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JOSEPH HYDE PRATT, STATE GEOLOGIST

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TERRACING OF FARM LANDS

BY

W. W. ASHE

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LETTER OF TRANSMITTAL

CHAPEL HILL, N. C., March 1, 1908.

To His Excellency, HON. ROBERT B. GLENN,

Governor of North Carolina.

Sir.—The report by Mr. W. W. Ashe, Forester, on Terracing of Farm Lands, which I have the honor to submit for publication as Bulletin No. 17 of the North Carolina Geological and Economic Survey series, should be of especial interest at this time when so much attention and thought are being given to the subject of the conservation of our natural resources.

Yours respectfully,

JOSEPH HYDE PRATT,

State Geologist.

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PREFACE

The subject of terracing of farm lands is one that should be more seriously considered by the farmers of North Carolina, especially those in the Piedmont section of the State where the farm lands are more subject to erosion. This is one of the methods that can be satisfactorily employed in conserving the soil and, for certain areas, no better or cheaper means can be devised. Where attempts have been made to use this method and they have not resulted as favorably as expected, it has usually been that sufficient care and attention were not given to the location and construction of the terrace. They have been either too steep, too far apart, or had too much grade on their upper sides.

These points in connection with terracing are discussed in detail in Mr. Ashe's report and it is hoped that this short report at this time will be the means of creating a more general use of terracing in the Piedmont section.

JOSEPH HYDE PRATT,
State Geologist.

INTRODUCTION

By Joseph Hyde Pratt.

The subject of soil conservation is one of considerable importance to the people of North Carolina, especially in the Piedmont section where the soils are composed of heavy red clays, yellow sand clays and mica red clays which are low in humus. As a general introduction to the subject of the conservation of these soils by terracing, it may be well to give a general outline of the physiography and geology of the State with special reference to the Piedmont plateau section.

As one travels across the State of North Carolina, from its eastern shores to its western boundary, it will be noticed that when about half the distance has been passed, there is left behind a region which is very level or gently undulating, the surface of which is covered with sand and loam soils, from which hard rocks are almost entirely absent; and there is entered another region, the surface of which becomes more and more hilly until it culminates in the high mountains in the western portion of the State, and that the soil is mingled more or less with hard, granitic, slaty rocks. It will also be noticed that the geological formations of the eastern half of the State are radically different from those of the central portions of the State, which are in turn different from the mountain regions.

These are the three great physiographic divisions in the State which have been designated as the coastal plain, Piedmont plateau and mountain regions respectively, whose boundaries in a general way are rather sharply defined. The ages of the rock formations, instead of being contiguous, are widely separated; that covering the coastal plain being some of the most recent formations while those of the Piedmont plateau are amongst the oldest, with the exception of the limited red sandstones of the Triassic areas.

These three physiographic divisions are indicated in a general way on the map (Pl. I), together with the minor geologic rock formations of the Piedmont plateau and mountain regions. In the coastal plain region the formations have to be shown practically as a unit for the reason that the rock formations lie one above the other so that, although there are at least five successive geological periods, only the uppermost is exposed except here and there in isolated places, and along the banks of such

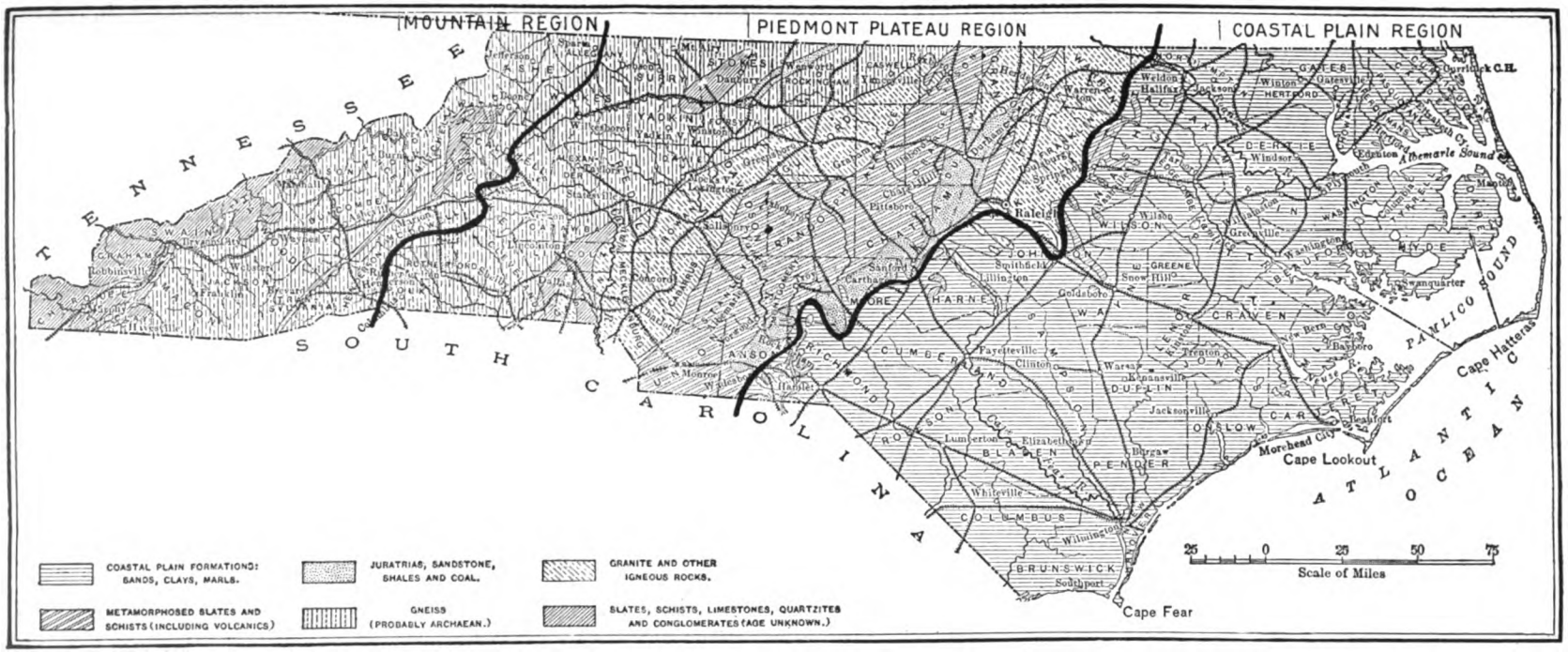
rivers as the Cape Fear and Roanoke, where these have cut down and left high steep bluffs, exposing a number of geologic formations.

Coastal Plain Region.—This region represents the most recent geologic formations composed of gravels, sands, clays and marls arranged in nearly horizontal layers with the finer material nearer the coast. Along its eastern borders this region contains the sounds and bays, the sand dunes and ridges, the swamps and marshes, and other characteristics of a seashore region. Further inland it is gently undulating and has more of the upland and less of the marsh and towards its western boundary the swamps disappear almost entirely, the upland predominates and the surface becomes more undulating and even hilly in places. The soils toward the east are composed of fine sand and silt, while nearer the western border of the region they contain a larger proportion of coarse sand or gravel mingled with clay. The extent of this region is from Raleigh eastward to the coast, with its western boundaries roughly defined as extending from the western part of Northampton through Franklin, Wake, Cumberland, Chatham, Moore, Montgomery and Anson counties.

Along the western border of the coastal plain region there are occasional outcrops of hard granites and slates exposed along the beds of streams, where the once overlying sands and clays have been washed away. In the southeastern counties of this region limestone is exposed at the surface along the banks of streams in a large number of localities.

With the exception of the extreme western portion of the coastal plain region, the subject of soil preservation is not a serious question on account of the character of the soil and the flatness of the land. The western portion, however, has some problems to consider similar to the adjoining Piedmont region, as the land has become more hilly and the soils contain a greater proportion of clay.

Piedmont Plateau Region.—The Piedmont plateau region, extending westward from the coastal plain region to the mountain region, is about 125 miles in width and has an average elevation approximating 900 feet. Crossing this Piedmont plateau obliquely are a series of geologic formations which are in general parallel to the mountains and seashore. The most eastern of these formations is a narrow belt of Triassic sandstone and shales which has a maximum width of about 15 miles, and extends from Oxford in Granville County across the State through portions of Wake, Durham, Chatham, Moore, Montgomery, Richmond and Anson counties. On the northeast of this sandstone and between it and the coastal plain region there are considerable areas of granite extending across portions of Wake, Franklin, Warren, Vance and Granville counties. To the west there is an older formation of metamorphosed slates and



SKETCH MAP OF NORTH CAROLINA, SHOWING THE THREE PHYSIOGRAPHIC DIVISIONS AND THE DISTRIBUTION OF THE PRINCIPAL GEOLOGIC FORMATIONS.

schists which cross through Person, Orange, Randolph, Montgomery, Stanly, and Union counties and has a general width of from 20 to 40 miles. Just west of this there is an area of granites, between which and the mountain region are gneisses, probably Archean. Near the western boundary of the Piedmont plateau region is the second of the two sandstone belts which is much more limited in area than the one to the east and extends from the Virginia line across portions of Rockingham and Stokes counties, having a maximum width of from 4 to 5 miles.

It is this region that the question of preservation or conservation of soil is of vital importance to the agricultural interests of the State and the descriptions given in the following pages regarding terracing apply largely to this Piedmont region, although they can be adapted to the coastal plain and the mountain regions.

Mountain Region.—The mountain region includes the Blue Ridge, Great Smokies, and the country between, which is cut across by the numerous cross ranges separated by narrow valleys and deep gorges. The average elevation of this region is about 2700 feet above the sea level, but the summits of many ridges and peaks are over 5000 feet. A considerable number of peaks reach a height of over 6000 feet, the highest of which is Mount Mitchell with an elevation of 6711 feet. Over the larger part of this region are to be found the older crystalline rocks, gneisses and granites, probably Archean, which are greatly folded and turned on their edges. On the western and eastern borders of this mountain region approximately along the line of the Blue Ridge and Great Smokies there are two narrow belts of younger rocks consisting of limestones, shales, and conglomerates and the metamorphosed marbles, quartzites and slates.

In this region, as in the Piedmont plateau, the rocks are decayed to a considerable extent and thus have produced deep soils which vary in character according to the rocks from which they have been derived. The soils are for the most part porous and fertile, affording a luxuriant vegetation, in many places the slopes of the mountains being covered by heavy virgin forests. Where the rocks that have decomposed contained a large percentage of aluminous minerals, a large amount of clay has been formed and such clay soils characterize a large portion of both the Piedmont and mountain regions. It is these soils that are very liable to erosion.

DEFORESTED AND TERRACED MOUNTAINS IN THE PROVINCE OF SHAN-SI, NEAR THE CITY OF WU-T'AI-HIEN, NORTH CHINA. SOIL EROSION AND SOIL PRESERVATION IS BY NO MEANS A PROBLEM LOCAL TO THE SOUTHERN STATES. IT IS COMMON TO ALL COUNTRIES WITH HEAVY INTERMITTENT RAINFALLS, HILLY LANDS AND CLOSE SOILS. IN CHINA THE PRESERVATION OF THE SOIL ON HILLS AND MOUNTAIN SLOPES HAS BEEN EFFECTED ONLY BY TERRACING. SLOPES NOT SO PROTECTED HAVE BEEN DESTROYED BY LESS THAN THREE CENTURIES OF CONTINUOUS TILLAGE. HOW WILL OUR SLOPES LOOK AFTER 300 YEARS OF CORN AND COTTON CULTURE? COURTESY OF MR. BAILEY WILLIS.

TERRACING OF FARM LANDS.

By W. W. Ashe.

VALUE OF THE SOILS OF THE PIEDMONT REGION.

The soils of North Carolina constitute one of its chief natural assets. Like the forests and the water power of the streams, they are natural resources, which, when destroyed through short-sightedness or ignorance, can be replaced only at enormous cost, and frequently not at all. For this reason their preservation and utilization is of the utmost importance and is essential to the development of the resources of the State, to their maximum earning capacity. The conservation, therefore of such resources for the welfare of the people of the commonwealth represents an obligation which neither the State nor the individual should neglect.

Notwithstanding the rapid growth of cotton manufacturing and woodworking establishments, agriculture still employs more persons than all other industries. The value of its products in 1905 was $110,000,000 compared with $142,000,000 for the products of all other employments; and there is every indication that hereafter the rate of increase in the value of farm products will be no less than at present.

In the Piedmont section, where an exceptionally good local market is being developed, this rate will undoubtedly increase, just as it has done in the larger manufacturing states, through the opportunities offered by diversified farming. The values of the farming lands of the Piedmont region are at present low, and their future appreciation will be proportional to their earning capacity.

The rolling uplands of this region constitute the greatest portion of its cultivated area. The alluvials, which form the bottoms along the streams, are of comparatively limited extent, but they are, where in good condition, far more productive than the upland soils. This is due partly to their origin. The alluvials have been built up by the fertile sediments which came from the hills before the timber was cut and the land cleared. Their enrichment comes then, in part at least, from the deposit of the most fertile material which was washed by heavy rains from the slopes. The same process of erosion of the uplands continues to-day but with a hundredfold more activity than existed before the forests were cut. When the hills were forested this washing or erosion from the slopes was slight, being hindered by the leaf mould, which had accumulated and covered

the soil. In the change from "new ground" to "old field" the leaf mould has been exhausted, and the eroding power of the heavy rains has increased at an accelerated rate. Now, a large portion of the soil from the cultivated slopes is yearly borne away in the muddy streams. The material thus eroded leaves many slopes deeply gullied, and impoverishes all. It no longer accumulates for the enrichment of the valleys; for the most valuable portion, the silt and finely divided organic matter, is swept past the bottoms by the streams, or it may occasionally settle in eddies as great mud banks. The coarser sand and gravel is deposited over the alluvials, injuring instead of enriching them, as was the case when only the fine black soil was deposited. Thus erosion of the cultivated slopes destroys both slope and alluvial bottom, and what was under purely natural conditions a constructive process, has under the influence of man become a menace. The retaining of this fertile soil on the slopes where it is so badly needed, will increase their productivity; lessen the deposit of sand and silt on the bottoms; and add to their earning power and value. Any system of management which will conserve the slopes will augment the earning power and increase the value of both hillside and valley.

EXTENT OF SOIL EROSION.

The erosion of soil from hillside farms probably assumes in middle North Carolina greater importance than elsewhere in the United States. It is very active in portions of several of the other Southern States, especially on the red clays of Northern Georgia and on the upland silts of Mississippi and Tennessee. It demands greater consideration in Piedmont, North Carolina, however, on account of the comparatively small area of level land, necessitating extensive hillside tillage (see Pl. I). A very large proportion of the farming lands are situated on slopes, many of them on steep slopes, from which erosion or soil transportation is continuous. Erosion thus becomes a problem that has to be considered on some portion of nearly every farm, while the difficulties of successfully preventing or lessening it are augmented by the prevailing steepness of the slopes. So general is it and so damaging in its effects that it is probably the most serious drawback to profitable farming on the "red clays." It is difficult to determine the extent of loss occasioned by it, but on land of moderate slope, it certainly amounts to several dollars an acre[1]; the loss rapidly increasing as the slopes become steeper, the erosion more rapid and more difficult to prevent, and the earning power of the land reduced in consequence. This loss does not include the cost of maintaining dikes,

[1] On land cultivated by the writer the yield, with cotton as a crop, was about three dollars an acre less from slope land than from nearly level land which did not erode.

or ditches, or the smaller yield on account of the land occupied by ditches, but refers only to the smaller crop yield from land situated on slopes compared with that from land in a level position (see Pls. III, IV and V).

It is evident, then, that when a large portion of a farm is hilly or rolling and is subject to washing or erosion, the cost of maintaining a soil which is tillable and free from gullies becomes a large drain upon its income. The productivity is reduced by the constant removal of the most fertile soil. The land owner must realize that every stream of muddy water that flows from his fields lessens their fertility and, therefore, their value.

When the soils are deep and the erosion slight, especially when it is superficial or flat erosion, which is characteristic of the early stages on the heavy clays, the injury is not permanent, since deeper plowing can again give the necessary depth, and the addition of humus can replace the dark colored top soil. But it is a costly process.

In the case of shallow soils, which are frequently eroded until the rock is exposed, especially on the granites and the hardest gneisses of the middle portion of the State, the soil, which has been washed away, can be replaced only by the slow decomposition of the underlying rock. When much eroded, the value of such a soil is largely destroyed for farming purposes.

Large V-shaped gullies, whether on deep or shallow soils, greatly lessen, frequently permanently destroy, the value of the soil for farming (Pl. IV). There are thousands of acres of the red lands in middle North Carolina which have been gullied in this manner, and their cultivation, at least temporarily, abandoned. Fortunately much of it has been stocked by volunteer pines, which not only have checked further erosion, but in many cases have been the means of promoting the filling in of the gullies.

Such a system of managing farm lands, however, is economically bad. It could exist as a system only where both land and labor were cheap, and where fresh, newly cleared land was available to take the place of that which has been abandoned on account of the gullies. This condition has now ceased to exist. Labor can be more profitably employed than in clearing new ground to replace worn and eroded fields. Moreover, the land which has already been cleared is usually the best land, and even if badly worn, its reclamation can generally be effected more cheaply than new land can be cleared; while it is possible, when once reclaimed, to maintain it by proper cultural methods, and greatly lessen or even prevent future erosion.

Two other points should be considered. Forest land is just beginning to have remunerative earning power. The steady rise in the value of

stumpage assures its continued appreciation. In many localities the proportion of forest is already too low, and timber for farm use must be purchased. It would seem sound policy to maintain in timber those areas which, from steepness of slope, stoniness or shallowness of soil, are least fit for farming.

Any addition to the area of uncultivated or waste land means more idle capital upon which the expenses of taxes and interest must be borne without return, while at the same time it is subject to continued depreciation. A better management of smaller cleared areas, whose fertility is carefully maintained, will yield more satisfactory financial returns. This also affords a better indication of the fertility of the soil, more favorably impresses settlers and prospective purchasers, and gives a farm quicker sale and a better value.

CAUSE OF SOIL EROSION.

The cause of erosion is the failure of the soil, in a hilly country, to absorb the rainwater which falls upon it.[2] If the rainfall is all absorbed, as by a coarse sandy soil, which is largely the case in the sand hill portions of Rockingham, Moore, Bladen, Cumberland, and Scotland counties, there is no run-off and no erosion. As the soil becomes finer in texture, more compact, and correspondingly less pervious, the rain is not absorbed as fast as it falls, and the very smallness of the grains which form the soil facilitates its transportation whenever there is sufficient slope. The impact of the rain drops loosens the fine cohering particles of soil and, unless absorption takes place, the drops gather into small streams taking with them, as they flow, the finest particles of soil, while the larger and heavier grains are left behind As soon as the streams gather power, either by the added volume of water or by increased slope, they, likewise, begin cutting loose and transporting the soil, and at a constantly accelerating rate, since the eroding and transporting action of water is increased by the increase in its volume. It is also multiplied four times by doubling the slope. That is, if one hill has twice the steepness of another it will erode with four times the rapidity, provided, the soils are similar; and it may also be stated that the difficulty of preventing erosion increases at a yet higher rate. So rapidly does erosion increase with greater velocity of the water, that whenever the velocity of a stream of water is doubled, as by increase in slope and added volume, its transporting or eroding power increases sixty-four times. For this reason the steeper land erodes very much more easily than that of gentle gradient. Since

[2] This paragraph, with some changes, is taken from a paper by the writer, on Turbidity of Potomac River. Bulletin 192, U. S. Geol. Survey.

the steepest slope is usually on the middle of a hill, the most rapid erosion takes place there. The heaviest transported material is deposited by the slackened current on the more gently sloping base, or on the bottom lands, while the lighter silt and clay is taken to the streams. For these reasons, it is extremely difficult to prevent erosion of steep land which has a soil like that of the micaceous clays and silts, deficient in binding power, yet not freely permeable, or, which has a compact clay soil formed of small particles which are freely moved when once loosened.

Erosion is more rapid in the Piedmont region than in either the coastal plain or in the higher mountains. The nearly level topography and prevailing sandy soils of the coastal plain are inimical to erosion (see Pl. I).

In general, erosion is not active in the higher mountains, although the steep slopes are favorable. This is due largely to the following reasons: (1) The prevailing soils are more sandy and, on account of their physical texture, have a naturally high absorptive power for rainfall. The heavy soils of the mountains, as the red clays, are in many places badly eroded. The Red Hill section of Mitchell County, the clays at Balsam Gap, the Upper Valley of the Little Tennessee River, and the red clays of Cherokee County, and elsewhere, have been more or less deeply seamed. (2) The fact that grazing is extensively practiced and grass occupies so important a place in the crop rotation contributes not a little to protect slopes. The sod, after being grazed for several years, is plowed under and corn planted upon it. This sod adds a large amount of humus which further tends to promote permeability and maintain the absorptive power for heavy rainfall. (3) In the high mountains, the coolness of the air and the frequently high humidity are other important factors operating to minimize the tendency to erode. These furnish conditions highly favorable for the growth of grass; they likewise retard the destruction of humus in the soil, which takes place by the natural process of nitrification and oxidation. For this reason the humus of the soils of the mountains is more stable than in the soils of the Piedmont. The climate determines the condition which leads to its formation and likewise retards its decay when once formed. This climatic favorableness increases with the altitude, and is also greatest on northerly slopes.

These same reasons explain why erosion is more rapid in the Piedmont of the South than in the Northern States. The level surface of the Lake States and the States of the Middle West presents fewer exposed features. In the more broken region of the northeast many of the widely distributed soils are permeable. The deep freezing and thawing of winter increase their porousness. The high humidity and cooler climate not only furnish suitable conditions for the growth of grass, but the soils, being of lower

oxidizing power, tend to preserve the humus. An additional and important factor is, that, not only is the rainfall to which plowed land is exposed less than in the southeast, but a considerable proportion is in the form of snow much of which is absorbed from beneath as it melts. The rainfall of the North is from 20 to 40 inches; that of Piedmont North Carolina is from 45 to 55, one-third of it, 14 to 17 inches, falling during the three summer months of June, July and August, in heavy summer showers.

It is evident that the soils of the Piedmont are advantageously situated for excessive erosion when compared with farming lands of the northern portion of the Mississippi Valley and the northeast. The heavier, concentrated rainfall, light snowfall, long warm growing season, and high oxidizing capacity of the Piedmont soils render them more exposed to erosion than soils of the northeast with similar slopes; while the deficiency of many of them in lateral cohesion, as the mica silts, is another favorable factor.

These features, however, are those which give the soils of the Piedmont their highest values. The long growing season renders possible the production of two or even three crops of many kinds; while the rainfall, if conserved by storing in the soils, is usually amply sufficient for their maturing and can be used beneficially in place of being a destructive force. Their oxidizing capacity possibly explains their warmth and earliness. Their ease of tillage proceeds from their friability, while their fineness of grain is one of the important elements of their fertility.

CHARACTERISTICS OF SOILS.

The essential characteristics of a productive soil are that it shall have a certain fineness of grain or texture; maintain an equable amount of moisture; and possess a suitable proportion of humus.

Texture.—In general, soils of medium fine texture are the most desirable, though not the strongest soils. They offer a large amount of surface for root action, yet are capable of maintaining a high content of available soil moisture. Soils of too close texture bake and puddle badly and are difficult to work. The red clays are generally not too heavy to be readily worked; the mica clays work easily. Soils which are too coarse textured are leachy and dry.

Moisture Capacity.—A soil must not be too wet, as are moist undrained bottoms. An excess of water causes lack of aeration of roots, and retards the decay of humus. It produces the condition known as sourness. The other extreme, a deficiency of moisture, checks growth. The upland soils of the Piedmont suffer more from lack of moisture than from an excess.

INCIPIENT OR FLAT EROSION, LARGELY CONFINED TO THE SHOULDERS OF SLOPES. VERTICAL GULLIES ARE JUST BEGINNING TO FORM.
(COURTESY OF FOREST SERVICE.)

Their subsoil drainage is generally good, probably on account of the low water table which normally stands in summer 40 to 60 feet below the surface. Drainage is more deficient in the heavy red clays than any other of the slope soils.[3] Nearly all of the Piedmont soils are dry during the autumn, in spite of the usually heavy summer precipitation.

Humus.—It is by means of humus that the proper conditions are secured for the development of soil bacteria, which are necessary to render the soil's fertility available for the use of the growing crop. Humus is also directly, or indirectly, through the growth of legumes, the source of most soil nitrogen. It largely increases the water storage capacity of the soil, especially the top soil, and likewise its permeability, tending to remove any excess of surface water, but retaining it until needed during dry weather. It also loosens a clay soil so that it is more easily penetrated by the roots of crops; it lessens puddling and baking of the surface, making tillage easier and the need for it less frequent.

EFFECT OF EROSION ON QUALITY OF SOIL.

The effect of erosion is to injure the texture of the heavier soils by eroding the sandier surface soil. Since so large a portion of the rainfall runs off, there is a decided loss in moisture, especially in the autumn when it is badly needed. The humus and small clay particles being the lightest constituents of the soil, are most easily borne off in the water. The most evident characteristic of an eroded red clay field is its "rawness" or deficiency in humus. The muddy water contains, in addition to the humus and the fine particles of soil, a large amount of material in solution. It has been estimated [4] that the amount of matter carried off in solution in the Potomac river water, which, however, is not so muddy a stream as those of the Carolina Piedmont, during the period of a year, is equal to four hundred pounds of matter for every acre of farmed land drained by the river, and the plant food in it is about equal to that removed by a crop. The amount of fertilizer yearly added just about equals the soluble matter so removed. While this soluble material is replaced with about the same rapidity as removed, the fine particles of silt and clay are replaced more slowly.

The conditions on the James River in Virginia more closely resemble those which exist on the streams of North Carolina. It has been estimated [5] that in a flood with a 10-foot crest 275,000 to 300,000 cubic yards

[3] Drainage of the Iredell clay soils is very deficient. The lands are too nearly level to be subject to erosion.

[4] Bulletin 192, U. S. Geol. Survey, Potomac River Basin, p. 292.

[5] Rept. Chief of Engineers, U. S. Army for 1885, part 2, p. 947.

of solid matter (earth and humus) are removed during twenty-four hours. Since the water in the James River attains or exceeds this stage during at least 10 days of the year, in addition to many other days when the turbidity of the water is very high, but the stage lower, there must be from 3,000,000 to 4,000,000 cubic yards of soil washed yearly from the farming lands on the James River situated above Richmond.

The Roanoke River probably bears as large an amount of solid matter as the James River. Only a small portion of its watershed, the Dan River, lies in North Carolina. The two North Carolina streams, of which the best data are at present available showing the extent of erosion, are the Neuse and the Yadkin rivers.

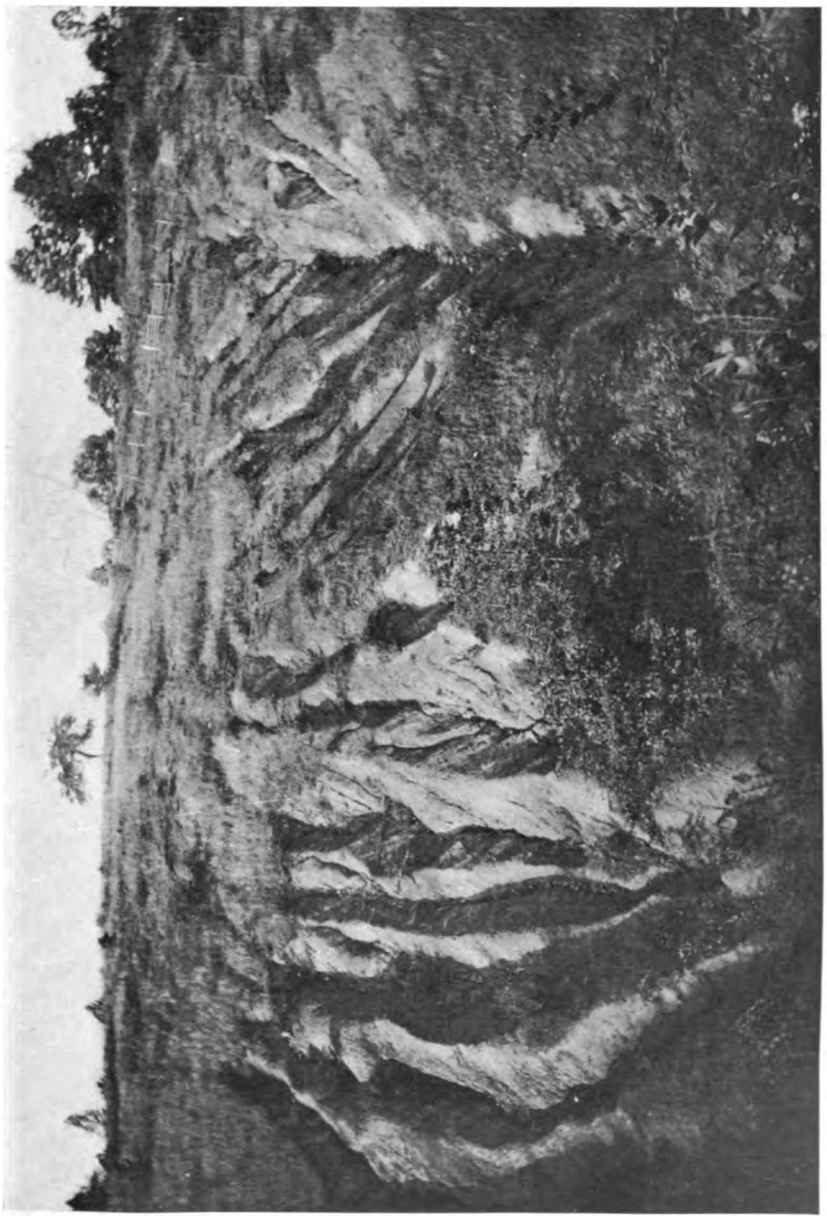
The influence of heavier rainfall, more broken topography and heavier soil is noticeable in the greater erosion on the basin of the Yadkin than on that of the Neuse. More than 850 pounds of soil are yearly washed from every acre of land on the Yadkin River above Salisbury.* Of this more than 125 pounds are organic matter, the balance being mineral soil. In addition there is a large amount of plant food contained in the matter in solution which amounts to more than 150 pounds a year from each acre. More than 380 pounds of soil are yearly washed from the Neuse above Selma. Of this, more than 50 pounds are organic matter. The organic matter is humus, which must be replaced. In addition to this solid matter there is a large amount of soluble salts washed out, amounting to more than 100 pounds per year from each acre.

The soil and soluble matter yearly washed in the rivers from the Piedmont, North Carolina, with an area of about 12,000,000 acres, certainly amounts to more than 4,000,000 tons, and the plant food in it has a value of more than $2,000,000.

SOILS SUBJECT TO EROSION.

While there is no soil type in the middle portion of North Carolina free from erosion, it is more active in some types than in others. Since it is primarily due to the failure of the soil to absorb heavy rainfall, which instead collects into flowing streams, it is the fine-grained, closely textured soils that are most subject to it. As the soil becomes more porous, by the grains being larger, the rainfall is more quickly absorbed and a heavier precipitation is required to produce a surplus and cause run-off. The actual capacity of a clay soil or fine silt for water is greater than that of a sandy soil, since its pore space is greater. The difficulty is, as King

*Amount of mineral matter eroded from the watershed of Yadkin and Neuse rivers is based on the turbidity record of the U. S. Geol. Survey. Organic matter based on analyses by N. C. Geol. Survey.



CHARACTERISTIC EROSION OF THE HEAVY RED CLAYS OF THE PIEDMONT PLATEAU REGION IN WHICH VERTICAL V-SHAPED GULLIES HAVE BEEN FORMED. WELL ADVANCED STAGE, VERTICAL V-SHAPED GULLIES HAVING BEEN FORMED. IT IS DIFFICULT TO RECLAIM FOR FARMING PURPOSES LAND IN THIS CONDITION. THE SOIL HOWEVER IS OFTEN GOOD AND SOMETIMES CAN BE RECLAIMED MORE PROFITABLY THAN NEW LAND CAN BE CLEARED.

has pointed out, that a heavy rain, especially a summer shower on a dry soil, quickly puddles the surface of the soil and the absorption of water is checked until the air can be gradually expelled. This takes place far more slowly on the heavy clays than on the open sands.

Erosion then, attains its maximum on steep slopes, with heavy clay soils deficient in humus; and it is at a minimum on level sands.

The three classes of soil which are most subject to erosion are the heavy red clays, the yellow sand clays, and the micaceous (isinglass) soils. Each of these erodes in a characteristic manner.

Heavy Red Clays.[1]—These clays are frequently nearly homogeneous in texture, that is, have their grains nearly of a size, although they contain a variable amount of coarse sand, the proportion of which is large in the top soil of the loamy phases. In its early stages, erosion of the heavy red clays takes place as broad shallow "washes," or "galls" especially on shoulders of the slope, or the steepest points. Plate III shows characteristic incipient erosion of this character. When constant tillage is taking place, these are "galled," "washed," or worn spots of the fields, and they are indicated chiefly by their unproductivity. A deficiency in humus is often evident. Later stages of erosion seam these soils into parallel V-shaped gullies which may ultimately descend from near the summit to the foot of even moderately gentle slopes. Plate IV illustrates an advanced stage of erosion, when value for agricultural purposes has been largely destroyed.

Yellow Sand Clays (Cecil Loams in Part).—These erode in much the same manner as the heavier red soils, but usually less easily. They are not homogeneous in texture, but contain a considerable amount of coarse sand with very fine-grained clay,[2] and generally have a naturally low

[1] The behavior of the soils of Piedmont North Carolina towards erosion, seems to be slightly affected by their origin. The clays, whether from hornblende-gneiss, diorite, serpentine, gabbro, or other basic rocks, erode similarly to those from the granites and acid rocks. Those soils richest in available potash and lime are usually more productive than those deficient in these materials if physical condition is the same. They will consequently often contain more humus and exhibit less erosion on gentle slopes. Other qualities being the same, the texture is, apparently, the determining factor.

The red clays of the Piedmont are classified by the U. S. Bureau of Soils, as Cecil clays. As they become sandier they are referred to lighter members of the Cecil series. When they are derived from mica-schists, and contain a large amount of finely divided mica, they are classified as Cecil silts, or Cecil mica loams. These are the mica red clays. The soils derived from sericite and talc schists have much the same texture and erode in the same general manner as the mica soils.

[2] It is probable that the mixture of sand and clay in some of these soils is in the same proportion as that used in the construction of the sand-clay road. Enough fine clay is present to fill the interstices between the sand. Such a mixture was noticed by Orris Brown of Norfolk, Va., to make a road, the surface of which was almost impervious to rains, and the mixture has been found natural in many places in the Southern States by the Office of Public Roads. Soils having their sand and clay content, about

humus content. Erosion is active even on the gentlest slopes, forming V-shaped gullies much like those of the heavy red clays, but broader. The heavy sand content of this soil is frequently deposited as a sand bar, or fan, over the more level land at the foot of the slope, or on the bottoms.

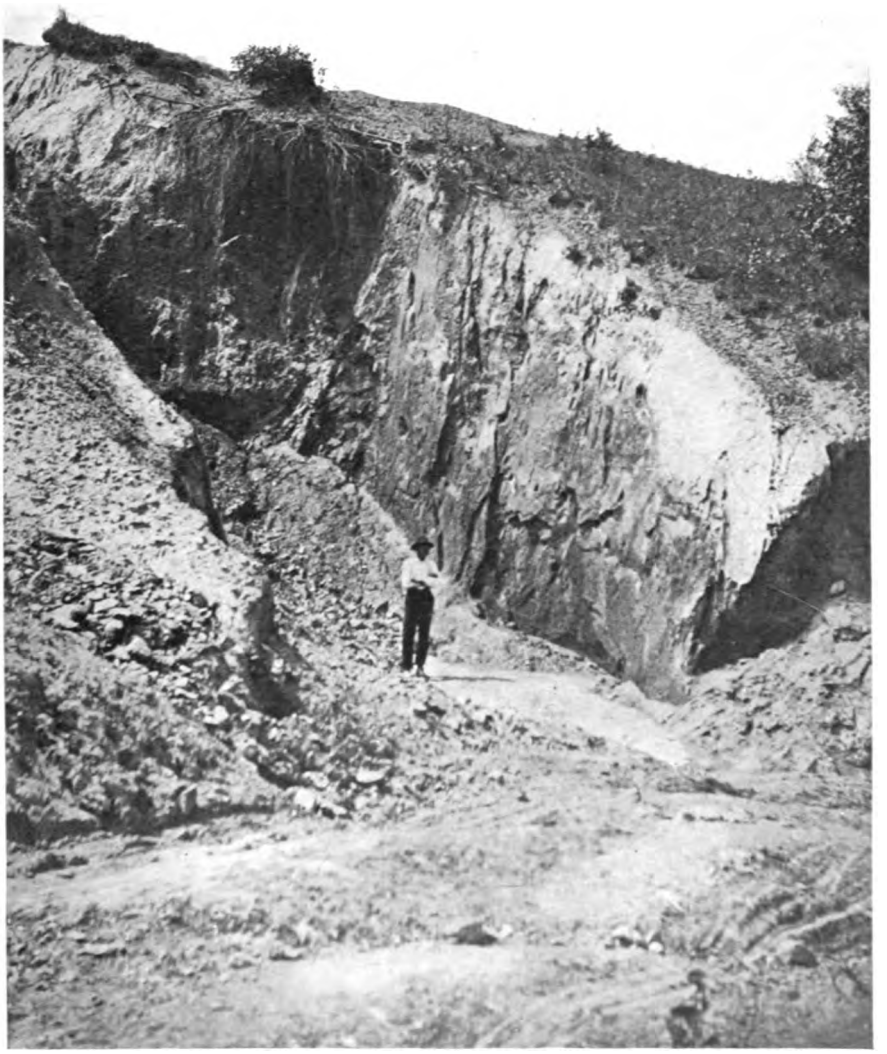
The sand-clay soils are not generally distributed, but occur most abundantly in the eastern part of the Piedmont where they are tobacco and cotton lands. They extend in the Roanoke River section well down into the coastal plain. A phase of these soils, which is much prized for farming, is the gray loam or sand top soil with a clay subsoil.

Mica Red Clays (Cecil Silt Loams, etc.).—Clays of this type are more seriously affected by erosion than any other soils of North Carolina. They contain, in addition to the mica, which is extremely finely divided, a large amount of other silty particles which, with a lack of horizontal lamination, render the soil decidedly deficient in cohesive qualities. On account of their silty character, they are permeable soils, and, under good tillage and with a large humus content, erosion is largely restricted to uniform soil transportation—a considerable amount of muddy run-off occurring during heavy rains, but few definite gullies being formed. When gullies once form, however, and are not promptly checked by proper cultural methods, erosion proceeds rapidly even on most gentle slopes; the gully deepens rapidly towards the drainage line and recedes on nearly the same level to the initial point of erosion. On account of the loose, friable nature of the silt and red micaceous soils they are readily undermined by running water and present in the later stages of erosion deep, vertically walled gorges. Since the mica-schist, from which this is derived, has decayed to a great depth, frequently to the natural drainage plain at depths of 50 to 60 feet, the bottom of the eroded gorge lies on a level with the draining stream. Plate V shows a characteristically eroded gully in the mica clays.[9] Immediately along the foot of the Blue Ridge

in the proportion of the sand-clay road mixture would have low permeability, and be subject to excessive erosion.

A portion of the clay content, not only in this soil, but in the heavy red clays as well (and probably a much larger proportion in the yellow clays in the beeswax and in niggerhead soils) is extremely fine grained or colloidal in texture. This clay is so fine that it settles with the greatest slowness even from perfectly quiet water. It is the cause of the characteristic turbidity of Piedmont streams even during dry seasons when very little surface water enters them.

[9] In the Western States there are extensive areas of unconsolidated silts which erode with even greater facility than these soils. Since they are subject, however, to only infrequent rains, they are not affected by surface erosion. They are easily undermined by streams, however, and are a serious drawback to the maintenance of irrigation ditches. A large part of the excessive turbidity of western streams during high water is derived from such soils, the silt burden in these streams at times amounting to as much as 5 per cent. Only in Mississippi and western Tennessee are there to be found in the east silt soils more disastrously affected by surface erosion than the mica-clays of the Carolina piedmont.



CHARACTERISTIC EROSION OF THE MICA RED CLAYS AND SILT SOILS. VERTICALLY WALLED GORGES ARE QUICKLY FORMED IN THESE LOOSE SOILS WHEN UNDERMINING ONCE BEGINS, RESULTING IN THE COMPLETE DESTRUCTION OF THE SOIL FOR FARMING PURPOSES.

there are extensive areas of such soils. Similar areas, but smaller, occur locally eastward to the very edge of the coastal plain. While usually not distinguished from the other red clays, the presence of the mica or the small particles of sericite or talc, the sparkle of which is very noticeable in the soils when dry and reduced to dust, and the slightly greasy feel which is also due to the mica or talc schist, will serve to identify them. These soils are very friable and far easier to cultivate than the heavy clays. They drain more freely and puddle more lightly, but form a heavy sticky mud when wet; become dry relatively more quickly after heavy rains; and crumble rather easily when dry; are warmer and earlier but difficult to maintain at a high productive capacity on account of the rapid oxidation of humus.

These three broad classes are the most extensively distributed types of heavy soil which lie on slopes in middle North Carolina. As these soils pass into sandy or gravelly phases, there is a corresponding increase in permeability to rainfall and lessened erosion, though even the sandy loams in the Piedmont, when underlaid by compact, less pervious subsoils (gray topsoil with clay subsoil) erode to some extent because the porous topsoil lacks depth. It is evident, therefore, that with few exceptions the soils of the Piedmont erode whenever the slope is favorable.

Since erosion is primarily due to the failure of the soil to absorb rainfall, followed by rapid flow of the accumulated surface water, it can be lessened by any means which will promote absorption or lessen the rapidity of the run-off.

ABSORPTION OF WATER BY SOILS.

The usual means for promoting absorption of rainfall by soils are by deeper plowing and by increasing the amount of humus in the soil. Both of these practices are undoubtedly advisable in managing most lands. Humus is secured by manuring or by plowing under a green crop. The increase of the humus content is particularly demanded on the heavy soils, although for certain crops it is inadvisable to add too large an amount of organic matter. The texture of bright tobacco is injured by an excess of humus, especially of legumes; rye humus is not injurious. Corn may preceed tobacco on a legume humus. When present in large quantities, humus produces, in the short growing season of most portions of Piedmont North Carolina, too weedy a cotton stalk, delaying maturity and lessening the amount of the top crop. This last condition, however, is infrequently realized and on most soils devoted to cotton culture a very large addition to the humus content can be made with the certainty of increasing the yield of cotton as well as lessening the tendency of the soil

to erode. The excess of nitrogen in legume humus may be balanced for cotton by the use of fertilizer deficient in nitrogen. It has recently been pointed out by the Georgia Agricultural Experiment Station, from experiments carried on in that State, that plowing deeper than 8 inches tended to lessen the yield of cotton. Comparatively little land prepared for cotton in North Carolina is plowed to that depth, however, and even plowing to that depth could do much to increase the water-carrying capacity of the soils subject to erosion. But, as a matter of fact, only a small amount of land in the Piedmont is plowed even 6 inches deep, while much of it is not plowed deeper than 4 inches. While it may be true that it is not advisable to plow to a greater depth than 8 inches for cotton, this is not true in regard to either corn or peas, which make greater demands on soil moisture than cotton. The low yields of corn especially can be attributed more largely to a deficiency of soil moisture than any other reason. A wet growing season invariably means a heavy corn crop on the uplands of the Piedmont.

METHODS OF LESSENING EROSION.

With the heavy concentrated rainfall which frequently takes place in the South, neither deep plowing nor an addition of humus can be relied upon to prevent erosion, although on land with only a gentle slope they considerably lessen it. Precipitations of 2 to 3 inches within an hour's time are not infrequent in summer showers, and they occasionally fall on earth which still contains a high percentage of water from previous rains. Theoretically, a soil in good tilth, deeply plowed, and containing a large amount of humus can absorb 4 to 5 inches of rainfall. The concentrated precipitation, however, which occurs in the South, frequently so compacts the surface that absorption is retarded and rapid run-off takes place, producing erosion. This condition has necessitated various artificial methods of soil conservation by terraces, hillside ditches, and dikes.

Dikes or Flat Dikes.—These consist of broad low mounds located nearly on a level, the cultivated rows in tilled crops crossing them. They are adapted only to land of gentle gradient.

Hillside Ditches.—These are channels supported by a strong embankment on the lower side. They are used on land of steeper grade for reducing erosion by collecting the water on strips between the ditches and conducting it through the ditch at a reduced fall, and consequently with lower eroding power, to a convenient hollow where the ditch empties.

Terraced Land.—In terracing, the land is built up in a series of steps, the intervals between the steps or rises being nearly or quite level (Pls. II and VI, *A* and *B*). Incomplete terraces are those in process of de-

velopment, the rises being slight and the slope of the intervening strip yet relatively steep. There is little or no run-off and no erosion from completely developed terraces.

There are two methods of diking used in North Carolina, neither unfortunately being very extensively employed. One is the Mangum dike (called terrace) which is adapted to land of only the most gentle slope. The other is the McLendon dike which can be used on somewhat steeper land.

The Mangum Dike.—This dike should be 4 to 5 feet broad and not less than one foot high on gentle slopes, the height increasing to 2 feet on hillsides the slopes of which amount to one foot in fifty, the maximum grade on which it should be used. It should have a fall of not more than one-half inch to the rod. When tilled crops are planted, the rows which cross the dikes obliquely should be so laid off as to have no greater fall than the dikes.

The McLendon Dike.—Steeper slopes can be cultivated by use of this dike. It is located on a level and built up very broad, 10 to 15 feet at base and 18 to 24 inches high. The rows are run in cultivated crops on a level, along the dike as well as on the intervening strips.

Dikes require strengthening every year as there is always some erosion from the lower slope and the upper slope tends to become level. The fall between two adjacent dikes should not exceed 3 feet.

Their use permits, when the surface will allow it, the cultivation of large fields having gentle slope without division into smaller areas, which is a necessary practice when terracing is required. There is no wasted land, as is the case with ditching and terracing. Diking, as already stated, is adapted only to the most gentle slopes; while deep plowing and a high content of humus to maintain mellowness and promote absorption are necessary adjuncts. Diked land tends to develop into a terraced system and would, if it were not that constant cultivation across the dike prevented the building up of the outer face.

Hillside Ditches.—These ditches are located with a sufficient fall to drain the water rapidly. Their spacing is closer the steeper the slope. The ditches are reinforced by a strongly built dike on the lower side. They limit vertical erosion, but erosion continues to take place in the ditches.

On land of gentle slope, diking is superior to hillside ditches, while on steeper slopes terracing is superior. Ditches are objectionable on land of any character. On gentle slopes they increase the cost of tillage above dikes and add a considerable proportion of waste land; on steeper slopes they do not prevent erosion, since soil transportation, flat erosion (Pl.

III), proceeds continuously, constantly removing the finer particles of soil and humus, and draining off the water, which is one of the most essential elements of fertility. An examination of many farms on which diking and hillside ditching are practiced leads to the conclusion that hillside ditching should be entirely abandoned, no matter how gentle the slope of the ditch; and that diking is applicable only to lands of the most gentle gradient.

Terraces.—It is usual to develop terraces gradually by means of high dikes located on a level, or nearly so. In their method of construction they are similar to hillside ditches, but are deficient in fall. Unfortunately, most of the so-called terracing is not such, and is planned in such a way that its efficiency is seldom greater than that of ditches laid off with a fall of 1 to 3 feet to the hundred feet, a sufficient fall to remove not only the water but a large amount of fine soil. Erosion continually takes place and terraces fail to develop.

Terracing rightly planned and well executed is so infrequent as to be noteworthy; and this is especially so when the gradient of the land is at all steep. There have been some well terraced farms in this State and a few are yet to be seen, but too frequently they have been poorly planned or poorly developed, and have failed to produce the results intended.

As is seen from Pl. II, soil erosion and soil preservation are by no means a problem local to the Southern States, but is common to all countries with heavy intermittent rainfalls, hilly lands and close soils. In China the preservation of the soil on hills and mountain slopes has been effected only by terracing. Slopes not so protected have been destroyed by less than three centuries of continuous tillage. The question arises with us as to how our slopes will look after 300 years of corn and cotton culture.

OBJECTIONS TO TERRACES.

The chief objections which can be urged against terraces are:

(1) There is a considerable proportion of waste land. This is less, however, than with ditches.

(2) The banks harbor weeds. This is also the case to a less degree than ditch banks, since only one face is exposed for their growth.

(3) There is difficulty in getting a team from one terrace to another. This can be obviated only by leaving a small strip at each end of the field unterraced and kept in good turf. Turnings of the team can be made on it. In California, hillsides are sometimes terraced for irrigation. This requires the intervals between the rises to be well levelled, yet by means of the slope at one end teams and farm tools are readily moved from terrace to terrace.

A. A STEEP, WELL TERRACED SLOPE IN MIDDLE NORTH CAROLINA. ALTHOUGH THE TERRACES ARE NARROW, THEY ARE NEARLY LEVEL, AND EROSION IS SLIGHT. (COURTESY OF BUREAU OF SOILS.)

B. INCOMPLETE TERRACES WELL LOCATED BUT TOO FAR APART, THE RISE BETWEEN THEM BEING TOO GREAT. AT LEAST ONE INTERVENING TERRACE SHOULD HAVE BEEN CONSTRUCTED.

These drawbacks are more than offset by the gain from increased yield and the greater ease of maintaining soil in good tilth. It is possible that in some very heavy soils terracing might make soils too wet for early spring plowing. If this should take place in any case it could easily be corrected by blind drains, either of tile or of green pine poles.

CONSTRUCTION OF TERRACES.

Terraces are largely developed by means of erosion, the very agent they are intended to lessen. The earth which is scoured from the slopes is deposited at the foot of the slope until aggrading has proceeded so far that erosion no longer takes place. The rapidity with which the deposit accumulates before leveling has reduced the slope, shows the extent to which erosion was taking place under open slope cultivation.

There are four very important stages in the development of terraces as follows:

First. To locate on a level, or nearly so, lines which follow the slope. The rise between each line, on which the terrace will subsequently be developed, should, at a maximum, not exceed 4 feet. The lines are approximately parallel.

Second. To construct with plows a strong dike or embankment of earth on the lines which have been located. A ditch is on the upper side or inside of the dike. As earth eroded from the slopes accumulates in the ditch it is used for increasing the height of the dike, until the leveling process is completed. If Bermuda grass is abundant the dike should be turfed with it. If it is not, red top or meadow oat grass should be used, or even one of the hardier vetches to give protection during winter and spring.

Third. To constantly watch and strengthen these dikes, especially during and after rains, until they have become thoroughly consolidated and turfed, or, until the slope has been greatly reduced by leveling. Holes made by mice, moles, rats and sometimes muskrats must be carefully noticed and stopped.

Fourth. To plow so as to turn the soil only towards the lower dike. This facilitates the leveling, lessens the danger of breaks in the banks, and prevents an undue deposit of the most fertile surface soil in the ditch on the upper side of the dike as the process of leveling by filling proceeds.

In order to develop terraces which are nearly level from the outer crest of one terrace to the foot of the one above, the rise between the two adjacent terraces should never exceed 4 feet, and on gentle slopes a rise of 3 feet is more advisable (see Fig. 2). When there is danger of an excessive accumulation of water it is preferable to have low rises and develop

temporary intermediate terraces which can be plowed up when the embankment of the permanent terrace becomes well consolidated and turfed. Many of the terraces on the State farm near Columbia, South Carolina, on a sandy loam soil, rise more than 4 feet, and in spite of their steep, almost vertical slopes, are so well turfed with Bermuda grass that they hold with no indication of weakness. When it is considered necessary to have a slight grade to the ditch on account of large collection of water, the fall should not exceed $\frac{1}{4}$ inch to a rod, and preferably $\frac{1}{8}$ inch. A fall of this amount will remove a large quantity of water very quickly, yet will allow some sedimentation of silt and clay, at least during moderate rains. If a greater fall than this is allowed a ditch is developed. The velocity of the water is too rapid to allow sedimentation except of gravel and coarsest sand, while the silt and light organic matter, which are the most valuable portion of the soil, are borne off in the muddy water to the impoverishment of the land.

The work of locating terraces should begin at the foot of the slope. The work of construction of dikes and ditches should begin with the upper terrace.

Locating Terrace Lines.—The lines of terraces can be laid off either with a surveyor's theodolite or transit; or a more simple home-made triangle, furnished with either plumb bob or level, can be used. The method of laying off the lines of terraces with a transit requires no explanation. It is important, however, that every land owner should know how to correctly lay off his own dikes. He can do it satisfactorily with the triangle.

The triangle[10] should be made of sound, well-seasoned lumber with straight edges, and should be sufficiently rigid to be handled without bending (fig. 1).

On a base 10 feet 8 inches long, of 1 x 4 inch board, complete the triangle by using two pieces 7 feet 6 inches long. The pieces should be so nailed that it will be 10 feet along the top of the base board between the inside of the two sides. It should be 7 feet $\frac{1}{2}$ inch on the inside of each of the sides.

Lay off 3 feet 8 inches above the base board along the inner edge of the sides and carefully nail a cross bar joining the two short sides so that its upper edge will be exactly at the 3 foot 8 inch mark. This cross bar must be a straight edge.

If a plumb bob is used, it can be hung from the angle made by the short sides. When the base is level it should hang in its center and this

[10] Triangles of this kind are used in the west for grading irrigation ditches. See Newells' Irrigation, p. 106.

should be marked. A vertical board from the base to the apex of the triangle, with broad staples in it through which the plumb line can swing, will limit the swing of the plumb bob and facilitate handling the triangle.

If a level is used, it is fastened to the center of the cross bar. It should be tested and adjusted before being fastened. If the cross arm has been correctly put on, when the bubble is in the center of the level the base of the triangle will be level. The level should be so fastened as to leave a narrow edge of the top of the cross arm clear for sighting. A projecting block one inch long should be nailed at the bottom of one end of the base board (*M* of fig. 1). The projection of the peg on which the other end rests should also be one inch. The block lessens the trouble with stones, clods, etc. which would be in the way of the base board.

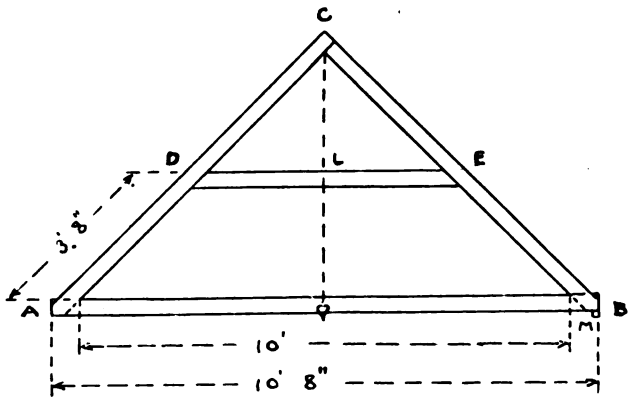


FIG. 1.—Triangle used in locating dikes. *AB* base board, 10 feet 8 inches long. *AC* and *CB* side pieces, 7 feet 6 inches long. *DE* cross-bar. *L* shows the location of the level. Plumb-bob hangs from *C* to middle of *AB*. M inch-high projection.

Use of the Triangle.—If it is intended to lay off level lines for dikes or embankments, the triangle is ready for use. Flat-topped pegs 6 to 8 inches long should be provided. One will be required each 10 feet; though if the curves are large, intermediate ones can be removed as the work proceeds.

The triangle is used in this way for level lines. A peg is driven until its top is within 1 inch of the ground, or the height of the projection on the base of the triangle. The end of the base of the triangle with no block is placed on this peg. The end with the block is moved until the plumb or bubble in the level shows the base to be on a level. A peg is then driven at the point where the projecting block is, its depth being adjusted until the triangle reads level. The triangle is then moved for-

ward, the end without the projecting block being placed on the last peg and the operation is repeated. The tops of the rows of pegs will each project 1 inch above the earth and will be on a level.

If it is desired to lay off the lines for the embankment with a fall, the short sides of the triangle must be of different lengths. For a fall of $\frac{1}{4}$ inch in 10 feet let the distance to the cross arm be shortened to 3 feet 7 11/16 inches on one side. For a fall of $\frac{1}{8}$ inch in 10 feet, let the distance be shortened to 3 feet 7 25/32 inches on one side of the triangle. Let the distance on the other side remain 3 feet 8 inches. The short end should be marked. In laying off, the short end will be the higher, and the slope will be from that end. The inch block should be at the long end. The same method of laying off is followed which has already been described.

The approximate rise between terraces is also determined by means of the triangle. Turn it at right angles to the terrace which has just been laid off and level it carefully on pegs, letting one end of the base board rest on one of the line pegs. A sight along the cross bar towards the hill will then locate a point 3 feet, or the height of the cross bar, above the terrace line just located.

When there are outcrops of large tight rocks, the terrace should preferably be located to include them. If their projection above the surface is slight, they may be located above the dike, since they will be so deeply buried in the course of leveling as not to interfere with plowing. If their projection is such that they will not be covered to a depth of at least one foot, they should be left below the terrace.

BUILDING UP THE TERRACES.

The method of dike or embankment construction is generally too well understood to require explanation (see Fig. 2). Earth should be thrown with the plow on the located line from both lower and upper sides. Large loose stones can advantageously be piled along the located line before plowing. The embankment should be built especially strong in the hollows and "swags" where a large volume of water rapidly gathers, frequently with high momentum, and where both undermining and overwashing are most likely to take place. It is frequently advisable to strengthen such points at the upper convex side by making a facing of inch boards, driven vertically side by side into the earth. Where the embankment dike rounds the crest of a sharp ridge, the deep concave bend on the upper side is extremely likely to erode if the ditch of the terrace has any grade to it. The weakest point is at and just below the center of the bend where the eroding power of the water, as it changes its course, is

greatest. A facing of boards will frequently be advisable here. Stone can often be used in place of boards.

Dikes should be constructed with the largest plows available. The field should be plowed at the same time that dikes are made. This increases the absorptive capacity of the soil and lessens the possibility of breaks in the dikes, which are weak for the first year until thoroughly consolidated. In plowing the strips between the dikes there are many short furrows. It is preferable to locate these short furrows either in the middle of the strip or against the upper dike. Since there is always some fall from the short furrows, the drain from them, if they open against the lower dike, tends to increase the quantity of water which accumulates against this dike. This is more essential in laying off for tillage than in plowing.

The weak point in the current practice is that the ditch is given too much fall and there is consequent failure of the filling or leveling process.

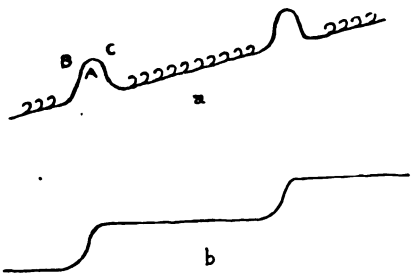


FIG. 2 a.—Terrace in process of formation, using level dikes and hillside plowing. *A*, dike. *B*, lower slope or face of dike. *C*, upper or ditch slope of dike. b. Completed or levelled terrace.

Frequently, after an interval of ten years, the ditch is yet open, being scoured clean by each heavy rain; and, since the hillside slope has not been materially reduced, destructive erosion is yet taking place. Moreover, unless filling takes place, ditches and dikes must be kept in repair at considerable cost.

Leveling.—Leveling can be hastened by the use of hillside plows. These differ from the plow in general use by having the mold board reversible. This permits the earth from every furrow to be turned down the slope. By using this plow the first furrow is turned into the ditch of the lower dike, while the last is turned away from the base of the upper dike. This greatly quickens leveling (see Fig. 2). An additional advantage is that there are no furrows up and down the slope which are subject to gully, and, since plowing is on a level, the draft is easier on the team. There is also no dead furrow or balk.

There are three general types of plows which are adapted to work of this character:

1. *The Walking Hillside Plow.*—The mold board of this plow is reversed by hand at the end of each furrow. This permits plowing very close to dike banks and is especially suited to small or narrow terraces. This plow is usually made in a two-horse size. It is adapted to level as well as slope lands, and can be used without turning the mold board if it is desired to do so. When only one heavy plow is used, it should be one of this character.

2. *The Reversible Disk Plow.*—These plows are sulky, made in two, three or four-horse sizes. They cut deep and wide, but are not suited to very stony land, since their cutting is on the principle of the disk harrow. They do well, however, on heavy clays. They do not admit of plowing quite so close to the dikes as with the hand plow. An additional point in their favor is that having no landside, they do not tend to compact the bottom of the furrow as do landside plows. The reversible disk plow is extensively used in northern Georgia.

3. *The Two-share Mold Board Plow.*—This plow seems to be made by only one American firm. It is adapted to a greater variety of soils and conditions than the disk plow, and there is a place for it on every large farm with an extensive area of gentle hillslide land. It is a sulky plow, made in two and three-horse sizes, with two shares, right and left, either of which can be raised by a lever enabling all the furrows to be turned in the same direction.

RECLAMATION OF WASHED LAND.

There are two classes of eroded land. One can be reclaimed profitably for farming purposes; the other cannot. Land to be profitably reclaimed must not be too deeply gullied; the soil must be of good quality, and have so moderate a slope that it can be terraced. A satisfactory method of filling gullies is to place in them small pine boughs with the stick portion turned down the slope. Grain straw can be substituted for the pine bough. Plow deeply the strip intervening between the gullies, lifting the plow across the gullies; then harrow. Both plowing and harrowing should be entirely on a level, never up and down the slope. Plant at once in field peas, using, if broadcast, not less than 5 pecks to the acre. In early fall turn under the pea vines and plant at once in rye. The following spring terracing should be begun.

Land which is too badly washed or too steep, too rocky or shallow-soiled to be reclaimed for farming purposes, should be planted in trees. The native pine is one of the most satisfactory trees. Seedlings 1 to 2

feet high taken from fence rows, old fields or very open woods should be used. Lay off on a level deep furrows 5 feet apart. Plant the trees 5 feet apart in the furrows, placing them no deeper than they stood at first. Press the earth firmly around the roots of the trees with the feet. Plant a row in the bottom of each gully. Red and black oak can be used in place of the pine, or mixed with it. If a large number of tree seedlings have to be used they can be cheaply grown. Write to the State Geologist, Chapel Hill, N. C., for directions for growing seedlings and planting trees on washed or other waste land.

SUMMARY.

Terracing is more than an artificial means of preventing erosion. Its beneficial effects may be summed up as follows:

1. A reduction in the constant cost and labor of maintaining a tillable surface soil which is free from gullies.

2. An increase in general fertility.

a. By an addition to the available soil moisture through soil storage, by lessening run-off, especially of summer rains.

b. By an increase in the humus content. Humus is one of the chief elements of fertility and is one of the means of storing moisture. It also retains much of the valuable soil solution which is lost in a soil deficient in humus.

c. By reducing the loss of soluble plant food and of the finer particles of soil. A portion of this loss is yearly replaced by commercial fertilizer.

3. There is a corresponding increase in land values.

4. In addition to reducing erosion, there is another urgent requirement of the soils of middle North Carolina. This is humus, the organic or manural portion of the soil. On account of the much greater loss of soil moisture by evaporation, this constituent must be larger in southern soils than in northern soils of the same texture. Terracing conserves the water, but the texture of the soil must be such that absorption of the rainfall must take place rapidly and without puddling or baking the soil. Deep plowing in connection with this is also necessary to give greater storage capacity, lest soils, after heavy rains, remain too wet for working.

Since few cattle are kept in the south, the manure is insufficient for maintaining humus. In the cattle-raising sections the grass sod, grass being one crop in the usual rotation which is plowed under, also adds a large amount of humus. In Piedmont, North Carolina it is necessary to plow under a green crop to secure this. The North Carolina Department of Agriculture has issued several valuable papers on this subject. The most valuable crops to plow under are legumes, which include clover,

peas, vetch, beans, or rye. Of these, perhaps crimson clover, cow peas, and rye are best suited for middle North Carolina. They should be used in connection with a definite system of rotation. The humus crop should follow the cotton or tobacco crop, since an excess is often injurious to these crops; deepest plowing should be for corn, if it proves true that this lessens the yield of cotton. Deep plowing means from 8 to 10 inches.

There is another aspect of erosion in which the land owner is less personally interested, though it cannot but affect him. A part of the silt and sand from the slopes destroys his bottoms. The other portion of it is swept past in the streams. Some settles in the reservoirs of dams and reduces the value of the water power of the streams and affects the industries dependent upon them. A portion settles further down in the channels of the navigable rivers, lessening their value and rendering navigation hazardous. While still another portion forms a part of the silt bars in the harbors, reducing their depth and necessitating constant dredging to maintain depth of harbor. The silt, clay and sand burden of the streams of the Piedmont probably amounts to more than 4,000,000 tons a year, the greater portion of which comes from the farms. The welfare of the entire State demands that this enormous quantity of soil, rich in humus, and in soluble plant food, be retained on the farms to maintain their fertility and not permitted to be washed into the rivers to destroy their earning value. Natural resources, when once destroyed, cannot be replaced. The civilization of a people is determined by the advantageous use they make of the gifts of nature.

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