Erosion Prevention and Control

A Seminar Thesis

By

Wilbur D. Cooper

April, 1937.
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Erosion Defined</td>
<td>2</td>
</tr>
<tr>
<td>Water Erosion Examples</td>
<td>2</td>
</tr>
<tr>
<td>Wind Erosion Examples</td>
<td>4</td>
</tr>
<tr>
<td>Causes of Erosion</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>6</td>
</tr>
<tr>
<td>Wind</td>
<td>9</td>
</tr>
<tr>
<td>Object in Control</td>
<td>10</td>
</tr>
<tr>
<td>Methods of Control</td>
<td></td>
</tr>
<tr>
<td>Water Erosion</td>
<td>11</td>
</tr>
<tr>
<td>Wind Erosion</td>
<td>12</td>
</tr>
<tr>
<td>Methods of Prevention</td>
<td>16</td>
</tr>
<tr>
<td>Conclusion</td>
<td>19</td>
</tr>
</tbody>
</table>
Illustrations

<table>
<thead>
<tr>
<th>Illustration</th>
<th>Facing Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erosion by Rivers</td>
<td>4</td>
</tr>
<tr>
<td>Planted Beach Grass</td>
<td>7</td>
</tr>
<tr>
<td>Results of Cultivation</td>
<td>9</td>
</tr>
<tr>
<td>Dry Farming</td>
<td>13</td>
</tr>
<tr>
<td>Check Dams</td>
<td>14</td>
</tr>
<tr>
<td>Check Dams</td>
<td>15</td>
</tr>
</tbody>
</table>
CROPS OR CANYONS?

During recent years we have seen and heard a great deal about the soil conservation, or erosion control movement. It is deplorable that something could not have been done several years ago to prevent the serious losses which have been suffered by people in the Plains states and in the southeastern part of the United States. "It has been estimated that erosion removes not less than 126,000,000,000 pounds of plant food material from the fields and pastures of the United States every year. This is more than twenty one times the amount removed by crops. The annual financial loss to farmers probably amounts to about $200,000,000."¹

An advertising booklet, published by a caterpillar tractor company, contains a picture of a gully which started under the eaves of a barn less than seventy-five years ago. Today it reaches across two counties, is 125-200 feet deep, and from 100 yards to one and one half miles across. It represents ten thousand acres, including farms, roads, woods, barns, homes, and churches, which were undermined by its growth — yet a simple diversion ditch could have stopped it all. In another case, an eighty acre farm, on which there were no gullies thirty five years ago, has been practically ruined for farming because of the formation of a large gully with many branches. This gully grew to a depth of fifteen to twenty feet and thirty to sixty feet wide, and finally ex-

¹Ramser, C. E. "Farm Terracing", Farm Bul. 1669 (1931) U.S.D.A.
pensive structures were required to prevent it from crossing two highways. All this damage might have been averted by digging a few ditches.

These gullies, however, are not the only evidences of soil losses in this country. The migration of farmers from the central states to the settlement in Alaska is evidence of the serious wind erosion in some parts of the country. When conditions become so bad that nearly whole states have to be abandoned, it is time that something be done to correct them.

Erosion may be defined as the displacement of soil by wind and water.

Few of us have seen any serious effects of wind erosion, but everyone, whether he realizes it or not, has seen considerable damage done by the washing of water. On half of the farms we pass as we drive along the highway there are small, or large, finger gullies reaching up the slope and growing with each rain. In some soil types and on moderate slopes they may not reach dangerous proportions, but, on steeper slopes and in silt or clay soil, they may become a real menace to the community. On these same fields, but not so apparent to us or even to the farmer, the soil is being washed off the surface of the ground at such a slow but constant rate that it may remove all the fertile top-soil before anyone becomes aware of the loss. This action is aided, generally, when the field has been recently cultivated, or

1. Ramser, C. E. "Gullies; --", U.S.D.A. Farm Bul. 1234 (1935)
when it has been frozen and then thawed.\(^1\)

Everyone, who has lived on a farm or been on one, has seen the washing away of the banks of irrigation ditches. This is carried to much greater proportions on the banks of rivers and creeks. The enormous amount of water flowing in some streams cuts under the banks on bends and finally causes the top of the bank to topple into the stream and be carried away.

An interesting type of erosion, often occurs in forests where the slopes are steep, the underbrush scant, and the ground heavily sodded. Water filters into the ground at the top of the hill and runs down the slope in the subsoil. At the bottom of the slope, where springs normally occur, the water is unable to escape fast enough because of the thick sod cover. The water then forms a hydrostatic head on the slope similar to the water in a standpipe above an electric power plant. When the head is sufficiently large, the sod erupts and the water rushes out. The result is a pile of dirt, perhaps ten feet across, left lying on the slope below the point of escape.

In the sandy lands of southern California and New Mexico there occurs a strange, very destructive type of erosion. It is always found next to streams and is caused by the action of water on the subsoil. Water, which runs down the slopes, seeps into the sand as it reaches the flats and flows, beneath the surface, toward the stream. Whenever possible it follows the animal burrows or other lines of little resistance, and

\(^1\) Ramser, C. E., "Gullies; --", U.S.D.A. Farm Bul. 1234 (1935)
This stream is washing away large chunks of the bank, and by meandering through low places in the land is spreading over a wide surface.

East of Corvallis.

This stretch of highway was ruined by a flooding mountain stream. Further up the road it was covered with one to two feet of sand by the stream.

On Mount Hood Loop Highway, east of the Mountain.
the collection of water enlarges the burrow until it becomes a tunnel. Portions of the crumbly soil fall into the tunnel and are washed away, until at last a small cavern is formed. Then a horseman who might chance to ride over the cavity would have the sand cave in and find himself in a shallow well. These wells are scattered about the flats and spoil the land for farming. As yet no practical means has been found to combat this destruction.

The other agent of erosion works more stealthily, as a rule, and is not as apparent. In the Northwest, where the moisture content of the soil is usually high, there is not much trouble from blowing, but in the Plains states, with their lack of vegetation, little rainfall, and with flat, rolling topography the damage of recent years is alarming. It has been the popular belief that the great dust storms which have occurred there have caused the loss of fertility, but, in reality, the blowing is only an indirect result of the farming methods that have been used. During several generations crops have been removed and nothing has been returned to the soil to maintain the fertility. As a result, the soil humus has been removed, and this, combined with a few years of low rainfall, has caused the soil to become dry and dusty. When it reaches this condition it is easily blown, especially after cultivation. There are, however,

some places in the Northwest where land is constantly being covered or laid bare by the blowing of the sand and loess soil. The most extensive area of this type is the Palouse area on the Columbia Plateau of eastern Washington. In some places the loess soil has reached a depth of one hundred feet. It has been carried there from other places where the moisture content is low, and the soil blows easily, as is proved by an interesting incident. A snowfall was, on the following morning, covered with a chocolate-brown dust which must have been brought a distance of over one hundred miles. It has been estimated that 7,500 pounds per acre per year is deposited on this area, and it has been removed from other parts of the country. Fortunately for the locality, the soil that is deposited is always fertile and improves the region for agriculture.

There are sections along the Columbia River, near The Dalles and on the beaches of the Pacific, where sand dunes are constantly moving along, almost as if they were rolling. The Union Pacific railroad sprayed the sand at The Dalles with crude oil, and this was temporarily successful in stopping the movement. However, in a few years, the oil broke up and the sand began to move again. Then wooden drift fences were built to stop the blowing, but they were soon covered. On the coast, the trouble is that the sand blows from the beaches toward the fertile land, and has been a nuisance in the maintenance of the coast highway as it collected in

the road cuts and against banks, making driving along the road dangerous. This trouble has been partially corrected by planting grasses and vines which will grow rapidly on the banks and dunes.

There are many causes of erosion, but it is safe to say that human occupation has been the main factor. We have never heard of dust storms arising while the "Forty Miners" were crossing the plains, and yet, in 1935 the newspapers all over the country were filled with stories of the great amount of damage done to farms, ranges, and even to cities by the blown soil. Erosion need not necessarily increase with the advent of settlers. The damage is done by removing from the land the properties which tend to control erosion. Geologists have stated that the rate of soil formation, under normal conditions, will slightly exceed the rate of removal.

Since the property that has the greatest effect on soil conditions is vegetation, whenever the plant cover is removed from the land, it begins to move toward an unstable condition. The growth of plants requires that there be some kind of nutrients in the soil, and when crops are produced for generations and nothing returned to the earth, it becomes depleted. The product of vegetation which influences the


This beach grass was planted in rows on sandy soil along the highway to prevent blowing. Low fences of woven brush may be seen between the rows of grass. The grass will eventually spread to form a complete cover. Scotch broom is scattered over the surface. In other places the broom is used alone, in place of the grass.
condition of soil is humus, or decomposed organic matter which has lost its physical characteristics. Humus contains plant nutrients, encourages soil granulation, and so increases the soil permeability, stores moisture, and decreases the dispersion ratio of the soil. When no organic matter is returned to the soil no humus can be formed, and so the soil becomes unstable and loses fertility. The same thing results if the litter or trash on the surface is burned. A sample of soil that has been burned over annually for forty two years, when compared with an unburned sample, showed a loss of 121,289 pounds of organic matter per acre.

There is a direct correlation between soil permeability and the rate of run-off. As long as soil is composed of large granules and correspondingly large pores, the rate of permeability is high, but when the soil begins to wash and the silt, which is most easily dispersed, is carried along, it is filtered out as the water penetrates the soil. This seals the pores and forms a crust on the surface. As soon as this happens the water can no longer penetrate and must flow off the surface. That is when erosion begins.


The rate of erosion is dependent on the slope of the ground. There is much land under cultivation that should not be used because it is so steep that soil is carried away with every little bit of water that flows off.

The method of tillage also greatly influences the rate of erosion. On soils which have been harrowed or only plowed there are holes which catch falling water and prevent its immediate run-off. In this condition it can only sink into the ground where it fulfills its proper purpose, but if the land is dragged or smooth the water will not be absorbed as fast and washing may result.

The direction of cultivation is also important. If the furrows run up and down the hill they will concentrate the effect of the running water. On the other hand, if the furrows run with the contours of the land the flow will be retarded.

When streams flow in the same course for many years their channels become well established and stable. If an amount of water larger than usual suddenly rushes down the channel, the banks are washed out, vegetation and debris are carried along, and much valuable soil may be lost. This is an example of what may occur as a result of removing all timber from an area. These timbered lands normally absorb and retain moisture, but when the trees are removed there is nothing left to hold the water. The result is that when heavy, or even light,

2. Laudermilk, W. C., "Influence of Forest Litter on Runoff, Percolation, and Erosion", Jr. of For. vol. 28, pp. 474-.
Silt deposited at foot of slope on smoothly cultivated, bare field. Three miles north of Corvallis.

The field in the foreground was cultivated, while that in the background is in sod. Note the six inch drop in the surface level near the fence, at the right.

East of Corvallis.
rains occur a torrent of water rushes down the canyons, moving great amounts of soil and debris, often endangering lives. When the water reaches level ground the sand and the litter are dropped, and as a consequence, much valuable agricultural land is wasted, or stream channels may be filled. The muddy Missouri River and the Mississippi delta illustrate the results of land denudation.

However, water is not the only cause of erosion. In the areas where the rainfall is below eighteen inches, wind erosion presents a problem of no small proportions. The recent dust storms of the central states serve as illustrations of erosion resulting from improper farming methods. For generations the land has been tilled; crops were removed but no fertilizers or nutrients were added, and in this manner soil fertility was gradually reduced and the humus removed. This means that the soil moisture, in a location where rainfall is naturally scant, was proportionally reduced. When the humus was removed, not only was the soil unable to retain moisture, but it did not readily absorb it. (This inability to hold moisture is

what causes the floods in the Mississippi valley.) During recent years the rainfall has been below normal, and when the soil was cultivated, it became dust. Then, when the wind blew, it lifted the dry silt and sand and carried them for miles. The same thing happened in the south-western cattle ranges, because owners were accustomed to carry as many cattle as possible on their range. Since, in every cycle of eight or ten years there are three or four "dry" years during which there is not enough plant growth to properly support the cattle on the range, something must be done.

Instead of each owner carrying about half the usual number of cattle during these "dry" years, he maintained the regular herd. Consequently grass was eaten and tramped down until it was killed, and the soil around the water holes was churned into a dust. The soil was not given any shelter from the plants which ordinarily grew there, and when winds blew the soil was carried away. A proper system of range management would have prevented all this damage to farms and ranges.

The object in the fight for control of erosion is not, as it has been in the recent past, merely to prevent the increase in damage of the erosion which is already started, but to correct the conditions which encourage erosion. It is far more desirable that we should correct our agricultural methods and thereby avoid the possibility of excessive.

erosion. It has been proved in erosion-control projects that land, when it is properly tilled, will not wash away with every little rain that falls. A good example of erosion control is a newly spaded lawn. When the soil is well spaded and bare, little lines are cut in it every time it is sprinkled; but as soon as the grass begins to come up the washing stops. It is just so with agricultural lands. Of course it is not possible or advisable to have the land producing constantly, but it is possible to have the land in such a condition that it will not wash away when it is idle.

On a recent tour of a soil conservation project I saw in practice the recommended methods for preventing erosion. The policy of the project had been to help only those farmers who realized their need for control. As a result, some farms were under proper control while others, just across the road, were still using old methods of cultivation. The soil from one field had washed down until it had filled the drain ditches along the road and then had washed across, leaving almost a foot of silt on the road. On the other hand, the field properly managed showed a negligible amount of washing. The superintendent of the project explained that

before they had begun control of this field there had been a gully several feet deep running through it. They had merely plowed some of the bank down to fill the gully within a foot or so of the top and then had planted grain over the strip. On previous work they had been accustomed to plow in arm-loads of straw with the top layers of soil, but, while working on this gully, the superintendent had conceived the idea of spading in lines of straw across the gully, just forcing in his spade and pushing it forward to make an opening. Another man carried an arm-load of straw and sprinkled it into the crack. Then they pounded it down with a spade and tramped the soil back. The result was a series of miniature dams across the channel, formed by the ends of the straw protruding from the ground. When any rain fell and the soil started to wash down, it was caught on the straw and held. This principle of using straw for soil binding is also useful in dry-farming to prevent blowing. Wheat farmers have been in the habit of burning the stubble and straw left after combine-harvesting because it interfered with the plowing of the soil. It is now known that if the straw is left on the ground its values will justify the increased cost of disk ing to work it into the soil. When the straw is disked in and the ends left projecting it is very useful in stopping the movement of dust by winds.


The field in the foreground was cultivated in the recommended manner, with straw and chaff disked in. The strips in the middleground are experiments in cover crops.

Eastern Oregon Experiment Station, near Vale.

Students examining strains of Ponderosa pine and Russian olive to be used for windbreaks.

Eastern Oregon Experiment Station.
Not all gullies are as easily controlled as the one mentioned, however. Some, approaching the size of the one referred to in the beginning of the article, require particular methods of control. Such serious gullying could have been prevented by proper control measures, such as planting soil-binding plants. Small gullies are occasionally covered naturally, but few plants can set in the larger gullies. Much experimenting has been done to find plants that are suitable for such locations. Black locust is undoubtedly the best tree that can be used in the large gullies, since it grows rapidly on exposed clay sub-soils and, being a legume, adds nitrogen to build up the soil. Willows grow well in moist soil and have the added advantage of producing sprouts when stakes made of them are used in dams. Shortleaf pine is another tree that grows well in sandy, poor soils within its geographical range in the southern states. There are several vines that are well adapted to the work of gully control, and these are useful because of the mat-like cover they form. Kudzu is the best vine for gully control, since it grows well on sands and clay. Japanese honeysuckle has grown so well that it has escaped cultivation. It is this kind of vines that is desirable because it covers the gully with a mat which prevents the water from stirring up the soil and carry-

These dams of wire, posts, litter, and dirt were built by a class in Erosion Control at Oregon State College. Three miles south-west of Corvallis.
ing it away, and the roots bind the soil so that large clods are not easily broken off.

In some gullies it may be necessary to construct check-dams. These may be made of logs, planks, dirt, rocks, sod, or concrete, although it makes little difference what material is used, as the principle governing factors are convenience and economy. On many farms there are plenty of straw and old fence wire available, and very effective small dams can be constructed by driving stakes into the sides of the gully, stringing the wire across, placing straw in front of the wire, and covering it with dirt to hold it down. Where timber is abundant log dams are commonly built, since these can be constructed by placing a log across the gully so that the ends of the log extend into both sides. Gullies on hillsides in which the water flows rapidly may require a concrete dam. These should be low in the center to withstand the force of the current and to prevent undercutting below the dam. In all such dams it is necessary that precautions be taken to prevent the water falling over the dam from cutting out the soil below. Although expensive, concrete is the best adapted to work of this kind because it can be formed into the proper shape and is solid. Often the most expensive part of a check dam is the spillway.

This gully was said to be about ten feet deep. These log dams have prevented further erosion, and in time will cause the gully to fill.
Near Vale, Oregon.

This dam was built of wire, posts, straw, and dirt. The dam in the background was made of dirt-filled burlap bags, with the overflow channel of one inch lumber.
On Wildhorse Reclamation Project, near Vale, Oregon.
Before it becomes necessary to use these extreme measures, it would be much better to use a little care in land management. There are several methods of land tillage that have been recommended by the agricultural experiment stations. If the land, when it is fallowed, is left with a rough surface it will be much less apt to wash away. When rain falls, if the surface is smooth, the water begins to flow. As it gathers volume and velocity it also gathers dirt and carries it away. If the soil surface is rough the water will gather in pockets and then soak into the soil. This is desirable, not only because it prevents washing, but because it helps to store water for future crops. As has been stated before, straw or trash disked into the soil impedes the flow. On valuable soils that are extremely erosive, it may be necessary to plant crops in contour strips. Alternate strips are farmed one season while the other strips are fallowed, and vegetation, in this manner, prevents any flow gaining momentum.

As a last resort, because they are very expensive, terraces may be constructed, although they will be prohibited economically if the value of the land is low. They are located on slope contours in the same manner as roads,


with just enough grade to encourage a moderate flow of water. The machines used in constructing terraces are plows, V drags, graders, elevating graders, and several other special tools. The dirt is thrown up in ridges to direct the flow, to prevent the collecting of a large volume of water, and to reduce the velocity. We have seen that the control of erosion is sometimes very expensive and always troublesome, and that it would be much easier to prevent the erosion in the first place.

Any success that is achieved in the prevention of erosion will depend on the cooperation of individuals. The problem has become so large that a national organization is necessary to combat it properly, but nothing can be accomplished if each individual does not accept his responsibility. As with disease, the best cure is prevention, and farmers must learn to use methods which are recommended by their agricultural experiment stations. These methods will affect cultivation, fertilization, crop rotation, irrigation, grazing, and systems of management for forest owners.

We shall consider these topics in their order. Perhaps the greatest error in cultivation is plowing or harrowing up and down the slope rather than with the contour. This obviously will direct the flow of water, rain or irrigation, down the steepest slope, and cause the maximum loss of soil and irrigation value. In a similar manner, making furrows or ridges perpendicular to the direction of the winds will

decrease soil blowing, because the soil particles are caught in the furrows when they start to roll and can not gain momentum. In plowing after harvest, part of the stubble and chaff should be left projecting from the ground to prevent blowing.

Fertilization not only increases plant growth but so affects soil structure that it absorbs water, holds it, is not easily dispersed, and is more permeable. Crop rotation and fertilization are not greatly different in effect. The theory of rotations is to raise alternate crops that will require different materials from the soil and return, or form, substances of value to the following crop.

Cattle owners in the south west must limit the size of their herds to the number that can be supported by the range during dry seasons. That number should be about one half as many as could be carried during favorable years.

In order to avoid depletion of our timber supplies, destruction of watersheds, and to prevent flooding of the lowlands with sand and debris, it is necessary that timber owners adopt plans of sustained yield in their timber management. Indiscriminate destruction of timber resources


in the past has wasted great areas of land in the Lake
states. Incredible as it seems most of the original
billion acres of forest in the United States has been cut
down. Destruction of forest litter and exposure of the soil
greatly increases the amount of erosion. Although the capi-
city of litter to absorb rainfall is insignificant, it
is important because of its ability to maintain maximum per-
colation capacity of soils. Since so much of our land has
been made useless, it is now necessary to find a means of
restoring the productivity.

Reclamation of most eroded marginal land requires only
simple, common sense methods. Some gullies will require
permanent dams; others can be stopped by planting such soil-
binding plants as Black locust, Kudzu, Japanese honeysuckle,
and Reed Canary grass.

In areas which have suffered from wind erosion, plant
covers should be encouraged. Often it is best to retire
the land and plant inexpensive perennial crops which will
build up the soil fertility, humus, and moisture.

Most of the annual precipitation in the semi-arid west


falls as snow. Consequently a knowledge of snow cover and its water content is necessary for proper utilization of this great natural resource. Accurate forecasts are important for proper distribution of water supplies and for flood protection. Recently a system of snow survey has been developed by which the depth and water content of the snow can be measured at the end of the precipitation season. In this manner it is possible to forecast stream flow, predict floods, and regulate the water supply for irrigation.

We have seen that most cases of serious erosion were brought about by human activities. Improper methods of cultivation reduce soil fertility, lower humus and moisture content, encourage rapid flow of large amounts of water down steep slopes, and permit movement of dust by winds. Since soil fertility losses affect land value, and land values increase with the soil nitrogen content, the erosion problem is a serious one. In rebuilding soil it may cost one hundred dollars per acre to add sufficient nitrogen fertilizers.

Removal of forests, destruction of litter, and exposure of the soil greatly increase the amount of erosion.


Light burning in the forest also causes a great deal of damage to the soil. The Forest Service for many years has emphasized the injury to tree growth and to future value of the timber as a result of burning. It depletes the potential supply of plant nutrients and the organic matter supply of the soil.

Control of erosion may be accomplished by construction of temporary or permanent dams, the filling of gullies mechanically, planting of trees or vines, or a combination of all these.

Success in the prevention of erosion will require the co-operation of every interested individual, even though the problem is of national importance. Farmers, cattlemen, and timbermen all must adopt modern methods of conservation if we are to solve the problem of erosion.

BIBLIOGRAPHY


