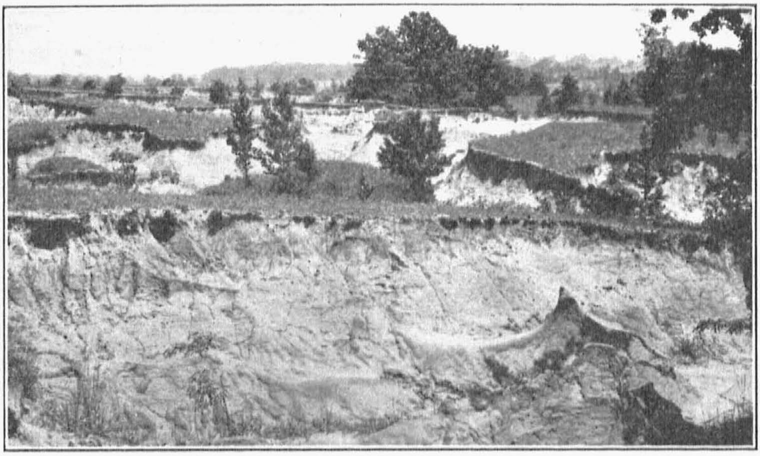
UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BULLETIN 271

The Control of Gullies



Gullying must be controlled or the fertility and beauty of our rolling farm lands will be destroyed.

COLUMBIA, MISSOURI
MAY, 1929

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE

Agricultural Experiment Station

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The Control of Gullies

R. E. Uhland and J. C. Wooley

A fertile soil is the basis of a profitable agriculture. No upland soil will maintain its fertility under continued cropping without the growing of restorative crops and the proper control of erosion. It is probably safe to say that the fertility of the average Missouri upland soil has already declined at least one-fifth by soil washing, while on the more rolling lands the decrease has been much greater. Heretofore, few farmers have realized the great importance of checking this loss, and as a consequence little effort has been made to control it.

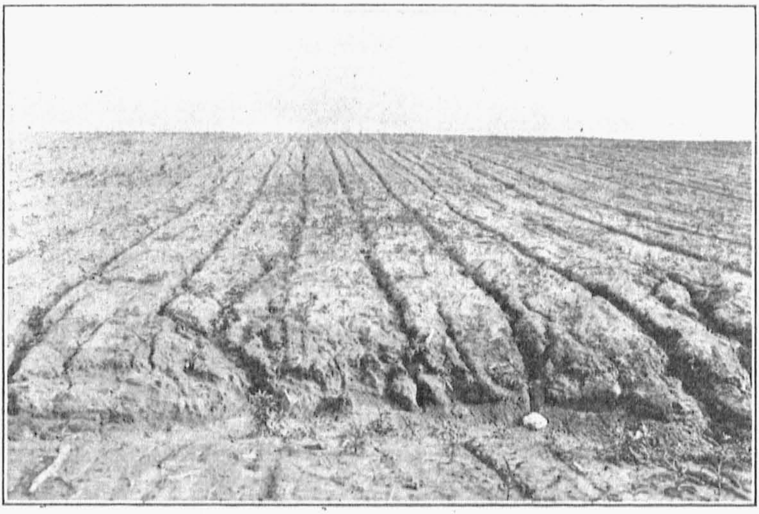


Fig. 1.—Gully erosion in a corn field recently planted. Many large gullies are started in this way.

Gully erosion has been especially severe and noticeable during the past few years. It has practically ruined some of the lands for farming and it has greatly decreased the value of other lands. This is becoming so great in parts of this state that it is calling for a decided change in our present system of soil management.

CAUSES OF GULLYING

Gullies are caused by erosion due to water collecting and flowing at a velocity sufficient to move and carry away soil particles. In sheet erosion, the water is said to move over the surface removing a more or less uniform layer of soil. However, the slope of most Missouri soils is not uniform, but contains small draws, which allow water to collect, giving the run-off greater volume and velocity and consequently greater erosive power. The water flowing in these draws rapidly forms gullies which, if unchecked, grow with each succeeding rain until they are often ten or more feet deep.

Careless Cultural Practices—Careless cultural practices have undoubtedly been responsible for the formation of many gullies. The cultivation of land directly up and down a slope, or the driving of a wagon down a hillside when the ground is soft, are among the common ways of starting gullies, which when once started grow very rapidly. Figure 1 shows the results of planting corn directly up and down a gentle slope. Paths formed by livestock are also responsible for the starting of many large gullies.

Character of Soils—Experience with the different soils in Missouri indicates that the physical properties of a soil are very important in controlling erosion. A sandy soil absorbs water rapidly so that the percentage of run-off is materially lower than on a silt loam or clay which absorbs water slowly. The bulk of Missouri soils are silt loams and these are quite subject to gullying.

Steepness of Slope.—The steeper the slope the greater is the erosive action of the water. If the slope is increased four times, the velocity of the water is about doubled and the power of the water to carry soil particles is increased nearly 32 times.

Lack of Organic Matter.—Soils low in organic matter absorb water very slowly, thus allowing a much larger percentage of run-off than is the case with soils well supplied with organic matter. For this reason lands that have been depleted of the supply of organic matter through long cultivation erode more readily than new lands. The lessening of the run-off of water as well as subsequent erosion caused by turning under clover stubble previous to planting corn are shown graphically in Figures 2 and 3, while the effectiveness of a good cropping system in controlling erosion is shown in Figure 4. The slope of the land where these measurements were made, is less than four per cent. It will be noted that the amount of soil eroded from the plot in continuous corn was more than six times as great as from the plot where a corn, wheat,

Soil Organic Matter Helps Reduce Water Runoff and Erosion

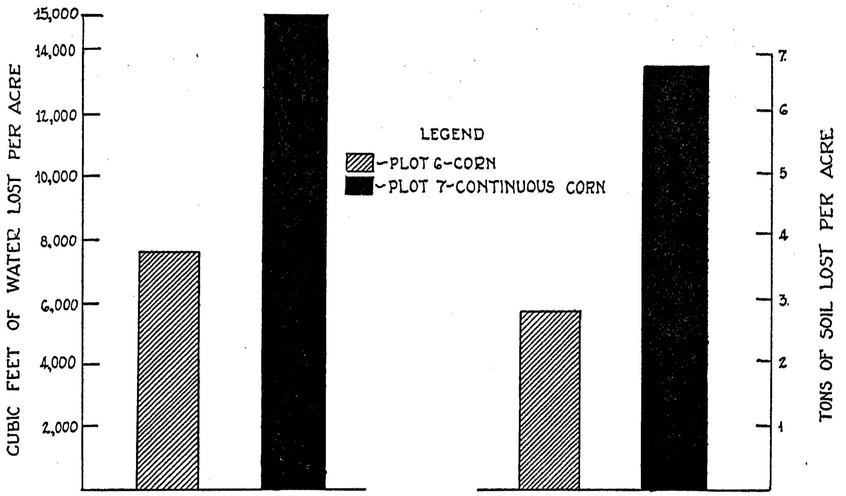


Fig. 2.—Water lost by runoff in cu. ft. per acre from two corn plots for the 5-month period, May 1 to October 1 (Av. 3 yrs). The water loss from Plot 7 was 15,000 cu. ft. per acre as compared to 7,868 cu. ft. for Plot 6. This shows that the water lost from Plot 6, where organic matter was incorporated by turning under clover stubble, was only 52 per cent as great as from Plot 7 in continuous corn.

Fig. 3.—Soil eroded in tons per acre from two corn plots for the 5-month period May 1 to October 1 (Av. 3 yrs). The soil lost from Plot 7 was 6.82 tons per acre while the loss from Plot 6 was 2.86 tons. These figures show that the incorporation of organic matter to Plot 6 by turning under clover stubble reduced the soil loss to 42 per cent of the loss where the land was in continuous corn.

A Good Cropping System Lessens Seasonal Erosion

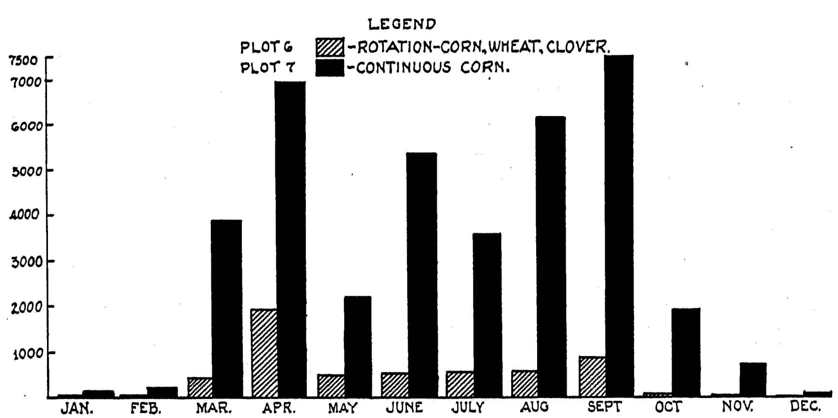


Fig. 4.—The average amounts of soil lost by erosion each month from two plots having different cropping systems for the 10-year period, January 1, 1918, to January 1, 1928. Height of columns indicates the average number of tons of soil eroded per acre each month.The annual erosion per acre for the land in rotation (Plot 6) was 5,400 pounds as compared with 38,600 pounds erosion from the land in continuous corn (Plot 7). The erosion loss from the land cropped to corn, wheat, and clover was only 14 per cent as much as from land in continuous corn.

clover rotation was followed. The use of a good cropping system will prove very effective in controlling sheet erosion and preventing the formation of gullies.

Occurrence of Torrential Rains.—Erosion data from this station show that heavy torrential rains, occurring when the soil is under cultivation are responsible for very serious losses from gullying. Thus during the month of June 1928, 14.86 inches of rainfall was recorded by the Government Weather Bureau of Columbia. The total amount of soil eroded from a plot in continuous corn during that month was greater than the total amount of soil lost from the same plot during the preceding 33 months.

TYPES OF GULLY EROSION

There are two types of gully erosion—headwater erosion and waterfall erosion.

Headwater Erosion.—Due to the occurrence of frequent heavy rains, soils are unable to retain all the water that falls on rolling land and the surplus accumulates in small draws and depressions. This water forms a stream, with a power to wash or cut gullies proportional to its size and velocity. Where the draw or depression is not sufficiently protected by grass or other cover, a gully begins to form which enlarges with each succeeding rain. The gully usually makes its first appearance at the lower end of the draw, because of the larger volume of water. As the eroding action of the water increases the steepness of the slope becomes greater and the gully gradually eats its way up the slope by what is commonly called head-water erosion.

This same type of erosion may occur as a result of careless cultural practices which give direction to the water. In many cases a dead furrow extending down a slope has caused the development of a very large and deep gully. Many gullies have also been started by the passing of a wagon down a hillside when the ground was soft.

Waterfall Erosion.—Waterfall erosion occurs where the surface material, to a depth of 1½ to 4 feet, is more resistant than that beneath. Water falling over the edge of the gully or ditch produces an undermining action on the more easily eroded material which causes masses of surface soil to break off and fall into the gully. This soil is then carried away by the water and the process repeated, thus allowing the water-fall to move slowly up the slope, leaving a narrow gully with very steep sides, which can be crossed only with difficulty.

The growth of these gullies is more dependent upon the size of the drainage area furnishing water than upon the slope of the land. As they eat their way up the slopes numerous branching gullies may start as shown in Figure 5. It is noted that a network of gullies is produced which greatly mars the appearance of the land and renders it unfit for cultivation.

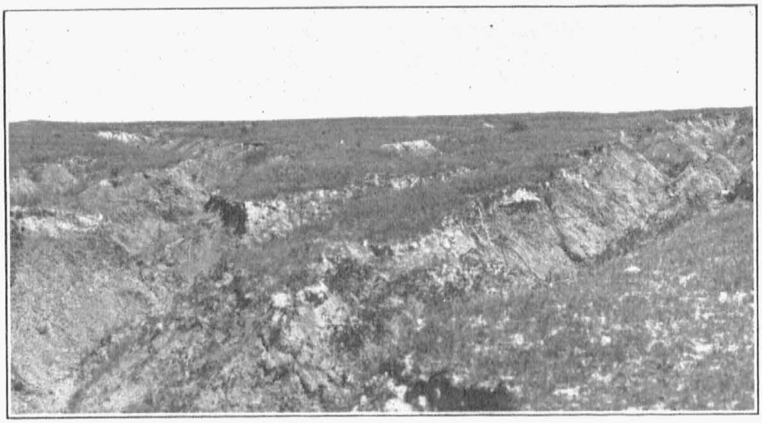


Fig. 5.—Network of gullies resulting from neglect to check the first one which started.

LESSENING THE TENDENCY FOR GULLIES TO FORM

If farmers could have foreseen the results of careless cultural practices or of neglect to spend a few minutes in checking the beginning of a small gully, many of our largest gullies would never have been formed. With the occurrence of frequent heavy rains coupled with the fact that most Missouri soils are unable to absorb all the water that falls, considerable run-off is inevitable.

The U. S. Weather Bureau reports a rainfall of 6.61 inches in 24 hours at Columbia and a fall of 3 inches in thirty minutes at Fayette, Howard county. Such rains as these are unusual, but during the past few years numerous rains have occurred which exceeded two inches in 24 hours. Such rains result in a high rate of run-off due to the fact that there is not sufficient time for the water to be absorbed by the soil. As a consequence, some gullies are formed in spite of one's best efforts. Nevertheless, anything which can be done to decrease run-off will lessen the number of gullies which start. It is seldom that gullies develop without a considerable amount of sheet erosion also taking place. Anything in the way of better cropping systems tends to lessen or control sheet erosion and likewise to prevent gullies from forming.[1]

[1]See Missouri Experiment Station Bulletin 211.

METHODS OF FILLING GULLIES

The most important principle in controlling gullies is to stop them when they are small. It costs little to stop small gullies, but much to stop large ones. Unfortunately, this principle is not always observed, so that all sizes may occur. Many means are employed in filling gullies depending upon the size and the conditions. Regardless of the method used, however, constant care is absolutely necessary if best results are to be secured. Gullies cannot be stopped by a lick and a promise. Whatever plan is adopted, it must be carried through.

Plowing-In and Seeding Gullies.—The plowing-in and seeding of gullies is applicable to those of both large and small size, provided the drainage areas are not too large. The small gullies should first be partly filled with manure, straw or cornstalks. A few stakes can be driven in the gully to help hold the straw. The dirt is then thrown toward the center of the gully with a breaking plow. An ordinary road drag serves quite well to push the dirt to the center of the ditch. When the gully is to be completely filled the plowing and dragging should be continued until the fill when completed, is slightly higher than the soil on either side. This is advisable to prevent the formation of a depression as the straw or manure decays and the dirt settles.

This freshly worked earth in the gully affords a good seed bed for plant growth. A heavy seeding of grass consisting of a mix-

Fig. 6.—Sorghum stops washes. This gully was very effectively checked by using this crop.

ture of timothy, red-top, blue grass, and alsike clover should follow. Where the soil is well enough supplied with lime some sweet clover may well be added to the mixture. When the work is done in the fall, rye should be seeded on these fills at the time of seeding the grass. If the work is done in the spring, some oats may be used. The rye and the oats serve as nurse crops and help to bind and hold the soil in place until the grass crops become established. Sorghum is especially efficient where rather large gullies are first worked in during the spring months. The sorghum should be sown on the loose soil. Figure 6 shows sorghum being used very effectively in stopping soil washes. These crops all have binding root systems which, if once established, will be very effective in preventing new gullies from forming. In some sections of Mississippi, gullies have been filled quite effectively by plowing and seeding down as indicated above. It is of great value, in securing a good stand and early growth of the grasses, to run a manure spreader along the fills giving them a top dressing of manure.

USE STRAW FOR SMALL GULLIES

Straw furnishes a cheap and effective means for stopping the small washes which often occur in wheat fields, corn fields, and even in pastures and meadows. This is especially true of gullies on moderate slopes where the drainage area is small. Such washes may be filled with well compacted straw in the fall, using sufficient soil on top of the straw to help hold it in place. Where the gullies are somewhat larger and there is danger of the straw being washed out, a few stakes may be used at intervals of several rods which will eliminate this danger. The stakes are extended across the gully and straw placed above the stakes.

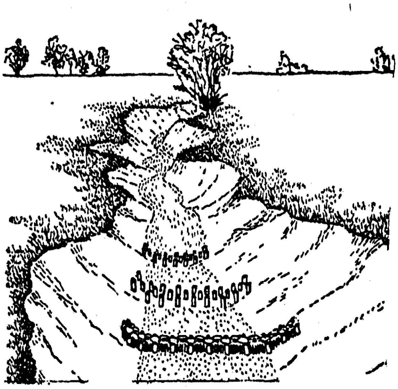


Fig. 7.—A small gully filled with straw. The straw is held in place by stakes driven every few rods.

There is no better plan of stopping these small gullies than by the use of straw. Other materials may be used, however, such as cornstalks, weeds, and waste hay. The coarser materials like cornstalks are not quite so effective for the smaller gullies, but they are good for those somewhat larger. In regions where cedar trees are common the small trees are excellent for stopping washes of a size around a foot deep and two or three feet across.

It should always be remembered that small gullies are the beginnings of large ones and that if these are given regular attention tremendous expense and much injury to the land may be prevented. A stitch in time saves nine. This is the most important principle in gully control.

BLUEGRASS SOD BARRIERS

One of the most effective yet inexpensive ways of checking small washes in wheat fields, meadows or pastures is the use of bluegrass sod placed in old burlap fertilizer or feed bags. The sod may be cut in about 6-inch squares carrying plenty of good dirt. This work should be done in the fall following wheat seeding or early in the spring before heavy rains occur. The bags are filled about 1/3 to 1/2 full of sod and securely tied. They are then placed crosswise in the small washes wherever an obstruction is needed, care being taken to spread out the partly filled sack of sod so that it will lie flat in the ditch.

Fig. 8.—Bags of bluegrass sod placed in a clover field to stop gullying on farm of J. O. Erhart, Cole County, Mo. Mr. Erhart, the originator of this method, stands at the right.

The burlap bags hold the sod in place and the early spring growth of bluegrass through the bags, forms a dense sod dam across the small wash. By fall of the first year the sack has completely rotted away but the sod dam has established itself and lessens all further washing. In case the wash is too wide for one sack to reach across it, two or more may be placed end to end, care being taken to have the center of the completed dam pointing downstream. This will tend to hold the water to the center of the wash and prevent it from cutting around the sides.

Old fertilizer bags which are usually considered practically worthless are particularly valuable for this work, since the small amount of plant food remaining in the bag stimulates the growth of the bluegrass and hastens the formation of a good sod dam.

These barriers have been used very extensively by J. O. Erhart of Cole county for a number of years. Although his farm was rather thin and badly eroded when he bought it more than 15 years ago, he has been successful not only in preventing the formation of new washes but also in almost completely filling those that were already formed. Even though Mr. Erhart's farm is quite rolling he now has no serious washes in his fields and he says that these bluegrass barriers have been one of his most effective ways of checking small washes. A look at his farm in the spring and early summer reveals a large number of these bluegrass barriers all over his meadows and wheatfields, but one fails to see the small washes that are so numerous on many farms that are much less rolling.

STRAW AND BRUSH FILLS

As described under types of erosion, gullies resulting from large volumes of water falling from one level to another are often quite difficult to control. It is important to cause the water to spend its energy so that it will erode as little as possible. In attempting to check these overfalls it is advantageous to make the dam serve a double purpose and not only stop the undermining action of the water but also make a dirt fill. For ditches of medium size (below six or eight feet in width and depth) the "fourpost overfall check" sometimes recommended proves quite satisfactory.

In the construction of this type of dam four good sized posts are set in the form of a square as shown in the above figure. Care should be taken to see that the posts all slant inward and that the dam will be "V" shaped when viewed from down stream. Guy wires are used to hold the posts firmly in place where pressure comes from the floating trash. By constructing the dam in this way the water will be kept in the center of the ditch and new channels will not be formed as is often the case where large piles of straw or brush are placed in gullies with the hope of filling them. The posts upstream should be set about one foot from the bank and placed about three feet apart, depending somewhat on the width of the gully. It is a good practice to undermine the banks somewhat so that the straw and brush can be compacted into the bank, thus causing the water to fall directly on it so that there will be no undermining action.

After the posts are set, the bottom of the ditch or gully is covered with a layer of well compacted straw, about one foot deep, extending well into the banks. A thin layer of brush which is cut so that it will reach the entire width of the gully is then placed crosswise and interwoven between the posts. This is followed by a heavy layer of brush with the tops placed down stream and the forked ends hooked over the posts and extending well into the banks. Care should be taken to see that the brush lies close and is well compacted and that it does not extend above the sides of the ditch. Wire may be used to hold the brush firmly in place by anchoring it to each of the posts. Where rocks are plentiful it may prove quite satisfactory to add a number of good size ones on top of the straw and brush. They will help to compact the fill and hold it in place.

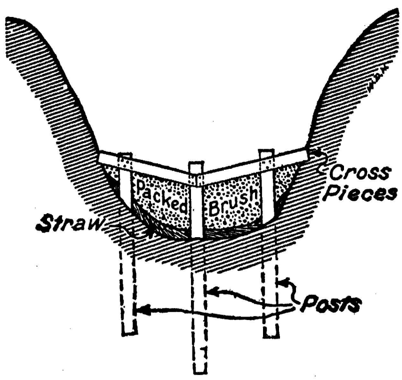


Fig. 9.—V-shaped straw and brush dam. Straw and brush are held in place by the posts and planks.

As a further aid in holding the straw and brush in place, boards, rails or poles of small diameter, are placed on the upper side of the posts upstream and broader or larger ones extending well into the side banks are used on the lower side. The straw and brush will remove much of the soil from the water which filters through the dam. The falling water will have lost the most of its energy by the time it passes through the straw and the retained soil will start a fill and prevent the gully from moving farther up stream or cutting into the sides of the banks. The dam should be inspected occasionally to see that it is in good condition and that the straw has not been carried from beneath the brush.

BRUSH AND STRAW BARRIERS

The deep narrow gully is one of the common types found in Missouri and one which greatly hinders the cultivation of the soil. With reasonable care such gullies can be controlled by the use of dams.

In attempting to fill a gully of this type it is always advisable to start at the head and work toward the mouth because there is less water at the head, which makes it easier to hold the dams. The spacing of the dams will depend on the slope of the ditch. If the slope is great, more dams are necessary thar if the fall is gradual.

To construct the dam three good fence posts are set in a "V" shape with the point of the "V" down stream, the posts at the point slanting in the same direction. The bottom of the ditch is then covered with a thin layer of straw which is tamped well into the sides of the gully. Brush of medium size, cut so that it will lie close together is added, placing the tops down stream and between the posts. A few good-sized rocks may be added to help compact the fill and hold it in place. The brush is further held in place by means of planks, poles or two by fours nailed to the posts as shown in Figure 9. It will be noted that the center is made lower so that the water will go over at this point first, thus keeping it in the center of the gully and preventing the undermining of the banks. The dam should not be made more than 2 or 2½ feet high in the center at the start but if the posts are of sufficient length, the height of the dam may be increased from time to time after the ditch is filled to the top of the dam. The extent to which the gully can be filled with safety will depend upon the size of the area to be drained and the slope of the land. After the fill is started it will prove quite advantageous to seed grass on it which will form a sod and help to hold the soil.

WOVEN WIRE DAMS

It is common to see drift and soil collected above a woven-wire fence that extends across a draw in a field. This doubtless suggested the wire dam fence for stopping gullies and it is now in common use in a number of states.

The common method of building these dams consists in setting a row of strong fence posts across the gully about four feet apart. Care should be taken to set the posts at least 3½ feet deep and anchor them by wire to other posts set 8 or 10 feet above the dam. The posts nearest the center of the gully should be set down stream a distance equal, approximately, to one-half the width of the stream so as to keep the water to the center of the channel. In addition the center posts should be slanted down stream somewhat as shown by Figure 10.

A trench should be dug into each bank to allow the woven wire to be fastened at least 6 or 8 inches below the surface. In some cases it may be advisable to have the wire extend several feet into the banks. To prevent undermining it may be necessary to cover the bottom of the ditch for a few feet above the dam with strips of hog wire laid flat on the bottom and attached to the dam. After securing the woven wire (which should be at least 3 feet high) to the inside of the posts and to the strips on the bottom, the trench in which the wire is placed should be filled and well tamped. Straw or fine brush can then be placed against the upper side of the wire which will help to fill the meshes in the wire and catch the soil.

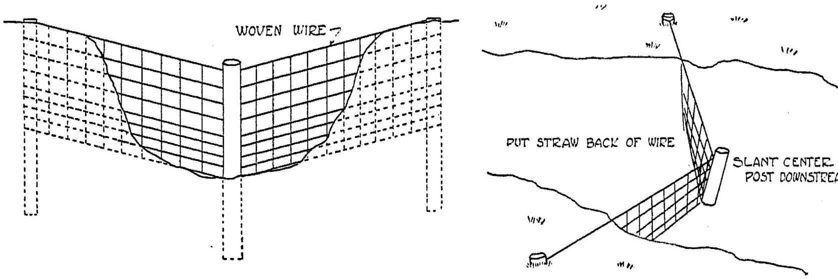


Fig. 10.—Woven wire dam, used for stopping gullies. Straw is placed above the wire to help collect the soil. (Left) Looking up stream. (Right) Looking across the gully.

SOIL SAVING DAM MADE OF EARTH

The earth soil saving dam with vertical drop inlet has proved one of the cheapest and most effective means of filling large gullies. The popularity of this type of dam is growing quite rapidly in Missouri. It has perhaps been used more extensively in Saline county than any other place in the state. It is claimed that several hundred have been built in this one county and that they are not only well suited for filling large gullies but that they may be used in comparatively small ones as well. Figure 11 shows a cross section diagram of the earth dam and Figure 12 shows land that has been reclaimed by such a dam near Troy, Missouri.

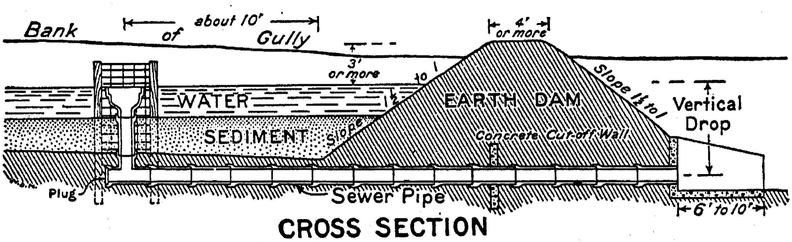


Fig. 11.—Sectional view of soil saving dam made of earth. Many find it very convenient to make the dam broad enough so that it may be crossed with a team and wagon. (By courtesy of the United States Department of Agriculture. Figures 7, 9, 11, and 15 are adapted from Farmers' Bulletin No. 1234.)

LOCATING AND CONSTRUCTING THE DAM

The lowest part of the gully is usually the best place to build the first dam but this will depend somewhat on the number of dams needed to make the desired fill. They should be constructed so that the fill from one reaches nearly to the outlet of the next dam above. It may be desirable to locate the dam so that the field fence or line fence may be built on it so it may be crossed with a team and wagon.

Fig. 12.—Land reclaimed by soil-saving dam. About a four-foot fill has been secured. The man is standing in the vertical intake pipe of the original dam.

Placing the Tile.—If a spillway is used to carry the water around one end of the dam during times of excess rains, the size of the tile can be materially decreased and the cost of building the dam will be greatly lessened. The excess water can usually be conducted around one end of the dam, over firm sodded ground, with little injury to the dam. It is advisable to use a tile of sufficient size to carry all the water except in case of a very heavy rain, since there is much less chance of injury to the dam. The size of the tile will of course vary with a number of factors such as the drainage area, the slope of land, relative length and width of area and the amount of storage room above the dam.

The following table gives estimates on the size of vertical inlets and tubes required to drain different areas which are quite rolling. Where drainage areas are less rolling the size of inlets and tubes may be reduced somewhat. A spillway around the end of the dam should always be provided to take care of extreme floods or accidental stoppage of the inlet.[1]

Drainage Area in Acres	Tile		Square Concrete Tube	
	Size of Inlet	Size of Hori. Pipe	Size of Inlet	Size of Hori. Tube
5	14"	12"		
7½	16"	14"	14" x 14"	12" x 12"
10	18"	16"	16" x 16"	14" x 14"
15	20"	18"	18" x 18"	16" x 16"
20	22"	20"	20" x 20"	18" x 18"
40	34"	30"	30" x 30"	26" x 26"
60	40"	36"	36" x 36"	32" x 32"
80	46"	42"		
100	50"	46"		

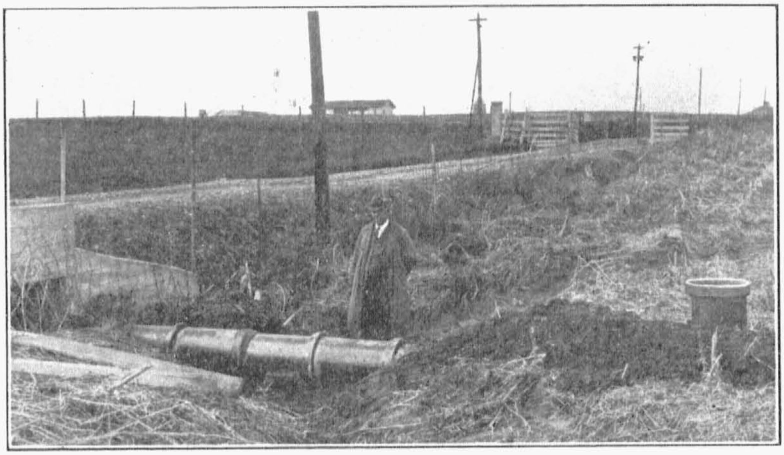


Fig. 13.—Soil saving dam on University Farm, ready for earth fill.

A shallow trench, in which to place the hard burned sewer tile is dug from a good outlet below the dam to ten or fifteen feet above the inside of the dam. Care should be taken to see that the course is straight and has a uniform fall in the bottom of the ditch. Excavations should be made under the bell of each tile so that the barrel will rest firmly on the ground. The joints should all be calked with clay after which the soil should be thoroughly compacted around the tile to hold them in place and prevent seep-

[1]The amount of run-off was figured from data reported in Experiment Station Bulletin 211, Table 3, and the figure for corn land was used since the maximum run-off occurs when the drainage area is planted to this crop. A rate of rainfall of 1 inch per hour was used in computing the above table. More rapid rainfall is encountered at times, making necessary the spill-way for protection.

age along the line. After the tile has been placed and well covered and the intake tile is in place work on the dam should be started. Figure 13 shows such a dam on the University Farm at Columbia.

Building the Dam.—All weeds, grass and debris should be cleared away and a trench about eight feet wide and one foot deep dug, so as to eliminate the possibility of seepage along the bottom of the dam. This precaution is especially important if the dam is to be more than 8 feet high.

The dam should be built in layers about one foot in depth using teams and scrapers. The horses feet and the scrapers help to compact the soil during the process of making. Soil for building the dam should be taken from above the dam and an allowance of about ten per cent should be made for the settling of the material in the dam. By adding a little water occasionally the embankment will be more easily compacted and more impervious to water. This will be unnecessary if the dam is constructed when the soil is a little damp.

The center of the dam should be made slightly higher than the sides which should extend to firm, sodded ground where excess water may be led around its ends. The top of the dam, when completed, should never be less than 4 feet wide and if it is to be used as a roadway, it should be at least 8 feet wide, with the bottom in each case wide enough to give the sides sufficient slope so they will stand up well.

Some sort of protection against erosion undermining should be provided where the water discharges from the outlet pipe into the gully below. A channel built of concrete is very effective for stopping the undermining action of water which may destroy a dam where no channel is provided. The channel is usually made six to ten feet long, depending upon the vertical drop of the water. The greater the vertical drop, the greater will be the velocity and eroding power of the water. The spillway allows the water to fall and thus lose its speed and energy before it comes in contact with the soil below the dam.

After the dam is completed it is advisable to seed a grass mixture together with oats or rye which will form a sod and help to bind and hold the soil. As the gully fills, the height of the dam and also the vertical inlet tile above the dam may be increased. The height of the dam should always be at least 2 or 2½ feet higher than the vertical intake tile. If it is desired to have the fill drained above the dam, it can easily be accomplished by attaching a small drain tile to the upper end of the tile which connects the horizontal tile with the vertical inlet tile. The upstanding inlet tile should always be protected from stock by setting posts and placing wire fencing around it.

ROCK DAMS

On farms where rocks are plentiful and often a nuisance in the fields, dams can be built very cheaply and often work quite well.

A loose-rock dam may be used in gullies of moderate slope and small drainage areas. It should not be made more than 2 or 3 feet high and should be 4 or 5 feet wide at the base and at least 2 feet wide at the top. The dam must be built well into the banks of the gully and the bottom rocks should be placed in a trench at least six inches deep extending across the gully. Only large rocks should be used on the top and bottom of such dams with the smaller rocks placed between.

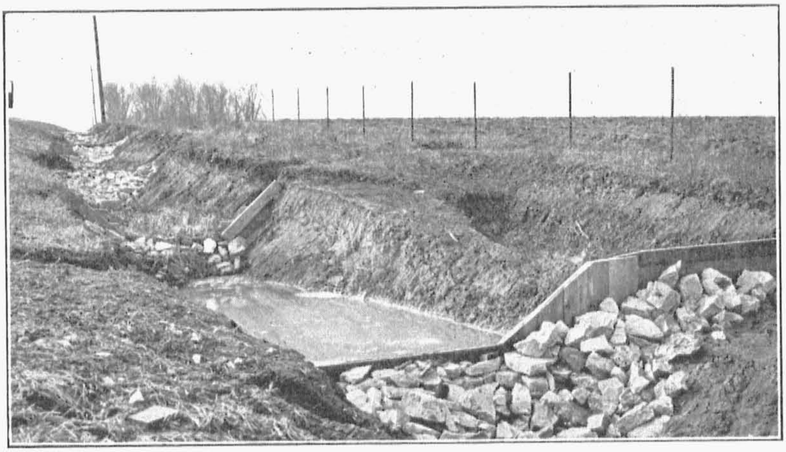


Fig. 14.—A series of board dams backed up by rock fills on Highway 40. The dams must extend well into the bank on both sides of the gully.

BOARD DAM BACKED UP WITH ROCKS

A V-notch board dam backed up with a rock fill may be used to prevent ditches from increasing in size or to fill large ditches. This type dam is shown in Figure 14. A large number of these dams are being used very effectively along the state highways in Missouri.

STONE MASONRY DAM

Where a little more permanent dam is needed a stone masonry dam proves quite satisfactory. Figure 15 shows such a dam located near Kansas City, Missouri, which is built across a gully draining a large area of land. As in the case of the loose-rock dam, the ends should extend well into the banks of the gully. The center of the dam is lower than the ends, which serves to keep the water in the center of the ditch. A spillway or trough is made just below the dam of rock and concrete. It is very essential that this be provided for catching the water and thus preventing the undermining of the dam which always occurs if no spillway is provided.

Due to the difficulty encountered in making this type of dam secure, coupled with the fact that it can only be used on very gentle slopes, this dam has not been very extensively recommended or used. Where rocks are plentiful and the slope very gentle, this type may be used quite satisfactorily.

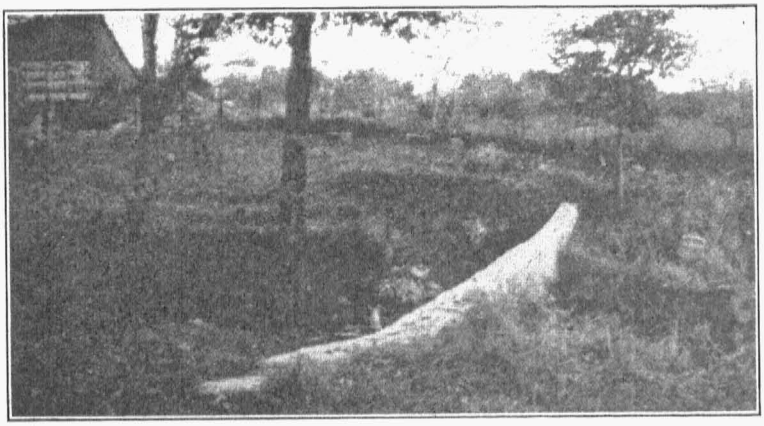


Fig. 15.—Masonry dam built across a gully draining a large area of land near Kansas City, Missouri.

TRIANGULAR-NOTCH CONCRETE DAM

This type of dam is very effective in broad ditches. It can be used on a fence line over a ditch, providing a flood gate is built to prevent excessive pressure against the fence in flood times. The vertical wall should be made six inches thick and should be reinforced with a half-inch reinforcing rod for each foot of height. The rod should be placed three-fourths of an inch from the down stream side of the vertical wall. The spillway should be reinforced as shown in Figure 16. Heavy hog wire may be used for reinforcement in place of the rods if desired.

Construction.—A trench six inches wide and to a sufficient depth to prevent heaving by frost should be dug across the stream. Forms should be set for the vertical wall and carefully wired and spaced. The top of the wall is made to slope to the center at the rate of 2 inches per foot. Thus a dam 24 feet wide will be 24 inches lower at the center than at the ends. It is only necessary to build the concrete wide enough to carry the heaviest rain, since the remainder of the fill can be constructed of earth at a much less expense. As soon as the forms can be removed from the vertical wall the spillway should be poured.

This type of dam causes a minimum of washing in the ditch below. In one installation a noticeable fill was produced about twenty to thirty feet below the dam. This is probably due to the fact that the momentum of the stream is largely destroyed by the cross currents set up by the slope of the spillway below the dam.

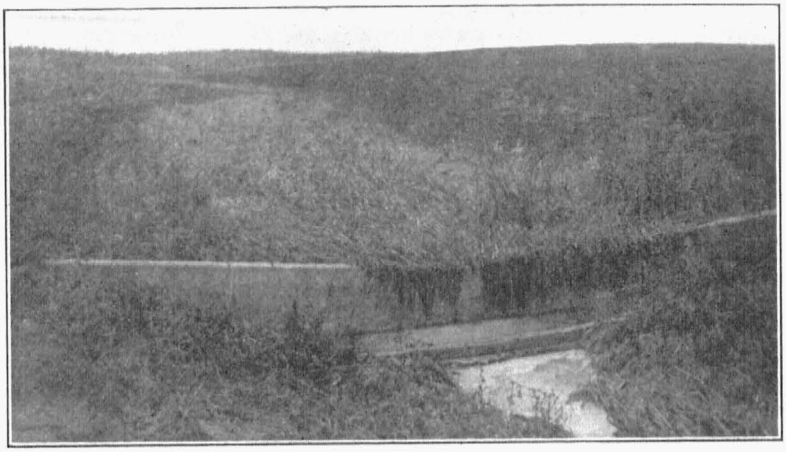


Fig. 16.—Triangular notch dam. Note the fill secured in one season.

The concrete should be made of one part cement, two parts sand, and three parts of screened gravel. Only sufficient water should be added to make the concrete plastic and workable. Reinforcing rods or wire should be extended out through the form on the down stream side of the wall in order to tie the spillway to the vertical wall. The mixture should be tamped well and small rocks (about 2 or 3 inches in diameter) may be added which will lessen the amount of cement needed and thus lower the cost of the dam.[1]

[1]A dam 8 feet wide and 4 feet high with a spillway 2½ feet wide will require about 20 cubic feet of concrete. The cost of the cement in the concrete at 40 cents per cubic foot is $8.00.

THE RECTANGULAR-NOTCH CONCRETE DAM

When a large drainage area is to be taken care of and where a permanent structure is desired a concrete notch dam can be used effectively. The wings are extended about 5 or 6 feet on each side of the notch and an earth fill used to complete the structure. The wings act as a core for the earth fill and serve to join the structure so as to prevent seepage. Figure 17 shows a rectangular-notched dam after being completed and Figure 18 shows the same dam one year later.

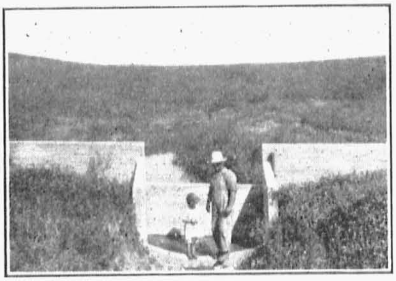


Fig. 17.—Rectangular-notched dam just completed.

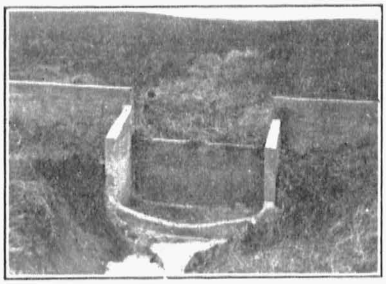
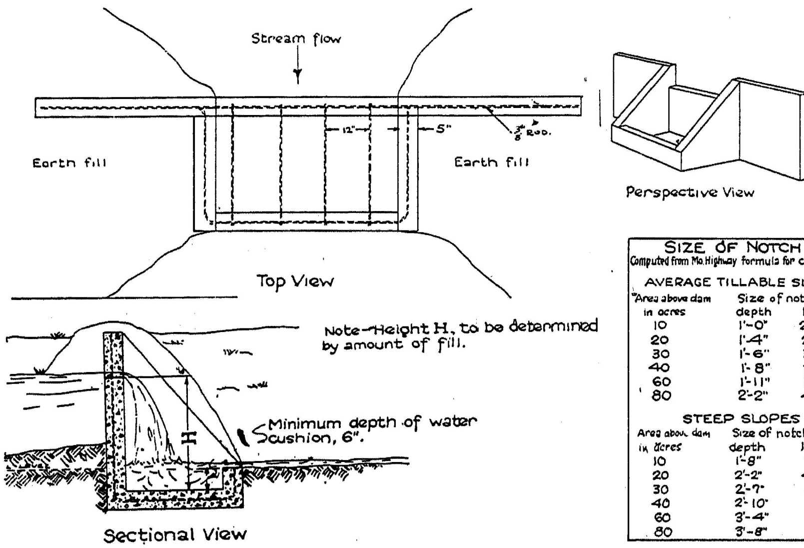


Fig. 18. Same as Fig. 17, but one year later. Note the fill above the dam.

When this dam was installed the ditch was 4 feet deep and 12 feet wide and extended about 65 feet above the location of the dam. A survey showed that if the stream filled level with the notch it would extend up stream 98 feet. The ditch has filled to a point 200 feet above the dam to a noticeable extent. Each deposit of earth and trash secured serves to check the rate of flow above it, causng further fill. The walls of the dam shown above were made 6 inches thick reinforced with hog wire and steel rods. The cost for 56 cubic feet of concrete at 40c, was $22.40, for reinforcing $3.00, making $25.40, not including the cost of forms which were constructed from waste lumber.

This dam should be reinforced with one-half inch reinforcing rods as shown in the plan Figure 19, or with a heavy grade of hog wire. The straight wall and tank can be poured first. As soon as the forms can be removed, the two brace walls can be poured. If the whole structure is poured at one time the construction of forms is somewhat difficult. The brace walls can be built up of brick if desired.

This type of dam provides a notch large enough to carry all the water that will run off from the drainage area above, except in the case of exceptional floods. The water falls through the notch into the tank below. The water in the tank is to be from 6 to 12 inches deep. This is called a water cushion. It is used to break the fall of the water and to slow down its rate of flow as much as possible. The erosion in the ditch below this type of dam seems to be much more rapid than in the case of the triangular notch. In the triangular notch the stream is kept wide and shallow while in the rectangular notch the stream is concentrated and its depth increased so as to speed up the flow.



SIZE OF NOTCH
Computed from Mo. Highway formula for culverts

AVERAGE TILLABLE SLOPE

Area above dam in acres	Size of notch in ft. depth	Size of notch in ft. length
10	1'-0"	2'-0"
20	1'-4"	2'-8"
30	1'-6"	3'-0"
40	1'-8"	3'-4"
60	1'-11"	3'-10"
80	2'-2"	4'-4"

STEEP SLOPES

Area above dam in acres	Size of notch in ft. depth	Size of notch in ft. length
10	1'-8"	3'-4"
20	2'-2"	4'-4"
30	2'-7"	5'-2"
40	2'-10"	5'-8"
60	3'-4"	6'-8"
80	3'-8"	7'-4"

Fig. 19.—Plan for rectangular notch concrete dam, showing size of notch to use.

SILO TILE DAM

A rectangular-notch dam shown in Figure 20, was recently built on a farm near Columbia as an experiment, using regular silo tile for the wall. These tile were laid in cement mortar with reinforcing rods in each of the mortar joints.

The vertical wall was built on a radius of 20 feet and a concrete footing was constructed in the ditch to this curve. Ditches were dug into the bank so as to prevent seepage around the ends of the wall. After the blocks were laid, a concrete anchor post was poured at each end of the block wall to tie in the reinforcing and to anchor the wall into the bank. The brace walls and tank were constructed of blocks.

There has been some leakage through the mortar joints but not in sufficient amounts to cause trouble. While this type of dam is more expensive than those built of earth or concrete, the plan offers opportunities, particularly where such tile are readily available. The size of the notch in this case is the same as for the concrete dam.

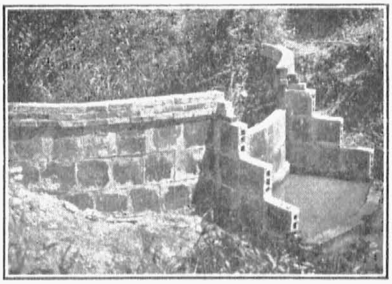


Fig. 20. — Rectangular-notch dam built of silo tile.

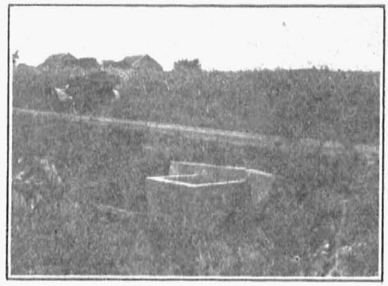


Fig. 21.—Fills on the highways offer many opportunities for the soil-saving culvert.

SOIL SAVING CULVERT

Many times the Missouri State Highway Department, if requested by the farmer, will build a vertical inlet for a road culvert. This may tend to decrease the maintenance on the culvert and will often pay for the slight additional cost. The roadway acts as a dam to hold the water back until it fills the pond above to the height of the wall of the inlet shown in figure 21. This storage area will soon fill and be very effective in saving the field above.

TERRACES FOR CONTROLLING GULLIES

The Mangum or broad-base terrace is perhaps the most effective method of controlling erosion and preventing the formation of gullies on fields where the slope is not too great. These structures are doubly effective when good cropping systems and cultural practices are employed in connection with them.

These terraces are broad ridges graded up similar to narrow roadways. They extend across the slopes on a gentle grade and the water is carried off slowly along the terrace instead of running swiftly down the steep slopes. While the water which falls on the slopes may not be sufficient to cause much erosion, great damage is done and gullies are formed when the large quantities collected on the tops of hills are added to that of the slopes.

While the importance of terracing in the control of gullies is recognized there is not sufficient space to treat fully with this subject in this publication. A separate bulletin will follow this one treating with terracing.

RECOMMENDATION FOR THE CONTROL OF GULLIES

1. Use a crop rotation which includes a sod crop and which calls for a limited amount of cultivation.

2. Keep the soil covered with a sod crop, preferably a legume, as much of the time as possible.

3. Incorporate organic matter into the soil and thereby increase the water-holding capacity, lessen the runoff and decrease very greatly the subsequent erosion.

4. Do not attempt to keep steep hillsides under cultivation but utilize them for pasture and timber.

5. Use straw and brush to check the erosion of small gullies and where a permanent structure is not desired. A masonry dam remains in the way after work is completed.

6. Plow in and seed gullies where the sodded areas will not interfere too greatly with farming operations.

7. Place blue grass sod barriers in small washes in wheat fields, meadows, and pastures.

8. Use woven wire dams in broad shallow gullies. Concrete triangular-notch dams can be used where a permanent structure is desired.

9. Erect earth soil saving dams with undershot tube, or concrete rectangular-notch dams in the deep gullies which drain large areas.

10. Secure permission from the road commissioner, if necessary, to use vertical inlet culverts wherever possible.

11. Plant locust trees where gullies are very deep and where they are rapidly working their way up the slopes. The trees will establish themselves quickly and thereby check the further destruction of valuable land.

12. Mechanical means of control will be effective only if carefully watched and repaired as needed and when accompanied by a practical system of soil management.