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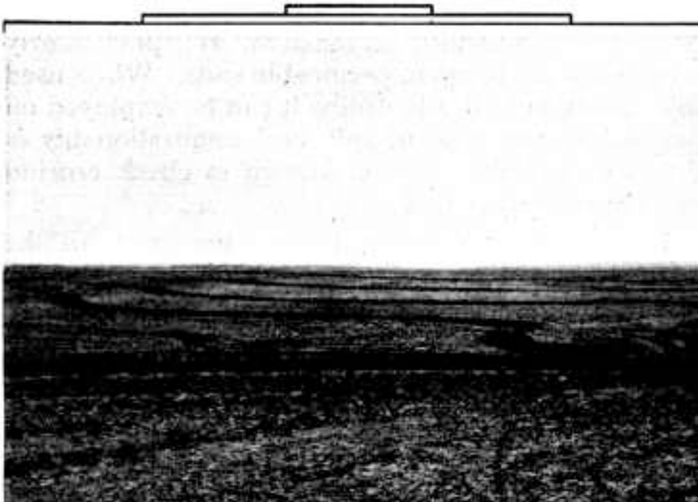
FARM TERRACING



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SOIL EROSION, which annually causes enormous losses to the farmers of the United States, is effectively controlled on moderate slopes by terracing. Two types of terrace—the modified Mangum and the level—are generally found best adapted to conditions in the United States. The former terrace is a broad-base, ridge type of terrace with a variable grade; the level terrace is similar except that it has no grade. Both can be crossed readily by modern farm machinery and without injury to the terraces. They may be planted to crops and cultivated in the same manner as the rest of the field.

The level terrace is most nearly an ideal terrace. Its distinct advantage is that it holds practically all of the soil and fertility on the field. It is particularly adapted to deep, open, permeable soils. When used in connection with tile drains it can be employed on practically any type of soil, and unquestionably is the most effective method known to check erosion and conserve moisture.

The modified Mangum terrace possesses all the advantages of the level type except that some of the fertile soil that is washed from the slopes and deposited in the terrace channel is carried off the field in the run-off water. It can be used on any type of soil, but is particularly recommended where the level terrace can not be used successfully without tile drainage.

This bulletin is a revision of and supersedes Farmers' Bulletin 1386, Terracing Farm Lands.

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FARM TERRACING[1]

By C. E. RAMSER, *Senior Drainage Engineer, Bureau of Agricultural Engineering*

CONTENTS

INTRODUCTION

IT IS ESTIMATED that erosion removes not less than 126,000,000,000 pounds of plant-food material from the fields and pastures of the United States every year. This is more than 21 times the amount removed by crops, according to an estimate of the National Conference Board. The annual financial loss to farmers probably amounts to about $200,000,000.

A test of crop yields on the department's soil-erosion experiment farm near Guthrie, Okla., on two comparable areas of eroded and virgin land with moderate slopes, resulted in a yield of 40.3 bushels of oats on the virgin land and a yield of 10.6 bushels on the eroded land. As the eroded land had been in cultivation about 30 years some of the difference in yield may be attributed to that fact. At a price of 45 cents per bushel for oats, the difference in the returns from the two areas would amount to $13.36 per acre. The cost of controlling erosion by terracing on badly gullied land that had been in cultivation about 35 years on the Guthrie farm was more than three times as great as on virgin land. This indicates the advisability of starting the control of erosion on virgin land when it is first broken rather than waiting until the land has become badly eroded and unproductive.

In regions of light rainfall, terraces serve also to conserve moisture. The results of experiments on the Oklahoma Agricultural Experiment Station farm at Goodwell, show that terracing to conserve the moisture on a land slope of only 2 feet in 100 feet increased wheat yields on an average of 21 per cent during a period of four years. On the Texas Agricultural Experiment Station farm near Spur, it was found that terracing increased crop yields from 20 to 40 per cent during a 3-year period.

Erosion injures fertile lands in a number of ways. The upper and most fertile parts of the soil are washed away until the land becomes barren and unproductive. (Fig. 1.) Deep gullies[2] are formed which mean an actual loss of cultivable land area, and result in a lowering of the water table and a deficient supply of moisture.

[1] This bulletin is based in part on studies conducted in cooperation with the Bureau of Chemistry and Soils.

[2] It is recommended that this bulletin be read in conjunction with Farmers' Bulletin 1234, Gullies, How to Control and Reclaim Them.

(Fig. 2.) Drainage ditches often become filled with sand, which frequently results in the flooding of the adjoining bottom land and the destruction of crops. (Fig. 3.) Rich bottom lands often are covered by deposits of sand washed from the hill lands. (Fig. 4.) Hence, the direct erosion losses of the upland farmer are the loss of

FIGURE 1.—Sheet erosion on a moderate slope in a wheat field. Note the strip of land in the center, rendered unproductive through sheet washing

FIGURE 2.—View from an airplane showing gullying which causes a loss of land and a lowering of the water table

the land area occupied by gullies, smaller crop yields each year, and continued decrease in the market value of the land. Some of the losses suffered by the bottom-land farmer are, cultivable land covered with sand, crops damaged by overflows or deposits of sand, continued decrease in the market value of the land, and the money invested in the construction of drainage ditches that have been wholly or partly filled with sand. Thus it is clear that both bottom-land farmer and the upland farmer should be concerned in effective measures for checking erosion.

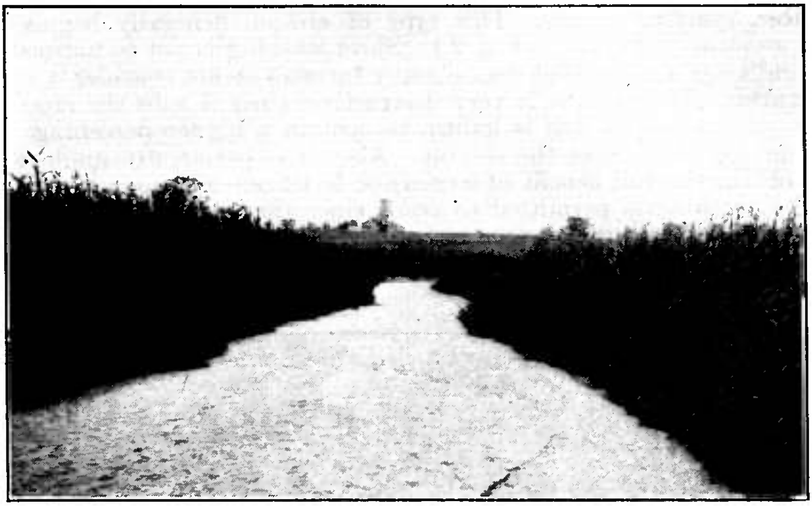

FIGURE 3.—Drainage ditch partly filled with sand washed from eroding hills

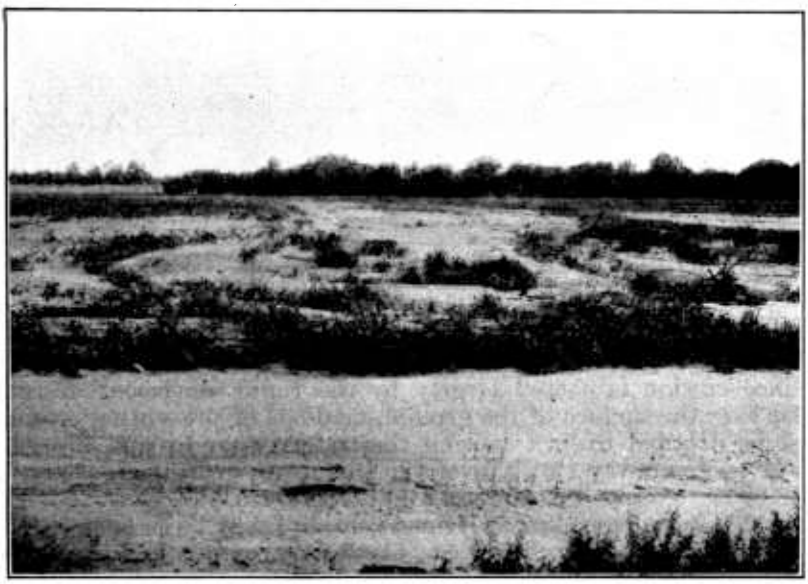

FIGURE 4.—Bottom-land field covered with sand washed from hill lands. Most of the deposit of sand shown is the result of one heavy rain

Erosion is caused chiefly by the direct action of heavy rains beating upon the ground; by the rapid movement of the rain water down the slopes of the land surface; and by the combined action of the freezing and thawing of saturated soil, followed by heavy rains.

(Fig. 5.) The steeper the slope the greater is the erosive action of running water.

Where the moving water is fairly uniformly distributed over the surface, the upper soil is washed away over wide areas; this form of erosion is known as sheet washing. (Fig. 1.) Where channels are washed down the slopes, by the concentration of large volumes of water, gullying occurs. This type of erosion generally begins in depressions or draws. (Fig. 2.) Sheet washing is not so noticeable as gullying, and for that reason many farmers do not consider it very harmful. However, it is very destructive, since it robs the land of the surface soil, which is known to contain a higher percentage of plant food than does the subsoil. Also, it is practically impossible to obtain the full benefit of expensive fertilizers and manure where sheet washing is permitted to occur since they are rapidly washed away along with the surface soil. If sheet washing were prevented, few gullies would ever occur in a field, because sheet washing finally develops into gullying.

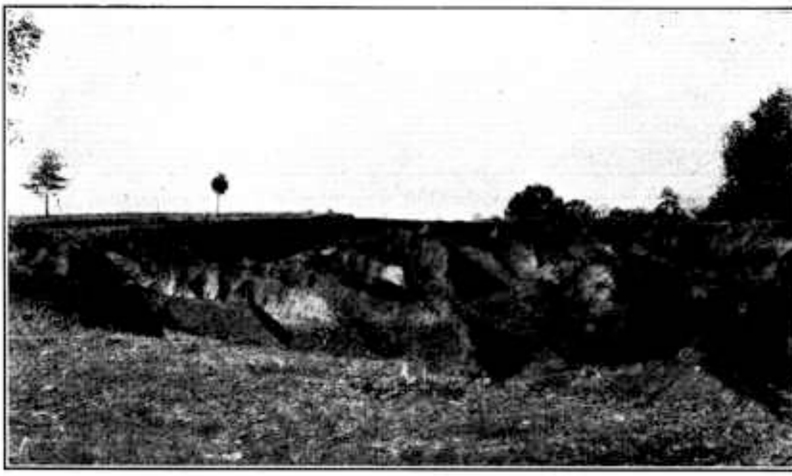

FIGURE 5.—Erosion on very silty soils which practically ruins broad areas of fertile land. Alternate freezing and thawing hasten the rate of erosion over such areas, particularly in the South

METHODS OF PREVENTING EROSION

Since erosion is caused largely by the rapid movement of rain water over the surface of the ground, methods of preventing erosion must be directed toward causing the water either to sink into the soil or to flow away slowly over the surface to a drainage channel.

In order to take up surface water rapidly a soil must be very permeable, which means that it must contain fairly large open spaces through which the rain water can pass easily, or in which it can be stored temporarily. Some soils are naturally very permeable; those that are not can be rendered more permeable by subsoiling or deep plowing; by plowing under organic matter such as manure, stubble, stalks, and cover crops; and by the practice of tile drainage.

Vegetation which covers the surface of the ground protects the soil from the direct action of the rain and checks the flow of water over the surface, thus giving the soil a better chance to absorb the water. It is therefore important that some kind of cover crop such as vetch, clover, oats, wheat, or rye be grown during the winter or at any time that the land is not used for other crops.

Contour plowing—which consists of breaking the ground along level lines across the slopes—reduces the flow of water directly down the slope. In planting and cultivating the crops the same level lines are followed, so that a shallow trough is made above each row, which catches and holds some of the rain water until it is absorbed by the soil. A great many gullies are caused in the beginning by the practice of plowing and cultivating directly up and down the slopes. (Fig. 6.)

THE MANGUM TERRACE[3]

The Mangum terrace consists of a broad ridge of earth thrown up across the hillside and having a grade in the direction of its length. (Fig. 7.) In throwing up this ridge a broad, shallow channel is formed along its upper side, through which the collected water flows at low velocity to the outlet channels at its ends. (Fig. 8.) The

FIGURE 6.—Erosion due to running cotton rows directly up and down the slope, a practice which is responsible for a large percentage of badly eroded lands

entire terrace is cultivated, and on moderate slopes the crop rows may run at an angle across the terraces (fig. 9), although better results are obtained when the rows are parallel with them.

HEIGHT

The top of the Mangum terrace should be from 15 to 24 inches higher than the bottom of the channel on the uphill side of the terrace. The terrace should be built ordinarily from 15 to 30 feet wide at the base, depending upon the slope of the land; the steeper the land the narrower the base. Wide terraces are the more desirable from the standpoint of crossing them with farm machinery. The width may be increased each year by throwing the soil to the center of the terrace in plowing until, on moderate slopes, the lower edge of one terrace meets the upper edge of the next terrace below, and the whole field, as often happens, becomes a series of terraces.

[3] Wherever the term "Mangum terrace" is used in this bulletin, the modified Mangum terrace is meant which has a variable grade. The true Mangum terrace has a uniform grade.

GRADE

In most soils it has been found that washing in the channel of the Mangum terrace takes place when the grade of the terrace is greater than 6 inches in 100 feet, and even with this grade some of the

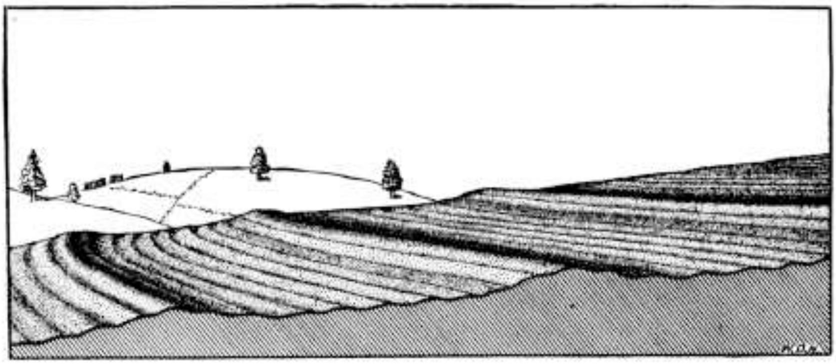

FIGURE 7.—Mangum terraces. These are simply ridges of earth thrown up across the hillside and given a slight grade in the direction of the terrace to carry off the water at a low velocity

fertile parts of the soil are carried away by the water. It is therefore advisable that there be as slight a grade as is practicable and never more than 6 inches in 100 feet.

FIGURE 8.—Water flowing off at a low velocity in a broad, shallow channel of a Mangum terrace

The grade of a terrace refers to its drop in 100 feet of length and may be either uniform or variable. By a variable grade is meant one that increases from the upper to the lower end of the terrace. A variable-graded terrace is superior to a terrace with uniform grade, since it removes the surface water with less washing in the terrace channel and with less probability that the terrace will break near the lower end owing to the piling up or concentration of the run-off water. Also if the upper part of a terrace has less grade than the lower part, the tendency is to store or hold back the upper water until the water below has a chance to flow off.

A good practice is to change the grade every 300 feet along the length of the terrace. The following tabulation gives grades suitable for use in laying out Mangum terraces with variable grade. If it is necessary to lay out a terrace longer than 1,500 feet it should be built higher for the additional length near the lower end, or else the terraces should be placed closer together than is indicated in the tabulation on spacing in the paragraph below.

FIGURE 9.—Soybeans planted in rows across a Mangum terrace

Length of terrace	Drop of terrace in 100 feet of length
0 to 300 feet	level.
300 to 600 feet	1 inch.
600 to 900 feet	2 inches.
900 to 1,200 feet	3 inches.
1,200 to 1,500 feet	4 inches.

SPACING

The vertical distance, or drop, between Mangum terraces depends principally upon the slope of the land. Terraces should be spaced close enough to prevent appreciable washing between them. The following tabulation gives the vertical distances between terraces recommended for use on different slopes.

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Slope of land per 100 feet	Vertical distance, or drop, between terraces[4]
Less than 1 foot	1 foot.
1 foot	2 feet.
2 feet	2½ feet.
4 feet	3 feet.
6 feet	3½ feet.
8 feet	4 feet.
10 feet	4½ feet.
12 feet	5 feet.
14 feet	5½ feet.

LIMITING LAND SLOPES

Where modern machinery is used in cultivating the land, the Mangum terrace is adapted for use on slopes of up to 10 feet in 100 feet. On steeper slopes there is difficulty in crossing these terraces with machinery. Where such equipment is not used Mangum terraces have, in certain instances, proved successful on slopes of as much as 15 feet in 100 feet. However, as a general rule it is advisable to leave slopes with a fall exceeding 12 feet in 100 feet in hay, pasture, or timber.

CAUSES OF FAILURES

Failure of Mangum terraces occurs most commonly at sharp bends, at crossings of draws or gullies, and at points where either an abrupt reduction in grade or size of channel has been made. Breaks at bends are caused by water washing against the terrace and cutting through the embankment of earth and occur commonly where the terrace has considerable grade and the water a high velocity. Such breaks may be prevented by seeding the terraces to grass at bends and on areas where there are sudden changes in grade and thus leaving them uncultivated. Breaks at crossing of gullies or draws are usually caused by failure to build the top of the terrace to the proper height across such places or by not making the proper allowance for the settlement of the terrace. The grade of the top of the terrace leading into a draw never should be greater—and preferably should be less—than the grade of the top leading out, because a greater grade above would result in much more water being brought into the draw than could be carried out on the lighter grade.

THE LEVEL TERRACE

In all terraced fields some washing is bound to occur on the slopes between the terraces. The rich soil particles washed from the slopes collect in the channel above the lower terrace. If the terrace has a grade, part of the soil is carried off with the water, the quantity depending on the steepness of the grade. If the terrace is level, practically all the soil remains on the field. From this it is seen that a terrace should have no more grade than is absolutely necessary, and wherever conditions will permit it should be level. The level terrace is particularly adapted to land composed of deep, porous soils.

The level terrace is built in the same manner and to the same dimensions as the Mangum terrace, except that it has no grade to

[4] These recommendations are for the Southern States, where rainfall, soil, and farming conditions are more favorable to erosion. For the Northern States, the vertical distance between terraces should be increased by from 10 per cent for a land slope of 2 per cent, to 30 per cent for a land slope of 15 per cent. Where the soil is extremely susceptible to erosion so that washing is likely to occur between the terraces, the vertical distances given above should be decreased by one-half foot. On the other hand, if the soil contains considerable humus and is capable of absorbing a large part of the rainfall so that it is not easily eroded, the vertical distances may safely be increased one-half foot.

carry off the water. The rain that falls between the terraces is collected and held above the lower terrace until it evaporates, is absorbed by the soil, or finds its way slowly to an outlet at the ends of the terrace. (Fig. 10.)

The ends of level terraces may be closed to prevent the escape of any of the surface water, or may be left open to allow the water to pass away slowly. If the soil in a field is capable of absorbing all of the rainfall so as to leave no water standing on the surface long enough to injure crops, the ends are closed; otherwise they are left open. Where the ends are closed the terraces should be built at least 18 inches high in regions of heavy rainfall. In Figure 11 is shown a plan of a terraced field where two of the upper terraces completely encircle the top of a hill, there being no way for the

FIGURE 10.—Water standing above a circular level terrace with no outlet, after a heavy rain

water to escape over the surface to a drainage outlet. These terraces have given complete satisfaction. This practice is very common and has proven successful in regions of light rainfall with permeable soils.

The following tabulation gives the proper drops, or vertical distances between level terraces with closed ends, for several kinds of soil in regions of comparatively heavy rainfall, it being assumed in each case that the soil is deeply plowed, contains considerable humus, and is capable of absorbing a large part of the rainfall.

Type of soil	Vertical distance, or drop, between terraces [5]
Sandy	4½ feet.
Sandy loam	3½ feet.
Clay loam	2½ feet.
Clay	2 feet.

[5] For land slopes greater than 10 feet in 100 feet, the drop between terraces should be increased one-half foot. For level terraces with open ends on porous, permeable soils use the same spacings as recommended for the terrace with grade on p. 8.

In crossing a gully or draw in a field it is almost impossible to prevent the formation of pockets above the terrace that tend to hold the water on the surface. To remove the water that stands in such pockets it is recommended that tile be laid down the middle of the draw to a drainage outlet at the foot of the slope. A profile view of a tile line laid in a draw and provided with a drop inlet above each terrace is shown in Figure 12. The use of the drop inlets allows particles of soil in the water to settle before the water is drained away.

In regions of light rainfall, or where crops suffer severely from drought, level terraces are especially effective in retaining a supply of moisture which is often much needed on rolling and hilly lands during the growing season and during periods of drought. The following tabulation gives recommended vertical distances between terraces for different slopes in regions of light rainfall, this distance being governed largely by the horizontal distance between terraces required to obtain the best distribution of moisture.

Slope of land per 100 feet	Vertical distance, or drop, between terraces
Less than ½ foot	½ foot.
Less than 2 feet	1 foot.
Less than 4 feet	2 feet.
Less than 8 feet	3 feet.
Less than 12 feet	4 feet.

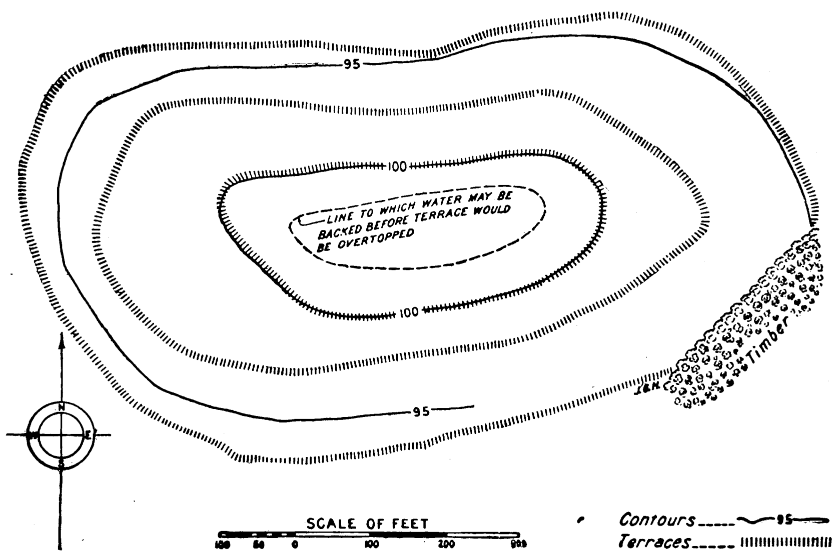

FIGURE 11.—An example of level terraces encircling the top of a knoll. The upper two terraces have no outlet

COMBINED SYSTEM OF LEVEL TERRACES AND TILE DRAINS

Some farmers who fully realize the importance and value of completely checking erosion on their farms have gone to the expense of installing complete systems of tile drains in connection with systems of level terraces. This unquestionably is the most effective method known to hold in place the soil of a hill farm, and its value can not be overemphasized. In a combined terrace and tile-drain system the lateral tile drains are laid in the depressions along the upper sides of the terraces and connect with the main tile drains that are generally laid down the center of gullies or draws to a drainage outlet at the foot of the slope. If the surface water does not pass rapidly through the soil to the tile drain it may be necessary to build surface inlets at intervals in the lateral tile lines to afford a direct flow of water into the tile.

It is advisable to employ the services of a competent and experienced engineer to design and superintend the construction of tile drains. Information relating to the proper design and construction of tile systems is given in Farmers' Bulletin 1606, Farm Drainage.

TERRACE OUTLETS

The provision of suitable outlets for the removal of surface water at the ends of graded terraces is often the biggest problem in terracing work. Natural watercourses make ideal outlets. However, they are not always available because the disposal of the water is generally limited to the field that is being terraced. To make the best use of natural drainage outlets, it is often advisable for neighboring farmers to cooperate in terracing adjoining fields. Where this is done, the

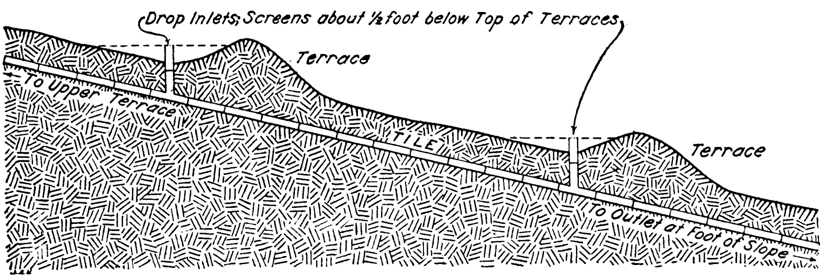

FIGURE 12.—Method of removing water standing above terraces in a gully or draw

terraces can be run across the property lines, and there will be no cause for the development of gullies at such lines as is often the case when it is necessary to end the terraces there.

Side ditches along farm roads are often used for terrace outlets. Where they are not protected in some way, bad washing may occur and cause considerable injury to the road. When it is desired to use the side ditches along a public highway as an outlet for water from terraces, the officials in charge of the highway should be consulted before any work is done, so that possible injury to highways may be avoided. Washing may be prevented by building dams of brush, rock, or concrete across the ditches at suitable intervals down the slope, or by lining the ditches with some hard material such as stone or concrete. Usually, where a terrace discharges into a roadside ditch a considerable drop of the water occurs at the end of the terrace. In such cases a gully invariably forms along the upper side of the terrace. This can be prevented by building a concrete drop or by the use of a wooden-box trough which discharges the water with a free overfall into the ditch at the end of the terrace. Sometimes a protection for both the terrace channel and the ditch is built of concrete.

Erosion is most active near the end of a terrace, where the largest flow of water occurs. For this reason it is sometimes advisable not to cultivate the last 25 to 50 feet of the terrace and terrace channel but to seed them to grass for protection against erosion.

Sometimes it is found necessary to use a natural draw in a field as a terrace outlet. Where this is the case the draw should either be seeded to grass or some other means—such as the soil-saving dam—should be employed to prevent the erosion of a deep gully. Farmers' Bulletin 1234, Gullies: How to Control and Reclaim Them, contains descriptions of soil-saving dams.

LAYING OFF TERRACES

In laying off a system of terraces it is first necessary to provide for suitable outlets. Wherever possible, outlets should be placed at both ends of the terraces. This divides the water of the field and gives each terrace the minimum quantity to handle. Short terraces are less likely to break than long ones and are, therefore, more desirable.

When a draw or depression occurs near the middle of the field it is desirable to begin the terraces in the draw, so as to avoid building a high embankment such as would be required for carrying the water across it. Of course, the possibility of doing this depends upon the size of the draw. Sometimes it is found necessary to use such a draw as a terrace outlet where suitable outlets are not available at the border of the field.

It is always best to lay out the uppermost terrace first. A starting or reference point for this terrace should first be fixed by measuring down the proper vertical distance from the top of the hill or the highest point in the field. If a terrace midway down the slope is laid out first, and a point from which to start is selected at random without respect to the top of the hill, the chances are that the upper terrace will drain either too large or too small an area. If it is made to drain too large an area—which is a very common mistake in terracing—the excessively large volume of drainage water generally breaks the upper terrace, and usually all of the terraces below are then broken in turn. If the upper part of a hill belongs to a neighbor an effort should be made to induce him to terrace it. Otherwise it will be necessary to dig a hillside ditch or an embankment along the upper side of the field to intercept the water draining from the neighboring farm above.

Homemade instruments are often used for laying off the terrace lines—such as the **A** frame with plumb bob or spirit level—but unless the work is done very carefully the results are generally poor. A farm level, costing about $20, is widely used, and any intelligent person with care can obtain good results with this instrument.

The field work required in laying off a system of Mangum terraces with variable grade is as follows: Set the leveling instrument about midway between the ends of the uppermost terrace, and high enough so that when it is level the line of sight will be above the highest point in the field. Have an assistant hold a level rod on this highest point and read the rod there and also at a point 50 feet directly down the slope. Twice the difference between the rod readings obtained is the slope of the land in 100 feet between those two points. From the tabulation on page 8 find the recommended vertical distance, or drop, between terraces for that slope.

Example

Rod reading at top of field	1 foot
Rod reading 50 feet down the slope	5 feet
Difference in rod readings	4 feet
Twice the difference in rod readings or slope of land in 100 feet	8 feet

According to the tabulation (p. 8) the vertical distance, or drop, between the top of the field and the first terrace in this case should be 4 feet.

Set the target on the rod at 5 feet (which is 4 feet above the rod reading at the top of the hill). Have the rodman move the rod down the hill until the line of sight through the telescope strikes the center of the target. The point thus located is 4 feet below the top and therefore is the starting point on the first terrace, provided an outlet is available at each end.

From this point locate the line of the terrace in both directions, giving it the grade shown in the tabulation on page 8. To do this, the rodman sets the target at 5 feet, one-fourth inch (in the example above), moves 50 feet along the side of the hill, and is directed up or down the slope by the man at the instrument until the line of sight through the instrument strikes the center of the target. The point on which the rod rests is one-fourth inch lower than the starting point and therefore is the second point on the terrace. The target is then moved up another one-fourth inch, the rod carried on 50 feet farther and the third point located in the same manner. In accordance with the tabulation (p. 7), after the first 300 feet of terrace has been located the target should be raised one-half inch (instead of one-fourth inch) for each 50 feet; after 600 feet, 1 inch; after 900 feet, 2 inches; and after 1,200 feet, 3 inches, to the end of the terrace. A terrace should not carry water more than 1,500 feet in one direction if it can be avoided. If a longer terrace is necessary the grade should not be increased above 3 inches in 50 feet, but instead the lower end of the terrace should be built to extra height to take care of the excess water.

After the uppermost terrace has been located from the middle of the field toward one outlet, the next step is to locate the other half of this terrace in exactly the same manner.

Sometimes it is impossible to provide an outlet at each end of a terrace; it is then necessary to carry all the water to an outlet at one end. Under such conditions the terrace should not exceed 1,500 feet in length unless the lower end is given an extra height as before mentioned. In the above example the rod reading on the first point located on the terrace line was 5 feet. Use this as a reference point although it may not prove to be exactly on the terrace line because in this case locating starts at the edge of the field. Lower the target 6 inches and have the rodman carry the rod to the edge of the field at the upper end of the proposed terrace and move it up or down the slope until the line of sight through the instrument strikes the center of the target on the rod. This is the starting point for the terrace and is 6 inches higher than the reference point. The purpose of starting the terrace 6 inches higher than the reference point in the middle of the field is to insure that the terrace line shall pass close to the reference point in the middle of the field. It is evident—since the terrace line continually falls—that if it were started at the same elevation as that of the reference point, the line would fall below the reference point by the time the middle of the field is reached. The terrace can now be laid off by raising the target each 50 feet exactly as described in the previous example.

Before starting to locate the second terrace, the slope of the land should again be measured. Read the rod at a point on the first terrace about midway between its ends. Measure 50 feet directly down the slope and read the rod at this point. It will sometimes be necessary to reset the instrument farther down the hill before this can be done. If the instrument is moved, both readings must be taken from the new position. Having determined the slope of the land, refer again to the tabulation on page 8 to find the proper vertical drop between the terraces for the new slope and proceed in the same manner as with the first terrace.

The level terrace is much simpler to lay off than the Mangum terrace because—since it has no grade—it is not necessary to measure distances along the terrace line. The reference point should be located, as in the case of the Mangum terrace, and the terrace line run in both directions through this point. The rod reading will be the same for all points on the terrace as long as it is not necessary to shift the instrument.

In terracing work distances are measured by pacing. In pacing the distances the rodman should try to estimate as nearly as possible where the next point will be, and when directed up or down the hill by the levelman should keep the proper distance from the last point. To avoid mistakes the rodman should always change the target before starting to pace off the distance. If the field has been cultivated in ridges, the points should be located by setting the rod either always on top of the ridges or always in the depressions between them. If after the proper distance between points on the terrace line has been determined it is found that the rod is too low when set in a depression between the ridges and too high when set in the next depression above, then the proper location for the line of the terrace lies between the two positions of the rod.

A man should accompany the rodman and set stakes at points on the proposed terrace lines. A plowman should follow immediately and lay out the first furrow. Care should be taken to see that no abrupt turns are made with the plow. All changes in direction should be made by smooth, regular curves. Where gullies or draws are crossed, stakes should be set on each side and the terrace run directly across.

Long sights with the level (exceeding 500 or 600 feet) should be avoided. Much more accurate results are obtained where short sights are taken. When it becomes necessary to move the level so as to avoid taking long sights or in order to see around a hill, the rodman should remain holding his rod exactly on the last point located. When the level is set up at the new position the rodman raises or lowers the target so that the new line of sight of the level passes through the center of the target and the work proceeds as already described.

BUILDING TERRACES

In terracing a field, the uppermost terrace should always be built first. If a lower terrace is built first and there is not time to build the upper one before a rain comes, the lower terrace is almost sure to be broken and badly washed by the large volume of water drained from all the land above.

Implements most widely used in the construction of terraces are the wooden V drag (fig. 13), the V-shaped ditcher (fig. 14), the single-blade ditcher or terracer (figs. 15 and 16), and the ordinary road grader. Terraces are also built with an ordinary plow or with a plow having a specially designed moldboard. The ordinary disk plow and the 1-way plow are also sometimes used in the construction of terraces.

The wing on the steel ditcher shown in Figure 14 is adjustable so that the dirt can be moved laterally different distances from the point of the machine, and an extension can be placed on this wing, as shown in the figure, which makes it possible to move the dirt still further.

The machine shown in Figure 15 has an adjustable blade operating somewhat on the principle of the ordinary road grader. The blade is held in position by revolving steel disks located near each end of the blade. Both the horizontal and the vertical angle of the blade can be adjusted by means of the two levers shown in the figure. In the machine shown in Figure 16, the steel disks which hold the blade in position are located close together, a short distance behind the blade.

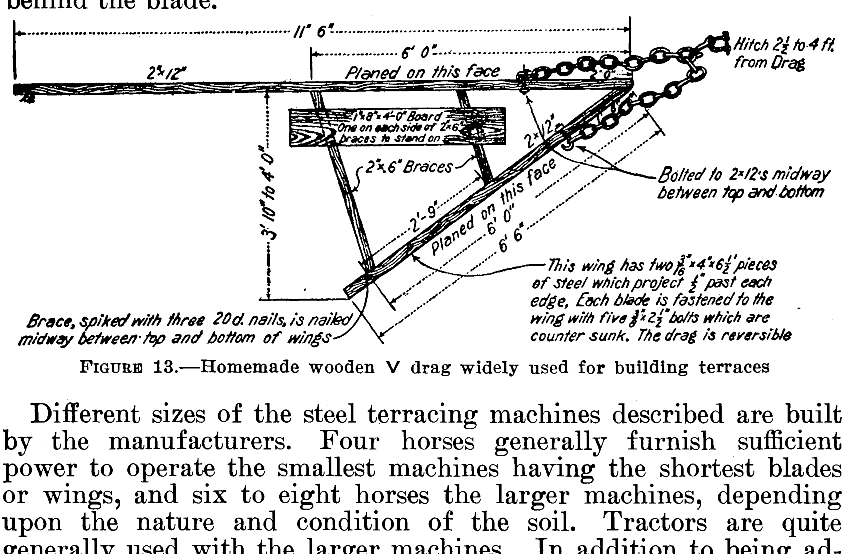

FIGURE 13.—Homemade wooden V drag widely used for building terraces

Different sizes of the steel terracing machines described are built by the manufacturers. Four horses generally furnish sufficient power to operate the smallest machines having the shortest blades or wings, and six to eight horses the larger machines, depending upon the nature and condition of the soil. Tractors are quite generally used with the larger machines. In addition to being adjustable both horizontally and vertically, the blade of the machine shown in Figure 16 can also be tilted forward or backward.

There are two general methods of building terraces. One method consists of moving all the dirt from the upper side, the other of moving the dirt from both sides. Each method has its advantages although the second method is most widely practiced. It does not require moving the dirt as far as does the first method and does not necessitate the reversing of the terracing implement at the ends of the terraces except where more dirt is moved from the upper than from the lower side. Moving all the dirt from the upper side has the advantage of making a larger channel above the terrace for the removal or storage of the run-off water. It is also easier to move the soil down than up the slope. However, this method has the disadvantage of hastening the movement of the soil down the slope.

In Figure 17 is shown an average cross section for a terrace built by moving the dirt from both sides. The most common method

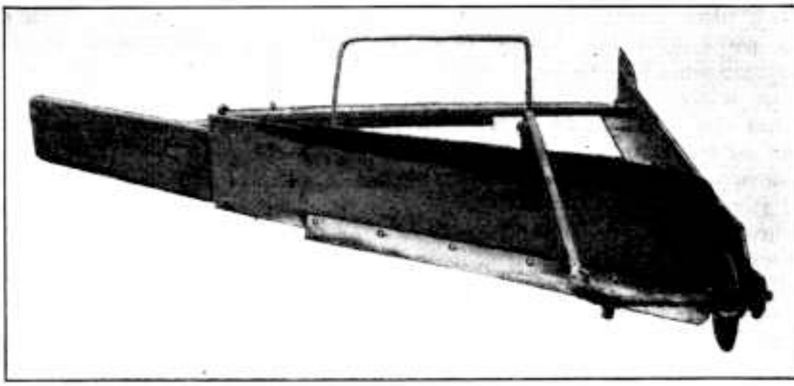

FIGURE 14.—V-shaped steel ditcher or terracer with extension board on movable wing

practiced by farmers in building terraces is to leave the earth shoulders, indicated by the dotted lines in the figure, to be smoothed down by farm operations. It is better, however, to cut back these shoulders as indicated and place the dirt on the terrace. Terraces

FIGURE 15.—A steel ditcher or terracer with steel revolving disks near each end of adjustable blade to hold blade in position

may be built either wider or narrower than that shown in the cross section. The wider the terrace the greater is the cost, but with large machinery it is easier to cultivate the wide terrace, particularly when it is crossed at an angle.

In building terraces with the V-shaped steel ditcher shown in Figure 14, where the dirt is moved from both sides, a backfurrow strip four furrows wide is first laid off with the plow. The terracing implement follows the second round with the plow, and it is generally advisable, under most soil and surface conditions encountered, to follow the plow each succeeding round with the terracer. The point of the machine is run in the plow furrow, the wing of the machine being set so as to move the dirt to the center of the terrace. As the terrace widens the wing of the machine is opened, and an extension is placed on it so that the dirt is placed as near the center of the terrace as possible. During the first few rounds the terrace should be built as high as possible. When there is not much vegetation on the ground and the soil is of uniform texture and easily worked, this machine is sometimes used without plowing except to lay out the

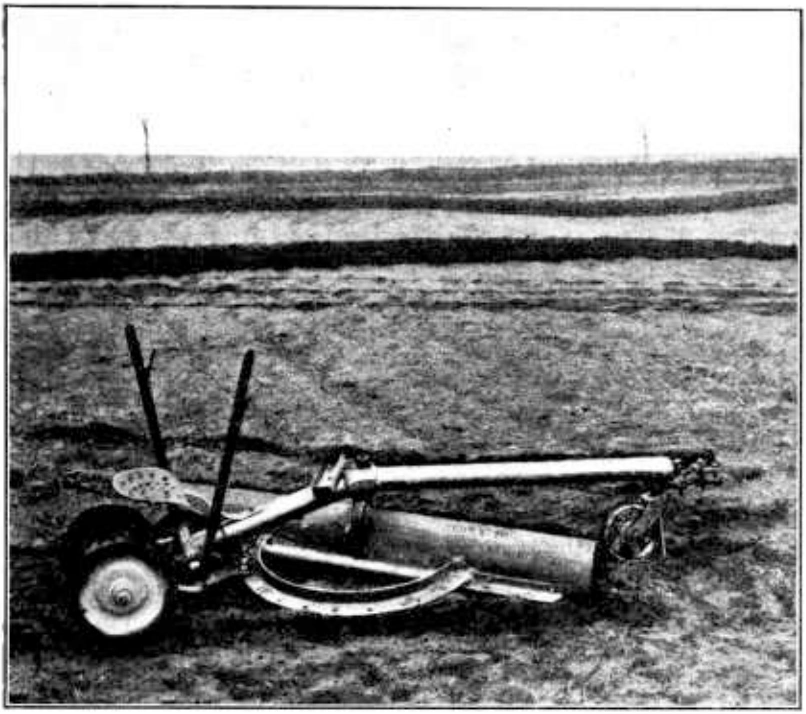

FIGURE 16.—A steel ditcher or terracer the blade of which can be tilted and is held in position by revolving disks a short distance behind the blade

terrace. If it is found that the terrace is not high enough or has not been built to the desired cross section, operations should be started at the center of the terrace and repeated for the full width of the terrace. The shoulder left where the last furrow is plowed should be beveled off and the dirt placed on the terrace embankment. Only one man is required to operate the V ditcher, but the best results are obtained when two men ride the implement and shift their weight as required for the most satisfactory operation. This machine operates quite successfully on rocky ground and in newly cleared ground.

In constructing terraces with the single-blade implement shown in Figures 15 and 16 different methods are employed. One is similar to the method above described, which consists of starting at the center of the terrace. Another is to start at the outside limits of the terrace and move the dirt to the center by repeated rounds, all vegetation that might interfere with the smooth operations of the implement being scraped to the center of the terrace with the first soil moved. Still another method, which is a compromise between these two, is to plow with the point of the implement parallel furrows 4 feet on each side of the center line of the terrace. (Fig. 18.) If sufficient dirt can not be plowed up in one trip to furnish a load for the machine, two plowing trips should be made before moving the dirt to the center of the terrace. The operation of plowing and then moving the dirt to the center of the terrace is repeated until the terrace is of the required width. In moving the dirt the blade is allowed to cut just enough into the firm ground to steady the implement and cause the blade to scour properly. In Figure 19 is shown one of these machines, which is plowing up dirt preparatory to moving it toward the center of the terrace on the next round. In Figure 20 the same machine is moving dirt to the center.

In building terraces with the wooden V drag the same method is employed as in using the V-shaped steel terracer. The only advantage of this drag over the steel terracer is its cheapness. In Figure 13 are given dimensions for the construction of a wooden V drag. Building terraces with this drag is a considerably slower process

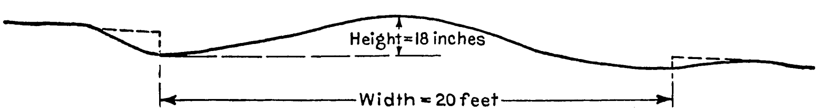

FIGURE 17.—Average cross section of a new terrace built by moving the dirt from both sides, showing the dimensions considered as the width and height of the terrace

than with the steel terracer, and it is necessary to loosen up with a plow practically all of the dirt to be moved. The weight of two men is required on the wooden drag for its satisfactory operation.

In building terraces by moving all of the dirt from the upper side it is necessary to reverse the implement at each end of the terrace. All of the implements described above are reversible. The method of moving the dirt from the upper side is somewhat similar to that employed where the dirt is moved from both sides, but much of the dirt must be moved over the top of the terrace to form the proper slope on the lower side.

Terraces are sometimes built with a plow and Fresno scraper, particularly on steep slopes. A strip of ground is backfurrowed with a plow, and the loose earth on the upper half of the strip is moved over on the lower half. This process is repeated until the terrace is built to the desired height and cross section.

To finish a terrace properly some work with the scraper is generally required. The top of the terrace should be tested with the level and rod to see that it conforms to the proper grade. Any low places detected should be filled with the shovel or scraper. All large embankments across draws and gullies should be built with the scraper, and it is necessary to build such embankments considerably higher than the rest of the terrace to allow for settlement. Most breaks in terrace systems occur at crossings of gullies or draws, and it is therefore very important that a high, broad, substantial embankment be built across these places.

Any obstructions—such as rocks, stones, and stumps—that lie along the line of the terrace should be removed, since their presence

FIGURE 18.—One method of starting the construction of a terrace with the single-blade terracing machine shown in Figure 15. One round with the machine has been made, the furrows being about 8 feet apart

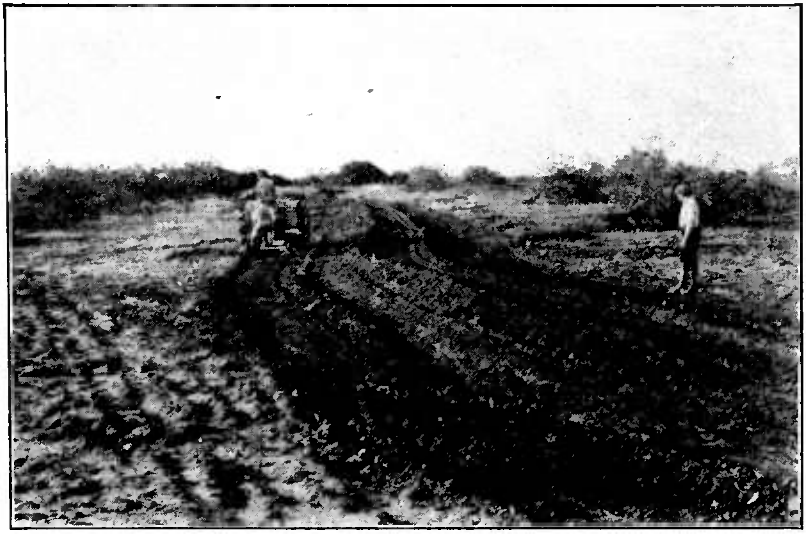

FIGURE 19.—Building a terrace with a single-blade steel terracing machine. The machine is cutting dirt to be moved toward the center of the terrace on the next round

might permit seepage and result in the failure of the terrace. In some parts of Texas the fields contain numerous large earth mounds generally known as gas mounds. These cause considerable difficulty in terracing fields. Where they lie along the lines of graded terraces it becomes necessary to provide passageways through them by means of the plow and scraper.

Where terraces are continued from one field to another across a fence row it is necessary to build the sections near the fence by hand labor, using the spade and shovel. It is very important that such parts of the terrace and channel be built of the same size as the rest, and considerable attention should be given later to see that the waterway is kept open so that the free flow of water shall not be obstructed.

POORLY BUILT TERRACES WORSE THAN NONE

The directions for laying off and constructing terraces should be followed carefully, and after the terraces are built they should be checked with a level to make certain that they have the proper grades

FIGURE 20.—Building a terrace with a single-blade terracing machine. The machine is moving dirt toward the center of the terrace

and that there are no low places in them. Poorly constructed terraces with improper grades are almost certain to fail and are likely to cause more serious erosion than would have occurred without terraces. The old maxim, "what is worth doing at all is worth doing well," is especially applicable to terracing work. If one has not time to terrace all of a field properly it is far better to terrace the upper part well than to attempt to terrace the whole field and do a hurried and poor job.

COST OF BUILDING TERRACES

Several variable factors affect the cost of constructing terraces. Some of these are, nature and condition of the soil, length of the terraces, vegetal covering, kinds of implements used, methods employed, and the skill and experience of the operator and the vigor with which he pushes the work. In some instances constructing terraces in wet soil may easily cost twice as much as in dry soil. More time and labor are required to build a terrace in a heavy clay than in a sandy loam soil. Short terraces cost more per running foot than long terraces, owing to the time lost in more frequently turning the equipment at the ends. A heavy covering of long grass or weeds usually interferes with terrace building and retards the progress of the work. Roots, rocks, sprouts, and stumps add materially to the difficulty of construction and in many cases make the cost of terracing prohibitive. The costs of constructing the same terraces by two experienced operators might easily vary as much as 50 per cent because of differences in skill. Farmers ordinarily do not have sufficient terracing work to do on their own farms to make them proficient in this work, and until an operator gains sufficient experience the cost of constructing terraces is appreciably greater than that for which he might do the same work later. To these several factors and to the fact that very little reliable cost data have been collected may be attributed the great differences of opinion among farmers and engineers with regard to the cost of terracing.

Where conditions are ideal for terracing work as regards type and condition of soil, uniformity of slope, freedom from stumps, roots and rocks, and absence of gullies or depressions so that no scraper work is required, a terrace 15 inches high, 20 feet wide, and not less than 1,000 feet long can be built on slopes of up to 6 or 8 feet in 100 feet at a cost of about $20 per mile or $1.50 per acre. The cost will range from the foregoing to as high as $180 per mile or $15 per acre where a field is badly cut up with many deep gullies. Table 1 may be taken as a general guide to the cost of building terraces of the dimensions given above, in light soils. For heavy soils, about 50 cents per acre should be added to the costs given in the table. The cost per acre will also increase on steeper land and for shorter terraces. Variations from the above costs will also occur on account of inexperience, poor equipment, and wet soil.

TABLE 1.—*Approximate costs*[1] *of constructing terraces 15 inches high, 20 feet wide, and not less than 1,000 feet long, in light soils on moderate land slopes*

Description of land	Cost per acre	Remarks
Clean-cultivated land, no gullies	$1.50-$2.50	
Grass or virgin land, no gullies	2.00- 3.00	
Clean-cultivated land, small shallow gullies	3.00- 6.00	Depending upon the number of gullies.
Clean-cultivated land, gullies 3 to 6 feet deep	7.00-15.00	Do.
Newly cleared land, no gullies, most stumps grubbed out.	7.00-12.00	Depending upon the kind and number of roots and stumps.

[1] The costs given above are based upon the use of a steel ditcher or terracer of the V shape or grader type. In using a wooden V drag the number of trips required to build a terrace to a given width and height is greater than that necessary with a steel ditcher or terracer, the time required amounting to from one-fourth to one-half more. Where the labor and power are paid for in cash the terraces thus constructed cost from 25 to 40 per cent more than when constructed with the steel terracer depending, of course, upon the soil conditions. Cost records also show that terraces built with a road grader in the hands of an experienced operator cost about 25 per cent less than when constructed with the steel terracer.

The costs of terracing work given are based upon the usual costs of labor and of team and tractor power. Frequently during seasons of the year when farm work is slack, labor and teams that would otherwise be idle can be employed to advantage on terracing work. By doing the work at such times and using a homemade V-drag, the cash outlay required is small. Under such conditions, lack of funds is a poor excuse for failure to protect land against erosion.

CARE AND CULTIVATION OF TERRACES

Terraces require considerable care and attention, especially during the first year before the loose soil has had time to become thoroughly settled. All apparently weak places should be visited after every heavy rain, and any breaks that occur should be repaired immediately. It is best not to cultivate the terraces the first year, but to seed them to some kind of cover crop.

On steep slopes it is advisable to run the crop rows parallel with the terraces, one row being on the top of the terrace if a single-row cultivator is used. The cultivation of the top row tends to keep the top of the terrace at the proper height. Where a 2-row cultivator is used it is better to run rows on each side of the top of the terrace, since with that implement it is difficult to cultivate a row on the top. Where the rows are run across the terraces—as is done commonly on moderate slopes, particularly where large farm machinery is used—the terraces tend to flatten out when cultivated, and more maintenance work is required than is the case where the rows are run parallel with the terraces.

All terraces that are cultivated should be plowed at least once a year, and the soil should be thrown to the center. In this way the height of the terrace is maintained and the base broadened each year. Some washing is bound to occur between terraces which tends to fill up the terrace channel. This deposit should be moved on to the terrace embankment.

Steep land that washes badly between the terraces should not be cultivated. The terraces should first be well built and then the entire field seeded to grass and used for pasture or meadow.

When it is necessary for terraces to cross a farm road they should be constructed without regard to the road. Where the terraces are as much as 20 feet wide, no provision need be made for passing traffic across them, but they should be carefully maintained to prevent possible breaks. With narrower terraces, considerable inconvenience to traffic and injury to the terraces generally result where no provision for crossing is made. Sometimes the water is carried under the roadway through culverts. The principal objection to this is that the capacity of the waterway is thus greatly reduced, and the free flow of water through the culverts is often obstructed by stalks or other trash washed from the field. A wooden bridge spanning the channel so as not to reduce greatly the cross-sectional area of the waterway, makes a more desirable and satisfactory crossing.

Following the terracing of eroded or run-down land it is generally advisable to improve the soil for at least one year by the use of cover and green-manure crops to be plowed under, rather than to attempt to grow a money crop on it immediately. The choice of crops for this purpose will depend upon locality, but for summer crops soybeans, cowpeas, and velvetbeans are among those of first consideration. As a winter cover crop to bind the soil and to add organic matter there is perhaps nothing that will equal rye and vetch. Manure, where available, should be used, especially on thin spots.

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