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SOIL EROSION—A NATIONAL MENACE

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UNRESTRAINED soil erosion is rapidly building in this country an empire of worn-out land. The cost of this evil to our farmers and ranchers amounts to at least $400,000,000 annually, to say nothing of the enormous damage to highways and railways and the costly silting of reservoirs, streams and ditches. This appalling wastage is speeding up with the washing off and blowing off of the absorptive topsoil, down to less absorptive, less productive, more erosive subsoil. Over this erosion-exposed material, usually consisting of comparatively impervious clay, rainwater flows away faster from millions of denuded acres to increase the frequency and volume of floods.

At least three billion tons of soil material are washed out of the fields and pastures of America every year. To load and haul away this incomprehensible bulk of rich farm soil would require a train of freight cars long enough to encircle the earth thirty-seven times at the equator. More than four hundred million tons of solid matter are dumped into the Gulf of Mexico every year by the Mississippi alone, along with many more millions of tons of dissolved substances. These materials come largely from the farms of the Mississippi Basin. The greater part consists of super-soil—soil richer than that of the Nile. But the sediments entering the oceans represent merely a fraction of the soil washed out of fields. The greater part is piled up along lower slopes, where it is not needed, or it is deposited over stream bottoms or laid down in channelways and reservoirs. Once the soil leaves a field, it is as irretrievably lost as if consumed with fire, in so far as pertaining to the field from which it is washed. It can not be economically hauled back, even that which is temporarily lodged not far down the slope.

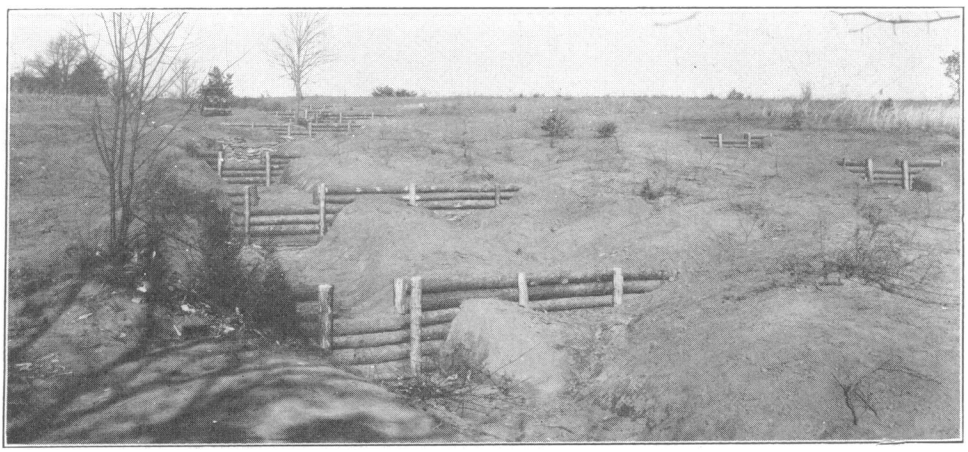
Thousands of farmers operating on slopes stripped of the more productive surface layer have but the slimmest opportunity to make a satisfactory living, whether prices are up or down. They have been lowered to the discouraging level of cultivating land whose productivity has been reduced from two to ten times or more by this tragic wastage, most of which could have been prevented. We find them, generally, not along the main highways, but in the back country, housed in miserable dwellings and living pitifully inadequate lives, with their system of cultivating little plots of ground scattered between gullies and abandoned fields.

WHOLESALE LAND WRECKAGE

Already, the nation has permitted the essential destruction of an area of formerly cultivated land that exceeds the combined extent of Illinois, Massachu-

setts and Connecticut. This is the equivalent of about 220,000 farms of 160 acres each. In addition, this washing of sloping fields has stripped off all or the greater part of the productive topsoil from 125 million acres of the land at present in cultivation; and now, wind erosion is rapidly developing other enormous areas of poor land, as well as destroyed land in our semi-arid belts.

Man's activities in subduing the forests of eastern America, then the prairies to the west and finally the plains,



FIRST STEP IN CONTROL OF EROSION

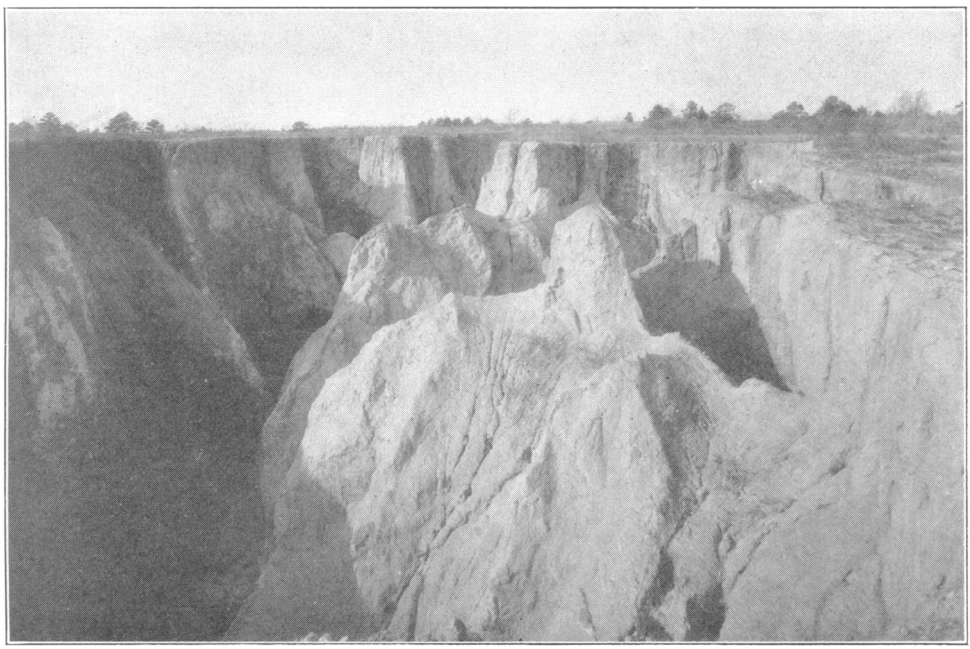
BY SOIL EROSION SERVICE ON THE SOUTH TYGER RIVER PROJECT, SOUTH CAROLINA. FOLLOWING THE INSTALLATION OF THESE CHEAP LOG DAMS, VEGETATION IS SET IN THE GULLIES AND BETWEEN THE GULLIES. SUCH SORE SPOTS MUST BE CONTROLLED IN ORDER TO PROTECT GOOD FARM LAND ON SLOPES BELOW.

valleys, mountains and intermountain basins beyond, have proceeded along lines of reckless land use. So vast were our original resources in land that no one was concerned with matters pertaining to soil conservation. But now the country may as well gird its belt for continuing battle against this process of land wastage, if we are to avoid the ominous eventuality of becoming the world's most outstanding nation of subsoil farming—which means, generally, submarginal farming, with all its attendant evils of poverty, declining social and economic values and a hopeless outlook upon life.

A New American Experience

On the eleventh day of May this year the sun was blotted out over a vast area of northeastern United States by a huge dust storm that originated in the drought-stricken wheat fields west of the Mississippi. This "dry blizzard" of sun-obscuring yellow dust, which swept an estimated bulk of three hundred million tons of rich soil from the sun-parched lands of the Great Plains, marked a stage in our system of land use that should alarm and arouse every thinking citizen. It was a thing that never before happened in America, at least, not since the coming of white men. It was a historic event of far more significance with respect to the continuing welfare of the country than most of the incidents included in our histories.

This onward sweeping dust cloud was not the result merely of an unprecedented set of seasonal conditions. For untold centuries droughts have characterized the Great Plains region. The very physical features of the land have been fixed by this climatic factor (the "caliche" or *mid-latitude pedocalic* soils, for example). The wind which



WHAT EVENTUALLY HAPPENS IF GULLIES LIKE THOSE IN THE PHOTOGRAPH ON PAGE 386 ARE NOT CONTROLLED

FORESTED VIRGIN LAND DAMAGED BY GULLIES

THAT STARTED IN AN ADJACENT HIGHER-LYING FIELD. SPARTANBURG COUNTY, SOUTH CAROLINA.

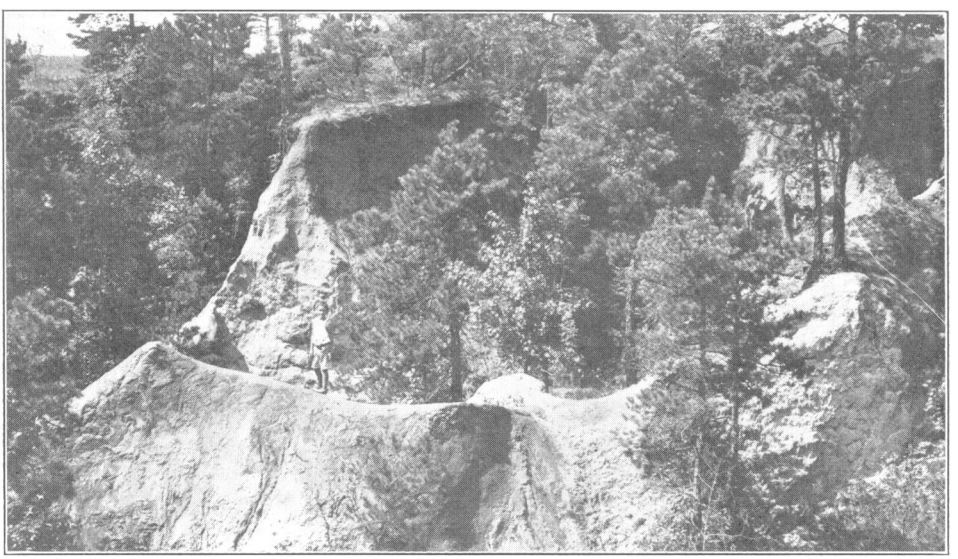
drove that stupendous bulk of soil material half way across the continent was not one which in itself could have accomplished the gigantic task. The real cause was man-induced, speeded-up soil erosion resulting from agricultural utilization of those dry-land areas, plus, of course, a high degree of ground desiccation and soil-lifting winds. Formerly, a natural cover of grass stabilized the ground against wind movement. When this cover was broken, first by farmers venturing beyond the prairies and later by large-scale wheat producers, with their tractors and combines, the loosened soil was laid bare to the driving force of the wind. Its natural firmness was further diminished by continuing cultivation, accompanied by dissipation of the vegetable matter in the soil and the breaking down of the natural structure of the soil—its granularity and fragmental character. Thus, man with his plows and crops developed an incoherent, powdery soil condition favoring the ready lifting of the finer particles into the high pathways of air currents and the leaving of the coarser infertile grains to drift at lower levels by a process of saltation, thus to cover productive land with relatively unproductive wind-assorted material.

This is the simple physics of the process of land stripping by wind, as it is also, essentially, of the still more powerful soil-transporting force of rainwater. It is not an expression of opinion, but a technically determined fact.

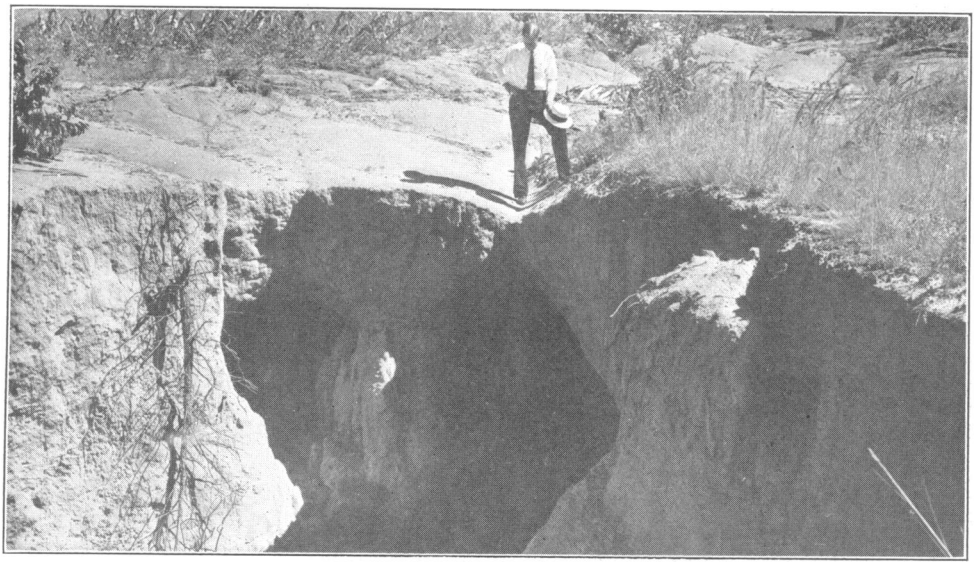
Erosion by Water the Major Evil

Land impoverishment by rainwash is an even more serious economic problem than that of wind erosion. The erosion problem in its entirety is a national problem, the economic gravity of which outstrips any of the temporary worries about which we have heard so much recently. But the nation has not yet realized this fact.

What has happened in Stewart County, Georgia, is an excellent illustration of the destructiveness of man-induced erosion. Approximately one fourth of the area of that county—70,000 acres—has been permanently destroyed by gullying. Originally most of this destroyed area consisted of the



THE ONLY HOPE FOR GULLIED LAND OF THIS KIND IS FORESTRY



UNDERCUTTING TYPE OF GULLY

THE KIND MOST DIFFICULT TO CONTROL. HERE CLAY SOIL IS UNDERLAIN BY SOFT, DECOMPOSED GRANITE WHICH CUTS OUT WITH EVERY HEAVY RAIN CAUSING THE SOIL ABOVE TO CAVE IN. SOUTHERN PIEDMONT REGION.

best farm land in the great coastal plain section of that state. There is no practical means by which these devastated lands can be rehabilitated, and the wastage is marching steadily ahead through the remaining areas of good land, of which there is none too much now.

Some of the gullies have cut to depths of 200 feet. One of these has engulfed a schoolhouse, two farm buildings and a graveyard with 50 graves. Thus, the intermingled débris of wasted land, human habitations and the contents of tombs that were supposed to be the peaceful resting places of man have set out upon a journey of death down the valley of the Chattahoochee River, towards the wastes of the Gulf of Mexico.

The 70,000 acres of land destroyed by erosion in this single Georgia county represent but a fraction of the gigantic stride America has made in the direction of land misuse and consequent land impoverishment and destruction. It is merely an example of the appalling cost of unplanned, haphazard, reckless use of the nation's most indispensable resource—the kind of use that falsely presupposes limitless and inexhaustible supplies of good agricultural land.

Erosion Not a Local Problem

Soil wastage by erosion is by no means restricted to the southern states. It has extended to the shores of California and to the very heart of the great Southwestern grazing region. In southwestern Wisconsin and parts of Iowa, Missouri, Kansas and other central states the rate of soil removal by unrestrained rainwater flowing down across unprotected slopes, has been even faster than in the old sections of the East and South, although not so large an area has been ruined as yet. For example, according to actual measurements, the principal type of corn soil on about the average slope (8 per cent.) of the north Missouri-south Iowa section of the corn belt is losing soil where corn is grown

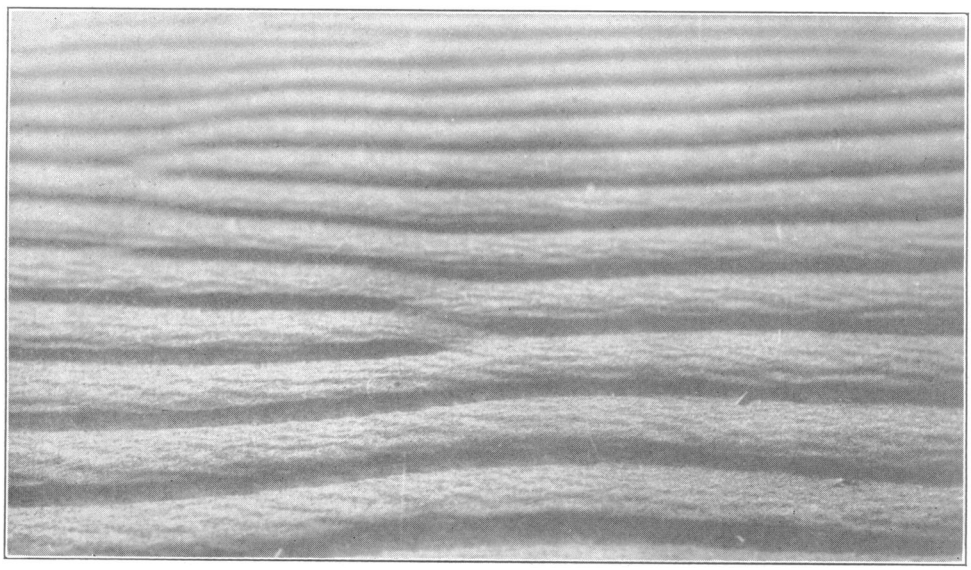
continuously at the destroying rate of 60 tons per acre annually, and with this 27 per cent. of all the rainfall is immediately lost as runoff. This means that the entire depth of the more productive topsoil (about 7 inches) is swept off in approximately 20 years. On the other hand, on exactly the same type of land, occupying the same degree of slope, and receiving the same rainfall, only two fifths of a ton of soil is lost annually per acre where alfalfa is grown and only a little more where timothy grass is grown. The water loss from alfalfa fields is at the rate of only 3 per cent. of the total rainfall. In other words, a thick soil-saving crop like alfalfa is 300 times more effective than a clean-cultivated crop like corn, with respect to conservation of soil. Also alfalfa causes the absorption of 9 times as much of the rainfall as continuous corn.

The average results of measurements made on 12 markedly different and very important agricultural soils, lying largely in the Mississippi Basin, show that grass and similar crops are about 65 times more effective with respect to soil conservation and 5 times more effective with respect to immediate absorption of rainfall than clean-tilled crops grown on the same soils under identically the same conditions as to slope and rainfall.

The Origin of a National Misconception

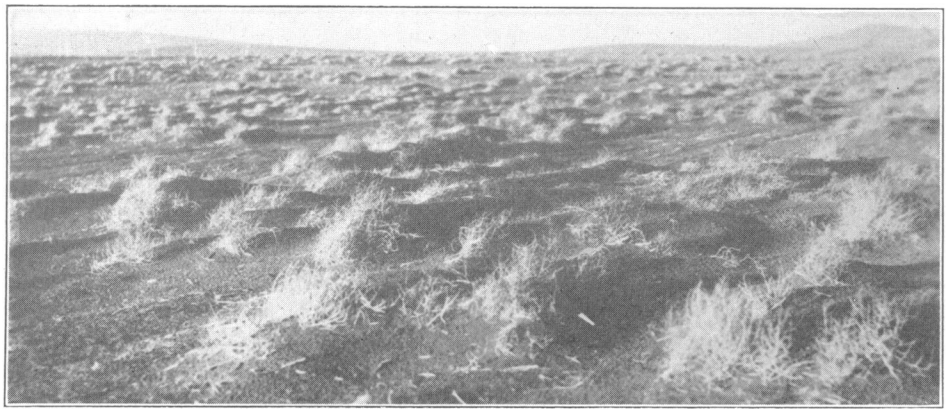
Immigrants to the American continent found a region so rich in land, timber, grass, game, fish, fur and navigable streams that there early developed in this country a false concept of inexhaustible resources. Unfortunately, this concept has persisted until to-day.

Except in an unimportant way, the Indians had done little to cultivate the soil or to change the virgin character of the land surface and the vegetation on it. The streams bore oceanward the residue of rainwater flowing gently from wooded and grass-covered slopes. Rivers ran clear, except in high flood.



WIND RIPPLES WHICH FORM IN THE DUST PILES FORMED BY WIND EROSION

The ripples average about 2 inches in height and are 4 or 5 inches across. South Dakota, summer of 1934.



HOW WIND EROSION AFFECTS A FIELD
SOUTH DAKOTA, SUMMER OF 1934.

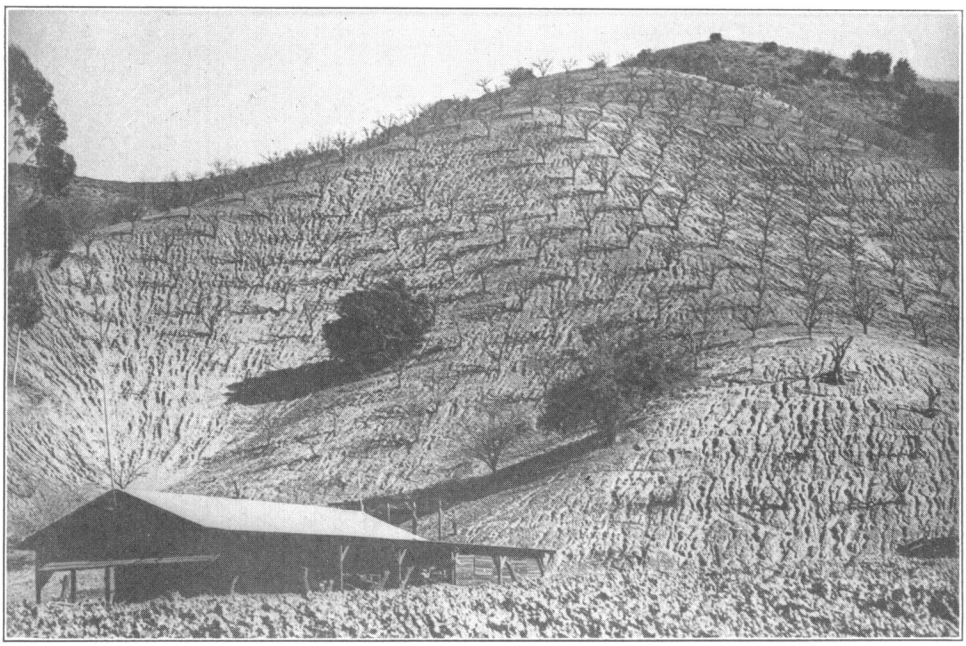
Into this virgin paradise entered the enthusiastic colonists. There began a transformation of the land surface at a rate probably never before occurring in the earth's history, and with it the creation of a nation of fabulous wealth. Reservoirs of population in Europe supplied in a comparatively short time millions of vigorous people to clear away the forests and to break out the prairies in their westward march of agricultural occupation. Frontiers were pushed farther and farther westward at a pace that eliminated planning, or discriminative use of the virgin land, or even thought of the effect of man's activities upon the abundant resources that everywhere swept to far horizons. Man was busy "subduing the wilderness," slaughtering the buffalo for their hides and plowing up the matted sod of the prairies. There seemed no necessity for even thinking of conservation in any form or degree.

Lands which had been thoroughly protected through thousands of years of time by unbroken mantles of vegetation were suddenly exposed over extensive areas to the dash and sweep of torrential rains. Topsoils were literally swept away, leaving raw subsoil exposed at the surface. So stupendous has been the work of this man-induced washing of the land as to reduce and destroy the productivity of millions of acres in numerous densely populated localities within less than a century. The economic and social aspects of this transformation have been tremendous.

Throughout the nation continuing erosion has carried with it consequences of first importance with respect to permanence of investment in the billions of dollars in navigation, power, municipal water supply, irrigation developments, farming and grazing. Products of surface wash and gully excavation have been carried by storm waters to be deposited in stream channels and reservoirs. Yawning gullies have concentrated rainfall in a manner to pass on to streams with greatest possible speed the downpours that gather on watersheds, to gorge the channelways of tributaries and trunk streams with destroying floods. Especially significant is the rapid rate of silting which is going on in reservoirs located on streams within critically eroding areas of the country, both in the East and in the West.

America faces alternatives in this respect. One is to let continue the process now destroying the productivity and utility of millions of acres and adding

annually to a bankrupt domain which is becoming an increasing burden upon counties, states and the Federal Government. Such a way out is not pleasant to contemplate. The other alternative is to diagnose the situation, take full account of the significance and the trend of destructive processes of soil wastage, increasing runoff and sedimentation of reservoirs and stream channels, to relate these to all types of practical land use within drainage basins and to control and reduce these processes to a rate as nearly as may be practicable to the rates that existed when white men found so much of the country covered with unbroken vegetation.



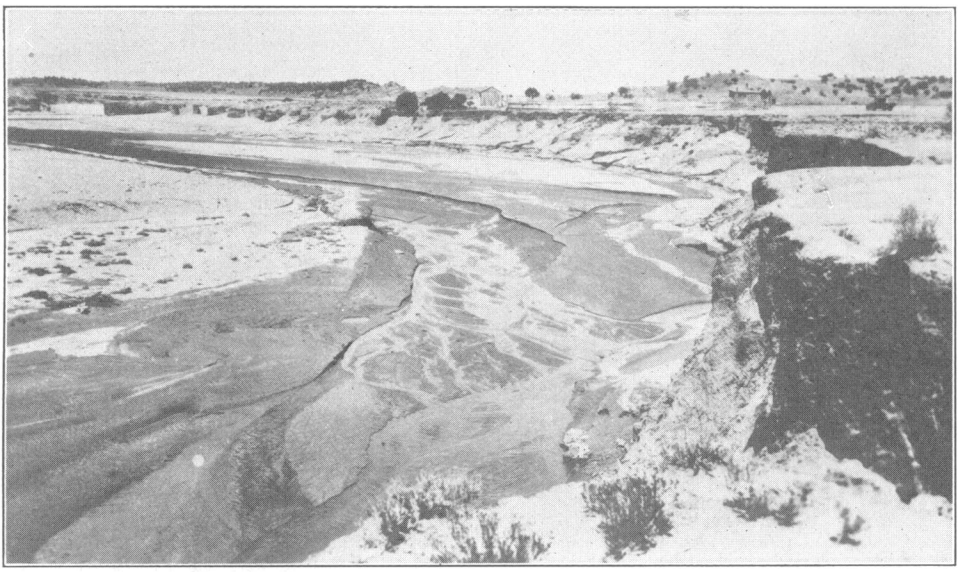
VIOLENT EROSION IN A STEEP, CULTIVATED APRICOT GROVE OF SOUTHERN CALIFORNIA

THE RESULT OF A HEAVY RAIN ON FEBRUARY 23, 1934. THE LOSS OF SOIL PER ACRE AMOUNTED TO 400 TONS. THERE WAS NO EROSION ON THE SAME FARM WHERE LAND OF THE SAME DECLIVITY WAS PROTECTED WITH NATIVE VEGETATION, NOT OVERGRAZED.

At the Crossroads

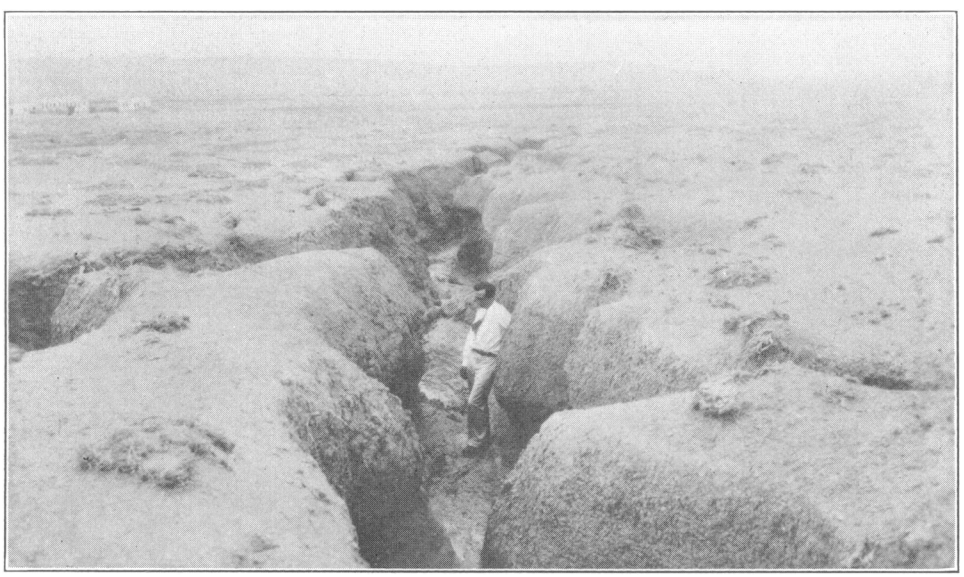
The nation may as well realize now that it has a land crisis on its hands—the problem of man-accelerated soil erosion, and that every stroke of work performed in opposition to this evil adds value to our most basic resource—that resource which offers the last safe refuge for numerous families thrown out of employment through increased use of machinery, and that resource which after all is the principal security behind our national investments, our national safety and our national future. Beyond this most acute crisis of the whole land problem, the country may as well recognize now the physical fact, not an expression of opinion, that there can be no cure of floods or prevention of stream and reservoir silting until runoff is better controlled, all the way from the crests of ridges down across the watersheds where floods originate and silt loads are picked up, on to the very channelways of streams, which like other conduits have limitations upon their carrying capacity.

Over many millions of acres a long



WIDENING CHANNEL OF PUEBLO COLORADO WASH

INCREASING FLOOD WATER RUSHING DOWN FROM THE DENUDED OVERGRAZED RANGES IS STEADILY CUTTING AWAY THE RICH ALLUVIAL DEPOSITS OF THIS VALLEY, THE FORMATION OF WHICH TOOK THOUSANDS OF YEARS. JUST ABOVE THE TRADING POST OF GANADO, NAVAJO INDIAN RESERVATION, ARIZONA.



FORMER GRAZING LAND

REDUCED TO ESSENTIAL STERILITY BY EROSION FOLLOWING OVERGRAZING, AT SANASTEE, NEW MEXICO, NAVAJO INDIAN RESERVATION. THE SOIL AND SUBSOIL HAVE BEEN WASHED OFF DOWN TO "ALKALI" MATERIAL, ON WHICH IT IS EXTREMELY DIFFICULT TO INDUCE ANYTHING TO GROW.

VEGETATION ON ALLUVIAL SOIL

OF A TRIBUTARY TO SAN SIMON WASH, GRAHAM COUNTY, ARIZONA. THIS AREA HAS BEEN PROTECTED AND REPRESENTS AN APPROXIMATION OF THE ORIGINAL CONDITION OF VEGETATION, SUCH AS CHARACTERIZED SAN SIMON VALLEY PRIOR TO THE CUTTING OUT OF THE IMMENSE WASH EXISTING THERE NOW—SINCE THE ARRIVAL OF THE WHITE MAN WITH HIS HERDS OF LIVE STOCK THAT OVERGRAZED THE UPLANDS.

ERODED CONDITION FOLLOWING OVERGRAZING

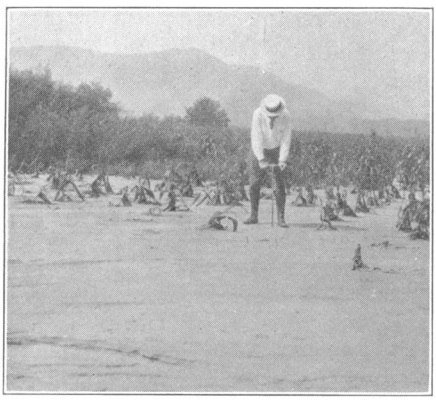
SAN SIMON VALLEY, GRAHAM COUNTY, ARIZONA. THIS AREA, NOW ESSENTIALLY DESTROYED, WAS FORMERLY COVERED WITH A THICK COVER OF VEGETATION LIKE THAT IN THE UPPER PHOTOGRAPH.

time was required to strip off the highly absorptive topsoil, down to stiff clay of low absorptive capacity; but now that this has been accomplished, and since the surface layer is rapidly being removed from additional millions of acres, the battle is definitely on, and with no secure second lines upon which to fall back.

We have a tremendous area of land in this country, but it is not all good land. Unfortunately, the remaining areas of good agricultural land are being cut into at a rate of probably considerably more than 100,000 acres destroyed every year and a much larger area sorely impoverished by the effects of sheet-washing proceeding with every rain heavy enough to cause water to run down across unprotected cultivated and overgrazed slopes. Most of us have seen the process in action, although without understanding it, and, therefore, without being concerned about it. Few have undertaken to interpret the phenomenon witnessed after every summer rain in the form of muddy waters coursing down gullies, creeks and rivers in the direction of the oceans. We have not stopped to consider that the material discoloring these unleashed waters consists of soil or that this material is derived chiefly from the surface of the ground, where lies the richest part of the land. Probably also most of us have not considered a number of other pertinent matters relating to this never-ending process. Have we considered, for example, the fact that the average depth of humus-charged surface soil over the uplands of the United States is only about seven or eight inches? Have we considered the further fact that beneath this surface layer, the building of which required the best efforts of nature's soil-forming processes over periods of thousands of years, generally lies raw clay subsoil which is not soil but the material from which soil is made, not in a few years but across the centuries? Have we been concerned that this exposed subsoil not only is from two to more than ten times less productive, generally, than was the cor-

CONTOUR FURROWING

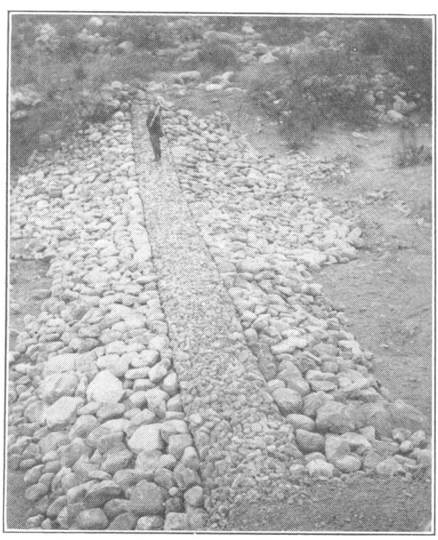
TO CHECK EROSION OF OVERGRAZED PASTURE ON SOIL EROSION PROJECT, WATERSHED OF ELM CREEK, CENTRAL TEXAS. PHOTOGRAPHED IN 1934.



RICH BLACK LOAM

AND THE CORN ON IT BURIED 4 FEET DEEP IN PLACES BY SAND WASHED OUT OF A NEARBY GULLY DURING A SINGLE SEASON. ROOT RIVER VALLEY, HOUSTON COUNTY, MINNESOTA.

responding topsoil; that it is more impervious to rainwater, is more difficult and costly to plow, and, what is exceedingly serious, that it is more erosive usually than the sponge-like surface layer? With most of us the answer unfortunately is a very decidedly negative one.



ROCK–FILL DAM

WITH ROCK SAUSAGE CAP CONSTRUCTED BY SOIL EROSION SERVICE IN HAWK HOLLOW WASH, GRAHAM COUNTY, ARIZONA, IN 1934.

Few people (scientist, economist or layman) know that it is at the stage of progressive erosion, marking the removal of the topsoil (the farmers' principal capital) that gullying usually sets in, or that gullying represents the beginning of the death stage of land—its final and complete destruction. This important fact, and many others, the average person knows little about.

CONTROL OF EROSION AN UNAVOIDABLE NECESSITY

Control of erosion is the first and most essential step in the direction of correct land utilization on something like 75 per cent. of the cultivated (and cultivable) area of the nation. If the soil is permitted to wash to a condition equivalent to skeletonized land, as has happened already over something like 35 million acres formerly cultivated, there will be nothing left to save. Failure to curb this insidious process will effectively and disastrously take care of all aspects of the land problem in numerous localities, both physical and economic; and after this deluge of waste, nature, in numerous instances at any rate, can do as good a job as man with the rehabilitation of the hopelessly devastated areas through the instrumentality of whatever vegetation comes in spontaneously.

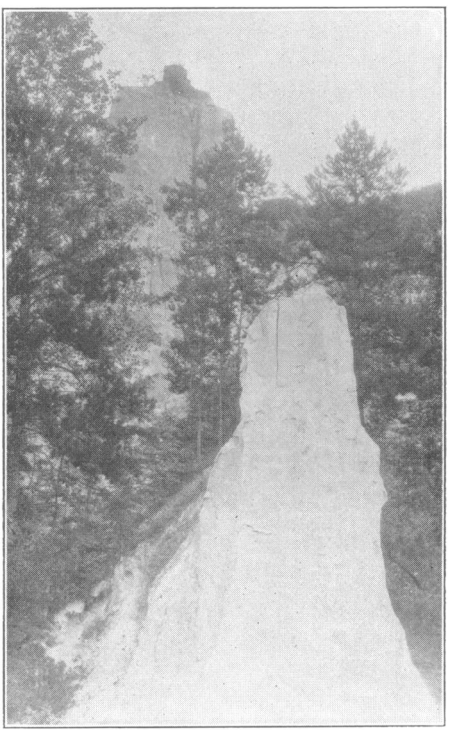
It seems scarcely necessary to add that whatever our inclinations may be, whatever opinions, conclusions or complexities our round-table, institute and academic discussions may lead us to, here assuredly is a physical job—the job of curbing erosion—that must be performed if the nation is to avoid early arrival at an inconceivably bad land situation. The Union of South Africa has reached this conclusion and is now busily engaged in an attack against the devastating erosion of that country, employing a plan of procedure very much like that developed by the Soil Erosion Service (as described below). The

Italian Government is engaged in an enormous land reclamation and conservation program—the Bonifica Integrale—the cost of which has been estimated at $500,000,000. Japan for many years has been spending many times the value of numerous critically eroding areas in order to protect indispensable valley lands from the silt issuing from such sore spots. The United States can no more afford to neglect any further this gigantic problem of waning soil productivity than South Africa or Japan or Italy, for the very simple reason that we are depleting our farm and grazing lands at a rate probably exceeding that taking place on any other important part of the globe.

Average Crop Yields Not Increasing

Regardless of our highly successful results with breeding more productive strains of crops and the introduction of new and better varieties from the ends of the world; in spite of the improved cultivation performed with more and better machinery, the increased practise of soil-building rotations and the growing of more soil-improving plants, the largely increased use of fertilizers and plant disinfectants; and further, in spite of all the education provided through our agricultural colleges, agricultural societies, clubs and institutes, soil surveys, economic surveys, experimental and extension services, farm journals, the press, thousands of books and millions of bulletins, with frequent prizes for the best producers, *our nation-wide yields have not increased—rather they have decreased in the instances of some of our major crops.* For example, the annual acreage yield of corn for the 10-year period from 1871 to 1880 was 27.04 bushels per acre; whereas, for the 10-year period from 1921 to 1930 the corresponding acreage production was 26.13 bushels, or a reduction of approximately one bushel an acre. That the maximum and minimum yields for single years during the former period were higher, respectively, than the maximum and minimum yields of the latter period indicate that the comparisons are significant.

When it is considered that corn growing has not been pushed onto the marginal and submarginal lands of semi-arid regions upon any extensive scale, and that the crop has not suffered from any



EROSION MONOLITHS

IN PROVIDENCE CAVE, STEWART COUNTY, GEORGIA. THESE LOFTY PINNACLES ARE REMNANTS OF A FORMER HIGHLY PRODUCTIVE COTTON FIELD. THEY STAND IN A GULLY WHICH WAS BEGUN BY THE DRIP FROM THE ROOF OF A BARN, ABOUT FIFTY YEARS AGO. THE GULLY HAS CUT DOWN 200 FEET AND HAS SWALLOWED UP THE BARN, A SCHOOLHOUSE, A GRAVEYARD AND SEVERAL TENANT HOUSES. IN THE COUNTY WHERE THIS PICTURE WAS TAKEN 70,000 ACRES OF LAND, ONCE HIGH-GRADE FARM LAND, HAVE BEEN PERMANENTLY DESTROYED BY UNCONTROLLED EROSION. EVERY ACRE OF THIS COULD HAVE BEEN SAVED.

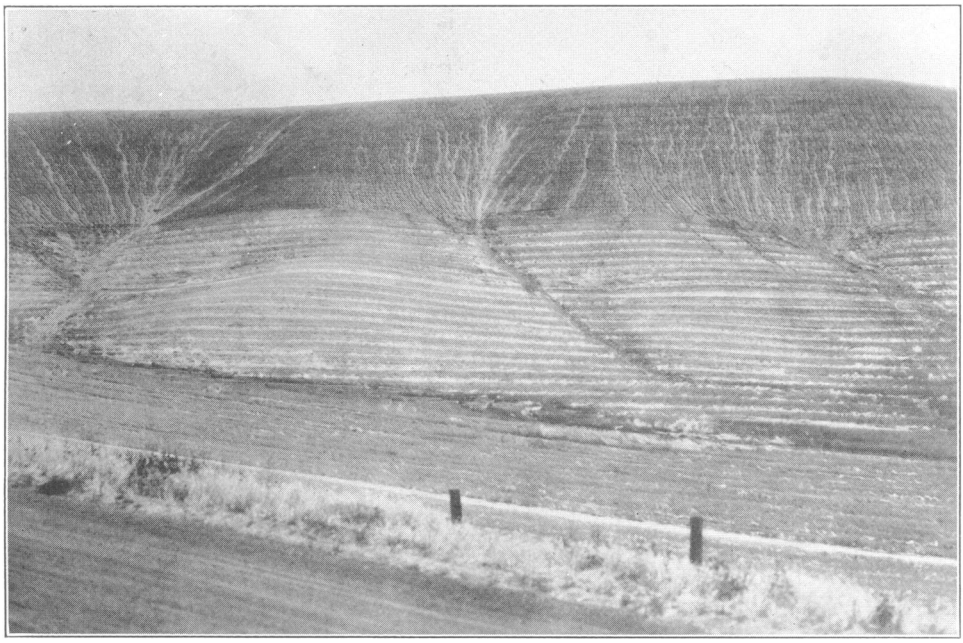
far-reaching, devastating insect or disease scourges, it is impossible to reach any other than the definite conclusion that erosion has thwarted our stupendous technical, educational and practical efforts to increase the yield of this crop.

A Major Effort at Erosion Control

During the latter part of 1933 the Soil Erosion Service was set up as a new branch of the Interior Department, with an allotment of $10,000,000 from Public Works Administration for the purpose of demonstrating the practical possibilities of curbing erosion and its allied evils of increased floods and costly silting of stream channels and reservoirs, operating within the various important geographic and agricultural regions where these evils are known to constitute major problems in connection with the use of the nation's resources of land and water. The general plan of procedure, as suggested by the President, is to treat complete watersheds within which the principal regional types of soil, average regional topographic conditions and representative regional systems of agriculture are found. The individual size of these watersheds, of which 21 are now under treatment in 20 states, ranges from 25,000 to 200,000 acres. The accompanying map shows the location of these watershed areas, and that of the huge project covering the Navajo Indian Reservation in Arizona, New Mexico and Utah; as well as several other projects and proposed projects of an experimental-demonstrational character. Altogether, the Soil Erosion Service is now actively engaged in combatting erosion and its associated evils of stream and reservoir silting, in-

SOIL WASHED DOWN OVER A SNOWBANK

BY THE MELTING OF SNOW ON SUMMER-FALLOWED LAND ABOVE, IN THE PALOUSE REGION, SOUTHEASTERN WASHINGTON.



SEVERE EROSION ON SUMMER-FALLOWED UPPER SLOPE
BY MELTING SNOW, WITH NO EROSION IN OLD WHEAT STUBBLE BELOW, IN THE PALOUSE WHEAT BELT, WASHINGTON STATE, 1934.

creasing floods, social disorganization and wild-life depletion, on approximately 27 million acres located in 27 states.

PLAN OF PROCEDURE

The method of attack is essentially a coordinated plan of correct land use. This plan involves not only the use of direct methods of retarding erosion (which necessarily calls for retardation of runoff by increasing absorption of the rainfall), but the use of indirect methods, such as the retirement from cultivation of steep, highly erosive areas from which accelerated runoff (resulting from incorrect land usage) descends with destructive effect upon lower-lying cultivated areas. Such retired critically vulnerable lands are being planted with thick soil-holding crops, as trees, grass, alfalfa, lespedeza, sorghum and clover.

Part of the cultivated land is being protected with the new system of strip-cropping, under which the clean-tilled crops, such as cotton, corn and tobacco (the real producers of erosion) are being grown between parallel bands of grass, lespedeza, sorghum and other dense crops planted across the slopes, on the level, *i.e.*, along the contours. These latter crops catch rainwater flowing down the slopes, spread it out and cause the suspended soil to be deposited and much of the water to be absorbed by the ground, thus protecting the crops growing on the plowed strips below. On certain slopes strips of permanent protective cover will be planted according to the French system, using trees, shrubs and vines. Here is an opportunity to make advantageous use of nut trees, persimmon, honey locust (producing feed for livestock), briar crops and other plants of economic value. It is hoped that it may be possible on some of the project areas to employ the Ecuadorian system of protecting steep slopes by bordering the down-hill sides of rectangular fields with soil-holding hedges.

Field terraces (embankments ad-

justed to the contours) are being employed where applicable, and in some localities it is planned to scarify certain types of land (especially summer-fallowed ground) with a machine which scoops out 10,000 basin-like holes to the acre, each of which retains about five gallons of rain, causing it to sink into the ground where it falls (machines for this purpose are now being manufactured). Soil-conserving crop rotations are being practised, and cover crops and other control measures are being employed.

Every farm is surveyed in advance of actual work, by specialists of the local erosion staff. Soils, slopes and extent of erosion are plotted on accurate maps. With the aid of this, the farmer and erosion specialists go over the farmstead, study it in detail and on the ground plan a course of procedure by assigning each acre to a particular use, in accordance with its needs, adaptability and appropriate place in a carefully planned coordinated land-use program for that particular farm. The work is carried out on a strictly cooperative basis with the farmers. Generally the latter are enthusiastically supporting every phase of the program. On some of the projects more than 95 per cent. of the farmers are going along with the program of the erosion specialists, agreeing to far-reaching reorganization of their fields and farm procedures. For example, on numerous farms fences are being relocated so as to permit contour cultivation, terracing, strip-cropping, the inauguration of soil-building rotations and the planting of the more vulnerable slopes to grass, trees, etc. Such hearty cooperation, it is believed, insures the success of the program. By putting through these initial educational watershed projects in a highly impressive manner, it is felt that it will then be possible to extend the work to all areas through the activities of the Soil Erosion Service, the Extension Service, the colleges of agriculture and other organizations.

First Coordinated Erosion-Control Effort

Here is the first attempt in the history of the country to put through large-scale, comprehensive erosion and flood control projects, such as apply to complete watersheds from the very crest of the ridges down across the slopes to the banks of streams and thence to their mouths. These are not engineering projects or forestry projects or cropping projects or soils projects or extension projects, but a combination of all these, operated conjointly with such reorganization of farm procedure as the character of the land indicates as being necessary. This procedure is based on the best information in the possession of scientific agriculturists: agronomist, forester, range specialist, soil specialist, erosion specialist, agricultural engineer, economist, extension specialist, game specialist and geographer. It is the application of accumulated knowledge pertaining to the great multiplicity of variables affecting the 3-phase process of absorption, runoff and erosion, employed not as single uncoordinated implements of attack, but collectively, according to the needs and adaptability of the land, in a combination of integrated control measures, supplemented by new information accruing from the experience of combat. No such coordinated attack has ever before been made against the evil of erosion in this country. The plan was worked out largely on the basis of the writer's many years of experience in the study of soils and of land-use procedure in the United States, the West Indies and Central and South America; plus the experiences of other specialists familiar with the land and its utilization. Considering the physical, economic and social factors involved, it is believed there is no other possible practical method of ever mak-

RESERVOIR FILLED WITH EROSIONAL DEBRIS

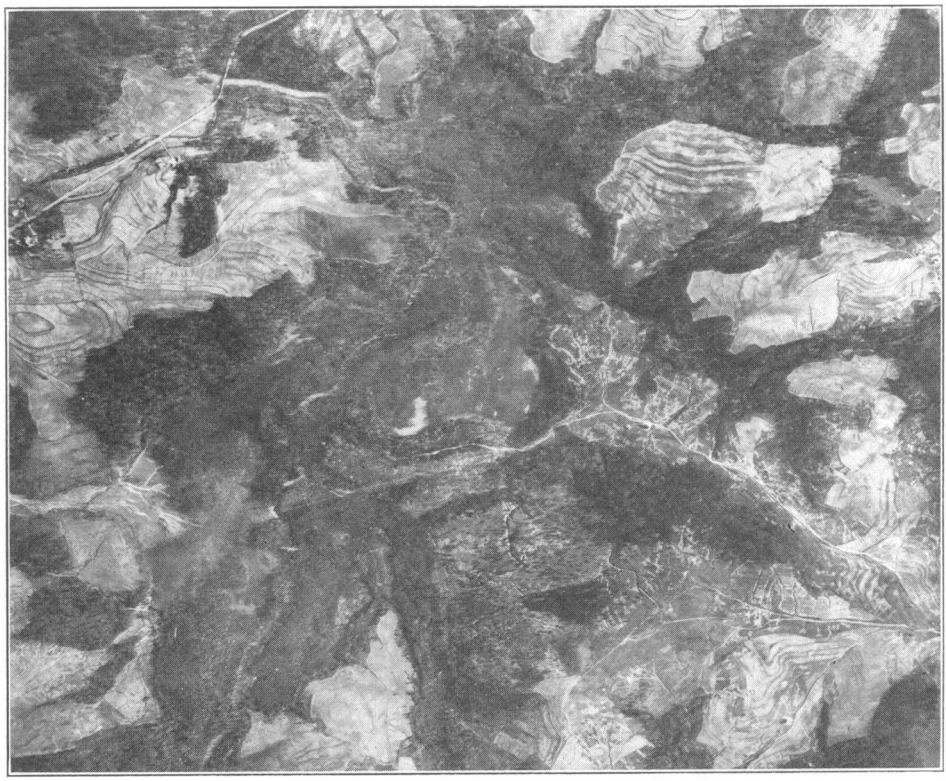
TO THE TOP OF THE DAM (BUT NOT TO THE TOP OF THE FLASHBOARD EXPEDIENT ON TOP OF THI STONE MASONRY FOR MAKING SOME LAST, SHORT-PERIOD USE OF THE COSTLY STRUCTURE). PACOLET RIVER, 7 MILES NORTH OF SPARTANBURG, SOUTH CAROLINA.

ing any effective headway against this vicious problem (1). Even if the government owned the land, it would still have to be used over large areas in the production of crops and for grazing; and here again precisely the same physical problems would have to be met and conquered, an eventuality that unavoidably precedes all other consideration relating to correct land use.

EXAMPLES OF PROCEDURE

In the Wisconsin erosion project (covering Coon Valley, near La Crosse), for example, some of the steep timbered areas, now eroding because of excessive grazing, are being taken out of use and given complete protection in order to stop the excessive runoff of rainwater, which has been speeding down across the cultivated slopes, ripping them to pieces with gullies or planing off the more fertile topsoil. Grass is being restored to these protected forest areas, and where the trees are too thin other trees are being planted. Small plantings and seedings are being made that furnish feed and cover for quail and ruffed grouse. Eventually, with increased stocks of these fine game birds, saved from starvation during prolonged periods of snow, as was done last winter, sportsmen will come from Milwaukee, St. Paul, Chicago and other places to pay the farmer for the privilege of hunting in his timbered lands.

Below the forested land, the steep slopes now washing rapidly to a condi-



AIR PICTURE OF APPROXIMATELY 1,000 ACRES

SHOWING BOTH GULLY AND SHEET WASHING. ALL THE TIMBERED LAND WAS FORMERLY CULTIVATED AND THEN ABANDONED BECAUSE OF EROSION. THE TREES (DARK-COLORED AREAS) ARE SECOND-GROWTH PINE (OR THIRD- OR FOURTH-GROWTH PINE, DEPENDING ON HOW MANY TIMES THE LAND HAS BEEN CLEARED, CULTIVATED AND RE-ABANDONED). MOST OF THE LAND IS NOW ESSENTIALLY RUINED AND CAN BE PUT TO USEFUL PURPOSE ONLY THROUGH TREE AND GRASS PLANTING. SOUTH TYGER RIVER PROJECT OF SOIL EROSION SERVICE, NEAR SPARTANBURG, SOUTH CAROLINA.

tion of low productivity are being taken out of the clean-tilled crops and put into permanent pasture to furnish the grazing that formerly was provided by the timbered areas. The grazing capacity of the farms is not thus increased or materially decreased, but the crop area is cut down to some extent. Better protection of the cultivated land from erosion will largely make up for this reduction, by way of higher acreage yields.

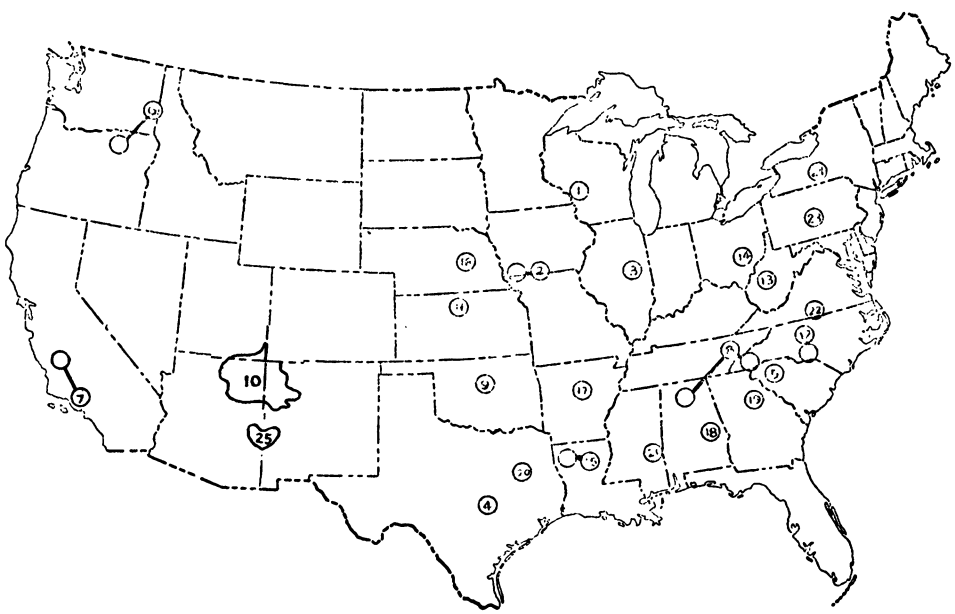
On the 150,000-acre watershed erosion project on Big Creek in north-central Missouri, extending into south-central Iowa, a report of progress submitted by the regional director of the soil erosion work, under date of June 23, 1934, includes the following highly pertinent statement with respect to accomplishment (work having begun on this area in the spring of 1934): "At this time we have 401 cooperative agreements signed up with the farmers of the Big Creek project, and over 63,000 acres of land under contract for a coordinated plan of erosion treatment. We have been successful in reducing the corn acreage over the next 5-year period by more than 37 per cent. on these farms. We have cut the acreage of land where corn follows corn for a second year (a very bad practise) more than 54 per cent. We have

very materially increased the acreage of pasture. We are planning an intensive program on pasture improvement, beginning this fall and continuing into next spring. While weather conditions have been quite unfavorable, it is felt that very good progress has been made to date."

Thus, all indications point to successful achievement with these coordinated, educational programs of erosion control —which, it should be emphasized in conclusion, are of an experimental-demonstrational nature, and which, by reason of the necessary procedures involved with the accomplishment of a complete job, extend beyond the mere task of controlling erosion.

(1) It seems unfortunate that some single-ideaed (or perhaps under-experienced) specialists still insist that this powerful agency of accelerated erosion can be overcome through the use of single implements of attack. With the pages of experience laid open to eyes that see over millions of acres of land ruined for crop use and more millions impoverished, and with the wastage proceeding faster than ever, it is discouraging to hear these specialists contend, for example, that erosion can be controlled solely with terracing (embankments of earth adjusted to land contours). Most specialists understand clearly that terracing is a very useful method of assisting with erosion control (see "A Proposed System of Erosion Control," *Agricultural Engineering*, V. 14, No. 6, June, 1933, pp. 150–151, by H. D. Sexton and E. G. Diseker). The system was devised about a hundred years ago in the southeastern United States and extensively employed, in several modifications, in that section, often with excellent results. In spite of the usefulness of the method, where properly applied, several million acres on which it was employed have, nevertheless, been abandoned because of continuing erosion. Some forty years ago Priestly Mangum developed on his farm near Wake Forest, North Carolina, a broad-base terrace which was a decided improvement over the older narrow type. This improved type, the Mangum terrace, has been extensively used since its development in various parts of the Southeast, and more recently it has come into quite extensive use in Texas, Arkansas and Oklahoma. Even the Mangum terrace, however, has not, where used alone, succeeded in controlling erosion, except on rather gently sloping land, although it has accomplished much good in slowing down the washing, especially where used on slopes not steeper generally than about 6 or 7 per cent.

Obviously, it is impossible completely to control erosion, a process that begins wherever rainwater contacts bare sloping ground, with



SOIL EROSION CONTROL PROJECTS

any implement which does not cover the entire surface. In other words, erosion goes on between the terraces, as well as on sloping soil exposed between any other installations of contour measures. Soil washes from below the upper terrace embankment to lodge against the next embankment below, where, according to common practise, it is plowed up and partly dumped over the embankment to renew its journey in the direction of tidewater. In this connection it might be added that we have recently been furnished with results of measurements of soil loss from terraced areas, misinterpreted as representing the entire acreage losses for the entire terraced field. Such reported losses were measured by collecting samples of the runoff, and its contained silt, at the ends of terrace embankments. The fallacy of presenting such results as measurements of acreage losses from entire fields is obvious. The simple facts involved are that the measurements represent only the soil that passes out of the field at the end of the terrace, leaving out of account entirely the much greater bulk of material washed from the upper slope of the inter-terrace area down to the lower slope, or into the terrace channel, where it is temporarily lodged and then passed on down the slope through the operations of "terrace maintenance"—as much lost, in so far as its place of origin is concerned, as if immediately dumped into the sea (since it is uneconomical under the American system of extensive agriculture to haul it back into the field). Of course, the temporary lodgement of productive soil material against any obstacle keeps it in the field, or on part of the field, for a while, and so gives some temporary benefit.

Still other features relating to this useful method of combatting erosion should be seriously considered before making indiscriminate use of it, otherwise more damage than good may result. The terraces must be accurately laid out and properly built, as a matter of course; but what is just as important is that they should be limited in their application, when used alone, to comparatively gently sloping areas, for the reason that on steep land larger embankments are required generally and the distance between them must be narrowed. Accordingly, so much of the fertile topsoil of the inter-terrace area goes into the building of the embankment that the land from which this surface material is removed is left poorer, where the soil depth is shallow, than it was, or is likely to be in some instances for generations to come. It must be remembered, too, that in building a terrace the slope is increased quite sharply along the lower side of the embankment, and accordingly susceptibility to erosion is increased at this critical point, unless stabilization is effected with some dense cover of vegetation, as grass.

But when we begin to support one measure with another, especially when we make use of nature's most powerful agency of controlling erosion—densely growing vegetation—as in the instance of stabilizing the vulnerable lower side of a terrace embankment with grass, we have, in that sensible acceptance of a supplemental agency, ceased to be advocates of a false practise—the practise of fighting erosion solely with a single implement, whether it be terracing, strip-cropping or what. It should be pointed out, of course, that, when the ground is completely covered with good stands of grass or trees or other dense types of vegetation, then with a single implement we may have complete or very nearly complete control of erosion (see charts, Trans. Am. Geophysical Union, Nat'l. Research Council, pt. 2, pp. 474–88, 1934, showing comparative soil losses from clean-tilled land and land covered with grass or trees). This paper, however, deals primarily with erosion on cultivated land, where the entire area can not be covered with such control measures.