

THE COST OF SOIL EROSION.*

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THE PROBLEM.

Unrestrained soil erosion is rapidly building a new empire of worn-out land in America: Land stripped of its rich surface layer down to poor subsoil, and land gullied beyond the possibility of practical reclamation. This wastage of the nation's most basic and indispensable asset is not merely continuing; it is speeding up. Over millions of acres the washing is becoming more rapid as the cutting away of the upper soil material lays bare the less stable substrata. Every rain heavy enough to cause water to flow across cultivated slopes and sparsely vegetated land removes part of the soil. Every one sees this in the muddied waters flowing away to the oceans, but few think of the material that discolors these flooded waters as soil material swept from the surface of the fields, where lies the most productive part of the land.

No other agency or combination of agencies remotely approximates the impoverishing effect of rainwater running wild across the slopes of America's farm lands. Three-fourths of the agricultural area of the nation is sloping enough to favor ruinous cutting away of the vital substance of the soil through the abrasive action of water. More than 100 million acres of the 350 million in cultivation have lost all or most of the precious material we call the topsoil. At least 160 million acres of the remainder are suffering in some degree. To date we have permitted the essential destruction of about 35 million acres of what formerly was largely good crop land, together with an enormous additional area of grazing land. This has been so deeply washed, so cut to pieces by gullying or so smothered with the products of erosion that it can not be reclaimed upon any practical basis by the average farmer. Much of it is permanently destroyed. Bedrock has been reached in countless places and deep gullies have torn asunder millions of sloping acres. All of this has been abandoned.

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No other part of the western hemisphere has been so wasteful of its land resources as we of America. Probably no nation or race of all history has permitted its agricultural lands to go to waste so quickly. Other parts of the world have been ruined by erosion, but the lands were used for many centuries, even thousands of years, before their devastation was completed. The enormous impoverishment and destruction that we have permitted, even encouraged by lack of interest and foresight, has taken place with but two centuries of cultivation. Most of the depletion has been accomplished during the past fifty to seventy-five years. This has come about because of carelessness, ignorance and the physical peculiarities of our soils, rainfall and farm methods. With respect to land use, we have proceeded, and continue to proceed, without plans. We have used all kinds of land, occupying every degree of slope, indiscriminately for every conceivable purpose. There has been too little of orderly selection on the basis of adaptability and fitness, and almost no effort has been given to the vitally important matter of soil conservation. We have looked upon our vast domain of agricultural land as limitless and capable of enduring forever. Because the vast areas which have been made so poor that a man may spend his lifetime upon it without bettering himself or his farm will still grow something, we continue to produce an abundance of everything. The point of gravest menace is not a matter of producing a sufficiency of food. We shall be able to meet our requirements of both food and clothing for many years to come. But how? What is the menacing aspect of this evil of erosion?

The sore points deserving immediate serious consideration are these: Our best lands are largely in use and have been for some time. The area of these more favorable soils is steadily diminishing as the result of excessive rain-wash. Acreage yields are declining in spite of all the education and experimentation devoted to improvement of methods, and in spite of increased use of improved varieties, better seed, better machinery, high-grade fertilizers, soil-improving crops and irrigation, along with continuing abandonment of worn-out land for land still retaining its topsoil. Cultivation of erosion-exposed clay is more difficult and costly, and need for fertilization and building up of the soil is steadily increasing. Water flows across the impervious clay exposed by the stripping off of the mellow, humus-charged topsoil more rapidly to augment

floods. Tens of thousands of hard-working farmers already are subsoil farmers. Subsoil farming is an impoverishing type of agriculture. Although producing a large aggregate of crops, the average yields at this low level of soil productivity are so pitifully meager, there is but slim opportunity for the operator to get ahead, whether prices are up or down. Reservoirs that were built to hold water, not solid soil material, are rapidly filling with mud washed down from unprotected slopes; stream channels are silting up and overflows are becoming more frequent and destructive. Vast areas of alluvial land of extraordinary original productivity are being covered with infertile sand and gravel; large sums are required to protect the embankments and roadside ditches of our highways and railroads; and flood protection calls for the expenditure of ever increasing millions.

From every conceivable angle erosion is a devastating agency. It is the greatest thief of soil fertility. It steals not only the plant food contained in the soil but the whole body of the soil, plant food and all. When this productive material that required centuries in the building is washed out of fields it can not be economically hauled back, even where it is washed no farther than from the upper to the lower slopes of fields. That which passes down into the beds of streams and on out to the ocean is lost as irretrievably as if consumed with fire. Our best estimates indicate that erosion steals 21 times as much plant food as the crops take out of the land. That removed by crops can be restored, but that taken by water and wind can not be restored. It is a net loss of almost incalculable magnitude. The process is the principal cause of worn-out land. There can be no permanent cure of dangerous floods so long as this principal contributor to the evil remains unleashed. Higher and broader and more costly levees may be built, but they can not insure any permanency of protection with ever increasing volumes of water charging out of erosion-denuded uplands.

Our surveys and soil-loss measurements indicate that at least 3,000,000,000 tons of soil are washed out of the fields and pastures of the United States every year. The value of the plant food contained in this amounts to more than two billion dollars, on the basis of the cheapest fertilizers. Of this almost inconceivable wastage, the direct loss to the farmers of the nation is not less than \$400,000,000 every year. This is

paid for in reduced acreage yields, increased cost of cultivation, fertilization and the growing of crops for the sole purpose of building up impoverished fields, in land abandoned, highways damaged, reservoirs, irrigation ditches and culverts choked with erosional debris, and accumulative thinning of the surface soil, the staggering cost of which is postponed until the last inch of soil is washed off.

In a single county of the old South Carolina Piedmont country, where farming has gone on for nearly two centuries, ninety thousand acres of once good farm land have been mapped as soil largely permanently destroyed by gulying. Countless ravines have chiseled to pieces former fields, exposing bedrock in numerous places, and all the soil has been lost. One farm of 1,004 acres, 200 of which were cleared of the virgin timber just after the Civil War, has not so much as a single acre of good farm land left in one place. No one lives on this once magnificent plantation. The palatial residence has tumbled to ruins. Silence pervades the desecrated acres; and all the surrounding country is much the same.

The same survey has shown in the same county forty-six thousand acres of stream bottom, formerly the best land of the entire state, which have been converted into swamp or so smothered with sand washed out of the hills that it no longer has value for crops. The stream channels are so choked that every rain of any importance sends flood waters over the alluvial plains.

Eight miles west of Lumpkin, Georgia, is the largest man-made gully of the western hemisphere. This chasm is 200 feet deep. It was started by the drip from the roof of a barn fifty years ago. Since then it has swallowed the barn, a schoolhouse, a tenant house and a graveyard with fifty graves. In addition to this huge gulch, there are thousands of others nearly as large. Altogether seventy thousand acres of the best farm land of the region have been permanently destroyed in one county by this irreparable devastation. To fill these gullies would require operations on the order of those employed in the construction of the Panama Canal. And yet, every one of them could have been stopped easily in their infancy, had the farmers known of the necessity and of the practical methods of procedure.

In five adjoining Alabama counties, 500,000 acres of formerly cultivated land, most of it once highly productive, have been

worn out with gullying and deep sheet washing. This is largely abandoned. Fortunately, much of it is growing up with pine trees. The growing of trees is the best possible use for such land.

In one county in southeastern Ohio, a soil survey made by the State and Government cooperating shows that nearly 200,000 acres of formerly cultivated land are no longer cultivated. Approximately half of this has been so terribly impoverished by erosion that it is no longer used for any purpose. First it was farmed, then turned over to pasture; now the fences have fallen down and only poverty grass, golden-rod and weeds are growing on it. This too could have been saved had the farmers known 50 or 75 years ago what we know today.

That the consciousness of the nation has not been aroused to the seriousness of this prodigiously costly evil is an ugly blot upon our record. In our textbooks we read of vast expanses of grass-covered prairies, of the buffaloes that grazed over these virgin grasslands; and we read of the enormous extent of our eastern forests and the fertile lands from which these have been cut. But we read little or nothing in these volumes of the desecration of these same areas following the breaking of the prairie sod and the cultivation of the lands that supported the forests; the destruction of millions of acres and the impoverishment and increasing impoverishment of a large proportion of the remainder. Are our children to believe that the present gullied and soil-skinned slopes of the nation represent normal conditions, or shall we tell them the truth in order to implant the germ of moral obligation to country and posterity which eventually would arouse that mobility of consciousness so vitally necessary for correction of our unwise land-use practices. If this is not done, if we continue as in the past cultivating steep lands and lands that wash away within a few short years following the first plowing, there can be but one outcome: Irreparable decline of the nation's most basic resource, its agricultural lands. This is not so much a prediction as an obvious physical eventuality based on the known depth of the productive topsoil and the known rates of soil removal and depletion by erosion.

At the moment there is widespread discussion of the evils of erosion and the necessity for controlling it. Some of these discussions seem to imply that all we have to do is to go out

and stop the wastage. We are fully aware of the fact that forests and grass and the thick-growing plants, such as lespedeza, alfalfa, sorghum and sweet clover, will largely reduce the washing; but we must continue to produce clean-tilled crops, as corn, potatoes, cotton and tobacco. It is in fields of these crops that the evil is so vicious and calls for immediate attention. There are various remedies and partial remedies. Some methods, effective on one soil occupying a given slope, are of little value for other soil conditions. For many kinds of land we have not yet ascertained the most economical and effective measures of control. The national program of soil erosion, described below, is striving with the greatest possible speed to develop the acutely needed methods for such lands.

In the discussions now going on a great deal of emphasis is devoted to gully control. Much good could be accomplished in this direction, especially in regions where gulying is widely prevalent; but on the whole necessity for gully control is of inconsequential importance in comparison with the need for control of sheet washing: That process of erosion which planes off a thin layer of soil with every rain heavy enough to cause water to flow across cultivated slopes. This process goes on so slowly that little attention is given it until infertile spots of clay subsoil and solid rock begin to make their appearance in fields, at which stage it usually is too late to do very much in the way of soil conservation, the soil having largely floated away in the direction of the oceans. Gulying usually begins at that stage of sheet washing when the soil is all gone.

Another unfortunate feature in connection with the erosion problem is that only a handful of soil specialists know how to distinguish sheet washing and to measure its effects. Practical capability in this important field calls for special knowledge of soil varieties, their morphological structure under virgin and cultivated conditions and their varying tendency to wash, as determined by soil type. Sheet erosion can be identified and its effects measured only by comparing eroded areas, soil layer by soil layer, with the original condition in woodlands and grass-covered areas. What will happen to a given area of a definite soil type if put into cultivation can be predicted only through this method of comparing and interpreting natural and abnormal soil conditions. What one kind of soil will suffer on a given slope frequently is entirely different from what will take place on another soil having

precisely the same gradient. This is one of the most fundamentally important aspects of the erosion problem, and without due consideration of these variables, erosion-control programs will suffer or come to nothing.

THE NATIONAL PROGRAM OF SOIL AND WATER CONSERVATION.

Finally recognizing the enormous cost of soil wastage by erosion and excessive loss of rainwater as runoff from unprotected cultivated slopes and from overgrazed ranges and pastures, Congress three years ago appropriated funds to begin a national program for studying the whole problem of erosion and for developing methods of control. The plan calls for accurate measurement of the losses of soil, water and fertility from various slopes undergoing different cropping treatments throughout twenty odd major regions of the nation where erosion is known to be a problem of enormous seriousness. To date, ten of these erosion experiment stations have been established.

At these stations every promising practical method for slowing down erosion is to be tried out on a field scale. Rates of soil loss and runoff are to be accurately determined from the different slopes planted to different crops and tilled in various ways. Terracing, strip-cropping, scarification of the land and other methods are being tried out, first on small plots and then in large fields, wherever the results have shown any promise of practical applicability. In some regions where livestock farming is important the land is being subjected to various conditions of grazing, in pastures containing a variety of grasses and other forage crops. The cheapest methods of reclaiming erosion-worn land are being determined, together with the cost. Various methods of gully control are being tested, using living dams of grass, trees, shrubs and vines, rock dams, dams made of poles, brush and other cheap materials. Conservation of the remaining soil, however, will be the prime endeavor of the program, rather than reclamation of depleted land.

As soon as the work at the stations gets well under way, every experiment of worth-while promise will necessarily constitute a demonstration. Field meetings are held on the farms at frequent intervals so that the farmers of the region may visit the station and see what is going on. The educational

phase of the work is being pursued in such manner as to acquaint the regional farmers with the precise meaning of erosion, its cost and the best methods for its control. There is no secrecy about any part of the program. Visitors are urged to come to the station from the very beginning of the work. They are urged also to bring to the specialists on the erosion farms any suggestions they may have which are based upon worth-while practices on their own farms, in order that every promising practice may be brought clearly out before all the farmers of the various regions.

To cite the work at one of these erosion farms: The Red Plains erosion station near Guthrie, Oklahoma, is located on the principal type of farm land in this highly erosive region, which comprise thirty-six million acres in Oklahoma and Texas. An erosion survey recently completed by the Oklahoma Agricultural College has shown that of the sixteen million acres under cultivation in that state, thirteen million acres are suffering seriously from erosion, nearly seven million acres of this having reached the stage of gullying. More than a million and a half acres have been ruined by deep washing and gullying during the past ten years. The annual cost of erosion to Oklahoma has been estimated by the state agricultural specialists to exceed \$50,000,000, under normal price conditions with respect to farm commodities.

The work at the Red Plains station has shown that when the principal regional crop, cotton, is grown continuously, the loss of soil from the average slope amounts to 32.5 tons per acre per year, along with a loss of 14 per cent of the total precipitation as runoff. This means that under cotton only 30 years are required to wash off the entire depth of the surface soil, down to stiff clay subsoil, which produces less than half as much cotton as the uneroded topsoil.

The results show, on the other hand, that on precisely the same kind of soil and the same degree of slope only .03 tons of soil and 1.7 per cent of the precipitation are lost where grass is grown. In other words, grass reduced the soil loss by 1,080 times and the water loss by 8 times. Where cotton is grown in rotation with grain and a leguminous crop, the loss of soil is reduced by 350 per cent and the loss of rainfall by 23 per cent, as compared with the losses under continuous production of cotton.

Beyond this, terracing and strip cropping have very largely reduced the erosion. The farmers of the region are visiting the station daily, and more and more of them are putting into practice the soil-saving and water-conserving methods which have been worked out on soils like those on their own farms.

The work, such as is proposed for the erosion stations, should have been begun 50 or 75 years ago. At this advanced stage of our civilization we have not yet obtained the fundamental facts relating to the erosion problem, such as are vitally necessary for the carrying out of protective measures. If this work should be delayed the problem of erosion control would simply become progressively more difficult, more expensive and more discouraging. It is a problem that must be attended to now, not something that can be put off for future generations to solve. No moratorium can be declared against erosion. It must be fought with determination and effective implements. If we refuse to ascertain what these implements are, then the fight will be lost, or seriously retarded, farming on sloping land will become steadily less profitable and finally altogether hopeless. Floods will flow down the rivers of the nation in ever increasing volume. Cooperation from every thinking individual is needed in this combat. Let's remember that erosion is the most powerful agency affecting the physical character of the earth, and let's not forget that already we are very late in getting started the studies which should have been made first of all, the studies having to do with land use and the maintenance of soil productivity. We can not afford not to pursue this problem with all the energy at our command.

Human Reproduction.

Sex and its manifestations in man have been traditionally subjects of taboo. Science, which is coming into its own these days, recognizes no forbidden subjects, and acknowledges no taboos. This complete and extremely interesting account of the biology of sex in man fills a long-felt want, both for the biologist himself and the general public. Questions everyone has wondered about are answered here: hermaphroditism, the hormones influencing sex, twinning, embryologic abnormalities and others. The book is a scholarly and dispassionate account of a difficult subject, and the author and publishers deserve a vote of thanks for the work. Abundant illustrations tell their story as no written words could, and add greatly to the value of the book.—L. H. S.

The Science of Human Reproduction, by H. M. Parshley. 319 pp. New York, W. W. Norton and Co. 1933.