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SOIL EROSION IN THE SOUTH.

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The study of eroding soils has been undertaken to determine if possible from both a field and laboratory examination the factors influencing erosion and the means applicable for its prevention or correction. A field trip involving this study was made through the States of Virginia, Tennessee, Missouri, Mississippi, Alabama, Georgia, South Carolina, and North Carolina. Observations were made on the nature of erosion, the effects produced by erosion, remedies applicable or in use, differences in forest or field, the topography and drainage, the nature of the soils and subsoils, and on such agricultural problems as terracing, crop rotation, seeding for pasture, labor, and economic conditions. In this paper are discussed the conditions affecting soil erosion as observed in the field. A study of the important soils is being made in the laboratory and a subsequent paper will deal with their physical characteristics and properties.

EROSION AS RELATED TO THE FORMATION OF SOILS.

It is necessary at the outset to understand something of the methods of soil formation and the causes producing soils. The two large classes of soils, according to the processes by which the soils material has been accumulated, are those derived from material accumulated by disintegration and decomposition of the rock in place, or residual soils, and those derived from material accumulated by deposition from wind, water, or ice.

RESIDUAL SOILS.

The accumulation of soil material through the disintegration and decomposition of rock material in place is effected by a number of forces both mechanical and chemical in their nature. The most important mechanical process and the only one worthy of mention

Note—This bulletin is of general interest, but especially in Virginia, Tennessee, Missouri, Mississippi, Alabama, Georgia, South Carolina, and North Carolina.

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here is the expansion of the rock material due to changes in temperatures, including the expansion of the water contained in the rock at the freezing point. The most important chemical process is solution, while oxidation and hydration are of great importance.

The layer of resulting material mixed with some organic matter and capable of supporting plant life is known as soil. Its composition does not differ very markedly from the rocks from which it is derived. At best this process of accumulation is slow, the rate depending somewhat on the activity of the agencies producing it.

TRANSPORTED SOILS.

Soil materials formed in one place and deposited in another through the agency of wind, water, or ice constitute or develop into transported soils. These, however, are not the eroding soils, but are the results of soil erosion.

TRANSLOCATION OF SOILS BY WATER.

The movement of soil material by water is limited by two inherent properties. Water can move only from a higher to a lower level, and it can affect only the surface with which it comes in actual contact.

Since water moves over the surface of the soil only under the force of gravity, its action is always directed toward moving material from the hills and depositing it in the plains. If a stream is arrested in its movement down hill by the construction of an impediment, such as a dam, it produces a lake which acts as a settling basin. The stream gives up its burden of detritus and the lake is gradually filled. Eventually this results in the bottom of the lake reaching the level of the dam, when the stream will then carry its burden to some lower lake or to the ocean and deposit it.

Streams can erode only those surfaces over which they flow, and this greatly restricts their power in this respect. Thus the larger part of the detritus of streams must be derived from the surface drainage of adjoining areas. Here the amount of surface drainage is dependent on the absorptive power of the soil and on its drainage. If the soil is more or less loose and porous its absorptive capacity is high, so that it may absorb rain as rapidly as it falls unless the precipitation be extraordinarily heavy. On the other hand, if the soil is close grained and compact the absorption is slow, even though the actual pore space within the soil be greater than in the case of the loose soil. In case of a gentle rain, absorption may be rapid enough to prevent surface drainage, but with any heavy and rapid rainfall the water runs off largely from the surface.

WATER-TRANSPORTED MATERIAL.

Physics.—The excess of water draining from the surface of a soil carries with it some of the material in suspension. The existing valleys are built up by the deposition of such material brought down from the hills, and new valleys are formed by the gradual enlargement of gullies on the hillsides.

The size of the material moved by running water varies from the finest material to the large bowlders rolled along the beds of swiftly flowing streams. The amount of material that any particular stream of water can carry in suspension is limited. and if that limit is reached no more material can be picked up as long as the velocity of the stream and the size of particles in contact with it remain the same.

The size of particles which can be carried in suspension by the water depends on the surface-mass ratio of the particles and on the velocity of the water. A discussion of the relation of the carrying power of water to suspended material leads to consideration of the special subject of suspensions or of disperse systems of matter.

It has been repeatedly stated that the slope affects erosion to such an extent that doubling the slope increases the erosive action four times, and that doubling the velocity of a stream increases its transporting power sixty-four times. Gilbert[1] has recently pointed out that these statements are slightly erroneous. Instead of the quantity of material moved varying with the sixth power of the velocity, it varies nearly as the fifth power.[2] However, the maximum size of grain or pebble that a stream is competent to move varies as the sixth power.

The factors which modify the capacity of a stream to transport débris along its bed are many. Width of stream and velocity of the water are factors. Both slope and depth affect velocity, and in turn depth is affected by discharge and slope. Size of material transported is an important factor, as much greater weight of fine than of coarse material may be carried. The shape and density of the material are also factors influencing the transportation. The course which the stream follows also exerts an influence, the carrying efficiency being affected by turns and curves. The viscosity of the water, varying with the temperature, the friction against the banks, and the nature of the dissolved or suspended material are factors. The interaction of these factors on one another makes the problem more difficult to study. It is most important to note that the transporting power is influenced most by the change in velocity.

The first action of the fallen drops of water as they collect is to carry with them some of the finest material, or the clay particles. As the streamlets grow, greater volume causes increased velocity and a transporting power increasing to such an extent that larger and larger particles are carried along in suspension or rolled along

[1] G. K. Gilbert, U. S. Geol. Survey, Prof. Paper 86 (1914).

[2] Deacon, G. F., Inst. Civil Eng., Proc. 98, (1914).

the stream bed. Where the velocity is greatest, generally midway between the crest and the foot of the hill, the erosion is greatest.

The modes of transportation as determined by experiment[1] show that some of the particles carried by a stream slide along, some roll, and many make short leaps, the process being called "saltation." Saltation itself grades into suspension. In saltation the particles are just on the verge of suspension; a slight difference in one of the factors may cause the particles to remain in suspension.

At the foot of the hill, where the slope becomes less steep, there is a deposition of the coarser material. The gravel and sand are deposited first, the silt next, and the clay particles last. The quantity of coarse material carried by a stream is greatest in times of floods, while during periods of normal flow the silt and clay particles greatly predominate. The smaller particles are carried in suspension until the plains are reached, or are transported to the sea.

SOURCE AND QUANTITY OF MATERIAL.

The source of the material transported by water is in the hills. The streams may deposit it at one place, later to take it up and move it to another; but this is only a part of the process of bringing the soil from the uplands and depositing it in the lowlands. A detailed discussion of the factors affecting sedimentary formations is given by Mather.[2]

The quantity of soil material moved during one year by the streams of the United States is very large. The great depths to which some of our rivers have cut represent the ultimate effect of the removal of soil material by the action of water. The Columbia River and the Colorado River have cut gorges to depths of 2,000 and 5,000 feet, respectively, Under more favorable conditions, where the soil is loose or incoherent, the action may be even more marked. The quantity of material carried in suspension to the sea by the Mississippi River, which drains over one-third of the area of the United States, has been variously estimated at 370,000,000 tons[3] to 680,000,000 tons[4] per annum. The total amount of soil material carried to the sea annually by the rivers of the United States is estimated by Dole and Stabler[5] as 783,000,000 tons. Estimates of the United States Geological Survey place the quantity of material carried in suspension annually by the Hudson River at 240,000 tons; by the Susquehanna, 240,000 tons; by the Missouri above Ruegg,

[1] C. K. Gilbert and E. C. Murphy, U. S. Geol. Survey, Prof. Paper 86 (1914); Jour. Wash. Acad. Sci., 4, 154 (1914).

[2] W. W. Mather, Physical Geography of the United States East of the Rocky Mountains; Am. Jour. Sci., 49, 14284 (1845).

[3] Humphrey and Abbott, Surveys of the Mississippi.

[4] Dole and Stabler, U. S. G. S., Water Supply Paper 234, 84 (1909).

[5] Bul. Geol. Soc. Am., 2, 130 (1894).

near its confluence with the Mississippi, 176,000,000 tons, with corresponding amounts carried by various other rivers. Enormous as these figures are, they do not represent by any means the total losses from the soils drained by the streams. No estimates of the total amount of material actually moved through the agency of water has been made, but it must be many times greater than the amount which reaches the sea in suspension.

A case is reported by Tarr [1] describing the intense action of a flood in an arroyo in the Rio Grande Valley, New Mexico, due to a local cloudburst in the Donna Ana Mountains of about half an hour duration and extending over an area of less than 6 square miles. Such large quantities of material were brought down from the hills that several acres were covered with silt and gravel. An adobe house about 10 feet high was buried to within 2 feet of the top. Several thousand tons of earth must have been transported during this sudden rush of water. Tolman [2] describes the transporting of material by streams of the arid region. The quantities of sand being carried to the sea are discussed by Marsh.[3] In addition to the solid particles carried to the sea by the streams, the quantity of dissolved material is also enormous. It is estimated that the Mississippi River carries annually to the Gulf of Mexico 86 tons of dissolved salts from every square mile drained by it. The rivers of the West carry much larger quantities than this.

MOVEMENT OF SOIL MATERIAL BY THE WIND.

The total amount of soil material moved by water is large, a fact well known, but the fact that almost equally as large amounts are moved through the agency of the wind is not generally appreciated. The wind exerts its action in any direction or in any climate. While it is true that the greatest effect is shown in arid or semiarid regions, the wind of the humid regions always carries a burden of suspended soil material. The dry material of an arid climate is more easily moved, and hence the greater effect produced.

In considering the transporting capacity of wind, Free [4] has estimated from experiments by Udden [5] that the capacity of winds blowing over the Mississippi basin is probably at least a thousand times as great as the transporting capacity of the river. The wind, however, is usually loaded to only a small fraction of its capacity, so that the amount of material transported is very much less than its capacity. It is certain that the quantities actually moved by the wind are very large, and this movement contributes much to the change of soil surface conditions.

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[1] Tarr, Am. Naturalist, **24**, 456 (1890).
[2] Tolman, Jour. Geol., **17**, 142 (1909).
[3] Marsh, The Earth as modified by Human Action, Ed. 1888, p. 528.
[4] E. E. Free, Bureau of Soils Bull. No. 68, p. 46 (1911).
[5] Jour. Geol., **2**, 326 (1894).

EXCESSIVE TRANSLOCATION OF SOIL MATERIAL.

The methods of translocating soil material either by wind or water have played important parts in the geologic history of the earth. The complex relations between topography, climate and erosion, and transportation and sedimentation can not be discussed in a paper of this character, but these relations are clearly brought out in articles by Joseph Barrell.[1]

It is not with this movement of material in its natural condition that we are especially concerned, but with conditions in which man has for some purpose, either for agriculture, lumbering, mining, or power, interfered with the natural process, so that an excessive removal of soil material results. Since it is necessary to follow the vocations that disturb the balance established by nature between rainfall, slope, and erosion, methods of minimizing this disturbance as much as possible should be determined and employed.

CAUSES OF EROSION.

Erosion of land surface is produced by water flowing over its surface or by wind action. Wind erosion has been studied and described by Free and the general principles underlying soil erosion by water have been described by McGee,[2] so that only a short statement is here necessary. In the South it is of course the action of water that plays the more important part in soil translocation.

Water reaching the surface of the soil either sinks into the soil, evaporates, or runs off the surface. That portion which evaporates enters into the formation of clouds and is later returned to the earth; the portion that sinks into the ground increases the underground store of water, a part of it reaching the streams and wells by seepage and a part being returned through capillary action to the surface, where it may be utilized in the growth of plants, or may join the evaporated portion. This downward movement into the soil causes a slight movement of particles, resulting in the alteration of the mechanical composition of the soils and subsoils,[3] but this is small in comparison to the movement of soil material by the water which runs off the surface. It is this water which lifts and carries along soil material, cutting into the soil surface and leaving it bare and gullied.

The water running off the surface of the soil has been estimated in a number of cases. The Illinois experiment station [4] reports that 48.9 per cent of the rain falling in the Savannah River basin reaches the sea. Of the rain falling in the Potomac drainage basin it is esti-

[1] Jour. Geol., **16**, 159, 255 and 363 (1908).

[2] W J McGee, Soil Erosion, Bul. No. 71, Bu. of Soils, U. S. Dept. of Agr. (1911).

[3] Davis and Fletcher; Distribution of Silt and Clay Particles in Soils. 8th Internat. Cong. of App. Chem., **15**, 81 (1912).

[4] Ill. Expt. Sta. Circ. No. 119 (1908).

mated that 53 per cent reaches the sea. When the mean annual rainfall on mountain topography is 40 inches, the run-off approaches 30 inches; if the rainfall is 25 inches, the run-off is about 12 inches; and if there is 15 inches rainfall, the run-off is less than 5 inches.

All effort should be directed toward lessening the surface run-off and increasing the quantity of water soaking into the soil. If all the water falling on the surface of a given area were absorbed by the soil, there could be no erosion. It is the water flowing over the surface that must be controlled to prevent damage from excessive soil washing.

The amount of water which the ground absorbs depends upon the slope, the character or condition of the soil, the nature and amount of vegetal covering, and the amount and character of precipitation. Perhaps the slope has the greatest influence of any of these factors, but even this may be more than balanced by the character of soil, the precipitation, and the vegetation. As has been previously pointed out doubling the slope results per se in greatly increasing the erosion, but the increased velocity of water flowing down the slope makes the erosive power about 32 times greater.

The character of a soil greatly influences the amount of water absorbed by it. Soils vary in composition from light or sandy soils to heavy or clayey soils. The difference is in the size of particles composing them. The loams lie between the two extremes and represent varying mixtures of the coarser and finer particles of soil. While it is true that the actual pore space in a clay soil is much greater than that in a sandy one, the size of the individual spaces is much smaller in the case of the clay, so that the movement of water within the clay is slower than in the sandy soil. The sandy soils, therefore, absorb rainfall more readily than the heavier soils. The power of a soil to absorb water rapidly depends not so much upon the total amount of pore space as upon the size of the individual spaces. Of course, the absorptive capacity should be such that all of the interspaces are not filled by the rainfall at any particular time. The size of the interspaces may be increased in the heavier soils by the introduction or incorporation of organic matter. Upon moderately rolling land the following classification shows the relative capacity of the soils for absorbing an ordinary rainfall:

Class.	Composition.[1]	Amount of water absorbed.
Sands	Less than 20 per cent silt and clay; 25 to 50 per cent sand.	Nearly all.
Sandy loams	20 to 50 per cent silt and clay, 25 to 50 per cent sand.	Large part.
Loams, silts, and clay loams	50 per cent silt and clay, less than 30 per cent clay.	Very little absorbed.

[1] From values given by Whitney, Bul. 78, Bureau of Soils, U. S. Dept. Agr., p. 12.

This classification holds for only very limited conditions. It shows the relative absorptive power of the soils named, other conditions being the same.

The depth of the soil is the ultimate measure of the amount of water it is capable of absorbing. When the soil is saturated the additional water falling on it runs off over its surface, carrying away soil particles. A thin layer of soil, underlain at shallow depths by an impervious layer, becomes saturated quickly and erosion at the surface is most active. The depth of plowing in cultivated areas has much to do with the depth of the soil and the amount of water necessary to saturate it.

Vegetation affects the amount of water absorbed by the soil by retaining the water for a longer time on the surface, giving it a better opportunity to be absorbed. An additional effect is that the soil is kept more or less open by the roots penetrating it, and these roots form channels along which the water may be conducted to the subsoil. The vegetation further affords protection to the soil in that it retards the movement of the water flowing over the surface and prevents the removal of soil particles.

All these factors influencing the absorption of water by the soil are under the control of man, with the single exception of the precipitation. However, this factor is fairly constant as to quantity, although slightly less so as to character, for any given locality. If 2 or more inches of rain fall during 24 hours, much of it will be absorbed by the soil, but if the same amount of rain falls during 1 or 2 hours, only a small part will be absorbed. Since the movement of water within the soil meets with considerable frictional resistance, this movement is rather slow. If the water moves into the lower layers at a rate slower than that at which water is furnished to the surface, the upper layer of soil soon becomes saturated and the additional water runs off over the surface. Again, if precipitation occurs in the form of rain, it is much less likely to be totally absorbed than if in the form of snow. The melting snow supplies water to the soil so gradually that it has ample time to be totally absorbed.

In the Southern States probably the most important factor influencing absorption is the character of the precipitation. This is mainly in the form of rain and is quite heavy at times. This means that generally this factor is most unfavorable for the retention of water by the soil and to prevent its flowing off the other factors must be made as favorable as possible. In the mountainous regions of Virginia, North Carolina, South Carolina, and Tennessee vegetation exerts great influence. Where the forests have been cut off the steep hillsides rapid erosion has followed, and in some places the soil has been removed down to the underlying bare rock. Other

TREES IN GULLY, CHECKING EROSION AND TENDING TO NATURAL RECLAMATION.

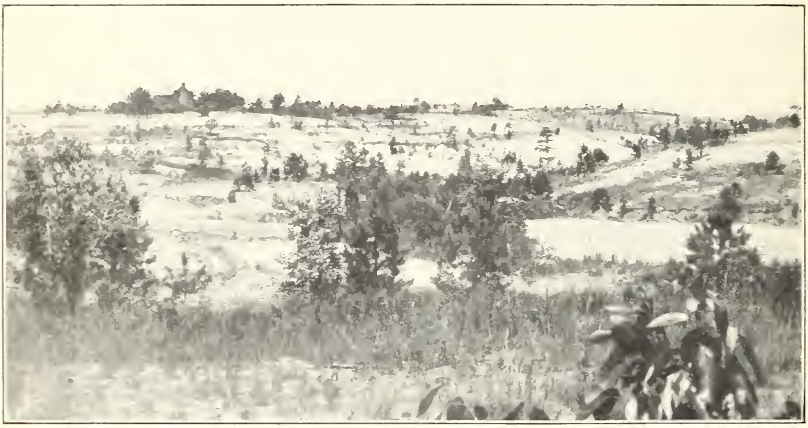
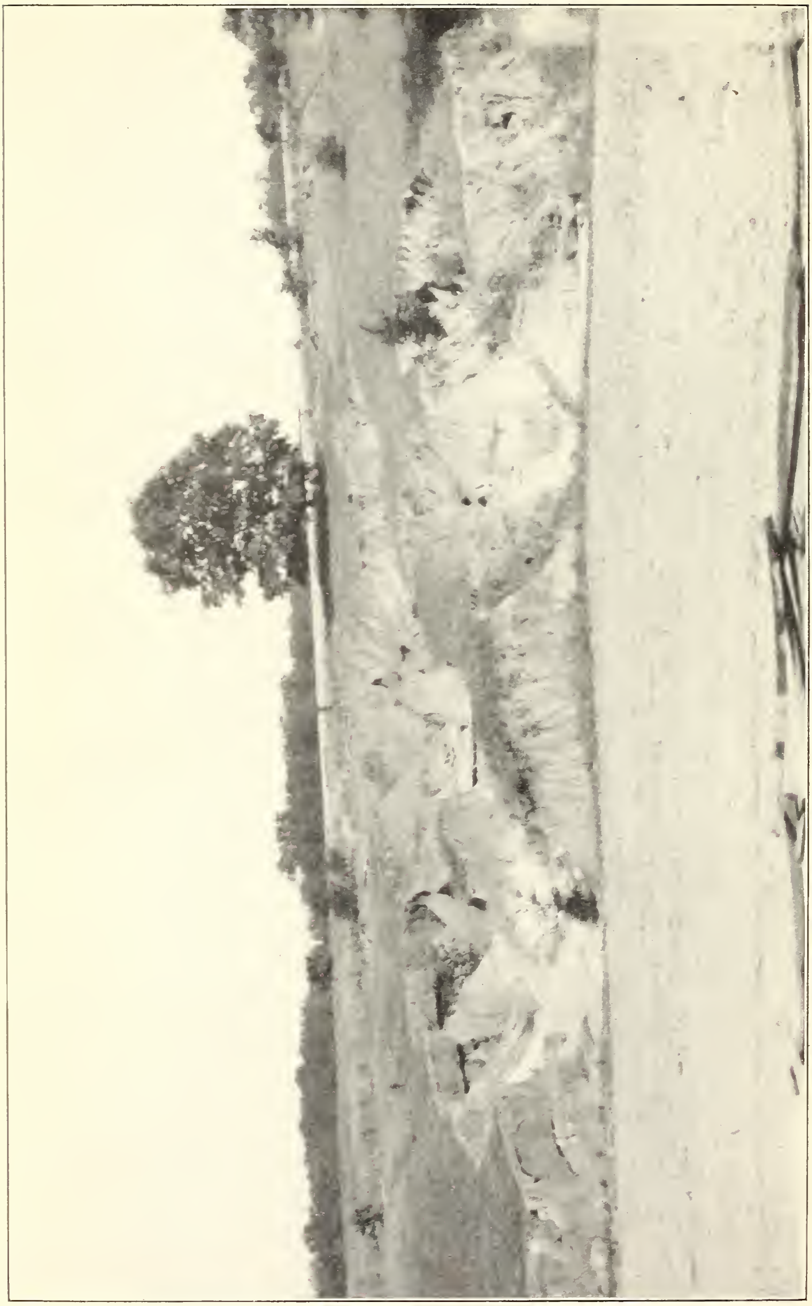


FIG. 1.—NATURAL RECLAMATION BY GROWTH OF SHRUBS AND PINES ON ERODED LAND.

FIG. 2.—NATURAL RECLAMATION BY VOLUNTEER GROWTH.

FIG. 1.—GULLY WITH SLOPING SIDES AND ROUNDED EDGES.

FIG. 2.—GULLY WITH VERTICAL SIDES AND CAVING BANKS.



SURFACE CLAY UNDERLAIN BY SANDY SUBSTRATUM.

localities, which will be described later, show the predominating influence of some other factor.

THE NATURE OF EROSION.

The erosion of the soil occurs mainly in two ways which are markedly different (1) as sheet erosion and (2) as the gully type of erosion. In sheet erosion the water falling on the surface of the soil carries off with it a small amount of soil material from every part of the field. In advanced stages there appear incipient gullies, parallel to each other, known as shoestring gullies. This type of erosion is not so destructive of the field on which it occurs as the gully type, for the removal is more uniform and, if a field is continually cultivated the physical evidence of erosion may be slight. A common result is the occurrence of a rounded knoll showing a difference in the character of the soil on the top and at the base, and often this difference extends to a difference in productiveness, the top of the knoll being less productive than the base. This type of erosion in advanced stages develops gullies with sloping sides and rounded edges. It is often spoken of as old-field erosion of parallel gully type.

The region in western Virginia extending to the Tennessee line commonly erodes in this manner. In some sections the soil wash is not serious enough to interfere with the cultivation of rather steep hillsides without contouring or terracing. However, on bare fields which remain out of cultivation for a few years, the gullies form and grow to considerable size. In eastern Tennessee the washing of the soil is somewhat greater, but here, even in the hills, terraces are hardly known. This same sort of erosion occurs in the Appalachian region of North Carolina and South Carolina and in northern Georgia and Alabama, but in the last-named States the formation of gullies is more rapid and the destruction greater.

The second type of erosion, or the gullying, develops where, owing to the occurrence of natural depressions, the water runs off in the form of streams. These cut into the soil and soon develop gulches of great depth with nearly vertical sides, which grow in length, breadth, and depth with every rain. This type of erosion is the most difficult to check, and renders the land on which it occurs practically valueless.

RESULTS OF EROSION.

Excessive erosion results in a change in the physical condition of the soil. As already pointed out, the bodily removal of soil particles takes place from the surface. There is a sorting of the soil particles, the larger and heavier being deposited first and the smallest last. The result is an impaired physical condition of the soil wherever this sorting action is taking place. Soils composed almost entirely of either sand or clay particles are not so good as those with a fair amount of each.

The quality of the soil is greatly impaired by the continual process of erosion. Rapid leaching takes place, removing a large part of the soluble salts; the surface soil is often washed down to the lowlands and sometimes out to the sea; gullying so defaces the land that it becomes difficult to cultivate. The organic matter is one of the first losses of eroded soils. Abandonment of the field follows, because the land is considered too poor for agricultural use, having lost its productiveness through the process of erosion.

The gullies in a field act as drainage ditches. The land between such gullies drains too rapidly, the water-table is lowered, and it is difficult for the crops to obtain sufficient water for proper growth or to withstand even a moderate period of drought. As these gullies occur on hillsides, the natural drainage is ample, if not excessive, so that the additional drainage furnished by the gullies is a positive disadvantage.

This removal of the best soil material and the impairment of that remaining results in the occurrence of much waste land. In the South the abandonment of land is traceable more often to erosion than to any other cause. In some of the States vast areas amounting occasionally to 50 per cent of the arable land of those sections have been abandoned to the ravages of water wash.

THE PREVENTION OF EROSION.

The necessity for the prevention of erosion is obvious. There is every indication that the public conscience is being quickened in this respect, and several States are beginning to appreciate the necessity of conserving their soil. The State of Tennessee is making a serious effort in this direction. The State geologist, with the aid of soil and forestry experts, is waging a campaign of education to teach the farmers how to prevent erosion and reclaim eroded lands. Some of these lands with proper care can be reclaimed for agricultural use, while others can be utilized for forestry. It is the function of the experts to determine the best use of eroded lands in various sections of the State.

A number of papers on the subject of erosion and its prevention[1] point out the damage from erosion and the general means of controlling it.

METHODS OF PREVENTION.

Methods employed for the prevention of erosion must embody either one or two principles: They must increase the capacity of the soil for absorbing water or must decrease the velocity of the running

[1] Farmers' Bul. No. 20, U. S. Dept. Agr.; Ill. Expt. Sta. Cir. No. 199; Soil Rept. No. 3, Ill. Expt. Sta.

water. The most effective methods make use of both principles. The porosity of the soil may be increased by the incorporation of organic matter and by breaking the soil to considerable depth. Deep plowing alone is not so beneficial as when used in conjuction with the incorporation of organic matter in the soil. The organic matter promotes a granulation of the soil particles and thus produces a soil with larger spaces between the soil granules. The rate of absorption is greatly increased and the storage capacity enlarged.

Tillage operations which move the soil to considerable depth tend to lessen erosion. They furnish a larger reservoir for the reception and retention of water. Preliminary experiments in this laboratory indicate that the dust mulch may have no advantage and is, possibly, a positive disadvantage. The fine particles of dust, when subjected to a sudden shower, are beaten into a thin layer of puddled soil on the surface which prevents rapid absorption and allows water to flow off the surface of the soil.

The methods that decrease the velocity of the running water are those in which impediments are placed in the path of the run-off. For every given velocity of running water there is a maximum amount of material that can be carried in suspension, and this amount increases with the velocity. If, then, flowing water carrying its maximum load has its velocity reduced it becomes overloaded and must deposit part of the load. If the velocity remains low the carrying power of the water is small. With the methods intended to check the velocity of the water belong the construction of various forms of terraces and the growth of vegetation or the placing of any impediments in the path of the water.

LAYING OFF TERRACES.

Terraces, no matter of what kind, should be laid off level or nearly so. The most common way is to use a leveling instrument and a rod with target attached. In laying off the terrace, the instrument is set on the highest part of the land and the bubble brought to the middle of its tube. The rod is placed by the level and the target moved to a height 3 feet above the line of sight. The rod should then be moved downhill until the target is in the line of sight. The bottom of the rod will then be 3 feet below the position of the level. Other points at the same level, 10 or 15 paces apart, should be located and through these points the terraces constructed. After the line of one terrace is located, the level may be set upon one of the points marked, proceeding as before. The terrace lines will then follow the contour of the hills. If slight depressions occur between two points, it is best not to change the terrace line, but to fill in the depression. Instead of using a level, good results may be obtained with an implement known as an A, which does not require any special skill in operating.[1]

KINDS OF TERRACES.

There are several kinds of terraces in use, such as the guide row, the level bench, and the Mangum terrace. The guide-row terrace is formed by throwing four furrows together along the contour line of a hill, the furrows following the line of the guide row. A row may be planted on top of the terrace to avoid the waste of any land. There is generally a drop of 3 feet between terrace rows. This type of terracing is used on rather open soil which will readily absorb the rainfall, and where the slope does not exceed 10 per cent.

The level-bench terrace is constructed on steeper lands and is so cultivated that the soil is moved from the higher to lower portions. In this way the terrace becomes practically level in a few years. By plowing with a hillside plow the furrows may all be thrown down hill. Quite often this type is developed from the guide-row terrace. Each bench must be cultivated separately and farm machinery or wagons must not be driven across the terraces, as this will result in their quick destruction by forming trenches which develop into gullies. Care should be exercised to prevent the growth of weeds along the terrace lines, though the presence of grass is often necessary to hold the soil. The cultivation may be done in furrows following the contour, or furrows may be run straight. This latter method results in some short rows, to which many farmers object. Probably the best method to prevent erosion is to follow the contour.

The Mangum terrace is one that has attracted considerable attention lately because of the fact that it eliminates the uncultivated lines between the terraces and cultivating or harvesting machinery may be driven across from one terrace to another. This terrace was first constructed and developed by Mr. P. H. Mangum, of Wake County,

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[1] Any frame in the shape of an A will do. The legs must have the same length and the crosspiece must be at equal distances from the ends of the legs. A plumb bob with string attached to the top of the A completes the apparatus.

The center of the crosspiece should be determined, as the A will be in a level position when the line of the plumb bob passes through the center of the crossbar.

In laying off a terrace, one leg of the A is held on a point and the other revolved about it until the plumb line crosses the point marking the center of the crossbar. This process is continued from point to point.

By constructing the A with certain dimensions, it may be used also for determining the grade or slope of a field or roadway. The sides are 16 feet long and the crossbar 13 feet 9 inches. A brace 16 feet long may be attached by a leather hinge. The ends of the A will then be 16 feet 8 inches apart when set up.

To use in determining grade, find the center of the crossbar and mark it zero. Then drive two pegs in the ground 16 feet 8 inches apart and on a level and set the A on them. The plumb line crosses at zero. Raise one end 2 inches and mark where the plumb line crosses the arm 1 per cent. Raise the same end 2 inches more and mark 2 per cent on the arm, and continue until the one leg has been raised several feet. Then repeat the operation on the other side. After the crossbar has been marked, if the A is placed on any slope, the plumb line will indicate the grade. The low side of the bar may be marked 2 inches, 4 inches, etc., corresponding to 1 per cent, 2 per cent, etc. A 3-foot fall between terraces may be obtained by moving one leg of the A downhill until the plumb bob reading is 36 inches. To obtain differences in elevation between two points, run over the line, keeping records of the plumb-line reading, all values going downhill in one column and uphill in another. Add the two columns and the difference between the sums will give the difference in elevation of the two points.

N. C. It differs from the others in that the terrace lines are not level, but contour the field at a grade of $1\frac{1}{2}$ inches to 14 feet. This terrace is a broad bank of earth with gently sloping sides. It is constructed along the lines laid off by back furrowing and pulling the soil to this line, thus forming a low dike. This terrace has been described in detail in a Government publication.[1] It gives a gradually sloping side both above and below its highest point, so that cultivation may be carried on across the ridge in any direction. While providing protection to the land it also eliminates the waste land and breeding places for insects afforded by the weeds or grass growing on the terrace ridges. For most agricultural lands it is the ideal terrace, but it may not be suitable for some soils of a light character.

OTHER METHODS OF PREVENTION.

In addition to the use of terraces to prevent washing of the soil it is generally advisable to plow deeply. By plowing deeply the soil is so loosened that the rate of absorption becomes much greater and the land is enabled to take care of a heavier sudden rainfall. The same thing is accomplished by incorporating organic matter in the soil or by use of tile drains. In fact, any method that will assist in the efficient drainage of a soil will also do much toward the prevention of excessive erosion. The interstitial spaces become larger in a well-drained soil, so that the movement of water through the soil is more rapid. Hence a heavy precipitation may be absorbed as rapidly as it falls.

Prevention of erosion is accomplished by having some vegetation cover the entire surface of the soil. This offers resistance to the water flowing over the surface and retains it long enough for the soil to absorb larger quantities than would be possible under clean culture. The expedient of alternating strips of cultivated soil with grass strips is sometimes resorted to, and on moderately rolling land this is fairly effective. Again, land that would be unsuitable to clean culture may be utilized for orchards with a cover crop on the soil.

The use of winter crops should find application especially in the Southern States. The winter precipitation, which constitutes a large part of the total, is largely in the form of rain, and in many cases it falls on land barren of any crop. The use of rye or some winter crop would be of great advantage in holding the soil and preventing the destructive erosion resulting from the winter rains.

The method of using hillsides for orchards and maintaining a grass cover crop has given rise to considerable discussion as to the relative value of the orchard with such a crop or with clean culture. As a means of preventing wash, the grass is effective, but the general

[1] Cir. No. 94, Bureau of Plant Industry, U. S. Dept. Agr.

question of the better orchard practice is still a mooted one. Such use for hilly lands is described by Smith [1] and by Seymour.[2]

CHECKING EROSION.

In places where erosion has begun, but has not advanced beyond the formation of small washes, it may be checked by filling these incipient gullies with brush, straw, or leaves. Contour plowing across such places is necessary under clean culture to prevent washing. Any field which is steep enough for the development of gullies should be terraced.

A method which has been used, so far as known, in only one locality is the construction of "christophers." (See fig. 1.) This consists of building across the mouth of the incipient gully a dam of earth or stone to hold back the surface run off and keep it on the field. The distinctive thing is the way in which the storm waters are disposed of. Passing through the dam is a sewer pipe connected with an upright pipe on the upper side of the dam. The water fills the valley until it reaches the height of the upright pipe, when it flows through this into the next field. The water left standing below the mouth of the upright pipe is removed gradually by a tile drain laid along the valley and connected to the sewer pipe. Rushing water is checked in the valley and deposits its burden of sediment; the water is removed largely by seepage into the tile drain and the ground remains in good condition for tillage.

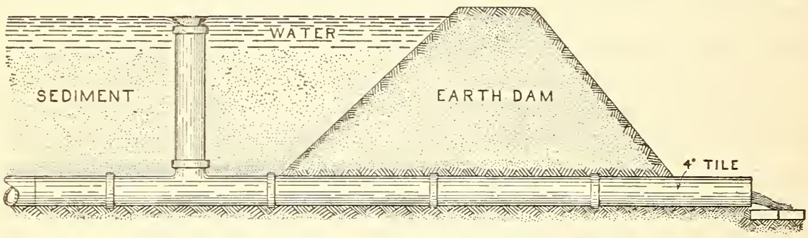


FIG. 1.—A "christopher" with tile drain connection.

This method is too expensive for ordinary use, but in cases where it is necessary to use tile drains and the soil washes badly, this is an excellent means of preventing the wash. This method was developed by Mr. John Adams, of Johnson County, Mo., and has been adopted by a number of farmers in that locality. Figure 1 shows the construction of the "christopher."

RECLAMATION OF ERODED LAND.

In the reclamation of eroded land it is necessary to make use of all the methods employed in prevention and to make every effort to stop the advance of the gullies into new lands, and even greater

[1] Smith, J. Russell, Plow and Poverty, Sat. Evening Post, 182, p. 14 (1909); Apples without Plowing, Country Gentleman 79, 778 (1914).

[2] Seymour, E. L. D., The Fruitful Land, Country Life in Amer., July, 1913.

efforts are required to bring the gullied land to a productive state. In fact, there are many places in which the latter object can not be accomplished economically if at all.

The land is generally reclaimed either for agriculture or for forestry, depending upon the character of the soil and the extent of erosion. For the purpose of forestry it is necessary to study the native vegetation and with the advice of a trained forester, to plant the kind of trees best suited to the climatic conditions of the particular locality. The trees must be generally deep rooted, on account of the lowering of the water table of gullied land, and the extremely rapid drainage afforded by the gullies. Shrubs and grasses may be utilized, and vines afford a protection on the nearly perpendicular face of a deep gully, or on steep slopes.

Most frequently land which is too badly eroded for agricultural use must be reforested in order to be reclaimed. The first effort is to stop the erosion. Trees should be planted thickly in the mouth of and as far up the gully as possible. These will afford an impediment to the water, and the soil material will be deposited. Thus there will be a gradual refilling, and the work should be pushed back toward the head of the gully as rapidly as the washing will permit. The relation of forests to rivers has been discussed by Ashe.[1]

It is generally best not to attempt the reclamation, for agricultural purposes, of land which is very badly eroded into gullies. With small washes, the growing of pasture grass, filling the wash with brush or litter and covering with soil is beneficial. In some cases the building of small masonry dams is necessary. If the land is put in cultivation it is wise to begin at once the construction of terraces, to incorporate a large amount of organic matter in the soil, to plow deeply, and, at the outset, to plant deep-rooted crops, such as rye. This produces a physical condition suitable for the ready absorption of water. Immediate results can hardly be expected, as it will take several years of good treatment and constant attention to bring the eroded soil into a state of productiveness.

In the rotation of crops practiced on land which is being or has just been reclaimed from erosion, it is well to include as often as possible crops of rye, grass, and clover, which may be used for pasture.

Two noteworthy examples of the reclamation of eroded lands were observed in the erosion districts of the South. In one case a tract comprising 38 acres, near Johnson City, Tenn., was purchased in 1911 for $53 an acre. At that time the land was badly eroded, and the owner described it as having then a gully 8 or 10 feet deep. The gully was filled with débris and soil, 200 loads of manure were applied, and the soil was plowed to a depth of 10 inches and planted to rye.

[1] Rept. of the U. S. Inland Waterways Com., 60 Cong., 2d session, S. Doc. 325 (1908).

The rye was being turned under at the time the place was visited, and the soil seemed to be in good physical condition. The owner kept an account of the cost of reclamation, and the total expenditure amounted to $376, or an average of about $10 an acre. An offer of $100 an acre had been refused. The deep plowing and the incorporation of large quantities of organic matter left the soil in such condition that practically all the water falling on the surface was absorbed.

Another example of similar character was encountered near Knoxville. A steep hillside of several acres, which had been badly eroded, was under cultivation by a truck grower. It had been reclaimed by starting terraces and cutting hillside ditches, and when this place was seen it supported an excellent crop of strawberries. The owner had not kept an account of expenses, but had bought the land at a very low price. His greatest trouble was in preventing further erosion. Reclamation at best is an expensive, though not a hopeless, process. It is infinitely better to use preventive measures in the first place.

NATURAL RECLAMATION.

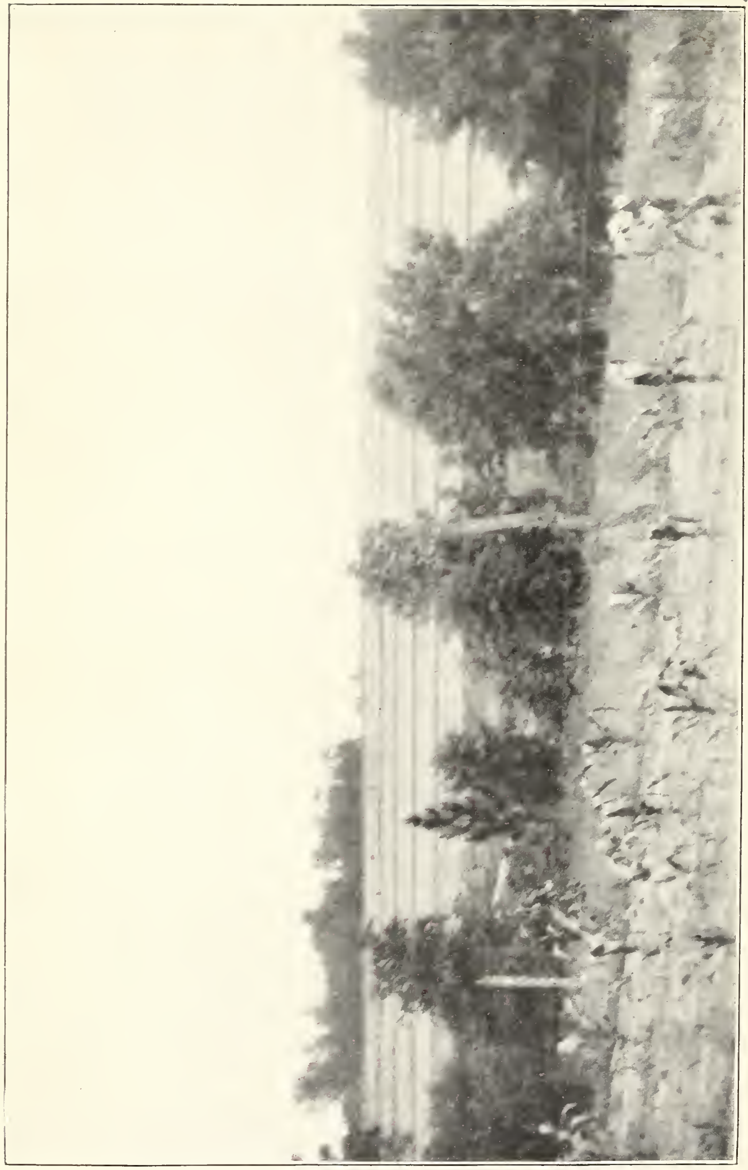
Nature attempts to check excessive soil waste by supplying a natural growth of vegetation to lands abandoned to soil erosion. Trees grow voluntarily in the ditches, and grasses and briers spread over the sides of gullies, retarding the extension of the gullies by erosion. The roots penetrating the soil give it more coherence and increase its resistence to water action. The leaves and other parts of the plants add to the organic matter in the soil, making it more absorptive of the precipitation. This vegetation constitutes an impediment to the water flowing over the surface. The velocity is checked and a part of the burden of soil material is deposited. In this way there is a slow building up of ditch bottoms and a tendency to flatten out the land surface. The natural reclamation begins at the mouth of the gully and extends back to the steep areas. It is not uncommon to find immense gullies with this process taking place, often with large trees growing in them. This is illustrated in Plate I, figure 1.

Nature, however, does not wait for large gullies to form before making an effort to check the erosion. A field abandoned before such devastation has resulted is soon covered with a growth of native brush and trees, which begin at once to prevent the rapid wash of the soil and to reclaim those gullies already begun. In Plate II, figures 1 and 2, abandoned areas, in which a natural growth of pines, shrubs, and grasses has started, are shown.

This natural growth often furnishes a suggestion as to the best method of reclamation by reforestation. From the character of the natural growth the kind of trees and shrubs best suited to the soil may be determined, and soils offering no hope of reclamation for agriculture may be used for forestry. One section of the State of Ten-

FIG. 1.—GRADUAL PRODUCTION OF A VALLEY FROM SMALL EROSION GULLY.

FIG. 2.—CAVING GULLY IN SOIL OF SANDY CHARACTER.



A TERRACED FIELD.

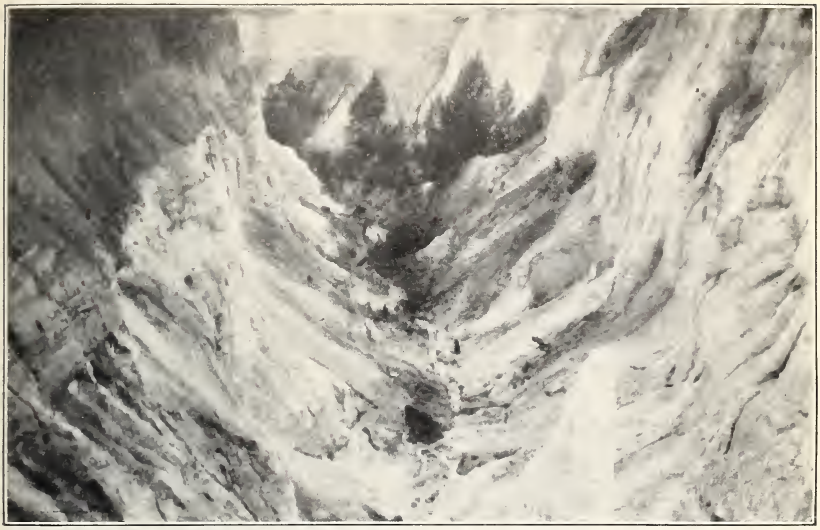
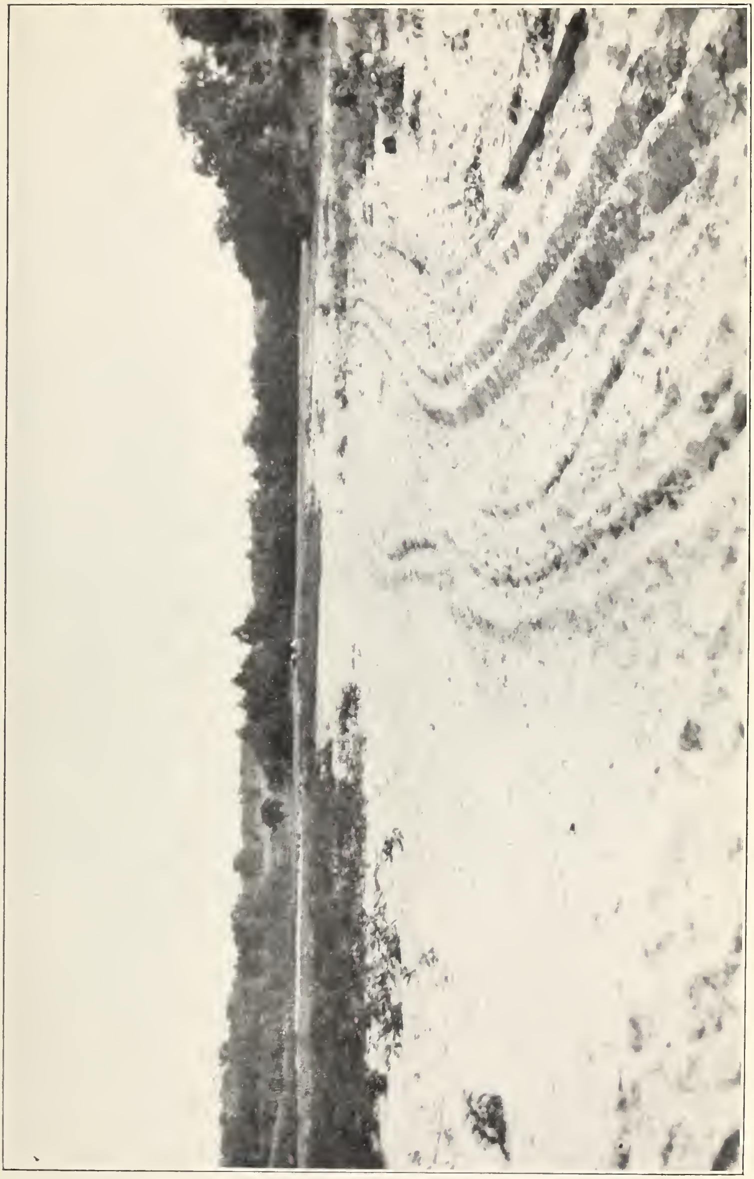


FIG. 1.—GULCH PRODUCED BY CAVING GULLY.

FIG. 2.—HEAD OF GULCH PRODUCED BY CAVING GULLY.

PLATE VIII.

DEVASTATION WROUGHT THROUGH EROSION.



FIELD COVERED WITH SAND FROM ERODING HILLS.

nessee presents such a problem, and the State is endeavoring to solve it by a study of the soil possibilities. The State geologist, working with a trained forester and soil expert, is preparing to reforest a large extent of country that has been injured through erosion.

The natural reclamation of flood plains covered with sand follows the prevention of wash from the hillsides. With the velocity of the water from the hills checked, only the finer material will be carried in suspension to the flood plain. By the continual deposition of silty material over the sand during times of flood, a soil which is well adapted to agriculture will gradually be built up. However, of all lands injured by erosion, it is probably hardest to develop a productive soil over those areas that have been covered to some depth with sand.

ERODED SECTIONS IN THE SOUTH.

Throughout the South erosion is probably worse than in other sections of the country. In the Atlantic Coast States the worst type is encountered in the Piedmont section. It is less marked in the mountains, probably because agriculture is less extensively practiced. Erosion is very marked in some of the States of the Mississippi Valley, some of the worst eroded sections of the country occurring in the hills of these States. It is probable that the climate has much to do with the fact that erosion is so rapid in the South. The character of the soil makes a marked difference in the rates of erosion under the same climatic conditions.

The heavy clay soils erode fairly rapidly, but passing from this heavy clay soil to soils of lighter character, containing a larger percentage of sand, the erosion changes in character from the surface or shoestring type, developing gullies with rounded edges, to gullies with caving sides. These two forms of erosion are illustrated in Plate III, figures 1 and 2. Any marked difference in the character of the soil and subsoil has a great influence on the erosion, which is apparently most rapid in silty soils or in soils having a thin layer of clay at the surface and a substratum of sand or sandy soil, as shown in Plate IV.

The region in the South subject to erosion comprises sections of a number of different soil provinces, the Piedmont Plateau, the Appalachian Mountain and Plateau,[1] the Atlantic and Gulf Coastal Plain, and the Glacial and Loessial regions, the greater part falling within the two first-named provinces. The Piedmont and Appalachian regions differ more in elevation than in character of soil. The Piedmont region extends along the eastern foot of the Appalachian Mountains through Virginia, central North Carolina, western South

[1] Erosion in the Southern Appalachian Region has been discussed by Glenn, with special reference to the effect on stream flow. U. S. Geol. Sur. Paper No. 72.

Carolina, northern Georgia, and central Alabama. It is in this Piedmont Plateau that the greatest difficulty is experienced in dealing with soil erosion.

GEOLOGY OF APPALACHIAN AND PIEDMONT REGIONS.

The soils are mainly residual, i. e., derived from the underlying consolidated rocks. The rocks are of three classes: Old igneous, as diorite, diabase, and granite; old metamorphic igneous and sedimentary, or gneiss, schist, phyllite, and slate; or young sedimentary, as Triassic sandstone, conglomerates, and shales.

SOILS.

Since the soils of these provinces are mainly residual, they are comparatively uniform. The subsoils are nearly always heavy clay, and the surface soils are often lighter in texture. Sandy loams, clay loams, and clays occupy by far the greater part of the province.

Where the subsoil is heavy clay, erosion is not so rapid as in the soils with lighter subsoils. This is noticeable in portions of western Virginia, western North Carolina, and eastern Tennessee, in the Appalachian Mountain province. The erosion begins in little depressions which gradually deepen, forming gullies with sloping banks and rounded edges, as shown in Plate V, figure 1. This is entirely a surface erosion and easily controlled if properly handled. In the mountainous regions terracing is not generally practiced, although without a doubt such a system would prove beneficial.

The Piedmont province of these States and of South Carolina, Georgia, and Alabama suffers more from erosion than the regions of higher altitudes. Especially is this true near the "Fall Line." And in this province also the subsoil is often sandy and less tenacious, so that when a gully forms the sides cave in. The erosion then often proceeds by the caving in of the walls at the head of the gully, so that, in advanced cases, there are formed extensive gulches with almost perpendicular sides. This form of erosion is illustrated in Plate V, figure 2.

The most important soils throughout the Piedmont country belong to the Cecil series, the Louisa soils probably ranking next in importance. These soils are mainly red and gray and have clay subsoils. The main differences in the series are that the Louisa soils are less productive and have more micaceous subsoils than the Cecil. This micaceous character increases their susceptibility to erosion.

The erosion in the Piedmont province is apparently more pronounced in the more southerly States. This is probably due largely to the climatic conditions. During the winter the temperature is not low enough to cause deep freezing, and cold periods are of short duration. The formation of ice crystals at the surface of the soil raises a thin layer, and when the ice melts there remains an inch or more of very loose, incoherent soil. These freezes and thaws are often followed by heavy rains which sweep away this loose surface layer. This process occurs repeatedly during the winter, and as a result large quantities of surface soil are removed. This soil is not protected from the action of winter rains like the soils of more northerly climates, where the soil is frozen during practically the entire winter, so that the rain can not remove the soil mantle. In addition, the precipitation in more northerly regions is largely in the form of snow, which melts gradually in the spring and is absorbed by the soil, instead of running off over the surface.

Terracing is practiced in the southern Piedmont region, and the destruction of the soil is thus greatly reduced. Since the precipitation is mainly in the form of rain, the soil must be made to absorb as much as possible. This can be done only by employing terraces and the other methods already described. Plate VI shows a well-terraced field in Piedmont Georgia.

One of the peculiar soil conditions encountered in many sections and most conducive to destructive erosion is a surface layer of heavy soil material, varying from 6 inches to several feet in thickness, underlain by sandy material. Erosion on this type of soil produces enormous gulches, 10 to 50 feet deep and several hundred feet wide, sometimes extending for 1 or 2 miles. They begin in the hills adjoining the lowlands, and by constant undercutting and caving push well back into the hills. They are very difficult to stop and often work their way across roadways, farms, forests, and even building sites. It is problematical whether the progress of these gulches can be entirely checked in any profitable way. However, it may be greatly retarded by continually dumping débris, brush, or other material into the gully, by planting wild honeysuckle around the head and sides and young pines or other trees in the mouth. Much soil material will thus be retained and in time the eroded area may be reclaimed. This type of gully is shown in Plate VII, figures 1 and 2. Sandy phases of the Orangeburg and Cecil soils suffer from this type of erosion most frequently.

Similar erosion is encountered in western Tennessee and northern Mississippi, but in a different type of soil. Here the most destructive erosion occurs in areas of silty soils. While the destruction is as great and the devastation possibly more complete, the hope of reclamation is not so remote. For one thing, the depth of the gullies does not generally exceed 15 feet, because more resistant material is encountered at about this depth. The sides are slightly less abrupt and there is a better opportunity for the growth of wild plants or even the gradual reclamation by reforestation.

Some of the lands have been stripped of their natural growth of timber by rapid erosion. Frequently a surface layer of heavy soil, less than a foot thick, covers a subsoil of much lighter material, in some places sandy, extending to a considerable depth. Where such areas are forested erosion is slow, but with the removal of the forest growth the erosion is very rapid. Any rut or path breaking through the upper layer of heavy soil soon develops into devastating erosion. In some places, owing to this condition, any attempt to cultivate the soil should never be made. With plowing and clean cultivation it is practically impossible to prevent erosion. In a few counties a rough estimate places the eroded and abandoned areas at 25 to 33 per cent of the total.

The great danger of losing large areas of valuable land is appreciated in Tennessee, and under the direction of the State geologist the best methods of preventing erosion and reclaiming eroded land are being studied. Plate VIII illustrates the seriousness of the situation in some parts of the State. The main problem is to arouse the farmers to a realization of the importance of treating their soil in the manner best suited to its condition. Soils that can not be cultivated without danger of erosion should be used for the production of hay, for pasture, or for forestry, either of which may pay better under the circumstances than the crops obtained from clean cultivation.

In extreme western Tennessee and Mississippi the deep silty soils erode in a slightly different way. The soils of nearly uniform composition to a great depth are compact and the pore spaces are comparatively large, so that in their natural condition they absorb much of the water falling on the surface. The surface soils and subsoils having the same composition, the sides of cuts are vertical, with very little tendency toward caving, such as occurs where the subsoil becomes saturated and is washed out, leaving the surface layer without support. The attrition of the surface, producing a loose layer, furnishes the most favorable condition for the ready removal of the soil by water, the loose soil being readily carried away with the surface run-off. This condition is most noticeable in old roadways which have been lowered by erosion sometimes 15 to 20 feet, and the vertical walls along the sides show little effect from later rains. The control of this type of erosion by terracing is a simple matter. Any sort of growth completely covering the ground will prevent the excessive removal of soil material.

DAMAGE TO FLOOD PLAINS.

In clearing slopes hillside erosion is often so increased that the streams carry a much larger burden of material than usual. The excess material is deposited in the lower courses of the streams, causing a filling or shifting of the channel. One result is that in times of heavy run-off the stream channel is not sufficient to carry the increased volume of water and overflows result. The flood plain is either covered with a layer of sand or is scoured into ditches and smaller channels, impairing the agricultural value of the land.

In some of the districts of the South the gullies, which are ordinarily dry, become filled with rapidly flowing water. This temporary stream carries a heavy burden of soil material, much of which is sand, as the soil conducive to the formation of these gullies is generally sandy. The velocity of the water is first checked in the valley and the sand is largely deposited. A formerly productive field covered in this way with a layer of sand 6 inches to 2 feet in thickness is shown in Plate IX.

AGRICULTURAL PROBLEMS.

As previously pointed out, the greatest damage from erosion generally occurs where the original growth has been removed and the land in being used for crop production. This most frequently means clean culture. The agricultural conditions in the South are especially favorable for erosion, as the main crop is cotton, which requires entire freedom from grasses and weeds. The rotations practiced may include some other clean cultivated crop, as corn, but in a great many cases cotton is the only crop grown.

The labor problem and other economic conditions have much to do with this system of farming. Ordinarily the small farmer and the tenant can obtain credit only by growing crops that can not be easily disposed of without the creditor's knowledge. The crop that meets all conditions best is cotton. Hence it oftens happens that the same land is cropped year after year to cotton, until the soil becomes so unproductive that its cultivation is not profitable, when it is allowed to "lie out," and becomes infested with weeds. It is then that erosion is most destructive. The soil is exhausted of organic matter, and even before the weeds begin to grow the rains form gullies over the surface. Probably the field will not be put under cultivation again, and in a few years it becomes devastated, without agricultural value, and a menace to the surrounding land.

The question of erosion must be considered in adopting crop rotations. In addition to the use of terrace and hillside ditches for checking the soil wash, it must be remembered that the incorporation of large quantities of organic matter produces an open, porous soil, capable of absorbing water, and that deep plowing furnishes a subsoil reservoir for the storage of surplus water. It is not always possible to practice these methods with certain crops, so that the tendency to erosion and the effects of certain practices must be considered before a given crop is included in the rotation. The Georgia experiment station,[1] for example, has conducted experiments which indicate that plowing below 8 inches lessens the yield of cotton. It is also known that the quality of tobacco is injured by legume

[1] Ga. Agr. Expt. Sta., Bul. 63, p. 124.

humus, although rye has no bad effect. If corn or other exhaustive crop precedes tobacco, the legume humus does not injure the tobacco. The presence of large quantities of humus in a soil tends to produce weedy cotton and to retard its maturity. It is thus apparent that the rotation worked out and the means employed in reducing erosion must be adapted to the crops desired and the soils on which they are to be grown.

The loss in productiveness alone should make it worth while to prevent erosion, not to mention the rapid depreciation of the money value of eroding lands. The amount of material removed from hilly land by erosion is enormous. The amount of solid material carried to the sea by the Potomac River is estimated [1] at 400 pounds per annum to every acre drained by it. The James River, with a flood of 10-foot crest, is said to remove an average of 275,000 to 300,000 cubic yards of solid material within each 24 hours, and to remove annually 3,000,000 or 4,000,000 cubic yards from the region above Richmond, in Virginia.[2] The loss from erosion on moderate slopes in the Piedmont region of North Carolina is said to amount to about $3 an acre yearly in decrease in crop value alone, making the total annual loss in this region over $2,000,000.[3] Since there are many hilly farms on which excessive erosion is effectually prevented, the eroded areas must far exceed this estimate in actual loss.

ECONOMIC LOSSES.

The losses resulting in depreciation of the land from erosion are only part of the total losses occurring from this cause. Large amounts are annually expended in removing from stream channels and storage reservoirs sediment brought down by rivers. In many places the sediment collects so rapidly that it has been found practically impossible to maintain the reservoirs, and the method of simply keeping a channel open has been adopted. This, of course, entails great losses in water power and in navigation. Many river bottoms fill so rapidly that it requires continual dredging to maintain channels for purposes of navigation. In the rivers of the Southern States the sediment carried is one of the great difficulties in developing power sites. Because of the peculiar soil conditions and the fact that practically all of the precipitation in both the valleys and the headwaters of the streams is in the form of rain, the rivers carry a great burden of sediment. In testimony before the Agricultural Committee of the House of Representatives in 1908, W. S. Lee stated that the capacity of the reservoirs of the Southern Power Co. on the Catawba and Broad Rivers in South Carolina was so reduced that in a few years only the flow of the rivers would be available.

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[1] U. S. Geol. Sur. Bul. 192.

[2] Rept. Chief of Engineers, U. S. Army, 1885, pt. 2, p. 847.

[3] Bul. 17, N. C. Geol. Sur.

In navigable streams the deposition of this sediment in the stream bed causes a filling or shifting of the channel and the formation of bars. The Roanoke River is reported to carry 3,000,000 tons annually, the Alabama 3,039,900 tons, the Savannah 1,000,000 tons, and the Tennessee 11,000,000 tons, while other rivers carry like amounts.[1] This indicates the extent of the loss of soil material, together with the additional losses just described.

The economic aspect of soil erosion has been discussed by a number of authorities,[2] who agree that the United States is losing millions of dollars each year from this cause. The report of the National Conservation Congress, 1909,[3] states that in the United States there are 6,076 square miles of farm land, or 3,888,640 acres, devastated by soil erosion an area which is equal to 100,000 farms of nearly 40 acres.

SUMMARY.

Soil erosion is a natural process, tending to level the land. Generally under natural conditions it is slower than the formation of soil material from the parent rocks.

Destruction of the natural growth and clean cultivation on hilly land, without protection against erosion, results in the removal of the soil material by water more rapidly than it is formed and in a very irregular manner.

Owing to the climatic and soil conditions the South is especially susceptible to excessive erosion. The economic conditions and type of agriculture of this section also contribute to the excessive erosion.

Methods of prevention should be practiced wherever hilly land is used for crops. Terracing is the best and most efficacious method, but should be supplemented by deep plowing and the incorporation of organic matter when permissible.

The agricultural problem involves the adoption of proper crop rotation in connection with preventative methods best suited to soil conditions and crop production.

The reclamation of eroded land is possible, but requires careful attention and patience. The use of such land for forestry is commonly advisable. Nature effects reclamation, but the process is slow and tedious.

The losses annually to agriculture and in expenses incurred at power sites and in maintaining navigable channels are enormous, and constitute one of our greatest national wastes.

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[1] Amer. Rev of Rev., 89, 439 (1909).

[2] See: N. S. Shaler, Economic Aspect of Soil Erosion, Nat. Geog. Mag., 7, 328–38 (1896); T. C. Chamberlain, Soil Wastage, Proc. of Conf. of Governors on Conservation, House Doc. 128, pp. 75–83 (1908); Pop. Sci. Mo., 73, 5–72 (1908); W. W. Ashe, Waste from Soil Erosion in the South, Amer. Rev. of Rev., 39, 439–43 (1909).

[3] Report Nat. Con. Cong., S. Doc., No. 676, 60th Cong., 2d sess. (1909).

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