate and erosion resistance and the effect of ridging on crop growth.

Although yield records were made on these plots, it is not clear whether the winter wheat or rye reduced the yield of corn. Many experiments, including those of Borst and Park (*6*) and McClelland (*25*) show that soybeans planted at a rate similar to that used here do lower the corn production. Regardless of this point, it would seem that interplanting either wheat or soybeans, particularly on short slopes, is of little value if the corn rows are definitely ridged in cultivating.

Effect of Pasture Treatment and Grazing on Soil and Water Losses From Pasture Plots

The five paddocks of approximately one-half acre (located in field J) used in this experiment were first seeded and fertilized in 1933.

Paddock 1 received no treatment. The remaining four were limed, fertilized, and seeded to a pasture mixture of Kentucky bluegrass, timothy, red top, alsike clover, and white Dutch clover. The seed was sown on the native sod, largely poverty oatgrass after it had been disked. Fertilizer applications, original and subsequent, are shown in table 40, Appendix. Several varieties of white clover were seeded in 1937 and in 1940.

Runoff records were begun January 1, 1937, from 1/40-acre areas, one in each paddock, equipped with metal borders, conduits, Geib divisors, and tanks. The land slope of these runoff areas varied from 13 to 16 percent.

From 1936 to 1939 all paddocks were grazed in the same way by three or four mature ewes in each paddock. At this time no change had taken place in the vegetation on the untreated paddock number 1. Poverty oatgrass was the chief species present. Other plants were broomsedge, yarrow (*Achillea millefolium*) and a small amount of Canada bluegrass (*Poa canadensis*), and annual weeds. The treated plots, however, were mostly a good sod of Kentucky and Canada bluegrass with some white clover. A sprinkling of poverty grass and broomsedge still remained.

During 1939 the runoff characteristics of the plots were studied and the plots were paired for subsequent grazing treatments on the basis of this study.

During 1940, 1941, and 1942, paddocks 1, 3, and 5 were grazed heavily (in some seasons continuously), whereas on paddocks 2 and 4 controlled grazing was used.

Soil and water losses and herbage yields are presented in table 34. Herbage yields were obtained from 4 cages (4×4 feet) in each paddock. Harvests were usually made in late June or early July.

It is evident that the fertilizer treatments improved the grass and as a result lessened erosion and runoff losses.

TABLE 34.—*The effect of treatment and grazing on runoff and soil loss from pasture plots for the 3-year period, 1940–42*

Plot No.	Treatment and grazing practice	Surface runoff				Soil loss per acre				Yields per acre			
		1940	1941	1942	Average	1940	1941	1942	Average	1940	1941	1942	Average
		In.	*In.*	*In.*	*In.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	Untreated, heavy grazing.	12.57	3.65	9.29	8.50	718.4	972.4	1,644.4	1,111.7	1,078	853	1,158	1,030
2 and 4	Treated, controlled grazing.	8.88	.76	4.50	4.71	337.0	25.0	259.3	207.1	2,071	1,150	2,169	1,707
3 and 5	Treated, heavy grazing.	9.94	1.31	4.82	5.37	415.2	79.8	316.1	270.4	2,417	1,558	2,077	2,017

The average annual runoff from the untreated paddock was 8.50 inches; that from the controlled grazed plots was 4.71 and that from the heavily grazed areas was 5.37. Erosion losses were 1,111, 207, and 270 pounds per acre, respectively, and herbage yields were 1,030. 1,797, and 2,017 pounds, respectively. The difference in runoff and erosion from the unimproved and improved grass is much greater than from the control plots in similar vegetative covers. It will be recalled that the control plots were not grazed. Under grazing conditions, the native grasses not only produced less herbage (probably of lower food value) than the bluegrass but also did not retain their soil-protecting value as well as the improved bluegrass sod.

Over a period of time, especially as the sod began to deteriorate, greater losses and larger differences would be expected as a result of the heavy grazing practice.

REVEGETATION AND UTILIZATION OF ERODED LAND

Studies dealing with the revegetation, rejuvenation, and profitable utilization of eroded and rundown land were carried on during the period covered by this report by the use of kudzu, Korean lespedeza, sericea lespedeza, and sweetclover.

Kudzu.—About a dozen Kudzu crowns were planted on an eroded site in the spring of 1935. There was a good survival of the original planting but no permanent spreading of the growth for several years. In the fall of 1939 the patch was mulched with straw and again in 1940. At present a thick mat of vegetation growing from many-rooted crowns covers the area. The planting shows that Kudzu will survive in this latitude and will spread if given winter protection. However, it is doubtful if the plant has an important place here, where other legumes can be grown with less difficulty and more return.

Korean lespedeza.—Both common and Korean lespedeza mature and reseed satisfactorily at this latitude. Observation of various plantings lead to the conclusion that sowing these annual lespedezas on pastures without preparation does not produce a satisfactory stand. Nor do they stand competition well with bluegrass or other grasses. Since they are annuals and produce little root growth, they are not promising plants for soil rebuilding or erosion control. They do have a place in pasture improvement, however.

Sericea lespedeza.—Plantings of sericea lespedeza have shown that it survives well at this latitude. It provides a good cover mulch and prevents erosion. As an economic crop it does not compete with either sweetclover or alfalfa, both of which have been shown to have a definite place in the reclamation of eroded land.

Sweetclover.—Sweetclover has been shown to have a place as a soil-rejuvenating crop on eroded and depleted land. An area of eroded abandoned land, covered with weeds and briars, after liming, fertilizing, and disking, was sown to sweetclover in 1940. In 2 years time the soil had a good cover of Canada bluegrass, and considerable sweetclover persisted. Sown on eroded and depleted pasture land, it has not only furnished pasturage itself but has improved the grass herbage of the pasture by the addition of nitrogen to the soil.

The trash-mulch method of establishing alfalfa on eroded land.—Despite a formerly current opinion that alfalfa will succeed only on fertile soils, this plant has been found to be the most satisfactory for the reclamation and profitable utilization of eroded soils (which are not too steep for the use of machinery and which are not badly gullied), when such soils are supplied with the necessary lime and phosphorus.

Experiments having for their objective the establishment of desirable vegetation on eroded, run-down land have been carried on at the station since its establishment. Early in 1936 a trial seeding of alfalfa was made on a badly eroded field, half of which was bare and the remainder covered by a sparse growth of poverty oat grass and briars. The results from the seeding were so promising that several similar plantings have been made during subsequent years. The field used in 1937 was similar to the one treated in 1936 and had been in pasture for more than 20 years. The five areas used in 1940, 1941, and 1942 had been abandoned for more than 10 years. Three cuttings of hay have been made on all of these areas each year since their establishment. First cuttings each year have been mixed hay but the second and third crops have been almost straight alfalfa. With the exception of 1 year (1941) the yields have equalled or exceeded those from the rotation meadows on the experimental farm.

TABLE 35.—*Hay yields obtained from alfalfa-grass meadows seeded directly on eroded land without plowing*

Meadow mixture seeded	Year sown	Hay yields			
		1939	1940	1941 [1]	1942
		Tons	*Tons*	*Tons*	*Tons*
Alfalfa, timothy, orchard grass	1937	2.60	2.77	1.75	2.08
Alfalfa and timothy	1938	3.00	3.25	2.25	3.90
Alfalfa and bromegrass	1940		0	1.90	3.35
Alfalfa and orchard grass	1940		0	1.75	3.00
	1941			0	[2] 1.66

[1] Yields low because of low rainfall.
[2] One cutting only.

Table 35 gives the yields of hay from fields thus established and figures 42 and 43 show areas as they appeared before and after being seeded to alfalfa.

In addition to the trials at the Zanesville Station, similar seedings were made at the Experimental Watershed Project near Coshocton, Ohio, and at the Ohio Agricultural Experiment Station at Wooster, Ohio, both of which were successful.

FIGURE 42.—Typical view of "broomsedge land" before treatment and sowing to alfalfa by the trash-mulch method.

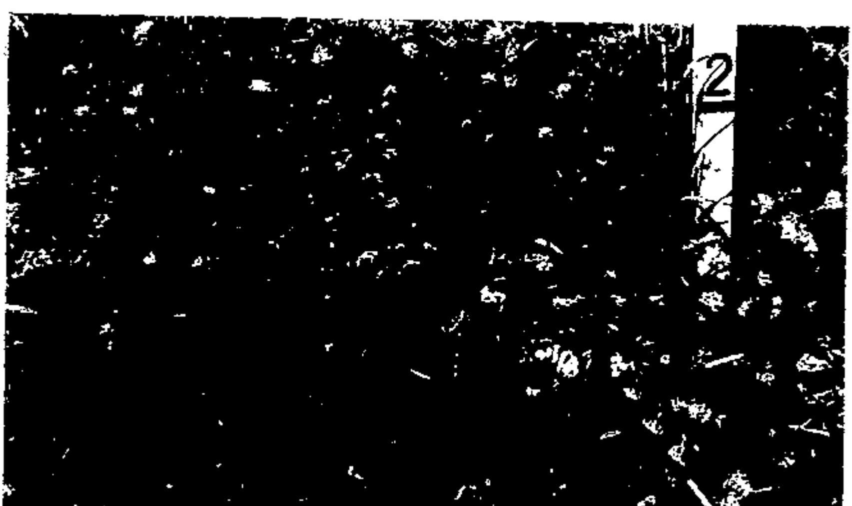

FIGURE 43.—Alfalfa and timothy established on eroded land by the trash-mulch method.

The seeding procedure has been fully described in a previous publication (*11*). Briefly, the treatment has been to apply sufficient lime (3-4 tons per acre) and fertilizer (approximately 400 pounds of an 0–14–6 mixture), disk the vegetation into the surface, and seed an alfalfa-grass seed mixture without a nurse crop. The areas have been cultipacked after seeding.

Under this trashy-fallow method of seeding alfalfa, the land is protected from the destructive forces of rainfall by leaving the soil covered with a blanket of organic material, thus promoting infiltration and decreasing runoff and erosion hazards. Seeding the meadow direct without the conventional small grain eliminates competition by the so-called nurse crop frequently used in the establishment of a new alfalfa seeding.

In general, abandoned or uncropped areas have been subjected to the treatment. Vegetation on such areas in this region usually consists of poverty oatgrass, broomsedge, three awn grass (*Aristida oligantha*), other annual weeds, and even running briars.

Plots plowed, rather than disked, have been compared with disked areas in 2 years of these trials. In 1941 two seedings were made on both plowed and disked land—one about April 15 and the other early in May. In the early seeding a satisfactory stand was obtained on both plowed and disked areas. Erosion was serious on the plowed plot and unapparent on the disked area. In the later seeding the alfalfa was nearly a failure on the plowed plot and satisfactory on the disked plot. A similar comparison was made for one seeding in 1942. The catch on two plowed plots was definitely poorer than on those disked.

Some study has also been made of the use of a complete fertilizer in comparison with one containing only phosphorus and potassium. Seedings made without nitrogen were fully as vigorous and successful as those made with it.

Although fields on comparatively steep slopes have been treated, erosion as a result of slope has not been evident. The trash mulch on the surface, coupled with the rough surface left by the method of preparation, have encouraged infiltration and prevented erosion. Areas thus treated have furnished highly satisfactory returns in hay or pasturage.

From these trials it seems that alfalfa holds promise as a crop to utilize profitably and at the same time rejuvenate eroded Muskingum and related soil. It also furnishes highly nutritious feed for dairy animals and other stock.

APPLICATION OF FINDINGS TO AGRICULTURE AND LAND USE IN THE PROBLEM AREA

The findings of the Northwest Appalachian Conservation Experiment Station bear out the evidence presented by erosion surveys, that the sloping soils of the area undergo severe erosion when devoted to "old style" general farming in which intertilled crops have a prominent place. The investigations of the station point the way to agricultural practices which not only will conserve rather than deplete the soil resources of the problem area but at the same time, if adopted generally, will add significantly to the Nation's food supply.

In general, the type of agriculture indicated is one in which grasses and legumes play a major role. On hill-land farms the growing of cultivated crops should be restricted to areas best suited by topography to their production—fairly level bottom lands and the gentler slopes. The remainder of the farms, in fact most of the acreage, should be devoted to pastures, pasture-meadows, and woodland. In the broad, comparatively level valleys, attention should be directed chiefly to rotation programs that will maintain the organic matter and the desirable structural characteristics of the soil.

The cropping of hill lands should be carried on only with all feasible practices for erosion control. Emphasis should be shifted from erosion-control practices in the narrow sense to a broader, more inclusive program designed to build up and conserve the productive capacity of soils in the fullest sense of the term. The rotations should include 2 years or more of sod crops. Meadows should be seeded with mixtures containing long-lived, deep-rooted legumes. Strip cropping, fortified by diversional grassed waterways and, where necessary, by terraces, should be practiced.

Not only should attention be directed to a more comprehensive soil-conserving program for cultivated lands, but emphasis should be shifted from cultivated crop acres to what is now considered non-cropland, potential grassland. Not only does a grass or legume vegetation control erosion effectively and conserve water for the replenishment of ground water, but it effectively rebuilds the dynamic organic-matter reserves of the soil and restores a desirable structure. The potential grassland of the areas should be recognized as being no less important for future income possibilities than the cropland and should, in general, receive more attention because it has been so neglected in the past. In short, "grass" should be looked upon and treated as a crop.

At present the noncultivated areas fall into three categories, pastures, woodland, and wasteland. To these should be added some acres now cultivated which should be "retired." To utilize profitably those areas suitable for grass requires a combination of the three "l's"—lime, legumes, and livestock. Areas too steep or too gullied for the use of machinery should be devoted to woods.

Dairying and sheep raising are now important farm enterprises. Small beef herds will fit well into the picture. The changing of the present type of unimproved native pasture from little more than "exercise lots" to fields producing all-summer herbage of high protein value can be a potent force in the present food-production program. Reclaiming a comparatively small area of the thousands of acres of virtually idle land, now growing broomsedge and poverty oatgrass, by the station's "trash mulch" method of seeding alfalfa-grass mixtures on such land, would add in no small way to the supplies of meat, milk and butter.

This change of practice can be accomplished by methods developed at this station.

Legumes such as alfalfa and Ladino clover are key plants in the utilization of potential "grassland." The legumes, in addition to furnishing much-needed protein to the pasturage, fill another important and agronomic need in that they furnish pasture throughout the grazing season. Kentucky bluegrass, the grass of improved pastures of the area, is prone to dry up and become semidormant after it forms seed in June. Later in the season, usually in September or October, it renews its growth. To bridge over this gap of low production of pasturage supplied by bluegrass, legumes fill a vital need. And, last but not least they are our greatest soil builders.

With the recognition of grasses and legumes as "crops" must come also a realization that they, like the so-called cultivated crops, must be fed. An intelligent fertilization program on grassland is essential to its success.

To summarize: The use of a minimum of cultivated land and long rotations, including deep-rooted legumes, in connection with strip cropping, terraces, and diversions—all known soil and water conserving practices; devoting of the large acreages to improved grassland for grazing and forage; returning to forest those areas unsuited to agricultural production—these are the bases for a permanent agriculture for the region.

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 36 to 55.

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 36.—*Description of the control plots from which soil and water losses were measured* [1]

[Muskingum silt loam]

Plot No.	Slope	Soil treatment	Cropping practice or surface condition	Measuring device
Feet	*Percent*			
1	12	No fertilizer	Continuous corn	Tank.[3]
2	12	do	do	
3	12	do	do	
13	12	Fertilized [2]	do	
4	12	No fertilizer, limed	4-year rotation, corn, wheat, meadow, meadow.	
5	12	do	do	
6	12	do	do	
7	12	do	do	
8	12		Surface bare, hard, fallow	
12	12	No fertilizer	Topsoil removed	
9	12		Wild grass sod	
10	12	Limed and fertilized [2]	Bluegrass sod	
11	12	do	do	
14	8	No fertilizer	Continuous corn	
15	20	do	do	
16	20	do	do	
17	20	Limed and fertilized [2]	4-year rotation, corn, wheat, meadow, meadow.	
18	12	do	do	
19	12	do	do	
20	12	do		
21	12		Surface bare, hard, fallow	

[1] All plots were 6 feet wide by 72.6 feet long except 1 and 2. Plot 1 was 36.3 feet and plot 2, 145.2 feet long.

[2] Plot 13 received 150 pounds per acre of 4-10-6 fertilizer in the row; plots 10 and 11 received 300 pounds per acre of sulphate of ammonia, annually, and 600 pounds per acre of superphosphate every third year; plots 17 to 20 received 150 pounds per acre of 3-12-12 fertilizer in the row on corn and 400 pounds per acre of 4-10-6 on the wheat. On the later 4 plots, second-year meadow received manure at 5 tons per acre and wheat was top-dressed with manure at 3 tons per acre.

[3] The amount of wash-off was computed from the total volume of material, measured in tanks for each rain.

TABLE 37.—*Description of field watersheds from which soil and water losses were measured*

Watershed designation	Area	Land slope	Soil type	Soil treatment	Cropping practice	Measuring device for—	
						Surface runoff	Soil loss in runoff
	Acres	*Percent*					
Cultivated	2.546	14	Muskingum and Eifort	Corn and wheat limed and fertilized.[1]	3-year rotation, corn, wheat, meadow.	Parshall flume and waterstage recorder.	Ramser silt sampler and silt box.
Pasture	3.568	14	Muskingum silt loam	Limed and fertilized[2]	Permanent pasture		
Wooded	2.227	14	Muskingum silt loam				

[1] Corn received 150 pounds of 4-10-6 fertilizer in the row; wheat, 300 pounds of 2-14-4. Lime as needed.
[2] 300 pounds of 0-14-6 fertilizer every third year, occasional applications of sulphate of ammonia and manure. Lime as needed

TABLE 38.—*Description of strip-cropped fields from which soil and water losses were measured* [1]

Field designation	Number of strips	Width of strip	Area	Soil treatment [2]	Cropping practice	Measuring device for— Surface runoff	Measuring device for— Soil loss in runoff
		Feet	*Acres*				
A	3	62-78	0.400	Corn and wheat, fertilized.	3-year rotation, corn, wheat meadow.		
B	3	73-78	.490	...do...	...do...		
C	4	66-68	.495	...do...	4-year rotation, corn, wheat, meadow, meadow.	Parshall flume and Leitz recorder.	Ramser silt sampler and silt box.
D	4	66-68	.592	...do...	...do...		
E [3]	3	70	.792	...do...	3-year rotation, corn, wheat, meadow.		
F [4]	6	35	.809	...do...	...do...		

[1] Muskingum silt loam, 15 percent slope.
[2] Corn received 150 pounds of 4-10-6 fertilizer in the row; wheat, 300 pounds of 2-14-4. Areas limed as needed.
[3] Field E had approximately 3-foot sod buffers between strips during the first rotation.
[4] Field F had approximately 6-foot sod buffers between strips during the first rotation.

TABLE 39.—*Description of the terraces from which soil and water losses were measured* [1]

Terrace No.	Length	Grade per 100 feet	Grade interval	Vertical spacing	Land slope	Soil type
	Feet		*Feet*	*Feet*	*Percent*	
A-3	1,200	Variable, 1, 2, 3, 4, 5 or 6 inches	200	7	12	
A-4	1,187	Variable, 1, 2, or 3 inches	400	7	12	
A-5	718	Level		7	12	Muskingum silt loam.
A-6	747	Variable, 1, 2, or 3 inches	200, 300, 300	7	12	
A-7	762	Uniform, 3 inches		7	12	
A-8	736	Variable, 2, 4, or 6 inches	200, 300, 300	7	12	
A-10	1,238	Uniform, 6 inches		7	12	
A-11	1,276	Uniform, 3 inches		7	12	
A-12	1,713	Level		7	12	
A-13	808	Uniform, 3 inches		7	10	
A-14	810	Uniform, 3 inches		7	10	
A-15	848	Uniform, 3 inches		7	10	Muskingum and F[illegible]fort.
C-3	1,200	Variable 1, 2, 3, 4, 5, or 6 inches	200	10	15	
C-4	1,200	Variable, 1, 2, 3, 4, 5, or 6 inches	200	8	15	
C-5	1,200	Variable, 1, 2, 3, 4, 5, or 6 inches	200	6	15	
B-7	1,148	Variable, 1, 2, 3, 4, 5, or 6 inches	200	10	12	
B-8	1,367	Variable 1, 2, 3, 4, 5, or 6 inches	200	8	12	
B-9	1,098	Variable, 1½, 3, 4½, 6, 7½, or 9 inches	200	8	12	
B-10	404	Level		7	12	Muskingum silt loam.
B-11	478	Level		7	12	

[1] Parshall flumes and water-stage recorders were used to measure surface runoff; Ramser silt samplers and silt boxes were used to measure soil loss in runoff. A and C terraces were cropped in a 3-year rotation of corn and meadow; corn received 150 pounds of 4-10-6 fertilizer in row; wheat, 300 pounds of 2-14-4. Lime was applied as needed. B terraces were in permanent pasture. Lime was applied as needed; 300 pounds of 0-14-16 fertilizer every third year.

TABLE 40.—*Description of the pasture paddocks from which soil and water losses were measured* [1]

Paddock designation	Soil treatment [2]	Cropping practice	Measuring device
1	Untreated		
2	Limed and fertilized		
3	...do...	Permanent pasture	Tanks and Geib divisors.
4	...do...		
5	...do...		

[1] Areas of 0.42 acre with slope of from 13 to 16 percent on Muskingum silt loam.
[2] Limed as needed on all but paddock No. 1. 250 pounds of 2-14-4 fertilizer applied to paddocks 2-5 at beginning of experiment; thereafter 400 pounds of 0-14-6 every fourth year.

TABLE 41.—*Soil and water losses from control plots in the length-of-slope and degree-of-slope experiments by months for the 9 years, 1934–42* [1]

Period	Rainfall: Amount	Rainfall: Maximum 5-minute intensity	Plot 1: Run-off	Plot 1: Soil loss	Plot 2: Run-off	Plot 2: Soil loss	Plot 3: Run-off	Plot 3: Soil loss	Plot 14: Run-off	Plot 14: Soil loss	Plot 15: Run-off	Plot 15: Soil loss
1934	*Inches*	*Inches per hour*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*
January	1.63	0.24	20.80	0.403	11.54	0.230	15.15	0.216	9.02	0.141	12.64	0.471
February	.31	0	0	0	0	0	0	0	0	0	0	0
March	3.27	.60	25.90	0	13.06	.077	47.52	.127	4.50	0	5.63	0
April	1.37	1.20	0	0	0	0	0	0	0	0	0	0
May	.91	3.60	0	0	0	0	0	0	0	0	0	0
June	4.18	3.00	13.56	4.581	9.38	5.462	13.66	6.710	20.26	5.478	11.46	4.228
July	1.16	1.08	0	0	0	0	0	0	0	0	0	0
August	6.25	4.08	55.39	18.052	49.78	21.415	55.15	21.322	52.62	21.188	40.30	20.369
September	4.28	2.16	55.07	4.952	48.83	3.962	55.49	6.934	44.74	4.582	37.01	4.028
October	.68	1.20	0	0	0	0	0	0	0	0	0	0
November	1.21	.48	45.62	.725	35.01	.519	51.74	.863	21.32	0	22.81	0
December	1.30	.24	13.00	0	7.02	0	14.15	0	0	0	0	0
Total	26.58		31.20	28.713	25.51	31.695	33.88	36.172	21.84	31.389	19.74	29.096
1935												
January	1.74	.84	0	0	0	0	0	0	0	0	0	0
February	2.07	.24	31.30	0	20.63	0	12.46	0	24.54	0	0	0
March	3.24	2.40	26.27	0	26.14	0	19.88	0	7.72	0	1.38	0
April	1.90	.24	7.00	.420	14.53	.530	20.74	.611	5.79	0	0	0
May	5.67	1.68	66.33	8.810	56.28	13.612	59.38	14.649	47.72	10.112	35.56	7.444
June	4.84	4.56	29.26	16.373	27.19	20.806	33.33	26.176	25.83	15.529	19.42	7.671
July	3.60	2.40	14.69	4.253	13.01	6.826	11.72	3.896	13.07	3.403	11.86	4.167
August	8.86	6.30	67.65	43.705	65.19	45.461	61.61	36.023	59.00	36.569	62.97	40.972
September	2.87	2.16	35.51	1.186	30.08	.968	31.99	.847	7.15	.965	24.84	1.278
October	1.84	.72	18.80	0	12.50	0	16.63	0	5.22	0	8.59	0
November	3.23	1.08	36.59	1.019	27.43	1.066	36.16	.842	20.43	.742	25.51	1.100
December	2.58	.30	10.00	0	25.70	0	17.83	0	0	0	5.00	0
Total	42.44		38.02	75.766	35.21	89.272	36.00	83.074	22.66	67.558	30.00	72.484
1936												
January	1.98	0.24		0		0		0		0		0
February	2.34	0.24		0		0.231		0		0		0
March	3.50	1.08	96.06	0	79.41	0	90.84	0	36.02	0	3.77	0
April	3.50	1.56	27.20	1.383	37.63	2.411	40.74	2.687	13.54	1.212	22.51	1.125
May	1.92	1.44	0	0	1.93	0	.94	0	1.93	0	1.98	0
June	1.42	1.32	0	0	0	0	0	0	0	0	0	0
July	6.38	9.36	56.11	65.367	50.11	80.828	53.93	62.805	47.96	44.741	49.70	84.650
August	4.95	3.60	51.94	22.745	50.22	20.616	50.93	16.371	43.86	16.193	47.25	20.863
September	2.81	1.56	48.36	3.475	46.26	2.553	45.80	3.038	44.16	2.924	45.34	3.976
October	5.59	2.52	59.27	11.918	57.87	12.656	62.59	12.280	49.53	11.604	51.81	13.624
November	3.62	.60	11.52	1.830	51.05	3.171	51.60	2.725	32.82	2.301	57.76	2.082
December	2.39	1.32	6.23	0	17.70	.082	19.25	.462	6.07	.685	.84	0
Total	40.40		51.83	106.718	48.69	122.551	53.52	100.368	34.41	79.060	31.96	126.320
1937												
January	10.29	1.44	59.73	7.897	93.71	17.055	91.78	12.055	48.91	11.730	123.28	13.671
February	1.28	1.20	3.27	.129	18.77	1.136	7.77	.182	21.03	.866	3.53	.418
March	1.80	1.68	10.62	1.145	16.37	1.612	19.04	.937	12.99	1.406	10.33	1.500
April	2.71	.84	1.16	[2]	.17	[2]	1.64	.079	3.40	.048	.34	[2]
May	4.50	2.04	23.06	10.805	11.78	22.305	18.58	13.470	26.83	7.530	21.33	16.024
June	6.83	4.56	55.36	43.916	66.87	83.726	52.57	45.331	50.59	36.526	53.59	58.340
July	2.90	1.80	16.25	1.348	14.79	2.180	16.81	2.337	16.53	1.393	15.82	3.227
August	3.54	2.28	44.31	8.101	36.58	9.611	42.41	8.900	36.26	4.699	36.93	12.632
September	1.62	2.16	30.61	.846	25.50	.921	29.76	.027	16.58	.420	17.36	.602
October	3.51	1.92	34.33	3.950	26.95	3.641	30.80	3.466	15.72	1.371	18.98	3.344
November	1.12	.96	12.30	.312	8.24	.412	11.31	.473	4.92	.090	3.00	.101
December	3.63	.84	1.38	.018	10.06	.105	13.36	.066	4.02	[2]	[2]	[2]
Total	43.74		34.69	78.467	41.78	122.697	43.06	88.223	29.59	66.088	45.80	109.868
1938												
January	1.57	0.48	58.9	.591	39.7	.668	57.2	.127	3.6	[2]	[2]	[2]
February	2.76	2.04	33.8	2.014	40.2	7.127	32.6	.798	8.7	11.874	10.7	4.141
March	5.08	1.32	77.7	3.738	51.8	0.591	31.9	4.298	17.9	32.702	22.3	5.318
April	3.77	2.40	51.7	2.004	46.5	3.506	40.3	2.550	39.6	4.868	42.1	8.130
May	6.61	4.20	36.6	13.640	31.9	22.217	38.6	18.148	32.9	8.697	20.8	17.838
June	4.72	3.60	44.1	34.472	41.8	62.430	46.2	49.424	40.4	12.613	41.4	59.078
July	2.43	1.80	5.8	.860	2.3	.288	7.0	1.367	4.2	.401	4.1	.841
August	3.85	2.88	47.8	16.611	43.8	24.138	52.6	23.159	44.0	3.020	44.7	23.450
September	4.63	3.62	50.4	13.315	55.8	15.718	62.0	13.762	46.2	0.500	51.7	16.997

See footnotes at end of table.

TABLE 41.—*Soil and water losses from control plots in the length-of-slope and degree-of-slope experiments by months for the 9 years, 1934–42* [1]—Continued

Period	Rainfall: Amount	Rainfall: Maximum 5-minute intensity	Plot 1: Run-off	Plot 1: Soil loss	Plot 2: Run-off	Plot 2: Soil loss	Plot 3: Run-off	Plot 3: Soil loss	Plot 14: Run-off	Plot 14: Soil loss	Plot 15: Run-off	Plot 15: Soil loss
1938	*Inches*	*Inches per hour*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*
October	0.57	0.84	9.7	0.308	6.6	0.147	8.7	0.303	5.8	0.162	1.9	0.152
November	3.19	1.26	30.3	3.700	36.7	6.150	44.6	1.712	21.0	2.978	21.6	3.788
December	1.39	.36	2.1	[2]	.6	[2]	.9	[2]	16.6	.115	1.3	[2]
Total	40.57	...	45.2	91.262	39.3	151.980	46.1	118.648	28.7	78.020	29.1	139.733
1939												
January	2.67	.48	67.1	1.181	35.5	.235	32.8	.140	15.5	2.131	4.9	.422
February	5.13	.60	58.6	1.890	48.6	7.831	46.3	3.076	26.1	3.333	12.6	4.472
March	3.30	.96	28.7	.604	21.1	1.624	16.5	.304	14.5	1.190	4.5	.260
April	4.64	.84	63.4	1.987	45.4	6.084	40.7	2.681	37.4	6.018	31.5	6.464
May	.95	1.68	0	0	0	0	0	0	.9	0	[2]	0
June	9.72	2.52	49.5	40.105	45.6	53.274	52.4	53.169	44.0	26.479	42.7	56.844
July	3.95	1.20	36.6	18.950	36.4	23.516	37.6	23.900	38.9	12.570	48.6	22.010
August	4.46	1.08	47.3	21.155	47.1	36.046	57.0	31.548	47.0	21.222	55.3	35.305
September	2.39	1.80	37.4	7.686	35.1	8.983	41.2	8.443	35.2	7.767	34.1	7.731
October	3.53	2.16	61.0	7.406	61.2	8.763	67.0	8.117	13.1	5.988	42.4	2.655
November	.90	.30	0	0	0	0	0	0	[2]	0	[2]	0
December	1.53	1.26	10.1	.718	9.0	1.001	11.6	.701	9.6	1.010	8.6	1.807
Total	43.17		46.9	101.195	40.2	117.160	42.4	132.343	34.2	87.468	31.0	142.810
1940												
January	1.25	.48	[3]	.228	[3]	.540	[3]	.389	[3]	.046	[3]	.002
February	3.45	.36		1.104		1.925		1.031		.332		.048
March	3.16	.96	88.53	1.011	56.72	1.006	50.86	2.549	29.10	1.518	4.51	.211
April	8.04	2.88	69.88	10.799	72.18	16.850	61.17	11.218	62.51	13.386	62.45	12.497
May	5.11	2.88	15.31	2.476	17.52	3.887	20.78	3.918	10.16	2.348	12.36	4.204
June	6.15	3.12	46.12	37.321	48.36	52.911	48.39	50.254	54.67	32.965	44.63	51.122
July	1.67	1.32	21.77	1.969	23.12	2.272	27.38	2.978	20.69	1.274	19.71	1.500
August	4.03	3.12	13.77	10.923	48.22	12.015	50.26	13.509	42.74	4.886	39.31	6.491
September	2.29	1.20	15.88	6.388	11.99	7.293	51.15	7.539	11.22	3.630	13.91	4.770
October	1.83	2.88	31.62	3.247	30.93	1.170	37.96	1.680	31.64	.962	29.98	2.323
November	3.73	.96	23.78	1.385	21.45	1.382	26.80	2.138	19.87	.778	20.70	.996
December	2.55	.48	.54	0	15.12	.225	3.51	.062	14.12	.871	21.32	1.006
Total	43.26		48.33	76.841	43.46	107.132	43.07	103.062	36.34	63.138	30.48	88.190
1941												
January	2.15	.60	2.31	0	6.82	.008	2.95	.086	2.81	.137	4.76	.154
February	.45	.03	[3]	0	0	0	0	0	3.47	.008	[2]	0
March	.74	.12										
April	1.01	.84	0	0	0	0	0	0	0	0	0	0
May	1.81	3.60	26.14	10.119	20.83	11.165	28.85	14.937	17.70	5.282	21.46	14.876
June	2.01	3.60	17.93	7.214	15.62	9.131	22.12	8.710	8.14	1.496	21.35	18.252
July	5.69	5.76	46.86	50.193	47.96	67.846	46.08	62.572	14.90	15.380	48.85	83.740
August	4.72	3.60	56.23	30.921	51.37	18.958	51.77	11.082	53.54	21.847	51.93	36.372
September	2.15	6.24										
October	1.10	1.08	32.59	1.385	20.99	1.874	36.62	2.199	17.13	.396	18.19	.572
November	1.79	.72	40.01	.706	31.55	.903	11.63	.812	33.86	.268	33.73	.615
December	1.62	1.44	8.70	.232	6.91	1.280	12.16	1.055	19.13	.922	8.09	.858
Total	31.27		53.30	100.770	29.63	111.251	31.19	131.493	28.72	78.714	30.23	155.440
1942												
January	1.27	1.08	8.68	0.108	7.75	1.305	13.01	.882	13.56	.801	7.86	1.380
February	2.82	.72	6.34	.159	71.50	3.115	27.00	.178	22.56	.617	13.27	2.330
March	4.10	3.48	35.76	6.072	68.63	21.652	30.29	12.616	45.98	12.510	36.88	16.080
April	2.48	.60	56.65	1.103	80.71	2.641	45.77	1.845	50.65	1.535	51.38	2.249
May	4.20	1.32	28.53	11.210	26.90	16.758	29.17	15.136	30.79	14.321	27.50	15.582
June	5.33	4.56	51.55	31.939	42.52	36.616	13.19	32.077	41.35	25.500	35.10	53.473
July	3.25	6.00	56.05	21.877	42.70	30.882	46.52	21.282	53.51	19.400	46.01	21.093
August	2.43	3.00	36.51	3.871	32.29	9.154	55.20	7.136	29.12	4.086	21.28	3.908
September	3.92	3.00	45.11	4.649	22.00	6.274	37.78	1.585	31.97	2.208	20.14	3.216
October	2.01	.18	26.01	.496	11.65	.380	21.95	.198	8.22	.064	15.07	.100
November	3.01	1.44	40.27	1.418	32.03	2.911	33.11	1.032	32.95	.823	30.78	.906
December	4.32	.48	21.23	.110	57.71	.650	8.93	.656	5.42	.056	2.88	.014
Total	38.61		37.13	83.102	43.38	132.667	32.08	100.321	32.58	82.055	27.83	120.331
9-year average	38.91		41.31	82.906	39.46	116.631	40.53	99.300	31.28	70.939	31.02	108.817

[1] See table 36, Appendix.
[2] Trace.
[3] Snow hold-over necessitated figuring runoff on 3-month basis.

TABLE 42.—*Soil and water losses from control plots in the length-of-slope and degree-of-slope experiments for the principal rains of the 9 years, 1934–42*

Date of rain	Rainfall: Amount	Rainfall: Maximum 5-minute intensity	Plot 1: Run-off	Plot 1: Soil loss	Plot 2: Run-off	Plot 2: Soil loss	Plot 3: Run-off	Plot 3: Soil loss	Plot 14: Run-off	Plot 14: Soil loss	Plot 15: Run-off	Plot 15: Soil loss
1934	*Inches*	*Inches per hour*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*
June 22	0.98	3.00	44.91	4.47	34.23	5.39	50.73	6.51	47.08	4.60	47.31	4.11
Aug. 2	2.79	4.08	56.62	11.01	53.67	13.40	59.40	14.16	55.54	12.24	37.54	10.61
Aug. 16	3.01	2.76	60.41	6.28	51.09	7.44	59.46	6.38	55.00	8.45	46.44	9.45
1935												
May 2-7	4.24	1.68	83.48	8.81	70.69	13.61	71.29	14.65	59.06	10.11	44.08	7.44
June 18-19	1.11	3.00	28.08	4.68	21.48	7.10	29.96	9.36	25.40	3.79	23.65	4.77
June 21-22	1.78	4.56	57.81	10.58	57.38	12.64	59.91	15.42	52.41	11.66	36.64	2.90
July 28	.92	2.40	52.74	4.25	50.37	6.65	44.47	3.90	30.68	3.40	46.36	4.17
Aug. 1	.74	2.52	40.87	3.87	37.10	5.46	40.13	4.36	33.25	3.19	34.56	5.56
Aug. 3	.93	2.88	75.79	8.60	71.88	8.48	69.06	5.61	61.24	7.78	67.49	9.67
Aug. 7	2.77	3.00	79.58	9.18	80.81	12.18	77.83	9.51	78.30	11.06	67.41	7.95
Aug. 10	1.76	6.30	82.71	14.74	74.81	12.46	73.45	9.43	77.12	11.40	80.19	16.74
1936												
July 4	2.18	9.36	73.05	43.534	70.28	58.954	79.17	46.332	68.86	32.337	70.80	67.590
July 23	1.32	3.36	34.19	7.438	20.42	4.306	20.60	3.321	23.00	2.550	18.97	6.998
July 27	2.51	2.28	60.48	12.845	55.71	15.568	57.12	11.037	49.46	8.847	46.46	9.591
Aug. 20	.65	2.28	76.43	5.095	76.89	4.280	74.50	3.508	65.94	3.610	74.17	4.088
Aug. 25	1.00	2.88	61.09	6.205	64.21	5.548	61.05	4.221	59.30	3.974	60.06	5.269
Aug. 28-29	1.67	3.60	62.05	8.617	58.83	8.199	62.63	6.000	53.58	7.614	55.32	0.151
Oct. 7-8	2.26	2.16	77.22	6.097	75.58	6.170	80.47	6.181	66.01	4.906	69.05	6.234
Oct. 9-10	1.45	2.52	60.80	5.190	70.21	6.047	74.73	5.752	62.09	5.538	64.37	6.550
1937												
Jan. 13-15	2.02	1.44	56.5	1.874	107.8	6.110	99.6	3.890	46.7	3.729	88.7	3.067
Jan. 20-22	2.76	.96	72.1	4.231	102.1	7.490	106.7	5.505	63.7	5.472	175.2	7.122
May 26-27	1.62	2.64	59.5	10.251	38.2	21.926	47.5	12.943	70.0	7.223	52.2	15.380
June 6	1.13	4.56	66.3	13.594	71.1	24.297	62.7	15.326	53.1	11.777	68.6	26.809
June 14	.57	3.36	84.1	7.088	79.2	9.885	71.0	7.272	77.6	4.728	96.0	7.247
June 20-21	3.37	4.32	73.8	23.194	76.3	29.463	71.6	21.733	71.6	20.022	73.9	24.172
Aug. 9-10	1.34	2.28	64.0	6.188	56.6	7.383	61.3	6.901	55.5	3.314	53.0	8.104
1938												
May 8	.84	4.20	38.7	6.368	32.0	9.118	36.2	7.285	32.9	3.180	31.2	5.612
June 11	1.10	3.60	60.2	13.234	56.8	26.161	50.3	19.196	59.1	11.642	62.3	25.784
June 22	.98	2.40	41.2	6.484	34.6	11.644	45.3	12.000	31.1	5.384	36.8	15.115
June 26-27	1.68	3.48	57.5	14.150	37.6	24.136	62.1	17.600	53.6	15.492	52.8	17.083
July 31-Aug. 1	1.48	1.41	45.6	5.127	36.2	6.307	51.0	8.084	36.9	2.671	39.5	7.770
Aug. 4	1.30	2.88	70.1	9.863	68.0	15.093	71.3	12.768	66.5	8.471	65.5	13.290
Sept. 12-13	2.42	3.62	67.8	11.200	64.0	13.050	68.6	11.414	53.9	9.272	62.7	15.678
1939												
June 3	.91	1.02	41.7	3.340	38.9	6.715	47.2	6.066	32.5	1.490	31.2	7.074
June 17-18-19	2.18	2.52	58.1	17.430	55.0	23.223	63.6	21.384	50.9	13.030	49.7	25.030
June 22	1.18	2.28	81.2	9.207	74.3	11.557	82.0	11.869	78.8	5.032	78.8	13.557
June 29	.92	1.68	78.7	6.836	75.3	7.230	79.5	8.986	76.9	4.018	77.9	7.004
July 4-5	1.96	4.20	73.7	18.950	73.1	23.509	74.6	23.099	78.4	12.570	97.4	21.916
Aug. 7	.89	3.00	54.4	4.771	53.8	9.733	63.7	8.652	59.1	3.870	58.2	8.027
Aug. 12-13	1.80	4.68	72.0	18.386	70.2	24.350	83.4	20.759	73.9	10.382	76.2	23.008
Sept. 4	1.26	6.00	61.4	7.054	60.1	8.507	65.9	7.869	61.8	7.411	62.8	7.380
1940												
June 9	.76	1.92	25.4	1.500	28.4	4.081	32.8	3.343	41.8	4.195	21.7	6.496
June 10	.54	2.40	66.1	4.682	71.1	7.903	69.4	6.678	84.5	4.806	61.4	11.816
June 11	.94	3.12	69.8	8.966	67.7	9.566	71.7	11.400	72.2	5.394	62.6	8.968
June 15	.55	1.80	65.2	4.278	70.9	4.450	69.1	5.286	81.4	.898	64.2	3.073
June 17-18	.51	2.76	50.7	4.663	51.7	4.200	55.7	5.102	59.4	2.265	48.5	2.788
June 28	1.05	2.88	69.3	10.527	71.1	18.090	72.1	15.124	83.1	13.510	68.6	17.601
Aug. 25-28	1.41	3.12	45.7	6.758	35.6	7.475	51.1	7.473	48.3	3.008	44.3	3.569
Sept. 24-25	2.07	4.20	50.8	6.388	46.1	7.263	56.6	7.339	48.9	3.630	48.9	4.730
1941												
May 16-17	1.68	3.60	31.7	4.366	29.4	6.318	35.7	7.588	22.4	3.043	28.5	7.374
May 31-June 4	2.20	3.60	41.1	5.753	31.4	7.817	46.0	7.319	26.9	2.092	34.5	5.443
June 12-16	1.49	3.60	18.7	6.830	18.3	8.275	25.6	7.102	6.5	1.118	30.9	17.552
July 7	1.06	4.20	55.8	11.545	51.7	18.499	58.1	15.936	32.2	4.402	53.5	11.014
July 15	1.18	3.36	41.6	8.635	35.2	12.296	27.4	5.866	37.7	6.546	42.6	12.944
July 18	1.02	5.76	70.2	26.743	79.9	32.447	72.5	37.276	83.3	33.304	80.1	53.891
Aug. 15-19	2.78	2.88	45.6	7.151	38.3	12.895	45.8	9.903	30.5	6.561	38.4	8.584
Aug. 25-26	1.66	3.60	69.8	6.298	64.6	9.659	71.3	8.036	61.8	4.033	61.4	7.704
Aug. 30-Sept. 3-5	2.31	6.24	62.8	17.472	60.3	26.105	56.5	23.143	65.1	14.250	62.2	19.995

TABLE 42.—*Soil and water losses from control plots in the length-of-slope and degree-of-slope experiments for the principal rains of the 9 years, 1934–42*—Continued

Date of rain	Rainfall		Plot 1		Plot 2		Plot 3		Plot 14		Plot 15	
	Amount	Maximum 5-minute intensity	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss
1942	*Inches*	*Inches per hour*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*
March 13-16	2.17	3.48	42.2	5.978	83.7	21.111	52.2	12.529	57.6	11.908	63.3	15.875
May 14-15	2.21	1.32	54.2	11.210	51.1	16.758	55.4	15.136	58.4	14.324	52.2	15.582
June 1	.58	5.04	43.1	6.884	19.8	3.070	34.4	5.705	18.8	1.962	53.2	17.277
June 4	.58	4.20	70.7	8.470	56.6	8.474	61.9	8.015	22.8	1.270	58.5	9.678
June 13-14	2.67	4.56	50.2	9.745	43.7	16.039	52.6	11.344	51.0	14.378	23.4	18.331
June 22	1.66	.80	63.2	6.840	55.3	8.763	39.5	7.013	64.3	7.989	44.6	8.227
July 3-6	1.03	2.40	48.5	6.542	32.4	6.536	35.3	6.067	38.6	4.374	32.6	6.520
July 27	1.10	6.00	76.0	12.752	66.8	21.506	70.9	15.972	86.3	12.466	74.3	12.634
Aug. 21-24	1.77	3.00	50.1	2.871	44.3	9.451	48.3	7.136	40.4	4.086	33.3	3.048

TABLE 43.—*Soil and water losses from control plots in grass and from the fertilized and desurfaced plots in corn by quarters for the 9 years 1934–42* [1]

Period	Rainfall		Plot 9		Plot 10		Plot 11		Plot 12		Plot 13	
	Amount	Maximum 5-minute intensity	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss
1934	*Inches*	*Inches per hour*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*
Jan.-Mar.	5.28	0.60	16.5	0.016	17.2	0.079	11.3	0.067	22.6	0.266	72.7	0.472
Apr.-June	6.49	3.00	0	0	0	0	0	0	17.1	14.428	8.6	3.990
July-Sept	11.69	4.08	3.8	0	2.1	0	1.4	0	52.8	60.050	48.6	21.787
Oct.-Dec.	3.19	1.20	0	0	0	0	0	0	8.1	.872	26.3	.911
Total	26.58	...	4.9	.016	1.3	.079	2.8	.067	32.8	75.616	40.9	27.160
1935												
Jan.-Mar.	7.05	2.40	.17	0	2.3	0	1.2	0	11.7	0	29.2	0
Apr.-June	12.41	4.56	2.0	0	3.2	0	2.7	0	36.2	21.907	44.0	31.432
July-Sept	15.33	6.30	16.0	.023	9.2	.020	9.6	.019	41.0	71.415	47.1	40.926
Oct.-Dec.	7.65	1.08	0	0	.31	0	.58	0	21.3	4.028	31.0	1.521
Total	42.41	...	6.4	.023	4.7	.020	4.6	.019	33.6	97.350	40.3	73.909
1936												
Jan.-Mar.	7.82	1.08	27.3	.028	29.9	.022	25.8	.017	71.7	0	78.3	0
Apr.-June	6.84	1.76	.54	0	5.5	0	2.8	0	14.6	1.034	28.6	3.112
July-Sept	14.14	9.36	8.3	0	4.4	0	3.2	0	51.2	93.706	42.2	47.813
Oct.-Dec.	11.60	2.52	2.2	0	5.6	0	2.7	0	46.3	10.275	49.3	14.143
Total	40.40		8.9	.028	9.9	.022	7.3	.017	47.6	105.015	49.0	65.068
1937												
Jan.-Mar.	13.37	1.68	19.3	.012	19.9	.019	9.0	.007	45.7	2.816	78.9	12.718
Apr.-June	14.05	4.56	7.7	.014	7.7	.006	6.9	.010	33.0	38.987	33.7	55.985
July-Sept	8.06	2.28	0	0	0	0	0	0	30.7	12.751	30.5	11.288
Oct.-Dec.	8.26	1.92	0	0	0	0	.48	0	11.5	1.798	28.4	4.308
Total	43.74	...	8.4	.026	8.5	.025	5.1	.017	33.0	56.352	45.9	84.299
1938												
Jan.-Mar.	9.41	2.04	.23	.002	1.3	.002	.51	.001	9.1	.571	90.9	8.056
Apr.-June	15.10	4.20	1.3	0	1.3	0	1.9	0	37.9	33.275	48.5	64.416
July-Sept	10.91	3.02	3.8	0	1.9	0	2.7	0	42.0	30.664	44.4	30.265
Oct.-Dec.	5.15	1.20	0	0	0	0	0	0	11.9	1.209	30.9	5.107
Total	40.57	...	1.6	.002	1.3	.002	1.6	.001	29.4	65.722	57.1	107.844

See footnotes at end of table.

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TABLE 43.—*Soil and water losses from control plots in grass and from the fertilized and desurfaced plots in corn by quarters for the 9 years 1934–42*[1]—Continued

Period	Rainfall		Plot 9		Plot 10		Plot 11		Plot 12		Plot 13	
	Amount	Maximum 5-minute intensity	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss
1939	*Inches*	*Inches per hour*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*
Jan.-Mar.	11.10	0.96	8.3	0.016	5.4	0.004	8.5	0.008	11.9	0.396	78.0	4.447
Apr.-June	15.31	2.52	3.1	.002	1.2	.002	3.2	.003	30.3	23.762	49.9	48.108
July-Sept.	10.80	4.08	10.9	.015	8.9	.009	11.5	.009	41.5	45.160	42.1	50.991
Oct.-Dec.	5.96	2.46	.81	0	.71	0	.81	0	32.1	4.318	42.6	9.791
Total	43.17		6.0	.033	4.2	.015	6.3	.020	28.7	73.636	54.2	113.340
1940												
Jan.-Mar.	7.86	.96	9.8	.012	11.0	.013	10.7	.004	14.1	.684	45.1	2.424
Apr.-June	19.30	3.12	11.7	.031	6.9	.018	6.3	.010	35.1	30.439	45.7	63.344
July-Sept.	7.99	4.20	1.7	.004	.51	.001	.51	.002	33.8	15.726	47.3	18.954
Oct.-Dec.	8.11	2.88	1.0	0	.68	0	0	0	15.6	4.411	23.9	7.642
Total	43.26		7.5	.047	5.8	.032	4.8	.016	27.4	51.260	41.8	92.364
1941												
Jan.-Mar.	3.34	.60	.21	0	1.6	0	.82	[2]	1.2	.002	3.4	.101
Apr.-June	7.86	3.60	0	0	0	0	0	0	15.7	5.520	22.0	22.052
July-Sept.	12.56	6.24	2.4	.015	2.0	.008	2.8	.010	55.1	70.320	54.9	79.871
Oct.-Dec.	7.51	1.44	.55	.004	0	0	0	0	19.7	1.098	33.9	4.280
Total	31.27		1.1	.019	1.0	.008	1.2	.010	30.9	76.940	36.1	106.304
1942												
Jan.-Mar.	7.69	3.48	5.6	.024	3.9	.014	.18	0	13.5	6.869	19.3	12.088
Apr.-June	12.01	1.50	1.4	.004	.69	0	0	0	37.0	23.354	43.3	60.121
July-Sept.	9.00	6.00	2.1	.005	3.0	.003	1.1	.002	33.8	19.423	41.2	30.854
Oct.-Dec.	9.31	1.41	0	0	0	0	0	0	18.6	1.231	25.3	3.976
Total	38.64		2.1	.033	1.8	.017	.32	.002	27.1	50.877	34.4	97.039
9-year average	38.91		5.4	.028	4.8	.023	4.0	.019	32.2	72.530	41.8	85.258

[1] See table 36, Appendix.
[2] Trace.

TABLE 44.—*Soil and water losses from control plots in the 4-year rotation experiment and the bare-fallow plot by months for the 9 years, 1934–42*[1]

Period	Rainfall		Plot 4		Plot 5		Plot 6		Plot 7		Plot 8	
	Amount	Maximum 5-minute intensity	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss
1934	*Inches*	*Inches per hour*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*
January	1.63	0.21	16.9	0.032	14.2	0.004	19.0	0.010	25.3	0.061	17.4	0.181
February	.31	0	0	0	0	0	0	0	0	0	0	0
March	3.27	.60	30.1	.025	37.2	.008	59.1	0	50.3	.010	34.5	.100
April	1.37	1.20	0	0	0	0	0	0	0	0	0	0
May	.94	3.60	0	0	0	0	0	0	0	0	0	0
June	4.18	3.00	15.4	1.955	9.3	2.159	0	0	0	0	55.2	18.128
July	1.16	1.08	0	0	0	0	0	0	0	0	19.1	1.868
August	6.25	4.08	54.1	4.297	43.4	9.317	12.0	.481	8.0	0	70.4	14.544
September	4.28	2.16	43.0	.980	38.7	1.790	3.4	0	0	0	61.1	5.755
October	.68	1.20	0	0	0	0	0	0	0	0	0	0
November	1.21	.48	18.3	.013	0	0	0	0	0	0	52.3	.743
December	1.30	.24	0	0	0	0	0	0	0	0	7.6	0
Total	26.58		27.6	7.322	23.3	13.278	13.6	.491	9.0	.071	44.0	41.319

Table 44.—*Soil and water losses from control plots in the 4-year rotation experiment and the bare-fallow plot by months for the 9 years, 1934–42*[1]—Continued

Period	Rainfall: Amount	Rainfall: Maximum 5-minute intensity	Plot 4: Run-off	Plot 4: Soil loss	Plot 5: Run-off	Plot 5: Soil loss	Plot 6: Run-off	Plot 6: Soil loss	Plot 7: Run-off	Plot 7: Soil loss	Plot 8: Run-off	Plot 8: Soil loss
1935	*Inches*	*Inches per hour*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*	*Pct.*	*Tons*
January	1.74	0.84	0	0	0	0	0	0	0	0	0	0
February	2.07	.24	19.6	0	30.6	0	4.1	0	11.5	0	18.7	0
March	3.24	2.40	42.1	0	32.7	0	5.9	0	30.6	0	17.8	0
April	1.00	.24	3.9	0	1.9	0	0	0	1.0	0	22.3	3.413
May	5.67	1.68	41.8	0	30.2	0	26.9	0	28.0	0	55.7	7.137
June	4.84	4.56	7.5	0	5.7	0	21.9	8.187	1.1	0	53.7	15.141
July	3.00	2.40	1.2	0	3.6	0	13.2	3.047	0	0	33.2	5.799
August	8.86	6.30	31.3	.188	34.8	.325	64.3	29.615	25.8	0	71.4	33.127
September	2.87	2.16	2.6	0	3.2	0	26.2	.842	.63	0	38.5	2.262
October	1.84	.72	0	0	0	0	9.4	0	0	0	16.0	0
November	3.23	1.08	.40	0	.28	0	2.0	.172	0	0	40.3	1.216
December	2.58	.30	16.4	0	20.0	0	6.9	0	6.1	.049	11.4	0
Total	42.44	....	18.6	.188	17.8	.325	21.4	41.863	12.9	.049	41.6	68.095
1936												
January	1.98	.24		0		0		0		0		0
February	2.34	.24	31.3	0	70.1	0	41.8	0	20.4	0	94.4	0.479
March	3.50	1.08		0		0		0		0		0
April	3.50	1.56	3.1	0	37.9	0	16.3	0	13.1	0	38.0	9.107
May	1.92	1.44	0	0	0	0	7.9	0	9.6	0	27.0	4.012
June	1.42	1.32	0	0	0	0	1.3	0	0	0	14.0	.970
July	6.38	9.36	1.7	.160	8.4	.312	66.7	9.881	37.3	31.566	67.9	41.130
August	4.95	3.60	1.5	0	1.5	0	49.2	8.761	43.6	9.578	57.0	21.267
September	2.81	1.56	.63	0	1.1	0	41.3	.123	14.9	1.536	54.8	3.201
October	5.59	2.52	9.5	0	14.1	0	30.4	.227	41.6	7.727	65.0	11.080
November	3.62	.66	15.8	0	49.3	0	35.6	.008	37.0	.767	59.8	2.444
December	2.39	1.32	1.9	0	17.3	0	11.5	0	1.4	0	17.4	4.046
Total	40.40	....	9.7	0.160	28.1	.312	36.5	19.000	28.6	51.274	59.6	97.745
1937												
January	10.29	1.44	36.6	.147	72.5	.160	68.4	.358	60.5	3.062	62.9	13.064
February	1.28	1.20	(2)	0	12.7	(2)	.82	(2)	8.4	.290	18.7	1.260
March	1.80	1.68	2.2	(2)	18.2	(2)	2.2	(2)	8.5	.372	22.5	6.185
April	2.71	.84	(2)	0	.61	(2)	(2)	0	(2)	0	7.8	.078
May	4.50	2.64	17.4	6.450	7.0	(2)	.32	(2)	16.0	.511	35.3	18.003
June	6.83	4.56	50.9	31.092	21.6	(2)	20.6	.055	42.9	1.109	58.9	45.035
July	2.90	1.80	4.2	.175	(2)	0	(2)	0	5.5	(2)	38.4	5.401
August	3.51	2.28	28.7	3.369	(2)	0	(2)	0	8.6	.050	53.9	13.161
September	1.62	2.16	31.5	.600	(2)	0	(2)	0	(2)	0	32.3	1.461
October	3.51	1.92	3.0	.113	0	0	0	0	.94	(2)	35.2	3.613
November	1.12	.96	(2)	0	0	0	(2)	0	0	0	9.4	.161
December	3.63	.84	1.3	(2)	25.6	(2)	2.4	(2)	3.6	(2)	14.7	.229
Total	43.74	....	22.6	41.016	21.4	.160	19.6	.413	25.0	5.391	42.2	[3]108.851
1938												
January	1.57	.48	30.7	.035	34.7	.007	16.7	.006	26.3	.008	31.6	.738
February	2.76	2.04	13.9	.100	20.6	.012	5.0	.016	17.0	.035	30.7	6.530
March	5.08	1.32	25.5	.114	20.9	(2)	19.2	(2)	10.5	(2)	43.0	8.339
April	3.77	2.40	18.3	.103	17.9	(2)	10.4	(2)	11.7	(2)	47.0	8.690
May	6.61	4.20	19.4	.679	23.4	7.449	3.1	0	5.2	0	51.7	28.530
June	4.72	3.60	34.1	1.459	42.7	31.528	1.0	0	9.7	.018	55.4	40.257
July	2.43	1.80	3.5	(2)	2.9	.388	0	0	(2)	0	16.0	3.532
August	3.85	2.88	27.0	.279	44.2	17.459	.21	0	1.1	0	53.0	19.028
September	4.63	3.02	33.1	1.253	49.9	11.018	.59	0	2.1	0	60.7	19.448
October	.57	.84	0	0	0	0	0	0	0	0	8.5	.322
November	3.10	1.20	3.4	(2)	11.3	1.696	(2)	0	(2)	0	30.0	3.705
December	1.39	.36	8.0	(2)	.70	(2)	(2)	0	1.4	(2)	2.2	(2)
Total	40.57	....	21.3	4.022	26.8	72.557	5.1	.022	8.1	.061	43.4	139.240
1939												
January	2.67	.48	53.6	.014	10.8	(2)	23.4	(2)	43.3	.020	28.5	.180
February	5.13	.60	50.9	.087	26.8	.603	10.1	.016	36.8	.052	30.7	4.714
March	3.30	.96	10.0	(2)	2.9	(2)	6.3	(2)	11.7	(2)	17.3	1.572
April	4.64	.84	31.1	.050	14.4	.235	7.4	(2)	21.5	(2)	35.0	3.046
May	.85	1.68	(2)	0	4.0	.287	0	0	0	0	26.4	4.184
June	9.72	2.52	18.6	.149	42.2	10.506	32.9	10.357	12.0	.049	56.2	46.476

See footnotes at end of table.

TABLE 44.—*Soil and water losses from control plots in the 4-year rotation experiment and the bare-fallow plot by months for the 9 years, 1934–42*[1]—Continued

Period	Rainfall		Plot 1		Plot 2		Plot 3		Plot 14		Plot 15	
	Amount	Maximum 5-minute intensity	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss
1939	*Inches*	*Inches per hour*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*
July	3.95	1.20	24.4	0.161	38.3	3.492	34.4	8.574	20.6	0.038	46.9	19.638
August	4.46	4.08	11.0	.052	42.1	2.680	28.6	8.815	10.0	.002	68.6	34.356
September	2.39	1.80	4.6	.042	28.6	.672	20.6	3.268	3.5	.001	44.6	16.069
October	3.53	2.16	5.1	.032	6.2	.088	17.3	1.863	2.6	.002	55.4	8.034
November	.90	.36	0	0	0	0	0	0	0	0	(2)	0
December	1.53	1.20	2.7	.004	(2)	0	2.4	.096	0	0	7.4	.424
Total	43.17		23.0	.021	25.2	18.032	20.6	32.080	16.3	.164	42.3	139.293
1940												
January	1.25	.48	(3)	.144	(3)	.132	(3)	.078	(3)	.006	(3)	.389
February	3.45	.36		.031		.077		.048		.014		.492
March	3.16	.96	40.4	.096	45.3	.470	30.0	.896	34.9	.060	30.1	2.766
April	8.04	2.88	65.0	.243	51.7	.786	49.0	4.231	35.3	.096	63.8	13.838
May	5.11	2.88	5.6	.004	3.0	.005	18.7	2.778	.27	.002	33.8	8.843
June	6.15	5.12	12.2	.038	6.5	.078	49.7	5.348	42.5	27.038	55.2	33.390
July	1.67	1.32	3.3	.002	.49	0	14.0	.031	17.8	1.298	16.7	.840
August	4.03	3.12	(2)	0	(2)	0	13.3	.172	25.6	6.906	59.3	9.610
September	2.29	4.20	1.2	.010	(2)	0	20.4	.090	40.1	5.025	61.8	8.165
October	1.83	2.88	(2)	0	(2)	0	6.8	.034	15.8	1.020	39.1	3.908
November	3.73	.96	8.9	.005	8.1	.004	5.9	.006	9.0	.240	37.3	1.120
December	2.55	.48	6.5	.002	4.3	.002	3.7	.002	11.3	.010	23.9	.158
Total	43.26		24.8	.575	20.1	1.561	27.7	13.714	26.3	41.818	46.0	83.522
1941												
January	2.15	.60	5.1	(2)	.64	(2)	2.2	(2)	6.4	.002	8.8	.038
February	.45	.08										
March	.74	.12	(2)	0	(2)	0	0	0	1.2	.001	3.5	.006
April	1.01	.84	0	0	0	0	0	0	0	0	0	0
May	4.84	3.60	18.8	4.926	(2)	0	(2)	0	3.0	.222	27.2	10.107
June	2.64	3.60	14.0	5.389	(2)	0	0	0	9.9	2.174	32.2	8.739
July	5.60	5.76	33.9	15.974	2.5	.052	4.0	.069	52.8	9.447	67.8	51.875
August	4.72	3.60										
September	2.15	6.24	47.9	21.752	3.0	.028	4.6	.026	49.0	10.927	68.1	43.608
October	4.10	1.08	2.8	.141	(2)	0	(2)	0	(2)	0	26.0	1.832
November	1.79	.72	4.6	.060	3.8	.003	1.5	0	7.7	.006	43.9	.620
December	1.62	1.44	(2)	0	6.0	.006	3.4	.001	25.5	.021	20.4	.488
Total	31.27		21.5	48.242	1.8	.080	2.1	.096	23.7	22.800	41.3	117.313
1942												
January	1.27	1.08	(2)	0	(2)	0	1.4	0	15.2	.009	11.5	.305
February	2.32	.72	3.0	.004	7.9	.006	(2)	0	65.9	.032	37.1	.088
March	4.10	3.48	17.5	1.538	20.0	.162	14.8	.287	38.0	1.006	44.7	9.040
April	2.48	.60	4.4	.011	25.6	.014	6.7	.004	58.3	.052	66.3	.887
May	4.20	4.32	10.8	.793	3.6	.400	(2)	0	6.9	.213	37.4	9.261
June	5.33	4.56	43.3	6.552	40.6	14.801	1.6	.008	26.8	.450	64.3	26.689
July	3.25	6.00	36.6	1.649	33.3	7.638	0	0	7.3	.054	51.5	16.062
August	2.43	3.00	20.4	.430	18.5	1.788	(2)	0	.85	0	36.4	6.700
September	3.92	3.00	4.2	.029	21.8	1.231	(2)	0	(2)	0	33.7	3.075
October	2.01	.48	0	0	0	0	0	0	0	0	14.4	.258
November	3.01	1.44	16.0	.022	13.0	.430	0	0	25.6	.016	45.8	1.256
December	4.32	.48	41.1	.046	13.7	.022	(2)	0	43.4	.020	27.7	.100
Total	38.64		20.1	11.674	10.0	26.491	2.3	.299	24.2	[illegible]	42.1	73.812
9-year average	38.91		20.8	12.680	21.1	14.826	17.6	12.099	19.6	14.057	44.8	96.576

[1] See table 36, Appendix.
[2] Trace.
[3] Snow hold-over necessitated figuring runoff on 3-month basis.

TABLE 45.—*Comparison of runoff and erosion from continuous-corn and rotation-corn plots during growing season*

Year	Rainfall	Treatment	May		June		July		August		September		5-month total		
			Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff		Soil loss
	Inches		*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Percent*	*Tons*
1934	16.81	Continuous corn	0	0	0.57	6.71	0	0	3.45	21.32	2.38	6.93	6.40	38.1	34.06
		Rotation corn (plot 5)	0	0	.39	2.16	0	0	2.71	9.32	1.66	1.79	4.76	28.3	13.27
1935	25.84	Continuous corn	3.27	14.65	1.61	26.18	.42	3.90	5.73	36.02	.92	.85	12.05	46.6	81.60
		Rotation corn (plot 6)	1.53	0	1.20	8.19	.47	3.05	5.69	29.61	.75	.84	9.64	37.3	41.69
1936	17.48	Continuous corn	.02	0	0	0	3.44	62.80	2.52	16.37	1.29	3.04	7.27	41.6	82.21
		Rotation corn (plot 7)	.18	0	0	0	2.38	34.87	2.16	9.38	.42	1.54	5.14	29.4	45.79
1937	19.39	Continuous corn	.84	13.47	3.59	45.33	.49	2.34	1.50	8.90	.48	.93	6.90	35.6	70.97
		Rotation corn (plot 4)	.78	6.45	3.48	31.09	.12	.18	1.02	3.37	.51	.60	5.91	30.5	41.69
1938	22.24	Continuous corn	2.55	18.15	2.18	49.42	.17	1.37	2.02	23.16	2.87	13.76	9.79	44.0	105.86
		Rotation corn (plot 5)	1.55	7.45	2.02	34.53	.07	.39	1.70	17.46	2.31	11.02	7.65	34.4	70.85
1939	21.47	Continuous corn	0	0	5.09	53.47	1.46	23.90	2.54	31.52	.98	8.44	10.07	46.9	117.33
		Rotation corn (plot 6)	0	0	3.19	10.36	1.36	8.57	1.27	8.82	.71	3.27	6.53	30.4	31.02
1940	19.25	Continuous corn	1.06	3.92	2.98	50.25	.46	2.98	2.03	13.51	1.17	7.34	7.70	40.0	78.00
		Rotation corn (plot 7)	.01	0	2.61	27.04	.30	1.30	1.03	7.00	.92	5.02	4.87	25.3	40.36
1941	19.41	Continuous corn	.38	7.59	1.46	16.09	2.62	62.55	2.46	17.94	1.31	23.14	8.23	42.4	127.31
		Rotation corn (plot 4)	.26	1.77	.93	8.55	1.93	15.97	1.91	9.16	1.39	12.59	6.42	33.1	48.04
1942	19.13	Continuous corn	1.22	15.14	2.30	32.08	1.51	24.28	.86	7.14	1.48	4.58	7.37	38.5	83.22
		Rotation corn (plot 5)	.15	.40	2.16	14.80	1.08	7.64	.45	1.79	.85	1.23	4.69	24.5	25.86
9-year average	20.11	Continuous corn	1.05	8.10	2.20	31.06	1.17	20.46	2.57	19.54	1.43	7.66	8.42	41.9	86.8
		Rotation corn	.50	1.79	1.78	15.19	.86	8.00	1.99	10.66	1.06	4.21	6.18	30.7	39.8

TABLE 46.—*Soil and water losses from three watersheds devoted to different land use by quarters for the 9 years, 1934–42* [1]

Period	Rainfall-maximum 5-minute intensity	Cultivated watershed			Pasture watershed			Wooded watershed		
		Rainfall	Run-off	Soil loss	Rainfall	Run-off	Soil loss	Rainfall	Run-off	Soil loss
	Inches per hour	*Inches*	*Percent*	*Tons*	*Inches*	*Percent*	*Tons*	*Inches*	*Percent*	*Tons*
1934										
January–March	0.60	4.05	20.5	1.771	4.05	12.0	0.067	4.05	0.17	0.011
April–June	5.04	6.23	11.2	1.930	6.23	0	0	6.23	0	0
July–September	4.08	11.16	32.8	7.923	11.16	5.3	.090	11.16	(2)	0
October–December	1.20	2.43	3.6	.020	2.43	0	0	2.43	0	0
Total	----	23.87	22.1	11.644	23.87	4.7	.157	23.87	.03	.011
1935										
January–March	2.40	6.97	11.3	.800	6.97	3.4	.014	6.97	0	0
April–June	3.60	12.21	22.1	.814	12.21	9.5	.031	12.21	6.3	.008
July–September	5.85	14.54	23.1	.816	14.54	12.8	.034	14.54	.19	.003
October–December	2.10	7.55	9.6	.017	7.55	7.5	.009	7.55	.00	(2)
Total		41.27	18.4	2.447	41.27	9.2	.088	41.27	1.9	.011
1936										
January–March	.60	6.68	22.3	.031	6.68	26.8	.050	6.68	2.4	.001
April–June	1.92	6.84	12.9	.101	6.84	16.1	.024	6.84	2.5	.002
July–September	9.36	13.61	36.0	56.845	13.61	2.8	.020	13.61	.11	(2)
October–December	1.92	11.67	37.6	15.416	11.67	22.1	.038	11.67	1.8	.001
Total		38.80	30.1	72.393	38.80	14.9	.132	38.80	1.4	.004
1937										
January–March	2.16	13.47	61.5	14.012	13.27	51.0	.100	12.07	20.4	.028
April–June	4.32	13.97	22.0	.826	14.25	16.0	.041	13.79	5.7	.017
July–September	3.48	8.32	6.5	.053	7.73	0	0	7.87	0	0
October–December	1.44	8.73	5.9	.009	8.28	9.4	.003	8.28	0	0
Total	----	44.49	28.8	14.900	43.53	22.6	.153	42.61	10.6	.045
1938										
January–March	2.40	9.50	34.9	.455	9.77	25.2	.026	9.51	4.1	.002
April–June	5.76	14.96	13.9	.072	15.03	15.8	.025	14.21	1.3	(2)
July–September	2.68	11.11	5.9	.022	11.14	7.0	.008	10.73	(2)	(2)
October–December	1.44	5.16	3.9	.003	5.11	2.8	0	4.82	0	0
Total	----	40.73	15.4	.552	41.05	14.2	.050	39.30	1.5	.002
1939										
January–March	0.96	10.76	31.9	.131	10.85	33.0	.064	10.11	4.8	(2)
April–June	2.52	15.73	24.3	17.102	15.51	18.7	.062	15.43	4.8	.004
July–September	4.08	11.21	28.5	13.709	10.43	20.0	.085	10.06	1.5	.003
October–December	2.16	5.92	3.3	.868	5.91	4.2	.001	5.70	0	0
Total	----	43.62	24.4	31.710	42.70	20.7	.212	42.20	3.3	.007
1940										
January–March	.96	7.24	35.2	1.338	7.56	32.6	0	7.01	1.6	0
April–June	3.12	18.24	25.3	2.426	19.26	22.6	.037	18.49	13.6	.023
July–September	4.20	8.55	10.7	.105	8.19	.05	0	7.94	(2)	0
October–December	2.88	8.47	9.7	.033	8.06	5.0	.003	8.27	0	0
Total	------	42.50	20.9	3.902	43.07	16.8	.040	41.	716.3	.023
1941										
January–March	.60	3.10	10.6	.009	3.32	.25	0	2.82	0	0
April–June	3.60	7.64	.05	0	7.86	0	0	7.73	0	0
July–September	6.24	11.36	8.2	.089	12.65	6.5	.034	11.37	.10	(2)
October–December	1.44	7.68	2.0	.009	7.49	1.9	.004	7.40	0	0
Total	------	29.78	4.7	.107	31.32	3.2	.038	29.32	.04	(2)
1942										
January–March	3.48	7.20	23.3	.520	7.30	17.1	(2)	7.11	2.0	.006
April–June	4.56	11.91	23.3	15.335	12.43	12.3	.023	11.91	1.4	.001
July–September	6.00	9.64	5.6	.868	9.60	.18	.003	9.64	.03	0
October–December	1.44	9.01	10.9	.195	9.34	16.5	(2)	9.01	.12	(2)
Total	----	37.76	15.9	16.927	38.67	11.2	.026	37.67	.87	.007
9-year average	-------	38.09	20.6	17.176	38.30	13.8	.102	37.35	3.2	.011

[1] See table 37, Appendix.
[2] Trace.

TABLE 47.—*Soil moisture in various horizons under cornland, grassland, and woodland, 1939–41*

Crop	Year	Horizon	Soil moisture											
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Corn	1939	0-12	4.10	4.08	3.85	3.76	2.66	3.41	2.96	2.98	1.94	2.42	3.20	3.90
		12-18	------	------	1.80	2.04	1.59	1.59	1.00	1.74	1.46	1.45	1.72	1.83
		18-30	------	------	3.29	3.10	3.01	2.91	3.04	3.20	3.68	2.73	2.93	2.96
		0-30	------	------	9.03	8.90	7.26	7.91	7.60	7.92	6.08	6.60	7.85	8.69
	1940	0-12	4.28	4.77	4.44	4.49	3.58	3.87	2.52	2.31	2.62	2.74	3.74	4.30
		12-18	1.91	1.98	2.00	2.21	2.01	2.03	1.76	1.33	1.49	1.61	1.73	2.15
		18-30	2.99	3.57	3.23	3.19	3.03	3.30	2.99	2.78	2.88	2.86	3.00	3.34
		0-30	9.18	10.32	9.67	9.89	8.62	9.20	7.27	6.42	6.99	7.21	8.47	9.88
	1941	0-12	4.75	5.24	4.70	3.23	2.67	2.32	2.59	2.08	2.07	2.29	3.75	4.25
		12-18	2.06	2.07	1.90	1.71	1.59	1.71	1.73	1.34	1.43	1.49	1.55	1.70
		18-30	3.29	3.40	3.33	3.17	3.01	3.22	2.92	2.78	------	2.70	2.90	2.97
		0-30	10.10	10.71	9.93	8.11	7.27	8.25	7.24	6.20	------	6.48	8.20	8.92
	3-yr. av.	0-12	4.38	4.70	4.33	3.83	2.97	3.53	2.69	2.46	2.21	2.48	3.56	4.18
		12-18	[1] 1.98	[1] 2.02	1.93	1.99	1.73	1.78	1.70	1.47	1.46	1.52	1.67	1.80
		18-30	[1] 3.14	[1] 3.48	3.28	3.15	3.02	3.14	2.98	2.92	[1] 2.78	2.76	2.94	3.09
		0-30	9.50	10.20	9.54	8.97	7.72	8.45	7.37	6.86	6.45	6.76	8.17	9.16
Bluegrass sod	1939	0-12	4.79	4.94	4.76	4.71	3.24	3.59	3.32	3.20	1.90	2.65	3.92	4.25
		12-18	2.24	2.29	2.39	2.30	1.98	1.99	1.95	1.88	1.60	1.55	1.94	2.23
		18-30	3.61	4.00	4.11	4.13	3.79	3.66	3.56	3.57	3.52	3.25	3.42	3.99
		0-30	10.64	11.29	11.26	11.14	9.01	9.24	8.83	8.65	7.02	7.45	9.28	10.47
	1940	0-12	4.07	4.82	4.64	4.76	4.14	4.41	2.83	1.98	2.51	2.60	3.98	4.53
		12-18	2.11	2.35	2.35	2.42	2.05	2.25	1.93	1.41	1.58	1.61	2.03	2.29
		18-30	3.72	4.31	4.12	4.35	3.74	4.07	3.72	3.14	3.38	3.33	3.55	4.18
		0-30	10.50	11.48	11.11	11.53	9.93	10.73	8.48	6.53	7.47	7.54	9.56	11.00
	1941	0-12	4.48	4.38	4.82	3.83	2.53	3.61	2.74	2.56	2.08	3.25	4.42	4.25
		12-18	2.42	2.30	2.33	2.21	1.65	1.80	1.70	1.62	1.99	1.51	1.81	1.79
		18-30	4.24	4.31	4.46	4.04	3.78	3.93	3.44	3.61	------	3.60	3.76	3.41
		0-30	11.14	10.99	11.61	10.08	7.96	9.34	7.88	7.79	------	8.36	9.99	9.45
	3-yr. av.	0-12	4.65	4.71	4.74	4.43	3.30	3.87	2.96	2.58	2.47	2.83	4.11	4.34
		12-18	2.26	2.31	2.36	2.31	1.89	2.01	1.86	1.64	1.72	1.56	1.93	2.10
		18-30	3.85	4.23	4.23	4.17	3.77	3.89	3.57	3.44	[1] 3.45	3.39	3.58	3.86
		0-30	10.76	11.25	11.33	10.91	8.96	9.77	8.39	7.66	7.64	7.78	9.62	10.30
Woods	1939	0-12	4.40	4.71	4.42	4.31	3.65	3.98	3.76	3.58	2.12	2.14	3.77	4.07
		12-18	2.14	2.15	2.09	2.13	1.75	1.75	1.74	1.78	1.46	1.16	1.74	1.89
		18-30	4.05	3.92	4.37	4.22	3.80	3.76	3.65	3.43	3.05	2.70	2.98	3.31
		0-30	10.68	10.78	10.88	10.66	9.20	9.49	9.15	8.79	6.63	6.00	8.49	9.27
	1940	0-12	4.18	4.60	4.45	4.28	4.36	4.10	2.94	2.44	2.38	2.06	4.15	4.40
		12-18	1.95	2.22	2.28	2.11	2.12	1.99	1.62	1.41	1.39	1.31	2.09	2.20
		18-30	3.73	4.22	4.47	4.23	4.27	4.13	3.39	3.03	3.31	2.98	3.54	4.30
		0-30	9.86	11.04	11.20	10.62	10.75	10.22	7.95	6.88	7.08	6.35	9.78	10.90
	1941	0-12	3.77	4.07	4.64	4.31	3.80	3.78	2.36	2.42	1.78	2.05	3.71	3.63
		12-18	2.00	2.32	2.19	2.15	2.03	1.97	1.48	1.48	1.10	1.40	1.58	1.87
		18-30	4.11	4.56	4.46	4.45	3.93	4.00	3.10	2.99	------	3.56	3.33	3.22
		0-30	9.97	10.95	11.36	10.91	9.76	9.84	6.91	6.89	------	7.01	8.62	8.72
	3-yr. av.	0-12	4.14	4.46	4.50	4.30	3.04	3.05	3.02	2.81	2.09	2.28	3.88	4.03
		12-18	2.06	2.23	2.19	2.13	1.97	1.90	1.61	1.56	1.32	1.29	1.80	1.98
		18-30	3.96	4.23	4.44	4.30	4.00	3.09	3.38	3.15	[1] 3.18	3.08	3.28	3.61
		0-30	10.16	10.92	11.13	10.73	9.91	9.84	8.01	7.52	6.59	6.65	8.96	9.62

[1] 2-year average.

TABLE 48.—*Initial run data, grouped by periods, from infiltration study, 1938–40*

Dates	Temperatures				Soil moisture			Infiltration			
	Air	Water	Soil at 3 inches	Soil at 12 inches	0–6 inches	6–12 inches	12–18 inches	First hour	Second hour	Third hour	Total 3 hours
	°F.	*°F.*	*°F.*	*°F.*	*Pct.*	*Pct.*	*Pct.*	*Inches per hr.*	*Inches per hr.*	*Inches per hr.*	*Inches per hr.*
Jan. 6, 1939	42	50	48	46	30.5	25.6	25.2	0.324	0.229	0.237	0.263
Feb. 14, 1939	52	59			31.5	26.3	25.2	.776	.647	.600	.675
Mar. 13, 1939	37	57	50	48	34.2	27.5	28.9	.025	.034	.043	.034
Apr. 24, 1940	61	66	56	48	34.8	26.0	27.4	.865	.680	.689	.745
Apr. 26, 1939	64	73	68	63	29.2	23.5	24.2	.739	.505	.535	.593
Average	51	61	56	51	32.0	25.8	26.2	.546	.419	.421	.462
May 6, 1940	72	68	56	52	27.3	24.1	24.8	1.393	.744	.764	.967
May 9, 1940	64	64	61	56	27.4	22.8	23.4	1.573	.848	.793	1.072
May 18, 1939	68	84	79	70	19.1	20.2	22.0	1.640	.470	.359	.827
June 7, 1938	68	------	65	------	27.8	23.5	23.9	.619	.301	.276	.399
June 7, 1939	84	94	93	84	19.9	17.7	19.2	2.569	1.151	.952	1.555

TABLE 48.—*Initial run data, grouped by periods, from infiltration study, 1938–40*—Continued

Dates	Temperatures				Soil moisture			Infiltration			
	Air	Water	Soil at 3 inches	Soil at 12 inches	0–6 inches	6–12 inches	12–18 inches	First hour	Second hour	Third hour	Total 3 hours
	°F.	*°F.*	*°F.*	*°F.*	*Pct.*	*Pct.*	*Pct.*	*Inches per hr.*	*Inches per hr.*	*Inches per hr.*	*Inches per hr.*
June 14, 1940	95	91	81	73	30.5	26.7	26.3	1.441	0.097	0.909	1.145
June 17, 1938	66		67		28.7	23.0	23.4	1.111	.642	.637	.796
June 27, 1938	62		62		32.0	25.2	24.5	.282	.213	.211	.235
Average	72	80	70	67	26.6	22.0	23.4	1.328	.672	.624	.874
July 18, 1938	68		68		22.7	18.2	20.0	1.168	.241	.176	.528
July 19, 1939	73	86	81	77	21.8	19.6	22.0	2.666	1.444	1.285	1.798
Aug. 8, 1938	82		76		30.7	26.6	25.7	2.005	1.530	1.747	1.701
Aug. 19, 1940	90	82	84	77	9.2	11.0	13.4	3.102	.303	.213	1.206
Aug. 29, 1938	78		70	73	11.9	15.3	10.2	3.104	1.239	1.191	1.844
Aug. 30, 1939	78	93	81	79	17.6	18.6	19.6	2.334	.909	.788	1.343
Average	78	87	77	76	19.0	18.2	20.0	2.412	.944	.900	1.418
Sept. 20, 1938	58		62	64	30.7	25.3	24.9	.941	.580	.540	.687
Oct. 10, 1938	63	73	59	59	20.5	20.2	19.9	2.668	1.372	1.222	1.754
Oct. 17, 1939	48	65	64		12.3	14.2	17.8	2.327	.336	.217	.960
Nov. 1, 1938	57	59	50	53	19.6	19.8	22.3	2.467	.901	.833	1.400
Nov. 14, 1939	44	49	41	41	28.2	25.0	25.0	1.399	.863	.804	1.022
Nov. 22, 1938	51	59	52	54	29.1	26.0	24.8	.738	.462	.420	.540
Average	54	61	55	54	23.4	21.7	22.4	1.757	.752	.673	1.060

TABLE 49.—*Second (wet) run data, grouped by periods, from infiltration study, 1938–40*

Dates	Temperatures				Infiltration			
	Air	Water	Soil at 3 inches	Soil at 12 inches	First hour	Second hour	Third hour	Total 3 hours
	°F.	*°F.*	*°F.*	*°F.*	*Inches per hour*	*Inches per hour*	*Inches per hour*	*Inches per hour*
Jan. 7, 1939	48	45	43	46	0.215	0.182	0.165	0.187
Mar. 14, 1939	50	64	52	48	.069	.058	.065	.064
Apr. 25, 1940	59	57	56	48	.627	.500	.453	.526
Apr. 27, 1939	67	75	70	64	.437	.396	.400	.411
Average	56	60	55	52	.337	.284	.271	.297
May 7, 1940	70	74	62	56	.395	.311	.318	.341
May 10, 1940	66	68	64	56	.539	.425	.413	.459
May 19, 1939	79	90	79	70	.273	.230	.238	.247
June 7, 1939	60	82	88	82	2.068	1.748	1.613	1.810
June 8, 1938	65		62		.307	.236	.236	.260
June 18, 1938	71		68		.727	.609	.657	.664
June 20, 1940	72	82	79	72	1.031	.858	.896	.928
June 28, 1938	71		62		.397	.349	.372	.373
Average	72	79	70	67	.718	.596	.593	.635
July 19, 1938	76		72		.220	.204	.171	.199
July 20, 1939	70	77	81	77	2.154	1.858	1.783	1.932
Aug. 9, 1938	83		77		1.614	1.511	1.531	1.552
Aug. 20, 1940	75	83	82	74	.353	.249	.204	.269
Aug. 30, 1938	81		73	74	1.910	1.718	1.743	1.790
Aug. 31, 1939	79	97	81	79	1.030	.838	.826	.898
Average	77	86	78	76	1.210	1.063	1.043	1.107
Sept. 21, 1938	52	61	50	63	.544	.271	.275	.363
Oct. 11, 1938	74	72	61	61	1.072	.913	.903	.962
Oct. 18, 1939	54	50	48		.161	.131	.127	.140
Nov. 2, 1938	61	57	50	54	.662	.498	.462	.541
Nov. 15, 1939	64	60	46	40	.547	.407	.405	.453
Nov. 23, 1938	29	41	55	50	.259	.107	.167	.178
Average	56	57	53	54	.541	.388	.300	.440

TABLE 50.—*Rate of infiltration on frozen soil*

Dates	Temperatures				Soil moisture		Depth (frozen)	Surface conditions	Infiltration (second and third hours)
	Air	Water	Soil at 3 inches	Soil at 12 inches	0-6 inches	12-18 inches			
	° F.	*° F.*	*° F.*	*° F.*	*Percent*	*Percent*	*Inches*		*Inches per hour*
Jan. 31, 1940	32.9	34.7	28.4	30.2	35.4	22.9	10		0.051
Feb. 1, 1940	33.8	32.9	30.2	31.1	40.7	22.6	10		.063
Feb. 12, 1940 [1]	54.5	46.0	32.0	32.0	34.8	22.8	12-14	Thawed ½ inch	.012
Average	40.4	37.0	30.2	31.1	37.0	22.8			.042
Jan. 11, 1940	35.6	33.8	30.2	33.8	45.0	22.8	4-5		.150
Feb. 12, 1940 [1]	54.5	46.0	32.0	32.0	29.6	24.7	12-14	Thawed ½ inch	.159
Feb. 28, 1940	34.0	33.0	29.0	32.0	39.7	23.4	4-6		.105
Feb. 29, 1940	36.5	35.5	32.0	32.0	40.7	22.9	4-6		.092
Mar. 4, 1940	35.5	34.0	31.0	32.0	30.6	23.1	4-6	Thawed ¾-1½ inches	.094
Average	39.2	36.5	30.8	32.4	38.9	23.3			.120
Mar. 13, 1940	47.0	45.0	32.0	35.0	39.6	27.9	0-2¾	Thawed 1½ inches	.580
Feb. 25, 1941	39.2	43.5	33.0	35.5	41.4	23.5	2¼-3		1.161
Feb. 26, 1941	34.5	38.3	33.0	34.5	38.4	27.2	2½-3		1.008
Average	40.2	42.3	32.7	35.0	39.8	26.2			.916

[1] Different groups of cylinders.

TABLE 51.—*Soil and water losses from different slopes of Muskingum silt loam* [1]

[Rain-simulator studies]

Slope (percent)	Dry run, 1 inch at 4 inches per hour			Wet run, 1 inch at 4½ inches per hour			Averages of both runs	
	Runoff	Soil loss	Infiltration	Runoff	Soil loss	Infiltration	Runoff	Soil loss
	Percent	*Pounds per plot*	*Inches per hour*	*Percent*	*Pounds per plot*	*Inches per hour*	*Percent*	*Pounds per plot*
2.9	53.8	23.9	1.49	82.5	22.4	0.54	68.2	23.1
2.9	62.3	20.4	1.19	79.3	33.5	.65	70.8	27.0
Average	58.0	22.1	1.34	80.9	27.9	.59	69.5	25.0
4.2	61.1	34.0	1.28	83.3	55.7	.52	72.2	44.8
4.2	51.6	22.9	1.62	76.4	52.3	.75	64.0	37.6
Average	56.3	28.4	1.45	79.8	54.0	.63	68.1	41.2
9.3	52.3	70.6	1.51	81.2	133.0	.59	66.7	101.8
9.3	52.6	63.7	1.59	83.7	122.0	.53	68.2	92.8
Average	52.4	67.0	1.55	82.4	127.5	.56	67.4	97.3
15.3	65.5	241.0	1.09	82.5	229.0	.52	74.0	235.0
15.3	67.0	329.0	1.07	80.0	227.0	.62	73.5	278.0
Average	66.2	285.0	1.08	81.2	228.0	.57	73.7	256.5
18.7	63.0	171.0	1.31	84.0	233.0	.53	73.5	202.0
18.7	66.5	232.0	1.20	81.5	341.0	.62	74.0	286.5
Average	64.7	201.5	1.25	82.8	287.0	.57	73.8	244.2
22.5	50.6	218.0	1.69	70.8	391.0	.66	65.2	304.5
21.6	57.1	248.0	1.45	85.2	359.0	.49	71.2	303.5
Average	53.8	233.0	1.57	82.5	375.0	.57	68.2	304.0

[1] 1/100-acre plots of bare soil.

TABLE 52.—*Soil and water losses from different slopes of Wooster silt loam* [1]

[Rain simulator studies]

Slope (percent)	Dry run, 1 inch at 4½ inches per hour			Wet run, 1 inch at 4½ inches per hour			Wet run, 1 inch at 9¾ inches per hour			Averages of all runs	
	Run-off	Soil loss	Infiltration	Run-off	Soil loss	Infiltration	Run-off	Soil loss	Infiltration	Run-off	Soil loss
	Percent	*Pounds per plot*	*Inches per hour*	*Percent*	*Pounds per plot*	*Inches per hour*	*Percent*	*Pounds per plot*	*Inches per hour*	*Percent*	*Pounds per plot*
2.2	58.9	6.77	1.23	82.2	7.89	0.56	84.1	9.73	0.87	75.1	8.13
2.2	60.3	16.78	1.25	80.3	23.38	.59	91.1	21.18	.38	77.3	21.45
2.2	61.9	14.04	1.14	82.5	17.95	.53	86.5	23.44	.65	77.0	18.48
Average	60.4	12.53	1.21	81.7	16.41	.56	87.3	19.12	.63	76.5	16.02
6.5	58.4	83.31	1.47	77.8	118.40	.78	88.2	165.33	.67	74.8	122.35
6.5	54.0	78.59	1.72	79.5	158.68	.77	77.1	166.18	1.43	70.3	134.48
6.5	62.3	51.24	1.54	89.2	58.41	.37	88.5	90.61	.60	80.0	66.75
Average	58.2	71.05	1.57	82.2	111.83	.64	84.7	140.71	.90	75.0	107.86
10.4	66.1	84.77	1.20	90.1	156.09	.33	89.2	211.50	.56	81.8	151.09
10.4	74.8	152.94	.89	89.7	213.94	.34	84.8	184.15	.93	83.1	183.68
10.4	68.0	73.17	1.16	87.1	121.48	.44	94.7	248.62	.28	83.3	147.76
Average	69.6	103.63	1.08	89.0	164.11	.37	89.6	214.76	.59	82.7	160.84
16.2	72.0	181.52	.93	91.2	282.76	.28	93.4	345.62	.34	85.5	269.97
16.2	75.6	323.51	.84	83.7	418.67	.51	92.0	495.79	.44	83.8	422.66
16.2	81.1	261.81	.62	92.3	396.00	.27	98.0	620.02		91.5	425.94
Average	77.2	255.61	.79	89.1	375.81	.36	94.5	487.14	.26	86.9	372.86

[1] 1/100-acre plots of bare soil.

TABLE 53.—*Soil and water losses from slopes planted with wheat* [1]

[Rain simulator studies]

Slope (percent)	Dry run, 1 inch at 4½ inches per hour			Wet run, 1 inch at 4½ inches per hour			Wet run, 1 inch at 9¾ inches per hour			Averages of all runs	
	Run-off	Soil loss	Infiltration	Run-off	Soil loss	Infiltration	Run-off	Soil loss	Infiltration	Run-off	Soil loss
	Percent	*Pounds per plot*	*Inches per hour*	*Percent*	*Pounds per plot*	*Inches per hour*	*Percent*	*Pounds per plot*	*Inches per hour*	*Percent*	*Pounds per plot*
3.9	75.8	0.344	0.55	88.5	0.325	0.26	95.6	0.622	0.13	86.6	0.430
3.9	77.2	.261	.44	89.0	.233	.25	95.8	.356	.14	87.3	.284
3.9	74.8	.157	.54	89.6	.218	.23	97.7	.254	.07	87.4	.210
3.9	72.8	.195	.65	86.2	.191	.32	92.6	.307	.24	83.9	.231
Average	75.15	.240	.545	88.32	2.42	.265	95.42	.385	.145	86.3	.289
9.5	70.2	2.476	.92	88.6	1.755	.33	94.2	2.858	.20	84.3	2.363
9.5	76.2	1.006	.71	92.1	1.636	.23	96.3	2.340	.12	88.2	1.891
9.5	84.6	.981	.45	90.2	.916	.27	96.7	1.612	.14	90.5	1.170
9.5	84.1	.680	.44	92.2	.880	.23	98.2	1.456	.07	91.5	1.005
Average	78.78	1.458	.63	90.78	1.297	.265	96.35	2.066	.125	88.6	1.607
15.5	74.4	4.672	.76	80.3	3.202	.31	91.1	4.738	.28	85.9	4.204
15.5	82.0	1.876	.54	92.5	2.178	.21	95.4	3.650	.18	90.0	2.568
15.5	94.5	1.644	.43	91.5	1.751	.19	9.33	2.997	.30	89.8	2.131
15.5	79.3	1.473	.02	89.6	1.674	.30	91.9	3.168	.34	86.9	2.105
Average	80.05	2.416	.59	90.72	2.201	.25	93.68	3.638	.275	88.2	2.752
23.8	69.1	7.578	1.05	81.6	4.924	.62	93.3	8.441	.32	81.3	6.981
23.8	78.4	3.241	.66	88.9	3.151	.34	94.4	5.720	.29	87.2	4.038
23.8	78.8	2.323	.65	91.0	2.643	.28	93.2	4.646	.29	87.7	3.204
23.8	85.7	2.466	.44	90.7	2.106	.27	92.9	4.340	.31	89.8	2.071
Average	78.0	3.903	.70	88.05	3.206	.38	93.45	5.787	.30	86.5	4.298

[1] 1/200-acre plots.

TABLE 54.—*Soil and water losses from slopes planted with soybeans* [1]

[Rain simulator studies]

Slope (percent)	Dry run, 1 inch at 4½ inches per hour			Wet run, 1 inch at 4½ inches per hour			Wet run, 1 inch at 9¼ inches per hour			Averages of all runs	
	Run-off	Soil loss	Infiltration	Run-off	Soil loss	Infiltration	Run-off	Soil loss	Infiltration	Run-off	Soil loss
	Percent	*Pounds per plot*	*Inches per hour*	*Percent*	*Pounds per plot*	*Inches per hour*	*Percent*	*Pounds per plot*	*Inches per hour*	*Percent*	*Pounds per plot*
4.2 [2]	35.5	1.37	2.02	71.5	1.39	0.76	80.1	2.43	0.80	62.4	1.73
4.2	43.6	.90	1.52	69.6	1.32	.81	77.3	.94	.70	63.5	1.05
4.2	34.0	.51	1.39	59.3	.53	.78	67.5	.80	.89	53.6	.61
Average	37.7	.93	1.64	66.8	1.08	.78	75.0	1.39	.80	59.8	1.13
9.3	67.1	8.46	1.04	81.8	6.24	.55	86.8	13.25	.56	78.6	9.32
9.3	51.6	1.74	1.38	68.2	1.36	.83	78.1	3.38	.77	66.0	2.16
9.3	50.6	1.36	1.08	68.2	1.02	.66	73.8	1.36	.69	64.2	1.25
Average	56.4	3.85	1.17	72.8	2.87	.68	79.6	6.00	.67	69.6	4.24
15.3 [3]											
15.3	55.6	10.47	1.33	80.0	11.31	.57	84.0	22.53	.60	73.2	14.77
15.3	58.8	7.80	1.03	76.0	6.88	.59	81.1	12.99	.61	72.0	9.26
Average	57.2	9.18	1.18	78.0	9.10	.58	82.6	17.76	.65	72.6	12.01
22.5	70.9	52.61	.87	84.1	20.98	.53	85.9	54.20	.58	79.4	45.61
22.5	63.9	19.68	1.14	82.6	14.81	.50	81.6	30.56	.85	76.0	21.68
22.5	59.1	10.29	.98	75.9	10.06	.60	81.1	15.98	.61	72.0	12.11
Average	64.6	27.51	1.00	79.9	15.28	.54	82.9	33.59	.68	75.8	26.47

[1] 1/100-acre plots.

[2] On each slope, the first run was made at the time when the beans were one-third grown; second run, when they were full grown; third run, when they were mature—when half the leaves had dropped.

[3] Data not satisfactory because surface of the plot was disturbed before run.

TABLE 55.—*Soil and water losses from strip-cropped areas, 1936–42* [1]

Period	Rainfall		A		B		C		D		E		F	
	Amount	Maximum 5-minute intensity	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss
1936	*Inches*	*Inches per hour*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*
January-March	6.92	1.08	13.6	0.194	15.5	0.282	25.7	0.309	13.2	0.126	25.4	0.132	33.1	0.125
April-June	6.81	1.56	8.8	.929	17.7	.978	10.4	.450	6.8	.196	14.2	.776	11.5	.415
July-September	13.91	0.36	24.7	11.283	41.2	16.035	39.0	10.548	24.6	4.209	25.8	6.854	27.5	6.420
October-December	11.62	2.52	15.9	1.218	20.9	1.315	21.0	1.015	13.8	.399	14.9	.955	15.4	.918
Total	39.26	9.36	17.4	13.624	26.6	18.610	27.3	12.322	16.3	4.930	20.7	8.717	22.1	7.878
1937														
January-March	13.20	1.68	29.5	1.008	28.4	1.255								
	13.61	1.68					39.1	.915	24.2	.447				
	13.18	1.68									29.8	.453	42.4	.915
April-June	14.40	4.56	21.3	6.779	26.2	7.112								
	14.68	4.56					25.0	3.494	19.5	2.466				
	14.39	4.56									15.1	1.638	15.6	1.853
July-September	8.00	2.28	7.6	.185	7.3	.174								
	8.30	2.28					10.3	.152	5.8	.042				
	7.94	2.28									4.1	.050	2.4	.065
October-December	8.64	1.92	5.2	.008	4.9	.008								
	8.67	1.92					3.1	.007	1.2	.001				
	8.17	1.92									.77	.001	1.5	.003
Total	44.33		18.1	7.980	19.3	8.549								
	45.26						22.4	4.568	14.9	2.957				
	43.68										14.9	2.141	18.7	2.836
1938														
January-March	9.80	2.04	14.8	.139	11.1	.108	12.4	.096	5.9	.042	8.1	.085	18.6	.127
April-June	15.10	4.20	16.1	6.972	20.9	8.758	17.1	.867	11.9	.549	13.5	4.582	14.5	2.881
July-September	11.23	3.62	8.3	.372	8.2	.332	9.2	.092	6.2	.045	7.6	.589	5.4	.425
October-December	5.05	1.20	2.8	.021	3.0	.031	1.4	.002	.40	(2)	.79	.023	.40	.005
Total	41.18	4.20	12.0	7.504	12.9	9.229	11.9	1.057	7.5	.636	9.0	5.279	11.3	3.438
1939														
January-March	10.32	.96	23.6	1.165	20.3	.992	23.0	.209	11.5	.101	22.0	.614	33.7	.615
April-June	15.70	2.52	22.7	1.015	21.0	1.026	23.2	5.524	17.7	5.090	18.4	.679	21.7	.666

July-September	10.97	4.08	36.1	1.476	36.6	1.213	32.1	3.066	28.6	3.072	26.9	1.174	27.1	1.017
October-December	6.01	2.16	9.6	.027	7.9	.038	8.3	.686	3.7	.292	6.4	.033	2.9	.015
Total	43.00	4.08	24.5	3.683	23.0	3.269	23.4	10.085	17.1	9.755	19.8	2.500	23.4	2.313
1940														
January-March	7.24	.96	36.3	.154	33.2	.124	31.8	.754	26.0	1.335	28.9	.094	43.0	.120
April-June	18.96	3.12	34.8	2.371	37.5	2.516	38.4	3.796	28.8	3.220	32.3	.731	35.7	1.238
July-September	8.23	4.20	10.4	.221	11.9	.189	14.7	.501	9.7	.289	1.6	.003	1.8	.012
October-December	8.22	2.88	17.8	.110	21.3	.138	13.7	.238	5.0	.088	6.7	.010	10.7	.018
Total	42.65	4.20	27.1	2.856	28.7	2.967	28.0	5.289	20.0	4.933	20.8	.838	25.6	1.388
5-year average	42.08		19.9	7.129	22.1	8.525								
	42.27						22.6	6.664	15.2	4.642				
	41.95										17.0	3.895	20.2	3.571
1941														
January-March	2.89	.60					1.1	.012	4.6	.001	8.4	.003	10.3	.003
April-June	7.88	3.60					1.9	.213	.30	.007	.96	.093	.34	.151
July-September	12.22	6.24					34.8	1.979	18.7	.717	40.8	9.678	31.5	8.538
October-December	7.68	1.44					3.3	.020	.28	.001	.56	.006	.47	.008
Total	30.67	6.24					15.6	2.264	7.6	.725	17.4	9.780	13.7	8.700
1942														
January-March	7.20	3.48					26.9	.588	9.4	.180	22.1	1.152	34.2	1.137
April-June	12.43	4.56					20.3	.213	8.3	.952	21.6	.516	19.2	.337
July-September	9.60	6.00					8.3	.153	1.4	.051	10.4	.202	3.4	.088
October-December	9.34	1.44					11.3	.037	1.4	.009	16.3	.023	17.9	.024
Total	38.66	4.56					17.1	.991	5.1	1.192	17.6	1.083	17.8	1.586
7-year avenge	40.10						21.0	5.225	13.0	3.590				
	39.87										17.2	4.462	19.2	4.020

[1] See table 38, Appendix.
[2] Trace.

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