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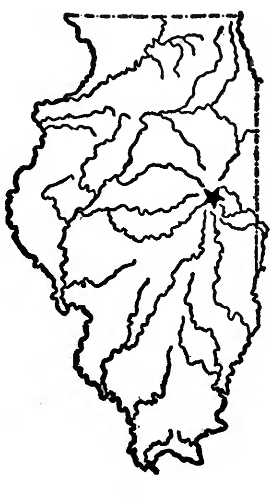
WASHING OF SOILS AND METHODS OF PREVENTION

By J. G. MOSIER and A. F. GUSTAFSON



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Contents of Bulletin No. 207

WASHING OF SOILS AND METHODS OF PREVENTION

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From careful measurements made of twenty-seven counties in various parts of Illinois, it has been determined that the state consists of approximately two-thirds prairie land and one-third timber land. A considerable proportion of the latter is rolling or hilly, but there is also much timber bottom land and some level timber upland. The total area of the state is 56,650 square miles, or more than 36 million acres. Of this large area, ~~about five and one-half million acres~~ are 7,2
rolling or hilly and subject to serious erosion. A large part of this land can be cultivated and cropped, but every practical means should be employed to prevent its rapid ruin by erosion.

Some Illinois land has already been completely ruined. Abandoned fields, impoverished by erosion beyond all possibility of reclamation by ordinary methods, are now to be found, especially in the broken and hilly areas of the southern half of the state. In most cases this land should never have been deprived of its protecting forest, the chief thing that made it valuable in the first place.

Fig. 1.—Advanced Stage of Erosion in Randolph County

TABLE 1.—APPROXIMATE AREA OF BROKEN AND HILLY LAND IN THE COUNTIES OF ILLINOIS COVERED BY THE SOIL SURVEY PREVIOUS TO 1917

County	Total area of county	Area of broken and hilly land	Percentage of broken and hilly land
	sq. mi.	*sq. mi.*	*percent*
Adams	833.00	233.00	28.00
Alexander	290.00	88.00	30.00
Bond	371.88	74.48	20.01
Boone	288.00	10.00	3.47
Brown	300.00	130.00	43.30
Bureau	877.00	79.80	9.00
Champaign	988.15	3.06	.31
Clay	467.73	69.25	14.85
Clinton	498.00	15.25	2.50
Cook	963.00	11.00	1.14
Crawford	453.00	25.02	5.52
Cumberland	340.43	34.98	10.28
DeKalb	632.70	.43	.07
DeWitt	406.00	19.00	4.75
Douglas	420.00	1.50	.36
DuPage	326.98	7.57	2.32
Edgar	617.27	45.41	7.36
Edwards	218.41	55.71	25.95
Franklin	436.00	30.00	6.88
Grundy	429.00	3.00	.70
Hamilton	438.00	83.00	18.70
Hancock	765.00	200.00	26.14
Hardin	168.00	132.90	79.10
Henderson	374.00	54.00	14.43
Iroquois	1 123.00	2.00	.18
Jackson	558.00	252.00	47.00
Jersey	360.00	151.20	42.00
Jo Daviess	656.00	421.00	64.20
Johnson	336.00	227.07	67.60
Kane	513.14	6.38	1.24
Kankakee	670.13	.92	.14
Knox	720.69	133.71	18.56
Lake	482.82	38.50	7.98
LaSalle	1 156.83	41.12	3.55
Lawrence	362.00	44.25	1.17
Livingston	1 030.00	1.50	.14
McDonough	573.94	144.41	25.16
McHenry	609.52	4.92	.81
McLean	1 168.60	27.43	2.35
Macon	606.00	19.30	3.36
Marion	570.00	46.75	8.20
Mason	553.99	10.01	1.81
Massac	238.00	100.00	42.00
Monroe	385.00	130.00	33.30
Montgomery	702.00	64.00	9.10

TABLE 1.—*Concluded*

County	Total area of county	Area of broken and hilly land	Percentage of broken and hilly land
	sq. mi.	*sq. mi.*	*percent*
Moultrie	341.06	2.19	.64
Ogle	768.00	33.00	4.69
Peoria	620.60	172.59	27.81
Perry	430.00	86.00	20.00
Pike	798.89	381.78	47.79
Richland	360.00	45.75	12.80
Rock Island	441.00	109.00	24.77
Saline	377.56	101.11	26.78
Sangamon	869.48	59.08	6.78
Scott	245.28	51.50	20.99
Shelby	780.00	70.00	9.00
St. Clair	680.00	129.00	19.00
Tazewell	646.91	67.18	10.39
Vermilion	928.00	36.00	4.05
White	512.00	42.00	8.30
Whiteside	700.09	74.24	10.59
Winnebago	515.66	37.17	7.21
Total	35 291.74	5 365.04	
Average for area surveyed			15.20

Besides the broken and hilly land, there is a large area of undulating to rolling land, both timber and prairie, that has not been badly damaged as yet, but which with continued cropping and consequent loss of organic matter is becoming more and more subject to injurious surface erosion. The area of undulating timber soil is approximately the same as that of the hilly land, shown in Table 1.

In the ~~sixty-two~~ 102 counties of Illinois that have been covered by the detailed soil survey, ~~15.2~~ 20 percent of the land, as an average, is of such a character that it is subject to serious damage from surface washing. Table 1 gives the area of these counties, together with the area and the percentage of broken and hilly land in each.

FIG. 2.—A GULLY IN MCHENRY COUNTY

Even gravelly glacial material erodes badly under certain conditions.

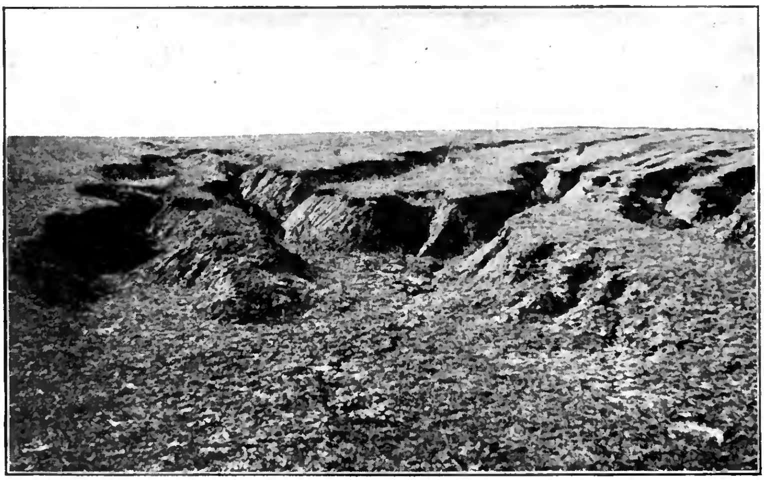

FIG. 3.—EROSION IN OGLE COUNTY

Not a bad slope, but even with the comparatively low rainfall of northern Illinois, considerable damage may be done when gullies are neglected.

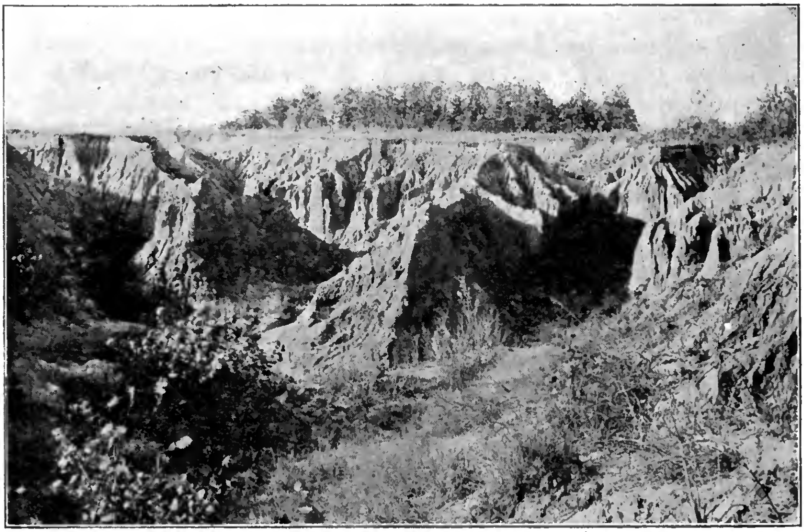

FIG. 4.—ADVANCED STAGE OF EROSION IN ADAMS COUNTY, DUE TO A SUBSTRATUM OF INCOHERENT SAND

RAINFALL IN ILLINOIS

Illinois lies in the belt of prevailing westerly winds. Much of the rainfall comes in moderate or gentle rains, during which a large proportion of the water enters the soil, but in the summer particularly there are very heavy rains, and as the soil is unable to absorb so much water in such a short time, much of it runs off the sloping land. From Table 2, which shows the average rainfall by seasons in the various sections of the state, it will be seen that the greatest rainfall is in the spring and summer months, when the soil is in the best condition to absorb water; but in spite of this fact there is an enormous run-off from the rolling land of the state.

TABLE 2.—AVERAGE SEASONAL RAINFALL IN ILLINOIS

District	Winter		Spring		Summer		Autumn	
	inches	*percent*	*inches*	*percent*	*inches*	*percent*	*inches*	*percent*
Extreme northern[1]	5.44	16.0	9.34	27.4	11.22	33.0	7.99	23.6
Central-northern[2]	5.80	16.8	9.61	27.9	10.75	31.6	8.11	23.7
Central[2]	6.82	18.0	10.43	27.9	11.04	30.7	8.60	23.4
Central-southern[2]	8.80	21.2	11.75	28.3	11.75	28.3	9.18	22.2
Extreme southern[1]	10.66	24.8	12.38	28.5	10.70	24.7	9.54	22.0

[1]1866 to 1915. [2]1856 to 1915.

RUN-OFF

The extent to which washing occurs depends upon the amount of surface run-off. The amount of run-off and the effect which it has depends to a large extent upon the character of the soil and subsoil, the length and steepness of the slope, the tillage practiced, and the vegetation growing upon it. Because of these many varying conditions, it is difficult to compute the amount of run-off. Considerable work has been done, however, which may form the basis for a fair estimate. Table 3 gives the results of the work of Mr. F. H. Newell, formerly Chief Hydrographer of the U. S. Geological Survey.

TABLE 3.—PERCENTAGE OF RUN-OFF FROM THE SAVANNAH, CONNECTICUT, AND POTOMAC RIVER BASINS

Basin	Time	Percentage of rainfall carried off in drainage
Savannah river	1884 to 1891	48.9
Connecticut river	13 years	56.5
Potomac river	1886 to 1891	53.0

It has been estimated that for broad valleys and gentle slopes in open country, a mean annual rainfall of 50 inches gives an annual run-off of about 25 inches, or 50 percent of the total rainfall. Where the rainfall is 40 inches, the run-off is about 15 inches, or 37.5 percent; and where the rainfall is 30 inches, the run-off is about 8 inches, or 26.6 percent. Greenleaf estimates the average run-off for the Illinois river basin at about 24 percent of the total rainfall of the catchment area. Leverett estimates the run-off for the entire state of Illinois at about 21 percent of the rainfall.

The work of the Illinois State Geological Survey shows that the run-off for the Spoon river basin is 21.5 percent of the total rainfall; for the Embarrass river basin, 25 percent; and for the Kaskaskia, 37.9 percent. Table 4 will be of interest as showing the run-off in the Kaskaskia river basin for the years 1907 to 1909. The very high

TABLE 4.—RAINFALL AND RUN-OFF IN THE KASKASKIA RIVER BASIN, 1907-1909

	1907	1908	1909	Average
Rainfall, inches	41.80	38.22	48.48	42.8
Run-off, inches	13.52	19.20	15.07	15.9
Percentage of rainfall lost as run-off	32.34	50.23	31.08	37.9

run-off in 1908 was due to the extremely heavy rainfall during February, April, and May, when it amounted to 19.57 inches, or more than the total for the rest of the year. The rainfall during May alone was 9.55 inches, or 25 percent of the total for the year.

If the Illinois river basin, with its extensive areas of level to gently rolling land, has a run-off amounting to 24 percent of the annual rainfall, it is certainly conservative to say that the hilly and broken land of the state with perfect surface drainage and slowly pervious soil, suffers at least twice as much loss of water.

WORK OF MOVING WATER

If a current of water with a given velocity is capable of causing a certain amount of erosion, it will be able to do four times as much work if the velocity of the current is doubled. If it is able to carry a certain amount of material at a given velocity, it will be capable of carrying thirty-two times as much with a doubled velocity. If a slowly moving stream carries particles of a certain size, it will carry particles sixty-four times as large when the velocity is twice as great. When a solid is immersed in water it loses weight equal to the weight of the water displaced by it, thus making the material relatively lighter in water than in air, and consequently more easily moved.

Considering the above laws of physics, it will be seen how powerful an agent is moving water for loosening and carrying away soil material.

Since the destructive work of water upon soil depends directly upon the amount and velocity of the water running over the surface, protective and preventive measures should, as a rule, include methods for diminishing the amount and velocity of the run-off.

KINDS OF EROSION

The erosion produced by run-off is of two kinds: (1) sheet erosion, or general surface washing; and (2) gullying, of which there are two phases—head-water erosion and waterfall erosion.

In sheet erosion, the water moves over a uniformly sloping surface, and if the soil and vegetative covering are uniform, the amount of material removed will be practically the same for all points. This form of washing results in the removal of the surface soil and in the gradual reduction of fertility. It occurs to a greater or less extent in practically every field.

Ordinarily, however, the process of washing is not so simple as this. More frequently the slope is not uniform, but contains small draws in which the water collects, giving to the run-off greater velocity and consequently greater erosive power. The water flowing in these draws soon forms a gully. The effect at first is usually greatest toward the lower end of the draw, because of the larger volume of water. Eventually, however, the eroding action of the water increases the steepness of the upper part of the slope, so that even with a smaller volume of water a large amount of work is done, and the gully gradually eats its way up the slope by what is called head-water erosion.

A draw is not always necessary for the beginning of gullies, but there must be something to give direction to the water. On uniform slopes they may be started by very simple agencies. Tunnels made by moles, the tracks of wagon wheels, or paths made by cows, pigs, or sheep may afford the small beginning—and nature will do the rest.

The waterfall type of erosion occurs where the surface material to a depth of two to four feet is more resistant than that beneath. If by any means a waterfall should start, as is often the case where water runs into a ditch or ravine, the undermining action of the water as it falls over the low precipice causes masses of the surface to break off and fall into the gully. This loosened material is carried away and the process repeated. By this means the waterfall slowly moves up the slope, leaving a narrow gully with very steep sides. The waterfall may vary from three to twenty feet in height, but it is usually four to six feet.

These waterfalls are most apt to occur in meadows and pastures where the grass roots make a resistant surface, altho any soil underlain by loose, incoherent material may erode in this way regardless of the method of cropping. The unprotected outlet of a tile ditch may

FIG. 5.—HEAD OF GORGE SHOWN IN FIG. 6

Note the condition of the tile outlet. The water undermines the tile by carrying away the incoherent sand at +.

furnish the necessary beginning, especially where the water at the end of the tile has a drop of several feet (see Figs. 5 and 6). Fig. 7 shows a well-protected tile outlet.

FIG. 6.—A GORGE IN MASON COUNTY

This gorge started about twenty years ago from a neglected tile outlet. The water from the tile washed a ditch, slowly undermined the end of the tile, and backed up about 30 rods, forming a gorge from 40 to 50 feet deep. At the head of this gorge the tile branched, and two gorges started. One of these is now 30 rods long, from 50 to 70 feet wide, and from 25 to 35 feet deep. A concrete dam has been placed near its head to stop further encroachment (Fig. 26). The other gorge has extended about 40 rods and is from 30 to 50 feet wide and from 20 to 30 feet deep. Near the end of this gorge the tile again branches, and two gorges are starting; these have advanced 4 to 6 rods along the tiles. At a depth of 4 to 8 feet there is a stratum of fine, incoherent sand, which washes out very readily, allowing the unsupported surface to cave in (Fig. 5).

EFFECTS OF EROSION

LOSS OF ORGANIC MATTER, NITROGEN, AND PHOSPHORUS

Nothing will completely ruin land more quickly than erosion, especially gullying. A great many fields have already been abandoned from this cause. A single season or even a single rain may produce gullies that cannot be crossed with ordinary farm implements. Unless erosion is practically stopped, the land soon becomes almost worthless (see Fig. 9).

While sheet washing may not ruin land so quickly and so completely as gullying, yet much more damage is done by it because it occurs over a much greater area. This type of erosion takes place to a damaging extent on the undulating land, and to a greater extent upon the more rolling and hilly lands. Prairie soils are not subject to so much erosion as timber soils, since their higher organic-matter content protects them to a considerable degree.

The first effect of erosion is to remove the surface soil. Since this commonly contains a larger supply of organic matter, nitrogen, and phosphorus than any other stratum, its removal naturally lowers the plant-food content in the type of soil most subject to erosion, and increases it in the one receiving the wash.

Hilly timber land is naturally deficient in organic matter, and after it has been cleared and cultivated the run-off soon removes a very large part of the surface soil and along with it the organic matter and the two most important elements of plant food, nitrogen and phosphorus. It should be noted, however, that soils naturally subject to erosion, such as yellow silt loam, may contain as much or even

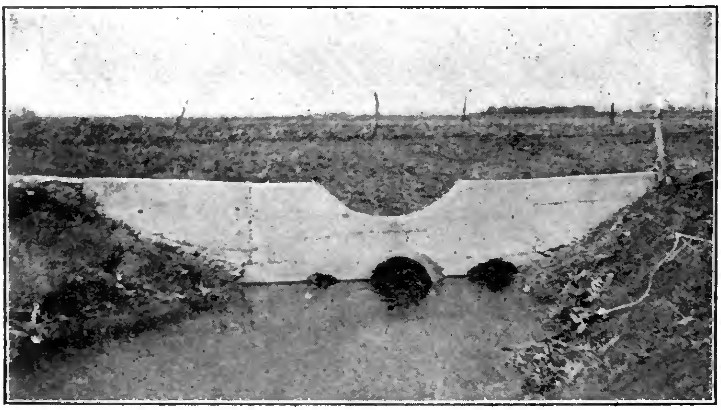

FIG. 7.—A WELL-PROTECTED TILE OUTLET

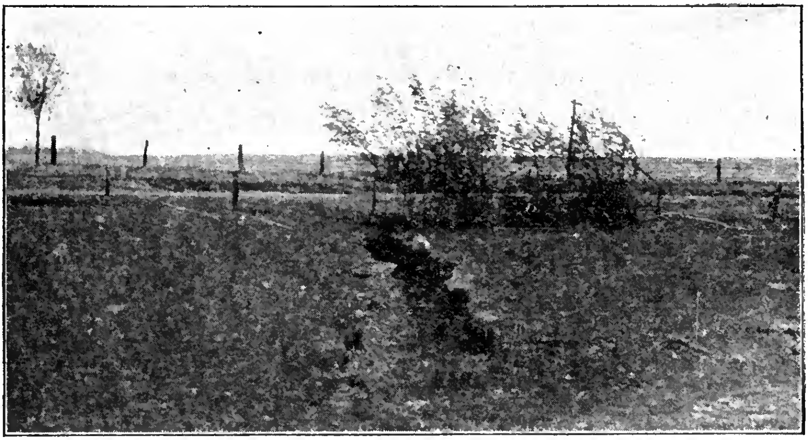

FIG. 8.—WATERFALL EROSION ON PASTURE LAND IN OGLE COUNTY

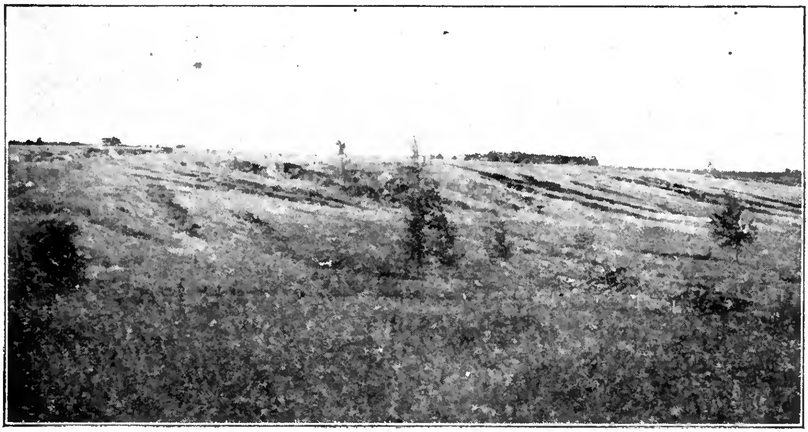

FIG. 9.—EFFECTS OF SHEET WASHING, PIKE COUNTY

more phosphorus in the subsoil or the subsurface than in the surface, even when equal weights are considered.

Table 5 shows the amount of organic matter, nitrogen, and phosphorus in the surface stratum of each of the two representative timber soils in the state and of the bottom land receiving their wash. Yellow-gray silt loam has not suffered much from washing, but yellow silt loam is generally badly eroded. The abandoned land is usually of this latter type. The bottom land receives much sediment from the yellow-gray silt loam areas and some from other less rolling types, but it receives perhaps even more from the yellow silt loam.

TABLE 5.—ORGANIC MATTER, NITROGEN, AND PHOSPHORUS IN THE SURFACE STRATUM OF REPRESENTATIVE TIMBER SOILS AND THE BOTTOM LAND RECEIVING THEIR WASH

2 million pounds of surface soil per acre (0 – 6⅔ inches)

County	Yellow-gray silt loam (undulating)			Yellow silt loam (hilly)			Bottom land (small streams)		
	OM	N	P	OM	N	P	OM	N	P
	tons	*lbs.*	*lbs.*	*tons*	*lbs.*	*lbs.*	*tons*	*lbs.*	*lbs.*
Bond	22.8	2 530	470	19.1	2 068	696	25.4	2 605	1 370
Clay	16.9	1 650	550	14.7	1 540	510	25.1	2 805	1 050
Hardin	13.4	1 520	870	11.0	1 250	840	11.6	1 195	615
Kankakee	26.9	2 710	810	20.7	2 040	720	97.1	9 020	1 560
Knox	22.4	2 440	860	21.9	2 330	820	52.4	4 910	1 790
Lake	27.8	2 720	750	18.1	1 880	720	77.1	8 190	1 490
LaSalle	28.1	2 527	1 033	20.7	2 093	773	36.7	4 440	1 260
McDonough	26.7	2 620	880	18.4	2 140	830	40.5	4 580	1 740
McLean	29.0	2 940	1 050	15.3	1 650	750	62.8	6 300	1 940
Moultrie	24.3	2 310	680	16.6	1 580	480	28.6	3 390	940
Pike	22.6	2 120	780	14.8	1 590	730	34.8	3 230	1 150
Sangamon	22.6	2 300	1 010	8.8	920	820	44.0	4 450	1 630
Tazewell	20.1	2 020	850	15.3	1 710	840	35.9	3 820	1 255
Winnebago	19.6	2 200	870	24.8	2 480	910	63.1	6 770	1 860
Average	23.1	2 330	819	17.1	1 805	746	45.3	4 693	1 403

This table shows that in the surface 6⅔ inches yellow-gray silt loam contains an average of 23.1 tons of organic matter per acre; yellow silt loam, 17.1 tons; and the bottom land, 45.3 tons. The nitrogen and phosphorus content in the surface soil of these three types varies in this same order, the types containing respectively 2,330, 1,805, and 4,693 pounds of nitrogen; and 819, 746, and 1,403 pounds of phosphorus per acre. A nitrogen content of only 1,805 pounds per

TABLE 6.—ORGANIC MATTER, NITROGEN, AND PHOSPHORUS IN THE SUBSURFACE STRATUM OF REPRESENTATIVE TIMBER SOILS

4 million pounds of subsurface soil per acre (6⅔ – 20 inches)

County	Yellow-gray silt loam (undulating)			Yellow silt loam (hilly)		
	OM	N	P	OM	N	P
	tons	*lbs.*	*lbs.*	*tons*	*lbs.*	*lbs.*
Bond	18.2	2 600	1 340	14.7	2 120	1 270
Clay	11.8	1 520	860	13.6	1 830	790
Hardin	11.7	1 500	1 820	8.2	1 390	1 930
Kankakee	20.7	2 710	1 280	17.4	2 160	1 400
Knox	14.5	2 210	1 420	14.7	1 870	1 610
Lake	22.6	2 630	1 300	20.7	2 720	1 620
LaSalle	20.7	2 280	1 907	15.5	2 280	1 387
McDonough	15.0	2 150	1 420	11.5	1 960	1 700
McLean	19.3	2 710	1 490	13.1	2 020	1 540
Moultrie	15.1	2 040	1 100	14.8	1 720	1 200
Pike	24.5	2 140	1 370	12.6	1 600	1 560
Sangamon	14.5	2 150	1 760	11.5	1 540	1 880
Tazewell	12.9	2 090	1 580	11.7	1 650	1 670
Winnebago	14.0	2 220	1 820	25.9	2 980	2 180
Average	16.8	2 210	1 462	14.7	1 990	1 553

acre is not sufficient to produce profitable crops. If that amount is not a sufficient reserve from which to grow fair and profitable crops, what can be expected from a soil whose nitrogen content has been reduced by washing to one-half the above amount, a condition which is produced when the surface soil is removed by erosion (see Table 6). In comparing the figures in Table 5 and Table 6, it will be well to remember that the subsurface stratum is twice the thickness of the surface layer; so that in the subsurface of yellow silt loam, for example, there are but 995 pounds of nitrogen in a stratum of the same thickness as the surface stratum.

CHANGES IN THE PHYSICAL CHARACTER OF THE SOIL

Two distinct changes in the physical character of the soil are produced by erosion: first, a change in color; and second, a change in the physical composition, or texture.

The surface soil of the rolling timber types has a brownish yellow color, owing to the mixture of organic matter and iron oxid. When erosion takes place, the yellow or reddish yellow subsurface or subsoil is exposed. The effect is to slightly reduce the temperature of the soil, since yellow soils do not absorb heat so readily as the darker colored soils.

The most important change in physical character is that of texture. The surface soil is usually a mealy, friable, silt loam, easy to work. The subsoil is often a somewhat tenacious, yellow clayey silt or silty clay, and when this is exposed by erosion it forms a soil that is very difficult to plow and still more difficult to reduce to a condition of good tilth for a seed bed. The physical condition of this subsoil renders it a slow absorbent of water, so that the run-off is actually increased by erosion.

METHODS OF REDUCING EROSION

It would commonly be taken for granted that the thing of first importance in reducing erosion is the preventing of the formation of gullies in cultivated fields, but this is not the case. The beginning of the trouble is usually due to sheet washing, and as a rule gullying occurs in the later stages of the general process of land ruin. If we can prevent sheet washing, we shall very largely lessen gullying in cultivated fields.

REDUCING SHEET WASHING

Five general methods are employed for the prevention of sheet washing: (1) growing cover crops, in order to decrease the movement of water and soil; (2) increasing the organic-matter content, in order to bind the soil particles together; (3) using methods of tillage which will check the velocity of the run-off and cause greater absorption; (4) tiling in order to increase the porosity of the soil and conduct the water thru safe channels; and (5) constructing terraces and embankments which encourage the absorption of the rainfall or so modify the slope of the land as to conduct the surplus water off at a grade that will cause little or no washing.

1. *Cover Crops.*—In the management of rolling land, a rotation should be adopted that will keep the land in pasture and meadow during a large part of the time, or that will at least keep a covering of vegetation on the soil as much of the time as possible. Before these rolling and hilly lands were brought under cultivation, they were largely covered with vegetation of some form. The leaves of trees and fallen branches, together with the smaller plants, formed a covering that did much to prevent the soil from washing. The rainfall was held by the layer of leaves and mold, and the water was allowed to pass off slowly to the streams. But as soon as the protecting forest was removed, the water ran off in a flood almost as soon as it fell. The upland timber soils of the state were usually in poor physical condition when first put under cultivation, or became so after a few years of cropping, and consequently percolation is comparatively slow.

If a cultivated crop is grown, such as corn, a cover crop should be put in just before or after the last cultivation, to protect the soil from washing during the fall, winter, and spring. Rye is one of the best cover crops for this purpose because it lives thru the winter and makes a fair growth of top and an abundance of fine, fibrous roots that hold the soil particles in place. It may be left for green manure or pasture in the spring. A mixture of rye and sweet clover may prove better than rye alone.

Cowpeas may be used as a cover crop with fair success, especially in the southern part of the state, but they do not have the binding power of rye and are killed by frost. The clovers, either sweet, red, or alsike, may make sufficient growth during favorable seasons to protect the soil during the winter and spring, but they are not so sure as rye unless the soil is treated or especially adapted to them. Besides, much of this rolling land in southern Illinois is sour and must be sweetened with ground limestone before clover will do its best.

As already stated, these legumes, aside from their value as cover crops, are also very beneficial to the soil for the nitrogen they supply. The clover may be left and turned under as a green manure in time to plant another crop, such as corn, or it may be harvested or pastured, or, what is better still from the standpoint of soil improvement, the entire crop may be turned under. It must always be borne in mind, however, that a large growth of clover removes a very large amount of moisture from the soil, and when turned under as green manure in dry seasons it may leave the soil so dry that the succeeding crop will suffer.

In general, any crop may be grown as a cover crop that will furnish sufficient material both of top and roots to hold the soil in place. The seeding of rye and timothy in the fall, with red clover and alsike in the spring, followed by pasturing, is one of the very best methods of treatment. Crab grass in corn may make a good cover also.

Much of the rolling and hilly land of the state should be kept in permanent blue-grass pasture (see Fig. 10). If sweet, alsike, or white clover can be grown along with the blue grass, much better results will be obtained. The binding power of blue-grass roots is very great, and gullying is almost entirely prevented except when waterfalls start

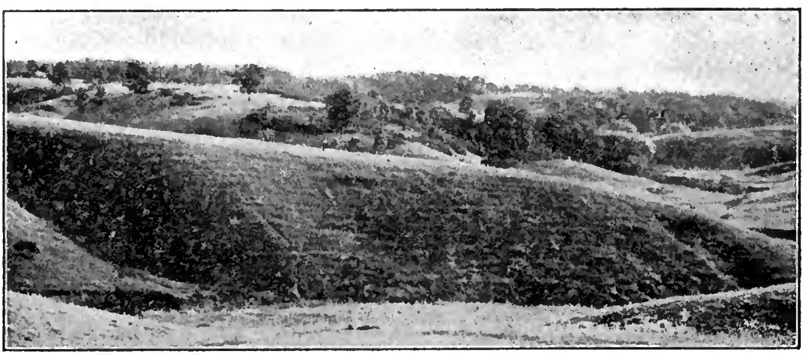

FIG. 10.—A GOOD WAY TO MANAGE HILLY LAND IS TO KEEP IT IN PERMANENT BLUE-GRASS PASTURE

(see Fig. 8) and gullies advance by head-water erosion. If blue grass only is grown, the soil becomes very compact, so that comparatively little rainfall will be absorbed. At most, the amount absorbed is small. Clovers, and particularly sweet clover, with its deep roots, loosen the soil, keeping it in good condition. Besides, the clovers furnish nitrogen for the grass.

2. *Increasing the Organic-Matter Content.*—In the management of the soils of rolling land, it is important to add organic matter, not only because of the effect it has in preventing washing and in producing good tilth, but also because it increases the moisture capacity, conserves the moisture, aids ventilation, and furnishes a supply of nitrogen for the plant (see Fig. 11). One of the effects of organic

FIG. 11.—WHEAT AFTER CLOVER

Farm of A. P. Schroeder, Pulaski county. Showing possibilities of production on rolling land.

matter on a soil is to keep it loose and porous by forming granules. In this condition the soil will readily absorb water and the run-off will be greatly reduced. A granular soil will not erode to any considerable extent, not only because there is less run-off, but also because the granules are too large to be moved readily by water. The organic matter also prevents to a large extent the formation of impervious crusts by beating rains.

The amount of organic matter naturally present in the soil varies quite widely with the type of soil. In general, the upland timber soils of the state have much less organic matter than the prairie types. The chief reason for this is the fact that in the prairie soils the roots of the grasses which once covered them, being protected by the moist soil, underwent only partial decay, while in the forest the leaves of the trees falling upon the surface of the ground were exposed to complete decay or to destruction by forest fires. Table 7 gives the amount of organic matter in the surface and subsurface strata of the principal types of timber and prairie soils of the state at the present time, calculated from the total amount of organic carbon found.

TABLE 7.—AMOUNT OF ORGANIC MATTER IN THE PRINCIPAL TIMBER AND PRAIRIE SOILS OF ILLINOIS
(Surface 2 million pounds, subsurface 4 million pounds per acre)

Area and county	0–6⅔" Timber 6⅔"–20"		0–6⅔" Prairie 6⅔"–20"	
	~~Surface~~	~~Subsurface~~	~~Surface~~	~~Subsurface~~
	tons	*tons*	*tons*	*tons*
Unglaciated:				
Hardin	12.6	10.4	....	....
Johnson	17.1	13.1	....	....
Average	14.8	11.8	....	....
Lower Illinoisan:				
Bond	19.9	12.4	26.0	26.6
Clay	15.4	10.9	22.9	29.8
Average	17.6	11.6	24.5	28.2
Middle Illinoisan:				
Sangamon	15.7	16.8	44.0	52.2
Upper Illinoisan:				
Knox	22.3	15.5	58.1	66 0
McDonough	27.2	11.7	50.0	59.2
Pike	18.9	17.9	31.5	46.2
Average	22.8	15.0	46.5	57.1
Early Wisconsin:				
LaSalle	24.4	18.0	52.0	47.7
McLean	22.2	17.1	50.7	54.6
Moultrie	19.3	14.8	50.9	48.4
Tazewell	17.5	12.1	57.9	62.7
Average	20.8	15.5	52.9	53.4
Late Wisconsin:				
DuPage	22.4	18.7	65.3	47.6
Lake	19.8	17.0	77.5	78.5
Average	21.1	17.8	71.4	63.1

To show the value of legumes on soils subject to erosion, the results obtained in some pot-culture experiments at the University of Illinois are presented. A soil taken from the washed hill land in Pulaski county was placed in pots, and different elements of plant food were added to all except one pot, which served as a check. Fig. 12 shows the difference in growth due to the different methods of treatment. Wheat was grown the first four years, after which wheat and oats were grown in alternate years. In Pots A2, A11, and A12, after

FIG. 12.—EFFECT OF NITROGEN AS SUPPLIED BY LEGUMES OR IN COMMERCIAL FORM

the wheat and oats had been harvested, cowpeas were seeded and turned under for the crop following. The yields obtained under the various treatments are shown in Table 8.

It must be remembered that these yields were obtained in the greenhouse under conditions much more favorable than are ordinarily found in the field. It is interesting to note that the average yields without treatment were 9.0 bushels of wheat and 41.5 bushels of oats

TABLE 8.—CROP YIELDS IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND AND NITROGEN-FIXING GREEN-MANURE CROPS
(Grams per pot)

Pot No.		A1	A2	A11	A12	A3	A6	A9	A8
Treatment		None	LLe	LLeP	LLe PK	LN	LNP	LNPK	LPK
1903	Wheat	5.0	10.0	14.0	16.0	17.0	26.0	31.0	3.0
1904	Wheat	4.0	17.0	19.0	20.0	14.0	20.0	34.0	3.0
1905	Wheat	4.0	26.0	20.0	21.0	15.0	18.0	21.0	5.0
1906	Wheat	4.0	19.0	18.0	19.0	9.0	18.0	20.0	3.0
1907	Oats	6.0	37.0	27.0	30.0	28.0	30.0	26.0	7.0
1908	Wheat	4.0	16.3	10.2	16.0	13.0	3.6	7.7	3.5
1909	Oats	10.2	27.2	24.2	34.6	27.4	66.8	51.8	10.2
1910	Wheat	2.1	15.3	20.0	32.8	21.0	37.4	31.4	4.1
1911	Oats	6.4	11.1	20.6	24.2	32.8	38.4	39.5	6.1
1912	Wheat	0.1	19.3	18.4	25.9	25.9	25.9	23.8	4.1
1913	Oats	6.2	26.2	22.2	24.5	27.6	30.8	21.6	7.0
1914	Wheat	0.3	19.9	15.6	21.6	12.2	13.1	9.7	5.2
1915	Oats	12.7	24.0	25.1	22.9	21.3	16.6	17.3	15.5
1916	Wheat	7.0	14.2	10.2	17.5	13.7	7.2	11.4	4.3
Average of 9 years	Wheat	3.4	17.4	16.2	21.1	15.6	18.8	21.1	3.9
Average of 5 years	Oats	8.3	25.1	23.8	27.2	27.4	36.5	31.2	9.2
Yield Calculated to Acre Basis (Bushels)									
Wheat		9.0	46.4	43.2	56.3	41.6	50.1	56.3	10.4
Oats		41.5	125.5	191.1	136.2	137.1	182.6	156.2	45.8

NOTE.—L=limestone; Le=legume; P=phosphorus; K=potassium (kalium) N=nitrogen.

per acre, and with lime, phosphorus, and potassium added they were 10.4 and 45.8 bushels respectively; that with lime and legumes added, the yields were 46.4 bushels of wheat and 125.5 of oats; while with lime and nitrogen (dried blood), they were 41.6 bushels of wheat and 137.1 bushels of oats; and that the average of all pots receiving nitrogen and other plant food was 49.0 bushels of wheat and 154.8 bushels of oats.

The experiment certainly demonstrates the fact that soils subject to erosion need nitrogen; and one of the great problems of the farmer on this kind of land is not only to maintain but to increase the supply of nitrogen in the soil. The most practical way of doing this on an extensive scale is to add organic matter by turning under legumes and manure, ground limestone being used as needed to correct acidity (see Bulletin 115 of this station).

To increase the organic matter in soils, it is necessary to utilize all the vegetable matter produced. Farm manure should be turned back into the soil as soon as possible. Too often it is left piled up against the barn, where it rots the boards and where much of the most valuable part of it leaches away. Weeds, stubble, and corn stalks should be plowed under instead of being burned, as is so frequently done. Crops of rye, or preferably legumes, should be grown and turned under; they will not only increase the organic-matter content, but at the same time augment the scanty supply of nitrogen in these

FIG. 13.—COWPEAS ON SERIES C, UNIVERSITY OF ILLINOIS EXPERIMENT FIELD AT VIENNA

When turned under, the cowpeas materially increase the nitrogen and organic-matter content of the soil.

soils (see Fig. 13). A crop of cowpeas or clover is not wasted if plowed under; the increased yield of the succeeding crops may more than pay for it. The turning under of cover crops will help to increase the supply of organic matter, but this is too slow a process on land that is washing badly; one or two entire crops in a four-year rotation should be plowed under until the supply is materially increased.

Sweet clover is one of the best crops to grow for the improvement of eroded land (see Fig. 14) for the following reasons: (1) a surer and better catch may be obtained with it than with red clover; (2) its very deep-rooting nature and large growth makes it most valuable for soil renovation; (3) it will grow on almost any kind of soil, whether badly eroded, good, or stony, the only necessary conditions being the presence of limestone and the proper bacteria; (4) it will furnish a large amount of excellent feed in the form of pasture or hay; (5) it possesses a feeding value as high as that of red clover; (6) it is one of our best honey-producing plants; (7) it will likely be a money crop because of the amount of seed it produces and the price the seed brings.

All forms of organic matter are about equally important to the soil from a physical standpoint, yet legumes are much more valuable than other plants because of the large amount of nitrogen which they contain. A ton of corn stalks contains 16 pounds of nitrogen; oat straw, 12 pounds; wheat straw, 10 pounds; clover, 40 pounds; cowpeas, 43 pounds; and sweet clover, about 40 pounds. A 50-bushel crop

FIG. 14.—SWEET CLOVER ON THE VIENNA EXPERIMENT FIELD

Growth during the first season (seeded in March).

of corn requires for its production 75 pounds of nitrogen. To provide this nitrogen, about 1,500 pounds of average soil humus must be decomposed and lost to the soil. If the average amount of humus in the surface seven inches is 2 percent, or 20 tons per acre, it would require only twenty-seven 50-bushel crops of corn to completely exhaust the supply of soil humus; from which it may be seen that even if a soil has a good store of organic matter to begin with, it does not require a great many years of cropping to reduce the supply below what it should be. This rapid depletion of organic matter is hastened materially by washing, and it soon reduces the soil to a condition of unproductiveness. The more a soil is "run down," the more difficult it is to grow clovers or other soil-renovating crops. (See Bulletin 115.)

3. *Tillage.*—Probably nothing that can be done to rolling land damages it more seriously than faulty methods of tillage. This is a fact which the farmers of Illinois have not yet learned. The direction of plowing, planting, and cultivation is usually determined by convenience alone, regardless of consequences. Plowing is more frequently done up and down the hill than any other way, and the making of dead furrows in this direction affords the best possible beginning for a gully. The work of one season's run-off may be sufficient to produce a gully that the next season's tillage operations will not fill, and the slight draw soon increases and becomes a source of constant trouble.

On land subject to serious washing, plowing should always be done along contour lines, or across slopes, the slopes being kept as uniform as possible in order to prevent any accumulation of water in draws. When done in this way, the water in running across the furrows meets with more obstructions and greater resistance than in running with the furrows, as in up-and-down-hill plowing, and more absorption takes place.

While the direction of plowing is important, the depth is of equal importance, for a deep layer of loose soil will absorb a heavy rainfall without run-off. The soil should be plowed to a depth of six to eight inches.

Planting also should be done across the slope. The authors have observed ditches six inches or more in depth in the track of a planter a week after seeding, where the rows had been run up and down hill. All the corn had been washed out by the water which had accumulated in and followed the planter track. If the corn rows had been run on the contour of the slope, this could not have taken place.

Cultivating up and down the hill allows the accumulation of water between rows, and this results in the formation of a large number of small gullies, in the making of which much soil material is removed (see Fig. 15 and 16). In contour planting, each row retards the movement of water down the slope, thus permitting greater absorption.

FIG. 15.—GULLIES PRODUCED IN A SINGLE SEASON (1916)
The corn was cultivated up and down the slope.

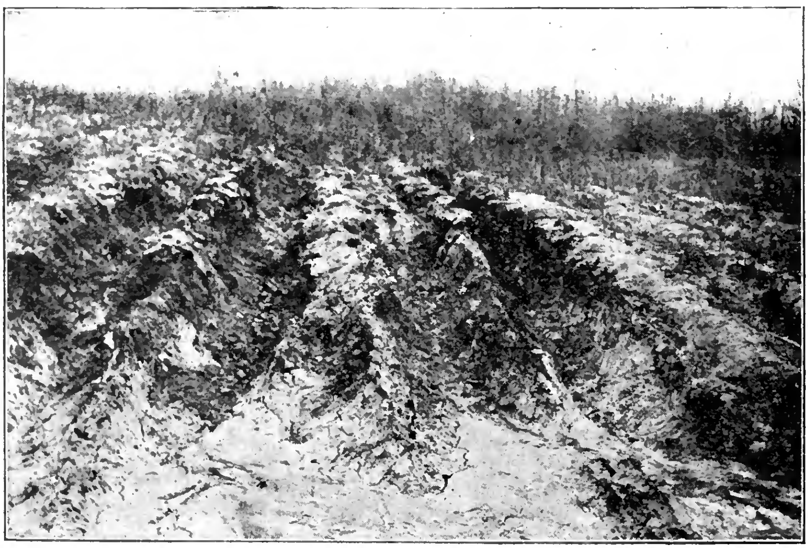

FIG. 16.—ADVANCED STAGE OF GULLYING STARTED IN THE SAME WAY AS IN FIG. 15

Such crops as wheat and cowpeas should also be drilled along contour lines.

4. *Tiling.*—The placing of lines of tile on slopes is a very effective way of reducing erosion. The soil is made more porous, and consequently a large part of the water is removed thru the tile, instead of collecting and running off in draws. Slopes frequently have places where the seepage water comes to the surface, producing cold, wet spots. This condition may be entirely remedied by tiling. The expense involved is the most serious objection to the use of tile in preventing erosion.

5. *Terraces.*—In the southern states it is a common practice to terrace cultivated slopes. The type of terrace depends on the steepness of the slope and the character of the surface soil and the subsoil. The "level bench," "guide row," and "mangum" are all in use.

The level bench is used on the steeper slopes. Contours are established at a difference in elevation of three to five feet. Each terrace is then plowed downward with a hillside plow. In a few years enough soil is moved to make a fairly level bench. Each bench must be cultivated separately, and cuts or tracks across the edge of the bench must be avoided in order to prevent destruction by erosion.

The guide row is developed by throwing several furrows together on contour lines. Crops are seeded along or parallel to these rows. In time, with the use of the hillside plow, these may easily be developed into the level bench. In both of these types there is a strip of uncultivated land on the edge of the terrace. This should have a good sod upon it to hold the soil. This uncultivated strip is undesirable, as it is a waste of land and considerable time is required to keep down the weeds, which aside from their encroachment upon the crop, serve also as a home for mice and moles and as a breeding place for injurious insects.

The mangum terrace (Fig. 17) differs from the terraces just described in that it has some fall from the back to the front of the terrace as well as a grade of about one inch in ten feet from one end of the terrace to the other. The width of the terrace depends on the general slope of the area. In order to build up an embankment, several furrows are thrown together along a line of proper fall established by means of a level, and, to increase its height, soil is drawn to it from the upper side, making a low, broad dyke. When the field is plowed again, the ridge may be raised by back-furrowing along the grade line. This process may be continued from year to year until the desired height is reached. The steeper slopes require a higher embankment. About six feet of fall is allowed between embankments, so that the terraces on very steep land will be 40 to 80 feet wide, and on more gently sloping land 100 to 150 feet wide. By this method the run-off

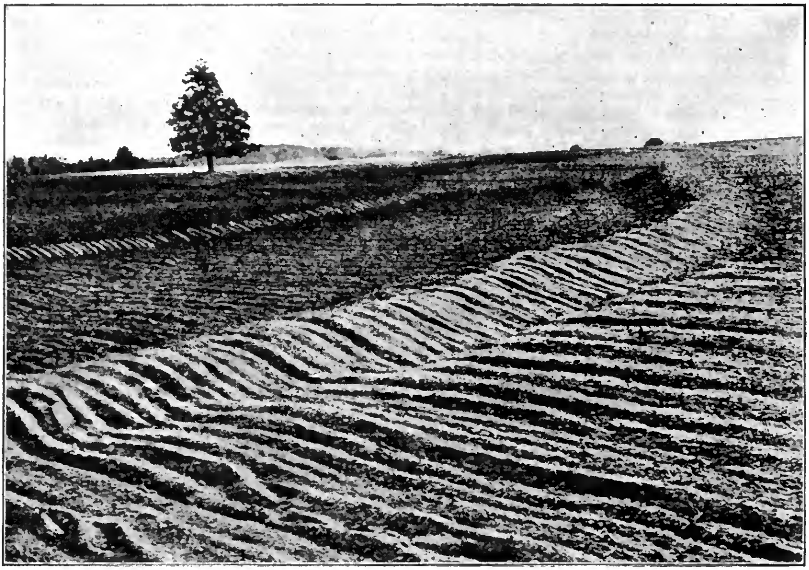

FIG. 17.—MANGUM TERRACE
(Courtesy, Bureau of Plant Industry, U. S. D. A.)

is conducted slowly around the slope in a broad-bottomed ditch to a natural outlet, without much washing. It is essential that the water be given no opportunity to get over the embankment, as it would cut a gully across it, drain the ditch, and ruin this and possibly several embankments below. Crops may be planted in any direction, with little reference to the terraces, but it is most desirable to have the rows run obliquely across them, so that there will be a slight fall along the rows toward the ditch. This should aid the soil in absorbing more of the rainfall. The mangum terrace has a distinct advantage over the other types in that there is no waste land. This form of terrace has attracted much attention, and of the various types, is the one best adapted to extensive farming.

If cover crops and organic matter are used to the best advantage, and if deep contour plowing and contour seeding are practiced, there will not be much need for any terracing in this state. However, the mangum terrace, properly constructed, may in some places be used to advantage.

FILLING AND PREVENTING GULLIES

The owner of rolling or hilly land must be constantly on the lookout for new gullies and must use every means for preventing their enlargement. No attempt should be made to crop the very badly gullied areas. It would be best to reforest these as rapidly as possible.

This will effectually prevent further erosion, and after a few years will be a source of profit as well. Fig. 18 shows a grove of black locust grown on gullied rolling hill land on the farm of J. C. B. Heaton, in Johnson county.

Care must be taken to prevent shallow draws from becoming deep, untillable gullies. A somewhat common method is to scatter straw in them, or to build dams of straw across them at frequent intervals. This is often done in wheat fields after seeding in the fall. Such a method may serve to check the velocity of the water and to catch the sediment, but frequently the run-off is so great that the water washes around the ends of the dams or carries the straw down the draw and deposits it at the base. These dams are sometimes held in place by rows of stakes driven across the draw.

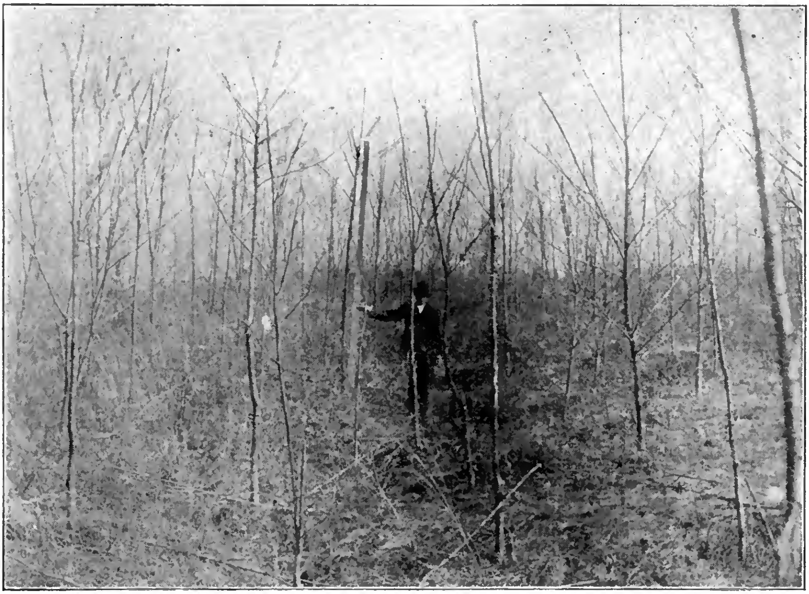

FIG. 18.—BLACK LOCUSTS GROWING ON BADLY ERODED LAND
Farm of J. C. B. Heaton, Johnson county.

A better plan, used a great deal in some parts of the state, is to keep these draws well sodded, at least until they are so well filled that there is little danger of gullies forming (Fig. 19). The sod binds the soil particles together, while the top growth checks the velocity of the water, causing the suspended sediment to be deposited. In time the draw becomes filled so that it may be cropped, but it should be seeded down again if there is danger of a gully forming. Almost any grass

FIG. 19.—SODDED DRAW IN MERCER COUNTY

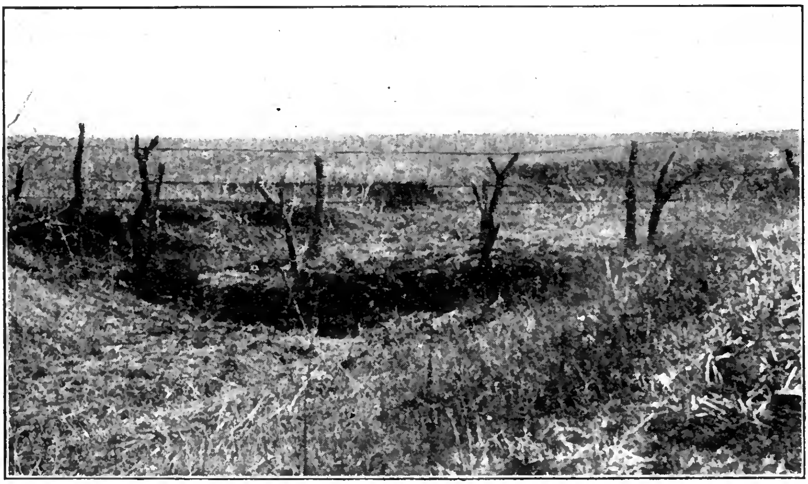

FIG. 20.—DAMS OF STRAW HELD BY WOVEN WIRE FENCING, MASON COUNTY

that forms a tough sod will answer the purpose, timothy, red-top, and blue grass being quite satisfactory. This method is practiced very successfully in some parts of the state.[1] The grass may be mowed for hay.

[1]Some owners in renting their land insert a clause in the lease forbidding the plowing up of these draws.

Where the gullies are small, the matter of filling them is a simple one, altho care and perseverance are required to keep them filled. If it is desirable to crop the field soon, and the gullies are not too deep, they may be filled with the plow and scraper in a comparatively short time and at little expense. A depression, or draw, must not be left where the gully formerly was, or it will be a constant source of trouble.

Dams of earth, stone, concrete, or straw held by woven wire (Fig. 20) are sometimes constructed across a gully in order to catch the sediment and thus fill the gully and prevent its later formation in the same draw. In many cases this method has been very satisfactory. It may be used for draws as well as for gullies.

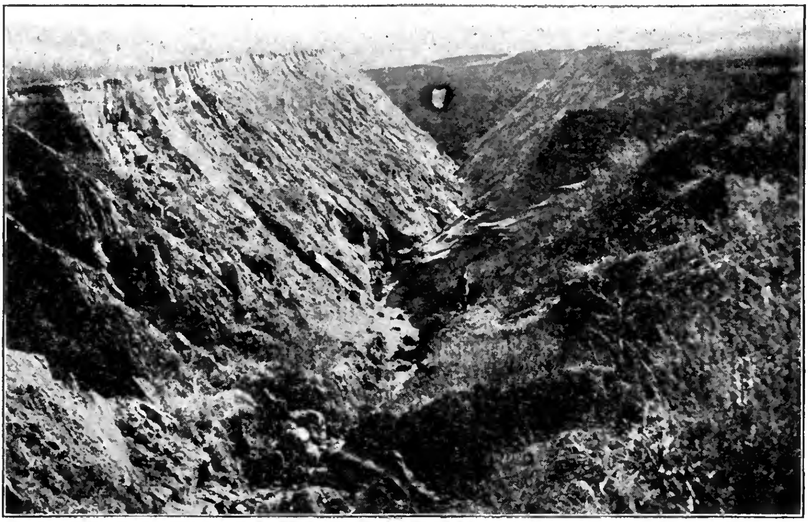

FIG. 21.—A GULLY IN CENTRAL ILLINOIS

This gully started less than forty years ago, and is now from 100 to 150 feet wide and from 25 to 65 feet deep.

The construction of these dams should vary with the size of the gully and the amount of water flowing thru it. If the gully is small, an earth dam constructed as shown in Fig. 22, may be all that is necessary to prevent its enlargement (see Fig. 23). If the gully is large, and the volume of water considerable, a concrete dam should be used which, in addition to the tile, has a spillway over which the excess water may flow. An apron of concrete should be placed under the spillway to prevent the undermining of the dam.

Fig. 24 shows a detailed plan that may be used as a guide in the construction of a concrete dam. The concrete should be well reinforced and anchored on each side. The tile may be placed so as to run either under the dam or thru it. Care must be taken to build the dam with sufficient strength to resist the pressure of the water. The concrete should extend at least two feet below the bed of the stream, or below the frost line. Figs. 25 and 26 show concrete dams in place.

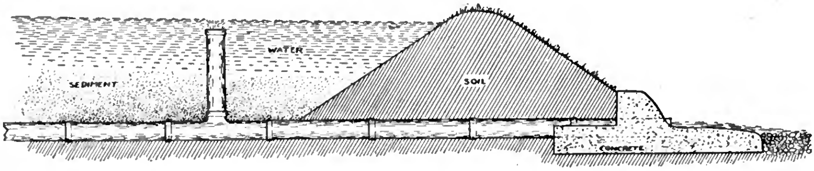

FIG. 22.—DAM OF EARTH

The tile, both vertical and horizontal, must be large enough to allow the water to flow away without any of it going over the dam, as that will ruin it.

The gully produced by a waterfall is one of the hardest to fill, since the fall of the water gives it great eroding power, making it very difficult to stop its undermining action. As such gullies generally occur where the field is in grass, there is a comparatively small amount of sediment carried, and consequently the filling goes on but slowly. The problem is to stop the recession. Straw and brush should be placed under the fall and weighted down with stones or sod, or held in place with stakes to prevent their being washed away. Dams of straw or brush should be placed at intervals below the fall, and even a solid dam of concrete where the gully passes into another field may be of much service in completely filling it in time.

FIG. 23.—DITCH IN CHAMPAIGN COUNTY FILLED BY MEANS OF EARTH DAM

The gully was six feet deep and sufficiently wide at the bottom for a team and wagon to stand crosswise. It was filled in less than ten years.

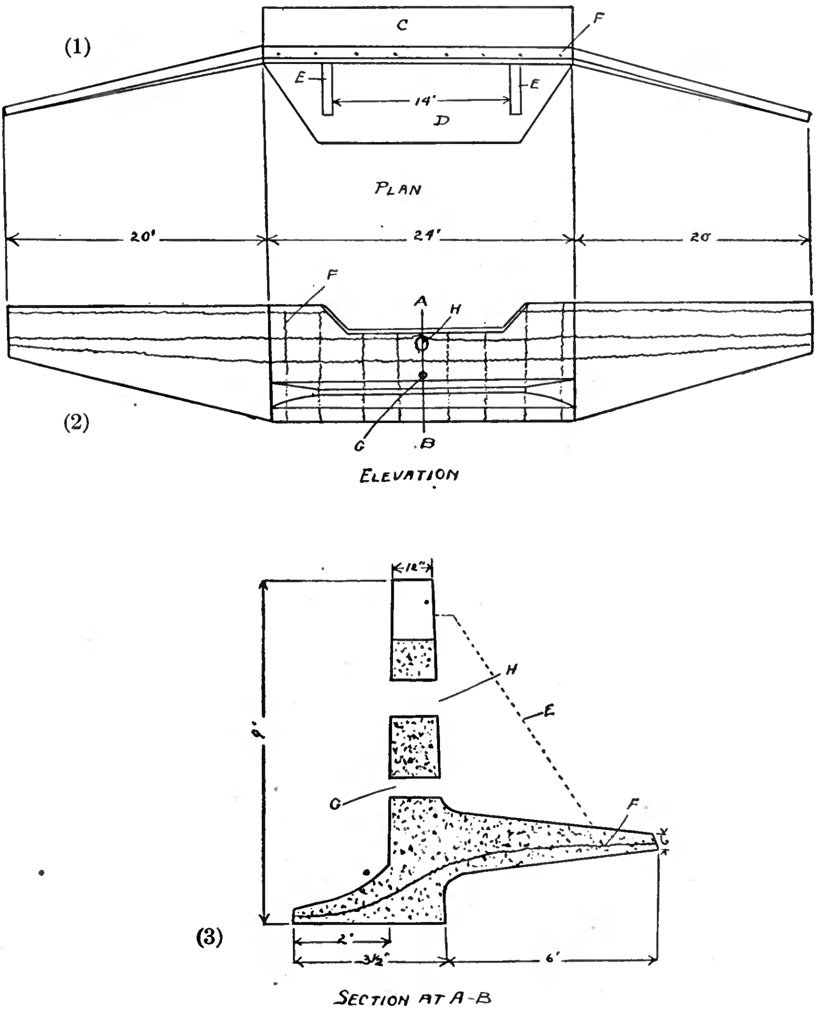

FIG. 24.—DETAILED PLAN FOR A CONCRETE DAM

(1) View from above; (2) Looking upstream; (3) Section. *C*—Upstream apron for preventing underwashing. *D*—Spillway apron of concrete. *E-E*—Concrete abutments for bracing the main dam. *F*—Steel reenforcing rods, horizontal and vertical. *G*—Permanent tile for draining ditch when filled with sediment (the size of the tile will vary with the needs, and may run under the spillway if the ditch is not deep). *H*—An opening may be left in the dam to take care of the water under ordinary conditions and reduce the size of the pond above the dam; this opening should be closed when the ditch is filled with sediment to that level.

FIG. 25.—FILLING A GULLY BY MEANS OF A CONCRETE DAM

FIG. 26.—A CONCRETE DAM

The gully shown in Fig. 26 is 15 feet deep and 25 feet wide. The dam should have been 4 feet higher, and the tile at *A* connected with that at *B*. During the winter of 1917-18 the water washed around one side of the dam, the wings not extending far enough into the bank of the gully. Note the concrete spillway between the abutments.

Smith

RECLAMATION EXPERIMENTS

JOHNSON COUNTY EXPERIMENT FIELD AT VIENNA, ILLINOIS

In the spring of 1906 the Agricultural Experiment Station of the University of Illinois purchased sixteen acres of land in Johnson county near Vienna. The whole area, with the exception of about three acres, had been abandoned because so much of the surface soil had been washed away, and there were so many gullies that further cultivation was unprofitable (Fig. 27). The land was bought for the purpose of reclaiming it and studying different methods of reducing erosion.

FIG. 27.—VIEW OF LAND IMMEDIATELY ADJOINING THE VIENNA EXPERIMENT FIELD

When the land was purchased, gullying had not gone very far. (See Fig. 28.)

Part of the land was occupied by scrub trees, persimmon, elm, and sassafras, and by blackberry and other brush. This was removed and used in making brush dams in the ditch running north and south across the middle of the field. Some of the gullies were from four to five feet deep, so that the first step in reclaiming the land was to fill them and make the slopes more uniform. This was accomplished with plows and scrapers.

The soil was extremely low in organic matter, the subsoil being exposed on about one-fourth of the field. These conditions were responsible for a large part of the run-off, the low productiveness of the soil, and the injury to crops by drouth. In two places, about a square rod of the underlying rock was exposed.

The field was divided into five series, A, B, C, D, and E, as shown in Fig. 29. The division, it will be noticed by the contour lines, was more or less natural to the lay of the land. Series A, B, C, and D, together with divisions and borders, occupy about thirteen acres, and Series E about three acres. A, B, and C were divided into four plots each; D, into three plots. For each series a somewhat different system of reclamation was planned in order not only to study the problems of reducing erosion, but also to determine which system of reclamation was best under these conditions, as indicated by the crop yields.

Series A includes the steepest part of the area and contained many gullies. These were filled and the area was terraced at vertical intervals of five feet. Near the edge of each terrace, which had a slight slope, a small ditch was placed, so that the water could be carried to a natural outlet at the side of the field without doing much washing. Each terrace was cropped as a separate area.

In two places in Series B were several small gullies, none of which was more than eighteen inches deep. On this series the embankment method was used, except at the steepest part, where two hillside ditches were made for carrying away the run-off.

Series C was washed badly but contained only small gullies. On this series an attempt was made to prevent washing by incorporating organic matter in practicable amounts. In the spring of each year, with the exception of two years, manure at the rate of about eight loads per acre was turned under for corn.

Series D lies just across the hollow from Series C, and was washed to about the same extent. As a check against the various methods for reducing erosion, Series D was farmed in the most convenient way, without any special effort being made to prevent washing.

FIG. 28.—SAME AS FIG. 27, BUT TEN YEARS LATER

These series (A, B, C, and D) were not entirely uniform. As already stated, some parts were washed worse than others, and sections of the lower part of the field had been affected by soil material brought from the higher land. When the field was secured, this higher land had a very low productive capacity, as shown by the yield of 9.7 bushels of corn on Series D, and 11.1 bushels on Series C, in 1906, the first year. Many spots would grow little or nothing.

Series E was badly eroded and gullied and was not cropped. An attempt was made to fill the gullies by putting brush into them and seeding to grass, but this was not wholly successful. The area above the gullies was soon covered with vegetation, so that there was little soil material washed into the ditches to aid in filling them. However, the grass and brush prevented the gullies from becoming larger.

Limestone was applied to the entire field at the rate of two tons per acre. No other mineral plant food was applied. Corn, cowpeas, wheat, and clover were grown every year in the order named, as a

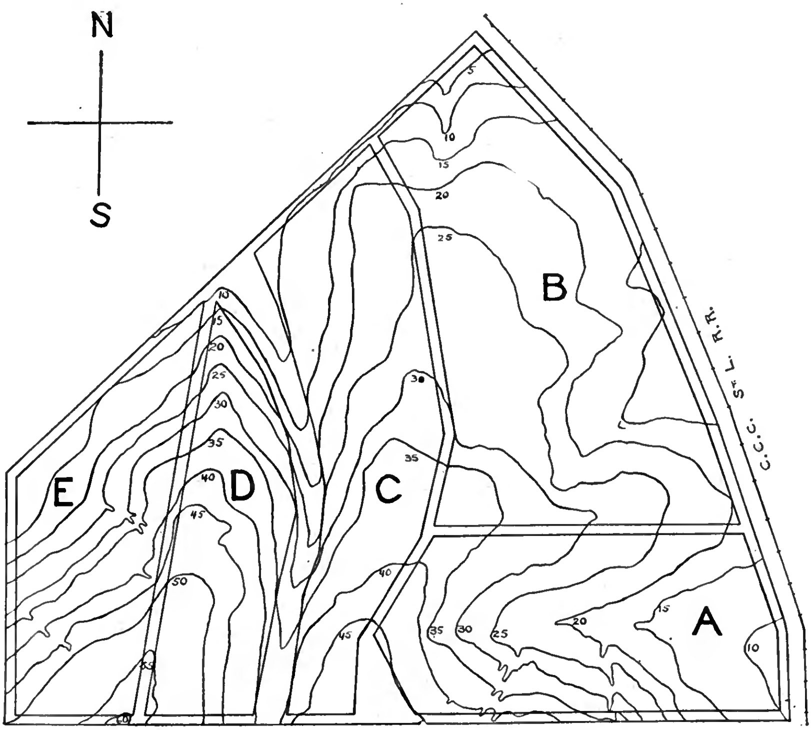

FIG. 29.—MAP OF UNIVERSITY OF ILLINOIS SOIL EXPERIMENT FIELD AT VIENNA

Showing location of the series and the approximate contour lines (5-foot intervals). The sharp bends in contour lines show where large gullies were located.

four-year rotation, together with additional cover crops when necessary. The corn stalks, the second growth of clover, and the cowpeas were turned back into the soil. When clover failed, soybeans were substituted, but these did not make a large growth (seldom more than an ordinary second growth of clover), and were turned under.

Tables 9, 10, and 11 give the yields of the crops by plots on each series.

TABLE 9.—YIELDS OF CORN IN SOIL EXPERIMENTS, VIENNA FIELD: 1906–1915
(Bushels per acre)

Year	Plot	A	B	C	D
1906	1	42.1	18.6	11.1	9.7
1907	4	17.8	24.8	31.0	No plot
1908	3	25.0	44.0	31.5	31.1
1909	2	30.8	41.5	41.2	13.5
1910	1	52.5	36.0	27.7	8.0
1911	4	30.0	31.9	36.5	No plot
1912	3	13.7	37.5	10.8	24.4
1913	2	24.6	36.4	41.8	8.2
1914	1	30.8	13.5	22.6	3.7
1915	4	24.5	14.8	32.1	No plot
Average		29.2	29.9	28.6	14.1

TABLE 10.—YIELDS OF WHEAT IN SOIL EXPERIMENTS, VIENNA FIELD: 1906–1915
(Bushels per acre)

Year	Plot	A	B	C	D
1906[1]	..	....	....	....	....
1907	2	8.9	10.6	9.4	5.6
1908	1	8.9	6.2	8.5	1.5
1909	4	7.3	7.0	12.0	No plot
1910	3	11.5	18.8	16.7	7.8
1911	2	13.1	19.6	20.1	3.7
1912	1	3.0	2.8	0	0
1913	4	6.9	10.0	12.5	No plot
1914	3	9.3	14.7	11.1	8.4
1915	2	8.5	15.3	14.8	5.1
Average..............		8.6	11.6	11.7	4.6

[1]Oats were sown instead of wheat, but they did not grow high enough to be harvested.

TABLE 11.—YIELDS OF CLOVER IN SOIL EXPERIMENTS, VIENNA FIELD: 1907–1915
(Tons per acre)

<table>
<tr><th>Year</th><th>Plot</th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>1907</td><td>3</td><td>.75</td><td>1.11</td><td>.29</td><td>.40</td></tr>
<tr><td>1908</td><td>2</td><td>.20</td><td>1.04</td><td>.30</td><td>.10</td></tr>
<tr><td>1909</td><td>1</td><td colspan="4">Clover turned under</td></tr>
<tr><td>1910</td><td>4</td><td>.46</td><td>1.08</td><td>1.20</td><td>No plot</td></tr>
<tr><td>1911</td><td>3</td><td colspan="4">Failure</td></tr>
<tr><td>1912</td><td>2</td><td colspan="4">Soybeans turned under</td></tr>
<tr><td>1913</td><td>1</td><td>1.09</td><td>.78</td><td>1.81</td><td>.14</td></tr>
<tr><td>1914</td><td>4</td><td colspan="4">Soybeans turned under</td></tr>
<tr><td>1915</td><td>3</td><td colspan="2">Sweet clover turned under</td><td colspan="2">Soybeans turned under</td></tr>
<tr><td>Average..........</td><td></td><td>.62</td><td>1.00</td><td>.90</td><td>.21</td></tr>
</table>

It is difficult to compare the results obtained from the various methods of treatment on the different series because of the variation in the soil, but it can be said that any system that conserves the soil will aid in maintaining the crop yields. Table 12 gives by periods the crop yields obtained under the different methods of management.

TABLE 12.—ANNUAL CROP YIELDS OBTAINED UNDER DIFFERENT METHODS OF MANAGEMENT TO REDUCE EROSION: VIENNA FIELD

Years	Terrace (A)	Embankments and hillside ditches (B)	Organic matter, deep contour plowing, and contour planting (C)	Check (D)
		Corn (Bushels per acre)		
1906–08	28.3	29.1	24.5	20.4[1]
1909–11	37.7	36.5	35.1	10.7[1]
1912–15	23.4	25.6	26.8	12.1[2]
Average	29.2	29.9	28.6	14.1
		Wheat (Bushels per acre)		
1907–09	8.3	7.9	10.0	3.5[1]
1910–12	9.2	13.7	12.3	5.7[1]
1913–15	7.6	13.3	12.8	6.3
Average	8.6	11.6	11.7	5.3
		Clover (Tons per acre)		
1907–8–10–13	.62	1.00	.90	.21

[1]Two-year average. [2]Three-year average.

The average yield of corn for 1912 to 1915 was less than for 1906 to 1908 in every case except where the organic matter was increased. This was due in part to the three dry seasons during the 1912 to 1915 period. Series C and D were on either side of a draw extending north and south, C facing west and D east. Series C received manure in addition to the cowpeas and residues turned under, and every effort was made to prevent washing, tho this was not successful in all cases. Series D, of which no particular care was taken, is now almost worthless because of gullying (Fig. 30). Table 13 gives the average yields for the four series, based on all comparable yields.

TABLE 13.—AVERAGE OF COMPARABLE YIELDS, VIENNA FIELD: 1906–1915

Crops	Years	Series			
		A	B	C	D
Corn (bu. per acre).........	7	31.4	32.4	27.9	14.1
Wheat (bu. per acre)	7	9.0	12.7	11.7	4.6
Clover (tons per acre).......	3	0.68	0.97	0.80	0.21

The average yield of corn for the protected series (A, B, and C) was 30.6 bushels per acre, as against 14.1 bushels for series D; wheat yielded 11.1 bushels in comparison with 4.6 bushels, and clover 0.82 ton in comparison with 0.21 ton.

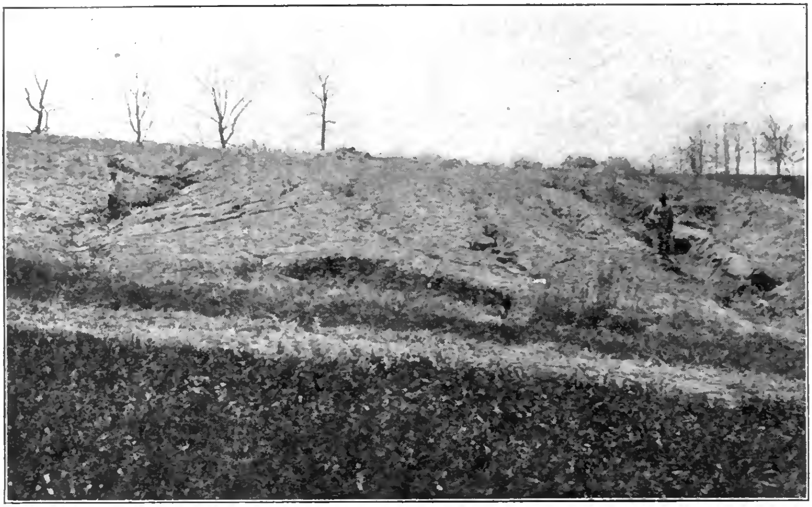

FIG. 30.—VIEW OF PART OF SERIES D, 1916, VIENNA EXPERIMENT FIELD

Note badly eroded condition.

The best biennial legume for soil improvement on eroded land is sweet clover, because as already stated, it catches readily and makes a large growth of both top and root. The second season's growth begins sufficiently early so that if desired a considerable amount may be plowed under for corn the same season (see Fig. 31).

The comparison between Series C and Series D may be somewhat in favor of C since C received some manure. Series A, however, was washed as badly as D in all except the northeast and southeast parts, and aside from terracing received the same treatment as D. The difference in yields here is almost as striking as between C and D. As an average of the comparable yields, A produced 31.4 bushels of corn per acre and D, 14.1 bushels; A produced 9.0 bushels of wheat and D, 4.6 bushels; A produced .68 ton of clover and D, .21 ton. Reclaiming and reducing erosion resulted in an increase of 17.3 bushels of corn per acre, 4.4 bushels of wheat, and .47 ton of clover hay.

Figuring corn at 60 cents and wheat at 80 cents per bushel and clover hay at $7 per ton, the value of the increase due to reclamation and control of erosion for one four-year rotation is $17.19. These three crops represent the total yield per acre, as the cowpeas were turned under. The average annual gain per acre is $4.30; which would mean $172 a year from forty acres, and $1,720 in ten years from forty acres.

The expense of reclaiming the land, which for series A and B consisted in filling gullies and building terraces and embankments, was approximately $18 on 5.8 acres. About two-thirds of this amount was spent on Series A, which had been completely abandoned when the tract was purchased and was badly gullied and more difficult to terrace. Series C and D required but little work, since they contained only a few small gullies and no terracing was done.

The value of the crops removed from Series A during the first rotation was $66.08, or at the rate of $26.43 per acre for four years, or $6.61 per acre per annum. The crops of cowpeas are not included in the above. If $6 per ton is allowed for the cowpea hay, the value of the crops will be increased about $4.50 per acre, making approximately $11.11 per acre on this formerly abandoned land. The approximate cost of maintaining the terraces on Series A was not over fifty cents per acre per annum, and much less on Series B.

This increase in returns pays for all labor of filling gullies and building terraces and maintaining them, and leaves a fair profit on each field where washing is largely prevented and the soil conserved. Series A is in a condition to be cultivated for years to come if properly cared for, while Series D cannot be cropped profitably in its present condition.

FIG. 31.—SWEET CLOVER ON VIENNA EXPERIMENT FIELD

About 30 inches high, May 31, 1914.

Increasing and maintaining the organic matter, using cover crops, keeping the land in pasture and meadow as much as possible, and practicing deep contour plowing and planting are the most practical means for reducing soil washing in Illinois. If these methods are practiced, much of the badly eroded land can be cultivated with profit.

FIG. 32.—CORN ON VIENNA EXPERIMENT FIELD

Upper Section—Series D, 1914; yield 3.7 bushels.
Lower Section—Series C, 1914; yield 22.6 bushels.

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