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EC123 Soil Washing : The Cause and Methods of Prevention

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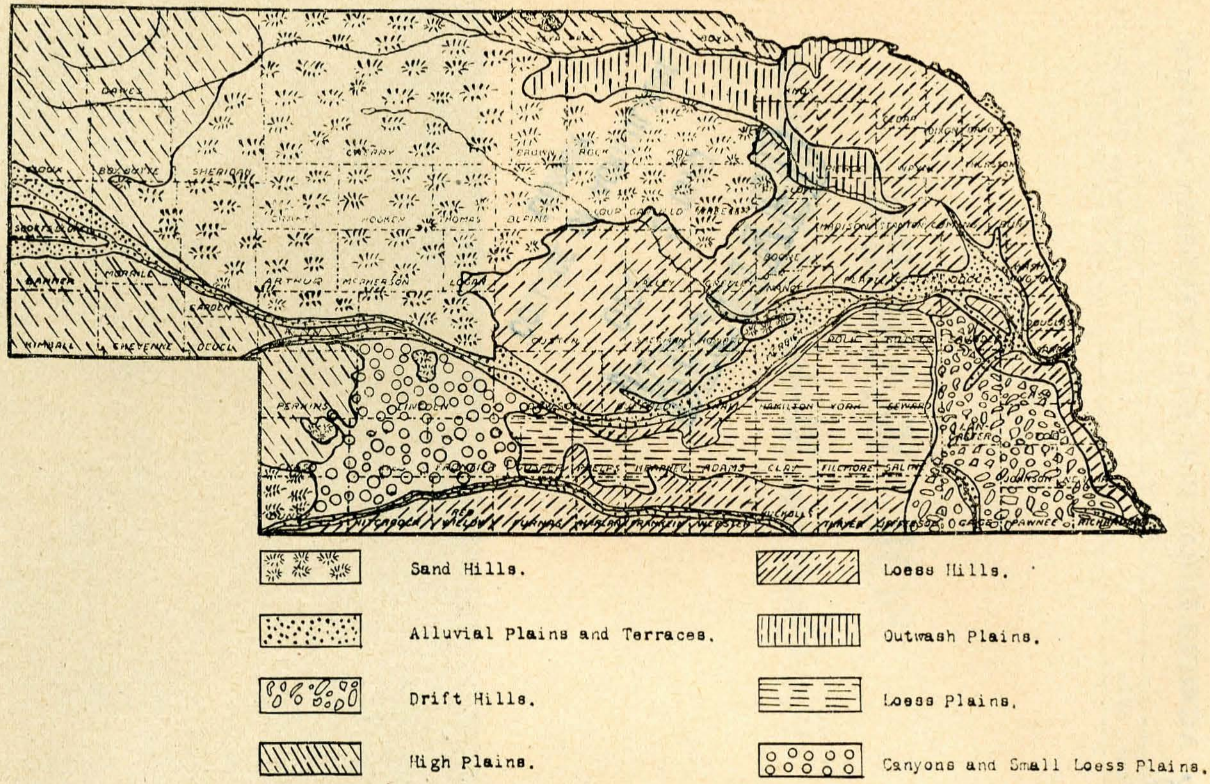


FIG. 1.—The chief soil areas of Nebraska.

SOIL WASHING

THE CAUSE AND METHODS OF PREVENTION

P. H. STEWART AND I. D. WOOD

The damage to farm lands by soil washing is important over much of Nebraska. Erosion removes the surface soil containing much of the organic matter and nitrogen; forms gullies and depressions which cause much loss of time and land, inconvenience, and breakage of machinery; and because of excessive run-off precipitation is lost which is often needed for crop production. Lands damaged by erosion have a correspondingly lower sale value and if eroded beyond control and reclamation may even be abandoned. According to government estimates, more than 4,000,000 acres in the United States have been ruined by erosion to the point of being abandoned and approximately 8,000,000 acres have been seriously damaged.

KINDS OF SOIL EROSION

Soil erosion may be considered of two kinds: (1) Sheet erosion or rather uniform surface washing and (2) gully erosion in which well defined ditches are cut. Sheet erosion is apt to be given less attention than the gully form but is

FIG. 2.—Gully erosion has ruined this area for cultivated crops.

of no less importance as the removal of the surface soil containing the greatest per cent of the organic or vegetable matter and nitrogen is a serious loss and is reflected in crop yields. Usually, however, instead of uniform surface washing the run-off gathers in depressions where its volume and velocity cause cutting and gullying.

SOIL AREAS WHERE EROSION IS A PROBLEM

Figure 1 shows the various soil areas of the state of Nebraska. Altho soil washing does some damage in every county of the state the area most damaged lies southeast of a line drawn from Knox county in northeastern Nebraska to Dundy county in southwestern Nebraska. Of this area, all but the level Loess plains counties south of the Platte river is damaged more or less.

The soil area most damaged by erosion is the portion known as the drift hills in southeastern Nebraska. The soil

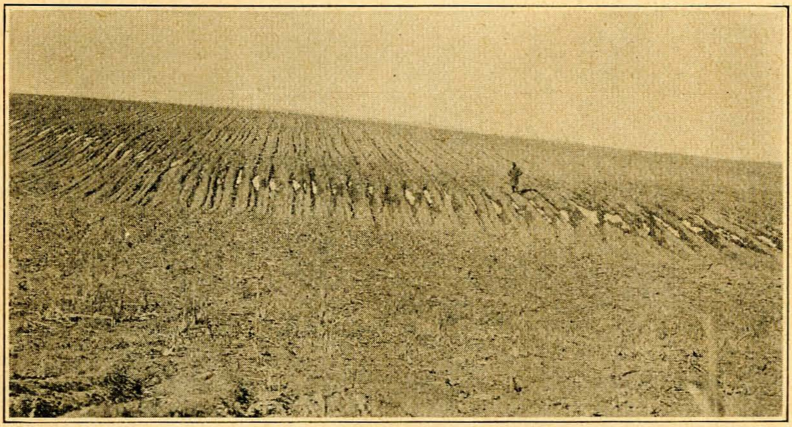


FIG. 3.—Sheet erosion in which the surface soil is rather uniformly removed reduces crop yields.

of this area is typically of glacial origin and can usually be identified by rock debris varying in size from small pebbles to boulders commonly spoken of as "niggerheads." Both sheet and gully erosion, but especially the latter, are serious problems over the 6,700 square miles composing the drift hill area.

The soil area next in order in respect to damage by soil washing is the loess hill area of some 11,900 square miles in

extent. The soil of this area is characterized by its upright columnar structure as evidenced in deep cuts where the soil stands in vertical pillar-like formations. Altho the soil of this area gullies considerably it is not nearly so subject to gullying as the glacial hill area. Sheet erosion is common and serious.

The loess canyon land comprising some 1,500 square miles of area, part of which is too scattered to map, is damaged to some extent by soil washing. The fact that most of this area is in native grass, protects it from erosion to a great extent. When broken out sheet erosion is especially serious altho gullying is also an important problem.

Alluvial plains and terrace lands making up first and second bottom soils of approximately 6,000 square miles in area while not eroded especially themselves, are damaged by erosion thru run-off from the higher lands causing gullying, flooding, and often the burying of crops under the sediment from fields above.

Thus more than 25,000 square miles or 16,000,000 acres are subjected to damage to an appreciable extent by erosion in Nebraska. There are also areas in western Nebraska where occasional dashing rains do considerable damage but there the erosion problem is not a very important one.

CAUSES OF SOIL EROSION

The characteristics of the soil, topography, amount and nature of the rainfall, and the type of farming carried on are the most important factors determining soil washing. The relative importance of these factors may vary in different parts of the state and on different farms.

THE SOIL

The soil factors most important in determining the damage by soil erosion are texture, structure, and the organic matter content.

Soil Texture.— Soil is composed of finely disintegrated rock particles thru which there is mixed more or less vegetable or organic matter from which the soil gets its black color. Soil texture, that is, the size of the soil particles, determines to a great extent, the rate of absorption of water. Clayey soils in which the particles are small and fit closely together absorb water much more slowly than open sandy soils composed of much larger individual particles.

The total pore or air space in a heavy clayey soil is greater than in a coarse sandy soil composed of large particles. The

individual pore spaces are, however, much larger in the sandy soil. The intake of precipitation is governed more by the size of the individual pore spaces than by the total pore space. During times of precipitation the water moves downward rapidly in coarse textured soils, and thus there is less danger of the surface soil of such areas becoming saturated and taking in but little water.

Soil Structure.— Soil structure, or the arrangement of the individual soil particles, has an important influence on erosion. Soils with a granular or crumblike structure in which many small particles are grouped together, even tho the texture of the particles themselves is fine, absorb precipitation readily. In tillage operations there should be formed on the surface of cultivated fields, a coarse mulch rather than a fine dust mulch. During heavy rains a fine dust mulch is likely to form a sticky slimy coat over the surface of the soil thru which water has difficulty in passing. On slopes this puddled surface tends to move downward and at the same time sheds water and increases the run-off.

It is a common observation that the glacial soils of Nebraska have a greater tendency to gully than have the Loess soils of the same texture and topography. This seems to be due, at least in part, to the vertical columnar-like structure of Loess soil. The greatest amount of erosion on glacial land, however, is on the Shelby loam type of soil which contains considerable sand and some pebbles, rocks, and even boulders. In many cases the covering of Shelby loam over the Aftonian formation, a sandy gravelly deposit underlying the glacial area, is very shallow and in places even lacking. The presence of this friable formation, which is easily eroded, either as a surface soil or subsoil accounts for the many gullies in a part of the glacial soil area.

Organic Matter Content.— The organic matter of virgin soil has been accumulating for centuries and when sod is first broken out its organic matter content is high. When land is cropped the organic matter is decreased by bacterial action and oxidation or burning out, and unless some provision is made to restore it, the amount in farmed land rapidly decreases.

Organic matter in the soil has many uses. It tends to increase the granulation and the size of pores of heavy soils and thereby promotes the absorption of water resulting in less run-off. It has a binding power which tends to hold the soil particles together. Organic matter also is able to absorb and hold much water. It acts as a food for soil bacteria and

breaks down into forms of nitrogen which plants may use. The lack of nitrogen is often evident on slopes where sheet erosion has removed the black surface soil, as is shown by the yellow color and short growth of grain crops. Ordinary soils low in organic matter tend to bake and puddle easily, take in water slowly, and are harder to manage than soils high in organic matter. A reduction in the organic matter of rolling cultivated soils is favorable to erosion.

TOPOGRAPHY

The topography or slope of the land, is one of the important factors determining erosion. Flat level land is not eroded by water regardless of what its texture, structure, or organic content may be. Regardless of how much care is practiced

FIG. 4.—Soil washing is a problem on the rolling farm lands of eastern Nebraska.

very rough land, especially of glacial areas, is likely to wash and such land should, therefore be kept seeded down continuously or for the most part.

The following statements sum up the effect of topography or slope on the velocity and cutting power of run-off:

1. If the rate of flow of water is doubled, the erosive power is increased four times. (Erosive power varies with the square of the velocity.)
2. If the rate of flow is doubled, the amount of material of a given size that can be carried is increased thirty-two times. (Amount of material that can be carried varies with the fourth power of the velocity.)

3. If the rate of flow is doubled, the size of particles that can be carried is increased sixty-four times. (Size of particle that can be carried varies with the fifth power of the velocity.)

Thus as long as water can be kept moving very slowly, its power to erode is small but slight increases in its velocity adds greatly to its cutting and carrying power.

CHARACTER AND AMOUNT OF PRECIPITATION

The rate, nature and total amount of precipitation are the main weather factors that have a direct effect on erosion. Nebraska, having a continental climate, is subject to torrential rains. The average annual precipitation for the state is 23.65 inches varying from 32 inches in the southeastern part to 15 inches in the western part. During the crop season, from April to August, inclusive, the average rainfall is 16.08 inches, varying from 20 inches along the Missouri river to about 10 inches along the western border. Table 1 gives the average monthly rainfall for Nebraska for the past 46 years.

TABLE 1.— *Average monthly rainfall for Nebraska,* 1876-1921

January	0.56	July	3.41
February	0.74	August	2.79
March	1.09	September	2.13
April	2.49	October	1.58
May	3.61	November	0.73
June	3.79	December	0.73
		Mean annual rainfall	23.65

It will be noticed that the heaviest rainfall normally comes in April, May, June and July. Thus the greatest precipitation occurs during that time of year when the fields are, at least to a considerable extent, in a loose, cultivated condition. There is considerable difference in the damage done by a rain in March or April as compared to May or early June. A hard dashing rain falling during May, when corn land is newly prepared or recently listed, will do an immense amount of damage. Likewise a late August or September rain of a "gully washing" type is likely to do more damage to land prepared for fall wheat than later rains after the soil has settled and the winter wheat has rooted and covered the ground.

There are on the average 64.9 days in the year during which rain or snow falls in Nebraska. Table 2 gives the seasonal distribution of such days with precipitation.

TABLE 2.— *Average number of days with precipitation during year*

January	3.2 days	July	7.2 days
February	3.8 days	August	6.9 days
March	4.6 days	September	5.2 days
April	6.8 days	October	3.9 days
May	8.6 days	November	2.8 days
June	8.5 days	December	3.4 days
		Total	64.9 days

A comparison of the data of Tables 1 and 2 shows that for an increase in the number of days with precipitation during the spring and early summer months, there is a correspondingly much greater increase in the total precipitation. Thus, the months of April, May, June and July, in addition to having the heaviest precipitation of the year, also have this moisture fall in a much shorter period of time as shown by the total amount of rainfall and the number of days during which there is precipitation. There is little need of winter cover crops to prevent soil washing in Nebraska because a relatively small amount of precipitation comes at that season.

TYPE OF FARMING

Often in farming operations, dead furrows, lister furrows, and depressions formed by single disking and in other ways, gather water during rains and are the beginnings of gullies. Fields farmed with the slope are likely to be injured by washing. Ditches which are just starting are sometimes allowed to go without attention and later it requires much more time and labor to control them than it would if they had been given attention in time. In some parts of the state where the land is rolling the common practice has been to list the corn. This has resulted in much injury to the land thru the removal of much good top soil and the formation of ditches and gullies.

Grain vs. Livestock Farming.— Due to the fact that on most rented farms grain farming predominates and, on the average, fewer livestock are kept, such farms are very likely to be lower in organic matter and consequently erode more. Fields continually put to grain crops are much exposed in a cultivated condition favorable to erosion. Diversified farming has proved to be more stable and profitable than straight grain farming and is especially important from the standpoint of keeping up soil fertility and organic matter.

Legumes.—Legumes such as alfalfa, red clover and sweet clover are very important from the standpoint of preventing

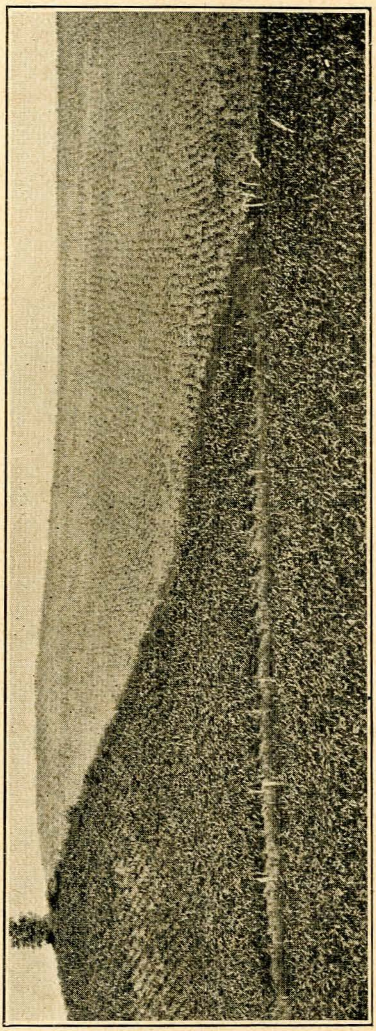


FIG. 5.—Fourteen years ago these two Washington County fields were very similar in fertility. The field to the left belongs to a farmer who has made use of livestock, legumes and manure. The field to the right has been in grain crops continually.

soil erosion. They form a cover which protects the soil from washing, add much organic matter, and promote the keeping of livestock. If a type of farming is carried on which does not include a reasonable acreage of grasses and legumes, the soil is very likely to become low in organic matter and wash easily.

FIG. 6.—Oats on a field which has been in rotation with legumes and occassionally manured. This soil is high in organic matter and nitrogen.

Farm Manure.— The use of farm manure tends to prevent erosion by helping to maintain the organic matter. Too often manure is washed instead of being returned to the land. Even if the crop is fed and all the manure put back on the land only about one-fourth of the organic matter originally in the crop is returned, the rest being retained by the animal or is lost. A normal application of manure on eastern Nebraska land will ordinarily increase grain crop yields from 10 to 20 per cent.

Leases.— Short time farm leases, which tend to promote grain farming, and to discourage the keeping of livestock and the seeding of legumes, have an important bearing on the maintenance of organic matter in the soil and on erosion. More than 43 per cent of the farms of Nebraska are leased. Observations show that almost without exception, the farms of a community which are leased for short periods, with frequent changes in renters, are the worst eroded and lowest in fertility. It is only natural that a renter, who knows that he is to be on a farm for but a short time, is apt to be careless in his farming operations, to haul little or no manure, to seed no legumes, and to pay but scant attention to ditches just starting or menacing the farm.

DAMAGE TO LAND BY SOIL WASHING

Eroded land is damaged by the loss of organic matter and nitrogen, and the exposure of a heavier subsoil which results

in the greater draft of implements and the need of more care and labor in preparing satisfactory seed beds. Erosion also results in a loss of rainfall for use in crop production and the waste of farm land.

On the average, sheet eroded soils have approximately 50 per cent and average cultivated, non-eroded soils approximately 70 per cent of the organic matter of virgin lands of the same neighborhood as shown in Table 3.

TABLE 3.— *Average percent of organic matter and nitrogen in soils from cultivated sheet eroded, cultivated non--eroded, and virgin fields*

	Ave. amt. organic matter	Ave. per cent organic matter as compared to virgin soil at same depth	Ave. amt. of nitrogen	Ave. per cent of nitrogen compared to virgin soil at same depth
Sheet eroded, cultivated land				
1-6 inches	2.51	50	.107	46
7-12 inches	1.82	44	.090	44
Non-eroded, cultivated				
1-6 inches	3.47	69	.159	68
7-12 inches	2.79	67	.145	71
Virgin land				
1-6 inches	5.02	100	.232	100
7-12 inches	4.15	100	.203	100

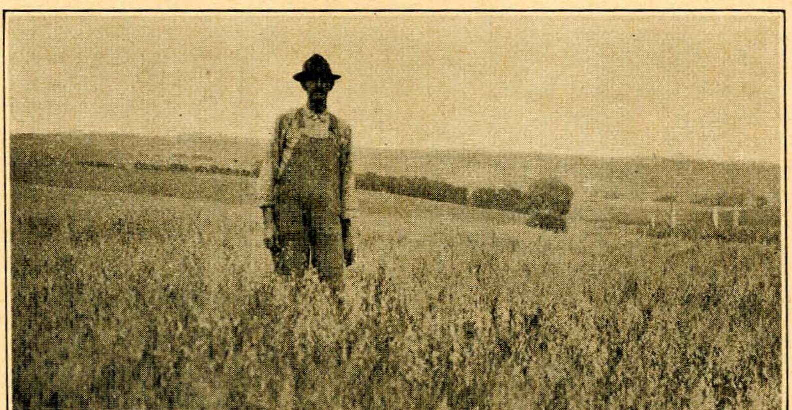


FIG. 7.—Oats on a field which has been grain farmed, bordering the field shown in Figure 6. The oat growth indicate a lack of organic matter and nitrogen.

Nitrogen, the plant nutrient most likely to be deficient in Nebraska soils, is furnished largely by organic matter. It may be observed in Table 3 that the percent of nitrogen has decreased in practically the same proportion as the organic matter. This is a serious loss from the standpoint of soil fertility.

The loss of organic matter and nitrogen on eroded fields has very markedly reduced the yields of all grain crops. As a result of this depletion the yield on some fields has been reduced to the extent that the land is not now cropped.

Soil Texture and Structure Changes.— Sheet erosion exposes the subsoil which is usually finer in texture, than is the surface soil. This is shown in Table 4.

TABLE 4.— *Mechanical analysis showing clay, silt and sand in first and second six inches of soil on eroded and non-eroded soils. Average of soils from* 5 *areas*

	Clay	Silt	Sand
Eroded soils			
First six inches	23.5	37.5	38.9
Second six inches	26.2	37.4	36.4
Non-eroded soils			
First six inches	20.8	38.7	40.5
Second six inches	26.8	38.0	35.2

Thus on eroded slopes a more clayey soil is exposed. Such soils being low in organic matter have a tendency to puddle and bake easily and to take on an unsatisfactory structural condition.

Ease of Seed Bed Preparation.— It is not unusual to hear a farmer say that his land plows a horse heavier than when it was broken out. This seems to be due to the heavier soil exposed on the surface and the lower organic matter content which makes the soil less friable and open. More care is needed on eroded lands in handling the soil to prevent it from baking, puddling, or getting into other unsatisfactory conditions. Eroded land low in organic matter is more apt to crust after rains and may thereby injure newly sown small seeded crops. Extra tillage may be necessary to secure a desirable seed bed where erosion has exposed the heavier subsoil.

Loss of Rainfall.— It is estimated that approximately 30 per cent of the precipitation on cultivated rolling Nebraska land is lost as immediate run-off. This means that approxi-

mately 10 inches of the 30 inches of precipitation falling in eastern Nebraska is lost for crop production purposes. In Nebraska, moisture is usually the limiting factor in crop production, and the storage of more of the precipitation means a greater yield of crops. Run-off is decreased by a high organic matter content of the soil, strip or contour farming, and terraces.

Loss of Land.— Hundreds of acres of land are lost for farming purposes because of ditches, gullies, and sheet erosion. Not only is the badly eroded land lost for farming but a great deal of time is spent in tending small irregular shaped fields, much machinery is broken in crossing ditches, and crop returns from eroded fields, particularly those which are sheet eroded, are much reduced. The sale value of eroded land is appreciably lower than similar land not eroded.

METHODS FOR PREVENTING SOIL EROSION

The best methods to use to prevent and control erosion will depend on conditions as to soils, the location in the state and the stage and condition of the erosion. A farming program designed to prevent erosion should be worked out and adopted. Such a program should consider the following points:

Maintaining the Organic Matter Content.— The first step in preventing soil erosion is to build up and maintain the organic matter content of the soil. But little progress can be made in stopping washing by means of dams and terraces unless the organic matter is built up at the same time.

The use of manure, cornstalks, and straw will help to maintain the organic matter content. It is not ordinarily possible to produce enough manure on the farm to cover the fields sufficiently often to maintain the organic matter in this way. Straw may best be utilized by using it as bedding for livestock or it may be applied as a top dressing for winter wheat. A rotation should be worked out whereby fields can be seeded down to red clover, sweet clover or alfalfa regularly.

Depth of Plowing.— The depth of plowing while perhaps not as important a factor in the absorption of precipitation as is often thought, has an important bearing on erosion. Often sheet eroded slopes are plowed very shallow, especially as the black surface soil is gradually washed away. It is a good plan to add manure and straw to such slopes and to gradually plow deeper and deeper, thus incorporating organic matter in an increasingly deeper furrow slice.

Contour Farming.— Steep slopes should be kept seeded down or at least farmed in contours or strips at right angles to the slope. On slopes inclined to wash, strips of legumes can often be seeded between cultivated fields and thus help materially to prevent erosion. Where fields on rolling lands are large, it is often not possible to farm across or around the slopes due to the fact that the land slopes in many directions. Sometimes, such fields can be divided into smaller fields which can be effectively farmed across the slope. Special care should be taken not to list such rolling land with the slope or to use other farm machinery which will leave furrows

FIG. 8.—Sweet clover is our leading crop for rebuilding badly run down soil.

and depressions which may collect the run-off and start gullies. Reducing the amount of run-off water through increasing the absorption in the soil and reducing the speed of water by means of broad flat depressions are important considerations in the prevention of erosion. Terraces to reduce the run-off and the rate of flow of water may also be used.

Legumes and Livestock.— Legumes through their ability to use the nitrogen of the air by means of bacteria on their roots, offer one of the best means of keeping up the nitrogen supply of soils. They also add much organic matter. Sweet clover, being a legume, is an excellent crop to grow on badly gullied and sheet eroded fields, to restore organic matter and nitrogen, act as a cover crop, improve the physical condition of the soil and at the same time furnish much pasture. Due to the ability of sweet clover to grow on heavy, clayey soils, newly exposed by erosion, it is possible to get satis-

factory results with it where red clover or alfalfa could be started only with difficulty. On less eroded fields, alfalfa, and in the eastern part of Nebraska, red clover are good crops to use. Every landlord should see that provisions are made in the farm lease for seeding legumes and that equipment is available to permit the tenant to carry on a diversified type of farming. It is a short sighted policy to grow only grain crops. As an actual illustration of the value and effect of red

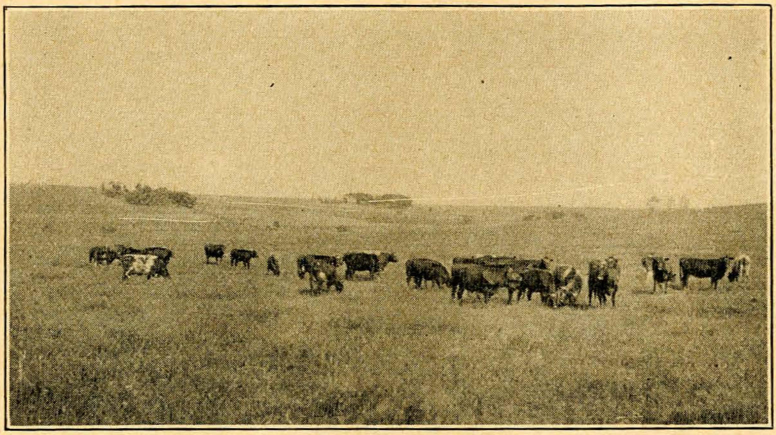


FIG. 9.—The growing of legumes and the production of livestock are essential in maintaining the organic matter and nitrogen content of Nebraska soils.

clover, figures on an eastern Nebraska farm which had been rented and grain farmed for a number of years, show that 36 bushels of corn per acre was the best yield that had been raised in recent years. A part of this farm was put to red clover for two years and then put to corn. The three following crops of corn made 65, 50, and 47 bushels per acre. The growing of legumes and the production of livestock are essential in maintaining the organic matter and nitrogen of Nebraska soils.

METHODS OF CONTROLLING EROSION

The best method to use to control erosion already established, may vary with each individual case. Many different practices are successfully used by farmers. Not all can be given here but some which have been tried and found to be particularly successful are described.

Plowing in and Seeding Down.— In spite of much care in maintaining the organic matter content of soils and in the methods used in farming operations, torrential rains, such as are common in Nebraska, are likely to start small gullies, paricularly in the fall, on newly prepared wheat land and in the spring on land prepared for corn. If the old adage of "A stitch in time saves nine" is ever true, it is in the case of checking these small washes before they have reached much size. They should be given attention at once.

One of the common ways of attacking these small newly formed ditches is to fill them with straw, cornstalks, cobs, or manure followed by plowing in the soil from the sides. The ditch may be filled its entire length with straw or other material or this material may be placed in piles at frequent intervals. Rows of short stakes are often driven through the material to help hold it in place. Dirt plowed and worked in from the sides should be worked down and seeded to some

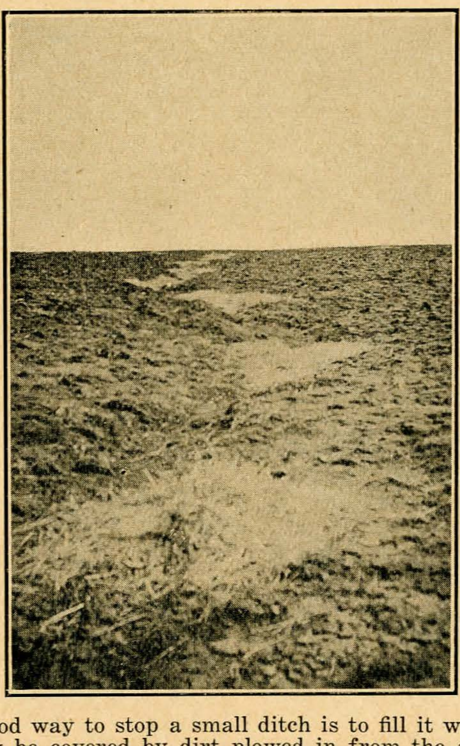


FIG. 10.—A good way to stop a small ditch is to fill it with straw which may be covered by dirt plowed in from the sides.

rapid growing crop such as sudan grass, or cane. The fills may be seeded down to permanent grasses such as brome grass or timothy and the plow lifted out thereafter in crossing. Where there is a considerable tendency for small ditches to form on slopes, it is a good plan to seed them down.

Straw Piles and Loose Brush.— It is a common practice to thresh straw piles into gullies or to throw large piles of brush into them. When put in in this way neither the straw

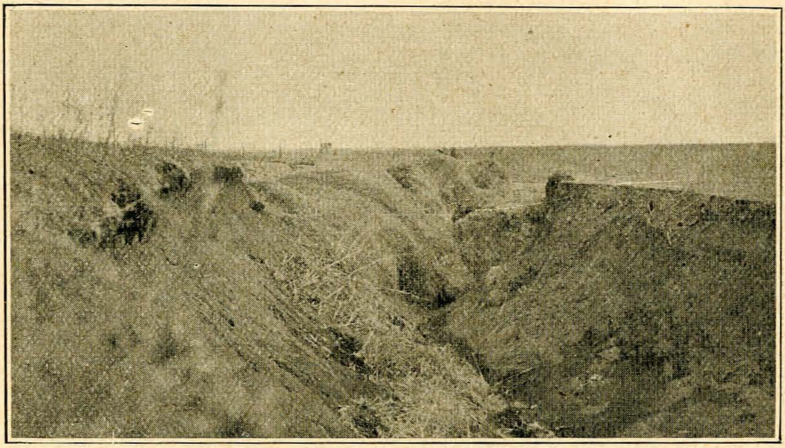


FIG. 11.—Straw stacks in the head of gullies may help to check them but often the water goes under or around the stack.

nor the brush is apt to do much good. In the case of straw piles, unless the drainage area is very small and the fall above the stack gradual, the water usually makes a new channel around the stack or else rots out the bottom of it and runs underneath. In either case the ditch is filled little if any.

Brush thrown loosely into the ditch without being staked or placed with some system, in most cases, washes out with the first hard rain, and does little good, and on the contrary, may do harm to fences, culverts, and bridges downstream.

Brush Dams.— Gullies draining less than 15 acres and ranging in depth from 2 to 8 feet can usually be filled by properly installed brush dams. It is a common fault in installing brush dams to put in a few very large ones rather than to build many smaller dams nearer together and each one filling back to another just above it and thus continuing to the head of the ditch. It may be necessary to build a series of dams at different intervals as a ditch is filled, rather than to

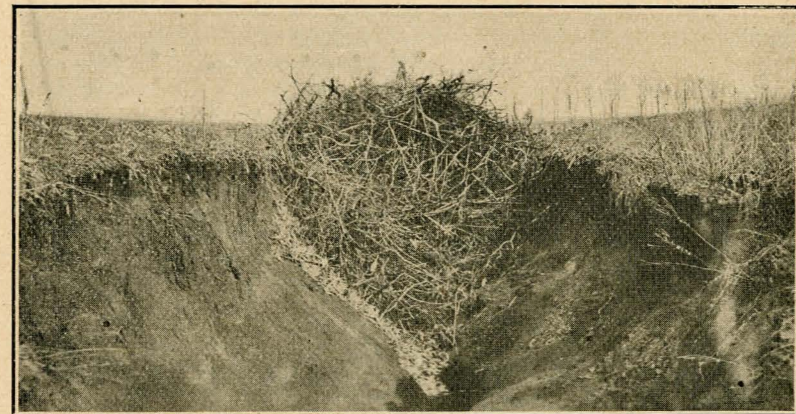


FIG. 12.—Brush piled loosely in a ditch and not staked is of very little value.

try to fill a deep gully with one set. The principle of the brush dam is merely to check the velocity of the water long enough to allow the sediment to settle out. The relation of the velocity of water to its carrying capacity has already been discussed. Where large brush dams are installed the great amount of water held above them usually carries the dam out, regardless of how well they may be constructed.

Brush dams may be installed in a number of satisfactory

FIG. 13.—Installing a series of brush dams.

ways. One plan particularly successful where tried in Nebraska is that of packing the brush in piles with the tops downstream. Where the gully is not more than 5 feet deep it can be filled with one series of dams. The brush should be so piled that the center of the dam is slightly lower than the sides. Four to six strong stakes or posts should be driven in a row across the brush about one-third of the way from the

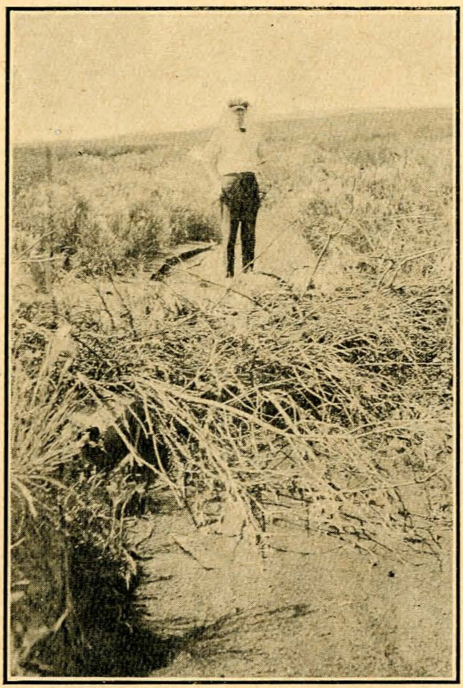


FIG. 14.—The effect of a brush dam installed two months.

upper side of the dam. Strong wire or poles should be strung from one post to another crosswise to the brush and then the stakes driven in firmly. This clamps the brush under the wire or crosspoles. Straw or coarse manure should be thrown in the gully on the upper side of the dam to help check the water.

It has been found that, on the average, soil will fill in with a raise of from 6 to 12 inches in every 100 feet upstream. The brush dams should, therefore, be placed so that each one fills back to the one above it, thereby filling the gully its entire

length. Where brush dams have been installed in this way, ditches five feet deep have been filled in one year's time. The rate of filling will depend on whether or not fields in the drainage basin are cultivated and in a condition to wash easily. When the ditches have filled they should be seeded to some fast

FIG. 15.—The brush dam shown in Figure 13 just one year after it was installed.

growing crop like sudan grass or cane, which will hold the soil and continue to catch sediment. The second year it is a good plan to seed the draw to grasses such as brome grass, timothy, or bluegrass. Some farmers refuse to try to fill gullies, stating as their reason that some water must run off and this requires a ditch. It is true that there will always be run-off but it should be kept in mind that what is wanted is a broad, shallow flat depression in order that the velocity of the water may be kept low. Slowly moving water neither cuts nor carries off much sediment.

EARTH DAMS

Earth dams are growing in popularity as a means of filling gullies. An outlet tube is placed in position as shown in Figure 16 and over it is built a firm earth dam which blocks all flood water forming a pond or lake causing the silt to settle and fill the gully. The pond above the dam may often prove large enough to contain all the flood water resulting from an ordinary rain while the tube and an earth spillway at one end

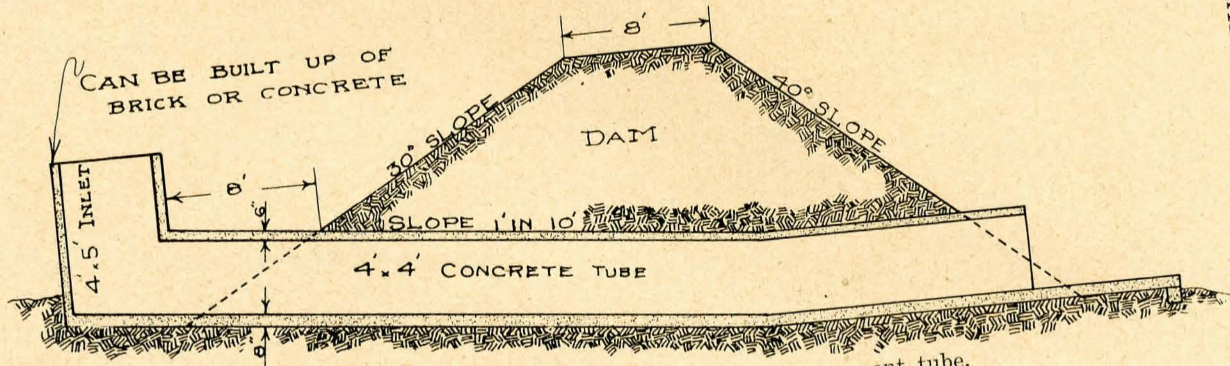


FIG. 16.—A cross section of a soil dam with a cement tube.

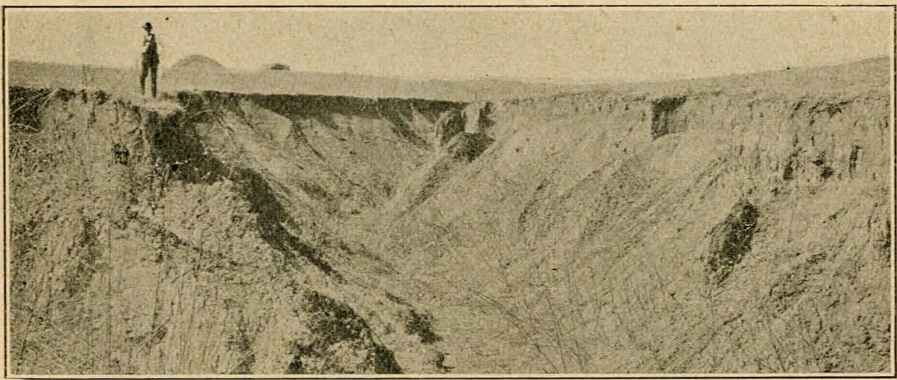


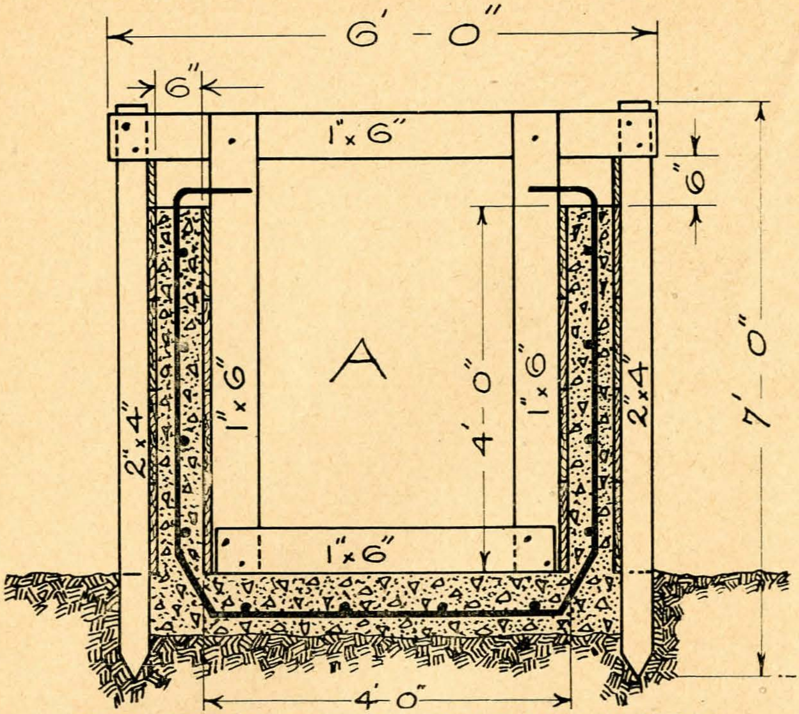
FIG. 17.—A soil saving dam is the best method to use to fill a gully of this sort.

of the dam together provide an outlet for heavy or excessive downpours.

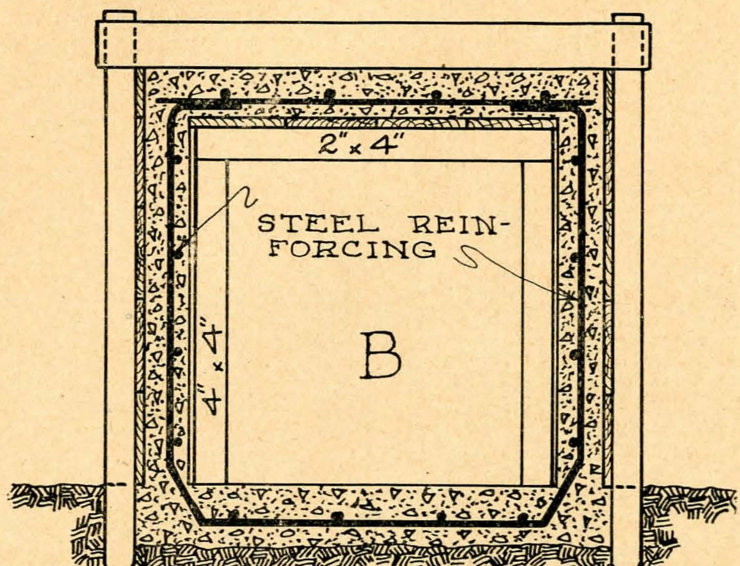
Great care must be exercised in building the dam to see that the banks of the ditch are well cleared of weeds or grass and well spaded or plowed so that a close bond will be formed between the earth of the dam and that of the banks. The earth used in the dam should be free from all trash or brush and may well be in a moist condition. For best results, the dirt should be spread in thin layers and well trampled.

Many designs of tubes have been used. For smaller drain-

FIG. 18.—A small soil saving dam in Otoe county.



CROSS SECTION SHOWING SIDE FORMS IN PLACE



CROSS SECTION WITH FORM FOR TOP IN PLACE

FIG. 19.—A cross section of a cement tube for a soil saving dam showing the methods of construction.

age areas vitrified sewer pipe or large reinforced concrete tile such as is used for road culverts will be found convenient and satisfactory. These tile or sewer pipes must be placed on solid ground, the dirt being removed under the bells or flange. The dam may be started after the joints are well concreted and a small concrete fill made under the flange where the earth has been dug out. The covering of any sort of tube with earth must be carefully done to prevent water from seeping along it and eventually washing out the dam or seriously injuring the outlet. It is recommended that all soil placed around the tube be dampened and well tamped when placed in position. One or more seepage collars or concrete cut-off walls as shown in Figure 21, are well worth while on any tube or outlet since their use practically eliminates danger from seepage.

The correct size of tube to use will depend on the size and shape of the drainage area as well as on the character of the soil and steepness of the hillsides. A steep, compact drainage area will give rise to profuse and sudden run-off. Hence, any gully which drains such an area will carry large quantities of water and if obstructed by a soil saving dam, means must be provided to care for this overflow since it is seldom practical to provide a tube large enough to do it.

The crest of the dam is made higher than the banks and around one end of the dam a spillway is cut with slip scrapers. The occasional flood which cannot be carried by the tube and which must find a means of escape through the spillway, will do little or no harm, particularly if the sides and bottom of this spillway are well covered with grass. The following table of

Area drained acres	Tube area square feet	Diameter round tube	Size rectangular tube
5	1.8	1′– 6″	1′–4″ x 1′–4″
10	2.9	2′– 0″	1′–5″ x 1′–5″
15	3.9	2′– 2″	2′–0″ x 2′–0″
20	4.8	2′– 6″	2′–0″ x 2′–5″
30	6.4	2′–10″	2′–6″ x 2′–6″
45	7.7	3′– 2″	2′–6″ x 3′–0″
50	9.1	3′– 5″	3′–0″ x 3′–0″
60	10.5	3′– 7″	3′–6″ x 3′–0″
70	11.5	3′–10″	3′–3″ x 3′–6″
80	12.7	4′– 2″	3′–3″ x 4′–0″
100	15	4′– 5″	3′–9″ x 4′–0″
120	17	4′– 7″	4′–3″ x 4′–0″
140	19.2	5′– 0″	4′–0″ x 5′–0″
160	21.4	5′– 3″	4′–3″ x 5′–0″
200	25	5′– 8″	5′–0″ x 5′–0″

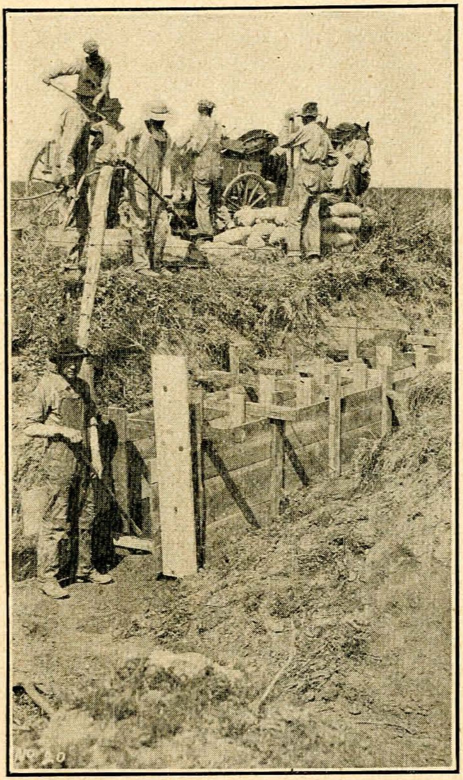


FIG. 20.—Installing a concrete tube for a soil saving dam.

tube sizes is intended for a guide in construction and will be found to meet average conditions in eastern Nebraska.

An efficient reinforced concrete tube of square or rectangular cross section may be constructed by the land owner, if form lumber, sand and cement are readily available. Figure 19 at A shows the forms in position and the concrete in place for the sides and bottom, while at " B " is shown the inside form removed and the form and concrete in place for the top.

It is well to use reinforcing rods in even the smallest size tubes to prevent cracking from expansion and contraction. The side walls and top are ordinarily made 6″ thick in tubes up to 4′-0″ square. In larger tubes special designing is necessary to meet individual needs.

As shown in Figure 16 the length of the tube must vary

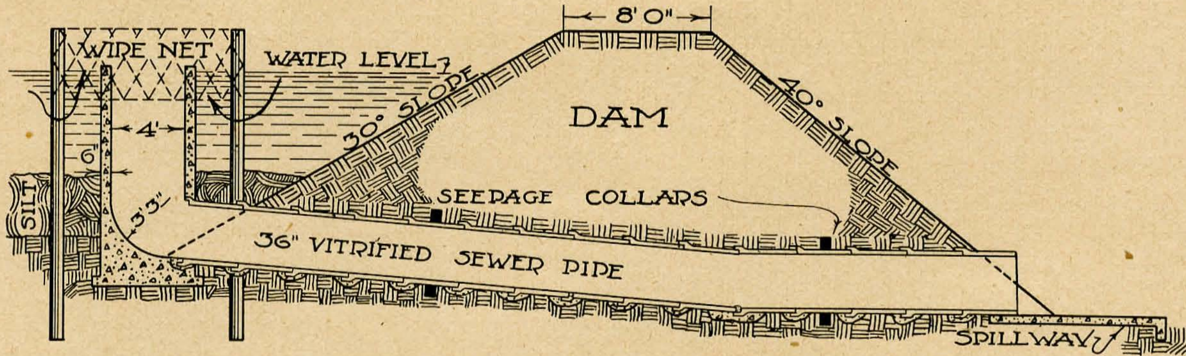


FIG. 21.—A cross section of a soil saving dam with a vitrified sewer pipe tube.

with the width of the base of the dam. The inlet may well be placed 8 ′ -00 ″ or more from the dam as in this position clogging from trash is less likely. Eddy currents around the inlet are also less likely to injure the earth work.

The design of the inlet is very important. In most cases the inlet is so poorly arranged that the tube never carries its full capacity. A hopper or funnel-shaped inlet pipe relieves the situation somewhat but the main trouble is encountered in the elbow which is invariably a sharp 90 ° bend. The churning effect of the falling water and the ease with which trash may clog such a bend renders its use undesirable when installing tubes of small dimension. Long radius bends or upright pipes of larger diameter than the main tube will be found more satisfactory.

In Richardson, County Nebraska, a large number of soil saving culverts have been installed in large ditches which cross the public road. The culverts are very much like the tube used in a soil saving dam while the earth fill of the roadway forms the dam. A sloping upright tube of concrete has met with considerable favor since it facilitates the entrance of water. Owing to the increased area and easy bend the main tube is kept working to full capacity at all times.

Some means must always be provided to prevent trash from clogging tubes up to 3′ -00″ in diameter. Four posts may be set around the upright tube and stout woven wire

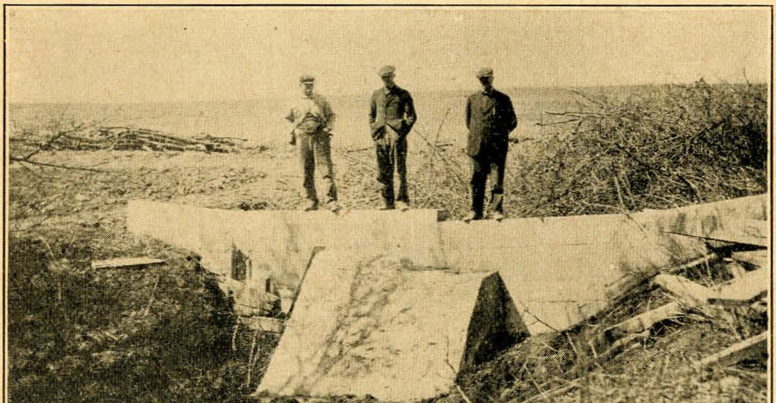


FIG. 22.—In building concrete dams care must be taken to install them properly, to reinforce them sufficiently, and to build a spillway to prevent undermining.

stretched around them as shown in Figure 3. This wire prevents any trash from entering and does not obstruct the flow which takes a course as shown by the arrows in Figure 3.

The outlet end of the tube must be protected by masonry to prevent the fall of the water from washing out a deep hole.

CONCRETE DAMS

Concrete dams have been used in many parts of the state for the control of erosion in ditches. In many cases results have been far from satisfactory due to poor design and poorer methods of construction. In far too many cases the builder in an effort to keep the cost down has used weak mixtures of concrete and built structures with insufficient strength to withstand the water pressure. Dams which have a height greater than 3′ -00″ should ordinarily be reinforced with steel bars. The following general statements apply to all classes of concrete dams.

1. The ends of the structure should extend into the sides of the gully a distance of several feet to prevent seepage around the concrete which will result in damage.
2. A spillway built in the center of the structure will provide a ready means of escape for flood waters but the sides near the banks of the gully must be as high or higher than the banks. See "A" Figures 23 and 24.
3. A spill apron below the dam (See "B" Figures 23 and 24) provides a place for the water to strike without causing erosion after rushing over the spillway.

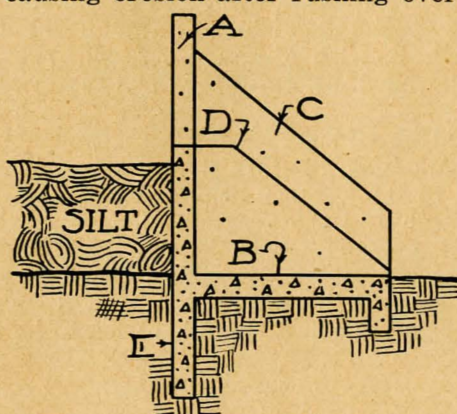


FIG. 23.—The cement dam to be satisfactory must be carefully designed and installed.

4. A mixture of one part Portland cement, three parts sand and six parts stone will be found satisfactory for structures of this kind.
5. A dam of more than two or three feet in height must be reinforced with steel bars and often a special design is called for because of local conditions. Larger concrete dams should not be attempted without special advice from trained engineer.

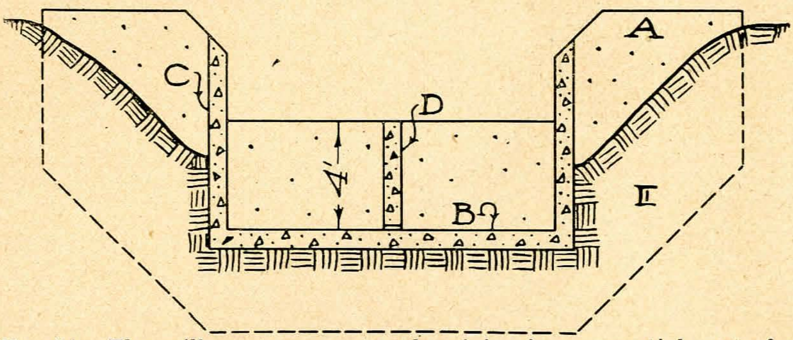


FIG. 24.—The spillway to prevent undermining is an essential part of a cement dam.

6. Buttresses help to support the structure when properly designed and placed. (See "C" and "D", Figures 23 and 24.)
7. A dam placed in a gully, the bed of which is underlain with gravel or sand will often be undermined and fail unless special provisions are made to cut off seepage beneath it with sheet piling or by extending the foundation down to impervious material.

TILING THE AREA ABOVE THE DAM

It may be some years before the fill above the dam can be farmed owing to its wet condition. Each rain brings in a layer of wet earth and the accumulation of flood water may keep the sub-soil soaked up for a depth of several feet. Several strings of drain tile laid at a depth of two and one-half or three feet and carried to the outlet tube will carry away the surplus moisture and permit the filled area to be farmed.

WOODEN STAKE DAMS

A cheap and yet very efficient method of filling large ditches of rather moderate slope consists of driving two rows

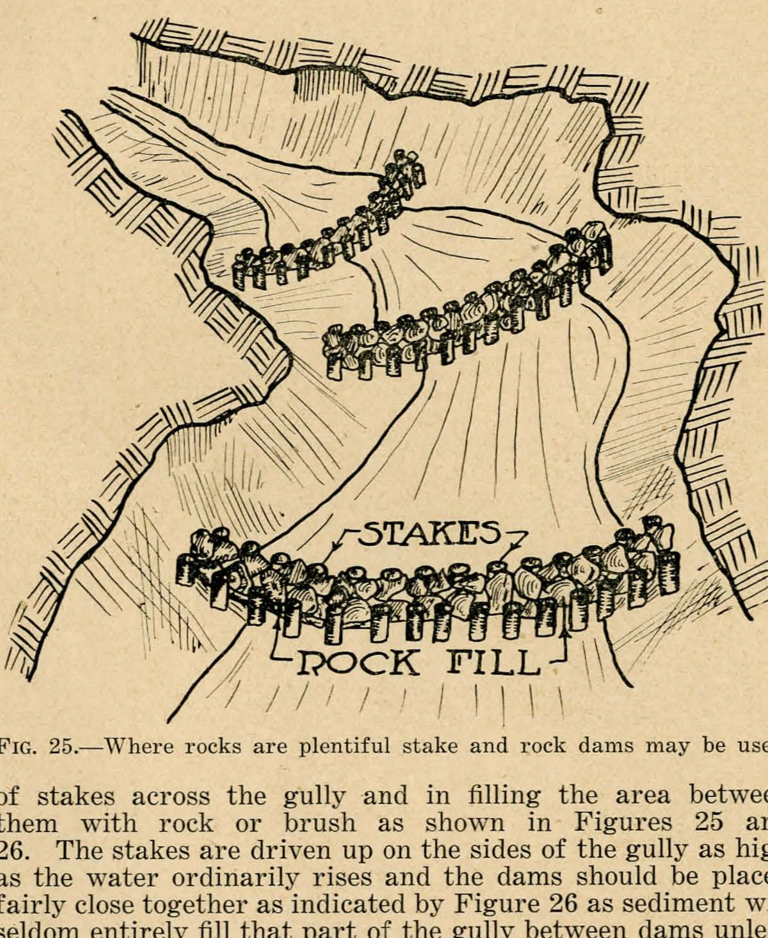


FIG. 25.—Where rocks are plentiful stake and rock dams may be used.

of stakes across the gully and in filling the area between them with rock or brush as shown in Figures 25 and 26. The stakes are driven up on the sides of the gully as high as the water ordinarily rises and the dams should be placed fairly close together as indicated by Figure 26 as sediment will seldom entirely fill that part of the gully between dams unless they are close together. This type of dam is not well adapted

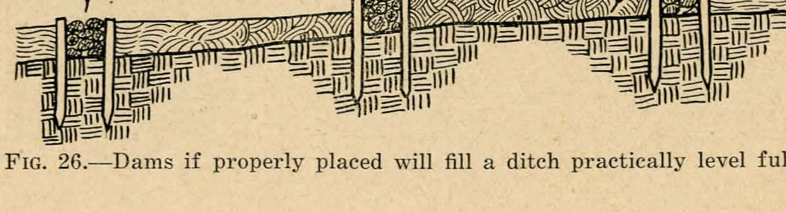


FIG. 26.—Dams if properly placed will fill a ditch practically level full.

to ditches, the bottom slope of which is greater than about two feet per one hundred feet. If the height of stakes used is about 24 inches then with a fall of 2′ -0″ per 100′ the dams should be not more than 75 feet to 80 feet apart.

TERRACES

There are some hillsides on which erosion can scarcely be prevented except by terracing. Long slopes even though they be gradual will often gully badly because of the great amount of water which passes over the surface of the ground during a heavy rain. Terracing should not be attempted unless other means such as planting leguminous crops and manuring have failed to stop the soil washing or unless many small gullies have formed on the slope and the terrace is resorted to as a means of filling them.

There are several kinds of terraces but the one best adapted to Nebraska conditions is the Mangum or broad terrace which may safely be used on slopes of less than 15 ′ rise to 100 ′ horizontal distance. It consists of a ridge resembling a road grade carried across the slope of the hill to conduct flood water in a thin sheet with slow velocity to the side of the field. This ridge is built to a height of 18″ to 24″ and has a width of 15′ to 20′ or even more at the base. Terraces are placed one above another on the hillside, the distance between them being governed by the steepness of the slope. Slopes of 6 ′ to 15 ′ per 100 ′ call for a terrace each 5 ′ or 6 ′ of vertical drop, while on the flatter slopes a wider spacing may be used and a terrace placed about 4 ′ of vertical

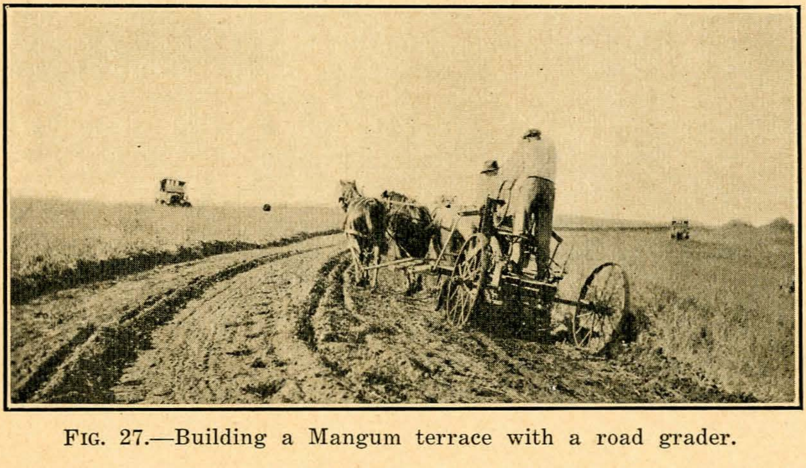


FIG. 27.—Building a Mangum terrace with a road grader.

drop in slope. Thus if a hillside were 1000 ′ long and in this distance there was a fall of 40 ′ about 10 terraces would be needed.

In order that the flood water may be carried above the terrace to one side of the field it is necessary to provide a certain amount of fall or slope to the terrace itself. It is important that this slope be uniform and sufficient to carry the water or it will break over the grade oftentimes causing damage to all the terraces below it. A slope of from 4 ″ to 6 ″ per 100 ′ has been found satisfactory but this may be made less on terraces of short length (200 ′ to 300 ′).

A place to allow the terraces to discharge is of primary importance, although much of the water caught by the terraces seeps into the soil and does not reach the point of discharge. Oftentimes the ditch at the side of the public road may be used or a gully in which erosion may be controlled with brush dams is convenient. A strip of wooded alnd or a pasture sod make an ideal place to allow the terraces to discharge as very little erosion is likely to occur in lands of this character.

It is necessary to have a leveling instrument of some sort to lay out a system of terraces. The first move is to find the actual slope of the hillside to determine the proper spacing. Each terrace is then staked out with lath or other light material with a fall of about 6 ″ per 100 ′. The stakes should not be over 50 ′ apart and 25 ′ is even better. This allows a man with a team to follow the line closely. When small gullies are

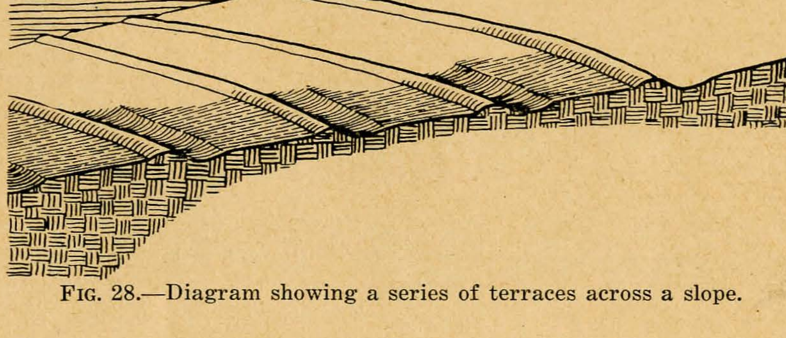


FIG. 28.—Diagram showing a series of terraces across a slope.

encountered the line is carried across thus avoiding any sharp turns. Slip scrapers are then used to make fills at each point where the terrace crosses a small gully. A man with a team and plow back furrows around the line of stakes until a strip of ground 16 ′ to 20 ′ wide is plowed after which the road grader is started and a ridge very much like a road grade is built. (See Figure 27.) This ridge may also be constructed with a drag or with various other devices which are made for the purpose.

Terracing work should be done in the fall if possible to allow plenty of time for settling before the spring rains. Land which has been in small grain and which is fall plowed or about to be plowed furnishes nearly ideal conditions for successful work. The terraces are constructed and allowed to settle through the winter and back-furrowed again in the spring. Terraced ground should be planted to small grain or leguminous crops the first year or two but never to corn unless the rows run around the slope with the terraces and not across them. Each time a terrace is crossed with the corn cultivator a small ditch is left which may result in an overflow at the first hard down-pour. Men who have successfully done terracing work have found it practical to back-furrow each terrace once every year or two.

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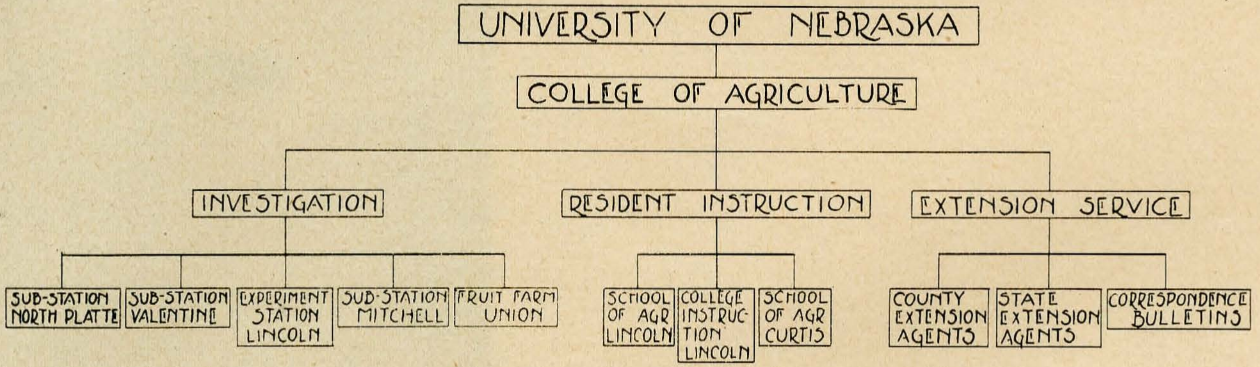
Director of Agricultural Extension Service. (6-24-10M)

THE COLLEGE OF AGRICULTURE AND ITS ACTIVITIES



This chart shows in graphic form the organization of the College of Agriculture. The College of Agriculture is one of ten colleges in the University of Nebraska, but has its own campus and buildings at Lincoln, besides experimental substations in various parts of the State. In addition to the customary instructional work of a college, it is responsible for experimental investigation and agricultural extension work. The instructional work includes instruction of college grade at Lincoln, instruction of high school grade thru the School of Agriculture at Lincoln, and instruction of high school grade thru the Nebraska School of Agriculture at Curtis. Experimental work and farming investigations are carried on at the main farms at Lincoln, and substations at North Platte, Valentine, and Mitchell, and at the fruit farm at Union. The Agricultural Extension Service represents the intimate contact between the college and the farmers of the State. This includes demonstrations by county and state extension agents, the distribution of bulletins, and practical service to the farmer, such as the answering of inquiries by mail.