

**SUPPLEMENTARY REPORT OF THE LAND PLANNING COMMITTEE
TO THE NATIONAL RESOURCES BOARD**

Published in eleven separate parts

PART I. General Conditions and Tendencies Influencing the Nation's Land Requirements

PART II. Agricultural Exports in Relation to Land Policy

PART III. Agricultural Land Requirements and Available Resources

PART IV. Land Available for Agriculture Through Reclamation

PART V. The Problem of Soil Erosion

PART VI. Maladjustments in Land Use

PART VII. Certain Aspects of Land Problems and Government Land Policies

PART VIII. Forest Land Resources, Requirements, Problems, and Policy

PART IX. Planning for Wildlife in the United States

PART X. Indian Land Tenure, Economic Status, and Population Trends


PART XI. Recreational Use of Land in the United States

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P R E F A C E

On November 28, 1934, the National Resources Board submitted to the President, in accordance with an Executive order, its report on National Planning and Public Works in Relation to Natural Resources and Including Land Use and Water Resources. Part II of that report was the Report of the Land Planning Committee. In the course of preparing part II of the above report a large volume of basic data and information was collected which could not then be included. The publication of the present report is for the purpose of making such data and information available to interested persons and organizations.

The present land report has been organized into 11 parts according to subject matter and the contributing agencies. These 11 parts are made available as 11 separate publications. Organization and publication on this basis was done because many persons and agencies are interested only in certain parts of the present report, and the necessity of purchasing the whole report in order to obtain the desired part or parts is thereby eliminated.

The present land report, when conceived as a whole, does not purport to be a complete work on the subject of land utilization, or of its related problems and proposed lines of action; neither is it designed to be a thoroughly integrated piece of work. The primary aim here has been to set forth the facts, analyses, and the recommended lines of action as developed by each of the various contributing governmental bureaus, divisions, sections, or individuals, on the problems with which each of such agencies or persons is concerned. The points of view are, therefore, those of the contributing agencies or individuals themselves. The Land Planning Committee presents the report as

information, but assumes no responsibility for the opinions expressed in it.

This report was prepared under the direction of Dr. L. C. Gray, director of the Land Section of the National Resources Board, aided by John B. Bennett, who served as administrative assistant and as secretary to the Land Planning Committee. Editing and preparation of the report for publication were under the direction of Mr. H. H. Erdmann, agricultural economist of the Land Section, National Resources Board.

Authorship by agencies and individuals is acknowledged in their respective contributions. The following governmental agencies have contributed to the whole report: The Geological Survey, the Division of Grazing Control, the Office of Indian Affairs, the National Park Service, and the Bureau of Reclamation, in the United States Department of the Interior; and the Bureau of Agricultural Engineering, the Biological Survey, the Bureau of Chemistry and Soils, the Forest Service, the Soil Conservation Service, the Weather Bureau, the Divisions of Land Economics, of Farm Management and Costs, and of Farm Finance in the Bureau of Agricultural Economics, and the Land Policy Section, the Production Planning Section, the Import-Export Section, and the Agricultural-Industrial Relations Section of the Division of Program Planning of the Agricultural Adjustment Administration in the United States Department of Agriculture. Credit also is due to the State agricultural experiment stations and extension services, State planning boards, commissions, and other State organizations and individuals for aid in preparation of several sections of the report.

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SOIL EROSION
A CRITICAL PROBLEM IN AMERICAN AGRICULTURE

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SUPPLEMENTARY REPORT OF THE LAND PLANNING COMMITTEE

SECTION I
THE CRISIS IN LAND UTILIZATION¹

Crises in land utilization in the United States are essentially twofold, economic and physical. Both crises are founded on changes. The economic are founded upon changes, favorable or unfavorable, induced chiefly by the demand and supply of products of the soil. The physical are founded generally upon changes in one direction; that is, in the direction of lessened productivity of the soil. Increase in prices of farm products may obscure the progressively diminishing productivity of land; and progressive soil wastage by accelerated erosion may convert good land into submarginal areas, or even destroy it, in the face of good prices and demand.

TABLE I.—Summary of erosion conditions in the United States areas within which more than 25 percent of the land has been affected as indicated

	Acres	Percent
Total area (exclusive of large cities and water).....	1,935,176,620	100.0
Areas on which erosion conditions were not defined.....	144,708,316	7.5
Areas with little or no erosion.....	576,238,371	30.3
Total area affected by sheet erosion.....	855,260,347	44.9
1/4 to 1/2 topsoil lost.....	653,199,473	34.5
Over 1/2 topsoil and some subsoil lost.....	192,060,874	10.1
Total area affected by wind erosion.....	322,181,740	16.9
Moderate wind erosion.....	233,321,336	12.2
Severe wind erosion.....	78,859,402	4.2
Destroyed by wind erosion.....	9,201,352	.5
Total area affected by gullyng.....	894,818,281	45.4
Occasional gullies.....	523,351,168	27.5
Severe gullyng.....	337,305,021	17.7
Destroyed by gullies.....	4,162,092	.2
Essentially destroyed for tillage.....	51,342,494	2.7

¹ In the Western States, a considerable proportion of the gullyng is normal geological dissection on which accelerated erosion may be, but is not necessarily, active.

The interplay of economic forces and land depletion and wastage may operate in the same or opposite directions. It is essential that any inquiry into the principles of land utilization affecting the sustained support of the people of the Nation should analyze the resultant effects of past land use to disclose and evaluate the pertinent factors involved. Thus, processes which destroy the physical body of the soil and therewith its utility must be differentiated from lowered income as a result of reduced prices, or of unfavorable competition from other districts and products. Different remedies are required to meet the crisis in agriculture for the different sections affected. It is not enough to say that the present progressive conversion of a vast area approximating one hundred millions of acres of our good land into submarginal

¹ Sections I to IX inclusive, prepared by the Soil Conservation Service, H. H. Bennett, chief, U. S. Department of Agriculture.

status through soil wastage by accelerated erosion alone is due to economic forces, and that price manipulation or tariffs will correct destructive practices of cultivation. And again, it is fundamentally important to differentiate between the depletion of plant nutrients from a soil safeguarded against erosion, and the loss of plant nutrients washed into streams from fields, along with the soil. In the former case, the physical integrity of the soil remains and good farm management will restore the plant nutrients in the form of commercial fertilizers, as a routine of good business; but in the latter case, the basic resource itself, the resultant of intricate soil-forming processes throughout thousands of years, is being destroyed beyond economical restoration. Provisions for sound national economy will make clear the distinctions between the forces that actually destroy a basic resource and the forces that merely affect the profitableness of the enterprise measured by the prices of the products derived from that resource. The agricultural enterprise is complex, but fundamentally it rests upon certain physical controls whose functions may be discovered. Correct evaluation of these controls will determine the safe uses of land for sustained productivity of foods and textiles, for sustained utility of water resources, and for the highest safeguard against flood damage.

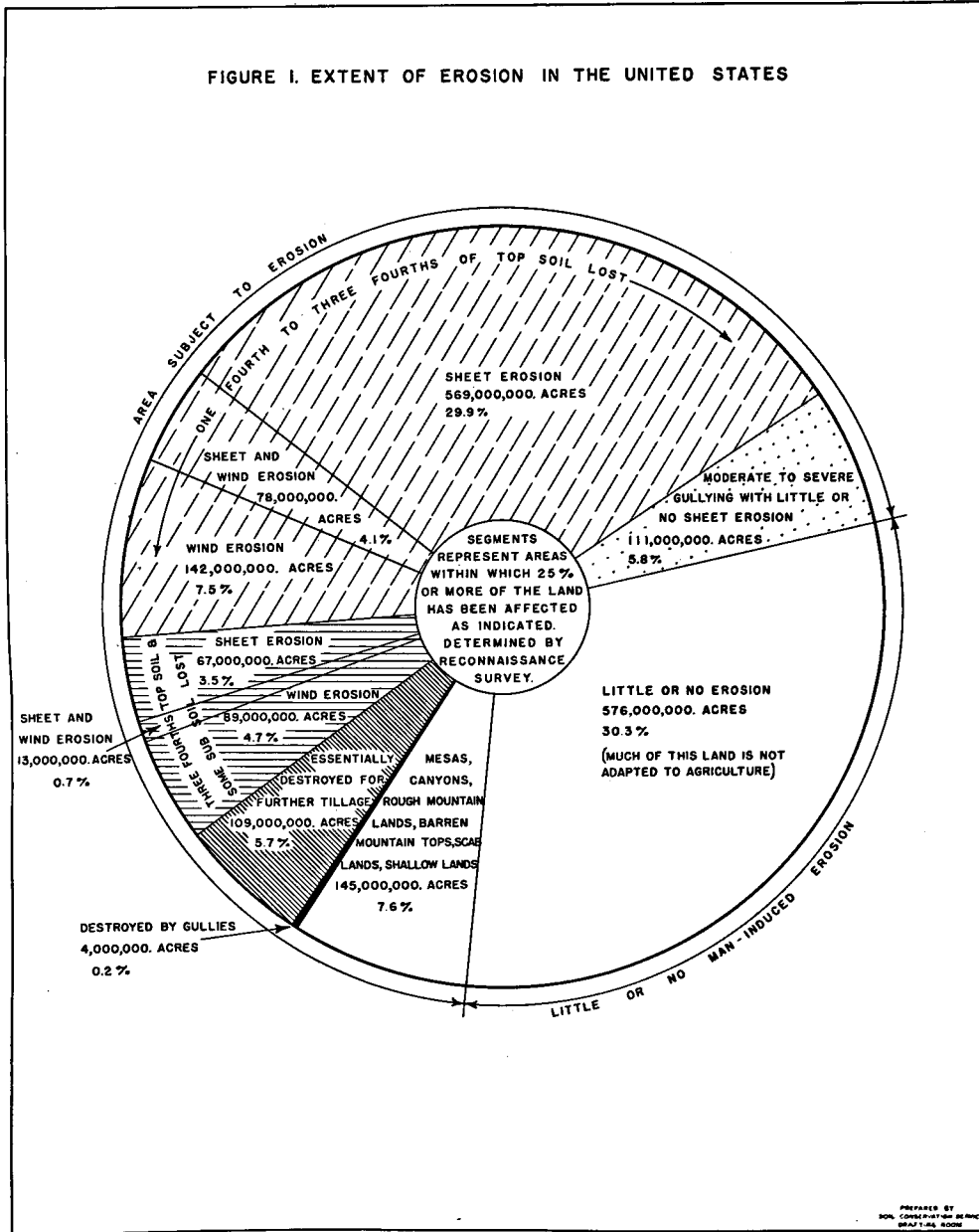
Safe Land Use

The conservative use of land resources rests upon compliance with the principles of safe land use as disclosed in the physical factors of control; its accomplishment is conditioned upon a number of considerations. Economic forces alone cannot be relied upon to effect conservative use of land. Policies and measures for the general welfare of local, State, or National Government interests may be required to supplement and/or guide economic factors in preserving the soil and its benefits to this and future generations.

The Physical Crisis of Land Use

The present physical crisis in land use within the United States is a consequence of the period of exploitation in the rapid occupation of the American continent by the American people. The time when wornout land can be abandoned for virgin soils lying to the West, with their stored fertility, is gone. Practically all of the better lands of the country have been occupied for agriculture. The old agricultural frontier has dissolved into the Pacific; the new frontier has re-

FIGURE I. EXTENT OF EROSION IN THE UNITED STATES



appeared under foot on the farms now under cultivation. The fundamental problems of land use now reside in the conservation of soil and water resources and intelligent soil and farm management.

First Settlers and Unlimited Resources

A brief review of the course of agricultural occupation of the American continent aids in clarifying certain problems of present land use and in forecasting some of the exigencies of a future soil conservation and land-use program vitally essential for sustained use of our land resources.

Except in an insignificant way, the aborigines of North America had done little to cultivate the soil or to change the virgin character of the land surface and its vegetation. The coverage of vegetation and the soil protected by it were natural responses to long processes of soil and plant development under favorable climates. The streams bore oceanward the residue of precipitation waters that flowed gently from sloping areas and nourished vast unbroken stands of vegetation. Rivers draining the regions covered with dense vegetation generally ran clear except in high flood, when channel erosion furnished the major burden of silt. This channel erosion generated soil creep from vegetated slopes and in addition to solution served to sculpture and wear down the land with the leisure of geologic processes. Moreover, where comparatively rapid differential land uplift through deep-seated geological processes had occurred within climatic zones too rigorous or too arid to support an unbroken cover of vegetation, storm waters carried substantial quantities of silt into the drainage of streams. Processes proceeded in these cases at more rapid rates; streams ran muddy throughout most of the year, as in the instances of the Missouri and Colorado.

In the broad expanses of the country, from semitropical to boreal climates, from humid to arid conditions, there spread before the eager colonists an infinite variety of conditions. By far the larger area was completely covered with vegetation ranging from grasses to dense forests. Such coverage had in the long period of interdependence of soil formation and vegetative succession protected the land surface from rainwash, and favored the absorption of rain and melting snow by deep soils honeycombed by the burrowing of insects and plant roots, and made porous by natural processes of soil development. Little surface washing occurred. Certainly the processes of erosion, which may be designated under these circumstances as geologic forms of erosion or normal erosion, had not proceeded at rates in excess of those of soil formation; for beneath the cover of vegetation lay the nourishing soils of varying depths, the product of an intricate process of soil formation during thousands of years.



FIGURE 2.—Gully erosion in South Carolina. This disheartening example of soil wastage was a cultivated field not so many years ago.

This fact is of highest importance in considering problems affecting long-time planning in land use. Soil erosion had not exceeded soil formation from beneath under these native conditions.

Into this pristine continent entered the colonists with a burst of energy that began a transformation of the earth's surface at a rate probably never before occurring in the earth's history, and with it the creation of a nation of fabulous wealth. There were reservoirs of population in Europe which supplied in a comparatively short time millions of vigorous people to clear away the forests and to cultivate the soil at an astonishing rate in their westward march of agricultural occupation. It was no steady infiltration into undeveloped regions, but a rapid advance over a wide front by farmers, lumbermen, and stockmen with their plows and herds. Frontiers were pushed farther and farther westward at a pace that eliminated planning or thought of the effect of man's activities upon the abundant natural resources that everywhere swept away to the horizon. Man was busy in clearing the land of forests, in "subduing the wilderness", slaughtering the buffalo for their hides, and breaking out first the sod of the prairies and then the short grass of the plains on the west. In his eagerness the settler lost sight of any need for conservation and a sense of his stewardship of the newly found continent.

Withal, it is only necessary here to call attention to the significant changes in rate of erosional processes occasioned by the clearing of vegetation, the breaking of the soil with plows, and the heavy consumption of the forage herbage by rapidly multiplying herds. Soils, which had been thoroughly protected through thousands of years of time by unbroken mantles of vegetation and had for this reason been weathered to fine textures and high organic contents to favorable "mellowness" and good fertility, were suddenly exposed to the dash of torrential rains characterizing extensive regions. There began under those conditions

a rate of soil erosion which was accelerated far above the rates that hitherto obtained. The significant fact of this period of unwise land use, still continuing over an expanding area, is that the rate of soil removal by rainwash greatly exceeded and still does exceed the rates of soil formation over vast areas—a sure process of soil destruction. Topsoils have been literally washed away, leaving raw, comparatively unproductive, unabsorptive, intractable subsoil exposed at the surface, such as is conspicuous throughout the major agricultural soil provinces of the Nation; as the Piedmont Plateau, the areas of rolling glacial and loessial soils, much of the Atlantic and Gulf Coastal Plains province, the Great Plains region, and the greater part of the crop and grazing areas of the West. Moreover, concentration of run-off has cut enormous gullies through the topsoil and into the underlying materials, from which true productive topsoil is formed through ages of natural processing. These gullies are cutting headward and laterally into valuable farms and forests, with maximum speed into drainageways and upon valley lands, discharging the concentrated rainfall descending from the upper watersheds. So enormous has been the work of accelerated erosion as to reduce and destroy the productivity of millions of acres of farm land of densely populated regions of the United States within less than a century.

It is estimated on the basis of erosion surveys and soil surveys that already the utility of approximately 50,000,000 acres of formerly good farm land has been destroyed for cultivated crops by gully erosion, representing an area about the size of Pennsylvania, Massachusetts, and Connecticut combined, or 312,000 farms of 160 acres. From about 125,000,000 acres more—land still largely in cultivation—the topsoils, representing the most productive part of the soil, have been washed away or largely washed off by the accelerated run-off of storm waters. In addition, approximately 100,000,000 acres of cultivated land are heading in the direction of the 125,000,000 acres of soil-stripped land. These prodigious losses do not take into account the wide-spread erosional wastage that is speeding up over the vast domain of the western grazing areas.

This wastage of the most basic and indispensable resource of the Nation, the soil, has become one of our most pressing problems. From a country with the greatest proportional area of rich agricultural land we are plunging, almost heedlessly, in the direction of a nation of predominantly poor agricultural land, as the result of unrestrained erosion.

The economic and social aspects of this tragic transformation have been tremendous. The acceleration of erosion in the East and in the South, in the North and in the West, has reached an annual cost to the Nation of probably not less than \$400,000,000 as measured by soil depreciation and reduced yield; and

has carried with it consequences of first importance to the permanence of investments in the billions of dollars in navigation, water power, municipal water supply, irrigation developments, agriculture, and grazing. Accelerated erosion has combined with and speeded up run-off of surface water from bared slopes to accentuate flood peaks and to augment the cutting power of stream flow. Equally significant has been the transformation of fertile soils into troublesome sediments. Products of surface soil wash (sheet erosion) and gully excavation have been carried by storm flows to be deposited in stream channels and in existing reservoirs. Shoaling of streams and rivers have followed large-scale erosion of upland soils. Particularly significant and important is the rapid rate of silting which is going on in reservoirs located on streams within critically eroding areas of the country, in the East as well as in the West.

Physical Bases and Risks in Agricultural Production

While soil erosion constitutes one of the major problems confronting American agriculture it cannot be considered apart from other factors involved in land productivity. The physical basis of production includes: (a) Climate, (b) topography, (c) soil fertility, and (d) the physical character of the soil profile. Production of crops is therefore conditioned by the attendant risks, of: (a) Climatic shifts, which in the major influences are beyond human control, (b) fertility risks, which lie within the limits of partial control, and (c) soil-wastage risks, which are almost completely within the powers of human control.

Climatic Risks.—The great drought of 1934 tragically demonstrated that climate is not a fixed quantity, but that climatic borders shift back and forth over wide zones. Between the humid region and the desert is a zone wherein agriculture is profitable, unprofitable, or entirely a failure, as influenced by the shifts of the humid and arid climatic limits. Such seasonal and periodic shifts affect the prevailing agricultural pursuits from cultivated crops to range lands. Frequency and extent of crop failures in response to shifts of adverse dry or cold climatic limits will determine the safe culture and measures of agriculture. Extensive areas of the Great Plains must be classed as unsuited to sustained cultivated crops, and should therefore never have been plowed, but retained in grass for stock raising. A thorough inquiry into the climatic risks and limits for different types of agriculture is emphatically called for.

Fertility Risks.—Our soils possess vast reserves of plant nutrients. Additions to and losses from these reserves are taking place constantly. Tables II and III offer in the most condensed form information about the reserves of nitrogen, phosphorus, potassium, cal-

cium, magnesium, sulphur, and organic matter; the annual additions thereto, and losses therefrom, for 1,365,000,000 acres of continental United States. The additions to the inventory are to be credited to atmospheric precipitations, crop residues, grass lands, forests, green manures, animal manures, lime and marl, commercial fertilizers, sewage, irrigation water, peat, and industrial byproducts. The losses are chargeable against removal by crops and animals, burning, erosion, and leaching. These calculations are based on soil analyses and lysimeter studies representing 365 million acres in harvested crops and 1 billion acres of pasture of all kinds. It is shown here that the surface soil (6½ inches) contains 12 billion tons, each, of calcium and potassium; 1,700 million tons of nitrogen equivalent; 800 million tons of phosphorus; 5,500 million tons of magnesium; 450 million tons of sulphur; and the estimated equivalent of 34 billion tons of organic matter. No data are recorded here for manganese, iodine, copper, fluorine, boron, zinc, and two or three other elements, significant for plant growth, but present in the soil in relatively minute quantities.

Notice should be taken of the ratios which the annual additions and net losses of the several nutrients bear to

TABLE II.—Plant nutrients annually lost from soils of the United States¹

[Thousands of tons]

Losses	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Sulphur	Organic matter
Crop (harvested areas).....	4,600	700	3,200	1,000	500	500	92,000
Grazing (pastures).....	3,000	500	3,700	1,000	500	400	60,000
Leaching (harvested areas).....	4,000	-----	6,600	26,600	6,000	7,400	80,000
Erosion (harvested areas).....	2,500	900	15,000	13,000	6,000	800	50,000
Leaching (pastures).....	1,000	-----	1,700	7,000	1,600	1,900	20,000
Erosion (pastures).....	1,000	400	6,000	5,000	2,200	300	20,000
Destruction of organic matter ²	-----	-----	-----	-----	-----	-----	-----
Additional losses ³	-----	-----	-----	-----	-----	-----	-----
Total.....	16,100	2,500	36,200	63,600	16,800	11,300	322,000

¹ Area considered: Harvested crops 365 million acres. Pastures and woodland grazing areas: 1,000 million acres.

² Not determined.

TABLE III.—Plant nutrients annually added to soils of the United States¹

[Thousands of tons]

Additions	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Sulphur	Organic matter
Resources of 6½-inch topsoil.....	1,700,000	800,000	12,000,000	12,000,000	5,500,000	450,000	34,000,000
Fertilizers and lining materials.....	300	300	300	2,100	(*)	700	(*)
Manures.....	2,600	800	2,000	1,200	600	300	100,000
Rainfall (1,365 million acres).....	1,300	-----	2,000	7,500	3,000	5,500	(*)
Irrigation (20 million acres).....	30	-----	500	3,000	1,000	2,200	(*)
Nitrogen fixation by legumes.....	900	-----	-----	-----	-----	-----	-----
Nitrogen fixation in other ways.....	6,800	-----	-----	-----	-----	-----	-----
Total additions.....	11,830	1,100	4,800	13,800	4,600	8,700	100,000
Net losses.....	4,370	1,400	31,400	39,800	12,200	2,600	222,000

¹ Area considered: 365 million acres harvested areas and 1,000 million acres pasture and woodland pasture.

² Included with calcium.

³ Small amounts.

⁴ Not determined.



FIGURE 3.—Gully erosion in the western range country. The Franklin flat in the Upper Gila Drainage, once covered with a dense stand of tobosa grass is now a somber scene of an erosional tragedy. All sediments cut out of these alluvial valleys are destined for the San Carlos Reservoir, there to destroy storage capacity of irrigation water required for the social security of 100,000 acres of the intensively cultivated San Carlos irrigation district.

the soil inventory. It will be noted that the balance sheet shows a net annual loss of considerable proportions for each of the essential plant-food elements. Part of this terrific loss is preventable. It is compensated for in part by the exposure of fresh rock material to weathering. Where the removal of the surface soil by erosion is a very gradual process, as under undisturbed conditions, this compensating factor is of importance. In the more serious form of accelerated erosion the compensating factors fail to protect the farmer against declining soil and resultant declining crop yields. Over large areas soil depletion has progressed to a point where the land is no longer economically valuable for agricultural use.

Table IV presents the results of analyses of the contents of the major rivers of the United States.

TABLE IV.—Summary of complete study of plant nutrients annually carried to American rivers (dissolved material only)

River basins	Area of river basins	Total nitrogen	Quantities of plant nutrients carried in solution			
			Potassium	Calcium	Magnesium	Sulphur
	Acres	Tons	Tons	Tons	Tons	Tons
Mississippi.....	809,600,000	183,878	2,438,374	18,111,633	5,636,269	7,825,154
North Atlantic.....	101,696,000	53,259	178,549	2,583,852	560,461	839,305
South Atlantic.....	79,315,000	21,887	273,297	1,085,637	252,002	245,149
Gulf of Mexico.....	231,565,000	44,039	912,953	7,945,251	1,512,703	2,527,878
Pacific coast.....	366,528,000	192,856	825,339	4,946,162	1,438,177	2,434,325
Hudson Bay tributaries.....	39,680,000	1,819	22,058	328,048	131,785	52,601
St. Lawrence.....	112,000,000	50,214	502,140	5,188,780	1,205,136	669,520
Great Basin.....	142,720,000	-----	-----	-----	-----	-----
Total U. S. Plant nutrients lost from soils estimated from lysimeter studies.....	1,883,104,000	547,952	5,152,710	40,199,363	10,736,533	14,593,932
Ratio of river estimates to lysimeter estimates (percent).....	-----	21.000,000	36,000,000	142,000,000	33,000,000	40,000,000
		2.6	14.3	28.3	32.5	36.5

¹ Denudation considered zero.

These data supplement those presented in table V. It will be noted that all of the losses of plant nutrients as estimated by lysimeter studies in the various areas are not accounted for in the data from the river gaging stations. This is because considerable proportions of the more active elements, such as nitrogen, phosphorus, and sulphur, are utilized by various forms of organic life, while most of the less active elements, such as calcium and magnesium, are deposited in comparatively insoluble form along the banks of our streams. It would seem, therefore, that the estimates presented in table IV present a very conservative picture of the annual losses of plant nutrients by leaching. These findings indicated the necessity for a positive program of soil conservation, and for the development by landholders and the public generally of a sense of social responsibility for the soil resources entrusted to their care.

Soil Wastage Risks.—The risks of soil wastage by erosion are comprehended only through an understanding of the nature of soil-forming processes and soil development, and the measures of maintenance and reclamation required to preserve or restore productivity. Risks are dependent on both the inherent productivity of soils and the damage which eroded material may cause in the way of infertile overwash upon lower slopes and deposition of water-transported material in stream channels and reservoirs. The hazards of soil erosion are dependent upon such factors as (a) climate, involving, particularly, means, maxima, and minima temperatures; amount, distribution, and intensities of rainfall; (b) erosivity of soils as reflected in profile, textural, structural, and consistency characteristics; (c) slope gradients; (d) methods of use.

The natural soils lying within climatic zones favorable to agriculture are generally clothed with a complete or nearly complete mantle of vegetation. Virgin soil is a product of processes of weathering of the parent material, such as rock, clay, and other raw material of the substrata, profoundly influenced by the effects of climate operating under vegetative controls or stabilization. On level and moderately sloping ground the

soil-forming processes, where permitted to continue a sufficient length of time, develop pronounced differentiations in the soil profile (the entire soil section from the surface downward to rock or other substratum material), resulting in the formation of distinct sectional layers: The topsoil (or A horizon), the subsoil (or B horizon), and the substratum of parent materials (or C horizon). This differentiation is so nearly uniform under similar conditions with respect to climate, parent material, and topography that comparison of the profile of cultivated areas with that of virgin or natural areas will reveal the degree of surface removal by erosion.

The layers, or horizons, from the surface downward, while remarkably uniform, within a distinct province or soil zone, particularly with respect to definite groups of soils, vary widely from zone to zone. The upper soil layer (A horizon) of an undisturbed virgin soil usually ranges from about 4 to 20 inches in depth; while the subsoil generally ranges from about 10 to 40 inches in thickness. However, the true topsoil—the relatively mellow, humus-charged surface layer—ranges from about 2½ to 16 inches in thickness over the uplands of the Nation, averaging in the neighborhood of 7 inches.

These virgin soils represent a resource which has been thousands of years in the making. The accumulation of the soil material, except in flood plains, and its subjection to long-continued soil development processes have been possible on distinctly sloping areas (about 80 percent of the surface of the Nation is sloping) especially through the protective influence of the natural cover of vegetation. On the other hand, the climax type of association of vegetation is dependent on the accumulation of soil. Thus, over long periods of time, there has been built up a dependent relation between soil and vegetation. Accordingly, the soil profile represents the response to a number of important chemical, biological, and physical processes. For example, the Marshall silt loam soil series of Missouri during the past 1,000 years has been subjected to the percolation of a column of water fully 1,700 feet deep. This soil has been developing since glacial time, a period of probably more than 10,000 years, during which period a column of water more than 3½ miles high has passed into the body of the soil, much of it downward through the entire profile. Such is the magnitude of the processes that have been at work to produce a soil.

Conservation of a product of this character, which is basic to the storage of precipitation waters—a great natural resource representing a laboratory which produces, stores, and expends plant nutrients—must be given the most serious consideration by the Government; for, once it is lost, there is no possibility of

TABLE V.—Comparisons between the results of two ways of estimating leaching and erosion losses—totals for all lands of the United States drained by rivers—1,880,000,000 acres¹

(Thousands of tons)						
	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Sulphur
Leaching:						
Based on lysimeter data...	21,000	.....	36,000	142,000	33,000	40,000
Based on dissolved matter in river waters.....	548	.....	5,153	40,200	10,738	14,594
Erosion:						
Based on data from erosion stations.....	10,500	4,000	64,000	53,000	25,000	3,500
Based on silt loads of rivers ²	3,500	1,700	25,000	25,000	11,000	900

¹ It is assumed that leaching and erosion from pasture and forested areas amounts to one-tenth of leaching and erosion from harvested crops areas.

² Erosion considered 3 times the silt load.

Soil Erosion

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recovery for centuries to come. Cultivation of soils for necessary crops interrupts many of the processes in soil development. Plant nutrients extracted in crops may be returned in the form of fertilizers, organic materials, and crops plowed under to replenish the humus supply; but the physical body of the soil itself, once it has been swept into the stream channels and oceans, cannot be restored to eroded slopes. Even

that which has been moved only so far as from the upper to the lower side of a field cannot be hauled back economically for the simple reason that a cubic yard of soil weighs more than a ton.

Soils are subject to conservative management, and in the interest of national economy the manner of their use, particularly the matter of their preservation, requires national recognition and action.

SECTION II

THE PROCESS OF SOIL EROSION

Erosion, in its broadest sense, is a continual process of surface planation. It is a normal geological activity which has contributed to the configuration or sculpturing of mountains, plateaus, plains, valleys, canyons, and mesas. However, this type of normal geological process should not be confused with what may be defined as "accelerated erosion." When the bared surface of a soil, hitherto protected by a mantle of vegetation, whether forest, brush, or grass, is exposed to the impact of rain and wind, erosional processes of a different order are set in motion. They proceed at a greatly accelerated rate over the slow surface planation that went on under natural conditions. This rapid destruction which follows removal of vegetative cover may be called "accelerated erosion" to differentiate it from the normal geological planation.

There has been some confusion in determining in the field whether the process of surface planation on a particular area was normal geological erosion or accelerated erosion. That the processes of planation in the absence of vegetative cover are vastly more rapid than in the presence of vegetative cover has been determined by quantitative measurement and research, which have disclosed the rates of surface run-off and the amounts of soil material removed by erosion, as well as some of the fundamental processes involved, under both natural and disturbed ground conditions. Table VI gives the comparative amount of erosion and the percent of the total precipitation lost as run-off from 12 widely separated, extensive and important types of soil. The contrast here is between two types of crops, one clean-tilled, as corn and cotton (erosion-inducive crops), and the other, thick-growing, as grass, alfalfa, and lespedeza (erosion-resistant crops).

If there has never been a vegetative cover on an area, then the processes of erosion are normal geological processes. If, however, there has been a vegetative cover, which has been destroyed incident to human occupation, then the erosional processes would be classed as accelerated.

Accelerated erosion reverses those processes of normal geological erosion under vegetative cover whereby a soil profile is developed. Under a vegetative cover, the rate of surface planation by gravitational movement and by wind and water action becomes retarded and another action which results in the development of a soil becomes of dominant importance. As a vege-

8

TABLE VI.—Comparison of erosion and run-off from 12 widely separated important soil types

Soil and location	Slope	Clean-tilled crop		Thick crop		Averages for periods covered by data ¹
		Soil loss (tons per acre)	Water loss (percent precipitation)	Soil loss (tons per acre)	Water loss (percent precipitation)	
Shelby silt loam, Bethany, Mo.	8	60.8	27.4	0.3	7.7	1931-33.
Shelby loam, Columbia, Mo.	3.7	19.7	30.3	.3	12.6	1918-31.
Colby silt clay loam, Hays, Kans.	5	13.2	17.5	.004	.04	1930-33.
Kirvin fine sandy loam, Tyler, Tex.	8.8	19.1	20	.2	1.5	1931-33.
Nacogdoches fine sandy loam, Tyler, Tex.	10	6.1	15.4	.02	1.4	July 1931-33.
Vernon fine sandy loam, Guthrie, Okla.	7.7	28.1	14.2	.04	1.5	1930-33.
Marshall silt loam, Clarinda, Iowa	9.6	44.6	12.5	1.3	6.5	June 1932-33.
Clinton silt loam, La Crosse, Wis.	16	59.9	19.2	.003	2.9	1933.
Abilene clay loam, Spur, Tex.	2	6.1	12.8	1.6	5.8	1926-33.
Houston black clay, Temple, Tex.	4	12	11.6	.00	.00	1931-33.
Ceall clay loam, Statesville, N. C.	10	13.8	9.3	.7	6.5	1931-33.
Palouse silt loam, Pullman, Wash.	30	*21.2	*29.8	.4	.3	July 1931-33.

¹ Average results show grass approximately 65 times more effective with respect to soil conservation than a clean-tilled crop on same kind of soil having the same slope; and approximately 5 times more effective with respect to conservation of water.

* Hard fallow (no continuous clean-tilled crop).

tative cover develops on an area subject to active geological erosion, the direction of movement of fine material changes until the major movement is downward rather than lateral. As surface material is broken down by disintegration or goes into solution, the fine mechanical material and that part which goes into solution are carried downward to be redeposited or reprecipitated in part at a lower depth to develop the subsoil layers. Thus a soil is developed which is the foundation upon which agriculture is established. It is a complex entity embodying both organic and inorganic material and is a product of a long period of development.

When the vegetative cover is removed, then the erosional processes are reversed and surface loss becomes accelerated by lateral movement by wind and water. That which has been built up through long periods of downward percolation becomes destroyed. First, the soil is decapitated by rapid removal of the surface soil and then the subsoil follows until the geological inert material is again exposed.

Types of Accelerated Erosion

Accelerated erosion occurs in two main groups: (a) water erosion and (b) wind erosion.

Types of water erosion include: (a) sheet erosion, (b) rill erosion, and (c) gully erosion.

Sheet Erosion.—Sheet erosion relates to the process of removing a thin sheet of soil, more or less evenly, from entire sloping fields. It accompanies every heavy summer rain and even the melting of snow, but it is much less conspicuous than the rill or gully types because of its insidious, less readily observable manner of action. Sheet erosion is by far more wide-spread than other types of soil washing and hence causes far greater damage. It usually proceeds without being noticed by farmers, at least not until the evidence is called to their attention or until the topsoil is gone. Farmers often have noted with surprise that their soil is changing in color from dark to light without recognizing the cause—erosion. “Clay galls” usually are evidence of subsoil spottedly exposed by erosion, and where such patches of clay occur the areas between generally have suffered by sheet washing in varying degrees. The presence of gullies usually means also that the areas between the gullies have been stripped of all or part of the more fertile topsoil. Aerial views frequently reveal sheet-eroded land by the lighter colored splotches across the landscape. Many farmers have deplored the progressive reduction in crop yields without recognizing that they have lost the topsoil of their fields, and are now farming heavy, intractable clay subsoil instead of the original mellow surface soil. Sheet erosion is a thief that stealthily robs the farmer of his principal capital—that is, his rich topsoil.

In its normal development, a virgin soil comprises three distinct layers: (1) the topsoil which is lightest in texture, (2) the subsoil which is heaviest in texture, and (3) the underlying geological material similar to that from which the overlying layers have developed and which is intermediate in texture between the topsoil and subsoil.

In the course of soil formation, the soluble materials and finer soil particles are gradually leached from the surface, leaving behind the coarser, less soluble soil particles. This comprises the topsoil which becomes the storehouse of organic plant food and bacterial activity and its physical characteristics determine the suitability of the land for tillage. The finer soil particles and soluble material are carried downward and deposited to form the subsoil which thus becomes the storehouse of soluble inorganic plant foods as well as the reservoir of moisture for plant growth.

When accelerated erosion removes the topsoil, there is not only a mechanical loss of that layer which constitutes the optimum seed bed for crop production and which cannot be replaced but also there is destruction of the balanced, complex and interdependent functions of the two soil layers which are necessary for optimum plant growth.



FIGURE 4.—Sheet erosion on land in Wheeler Canyon, Calif., following a 2-inch rain. Erosion and run-off were negligible in pasture and weeds along fence row. Weed strips in the apricot grove lessened the erosion.

There is wide variation in the susceptibility of different kinds of soil to sheet erosion, dependent upon variations in texture and structure of the soil itself as well as upon topographic and climatic relationships. For example, soils which have silty or sandy topsoils with heavy, slowly pervious subsoils are susceptible to extremely severe sheet erosion if the soil is left bare on sloping topography.

Rill Erosion.—Rill erosion is characterized by small gullies, often only an inch or two deep, very narrow, and usually with vertical side walls. These are formed by streamlets of water accumulating over bared soil surfaces. The development of rills is dependent on rainfall in quantity sufficient to result in rapid collection of the surface water into streamlets having cutting and transporting power. Thus, heavy rainfall of high intensity falling on land of reduced absorptive capacity stimulates rill erosion. The silty soils are the most susceptible to this evil. Following the rains, the soil is plowed, the rills are effaced and the farmer forgets that he has lost a considerable part of his limited capital of humus-charged topsoil. Because of this easy obliteration of rills by tillage, this class is considered as a phase of sheet erosion insofar as treatment is concerned.

Gully Erosion.—Wherever concentration of run-off waters occurs on a bared field, there is increased cutting power due to increased volume and velocity which results in the rapid formation of gullies. They may result from advanced sheet erosion or from advanced rill erosion or they may develop from some careless field operation which allows concentration or provides a channel more accessible for rapid run-off. Thus gullies develop commonly through a terrace broken by careless tillage methods or in a rut caused by a wagon wheel driven up or down hill, on soft ground.

The type or form of gullies is dependent upon the character of the soil material in which they develop. The barranca type, common in the southwest and in

the loessial soils, has vertical walls which result from undermining and caving in of the banks. This type develops on soils in which both topsoil and subsoil are friable and relatively light-textured, such as in the loessial soils and alluvial valley fills of the West.

The V-shaped gully develops where the subsoil is heavy textured and where the underlying geological material is not essentially lighter textured than the subsoil. This is the common type of gullies found in the humid region on the soils with light-textured topsoils and heavy clay subsoils.

The third type of gullies is a combination of the two preceding types in that it develops as a V-shaped gully until the bottom penetrates through the subsoil layer into a loose, friable, underlying geological substratum. Then it becomes a U-shaped gully. Such gullies develop by undercutting in the exposed friable geological material to undermine the hard brittle subsoil which eventually caves off in blocks. These gullies are more common in the southern Piedmont region and in the higher southern Atlantic and Gulf Coastal Plain, where examples have been found which have developed on tilled land in half a century until they exceed 100 feet in depth.

Whereas sheet erosion acts slowly and insiduously, gully erosion often develops rapidly to a stage which renders the land permanently unsuited to tillage. Severe gully erosion renders the land valueless for pasture or forest.

Wind Erosion.—Until recently, destructive movement of soil by wind has been associated principally with areas of deep sands, as dunes, and the western deserts and bad lands of the arid regions. Within the past few years the problem of wind erosion has become increasingly grave. In some regions it has become so destructive that the public has demanded that the problem be recognized and control measures undertaken.

Under normal conditions of ground cover and stability, wind erosion, like water erosion, proceeds slowly. Across millenia, wind, supplementing the activities of water, has been a powerful agency in transporting soil material, sculpturing the earth's surface and carving fantastic patterns from rock and unconsolidated geologic strata. This has been especially true within areas of arid and semiarid climates. Large belts of wind-blown (loessial) soil have been formed along the Missouri, the lower Mississippi, the Columbia Rivers, and in other parts of the country.

With the advent of cultivation and grazing the action of wind erosion was accelerated far above the rates which obtained under undisturbed conditions, particularly in treeless regions. At first it was local and infrequent, with dust storms and whirlwinds that were annoying but not generally destructive. As culti-

vation became more extensive and intensive, the surface soil lost its resistance to the frequent strong winds, and steadily the process was accelerated. Destructive wind erosion, accordingly, became a serious problem in various critical regions.

The major factor favoring accelerated wind erosion is the alteration of the surface soil by cultivation and overgrazing. The loose sandy lands generally begin to drift immediately after plowing. The finer grained soils, however, are much more resistant. Nevertheless, these, with continuing cultivation, lose their firmness. Cultivation destroys the mechanical holding effect of virgin grass roots and favors depreciation of the absorptiveness of the spongy humus contained in the virgin soils. Depletion of the organic supply and constant stirring of the soil develops a highly pulverized, loose condition. Winds sweeping across the bare, dry surface lift the smaller, lighter particles into the high pathways of air currents, and carry dust great distances, as was the case in the great dust storm of May 1934. The coarser, less productive particles left by this process of wind assortment roll or leap along the surface until stopped by some obstacle in the pathway, thus covering fields of good soil and burying fences and other structures.

The principal wind erosion areas lie within the semi-arid regions of the Great Plains, both north and south, where the annual rainfall is less than 25 inches. There are other important affected areas, however, in many parts of the West. Much of this declining land lies within extensive agricultural sections.

An essential difference between wind erosion and water erosion is that the latter is operative only on sloping ground while the former affects land of any topographic character, whether level or steeply sloping. Wind erosion probably is more wide-spread, or even more prevalent, in the western plains than water erosion. It is typified in the atmosphere by drifting dust particles ranging in density from yellow clouds that turn day into night to a barely discernible haze, with occasional moving dust "twisters." The surface characteristics are hummocky accumulations of drifted soil, usually of loose sandy material, filled depressions, and fields swept clean to depth of cultivation. Neither coarse sands nor heavy clays are immune. The sands are rolled along the surface or leap forward to accumulate in drifts. Clays are deflocculated to form minute particles that are carried hundreds of miles by air currents, or form clay granules that roll and drift.

Erosion Pavement

On a soil containing rock fragments, as remnants of weathered country rock or gravelly material from water-transported debris, erosion pavement develops as a result of soil wash. Erosion pavement, not unlike

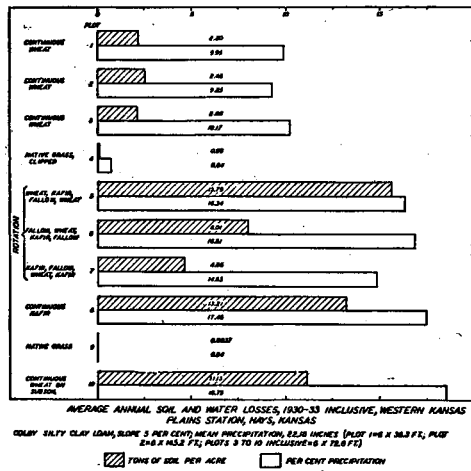
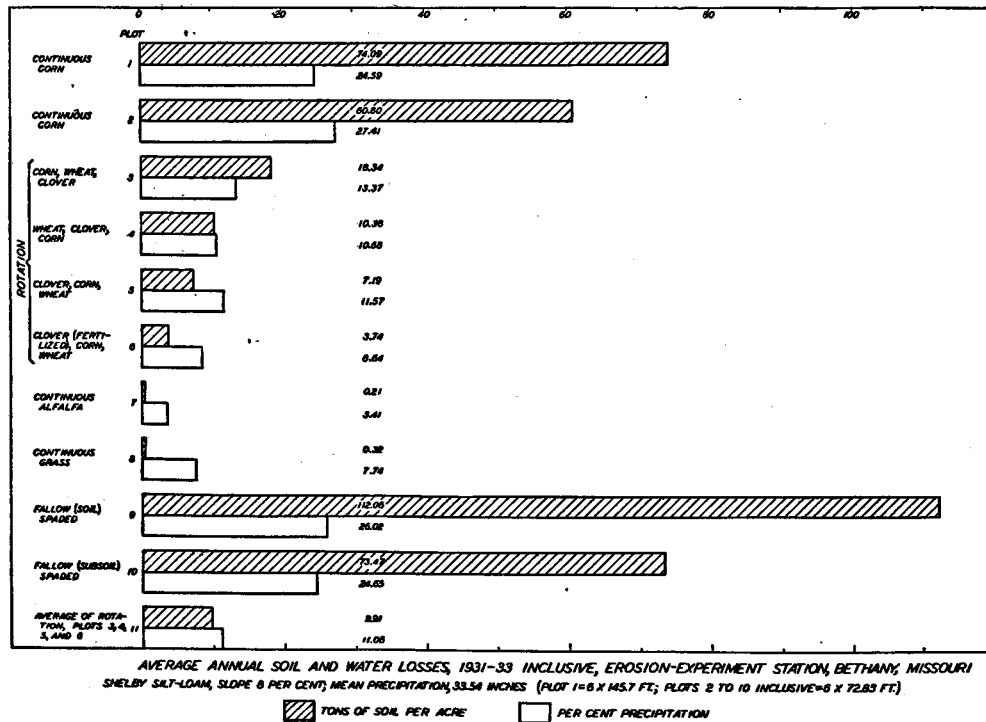


FIGURE 5 (left).—At the Bethany station, corn stubble and fallow land, essentially bare land, lost as run-off as much as 75.5 percent of one rainfall and suffered a maximum soil loss of 33.82 tons per acre. In marked distinction, those plots in erosion-resisting, close-growing crops—alfalfa, clover, and bluegrass—suffered almost no soil loss from the same rain, and 40 to 69 percent less run-off.

FIGURE 6 (below).—The chart shows average annual soil and water losses resulting from a continuous clean cultivated crop; from the practice of fallowing; from a 3-year rotation; and from continuous grass or legumes. It is outstanding that the land used continually for corn or left fallow, both common practices, suffered an average annual soil loss of 98.43 tons per acre, while the land in rotation suffered an average loss of 9.91 tons per acre, and the land in grass or legumes suffered an annual loss of less than one-third ton per acre. These results indicate the effectiveness in checking erosion of close-growing crops, whether grown alone or in suitable rotations.



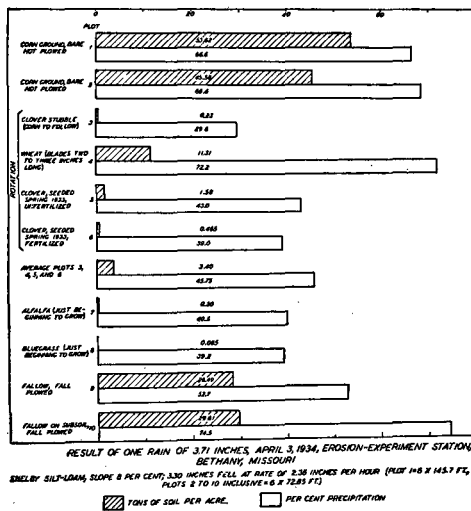


FIGURE 7.—The chart teaches two distinct lessons in land use practices at Hays, Kans. First, the function of the topsoil is indicated when its absorptive capacity is compared with that of exposed subsoil. The average annual loss from continuous wheat on land with a topsoil was 2.20 tons per acre, compared with an average annual loss of 11.13 tons per acre on land with no topsoil planted to continuous wheat. The second lesson shows that the use of a rotation which includes a clean cultivated crop and the practice of fallowing increases annual soil loss over that from land in a continual close-growing crop. It shows, also, that the soil loss from any annual crop is much greater than that from the native grass cover.

desert pavement, forms as the result of the washing away of the fine soil, leaving behind the rock fragments too large and heavy to be moved by the shallow sheet flow of rainwash. As fine soil is gradually removed by sheet erosion, more and more of the included fragments appear at the surface, and in time come to form a cobbled or gravel-covered surface. Such pavement tends to reduce further erosion and to check the development of rill or gully washing, except where storm run-off currents accumulate in sufficient force to move the rock fragments. Gully erosion then enters upon the scene to cut and undermine the soil, and thereafter erosion proceeds apace.

Factors Affecting the Rate of Accelerated Erosion

Since the character and condition of the soil and its cover determine the rate of percolation, the rates of surface run-off may vary widely under the same rainfall intensities. Results of experimental studies of factors affecting rate of run-off are shown in figures 5 to 7. These comparative studies establish beyond question the relative influence of the condition of the cover of a soil and the importance of managing erosive land so as to prevent important soil losses.

SECTION III

THE EFFECTS OF SOIL EROSION

Wind Erosion

Damage by wind erosion is wide-spread; it is evidenced not only by impoverishment of land through stripping and covering, but by obstructive accumulations in fields, along fences, highways, and railroads; and by filling of ditches and covering of farm machinery and buildings. Also, considerable damage is caused through the cutting off of young grain by the abrading sand, and by covering of pasture grasses to be followed by weedy vegetations. Fine material sifting into dwellings and shops damages the furnishings and other contents. General discomfort and menace to the health of the population are among other undesirable features of all wind-eroding areas.

Control of wind erosion is imperative, as the damage is progressive. Once started, it will spread with accelerated intensity. Partial control is insufficient, as damage spreads outward from each single erosive area to affect protected areas. Thorough study and investigation are necessary to develop adequate control measures that will not be unjust to agricultural possibilities within the region but still be effective in controlling damage in vulnerable areas.

Some of the more effective control measures are strip cropping, "listing" (plowing the soil in rows), selective retirement of the more erosive areas from clean cultivation and seeding them to soil-holding vegetation, cultivating so that not all crop residues are covered, cloddy plowing, crop rotation, and level terracing to trap the rainwater. The Soil Conservation Service has in operation now a demonstrational project for wind erosion control in a severely affected section of the Texas Panhandle, where all of the above measures and others are being applied to the land in accordance with the needs and adaptability of the different kinds of soil and topographic features.

Water Erosion

The direct effects of water erosion are twofold: (1) The destruction caused on once fertile upland areas by loss of topsoil and, often, subsoil also; and (2) the destruction caused by subsequent deposition of the material (a) on bottomlands, (b) in reservoirs, and (c) in stream channels. The indirect effects of erosion are evident (1) in increased flood hazards, and (2) in diminished water storage capacity of watershed areas.

Accelerated soil erosion proceeds at rates in excess of soil formation; it destroys the integrity of the soil profile, and aside from the production of troublesome erosional debris lowers the aggregate productivity of land. Soil nutrients are removed from the soil in suspension and in solution in the surficial run-off, and the cultivability of fields is destroyed by the riddling effect of gullies. Most significant is the insidious nature of the process of accelerated sheet erosion which planes off the soil until a point is reached where the value of the land will not pay for the control of erosion on it. Thus, eventually, the problem passes beyond the resources of an individual landowner. Erosion unabated becomes a concern for the community, the State, and the Nation.

To understand the effects of sheet erosion upon the soil, and in particular upon soil productivity, the role of the topsoil and of the subsoil, independently and collectively, must be analyzed. The formation of these two soil layers has been explained. The topsoil is the feeding ground for plant roots. In it, bacterial action provides nitrogen and reduces organic matter to forms which can be used for plant food. The depth, texture, and structure of this layer determines the suitability of a soil for tillage. The same factors determine the readiness with which a soil absorbs rainfall, and are important in determining whether the soil retains the moisture for plant use or loses it rapidly by evaporation.

The subsoil is the storage reservoir of mineral plant food and moisture for plant growth, both of which are closely related to the depth, texture, and structure of the subsoil material. If the subsoil is too shallow, it does not supply adequate moisture and plant food. If it is too heavy in texture, or hard and impervious in structure, it does not absorb moisture readily.

Therefore, when a combination of soil and subsoil are found, both of which provide optimum conditions for tillage and plant growth, it should be carefully conserved, because when the topsoil is lost by erosion the balanced function of the interdependent soil layers is destroyed. The plant food content of the topsoil is gone and the subsoil ceases to function in its normal capacity. Exposed subsoil is difficult to plow and till; it does not absorb rainfall readily; and it does not preserve the moisture from evaporation so well. This can be readily observed on any field where the topsoil has been removed in spots. These "galled" spots produce



Sodded terrace outlets, employed by the LaCrosse, Wis., project, to conduct water safely from terraces to lower levels.



Contouring of pastures—one unit in a balanced erosion control program, Texas.



Orange grove on land near Santa Paula, Calif., protected from erosion. The trees are grown on benchlike positions on the contour, with vegetation protection.



Lister furrowing at intervals of 1 or 2 rods will do much to reduce wind erosion.

FIGURE 8.

short crops which show lack of plant food; yellow leaves which indicate lack of nitrogen; and usually dry up in early summer from lack of moisture. This can be observed in fields of oats, wheat, or corn in the north; and cotton or corn in the south.

Vast acreages of the most desirable soils for tillage were found when pioneers broke the sod as they proceeded westward from the Atlantic seaboard. Due to the apparent limitless supply of good soils, early agriculture developed in many sections with wanton, ruthless disregard for preservation of those good soil areas which had required countless ages in the building.

The southeast was outstanding in soil devastation, due, not to greater carelessness, but rather to a combination of high rainfall, soils highly susceptible to erosion, and a major acreage devoted to clean-tilled crops. Lands were cleared of the protective vegetative covering on steep slopes and on rolling topography. The steeper the slope the shorter was the period of use before erosion removed the topsoil and riddled the fields with gullies. Only the more level areas have withstood the farming practices which have prevailed.

Agriculture has proceeded across the country not entirely by bringing additional land into cultivation, but too much by substituting new fields for erosion-ruined ones. There has not been inherent regard for the soil as a capital asset. Too many farmers are found, even today, who boast, instead of hanging their heads in shame, at the number of farms they have "worn out."

In marked distinction from the eroded and gullied lands seen so commonly in the rolling and hilly sections there are a few sections where the farmers, since earliest settlement, have preserved their lands. Farms can be found which have been in cultivation for more than 200 years and which are undoubtedly as productive today, if not more so, than when they were cleared. Those farmers have had inbred and inherited interest in the soil as something given them in trust which they must preserve for their dependents.

Due to the progressive destruction which has taken place since the advent of agriculture in this country there is a greatly diminished acreage of good agricultural soils left as disclosed by the erosion survey made last summer. The problem of conservation of our remaining agricultural soils is of national concern and a consciousness of soil conservation must be awakened in negligent farmers in the interest of national economic security.

Sedimentation

General.—The sediment produced by erosion in upland areas is carried along by gathering waters and outflowing streams and deposited at lower elevations. The sediment accumulations thus produced do a great

deal of harm by filling reservoirs, covering bottom lands with inferior soil, and filling up stream channels and changing their form and grade. The amount of harm done by sedimentation relates directly to erosion and is accentuated in like degree wherever erosion is accelerated.

Reservoirs.—Siltation of reservoirs is taking place at exorbitant rates all too generally over broad areas of the United States where tributary streams are abnormally loaded with products of erosion. Serious inroads have already been made on developed water power, municipal water supply, and irrigation reservoir resources and it is apparent that this menace has lately tended to spread in area and increase in intensity in keeping with advancing phases of erosion.

Systematic study of the silting of reservoirs has been made in but few instances in the past, mostly in the Southwest where its importance is conspicuous and unmistakable. Detailed surveys of reservoirs to determine rates of silting were begun by the Soil Conservation Service, in the southeastern section of the country in July 1934 and later in the southern Great Plains and in the Southwest. Table VII presents available data on silting of representative reservoirs of these areas. These are derived from actual surveys by various agencies and should be generally dependable indices of characteristic rates of sediment production in the erosional provinces represented.

It may be said in general that in all three areas rapid silting of reservoirs is in process. In the southern piedmont the rates in excess of 60 acre-feet a year per 100 square miles of drainage area are broadly representative. The rate 568 acre-feet a year, nearly 10 times as great, is significant. The rate of 90.3 acre-feet at Zuni Reservoir is particularly conclusive in that it has been derived by very careful resurveys each year since the reservoir was put in use.

In addition to the tabulated records of silt surveys on the foregoing reservoirs, field examinations have shown extensive deltas and notable depths of bottom clays extending down to the dams on Lake Waco, Lake Worth, and Lake Penick in Texas, Lake McMilian in New Mexico, and San Carlos Reservoir above Coolidge Dam in Arizona. Also, of 56 reservoirs examined by the Soil Conservation Service in the southern piedmont in 1934, 13 major reservoirs with dams, averaging 29.8 feet in height were completely filled with products of erosion within an average period of 29.4 years. In the West, significant instances of complete filling of reservoirs include the Austin Dam at Austin, Tex., which was nearly filled in 5 years and completely filled in 15, and the Harding Reservoir near Santa Ana, Calif., which filled almost entirely during a single month of heavy rains following a burn in the basin during 1927.

Differences in rates of silting depend upon a variety of factors from one region to another. In the Southeast the high rate of reservoir silting is the result chiefly of erosion of deep residual soils as influenced by human occupation. In mountainous and other regions where the natural forest cover is practically intact, lower rates of silting occur. At the Greensboro and High Point Reservoirs in North Carolina and the Spartanburg and Appalachee Reservoirs in South Carolina where only about one-half of the drainage area is in forest the rate of silting is high. But at a series of Appalachian Mountain reservoirs—Little River Reservoir near Brevard, N. C.; Green River Reservoir near Tuxedo, N. C.; and Burton, Raburn, Nacoochee, and Tallulah Reservoirs on the upper Tugaloo River Basin near Tallulah Falls, Ga.—where almost all of the drainage area is in forest—the rate of silting is almost negligible.

In the southern Great Plains area high rates of silting are correlated with erosion of sedimentary soils resulting from unfortunate cultivation practices and overgrazing. At the Rogers (Tex.) Municipal Reservoir; Lake Waco, Waco, Tex.; White Rock Reservoir, Dallas, Tex.; Lake Dallas; Lake Worth; and Lake Penick, the drainage areas are almost entirely under cultivation, and the rates of silting are high.

In the Southwest high rates of silting are largely the result of overgrazing, which induces extraordinary sheet and gully erosion. At the Elephant Butte and Zuni Reservoirs in New Mexico and the Coolidge and Roosevelt Reservoirs in Arizona, the watersheds are subject to both sheet and wind erosion and to arroyo and gully development and the bad lands type of dissection. In the watershed areas of the Zuni and Roosevelt Reservoirs, sheep grazing under arid conditions which has reduced the vegetal covering is responsible for much of the accelerated erosion.

In the California region higher rates of reservoir silting are the result for the most part of watershed fires. At the Gibraltar Reservoir, near Santa Barbara,

fires have occurred regularly in the watershed basin, and the rate of silting has increased progressively with the extent of the burning. At the Harding Reservoir near Santa Ana, practically all of the basin was burned over in 1926. Prior to the fire the reservoir silted very little. After the fire, a series of heavy rains induced severe erosion and the reservoir was practically filled within a month of time. At the Santiago Creek Reservoir, which is located about 6 miles downstream from the Harding Reservoir, fires have been few and the rate of silting has been very low.

Bottom Lands.—Wherever there is accelerated erosion there is generally an increase in the covering over of bottom lands with silt and sand from the land above. In the Piedmont region of the South, the new soils made up of the material which has washed off from the upland areas are generally sandy, poorly drained, and less productive than the old soil underneath. These lower grade lands have developed largely on areas of former cultivated and highly productive alluvial land; at the present time they are given over largely to brush and timber and seasonal pasture. The tens of thousands of acres of so-called "meadow soils" of southern valleys are of this origin. The impoverishment of the bottom lands increases with increasing erosion, for in general the farther advanced and deeper the erosion of tributary uplands, the poorer are the resultant overwash soils.

In the West, corresponding bottom land overwash deposits are mostly sand, gravel, and boulder beds that grow little vegetation except weeds and brush.

Stream Channels.—Streams that are overloaded with abnormal amounts of sediment produced by accelerated upland erosion tend to fill up their channels and become relatively broad and shallow. At the same time, through building up of bottom lands, they tend to steepen their grades, elevate their flow lines, and deliver increasing volumes of sediment downstream into succeeding streams of the general river system. The influence of overload in the upper and smaller

TABLE VII.—*Silting of reservoirs*

Reservoir	Period	Years	Total sediment (acre-feet)	Drainage area (square miles)	Annual rate of silting (acre-feet per 100 square miles of drainage area)	Original margin of capacity over annual or seasonal draft (percent)	Annual loss of storage capacity (percent)	Time to reduce capacity to average annual draft	Survey agency and date
Spartanburg, S. C., city reservoir.....	1926-34	8	463	92	63.0	78	2.14	26 years, ¹ or to 1952.....	Soil Conservation Service, 1934. U. S. Geological Survey and Soil Conservation Service, 1934.
High Point, N. C., city reservoir.....	1927-34	7	247	58	60.8	82	.94	97 years, ¹ or to 2024.....	
Rogers, Tex., city reservoir.....	1922-34	12	37.5	0.55	568.2	15	1.90	13 years, ¹ or to 1935.....	Soil Conservation Service, 1934. Bureau of Reclamation, 1925. U. S. Indian Irrigation Service, yearly. Salt River Valley Water Users Association, 1925.
Elephant Butte Reservoir, N. Mex.....	1915-25	10	231,500	30,000	72.0	69	.89	77 years, ¹ or to 1932.....	
Zuni Reservoir, Black Rock, N. Mex.....	1910-27	17	10,136	660	90.3	67	3.62	15 years, ¹ or to 1926.....	
Roosevelt Dam Reservoir, Ariz.....	1910-25	15	101,000	5,760	116.9	51	.41	124 years, ¹ or to 2034.....	

¹ Does not allow for increase in population. Utility draft assumed 75 days' supply for present population at 100 gallons per day per person, which is the Spartanburg rate.

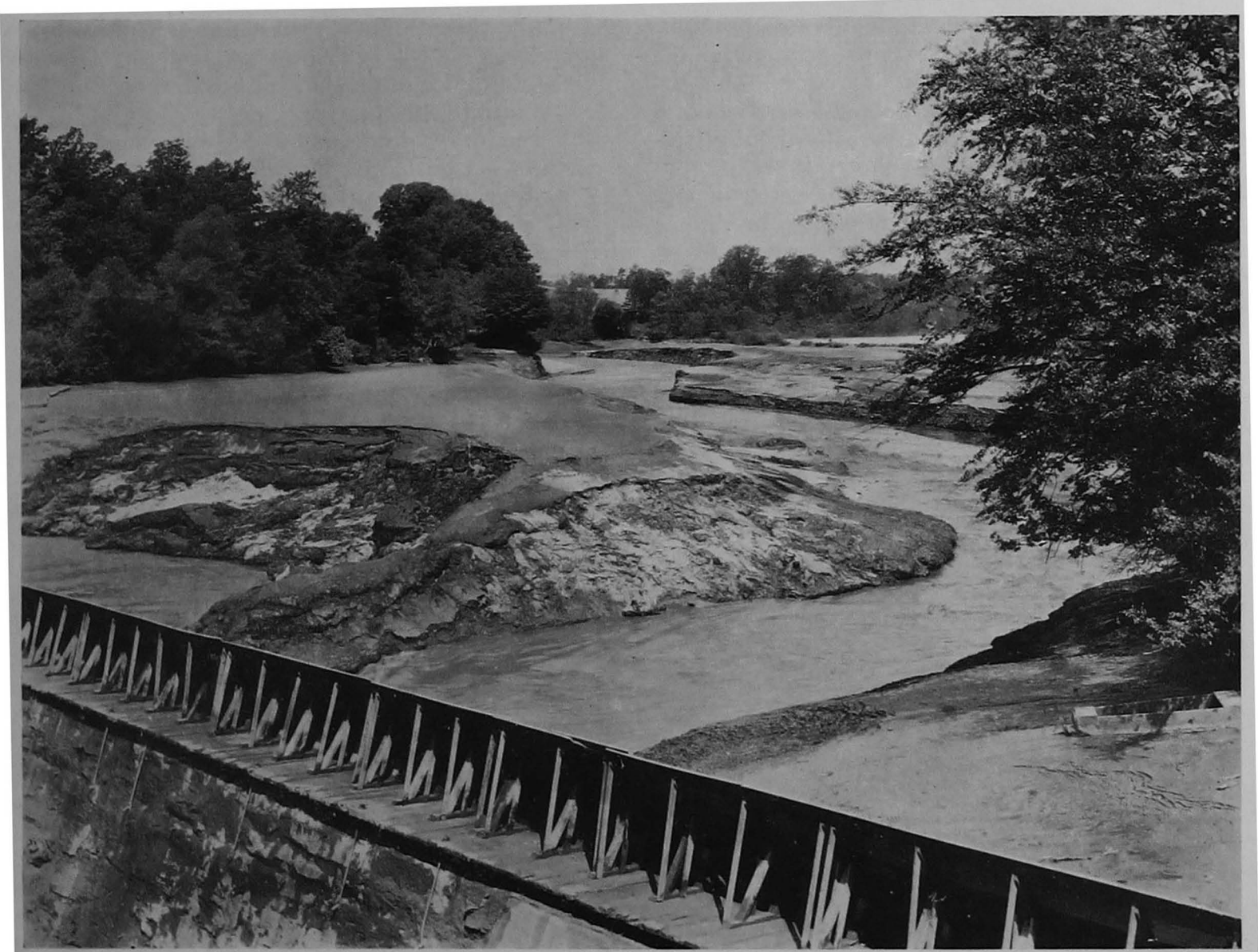


FIGURE 9.—Sedimentation in a reservoir on the Pacolet River in North Carolina. This reservoir has been almost completely filled with erosional debris washed from the hilly fields.

streams thus extends in time toward main streams of even the largest river systems and eventually causes them to lose depth and discharge capacity and to flow at higher levels.

Floods.—Accelerated erosion tends to increase frequency and height of floods through increased volume and flashiness of run-off, and decreased discharge capacity of alluvial channels.

The volume of run-off is increased chiefly by lowered permeability of eroded soils and lessened time of possible percolation.

The flashiness of run-off from margin to center of drainage basins is increased by accelerated erosion, chiefly by development of gully systems. These extend depressions and abnormal slopes toward divides, providing for immediate gather and torrential inflow of surface waters from peripheral uplands, into main valleys of drainage basins. Peripheral rainfall thus tends to overtake and join with waters falling closer

in, to congest major valleys with flood waves of abnormal height and abrupt frontal slope. Abnormally rapid downstream propagation and junction of such waves, from confluent headwater basin, build abnormal floods in succeeding major valleys.

The water discharge capacity of alluvial channels leading out of regions of accelerated erosion is decreased by accumulations of sediment, due to overloading of the stream by abnormal waste from headwater areas. Flood discharge is thus more largely diverted to over-bank area, where velocities are lower, and flood levels of given discharges are correspondingly elevated.

Water Supply.—Accelerated erosion tends generally to increase surface run-off at the expense of natural replenishment of underground waters. This must tend in time to lower the water table, both locally and generally, in regions of notably accelerated erosion. There has been complaint of a gradual lowering of the water

table in many sections of the United States, critically dependent upon underground water supply, during the time of agricultural acceleration of erosion. This has continued through such a variety of rainfall periods as to indicate the possibility, if not the probability that excessive run-off, due to man-induced erosion is a major contributing factor of waning underground water supply.

In the special case of water supply from the outflow of improved mountain watersheds, accelerated erosion generally tends to increase gross yield of water, but to decrease net supply available for actual use.

The increase in gross yield is due to reduced interception of rainfall by foliage, reduced percolation of surface waters into the soil, and reduced transpiration of soil water by vegetation.

The hazard of decrease in usable water supply is due to increased production of sediment. Waters of flood flows from erosive basins are often so heavily charged with sediment that they are unfit for direct domestic, irrigation, or underground storage purposes, and must be bypassed beyond such service plants and wasted.

SECTION IV

NATIONAL EROSION RECONNAISSANCE

A reconnaissance survey of the entire United States was made by the Soil Conservation Service in 1934, to provide a basis upon which to formulate a sound plan for a national program of soil and moisture conservation. While the extent and serious nature of accelerated soil erosion has been recognized for a number of years, no Nation-wide, comprehensive field survey of the damage caused by erosion to the lands of the Nation had been made. This reconnaissance survey was part of the study of land conditions carried out on a national basis to determine the character and prevalence of the different conditions of erosion and their relation to soil character, topography, and present methods of land use.

The survey was made by 115 trained soil-erosion specialists, who visited every county in the United States and prepared an erosion map on the basis of actual reconnaissance.

Extent and Distribution of Erosion

The map shows the conditions and extent of erosion, the dominant soil types, the character of topography as expressed in degree of slope, and the present land use. Since the survey was made in 2 months, ending October 15, 1934, it was impossible to indicate more than generalized or predominant conditions. With the information supplied by this survey it is possible to correlate the relationship of the character and extent of erosion to the dominant soil types, to topographic conditions, and to present land use. It is possible also to determine these conditions and relationships for each of the major watersheds of the United States; for each of the major physiographic regions; for the major soil regions; and for individual States. In brief, information has been acquired by this reconnaissance survey upon which a sound national policy of land and water conservation can be predicated, insofar as the physical features of the land relate to the problem.

In this reconnaissance, three general types of erosion are recognized: Sheet erosion, including rill erosion, gully erosion, and wind erosion. Since much of the eroded lands and eroding lands of the country suffer from combinations of these major types of erosion, rather than from one type alone, such combinations were recognized, and are indicated by number symbols on the accompanying map.

The western mountain and intermountain basin region has been shown by an inclusion boundary on the map. This region extends from the eastern foothills of the Rocky Mountains westward to the top of the Cascade Mountain divides and includes arid and semiarid regions which have developed due to the barrier presented by the Cascade Mountains to the advance of moisture-laden clouds from the Pacific Ocean. Within this region three classes of geological erosion were delineated on which the conditions of accelerated erosion were not differentiated: (1) Mesas, canyons, and rough mountain lands; (2) barren mountain tops; (3) scablands, shallow rocky soils. Within this region other areas of similar conditions were found which were too small to be shown separately by the reconnaissance survey and, therefore, were included with the erosion classes predominating in that section. In this region on many of the areas shown as severely gullied, the gullying was the product of natural geological dissection. On some of these gullied areas, accelerated erosion was induced on the geological dissection by severe fires, overgrazing, or similar causes.

The erosion areas as delineated on the map represent the predominating erosion conditions of that particular area and not specific designations of erosion conditions on an individual farm. For example, if a timbered area had many small cultivated clearings which were severely eroded, but the predominating condition because of the extensive forest cover was one of slight erosion, it was so mapped.

A description of all erosion classes shown on the United States Reconnaissance Erosion Survey Map is given below with the number symbols designating each erosion class preceding each description.

Description of Erosion Classes

1. Little or no erosion:

This class has 0-25 percent of the surface removed generally. Visible evidence of surface erosion not generally perceptible, with practically no gullies. Includes flat lands and swamps such as occur on the lower coastal plains, and on old glacial lake plains of the North where little or no erosion has occurred; gentle undulating plains, where gently sloping lands may have lost small amounts, up to 25 percent, of surface soil; smooth to gently undulating brush covered plains of the arid west; forested lands, which have been protected by vegetative cover from appreciable erosion.

17. Slight sheet erosion—occasional gullies:

Less than 25 percent of the surface soil removed; gullies are usually shallow, occurring at infrequent intervals. Occurs chiefly on forested areas or cut-over lands where the disturbance of the surface soil has induced in places slight sheet erosion and the formation of occasional gullies. Included are the areas where lumbering, grazing, and fires have disturbed the cover and have subjected the surface soils to accelerated erosion.

18. Slight sheet erosion—frequent gullies:

Less than 25 percent of the surface soil removed. Frequent shallow or deep gullies. This class is similar to 17 except it has more numerous and deeper gullies, which are generally active. The surface soil is but little disturbed by sheet erosion generally. This occurs largely on cut-over lands, as a result of destructive logging operations. In the arid region gullies are not only removing bodies of flood-plain soils, but the heads of the gullies are reaching upward onto the steeper residual slopes. Many cuts and gullies in this region are the result of natural geologic erosion inception where accelerated erosion may or may not have been induced by overgrazing or burning.

2. Moderate sheet erosion:

Twenty-five to seventy-five percent of surface soil removed generally. Occurs mostly on cleared lands with moderate slope where tillage methods and cropping systems have induced sheet erosion without gullying. Also occurs on severely cut-over and burnt-over lands where sheet erosion has been induced by logging operations, by grazing, and by burning. In the western interior mountain basins, moderate sheet erosion is found on the gravelly, moderately sandy, desert plains, where under the prevailing type of rainfall on moderate slopes, there is a noticeable movement of surface soil which accompanies heavy rains of short duration.

27. Moderate sheet erosion—occasional gullies:

Twenty-five to seventy-five percent of the surface soil removed. Gullies occur infrequently. Much cultivated land is in this class, but crop yields and farm efficiency have been reduced by soil losses, caused by inefficient soil conservation practices. Much of this type of erosion occurs on semiarid lands, where overgrazing and the attendant reduction of grass and browse cover has induced soil losses. Includes extensive areas of forest and cut-over lands where logging operations, burning, and uncontrolled grazing have induced both moderate sheet erosion and gullying.



FIGURE 10.—Wind erosion in South Dakota. This huge soil drift has almost completely covered the farm buildings. (Rosebud Photo Co.)

28. Moderate sheet erosion—frequent gullies:

Twenty-five to seventy-five percent of the surface soil lost. Frequent gullies usually deep. Differs from 27 in having more numerous gullies. In arid regions, gullies are active generally, developing by both head and lateral cutting. Many gullies approximate small canyons in dimensions. This type of erosion occurs on cut-over areas which have been severely burned or overgrazed. In farming areas where this class occurs, much of it is still cultivated, although tillage is difficult and inefficient. A large total area of the affected land is devoted to pasture, or allowed to grow up to brush or timber.

3. Severe sheet erosion:

Over 75 percent or all surface soil removed. On lands affected by this type of erosion, most of the surface soil is washed away, and the subsoil is exposed in many places or has been removed to varying depths. This class of erosion is of minor extent, since gullying generally accompanies such severe sheet erosion.

37. Severe sheet erosion—occasional gullies.

Over 75 percent of all surface soil removed, infrequent gullying. Loss of surface soil is severe and generally complete; gullies are beginning to develop but are not so numerous or generally so deep as to destroy the land completely.

38. Severe sheet erosion—frequent gullies:

Over 75 percent of the surface soil lost. Frequent gullies, usually deep. Large areas of these lands are essentially ruined for cultivated crops. These conditions have resulted in abandonment of large areas. Only on the deeper, loessial soil areas along the Mississippi and Missouri Rivers is continued cultivation practicable, although crop yields and economic handling are severely impaired. Most of the land in this class with the above exception is submarginal for crop production and is better suited to pasture or forest development.

9. Destroyed by gullying:

Land so mapped has been destroyed by gully erosion generally. This class represents maximum destruction by gully erosion. Such land is of little value for pasture or forest.

4. Moderate wind erosion:

Local evidence of slight soil drifting shown. Small amounts of surface soil are removed, usually accompanied by slight accumulations along fences, ditches, furrows, and clumps of vegetative growth. Lands moderately affected by wind erosion occur most extensively in the dry-farming and grazing regions of the Great Plains. All types of soil, including sands and clays, under certain conditions of culture and drought combined with high wind, are subject to this comparatively slow form of soil damage. In eastern United States, only unprotected sandy lands are affected by wind erosion usually.

24. Moderate sheet and moderate wind erosion:

Twenty-five to seventy-five percent of the surface soil lost. Land of this class shows a marked degree of sheet erosion. Wind erosion is infrequent, except where all the conditions are favorable to blowing. Soil drifting slight as in 4. Land thus affected occurs chiefly in States adjacent to the central Mississippi basin where the soil, slope, and rainfall are conducive to sheet erosion, under cultivation, without gullying. In seasons of subnormal rainfall, wind erosion is active but not serious. Satisfactory control of sheet washing will greatly reduce damage from wind erosion.

47. Moderate wind erosion—occasional gullies:

Slight local accumulations of soil drifting as in 4 above. Gullies are infrequent generally. Wind erosion is slight, occur-

17. Slight sheet erosion—occasional gullies:

Less than 25 percent of the surface soil removed; gullies are usually shallow, occurring at infrequent intervals. Occurs chiefly on forested areas or cut-over lands where the disturbance of the surface soil has induced in places slight sheet erosion and the formation of occasional gullies. Included are the areas where lumbering, grazing, and fires have disturbed the cover and have subjected the surface soils to accelerated erosion.

18. Slight sheet erosion—frequent gullies:

Less than 25 percent of the surface soil removed. Frequent shallow or deep gullies. This class is similar to 17 except it has more numerous and deeper gullies, which are generally active. The surface soil is but little disturbed by sheet erosion generally. This occurs largely on cut-over lands, as a result of destructive logging operations. In the arid region gullies are not only removing bodies of flood-plain soils, but the heads of the gullies are reaching upward onto the steeper residual slopes. Many cuts and gullies in this region are the result of natural geologic erosion inception where accelerated erosion may or may not have been induced by overgrazing or burning.

2. Moderate sheet erosion:

Twenty-five to seventy-five percent of surface soil removed generally. Occurs mostly on cleared lands with moderate slope where tillage methods and cropping systems have induced sheet erosion without gullying. Also occurs on severely cut-over and burnt-over lands where sheet erosion has been induced by logging operations, by grazing, and by burning. In the western interior mountain basins, moderate sheet erosion is found on the gravelly, moderately sandy, desert plains, where under the prevailing type of rainfall on moderate slopes, there is a noticeable movement of surface soil which accompanies heavy rains of short duration.

27. Moderate sheet erosion—occasional gullies:

Twenty-five to seventy-five percent of the surface soil removed. Gullies occur infrequently. Much cultivated land is in this class, but crop yields and farm efficiency have been reduced by soil losses, caused by inefficient soil conservation practices. Much of this type of erosion occurs on semiarid lands, where overgrazing and the attendant reduction of grass and browse cover has induced soil losses. Includes extensive areas of forest and cut-over lands where logging operations, burning, and uncontrolled grazing have induced both moderate sheet erosion and gullying.

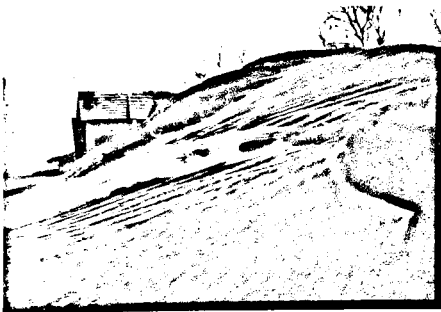


FIGURE 10.—Wind erosion in South Dakota. This huge soil drift has almost completely covered the farm buildings. (Rosebud Photo Co.)

28. Moderate sheet erosion—frequent gullies:

Twenty-five to seventy-five percent of the surface soil lost. Frequent gullies usually deep. Differs from 27 in having more numerous gullies. In arid regions, gullies are active generally, developing by both head and lateral cutting. Many gullies approximate small canyons in dimensions. This type of erosion occurs on cut-over areas which have been severely burned or overgrazed. In farming areas where this class occurs, much of it is still cultivated, although tillage is difficult and inefficient. A large total area of the affected land is devoted to pasture, or allowed to grow up to brush or timber.

3. Severe sheet erosion:

Over 75 percent or all surface soil removed. On lands affected by this type of erosion, most of the surface soil is washed away, and the subsoil is exposed in many places or has been removed to varying depths. This class of erosion is of minor extent, since gullying generally accompanies such severe sheet erosion.

37. Severe sheet erosion—occasional gullies:

Over 75 percent of all surface soil removed, infrequent gullying. Loss of surface soil is severe and generally complete; gullies are beginning to develop but are not so numerous or generally so deep as to destroy the land completely.

38. Severe sheet erosion—frequent gullies:

Over 75 percent of the surface soil lost. Frequent gullies, usually deep. Large areas of these lands are essentially ruined for cultivated crops. These conditions have resulted in abandonment of large areas. Only on the deeper, loessial soil areas along the Mississippi and Missouri Rivers is continued cultivation practicable, although crop yields and economic handling are severely impaired. Most of the land in this class with the above exception is submarginal for crop production and is better suited to pasture or forest development.

9. Destroyed by gullying:

Land so mapped has been destroyed by gully erosion generally. This class represents maximum destruction by gully erosion. Such land is of little value for pasture or forest.

4. Moderate wind erosion:

Local evidence of slight soil drifting shown. Small amounts of surface soil are removed, usually accompanied by slight accumulations along fences, ditches, furrows, and clumps of vegetative growth. Lands moderately affected by wind erosion occur most extensively in the dry-farming and grazing regions of the Great Plains. All types of soil, including sands and clays, under certain conditions of culture and drought combined with high wind, are subject to this comparatively slow form of soil damage. In eastern United States, only unprotected sandy lands are affected by wind erosion usually.

24. Moderate sheet and moderate wind erosion:

Twenty-five to seventy-five percent of the surface soil lost. Land of this class shows a marked degree of sheet erosion. Wind erosion is infrequent, except where all the conditions are favorable to blowing. Soil drifting slight as in 4. Land thus affected occurs chiefly in States adjacent to the central Mississippi basin where the soil, slope, and rainfall are conducive to sheet erosion, under cultivation, without gullying. In seasons of subnormal rainfall, wind erosion is active but not serious. Satisfactory control of sheet washing will greatly reduce damage from wind erosion.

47. Moderate wind erosion—occasional gullies:

Slight local accumulations of soil drifting as in 4 above. Gullies are infrequent generally. Wind erosion is slight, occur-

ring only when surface conditions of the soil are favorable to wind action. Gullies develop on sloping areas in cultivated regions, due to concentration of water following heavy rains. In the grazing sections the gullies follow stock trails or advance up slopes along natural depressions and along lines of accelerated cutting. Wind erosion occurs in the grazing regions only where the sod has been broken or where the land has been so severely grazed that the resultant inferior cover is incapable of protecting the soil from blowing. Unless controlled, these initial conditions of land damage become increasingly serious. Lands so eroded are more common in the grazing and dry-farming areas of the western Great Plains.

48. Moderate wind erosion—frequent gullies:

Slight soil drifting found locally, with gullies frequent and often deep. Erosion of this class occurs chiefly in western grazing areas where torrential downpours are constantly ripping out new and deeper gullies, and in loessial regions where gully cutting proceeds rapidly following the cutting through of the surface soil layer. This class is a more advanced stage of class 47.

247. Moderate sheet and wind erosion—occasional gullies:

Twenty-five to seventy-five percent of the surface soil lost. Represents areas moderately affected by wind erosion, with infrequent gully cutting. Small accumulations of wind-drifted soil are found locally. Considerable areas of this class of eroded land are found in western South Dakota and in adjoining parts of the western Great Plains, as well as in many parts of the rougher western grazing areas. Moderate wind erosion is generally active on the more exposed surfaces. Due to steepness, scant cover, and mulchy character of the surface soil, moderate sheet erosion has taken place, with accompanying gully cutting, in those places favoring concentration of the run-off. Considerable material accumulates at the base of the slopes and spreads out over the adjacent level land. This is a more severely eroded class than 47.

248. Moderate sheet and wind erosion—frequent gullies:

Twenty-five to seventy-five percent of topsoil lost. Frequent deep gullies and moderate wind erosion, as evidenced by slight local drifting. Land thus affected occurs in situations similar to those occupied by land of class 247, except that the slopes are steeper. This condition is encountered also in slightly rolling country damaged by heavy grazing. These areas are subject to occasional torrential rains. Character of cover, soil, and slope favor active sheet erosion and gully cutting. In the western arid region, if present progressive wastage continues, land of this class will be converted into land of class A.

347. Severe sheet erosion—moderate wind erosion—occasional gullies:

More than 75 percent of the surface soil has been lost, occasional small gullies have formed and some damage has resulted from blowing. Wind erosion is evidenced by slight drifting of soil material along fence rows and vegetative clumps. This class occurs chiefly in the Southwestern States, as relatively small scattered areas. On farmed areas, cultivation is largely responsible for the extra loss by wind action. This type is tending toward abandonment for agricultural use. On the United States Reconnaissance Map, the class has been included in class 6 because of its limited extent.

348. Severe sheet and moderate wind erosion—frequent gullies:

Over 75 percent of the surface soil has been removed, numerous gullies have been cut too deep to be crossed by agricultural machinery, and the land has been damaged to some extent by blowing. Slight soil drifting found locally. Land of this class resembles that of class 248, except that more surface soil has been removed. Erosion of this nature is characteristically associated with steep, choppy areas and unstable soils, affected by torrential rainfall. Also, such land is found in subhumid regions where water erosion is very active, with periods when high winds also cause damage. Water erosion is the principal destroying agency. These lands are nonarable and are diminishing in grazing value. They are not very extensive.

5. Severe wind erosion:

Land affected by this kind of erosion differs from class 4 in degree of severity. Areas so mapped are in general more consistently subject to damage by soil blowing, and have been more seriously damaged than lands of class 4. This class is characterized by the presence of drift accumulations along fence lines and as hummocks in fields. Such wind deposit consists of surface soil drifted from nearby areas where the soils have been blown off to depths ranging from 1 to 6 inches. The productive use of this land has been materially lessened, and the tendency is for its condition to become increasingly worse.

25. Moderate sheet and severe wind erosion:

Twenty-five to seventy-five percent of the surface soil has been lost by sheet erosion. Wind erosion is severe, from 1 to 6 inches of soil frequently removed in tilled areas, with attendant drifting. Land of this class is associated with that of class 24 in areas of lighter textured soil along the western, more arid border. Climate, soil, and land-use practices are of such nature that the sloping areas are largely subject to sheet erosion and periodically to serious wind erosion. Land of this class is of very limited extent.

35. Severe sheet and severe wind erosion:

Over 75 percent of surface soil has been lost; wind erosion has been severe, major accounts of surface soil being removed, usually accompanied by locally destructive accumulations. Land of this classification comprised scattered western areas of very unstable soil. The two conditions of erosion are associated on these areas or overlap. On sloping land with scant vegetation, or where continuously cultivated, the two types of erosion, alternating, quickly remove the unprotected surface soil. Land of this nature has little value and should be retired from cultivation or protected from overgrazing.

57. Severe wind erosion—occasional gullies:

Removal of surface soils to depths of several inches has occurred locally, with accumulations of soil hummocks and drifts. Eroded land of this class occurs in scattered parts of the Great Plains, largely in the southwestern section. Networks of small, intermittent drainage lanes have cut into the smoother areas and continue to advance. On slopes leading to these drainages, gullies develop gradually wherever water concentrates. Gullies are rare in those areas affected by severe wind erosion, being more common where there is less damage by wind. These lands differ from those of class 47 in that the soils are usually less coherent and therefore more subject to blowing.

58. Severe wind erosion—frequent gullies:

This class of land includes those areas where wind erosion has locally removed most of the surface soil and formed soil drifts. The areas have been incised by numerous deep gullies. Wind erosion has been responsible for most of the damage. Eroded lands of this nature occur in western semiarid regions of light-

textured soils, partly under cultivation, and locally interrupted by gullied slopes. Land of this nature cannot be maintained in cultivation. It is of every limited extent.

257. Moderate sheet and severe wind erosion—occasional gullies:

Twenty-five to seventy-five percent of the surface soil lost. There has been little gullying and some severe wind erosion where the surface soil has been removed to a depth of several inches locally, with attendant soil accumulations. The areas are somewhat similar to those of class 57, in that the areas affected by wind erosion are scattered, or are abundant only where soils are subject to moderate sheet erosion and gullying. Sparse cover, erodible soil, sloping surface, heavy grazing, and excessive cultivation are factors that have led to the development of this condition. The productive use of this land has been materially lessened, and the tendency is for erosion to become worse.

258. Moderate sheet and severe wind erosion—frequent gullies:

Twenty-five to seventy-five percent of the thin surface soil has been lost by sheet erosion. In addition, during drought periods and when soil conditions favor the action, wind erosion has been sufficiently severe to remove more surface soil, either to be blown away entirely or shifted into drift formation. Torrential rains have produced deep and frequent gullies at points where waters have converged and soil resistance was low. This class is slightly more severely eroded than 257. It has a very limited extent outside the arid region. Overgrazing has been largely responsible for this condition, which is destroying the range and adjacent cultivated areas.

357. Severe sheet and severe wind erosion—occasional gullies:

Over 75 percent of the surface soil has been lost, and there has been severe wind erosion, with occasional gullying. Wind erosion is evidenced by local accumulations. Land of this extremely eroded condition is of limited extent, confined to a few western localities. Such land has little agricultural value for either cultivation or grazing.

358. Severe sheet and severe wind erosion—frequent gullies:

More than 75 percent of the surface soil has been lost. In addition wind erosion has been markedly severe, evidenced by drifts of soil materials. Serious gullies are frequent. The greatest bulk of this class was found in New Mexico with smaller areas in California, Texas, and Oklahoma. It is associated with 357, but is more severely gullied. Its grazing value is very low. Its scattered distribution in the arid western regions is determined by the limited extent of the extreme conditions that produce this type of erosion.

6. Very severe wind erosion:

This class of erosion represents a condition of land depletion amounting to essential destruction for agricultural use. Such land is represented largely by the deep sandy areas of the southwestern Great Plains. Low rainfall, with resultant sparse vegetation, combined with deep, loose sandy soil and winds of high velocity, have favored rapid drifting wherever cultivation is attempted. These lands should be withdrawn from cultivation and stabilized with suitable vegetation.

67. Very severe wind erosion—occasional gullies:

Wind erosion has either removed the topsoil completely or formed active drifts or dunes, so that cultivation is not feasible. Torrential rains of periodic occurrence have caused moderate gullying in unprotected or exposed areas. This class has been combined with class 6 on the United States reconnaissance map because of its limited extent. The largest total area was found in Montana with a few small areas located in Texas. This land has no value for either cultivation or grazing.

68. Very severe wind erosion—frequent gullies:

Wind erosion has removed surface soil and formed dunes and drifts. Deep and frequent gullies have developed as a result of occasional torrential rains on the erosive, unprotected soil. It is slightly more pronounced in relief than 67. It was most extensive in Arizona with smaller areas occurring in Oklahoma and Texas. This class has no agricultural or grazing value. On the United States reconnaissance map, this class has been grouped with class 6 because of its limited occurrence.

W. Scablands, shallow rocky soils:

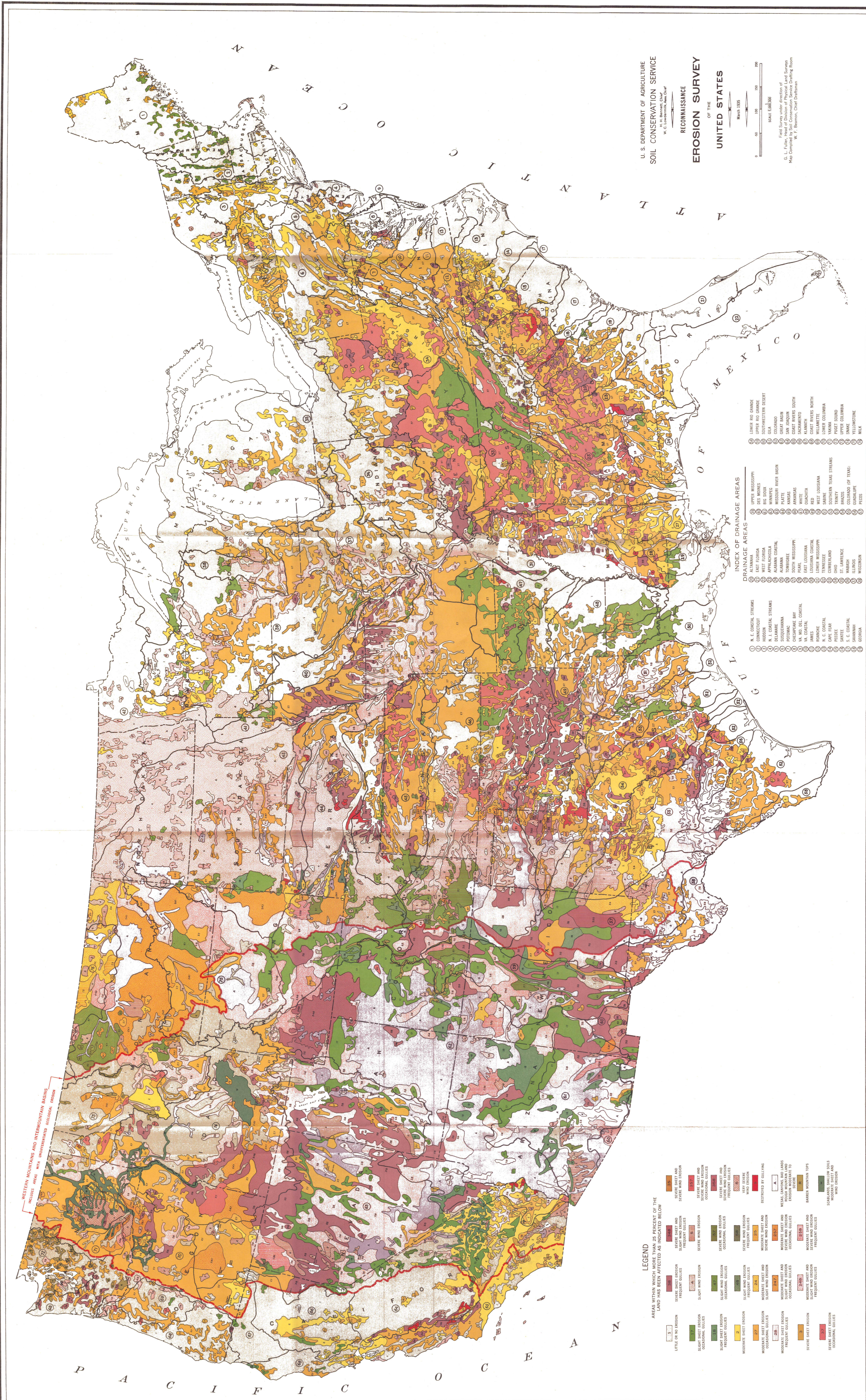
Includes the shallow "scabland" soils of Oregon and other western States. Rock outcrops predominate, and the shallow soils are subject to shifting and re-sorting by water and wind where vegetation is sparse. Accelerated erosion may or may not be present but is commonly subject to moderate wind and water erosion.

A. Mesas, canyons, bad lands, and rough mountain lands:

This class of land comprises areas of natural geologic erosion mostly, on which conditions of accelerated erosion were not evaluated. Accelerated erosion may be present due to overgrazing or other causes. This class occurs principally in the western mountain and intermountain basin region. Accelerated erosion is often moderate to severe and includes both water and wind erosion.

R. Barren mountain tops:

Includes rocky areas above timber line, of normal geological erosion.



U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
RECONNAISSANCE
EROSION SURVEY
OF THE
UNITED STATES

Scale 1:500,000
March 1935

Field Survey under direction of
G. L. Fuller, Head of Division of Physical Land Surveys
Map Compiled by Soil Conservation Service Drafting Room
W. F. Bennett, Chief Draftsman

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 - ② MINNESOTA
 - ③ N. J. COASTAL STREAMS
 - ④ DELAWARE
 - ⑤ SUSQUEHANNA
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 - ⑫ WYOMING
 - ⑬ S. C. COASTAL
 - ⑭ COLORADO (OF TEXAS)
 - ⑮ YELLONSTONE
 - ⑯ MEX.































WESTERN MOUNTAINS AND INTERMOUNTAIN BASINS
INCLUDING AREAS WITH UNDEVELOPED GEOLOGICAL EROSION

- LEGEND**
- AREAS WITHIN WHICH MORE THAN 25 PERCENT OF THE LAND HAS BEEN AFFECTED AS INDICATED BELOW
- 1. LITTLE OR NO EROSION
 - 2. SLIGHT SHEET EROSION OCCASIONAL GULLES
 - 3. SLIGHT WIND EROSION OCCASIONAL GULLES
 - 4. MODERATE SHEET EROSION FREQUENT GULLES
 - 5. MODERATE SHEET EROSION FREQUENT GULLES
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 - 100. MODERATE SHEET EROSION FREQUENT GULLES



LEGEND

AREAS WITHIN WHICH MORE THAN 25 PERCENT OF THE LAND HAS BEEN AFFECTED AS INDICATED BELOW

			
LITTLE OR NO EROSION	SEVERE SHEET EROSION FREQUENT GULLIES	SEVERE SHEET AND SLIGHT WIND EROSION FREQUENT GULLIES	SEVERE SHEET AND SEVERE WIND EROSION
			
SLIGHT SHEET EROSION OCCASIONAL GULLIES	SLIGHT WIND EROSION	SEVERE WIND EROSION	SEVERE SHEET AND SEVERE WIND EROSION OCCASIONAL GULLIES
			
SLIGHT SHEET EROSION FREQUENT GULLIES	SLIGHT WIND EROSION OCCASIONAL GULLIES	SEVERE WIND EROSION OCCASIONAL GULLIES	SEVERE SHEET AND SEVERE WIND EROSION FREQUENT GULLIES
			
MODERATE SHEET EROSION	SLIGHT WIND EROSION FREQUENT GULLIES	SEVERE WIND EROSION FREQUENT GULLIES	VERY SEVERE WIND EROSION
			
MODERATE SHEET EROSION OCCASIONAL GULLIES	MODERATE SHEET AND SLIGHT WIND EROSION	MODERATE SHEET AND SEVERE WIND EROSION	DESTROYED BY GULLYING
			
MODERATE SHEET EROSION FREQUENT GULLIES	MODERATE SHEET AND SLIGHT WIND EROSION OCCASIONAL GULLIES	MODERATE SHEET AND SEVERE WIND EROSION OCCASIONAL GULLIES	MESAS, CANYONS, BAD LANDS ROUGH MOUNTAIN LAND EROSION MODERATE TO SEVERE
			
SEVERE SHEET EROSION	MODERATE SHEET AND SLIGHT WIND EROSION FREQUENT GULLIES	MODERATE SHEET AND SEVERE WIND EROSION FREQUENT GULLIES	BARREN MOUNTAIN TOPS
			
SEVERE SHEET EROSION OCCASIONAL GULLIES			SCABLANDS, SHALLOW SOILS MODERATE SHEET AND WIND EROSION

SECTION V

EROSION CONDITIONS IN THE UNITED STATES

soil erosion reconnaissance survey showed over the United States to be much more wide- and more severe than had been previously ed. (See tables VIII, IX, and X.)

total area of the United States exclusive of the ties and water as covered by this survey com- 1,903,176,620 acres. Of this area 144,768,315 occurring principally in the western mountains ountain basins region, were not separated sion classes, due to the multiplicity of condi- ffecting the character and extent of erosion in ion. It was found impossible in many localities western regions to differentiate accelerated ero- man-induced erosion from normal geological , during the brief time available for the survey. areas where normal geological erosion predomi- ncluded rough mountain land, mesas, canyons, ountain tops, scablands, and rough stony on which accelerated erosion was not designated.

or no erosion was found on 576,236,371 acres ted in nearly all sections of the country. These aried in topography from rough timbered moun- ges to flat upland plains, having a wide range ate, with a difference in annual rainfall of from s to over 200 inches. These slightly eroded or ed areas comprise predominately cut-over and and well protected by vegetation; flat alluvial cattered along the many waterways, including le Deltas of the lower Mississippi River—this curs on the gently rolling to flat uplands and rams on the lower coastal plains of south and stern United States—undulating to flat prairie the Midwest; the old glacial plains of the north rth central region with undulating to flat con- nal topography. The most extensive areas are sted regions of the Northeast, Northwest, and e wide forest belt extending from Canada to bordering the Pacific coast, and on extensive r and timbered areas in the States bordering at Lakes.

ences of accelerated or man-made erosion in one another, exclusive of that undifferentiated in stern mountains and inter-mountain basins was found as a prevailing condition on a total nprising 1,069,656,563 acres as outlined on the ed erosion map. Not all of the erosion was

TABLE VIII.—Reconnaissance erosion survey of the United States Areas within which more than 25 percent of the land has been affected as indicated

Code no.	Description	Acres	Per- cent
1.....	Little or no erosion.....	576,236,371	30.3
17.....	Slight sheet erosion—occasional gullies.....	94,354,965	5.0
18.....	Slight sheet erosion—frequent gullies.....	16,532,933	.9
2.....	Moderate sheet erosion.....	87,850,718	5.1
27.....	Moderate sheet erosion—occasional gullies.....	296,406,164	15.6
28.....	Moderate sheet erosion—frequent gullies.....	174,460,705	9.2
3.....	Severe sheet erosion.....	6,760,021	.4
37.....	Severe sheet erosion—occasional gullies.....	60,633,625	3.2
38.....	Severe sheet erosion—frequent gullies.....	108,819,243	5.7
9.....	Destroyed by gullying.....	4,162,022	.2
4.....	Slight wind erosion.....	124,378,757	6.5
24.....	Moderate sheet and slight wind erosion.....	18,780,583	1.0
47.....	Slight wind erosion—occasional gullies.....	16,189,083	.9
48.....	Slight wind erosion—frequent gullies.....	1,271,274	.1
247.....	Moderate sheet and slight wind erosion—occasional gullies.....	42,879,814	2.3
248.....	Moderate sheet and slight wind erosion—frequent gullies.....	16,838,947	.9
247.....	Severe sheet and slight wind erosion—occasional gullies.....	3,953,190	.2
348.....	Severe sheet and slight wind erosion—frequent gullies.....	9,029,088	.5
5.....	Severe wind erosion.....	54,776,159	2.9
25.....	Moderate sheet and severe wind erosion.....	5,902,905	.3
35.....	Severe sheet and severe wind erosion.....	192,390	(¹) .3
57.....	Severe wind erosion—occasional gullies.....	5,766,630	.3
58.....	Severe wind erosion—frequent gullies.....	278,592	(¹) .1
257.....	Moderate sheet and severe wind erosion—occasional gullies.....	2,840,644	.2
258.....	Moderate sheet and severe wind erosion—frequent gullies.....	7,229,015	.4
357.....	Severe sheet and severe wind erosion—occasional gullies.....	248,068	(¹) .1
358.....	Severe sheet and severe wind erosion—frequent gullies.....	2,424,019	.2
6.....	Very severe wind erosion.....	8,702,102	.5
67.....	Very severe wind erosion—occasional gullies.....	78,375	(¹) .0
68.....	Very severe wind erosion—frequent gullies.....	420,875	(¹) .2
W.....	Scablands, shallow soils—moderate sheet and wind erosion.....	10,049,727	.5
A.....	Mesas, canyons, bad lands, rough mountain land—erosion moderate to severe.....	130,135,388	6.9
R.....	Barren mountain tops.....	4,585,200	.3
	Total.....	1,903,176,620	100.0

¹ Less than one-tenth of 1 percent.
² Exclusive of large cities and water area.

serious and many included areas were not eroded at all. For instance, 94,354,965 acres were found on which, generally, there were scattering gullies, but on which there was no widespread occurrence of sheet erosion.

Of the three types of soil erosion, (1) sheet erosion including rill erosion, (2) gully erosion, and (3) wind erosion, the first was most extensive, occurring on 855,260,347 acres, distributed, generally, over the entire country, in varied degrees of severity.

Serious sheet erosion was found over a much larger area than was suspected. The survey revealed that the prevailing condition on 192,060,874 acres or 10.1 percent of the total land area was a loss of over three-fourths of the topsoil and some subsoil. The major part of this type is now unsuited for tillage. On the deeper loessial soils found in this class, occurring on



FIGURE 11.—Strip-cropping in the Black Belt of Texas. Strips of close-growing crops such as oats, sorghum, or sudan grass alternated with cotton prevent erosion.

gentle to steep slopes, the land has not all become submarginal but productivity has been materially lowered and a considerable acreage is submarginal with many small acreages locally being destroyed for cultivation. These deeper loessial soils occur on the uplands adjacent to the Mississippi, Missouri, and Ohio River Valleys, extending back from 50 to 100 miles or more, the more severely eroded soils usually being developed on the sharply rolling hill lands bordering the valleys of master and tributary streams. In the southeast, south, and southwest-central United States extensive areas of this class formerly productive are now non-agricultural and have been abandoned. These soils are largely in the coastal plain and Piedmont regions. In the western mountains and intermountain basins region, this class comprises low mountainous areas with long narrow bodies of intervening valley lands and smooth undulating plains, which were grouped into the class as representing the predominating conditions. In northwestern Washington and southwestern California extensive areas of this class occur on low mountain ridges and foothills, due largely to denudation of slopes through intensive logging operations.

In addition to the above severely eroded lands, there were 663,199,473 acres, comprising 34.8 percent of the entire country, which has lost from one-fourth to three-fourths of the topsoil, generally. Much of this is still good agricultural land but cultivated areas are rapidly

losing additional topsoil. This class is the predominant condition of erosion on the agricultural lands of the United States and on the grazing lands of the Northwest. It occurs generally in all sections of the country. While the western areas are mostly nonagricultural, much of our better agricultural lands are involved and conservation practices are badly needed.

Gullying was found to be wide-spread, occurring with more or less frequency on 864,818,281 acres, or 45.4 percent of the country accompanying sheet erosion in various degrees of severity, except on 94,354,965 acres on which gullying occurred with little or no attendant sheet erosion.

Severe gullying embodying frequent and deep dissection on agricultural, cut-over, and abandoned lands, was found to prevail on 337,305,021 acres, while 4,162,092 acres more were destroyed by gullying alone. Gully development in the more arid regions is largely a geological process that often has been accelerated by land-use practices.

Wind erosion was found to have affected a total area of 322,181,740 acres, principally in the Middle Western States east of the Rocky Mountains extending from southwestern Texas through North Dakota. Throughout the Northwest and east of the Cascades other areas were found to be affected by wind erosion. Large areas adjacent to the Great Lakes, mostly sandy lands, were found damaged by wind erosion, which has resulted in dune formations where most severe.

Land seriously damaged by wind comprised 79,659,052 acres of the total area, lying largely in the mid-western region described above. Here dry farming, overgrazing, and periodic drought make ideal conditions for active wind erosion. Fallowed lands exposed for considerable periods are sometimes carried away to the depth of plowing by one storm. Both fertility and subsoil moisture are rapidly depleted by these severe aerial soil migrations. All together 9,201,352 acres more have been essentially destroyed.

On an additional 233,321,336 acres wind erosion has been moderately active but is becoming more pronounced. This is part of our more valuable agricultural land which will gradually become submarginal if a conservation program is not inaugurated.

TABLE IX.—Reconnaissance erosion survey of the United States by States. Areas within which more than 25 percent of the land has been affected as indicated

Code no.	Erosion class—description	Alabama	Arizona ¹	Arkansas	California ¹	Colorado ¹	Connecticut	Delaware	Florida
1	Little or no erosion.....	5,616,851	621,349	19,621,039	52,112,417	237,068	2,899,643	1,172,651	33,190,982
17	Slight sheet erosion—occasional gullies.....	1,783,216	6,122,221	7,029,335	5,029,382	12,089,008	781		7,573
18	Slight sheet erosion—frequent gullies.....	105,220	8,140,114		1,727,343	2,088,938			5,978
2	Moderate sheet erosion.....	3,127,074		1,121,038	21,342,237	41,061	183,555	41,846	1,433,210
27	Moderate sheet erosion—occasional gullies.....	12,138,832	362,686	6,010,228	10,150,029	384,604	781	40,653	809,468
28	Moderate sheet erosion—frequent gullies.....	1,916,260	11,168,558	559,433	2,989,569	6,430,730			8,989
3	Severe sheet erosion.....	1,308,062		2,391	713,415	11,558			
37	Severe sheet erosion—occasional gullies.....	6,006,644		225,583	333,193	92,098			
38	Severe sheet erosion—frequent gullies.....	928,248	2,407,280	990,810	2,039,740	3,745,233			
9	Destroyed by gullying.....	5,181		48,628	314,461	74,131			
4	Slight wind erosion.....		207,648		26,109	9,008,000			
47	Slight wind erosion—occasional gullies.....		147,864			7,082,843			
48	Slight wind erosion—frequent gullies.....		91,688		7,971	732,147			
247	Moderate sheet and slight wind erosion—occasional gullies.....					186,524			
248	Moderate sheet and slight wind erosion—frequent gullies.....		873,636						
348	Severe sheet and slight wind erosion—frequent gullies.....					2,954,697			
5	Severe wind erosion.....		2,088,434		1,086,468	4,143,388			
26	Moderate sheet and severe wind erosion.....				432,435				
87	Severe wind erosion—occasional gullies.....				7,174				
88	Severe wind erosion—frequent gullies.....				40,254	3,916,613			
257	Moderate sheet and severe wind erosion—occasional gullies.....					4,783			
258	Moderate sheet and severe wind erosion—frequent gullies.....		2,720,147			580,986			
6	Very severe wind erosion.....				369,768				
68	Very severe wind erosion—frequent gullies.....		364,172						
W	Scrublands, shallow soils—moderate sheet and wind erosion.....					72,986			
A	Massa. canyons, bad lands, rough mountain land—erosion moderate to severe.....		37,204,424		863,672	11,224,634			
R	Barron mountain tops.....					1,673,899			
	Total.....	32,913,568	72,551,180	33,619,407	99,634,672	66,401,445	3,084,800	1,255,462	35,451,777

Code no.	Erosion class—description	Georgia	Idaho ¹	Illinois	Indiana	Iowa	Kansas	Kentucky	Louisiana
1	Little or no erosion.....	14,932,798	21,045,762	21,496,626	13,235,900	15,045,658	8,648,351	1,363,890	20,798,763
17	Slight sheet erosion—occasional gullies.....	375,402				333,003	491,821	5,382,504	6,473,747
2	Moderate sheet erosion.....	2,490,177		418,488	2,100,192	403,883	185,728	1,903,102	680,895
27	Moderate sheet erosion—occasional gullies.....	13,059,110	6,147,729	8,067,176	4,417,386	13,070,941	19,891,577	5,288,040	1,060,634
28	Moderate sheet erosion—frequent gullies.....	356,311	9,408,791	4,756,872	1,148,467	3,301,277	850,917	39,457	13,192
3	Severe sheet erosion.....	13,151				1,597	13,550	64,965	
7	Severe sheet erosion—occasional gullies.....	4,302,412	1,056,970		81,326	380,408	4,990,721	5,964,731	
33	Severe sheet erosion—frequent gullies.....	1,907,092	3,202,601	843,743	1,442,445	2,890,708	2,622,696	2,672,495	1,594
9	Destroyed by gullying.....	231,961						15,544	
4	Slight wind erosion.....		131,126		609,349	3,160	5,864,368		
24	Moderate sheet and slight wind erosion.....						2,722,140		
47	Slight wind erosion—occasional gullies.....		805,294				263,692		
247	Moderate sheet and slight wind erosion—occasional gullies.....		3,389,852		3,968				
347	Severe sheet and slight wind erosion—occasional gullies.....		2,780,706						
348	Severe sheet and slight wind erosion—frequent gullies.....		221,696						
5	Severe wind erosion.....			163,010	21,819		4,638,008		
26	Moderate sheet and severe wind erosion.....		607,798				266,672		
87	Severe wind erosion—occasional gullies.....						101,632		
257	Moderate sheet and severe wind erosion—occasional gullies.....						281,780		
6	Very severe wind erosion.....		620,183		8,331		411,310		
W	Scrublands, shallow soils—moderate sheet and wind erosion.....		4,005,496						
A	Massa. canyons, bad lands, rough mountain land—erosion moderate to severe.....								
R	Barron mountain tops.....		330,823						
	Total.....	37,668,334	53,265,767	35,875,638	23,068,800	35,675,040	23,620,949	25,701,698	28,877,785

Code no.	Erosion class—description	Maine	Maryland	Massachusetts	Michigan	Minnesota	Mississippi	Missouri	Montana ¹
1	Little or no erosion.....	17,357,210	4,111,904	4,908,970	29,652,833	27,961,147	10,230,444	6,684,835	17,967,388
17	Slight sheet erosion—occasional gullies.....	750,680		115,960	290,635	918,270	107,782	2,813,335	
2	Moderate sheet erosion.....	389,611	741,713	55,001	2,235,428	3,227,108	5,424,701	396	2,227,881
27	Moderate sheet erosion—occasional gullies.....	617,015	991,639	34,078	1,306,650	6,133,623	8,204,744	19,599,432	7,303,334
28	Moderate sheet erosion—frequent gullies.....	6,511	181,843		58,190	507,362	2,228,444	12,978,804	10,064,277
3	Severe sheet erosion.....						50,963		
37	Severe sheet erosion—occasional gullies.....	384	119,667				1,299,280		816,485
38	Severe sheet erosion—frequent gullies.....		121,162			2,760	1,694,194	1,857,438	
9	Destroyed by gullying.....		23,116				441,168	20,090	
4	Slight wind erosion.....			27,600	1,662,664	9,063,368			3,057,385
24	Moderate sheet and slight wind erosion.....	11,469		15,544	344,752				6,254,604
47	Slight wind erosion—occasional gullies.....				11,568				7,250,654
247	Moderate sheet and slight wind erosion—occasional gullies.....				199,277	173,372			21,822,163
347	Severe sheet and slight wind erosion—occasional gullies.....					3,966			4,418,402
5	Severe wind erosion.....				337,975	3,301,710			1,947,796
26	Moderate sheet and severe wind erosion.....			19,928	96,843				1,512,022
87	Severe wind erosion—occasional gullies.....					13,949			946,777
257	Moderate sheet and severe wind erosion—occasional gullies.....				137,502	15,548			
358	Moderate sheet and severe wind erosion—frequent gullies.....				4,394				

¹ Includes areas with undifferentiated geological erosion.
² Exclusive of large cities and water areas.

TABLE IX.—Reconnaissance erosion survey of the United States by States. Areas within which more than 25 percent of the land has been affected as indicated—Continued

Code no.	Erosion class—description	Maine	Maryland	Massachusetts	Michigan	Minnesota	Mississippi	Missouri	Montana
6	Very severe wind erosion.....			25,100	37,862	15,543			21,181
A	Mesas, canyons, badlands, rough mountain land—erosion moderate to severe.....								7,250,141
R	Barren mountain tops.....								1,172,305
	Total ¹	10,132,800	6,200,414	5,103,114	36,830,603	61,462,304	29,671,090	43,985,280	93,523,841

Code no.	Erosion class—description	Nebraska	Nevada ¹	New Hampshire	New Jersey	New Mexico ¹	New York	North Carolina	North Dakota
1	Little or no erosion.....	11,644,617	235,547	5,364,563	3,862,443	1,027,478	19,890,342	10,086,264	28,601
17	Slight sheet erosion—occasional gullies.....	190,909	6,440,659	308,883		12,374,049	98,443		115,777
18	Slight sheet erosion—frequent gullies.....		1,120,740			2,343,612			
2	Moderate sheet erosion.....	741,712	196,887	38,659	342,360	178,554	5,457,829	5,774,679	106,611
27	Moderate sheet erosion—occasional gullies.....	6,828,672	4,813,794	9,964	287,761	2,967,652	3,266,047	3,579,830	
28	Moderate sheet erosion—frequent gullies.....	4,294,478	24,330,262		21,123	13,426,930	19,132	13,930	
3	Severe sheet erosion.....	93,661				559,971		335,983	
37	Severe sheet erosion—occasional gullies.....	244,315				366,672	296,528	639,083	
38	Severe sheet erosion—frequent gullies.....	2,728,115	18,406,920		28,666	19,182,512	28,695	1,410,490	
9	Destroyed by gullying.....	1,011,536					5,580		
4	Slight wind erosion.....	14,957,815		17,537	27,102	1,196	348,737		33,266,291
24	Moderate sheet and slight wind erosion.....	622,146				2,621,018	88,480		
47	Slight wind erosion—occasional gullies.....	3,188				616,966	1,694		36,668
48	Slight wind erosion—frequent gullies.....								
247	Moderate sheet and slight wind erosion—occasional gullies.....	1,602,369	13,949		306,241	116,378	24,313		318,665
248	Moderate sheet and slight wind erosion—frequent gullies.....	194,493			49,820	2,283,726			
347	Severe sheet and slight wind erosion—occasional gullies.....					22,319			
5	Severe wind erosion.....	3,458,669	1,983,724			3,404,940	160,618		9,026,501
25	Moderate sheet and severe wind erosion.....						148,263		
57	Severe wind erosion—occasional gullies.....					671,131			
58	Severe wind erosion—frequent gullies.....		124,350						
257	Moderate sheet and severe wind erosion—occasional gullies.....					415,694	96,452		
258	Moderate sheet and severe wind erosion—frequent gullies.....		2,023,672			970,086			
357	Severe sheet and severe wind erosion—occasional gullies.....						2,391		
358	Severe sheet and severe wind erosion—frequent gullies.....					2,385,788			
6	Very severe wind erosion.....		569,935			294,951	26,365		82,103
W	Scablands, shallow soils—moderate sheet and wind erosion.....	421,671							
A	Mesas, canyons, badlands, rough mountain land—erosion moderate to severe.....	866,461	10,056,368			10,499,967			1,972,454
R	Barren mountain tops.....					10,761			
	Total ¹	49,291,829	76,286,188	6,770,295	4,818,546	77,588,536	30,328,333	31,276,299	44,948,773

Code no.	Erosion class—description	Ohio	Oklahoma	Oregon ¹	Pennsylvania	Rhode Island	South Carolina	South Dakota	Tennessee
1	Little or no erosion.....	13,502,318	8,319,859	17,299,330	14,079,392	632,907	12,823,083	466,799	3,656,314
17	Slight sheet erosion—occasional gullies.....	3,959	1,732,126	112,393	53,407			1,463,867	5,886,056
18	Slight sheet erosion—frequent gullies.....		85,661					361,899	
2	Moderate sheet erosion.....	3,554,302	3,085,224	1,194,872	5,698,117		1,044,678	1,196	1,251,381
27	Moderate sheet erosion—occasional gullies.....	4,287,223	3,389,718	25,305,134	8,435,439	20,726	2,320,411	233,953	4,121,228
28	Moderate sheet erosion—frequent gullies.....	531,498	865,917	3,362,112	186,315		266,322	192,901	745,055
3	Severe sheet erosion.....	36,814	673,560		13,152				251,465
37	Severe sheet erosion—occasional gullies.....	3,123,224	6,950,417	2,314,813	372,650		2,016,834		8,576,687
38	Severe sheet erosion—frequent gullies.....	1,004,262	11,798,496	3,969,220	41,460		330,929	7,573	2,965,761
9	Destroyed by gullying.....	3,566						9,167	108,753
4	Slight wind erosion.....	88,061	109,278			19,526		35,729,371	
24	Moderate sheet and slight wind erosion.....		102,030	562,761					
47	Slight wind erosion—occasional gullies.....		39,659					440,405	
38	Slight wind erosion—frequent gullies.....		91,269	4,310,784				16,739	
247	Moderate sheet and slight wind erosion—occasional gullies.....							3,121,093	
248	Moderate sheet and slight wind erosion—frequent gullies.....							2,281,544	
347	Severe sheet and slight wind erosion—occasional gullies.....								
5	Severe wind erosion.....		3,273,742	568,747				4,020,641	
25	Moderate sheet and severe wind erosion.....		882,016	153,046					
35	Severe sheet and severe wind erosion.....		129,133						
57	Severe wind erosion—occasional gullies.....		17,536						
58	Severe wind erosion—frequent gullies.....		106,205						
257	Moderate sheet and severe wind erosion—occasional gullies.....		77,321	887,668					
357	Severe sheet and severe wind erosion—occasional gullies.....		208,843						
358	Severe sheet and severe wind erosion—frequent gullies.....		38,261						
6	Very severe wind erosion.....		1,952,825	36,667					
W	Scablands, shallow soils—moderate sheet and wind erosion.....		1,028,276						
A	Mesas, canyons, badlands, rough mountain land—erosion moderate to severe.....		854,507					665,116	
R	Barren mountain tops.....		74,530						
	Total ¹	26,079,600	44,556,681	61,443,019	26,784,516	678,162	19,516,800	49,011,262	26,679,660

Code no.	Erosion class—description	Texas ¹	Utah ¹	Vermont	Virginia	Washington ¹	West Virginia	Wisconsin	Wyoming ¹
1	Little or no erosion.....	38,597,844	205,656	5,073,383	9,351,329	12,197,011	1,477,050	19,353,832	9,077,115
17	Slight sheet erosion—occasional gullies.....	2,567,732	4,720,496	259,501	271,417	86,110	48,624	1,359,570	6,102,262
18	Slight sheet erosion—frequent gullies.....	1,185	357,577		10,761			188,674	33,081
2	Moderate sheet erosion.....	13,111,062		84,152	1,186,962	15,544	5,013,429	65,527	41,051
27	Moderate sheet erosion—occasional gullies.....	36,495,098	1,788,215	419,364	13,445,392	12,801,029	4,584,968	7,678,961	3,929,532
28	Moderate sheet erosion—frequent gullies.....	23,233,941	11,166,830	2,740	116,777	4,095,961		133,968	15,862,573
3	Severe sheet erosion.....	1,376,661						470,296	
37	Severe sheet erosion—occasional gullies.....	3,669,783	25,506		658,016		3,216,745		

¹ Includes areas with undifferentiated geological erosion.

² Exclusive of large cities and water areas.

TABLE IX.—Reconnaissance erosion survey of the United States by States. Areas within which more than 25 percent of the land has been affected as indicated—Continued

Code no.	Erosion class—description	Texas ¹	Utah ¹	Vermont	Virginia	Washington ¹	West Virginia	Wisconsin	Wyoming
23	Severe sheet erosion—frequent gullies	8,029,134	6,448,248		351,925	981,244	345,150		2,218,792
9	Destroyed by gullying	1,093,703					39,456		
4	Slight wind erosion	7,512,299				713,016		1,315,987	428,060
24	Moderate sheet and slight wind erosion	5,437,972				23,116		1,685	622,943
47	Slight wind erosion—occasional gullies		37,993					21,801	22,718
48	Slight wind erosion—frequent gullies					814,650			7,174
247	Moderate sheet and slight wind erosion—occasional gullies	1,911,090				228,127			6,084,757
248	Moderate sheet and slight wind erosion—frequent gullies	296,899							4,247,308
347	Severe sheet and slight wind erosion—occasional gullies	178,803							
348	Severe sheet and slight wind erosion—frequent gullies		355,911						5,497,684
5	Severe wind erosion	6,134,885	2,973,027					1,895,407	
25	Moderate sheet and severe wind erosion	170,147	475,477			1,030,268			
35	Severe sheet and severe wind erosion	63,257							
57	Severe wind erosion—occasional gullies								491,519
257	Moderate sheet and severe wind erosion—occasional gullies	463,072				514,934			
258	Moderate sheet and severe wind erosion—frequent gullies		78,516			80,487			765,627
357	Severe sheet and severe wind erosion—occasional gullies	37,464							
6	Very severe wind erosion	1,164,238	30,457			2,770,763		7,627	120,783
67	Very severe wind erosion—occasional gullies	78,375							
68	Very severe wind erosion—frequent gullies	21,122							
W	Scablands, shallow soils—moderate sheet and wind erosion	119,304				4,404,045			
A	Measas, canyons, bad lands, rough mountain land—erosion moderate to severe	19,653,364	23,788,225						4,926,949
R	Barren mountain tops					1,673,953			
	Total ¹	169,325,465	32,865,688	5,839,360	25,392,410	42,431,484	15,333,648	35,363,840	62,369,259

¹ Includes areas with undifferentiated geological erosion.

² Exclusive of large cities and water areas.

TABLE X.—Reconnaissance erosion survey of the United States by major watersheds. Areas within which more than 25 percent of the land has been affected as indicated

Code no.	Erosion class—description	Alabama	Alabama coastal	Altamaha	Appalachians	Arkansas ¹	Big Sioux	Brazos ¹	Cape Fear
1	Little or no erosion	2,715,082	3,312,001	2,253,638	3,752,408	14,913,644	309,500	4,788,143	3,796,239
17	Slight sheet erosion—occasional gullies	714,596	318,847	36,666	170,983	3,025,594	249,785	1,173,809	
18	Slight sheet erosion—frequent gullies	39,059	70,943			1,313,426		1,186	
2	Moderate sheet erosion	698,742	1,270,198	3,033,456	1,241,890	2,821,377	6,156	4,244,171	1,137,878
227	Moderate sheet erosion—occasional gullies	5,375,229	3,157,726	3,595,092	4,396,078	12,182,256	958,357	6,823,742	675,914
26	Moderate sheet erosion—frequent gullies	601,025	629,283	64,965	455,549	8,085,017	88,878	1,385,949	
3	Severe sheet erosion	382,215	124,740	3,188	28,169	614,373		915,193	65,762
37	Severe sheet erosion—occasional gullies	3,095,284		1,294,111	2,095,912	5,983,601		1,555,629	90,473
38	Severe sheet erosion—frequent gullies	519,720	3,687	1,014,728	488,629	12,134,630	166,102	1,696,856	15,942
9	Destroyed by gullying	3,188		2,790	221,997	3,865	9,167	145,379	
4	Slight wind erosion					7,848,621	3,030,818	1,870,145	
24	Moderate sheet and slight wind erosion					2,339,924		1,289,395	
47	Slight wind erosion—occasional gullies					3,074,664	32,682		
48	Slight wind erosion—frequent gullies					457,252		321,215	
247	Moderate sheet and slight wind erosion—occasional gullies					203,551			
248	Moderate sheet and slight wind erosion—frequent gullies					74,907			
347	Severe sheet and slight wind erosion—occasional gullies								
348	Severe sheet and slight wind erosion—frequent gullies								
5	Severe wind erosion					13,644,293	11,957	1,149,700	
25	Moderate sheet and severe wind erosion					1,001,070		53,349	
35	Severe sheet and severe wind erosion					50,219			
57	Severe wind erosion—occasional gullies					2,861,833			
58	Severe wind erosion—frequent gullies					4,783			
257	Moderate sheet and severe wind erosion—occasional gullies					122,756		84,688	
258	Moderate sheet and severe wind erosion—frequent gullies					199,677			
357	Severe sheet and severe wind erosion—occasional gullies					209,242			
358	Severe sheet and severe wind erosion—frequent gullies					2,246,260			
6	Very severe wind erosion					21,123			
67	Very severe wind erosion—occasional gullies								
68	Very severe wind erosion—frequent gullies								
W	Scablands, shallow soils—moderate sheet and wind erosion					25,507		119,304	
A	Measas, canyons, bad lands, rough mountain land—erosion moderate to severe					6,231,465		697,831	
R	Barren mountain tops					245,909			
	Total ¹	14,912,740	8,797,331	9,298,831	12,819,554	102,537,648	5,556,403	28,022,584	5,684,288

¹ Includes areas with undifferentiated geological erosion.

² Exclusive of large cities and water areas.

Code no.	Erosion class—description	Chesapeake Bay	Colorado ¹	Colorado ¹ of Texas	Connecticut	Cumberland	Delaware	Des Moines
1	Little or no erosion	3,342,661	1,128,313	3,312,419	6,481,267	697,357	5,588,660	4,879,136
17	Slight sheet erosion—occasional gullies		15,545,283	184,363	249,366	3,691,535		167,568
18	Slight sheet erosion—frequent gullies		7,862,319					
2	Moderate sheet erosion	333,194	1,979,629	4,853,400	168,282	497,839	1,262,627	78,517
27	Moderate sheet erosion—occasional gullies	365,476	2,302,080	4,738,357	25,562	1,883,456	1,113,568	2,335,643
28	Moderate sheet erosion—frequent gullies	7,174	13,357,159	3,841,944		32,116		1,369,239
3	Severe sheet erosion			684,347		227,052	13,152	
37	Severe sheet erosion—occasional gullies	50,617	193,300	288,591		4,270,947		3,160
38	Severe sheet erosion—frequent gullies	110,002	6,627,553	1,518,009		134,750		96,797

¹ Includes areas with undifferentiated geological erosion.

² Exclusive of large cities and water areas.

TABLE X.—Reconnaissance erosion survey of the United States by major watersheds. Areas within which more than 25 percent of the land has been affected as indicated—Continued

Code no.	Erosion class—description	Chesapeake Bay	Colorado ¹	Colorado of Texas	Connecticut	Cumberland	Delaware	Des Moines
9	Destroyed by gullying.....	23, 116		79, 401				
4	Slight wind erosion.....		17, 138	1, 422, 168	390		27, 102	542, 435
24	Moderate sheet and slight wind erosion.....		638, 298	2, 262, 697	15, 544			
47	Slight wind erosion—occasional gullies.....							
48	Slight wind erosion—frequent gullies.....		91, 668					
247	Moderate sheet and slight wind erosion—occasional gullies.....						270, 241	
248	Moderate sheet and slight wind erosion—frequent gullies.....		1, 028, 658				49, 820	
347	Severe sheet and slight wind erosion—occasional gullies.....							
348	Severe sheet and slight wind erosion—frequent gullies.....		8, 807, 295					
5	Severe wind erosion.....		180, 148	2, 046, 431				
26	Moderate sheet and severe wind erosion.....		11, 160					
35	Severe sheet and severe wind erosion.....							
57	Severe wind erosion—occasional gullies.....							
58	Severe wind erosion—frequent gullies.....							
257	Moderate sheet and severe wind erosion—occasional gullies.....							
258	Moderate sheet and severe wind erosion—frequent gullies.....		2, 492, 969					
357	Severe sheet and severe wind erosion—occasional gullies.....							
358	Severe sheet and severe wind erosion—frequent gullies.....							
6	Very severe wind erosion.....		121, 959	214, 183				
67	Very severe wind erosion—occasional gullies.....		394, 172					
68	Very severe wind erosion—frequent gullies.....							
W	Seablands, shallow soils—moderate sheet and wind erosion.....		25, 109					
A	Mesas, canyons, bad lands, rough mountain land—erosion moderate to severe.....		56, 129, 463	1, 295, 706				
B	Barren mountain tops.....		865, 064					
	Total.....	4, 232, 270	122, 692, 734	26, 845, 938	6, 940, 472	11, 116, 372	8, 234, 170	9, 272, 545

Code No.	Erosion class—description	East Florida	East Louisiana	Georgia	Gila ¹	Great Basin ¹	Guadalupe	Hudson
1	Little or no erosion.....	12, 663, 724	2, 088, 608	2, 357, 458	621, 349	8, 927, 290	1, 958, 227	6, 240, 920
17	Slight sheet erosion—occasional gullies.....	15, 145	486, 281	35, 472	5, 385, 689	12, 373, 574		29, 627
18	Slight sheet erosion—frequent gullies.....				2, 539, 204	2, 006, 730		
2	Moderate sheet erosion.....	99, 639	375, 784	219, 208	8, 552, 307	830, 666		1, 680, 614
27	Moderate sheet erosion—occasional gullies.....	128, 734	152, 067	787, 149	288, 156	16, 176, 600	1, 621, 017	598, 475
28	Moderate sheet erosion—frequent gullies.....	13, 955		3, 189	6, 844, 006	32, 425, 341	419, 902	
3	Severe sheet erosion.....					408, 919		177, 357
37	Severe sheet erosion—occasional gullies.....		11, 382	40, 253		54, 204	117, 792	112, 792
38	Severe sheet erosion—frequent gullies.....			3, 188	3, 045, 563	21, 307, 213	614, 405	15, 145
4	Slight wind erosion.....				190, 510	199, 278		76, 923
24	Moderate sheet and slight wind erosion.....					295, 655		69, 951
47	Slight wind erosion—occasional gullies.....				147, 864	253, 082		
247	Moderate sheet and slight wind erosion—occasional gullies.....					2, 281, 325		7, 573
248	Moderate sheet and slight wind erosion—frequent gullies.....					7, 174		
5	Severe wind erosion.....				2, 190, 065	6, 240, 694		
25	Moderate sheet and severe wind erosion.....					942, 586		97, 647
57	Severe wind erosion—occasional gullies.....					164, 604		
58	Severe wind erosion—frequent gullies.....							
257	Moderate sheet and severe wind erosion—occasional gullies.....				327, 215			9, 964
258	Moderate sheet and severe wind erosion—frequent gullies.....				1, 031, 803	2, 101, 888		2, 391
357	Severe sheet and severe wind erosion—occasional gullies.....							
6	Very severe wind erosion.....					1, 041, 426	1, 216, 966	
A	Mesas, canyons, bad lands, rough mountain land—erosion moderate to severe.....				16, 130, 765	11, 747, 843		
	Total.....	12, 921, 192	3, 117, 682	3, 445, 915	29, 014, 666	127, 447, 913	6, 478, 975	9, 129, 009

Code no.	Erosion class—description	Illinois	James	Kansas ¹	Klamath ¹	Louisiana coastal	Lower Columbia ¹	Lower Mississippi
1	Little or no erosion.....	11, 007, 561	2, 200, 466	7, 283, 813	6, 677, 810	598, 631	4, 657, 528	24, 136, 620
17	Slight sheet erosion—occasional gullies.....		15, 942	500, 588	67, 755			800, 581
18	Slight sheet erosion—frequent gullies.....		10, 761					
2	Moderate sheet erosion.....	365, 574	10, 762	201, 969	848, 963			1, 299, 517
27	Moderate sheet erosion—occasional gullies.....	3, 873, 905	3, 438, 342	12, 732, 204	2, 118, 724		9, 625, 134	9, 081, 796
28	Moderate sheet erosion—frequent gullies.....	2, 017, 016		1, 319, 620	9, 954		2, 521, 664	5, 059, 564
3	Severe sheet erosion.....			6, 775				22, 121
37	Severe sheet erosion—occasional gullies.....		228, 184	2, 615, 309	3, 188		15, 543	713, 001
38	Severe sheet erosion—frequent gullies.....	1, 587	85, 689	2, 534, 419	29, 493		1, 396, 143	3, 097, 250
9	Destroyed by gullying.....			239, 930				413, 126
4	Slight wind erosion.....	391, 493		6, 905, 785				
24	Moderate sheet and slight wind erosion.....			416, 063			477, 071	
47	Slight wind erosion—occasional gullies.....			1, 273, 386			23, 116	
48	Slight wind erosion—frequent gullies.....			60, 182				
247	Moderate sheet and slight wind erosion—occasional gullies.....						833, 382	
248	Moderate sheet and slight wind erosion—frequent gullies.....						5, 580	
5	Severe wind erosion.....	126, 641		161, 415			188, 617	
25	Moderate sheet and severe wind erosion.....						153, 046	
57	Severe wind erosion—occasional gullies.....			404, 535				
257	Moderate sheet and severe wind erosion—occasional gullies.....			280, 983			1, 064, 544	
258	Moderate sheet and severe wind erosion—frequent gullies.....						67, 755	
6	Very severe wind erosion.....			7, 573			461, 528	
W	Seablands, shallow soils—moderate sheet and wind erosion.....						850, 520	
B	Barren mountain tops.....						310, 078	
	Total.....	17, 663, 777	6, 067, 145	37, 964, 073	9, 855, 807	598, 631	22, 631, 149	44, 624, 554

¹Includes areas with undifferentiated geological erosion. Excludes of large cities and water areas.

TABLE X.—Reconnaissance erosion survey of the United States by major watersheds. Areas within which more than 25 percent of the land has been affected as indicated—Conti nued

Code no.	Erosion class—description	Lower Rio Grande	Milk †	Missouri River Basin †	New Jersey coastal	North Carolina coastal	Northeast coastal	Ohio	Ouchita
1	Little or no erosion.....	2,761,459	325,155	13,468,831	2,140,016	10,028,470	27,712,677	15,453,556	9,015,983
17	Slight sheet erosion—occasional gullies.....			1,994,476			1,014,907	3,844,848	3,107,328
18	Slight sheet erosion—frequent gullies.....			361,889					
2	Moderate sheet erosion.....	92,334		500,890	10,761	1,186,501	628,848	12,220,424	163,099
27	Moderate sheet erosion—occasional gullies.....	2,522,328	67,855	20,201,052	163,938	1,362,263	622,452	18,305,635	2,239,884
28	Moderate sheet erosion—frequent gullies.....	5,045,490	471,454	21,522,128	21,123		6,511	1,320,838	23,116
3	Severe sheet erosion.....			28,696		11,558		582,631	
37	Severe sheet erosion—occasional gullies.....			1,088,020				14,474,960	39,866
38	Severe sheet erosion—frequent gullies.....	2,129,367		3,937,675	28,050		5,580	4,806,440	
9	Destroyed by gullying.....			503,642				21,523	
4	Slight wind erosion.....	245,080	511,480	35,069,853			90,403		
24	Moderate sheet and slight wind erosion.....	3,163,081	3,471,123	3,471,123					
47	Slight wind erosion—occasional gullies.....	1,064,499	5,408,835				30,689		
48	Slight wind erosion—frequent gullies.....		23,913						
247	Moderate sheet and slight wind erosion—occasional gullies.....		915,038	10,249,731					
248	Moderate sheet and slight wind erosion—frequent gullies.....			3,282,030					
347	Severe sheet and slight wind erosion—occasional gullies.....	460,732							
5	Severe wind erosion.....		276,510	11,539,522			3,036		
23	Moderate sheet and severe wind erosion.....	1,374,744		157,279			19,928		
57	Severe wind erosion—occasional gullies.....			646,777					
258	Moderate sheet and severe wind erosion—frequent gullies.....			22,718					
6	Very severe wind erosion.....			20,045			34,278		
W	Scablands, shallow soils—moderate sheet and wind erosion.....			111,994					
A	Mesa, canyons, bad lands, rough mountain land—erosion moderate to severe.....	6,662,419	1,272,787	7,933,183					
R	Barren mountain tops.....			190,230					
	Total ².....	19,973,672	9,465,542	170,824,465	2,373,404	12,388,792	30,210,641	71,521,234	15,249,183

Code no.	Erosion class—description	Pearl	Pecos †	Feedee	Platte †	Potomac	Fuget Sound †	Red †	Roanoke
1	Little or no erosion.....	1,369,081	646,038	7,240,791	6,481,321	3,532,403	4,553,503	9,846,486	1,531,265
17	Slight sheet erosion—occasional gullies.....	73,127	2,840,184		6,217,876			2,335,124	4,783
18	Slight sheet erosion—frequent gullies.....		856,563		43,228				
2	Moderate sheet erosion.....	1,306,227	916,916	1,874,590	605,405	1,094,435		2,415,678	762,040
27	Moderate sheet erosion—occasional gullies.....	2,249,591	4,869,132	827,006	3,012,226	3,868,422	2,624,095	5,329,048	2,702,610
28	Moderate sheet erosion—frequent gullies.....	25,677	4,015,079		7,081,149	300,512	355,519	2,585,151	122,357
3	Severe sheet erosion.....			176,746	69,748			83,270	153,046
37	Severe sheet erosion—occasional gullies.....	288,664	176,783	414,816	56,994	105,812		2,527,916	367,468
38	Severe sheet erosion—frequent gullies.....	118,667	6,271,340	907,101	3,877,973	80,110	155,037	6,282,539	465,115
9	Destroyed by gullying.....	24,509		7,124				819,398	
4	Slight wind erosion.....		60,273		14,889,546			1,889,993	
24	Moderate sheet and slight wind erosion.....		1,977,871		332,870			261,962	
47	Slight wind erosion—occasional gullies.....				2,510,905				
48	Slight wind erosion—frequent gullies.....				266,634			17,138	
247	Moderate sheet and slight wind erosion—occasional gullies.....				3,236,675			693,970	
248	Moderate sheet and slight wind erosion—frequent gullies.....				2,264,958			258,959	
347	Severe sheet and slight wind erosion—occasional gullies.....							434,044	
348	Severe sheet and slight wind erosion—frequent gullies.....				707				
5	Severe wind erosion.....		1,237,936		1,864,843			1,056,588	
23	Moderate sheet and severe wind erosion.....							368,503	
35	Severe sheet and severe wind erosion.....							142,171	
57	Severe wind erosion—occasional gullies.....				491,819				
58	Severe wind erosion—frequent gullies.....							106,265	
257	Moderate sheet and severe wind erosion—occasional gullies.....							314,099	
258	Moderate sheet and severe wind erosion—frequent gullies.....				742,900				
357	Severe sheet and severe wind erosion—occasional gullies.....		2,385,758					37,055	
358	Severe sheet and severe wind erosion—frequent gullies.....							38,261	
6	Very severe wind erosion.....		665,064		11,957			619,190	
57	Very severe wind erosion—occasional gullies.....							5,650	
58	Very severe wind erosion—frequent gullies.....							78,375	
W	Scablands, shallow soils—moderate sheet and wind erosion.....				331,990				
A	Mesa, canyons, bad lands, rough mountain land—erosion moderate to severe.....		6,020,500		1,704,223			1,185,350	
R	Barren mountain tops.....				130,894			906,315	
	Total ².....	857,533	31,815,597	11,451,187	56,423,904	9,007,767	8,562,469	42,741,645	6,108,674

Code no.	Erosion class—description	Sabine	Sacramento †	San Joaquin †	Santee	Savannah	Snake †	South Carolina coastal	South Mississippi
1	Little or no erosion.....	3,212,397	13,010,634	15,894,855	2,777,033	2,850,853	21,880,338	4,925,402	2,169,966
17	Slight sheet erosion—occasional gullies.....	1,506,590	437,217	110,967		94,050			5,181
2	Moderate sheet erosion.....	390,493	2,697,032	1,962,837	624,926	387,649	20,725	114,584	2,436,870
27	Moderate sheet erosion—occasional gullies.....	3,194,498	1,355,962	1,496,383	3,459,383	1,087,261	10,539,021		1,959,568
28	Moderate sheet erosion—frequent gullies.....	4,334,231		182,812	272,710	1,082	11,071,862		29,957
3	Severe sheet erosion.....			82,501		390			3,112
37	Severe sheet erosion—occasional gullies.....	17,814		19,928	1,374,856	1,225,044	2,394,154		182,116
38	Severe sheet erosion—frequent gullies.....	77,161		367,033	363,292	268,916	7,557,422		264,632

† Includes areas with undifferentiated geological erosion.
 ‡ Exclusive of large cities and water areas.

TABLE X.—Reconnaissance erosion survey of the United States by major watersheds. Areas within which more than 25 percent of the land has been affected as indicated—Continued

Code no.	Erosion class—description	Sabine	Sacramento ¹	San Joaquin ¹	Santees	Savannah	Snake ¹	South Carolina coastal	South Mississippi
9	Destroyed by gullying.....			254, 077	466, 077	243, 732			40, 070
24	Moderate sheet and slight wind erosion.....						419, 979		
247	Moderate sheet and slight wind erosion—occasional gullies.....						5, 012, 243		
347	Severe sheet and slight wind erosion—occasional gullies.....						2, 852, 068		
348	Severe sheet and slight wind erosion—frequent gullies.....						221, 490		
5	Severe wind erosion.....			45, 435					
25	Moderate sheet and severe wind erosion.....						653, 695		
257	Moderate sheet and severe wind erosion—occasional gullies.....						2, 188		
5	Very severe wind erosion.....			47, 429			465, 014		
W	Scablands, shallow soils—moderate sheet and wind erosion.....						5, 668, 603		
A	Mesas, canyons, bad lands, rough mountain land—erosion moderate to severe.....			40, 254			330, 872		
R	Barren mountain tops.....						77, 718		
	Total.....	12, 726, 244	17, 508, 975	20, 630, 464	9, 676, 290	7, 095, 565	69, 190, 128	5, 039, 936	7, 031, 492

Code no.	Erosion class—description	Southern Texas	Southwest Desert ¹	St. Lawrence	Susquehanna	Tennessee	Tombigbee	Trinity	Upper Columbia ¹
1	Little or no erosion.....	17, 056, 455		61, 827, 202	8, 753, 885	5, 163, 607	2, 983, 391	2, 088, 065	13, 387, 280
17	Slight sheet erosion—occasional gullies.....	151, 160	369, 463	1, 028, 354	45, 834	4, 673, 015	113, 986	1, 085, 626	80, 110
18	Slight sheet erosion—frequent gullies.....		464, 246	181, 539			1, 196		
2	Moderate sheet erosion.....	412, 779	5, 820, 915	4, 054, 978	1, 822, 203	1, 768, 650	971, 674	1, 844, 062	
27	Moderate sheet erosion—occasional gullies.....	5, 443, 881	7, 174	5, 540, 501	4, 203, 569	5, 700, 259	4, 917, 093	4, 260, 197	8, 290, 085
28	Moderate sheet erosion—frequent gullies.....	822, 020	275, 004	245, 771	189, 315	334, 778	649, 706	1, 747, 882	3, 850, 402
3	Severe sheet erosion.....		69, 747	88, 579	830, 314		367, 492	49, 556	
37	Severe sheet erosion—occasional gullies.....	841, 085		91, 224	135, 510	6, 263, 717	1, 666, 082	292, 916	876, 975
38	Severe sheet erosion—frequent gullies.....	361, 981	2, 180, 501	38, 927	41, 450	1, 128, 732	583, 691	630, 335	51, 812
9	Destroyed by gullying.....			5, 580			21, 787	49, 329	
4	Slight wind erosion.....			2, 586, 863					
24	Moderate sheet and slight wind erosion.....			372, 631					516, 539
247	Moderate sheet and slight wind erosion—occasional gullies.....		230, 365	15, 162					
248	Moderate sheet and slight wind erosion—frequent gullies.....		602, 218						1, 141, 249
5	Severe wind erosion.....		1, 510, 628	1, 057, 461					
25	Moderate sheet and severe wind erosion.....			134, 314	15, 145				928, 637
257	Moderate sheet and severe wind erosion—occasional gullies.....			88, 479					
258	Moderate sheet and severe wind erosion—frequent gullies.....		165, 401	4, 384					
6	Very severe wind erosion.....			71, 258					2, 119, 920
W	Scablands, shallow soils—moderate sheet and wind erosion.....								2, 626, 500
A	Mesas, canyons, bad lands, rough mountain land—erosion moderate to severe.....	1, 793, 805	1, 579, 478						
R	Barren mountain tops.....								1, 019, 244
	Total.....	27, 482, 156	7, 492, 867	79, 871, 818	17, 537, 063	25, 772, 917	13, 103, 294	11, 265, 074	36, 932, 992

Code no.	Erosion class—description	Upper Mississippi	Upper Rio Grande ¹	Virginia-Maryland-Delaware Coastal	Virginia Coastal	Wabash	West Coast Rivers North	West Coast Rivers South	West Florida
1	Little or no erosion.....	32, 305, 301	942, 427	664, 356	2, 067, 308	13, 368, 336	16, 143, 113	4, 291, 192	22, 484, 256
17	Slight sheet erosion—occasional gullies.....	1, 342, 599	6, 478, 505				229, 966	70, 146	
18	Slight sheet erosion—frequent gullies.....	7, 135	636, 894				69, 249		
2	Moderate sheet erosion.....	2, 991, 524	355, 198	194, 498	1, 431, 674	875, 516	5, 987, 112	1, 022, 996	
27	Moderate sheet erosion—occasional gullies.....	13, 786, 484		1, 361, 968	4, 337, 917	2, 636, 426	3, 239, 909	1, 445, 596	
28	Moderate sheet erosion—frequent gullies.....	7, 129, 237	4, 243, 055	970, 544		333, 900	612, 180	30, 291	
3	Severe sheet erosion.....		578, 196				15, 145	299, 261	
36	Severe sheet erosion—occasional gullies.....	29, 232	295, 155		39, 599	38, 877	172, 176	155, 335	
37	Severe sheet erosion—frequent gullies.....	954, 643	6, 458, 628			722, 628	625, 668	664, 285	2, 790
9	Destroyed by gullying.....						260, 639	69, 784	
4	Slight wind erosion.....	5, 818, 917	17, 421					25, 109	
47	Slight wind erosion—occasional gullies.....	15, 136	860, 831						
48	Slight wind erosion—frequent gullies.....	21, 801	354, 715					7, 971	
247	Moderate sheet and slight wind erosion—occasional gullies.....	184, 531							
248	Moderate sheet and slight wind erosion—frequent gullies.....	12, 754							
347	Severe sheet and slight wind erosion—occasional gullies.....		122, 439						
5	Severe wind erosion.....	3, 033, 985	543, 631				1, 968	13, 166	
25	Moderate sheet and severe wind erosion.....	13, 949	1, 340, 743						
257	Moderate sheet and severe wind erosion—occasional gullies.....	13, 543							
258	Moderate sheet and severe wind erosion—frequent gullies.....		381, 019						
6	Very severe wind erosion.....	10, 761	128, 335				19, 131	81, 884	
A	Mesas, canyons, bad lands, rough mountain land—erosion moderate to severe.....	3, 065, 791	332, 793						
R	Barren mountain tops.....						50, 617		
	Total.....	72, 663, 552	29, 785, 455	664, 356	3, 662, 230	20, 868, 715	21, 772, 126	15, 615, 365	24, 958, 968

Code no.	Erosion class—description	West Louisiana	White	Williamette ¹	Winnipeg	Wisconsin	Yakima ¹	Yellowstone ¹
1	Little or no erosion.....	4, 452, 670	4, 078, 637	4, 624, 848	11, 626, 798	3, 225, 942	1, 058, 545	6, 035, 750
17	Slight sheet erosion—occasional gullies.....	678, 343	6, 547, 493	49, 820	8, 768	313, 929		1, 491, 821
2	Moderate sheet erosion.....	25, 906	52, 809		533, 067			
27	Moderate sheet erosion—occasional gullies.....		5, 722, 729	1, 474, 260	740, 518	761, 383	1, 525, 278	5, 855, 568
28	Moderate sheet erosion—frequent gullies.....		678, 064	375, 628	12, 754	1, 518, 912	35, 936	9, 266, 444

¹ Includes areas with undifferentiated geological erosion.

² Exclusive of large cities and water areas.

TABLE X.—Reconnaissance erosion survey of the United States by major watersheds. Areas within which more than 25 percent of the land has been affected as indicated—Continued

Code no.	Erosion class—description	West Louisiana	White	Williamette ¹	Winnipeg	Wisconsin	Yakima ¹	Yellowstone ¹
27	Severe sheet erosion—occasional gullies		46,232	231,182				
38	Severe sheet erosion—frequent gullies		505,751					
9	Destroyed by gullying		48,624					
4	Slight wind erosion				18,861,310	184,314		1,104,591
24	Moderate sheet and slight wind erosion							359,669
47	Slight wind erosion—occasional gullies							1,230,407
247	Moderate sheet and slight wind erosion—occasional gullies				16,841		327,215	6,941,559
248	Moderate sheet and slight wind erosion—frequent gullies						223,192	4,017,540
5	Severe wind erosion				5,782,051	858,153		
257	Moderate sheet and severe wind erosion—occasional gullies						304,895	
258	Moderate sheet and severe wind erosion—frequent gullies						18,732	
6	Very severe wind erosion				86,885		209,242	
W	Scablands, shallow soils—moderate sheet and wind erosion						90,074	
A	Mesa, canyons, bad lands, rough mountain land—erosion moderate to severe							5,177,173
R	Barren mountain tops			30,058			31,584	273,397
	Total ¹	5,156,919	17,678,469	6,797,774	37,939,692	7,563,085	3,842,880	44,676,927

¹ Includes areas with undifferentiated geological erosion.² Exclusive of large cities and water areas.

SECTION VI

EROSION CONTROL DEMONSTRATION ON A NATIONAL SCALE

Any effective erosion-control program must involve a reduction of the soil transporting power of meteoric waters by the use of practical methods of land treatment which will so reduce the rate of off flowage as to cause a large proportion of the rain water to sink into the ground at or near where it falls. These practical measures will be, principally, (1) various adaptations of thick-growing vegetation to practical farm operations, (2) use of engineering structures and mechanical devices where applicable, and (3) retirement of excessively erosive land from cultivation.

The wasteful process cannot be minimized in any large measure by the use of any single unsupported method of combat. Effective accomplishment can be achieved only through the use of all applicable measures, such as correct cropping and beneficial rotations, engineering aids, land retirement, and pasture and forestry methods, employed in programs so coordinated and applied as to meet the specific requirements and adaptabilities of the diverse soils and slopes. There is an abundance of empiric and experimental information to show that any other method of procedure must inevitably lead to only partial success or complete failure. No other plan will meet the requirements of a program to safeguard soil and water resources for this and future generations.

General Methods of Procedure

In order to carry through practical regional programs of correct land utilization embodying a coordinated plan for erosion control procedure, such as must be employed to bring about maximum results in control of soil erosion, flood reduction, and needed reorganized farm practice, the Soil Conservation Service has put into effect a plan of operation on demonstration areas selected in regions throughout the United States where the risk of erosion wastage is high. (See fig. 12, soil erosion control projects.) Most of the work is being carried out on the watershed method of treatment. Though predicated upon a unified method of attack, it is sufficiently flexible in working details to permit adjustment in every important step, not only to the requirements and adaptabilities of different kinds of land, as determined by soil, slope, rainfall, and type of agriculture, but to those conditions permitting necessary coordination with the broader regional requirements of land use. The procedure being followed on

these projects involves the following major steps of surveys, cooperative agreements, and field work:

Surveys.—A good aerial photographic map is made of the entire working area, such as can be enlarged to convenient scales for field use. Erosion surveys and other surveys are then made contemporaneously of all the land, the individual farm constituting the working unit, as a rule. First, those farms are taken up where the operators agree to cooperate in the program of the Soil Conservation Service.

These surveys show the distribution, by fields, of the soils, the slope gradients, and the different degrees of erosion by classes, as well as the susceptibility of the cultivated, idle, forested, and grassed areas to future erosion. Where necessary the condition of the soil with respect to acidity or alkalinity is shown also. The maps show the lay-out of fields, and the location of fences, wooded areas, and streams. With these physical facts in usable form, a practical farm plan is prepared in conference with the farmer for putting into effect the major control measures of soil conservation. Each farm within the watershed is carefully gone over by the erosion and cropping specialists, in company with the farmer, and working plans for stabilizing all eroding areas are cooperatively developed on the ground. (See figs. 13 to 17.) The completed plan, involving usually considerable reorganization of fields, is incorporated in a cooperative contract with the farmer, in which he agrees to contribute in labor, equipment, and materials, 30 to 50 percent of the total cost of the work and to maintain the prescribed practices and structures for a period of 5 years.

Field Work.—Following this, the actual work of strip cropping, terracing, scarification of the land, discontinuous furrowing, rearrangement of fence lines and fields to permit contour cultivation and the practice of crop rotations, seeding, liming, fertilizing, and other necessary farm procedures are put into effect under the supervision of the best trained specialists obtainable. Skilled foresters proceed with the task of planting the steeper and more erosive lands eliminated from cultivation with the most adaptable species of trees. Plans for practical fire control and prevention of overgrazing are also worked out and put into effect. Where game possibilities are of any promise, specialists in this field prepare and put into operation programs for developing such wildlife as may afford the farmer some opportunity for selling hunting privileges, this work

being emphasized only where the methods of game rehabilitation involves the planting of soil-saving plants. Other especially vulnerable areas are seeded to such thick-growing, soil-conserving crops as grass, clover, Lespedeza, and sorghum.

Land which has been hopelessly eroded in some instances will be left to revegetate naturally to volunteer species. In some cases the recuperation of such areas will be quite rapid with the aid of effective fire protection; in other instances regulation of grazing will suffice to speed recovery. There are many badly eroded areas requiring special treatment in the form of check-dams built of local materials and supported by planting of trees, grasses, and vines adapted to gully conditions. It has been possible, for example, to obtain quick and complete control of rapidly expanding gullies in the central prairie States by the planting of black locust. In other instances gullies of lesser magnitude have been effectively and cheaply controlled by placing across them old fertilizer sacks filled with the seed or roots of adaptable grasses. The grasses puncture the sacks and rapidly take hold of the ground, establishing generally such effective barriers to further washing as almost completely to obliterate the effects of gully erosion.

It is recognized, however, that even after every gully in the country may have been closed, the major problem of erosion control will still stand out ahead—that of the sheet washing which takes place in every sloping cultivated field with every rain heavy enough to cause water to run across it. Sheet erosion constitutes the major problem, by reason of its extensiveness, deceptiveness, and difficulty of control.

In the Palouse Wheat Belt of Washington, Oregon, and Idaho, for example, approximately 25 percent of the land now used for wheat on the majority of the farms is being taken out of this crop, wherever the operator can be brought to see the logic of such procedure; these acutely vulnerable portions of the farm are planted to such soil-saving crops as grass, alfalfa, and sweet clover that are known to be highly effective in controlling run-off and erosion. So long as a good growth of wheat is on the ground the land is not subject to serious erosion, but the Palouse type of farming, as it has been practiced to the present time, calls for summer fallowing of approximately one-half of the crop area. Summer fallowing is a good practice on gently sloping or flat land, provided the soil is not of the kind that suffers disastrously from blowing; but this practice as it relates to the steeper slopes of the Palouse country, as well as to other parts of the Wheat Belt, probably represents the best possible procedure for putting the ground into the most favorable condition for disastrous washing.

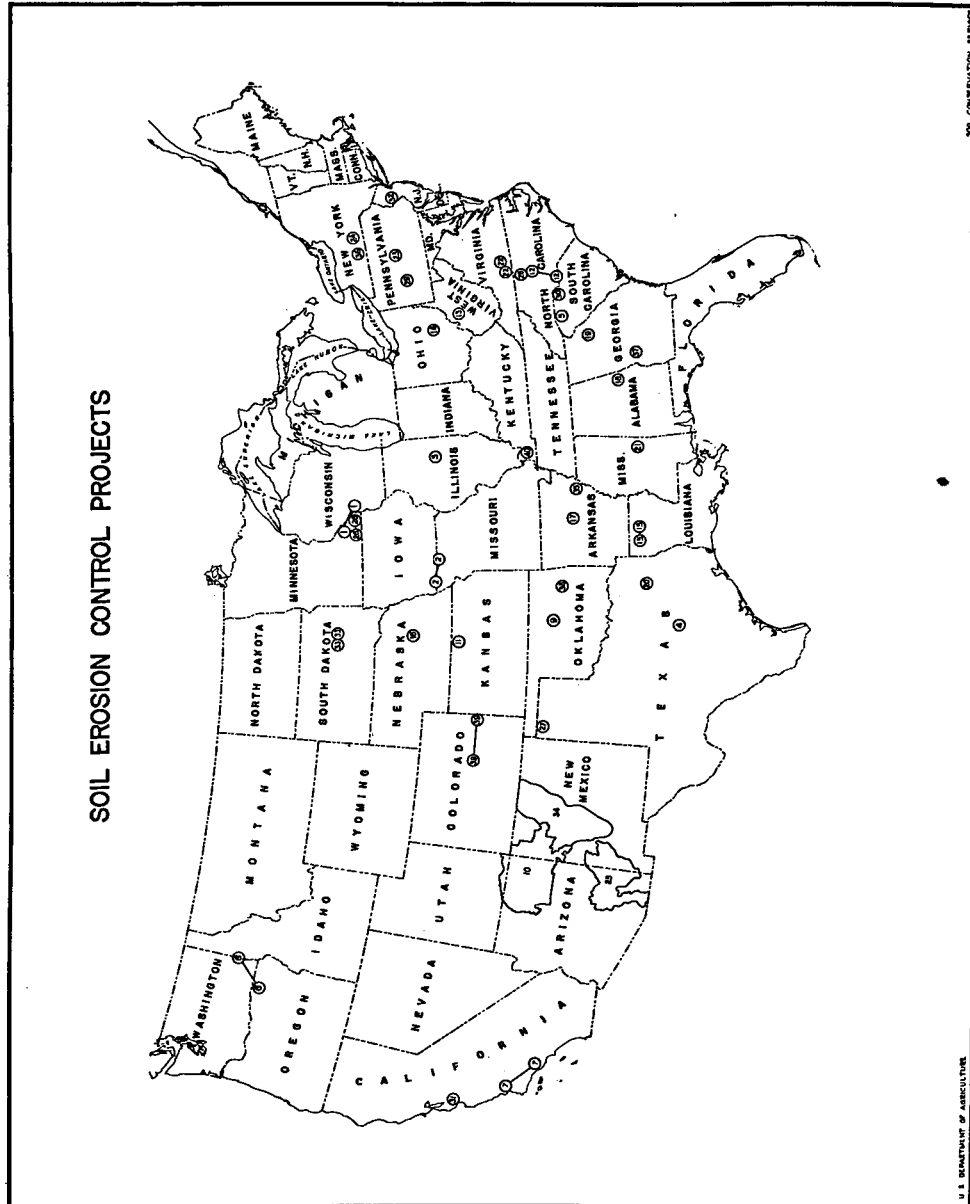
On the erosion project of the Soil Conservation Service in Washington and Idaho, the Palouse wheat growers

have accepted the plan for eliminating approximately 25 percent of their steeper slopes, to the extent of 90 percent of all operators. This is an outstanding instance of the progress that is being made with the erosion-control program now in operation.

In the grazing regions of the West and Southwest, where erosion and run-off have been enormously speeded up through destructive practices of overgrazing, the first essential step to procure any reasonable measure of permanent recovery is the regulation of grazing. Without this not much can be achieved; but with it much can be accomplished. At the present time a characteristic of the alluvial plains of the dry Southwest is the presence of rapidly expanding arroyos. These are cutting out the rich accumulations of the ages at a rate which means that most of this fine soil will be swept down into the reservoirs and stream channels, or away to the sea, within a few more generations. Continuation of such disastrous land wastage certainly will doom civilization over large areas dependent on agriculture.

Already some of the valleys, originally richly clothed with valuable grass and herbaceous cover, and unbroken by arroyos, have been completely gutted from the foot of the hills on one side to the foot of the hills on the other side; and in the wake of such devastation there remains no vegetation of any important grazing value. Not only this, but the uplands over a tremendous total area have been stripped of the surface soil and frequently of the subsoil down to hard rock. Over many large areas it is impossible to find enough of the original soil left to determine the virgin profile. Drifting sand dunes are developing within these afflicted areas—meaning the gradual conversion of former valuable land into desert wastes.

Control under these conditions of dislocated balance between the soil and a stabilizing cover of vegetation calls for reduction of the number of livestock permitted to graze a given area, and, in some instances, even the complete elimination of grazing for awhile. This will give some recuperation of herbaceous forage. Additional necessary work will be reseeding of those plants that have been largely or completely eliminated by poor range management, and the introduction of new species that show any real promise under the varying environmental conditions. There is no question whatsoever but that effective erosion control can be brought about along just such lines as the above. Once an area has been restocked with a reasonable cover, experiments have shown that a certain degree of grazing can be carried on without interrupting the forward march of vegetative recovery. There is no other possibility of accomplishing anything worth while in the way of reduced run-off, sedimentation, and erosion in this great region. The Soil Conservation Service is now engaged in a coordinated plan of this kind on



U.S. DEPARTMENT OF AGRICULTURE

FIGURE 12

SOIL CONSERVATION SERVICE

Soil-erosion control projects shown on map on opposite page

Project no.	Name of project	Regional director	Office location	Approximate acres
1	Coon Creek	R. H. Davis	La Crosse, Wis.	93,000
	Gilmore Creek, Minn.			6,500
2	Big Creek	R. F. Uhlend	Bethany, Mo.	186,000
	West Tarkio Creek	F. A. Fisher	Urbana, Ill.	106,000
3	Saugamon River	H. V. Geib	Temple, Tex.	133,000
4	Elm Creek	T. S. Bule	Spartanburg, S. C.	207,000
5	South Tyger River			111,000
6	South Palouse River	W. A. Rockle	Pullman, Wash.	98,000
	Wildhorse Creek, Oreg.			32,000
7	Arroyo Las Posas	H. E. Reddick	Santa Pauls, Calif.	45,000
8	Arroyo Grande	N. E. Winters	Stillwater, Okla.	10,000
9	Stillwater Creek	H. G. Calkins	Albuquerque, N. Mex.	177,000
10	Navajo			16,000,000
11	Limestone Creek	F. L. Duley	Mankato, Kans.	114,000
12	Deep River	J. H. Stallings	High Point, N. C.	138,000
13	Brown Creek	J. S. Cutler, acting	Spencer, W. Va.	93,000
14	Reedy Creek	J. S. Cutler	Zanesville, Ohio	87,000
15	Salt Creek	H. M. Mims, acting	Minden, La.	93,000
16	Cocoy and Brushy Creeks	R. L. von Trebra	Albion, Neb.	55,000
17	Cypress Creek	F. B. Howe	Conway, Ark.	45,000
18	Elum Creek	R. Y. Bailey	Dadeville, Ala.	118,000
19	East Cadron Creek	L. E. Rast	Athens, Ga.	116,000
20	Buck and Sandy Creeks	L. P. Merrill	Lindale, Tex.	107,000
21	Duck Creek	C. B. Anders	Meridian, Miss.	28,000
22	Okatibbea River	P. F. Kell	Chatham, Va.	144,000
23	Banister River	A. L. Patrick	State College, Pa.	149,000
24	Sandy River	B. P. Fleming	Ithaca, N. Y.	26,000
25	Soil erosion survey			
26	Gila River		Safford, Ariz.	11,520,000
27	Root River, Minn.			
	Deer and Bear Creeks	R. H. Davis	La Crosse, Wis.	151,000
	Beaver Creek			34,000
28	Dalhart area	H. H. Fennell	Dalhart, Tex.	48,000
29	Reedy Fork	J. H. Stallings	Greensboro, N. C.	45,000
30	Crooked Creek	A. L. Patrick	Indiana, Pa.	135,000
31	Fishing Creek	T. S. Bule	Rock Hill, S. C.	52,000
32	Carrizosa Creek	H. E. Reddick	Watsonville, Calif.	68,000
	Baritan River			
	Neshanic River	L. L. Lee	New Brunswick, N. J.	37,000
33	Shus Creek	H. J. Clemmer	Huron, S. Dak.	144,000
34	Wolsey area	H. G. Calkins	Albuquerque, N. Mex.	45,500
	Rio Grande			15,968,000
35	Crowleys Ridge	F. O. Newport	Forrest City, Ark.	32,000
36	Cohocton River	F. B. Howe	Ithaca, N. Y.	150,000
37	Muckalee Creek	L. E. Rast	Americus, Ga.	59,500
38	Pecan Creek	N. E. Winters	Muskogee, Okla.	37,000
39	Black Squirrel Creek	A. E. McClymonds	Colorado Springs, Colo.	150,000
40	Smoky Hill River			150,000
	Massac Creek	H. W. Alberts	Paduash, Ky.	27,000

16 million acres comprised in the Navajo, Hopi, and Zuni Reservations in Arizona, New Mexico, and Utah, and is getting under way other large projects in the western grazing country, where not only the ranges are being depleted and destroyed, but valuable irrigated and irrigable valley lands are being ripped out and reservoirs and irrigation ditches are being filled with the products of erosion.

Local Forests

There is splendid opportunity to expand the erosion projects, in connection with retirement of submarginal areas from production and the rehabilitation of scantily forested abandoned areas, as those in many parts of the Virginia-Carolina-Georgia-Alabama Piedmont country. The larger, more compact areas of such eroded and erosive lands may be effectively handled by inclusion in national forests. The smaller farm tracts can best be handled as an individual farm project; but between these extremes there are numerous areas that

offer opportunity for worth-while development upon some suitable community, county, State, or town basis. Many of the tracts certainly could be brought up rather speedily to a condition of productivity that would cover all interest requirements, and with good management would pay dividends.

Cooperation

The closest kind of cooperation between land users and erosion-control specialists is necessary for the success of any of this soil-saving and water-control work. Thus far the farmers, and even the Indians of the Navajo Reservation, are giving splendid cooperation. From 70 to about 100 percent of the farmers of the various regions have agreed to go squarely along with the regional programs now being rushed by the Soil Conservation Service. Cooperation with State colleges of Agriculture, experiment stations, and extension services is in effect in all field operations, and must be closely maintained at all times.

The projects of the Soil Conservation Service are largely demonstrational, but it has been found necessary to carry on a certain amount of experimental work in some of those regions where no effort has ever been made to determine, for example, at what declivity plowing should cease and the planting of permanent soil-saving crops should begin, or how much grazing the different slope declivities of the different major soil types will withstand. Plans have been worked out for procuring this vitally necessary fundamental information with the greatest possible speed. Additional information about erosion control and increased absorption of rainfall is being accumulated as the demonstrational work advances. In that each watershed project will show how a complete job of surface treatment for erosion control will affect the flood and silting problem, each project is necessarily of an experimental nature and represents the first experiment of the kind carried out in America.

After all is said, it is erosion that constitutes the real American crisis in land use. The step that inevitably must be taken to control devastating erosion, and the causative process of speeded-up run-off, is the application of a coordinated land-use program fitted to the specific needs and adaptabilities of every acre of land within watershed areas.

Extension

If this demonstrational and experimental work can be successfully put through, the educational effect will be far-reaching. Already the projects have met with such strong local approval that groups of farmers, backed by local and State organizations and business men, are appealing for the establishment of new projects in every part of the country. For example, farmers

outside the Washington-Idaho project are clamoring for admission into the program, as they are also on the other projects. Insurance companies having numerous farms on their hands have requested the Soil Conservation Service to come on their lands and carry out the same kind of rehabilitation and protective work as that of the watershed projects at the expense of the company.

It seems scarcely necessary to add that whatever our inclinations may be, whatever opinions, conclusions, or complexities our academic discussions may lead us to, here 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- and water-control 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 Conservation Service. 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.

Conditions of Erosion and Corrective Treatment

Figures 13, 14, 15, 16, and 17 and table XI show the conditions and distribution of erosion on representative areas selected in scattered sections of the United States on watershed project areas of the Soil Conservation Service. They show also the treatments adopted to check the activity of the various kinds of erosion. These treatments embody reorganized land-use practices with the objective of land and moisture conservation. Certain mechanical structures have been necessitated in this conservation program to assist in the control of certain kinds of erosion, but these have been built to assist in initiation of vegetative means of control.

First are shown maps of five individual farms from different sections of the country showing the results of a detailed erosion survey which depicts the condition of erosion, the kind of soil, the topography, and the land use, together with the corrective treatment adopted to meet the specific conditions encountered (figs. 13, 14, 15, 16, and 17).

Following these detailed farm surveys is a table showing the acreages affected by different degrees of

erosion and the acreages of the various corrective treatments adopted from a group of representative farms from 15 regions of the country (table XI).

Finally, a summary table is given showing the total acreages of all corrective measures applied on cooperating farms by the Soil Conservation Service to February 28, 1935 (table XII).

Farm Reorganization Maps

The program of farm reorganization adopted by the Soil Conservation Service to insure efficient soil and moisture conservation is based on an inventory and study of actual conditions on each individual farm. Such an inventory is made by actual survey of each farm, showing for each field the condition of erosion in its relationship to degree of slope, kind of soil, and previous land use. These surveys are made on aerial base maps at a scale of about 1 inch to 500 feet. Individual farm reorganization is then made in cooperation with the farmer to correct the causes of conditions shown by the initial survey and to put the land to the use to which it is best adapted in its existent condition, taking into consideration the kind of soil and its condition of erosion.

Reorganization of the farm consists first in rearranging fields so as to permit the most efficient and economic handling for the conservation of the soils. As an example, on one of the farms shown the number of fields has been reduced from 18 to 9. Further steps provide for the taking out of cultivation of land wholly unsafe for cultivation by reason of steepness of slope, high erosivity of soil, or present eroded condition. These lands are seeded down or planted to trees for establishing permanent erosion control cover. The land to remain in cultivation is accorded treatment necessary to establish erosion control in each individual field, putting the entire farm under a permanent erosion-control and soil-conservation program. This is set up with a definite cropping and treatment program, to which the farmer agrees under a specific cooperative agreement with the Soil Conservation Service to carry out in detail for a 5-year period. The treatments used on these farms are fundamental practices which have been proven in actual use to be economically sound and efficient. These practices for establishing permanent erosion control and soil conservation include such procedures as strip cropping or the growing of alternate bands of clean-tilled crops and small grain, grass, or forage, usually leaving the clean-tilled crops on the same strip for only 1 year. Balanced rotations are worked out which will adequately control erosion, supply necessary legumes for soil building, and furnish the farm with needed cash and feed crops. Field terraces are constructed where necessary to aid in erosion control and conservation of moisture. Diversion terraces are installed to prevent the destructive

FIGURE 17

SOUTHEASTERN OHIO SALT CREEK PROJECT

REPRESENTATIVE FARM - MUSKINGUM COUNTY, OHIO - 150 ACRES

SCALE
0 250 500 750 1000 FT.

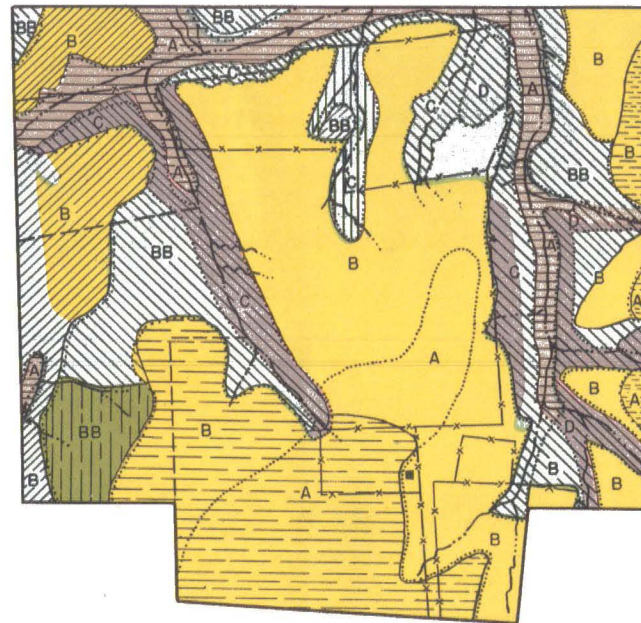


FIGURE - 17A

PHYSICAL CONDITION OF LAND

LEGEND

- | | |
|-------------------------|-----------------------|
| No apparent erosion. | Wellston Silt Loam. |
| Slight sheet erosion. | Pope Silt Loam. |
| Moderate sheet erosion. | Zanesville Silt Loam. |
| Severe sheet erosion. | Muskingum Loam. |
| | Muskingum Silt Loam. |
| | Holston Silt Loam. |
| | Atkins Silt Loam. |

- | |
|------------------|
| A 0% to 5% slope |
| B 5% to 12% " |
| BB 12% to 20% " |
| C 20% to 30% " |
| D Over 30% " |

- | |
|--------------------------|
| Streams. |
| Gullies. |
| Fences. |
| Field Boundaries. |
| Slope Boundaries. |
| Soil Boundaries. |
| Farm Buildings and Lots. |



FIGURE - 17B

PRECEDING LAND USE

LEGEND

- | | | |
|----------------------|----------------------|---------------------------|
| Clean Tilled Crops | Fences | 1 No apparent erosion |
| Close Growing Crops | Streams | 2 Slight sheet erosion |
| Hay and Legume Crops | Gullies | 3 Moderate sheet erosion |
| Pasture | Field Boundaries | 37 Moderate sheet erosion |
| Woods | Erosion Boundaries | 4 Severe sheet erosion |
| | Farm Building & Lots | |

CONDITION OF FARM BEFORE COOPERATION WITH SOIL CONSERVATION SERVICE

- 1 - Farm 150 Acres. Crop land 94 Acres.
- 2 - Sheet erosion serious, 1/4 to all top soils removed on 41% of entire farm.
- 3 - Poor pastures.
- 4 - Gullies serious.
- 5 - Small eroded area unsuited for cropping, 6 Acres.
- 6 - Unorganized farm plan.

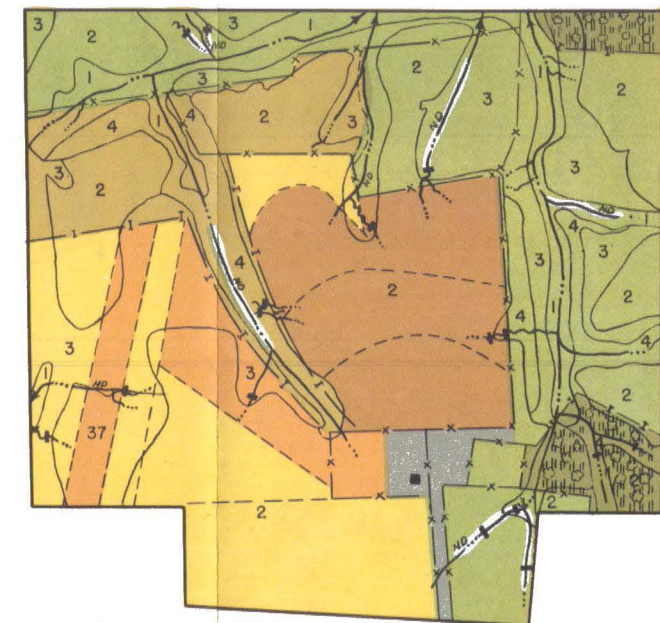


FIGURE - 17C

REORGANIZED LAND USE

LEGEND

- | | |
|----------------------|-------------------------|
| Clean Tilled Crops | Farm Buildings and Lots |
| Close Growing Crops | Gullies |
| Hay and Legume Crops | Old Fences |
| New Pasture | Relocated Fences |
| Strip Cropping | Check Dams |
| New Tree Plantings | Field Boundaries |
| ND New Seedings | |
| Old Pasture | |

REORGANIZED FARM

- 1 - Farm 150 Acres. Crop land 62 Acres. Retired from cultivation 32 Acres.
- 2 - Sheet erosion controlled on entire farm by strip cropping 48A, crop rotation 62A; 76% cultivated land in small grain, hay and legumes; 3A permanent meadows.
- 3 - Old pastures treated. 23A, previously cultivated, retired to pasture.
- 4 - Gullies controlled with structures, by seeding, tree and shrub plantings.
- 5 - Planted to trees, 6 Acres.
- 6 - Reorganized plan: Fields rearranged, fences relocated, balanced cropping system, giving erosion control.

SOUTHEASTERN

OHIO

REPRESENTATIVE FARM - M

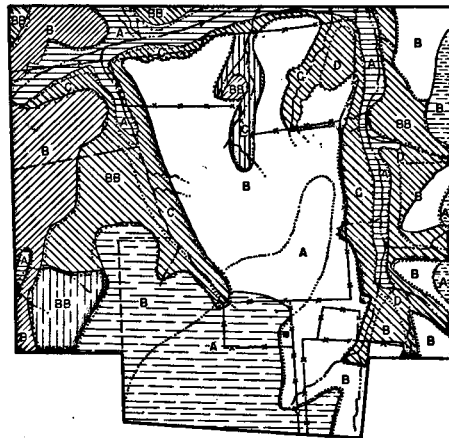
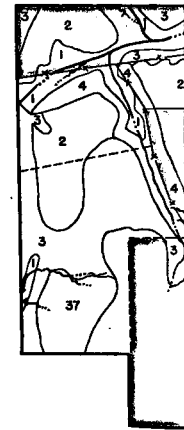


FIGURE - 17A



PHYSICAL CONDITION OF LAND

PRECEDES

LEGEND

- | | | | |
|--|--|--|---|
| <ul style="list-style-type: none"> No apparent erosion. Slight sheet erosion. Moderate sheet erosion. Moderate sheet erosion and occasional shallow gullies. Severe sheet erosion. | <ul style="list-style-type: none"> Wellston Silt Loam. Pope Silt Loam. Zanesville Silt Loam. Muskingum Loam. Muskingum Silt Loam. Holston Silt Loam. Atkins Silt Loam. | <ul style="list-style-type: none"> Clean Tilled Crops Close Growing Crops Hay and Legume Crops Pasture Woods | <ul style="list-style-type: none"> Fences Streams Gullies Field Boundaries. Slope Boundaries. Soil Boundaries. Farm Buildings and Lots. |
|--|--|--|---|
-
- | | |
|---|--|
| <ul style="list-style-type: none"> A 0% to 5% slope B 5% to 12% " BB 12% to 20% " C 20% to 30% " D Over 30% " | <ul style="list-style-type: none"> Streams. Gullies. Fences. Field Boundaries. Slope Boundaries. Soil Boundaries. Farm Buildings and Lots. |
|---|--|
-
- | |
|--|
| <h3>CONDITION OF COOPERATION WITH SOIL</h3> <ul style="list-style-type: none"> 1 - Farm 150 Acres. Crop land 2 - Sheet erosion serious, 1/4 to 1/2 3 - Poor pastures. 4 - Gullies serious. 5 - Small eroded area unsuited 6 - Unorganized farm plan. |
|--|

NORTH CENTRAL MISSOURI AND SOUTH CENTRAL IOWA ~ BIG CREEK PROJECT

REPRESENTATIVE FARM - HARRISON COUNTY, MISSOURI - 242 ACRES

SCALE
0 400 800 1200 1600 FT.



FIGURE 13A

PHYSICAL CONDITION OF LAND

LEGEND

- | | |
|---|------------------|
| Little or no erosion | A 0% to 2% slope |
| Moderate sheet erosion | B 2% to 6% " |
| Moderately severe sheet erosion and occasional shallow gullies. | C 6% to 10% " |
| Severe sheet erosion with severe gully. | CC 10% to 15% " |
| | D Over 15% " |

- | | |
|------------------|-------------------------|
| Grundy Silt Loam | Deep Gullies |
| Shelby Loam | Shallow Gullies |
| Lindley Loam | Lakes and Ponds |
| | Fences |
| | Slope boundaries |
| | Farm Buildings and Lots |
| | Soil Boundaries |

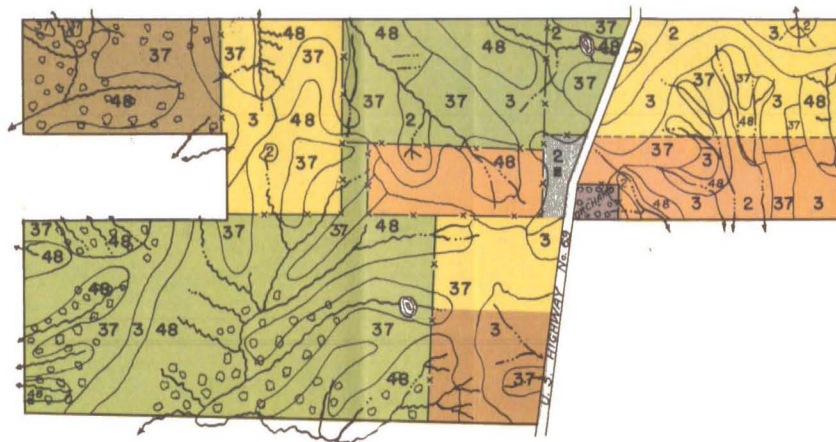


FIGURE 13B

PRECEDING LAND USE

LEGEND

- | | |
|----------------------|-------------------------|
| Clean Tilled Crops | Fences |
| Close Growing Crops | Field boundaries |
| Hay and Legume Crops | Deep Gullies |
| Pasture | Shallow Gullies |
| Woods | Farm Buildings and Lots |
| Orchard | Erosion boundaries |
| | Lakes and Ponds |

CONDITION OF FARM BEFORE COOPERATION WITH SOIL CONSERVATION SERVICE

- 1 - Farm 242 Acres. 236.5 Acres have 4 inches to 16 inches of top soils removed.
- 2 - Sheet Erosion severe. Practically all top soils removed on 42% of area, leaving infertile yellow clay sub-soils exposed.
- 3 - Gullying serious; affects 73.9% of farm.
- 4 - Indefinite rotations.
- 5 - Poor pastures.
- 6 - Forest had dense under-brush.
- 7 - Unbalanced cropping plan induced soil destruction.

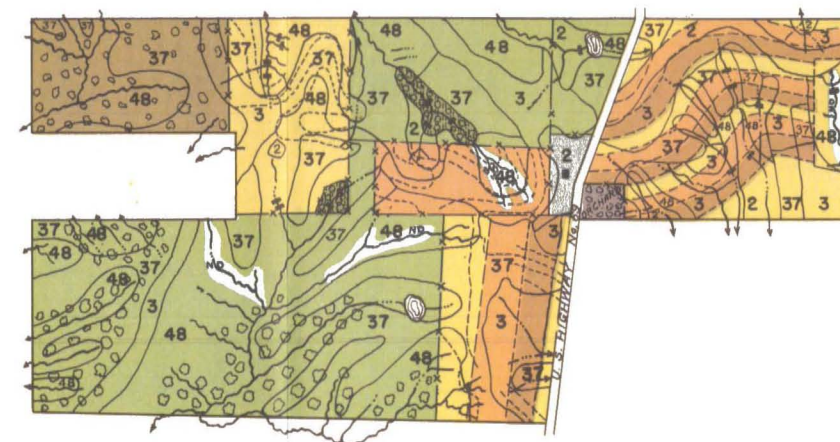


FIGURE 13C

REORGANIZED LAND USE

LEGEND

- | | | |
|--|----------------------|---------------------------|
| 2 Little or no erosion | Clean Tilled Crops | ND New Seedings |
| 3 Moderate sheet erosion | Close Growing Crops | New Tree Plantings |
| 37 Moderately severe sheet erosion and occasional shallow gullies. | Hay and Legume Crops | Strip Cropping boundaries |
| 48 Severe sheet erosion with severe gully. | Pasture | Improved type Terraces |
| | Woods | Check Dams |
| | Orchard | Farm Buildings and Lots |
| | | Lakes and Ponds |

REORGANIZED FARM

- 1 - Farm 242 Acres. Five year program adopted for soil building and conservation. 26 Acres retired from cultivation.
- 2 - Extensive strip cropping alone; terracing and strip cropping; contour furrowing used to control sheet erosion.
- 3 - All Gullies stabilized by check dams, seedings and tree plantings. Also diversion ditches and terraces.
- 4 - Definite rotation with legumes for soil building; fields in corn one year only.
- 5 - Pastures improved; grazing controlled.
- 6 - Forest thinned and protected.
- 7 - Balanced cropping plan provides adequate return.

NORTH CENTRAL MISSOURI AND SOUTH

REPRESENTATIVE FARM - HARD

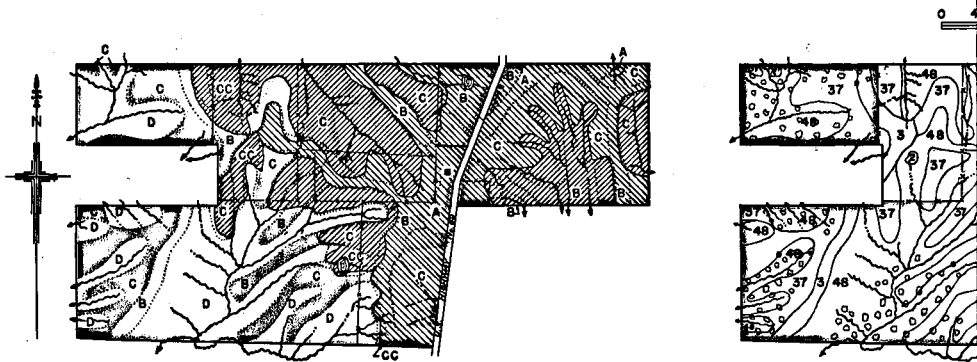


FIGURE 13A

PHYSICAL CONDITION OF LAND

PRECED

LEGEND

- | | |
|---|------------------|
| Little or no erosion | A 0% to 2% slope |
| Moderate sheet erosion | B 2% to 6% " |
| Moderately severe sheet erosion and occasional shallow gullies. | C 6% to 10% " |
| Severe sheet erosion with severe gullying. | CC 10% to 15% " |
| | D Over 15% " |

- | |
|----------------------|
| Clean Tilled Crops |
| Close Growing Crops |
| Hay and Legume Crops |
| Pasture |
| Woods |
| Orchard |

- | | |
|------------------|-------------------------|
| Grundy Silt Loam | Deep Gullies |
| Shelby Loam | Shallow Gullies |
| Lindley Loam | Lakes and Ponds |
| | Fences |
| | Slope boundaries |
| | Farm Buildings and Lots |
| | Soil Boundaries |

CONDITION COOPERATION WITH

- 1 - Farm 242 Acres. 236.5 soils removed.
- 2 - Sheet Erosion severe. Practice leaving infertile yellow clay.
- 3 - Gullying serious; affects 7.
- 4 - Indefinite rotations.
- 5 - Poor pastures.
- 6 - Forest had dense underbrush.
- 7 - Unbalanced cropping plan.

FIGURE 14

EAST CENTRAL NEBRASKA PLUM CREEK PROJECT

REPRESENTATIVE FARM - BOONE COUNTY, NEB. - 160 ACRES

SCALE
0 330 660 990 1320 FT.

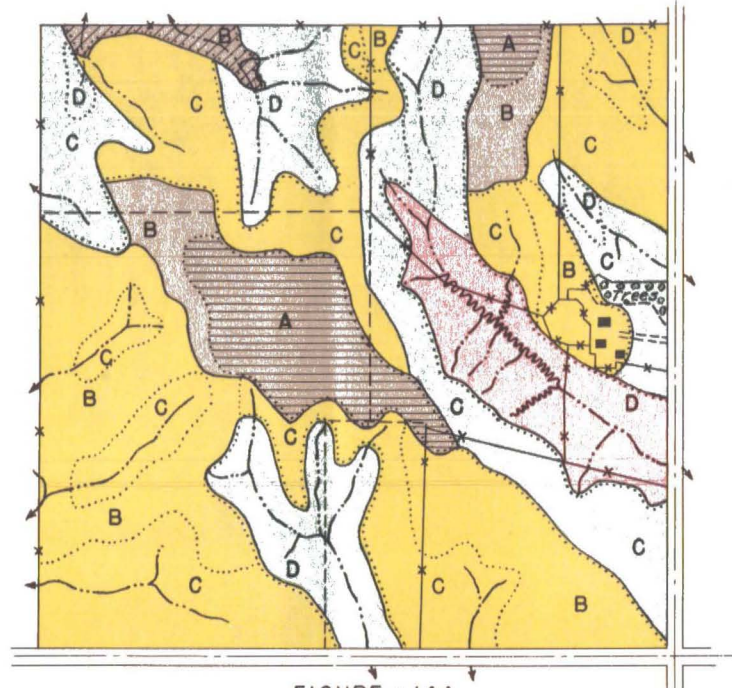


FIGURE - 14A

PHYSICAL CONDITION OF LAND

LEGEND

A 0% to 3% slope	Moody silt loam
B 3% to 8% "	Moody silt loam (Talus slope phase)
C 8% to 12% "	Hastings Silt loam
D Over 12% "	
No apparent erosion	Deep Gullies
Slight sheet erosion	Shallow Gullies
Moderate sheet erosion	Fences
Severe sheet erosion with severe gullying	Slope boundaries
	Erosion boundaries
	Field boundaries
	Farm Buildings and Lots

CONDITION OF FARM BEFORE COOPERATION WITH SOIL CONSERVATION SERVICE

- 1 - Farm 160 Acres. 153 acres in cultivation.
- 2 - Sheet erosion serious; 90% farm on 5% to 15% slope.
- 3 - Gullies severe; 74% of farm affected by gullies.
- 4 - Steeper slopes eroded and gullying.
- 5 - Large percentage highly erosive crops.
- 6 - Unbalanced crop rotation.

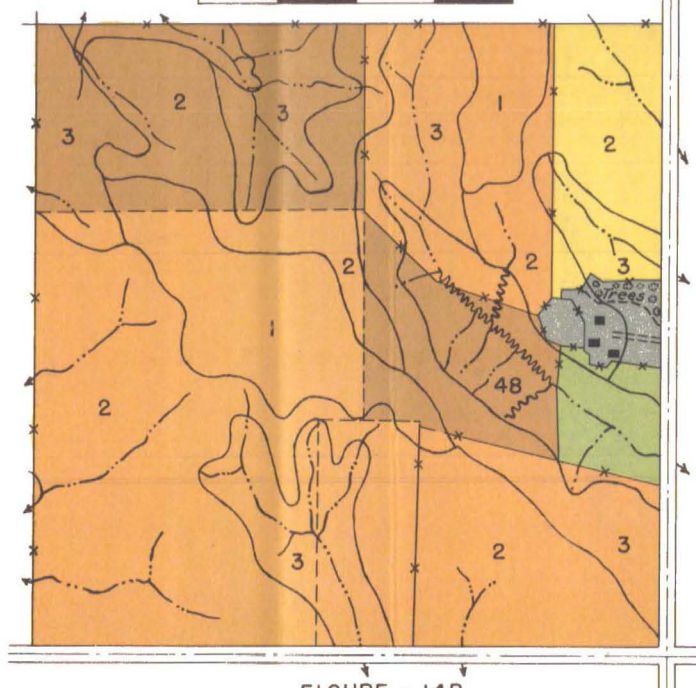


FIGURE - 14B

PRECEDING LAND USE

LEGEND

Clean tilled crops	Fences
Close growing crops	Field boundaries
Hay and Legume crops	Deep Gullies
Pasture	Shallow Gullies
	Erosion boundaries
	Farm Bldgs & Lots

- | | |
|---|--|
| 1 No apparent erosion | |
| 2 Slight sheet erosion | |
| 3 Moderate sheet erosion | |
| 48 Severe sheet erosion-severe gullying | |

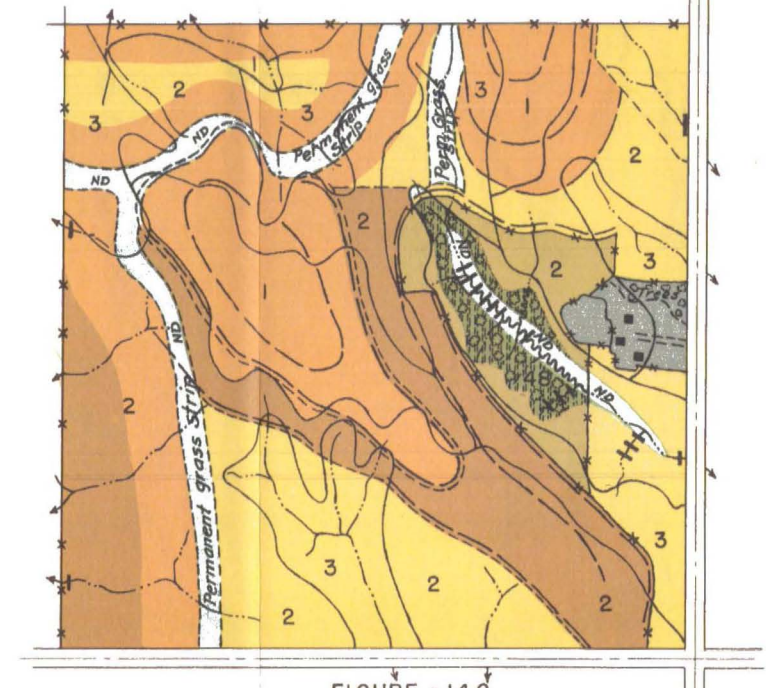


FIGURE - 14C

REORGANIZED LAND USE

LEGEND

Clean tilled crops	New Tree Plantings
Close growing crops	Farm Bldgs & Lots
Hay and Legume crops	Field Boundaries
Strip Cropping	Improved type terraces
New pasture	Check dams
ND New Seedings	Relocated fences

- | | |
|---|--|
| 1 No apparent erosion | |
| 2 Slight sheet erosion | |
| 3 Moderate sheet erosion | |
| 48 Severe sheet erosion-severe gullying | |

REORGANIZED FARM

- 1 - Farm 160 Acres. Loessial Soils; highly Erosive.
- 2 - Sheet erosion controlled by strip cropping, new type terraces, field stripping, contour furrowing and crop rotation.
- 3 - Gullies controlled by diversion ditches at heads, check and brush dams; grass seeded and trees planted in gullies and waterways. Gullies and steep slopes protected by diversion terraces, permanent grass strips.
- 4 - Seeded down; 51 acres retired from cultivation.
- 5 - Erosion resisting crops increased by 61 acres. 36 acres seeded to alfalfa.
- 6 - Rotation balanced, providing adequate forage and grain crops, cropping system reorganized; field fences relocated to permit contour cultivation and strip cropping. Erosion control established on entire farm.

EAST PROJECT

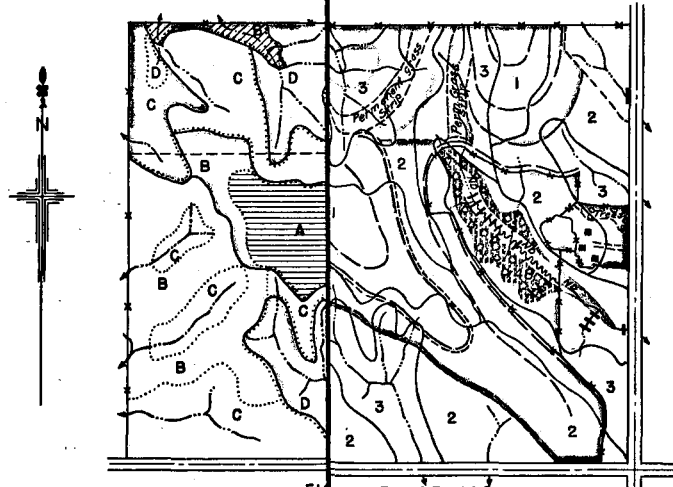


FIGURE - 14C

PHYSICAL ORGANIZED LAND USE

LEGEND																													
<table border="0"> <tr> <td style="width: 20px; text-align: center;">A</td> <td>0% to 3% sloped crops</td> </tr> <tr> <td style="width: 20px; text-align: center;">B</td> <td>3% to 8% " rowing crops</td> </tr> <tr> <td style="width: 20px; text-align: center;">C</td> <td>8% to 12% " Legume crops</td> </tr> <tr> <td style="width: 20px; text-align: center;">D</td> <td>Over 12% " cropping pasture</td> </tr> <tr> <td style="width: 20px; text-align: center;">[Symbol]</td> <td>No apparent erosion</td> </tr> <tr> <td style="width: 20px; text-align: center;">[Symbol]</td> <td>Slight sheet erosion</td> </tr> <tr> <td style="width: 20px; text-align: center;">[Symbol]</td> <td>Moderate sheet erosion</td> </tr> <tr> <td style="width: 20px; text-align: center;">[Symbol]</td> <td>Severe sheet erosion with severe gullying</td> </tr> </table>	A	0% to 3% sloped crops	B	3% to 8% " rowing crops	C	8% to 12% " Legume crops	D	Over 12% " cropping pasture	[Symbol]	No apparent erosion	[Symbol]	Slight sheet erosion	[Symbol]	Moderate sheet erosion	[Symbol]	Severe sheet erosion with severe gullying	<table border="0"> <tr> <td style="width: 20px; text-align: center;">[Symbol]</td> <td>New Tree Plantings</td> </tr> <tr> <td style="width: 20px; text-align: center;">[Symbol]</td> <td>Farm Bldgs & Lots</td> </tr> <tr> <td style="width: 20px; text-align: center;">[Symbol]</td> <td>Field Boundaries</td> </tr> <tr> <td style="width: 20px; text-align: center;">[Symbol]</td> <td>Improved type terraces</td> </tr> <tr> <td style="width: 20px; text-align: center;">[Symbol]</td> <td>Check dams</td> </tr> <tr> <td style="width: 20px; text-align: center;">[Symbol]</td> <td>Relocated fences</td> </tr> </table>	[Symbol]	New Tree Plantings	[Symbol]	Farm Bldgs & Lots	[Symbol]	Field Boundaries	[Symbol]	Improved type terraces	[Symbol]	Check dams	[Symbol]	Relocated fences
A	0% to 3% sloped crops																												
B	3% to 8% " rowing crops																												
C	8% to 12% " Legume crops																												
D	Over 12% " cropping pasture																												
[Symbol]	No apparent erosion																												
[Symbol]	Slight sheet erosion																												
[Symbol]	Moderate sheet erosion																												
[Symbol]	Severe sheet erosion with severe gullying																												
[Symbol]	New Tree Plantings																												
[Symbol]	Farm Bldgs & Lots																												
[Symbol]	Field Boundaries																												
[Symbol]	Improved type terraces																												
[Symbol]	Check dams																												
[Symbol]	Relocated fences																												

- cow type terraces, station.
- 1 - Farks, check and brush
 - 2 - Sheds and waterways.
 - 3 - Gullyion terraces, permanent grass strips.
 - 4 - Steeion.
 - 5 - Land acres.
 - 6 - Unbl
- age and grain crops, cropping system
 contour cultivation and strip
 entire farm.

FIGURE 15

NORTHEAST TEXAS DUCK CREEK PROJECT
 REPRESENTATIVE FARM — SMITH COUNTY, TEXAS

SCALE
 0 250 500 750 1000 FT.

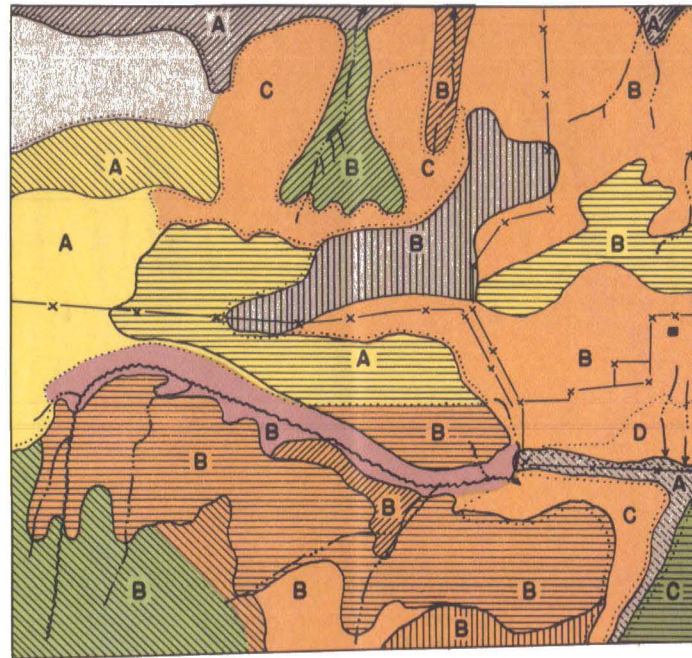


FIGURE - 15A

PHYSICAL CONDITION OF LAND
 LEGEND

- | | |
|---|--------------------------------------|
| No apparent erosion | Kirvin fine sandy loam |
| Slight sheet erosion | Kirvin stony loam |
| Slight sheet erosion - occasional shallow gullies | Nacogdoches gravelly fine sandy loam |
| Slight sheet erosion - severe gullying. | Bowie fine sandy loam |
| Moderate sheet erosion - severe gullying | Ruston fine sandy loam |
| Destroyed by gullying | Hannahatchie fine sandy loam |
| A 0% to 3% Slope | Shallow gullies |
| B 3% to 8% " | Deep gullies |
| C 8% to 10% " | Fences |
| D Over 10% " | Slope boundaries |
| | Soil boundaries |
| | Farm buildings and lots |

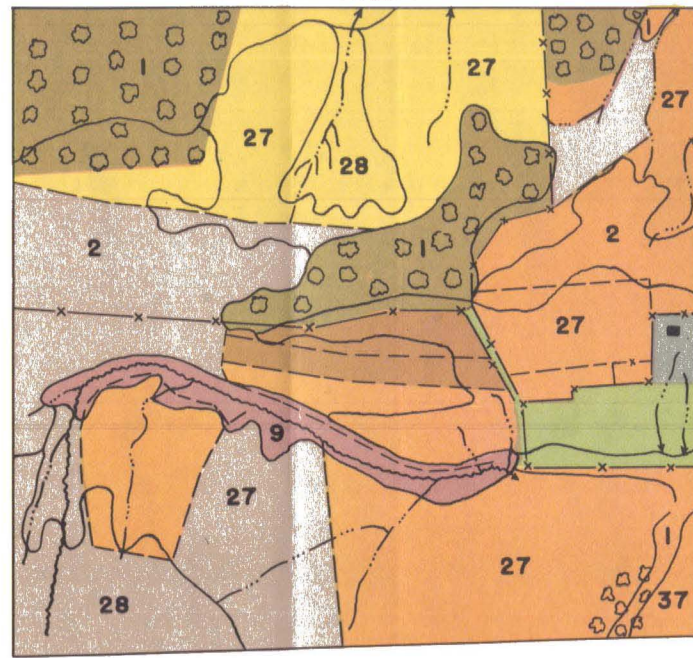


FIGURE - 15B

PRECEDING LAND USE
 LEGEND

- | | |
|----------------------------|---|
| Clean tilled crops | No apparent erosion |
| Close growing crops | Slight sheet erosion |
| Hay and legume crops | Slight sheet erosion - occasional shallow gullies |
| Pasture | Slight sheet erosion - severe gullying |
| Woods | Moderate sheet erosion - severe gullying. |
| Idle lands | Destroyed by gullying. |
| Land destroyed by gullying | Shallow gullies |
| | Deep gullies |
| | Fences |
| | Farm buildings and lots |
| | Field boundaries |
| | Erosion boundaries |

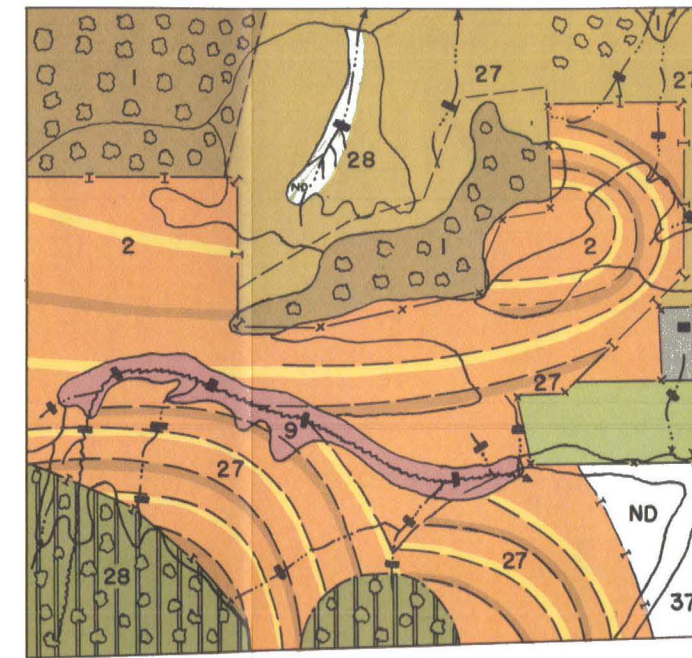


FIGURE - 15C

REORGANIZED LAND USE
 LEGEND

- | | |
|----------------------------|--|
| Clean tilled crops | No apparent erosion |
| Close growing crops | Slight sheet erosion |
| Hay and legume crops | Slight sheet erosion - occasional shallow gullies. |
| Strip cropping | Slight sheet erosion - severe gullying. |
| Improved type terraces | Moderate sheet erosion - severe gullying. |
| ND New seedings | Destroyed by gullying |
| New tree plantings | Shallow gullies |
| New pasture | Deep gullies |
| Old pasture | Fences |
| Old woods | Field boundaries |
| Land destroyed by gullying | Erosion boundaries |
| | Check dams |
| | Farm buildings and lots |
| | Relocated fences |

CONDITION OF FARM BEFORE
 COOPERATION WITH SOIL CONSERVATION SERVICE

- 1 - Farm 100 Acres. Cultivated land; 62.6 Acres.
- 2 - Sheet erosion serious. On 79% of entire farm, 1/4 to all of top soils removed.
- 3 - Gullies serious; 12% of land destroyed for cultivation.
- 4 - No definite cropping rotation.
- 5 - Extremely poor pasture.
- 6 - Large percentage highly erosive crops.
- 7 - Eighteen irregularly shaped fields.

REORGANIZED FARM

- 1 - Farm 100 Acres. Retired from cultivation, 10 Acres.
- 2 - Sheet erosion controlled on entire farm by strip cropping, seeding, new type terraces, contour farming and contour furrowing.
- 3 - Gullies, controlled on 64 Acres with soil saving dams.
- 4 - Definite rotations for uninterrupted erosion control.
- 5 - All pastures reseeded and contour furrowed.
- 6 - Low percentage erosive crops. Cotton reduced 40 percent.
- 7 - Nine fields - rearranged for efficient handling and cropping.

NORTHEAST TEXAS

REPRESENTATIVE FARM



FIGURE - 15A

PHYSICAL CONDITION OF LAND

LEGEND

No apparent erosion	Kirvin fine sandy loam	Clean tilled crops
Slight sheet erosion	Kirvin stony loam	Close growing crops
Slight sheet erosion - occasional shallow gullies	Nacogdoches gravelly fine sandy loam	Hay and legume crop
Slight sheet erosion - severe gullying	Bowie fine sandy loam	Pasture
Moderate sheet erosion severe gullying	Ruston fine sandy loam	Woods
Destroyed by gullying	Hannahatchie fine sandy loam	Idle lands
A 0% to 3% Slope	Shallow gullies	Land destroyed by gully
B 3% to 8% Slope	Deep gullies	Shallow gullies
C 8% to 10% Slope	Fences	Deep gullies
D Over 10% Slope	Slope boundaries	Fences
	Soil boundaries	Farm buildings and lots
	Farm buildings and lots	Erosion boundaries

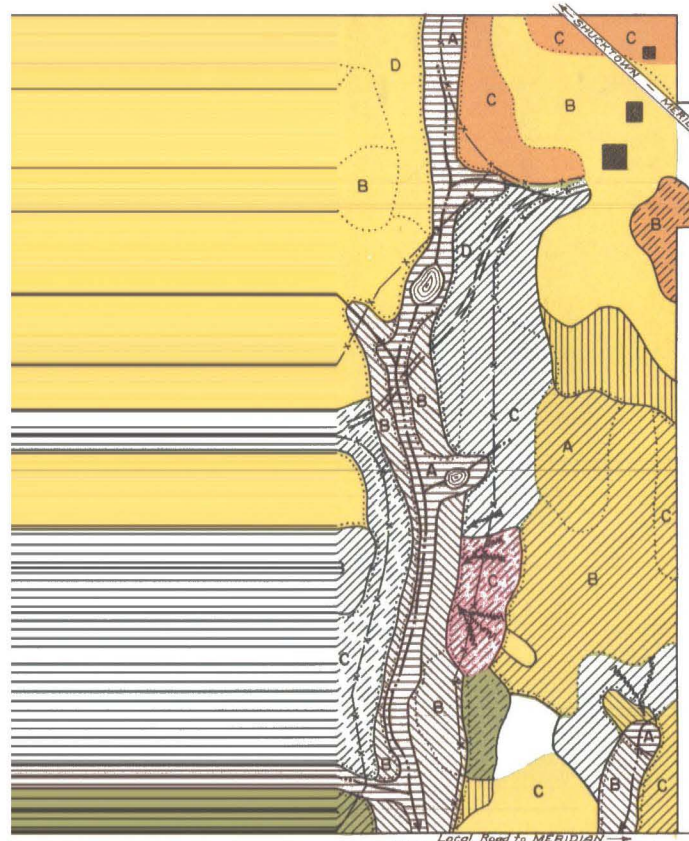
PRECED

- CONDITION OF FARM BEFORE COOPERATION WITH SOIL CONSERVATION SERVICE**
- 1 - Farm 100 Acres. Cultivated land; 62.6 Acres.
 - 2 - Sheet erosion serious. On 79% of entire farm, 1/4 to all of top soils removed.
 - 3 - Gullies serious; 12% of land destroyed for cultivation.
 - 4 - No definite cropping rotation.
 - 5 - Extremely poor pasture.
 - 6 - Large percentage highly erosive crops.
 - 7 - Eighteen irregularly shaped fields.

EAST CENTRAL MISSISSIPPI OKATIBBEE RIVER PROJECT

REPRESENTATIVE FARM, LAUDERDALE COUNTY, MISS. 81.46 ACRES

SCALE
0 200 400 600 800 FT.



PHYSICAL CONDITION OF LAND

LEGEND

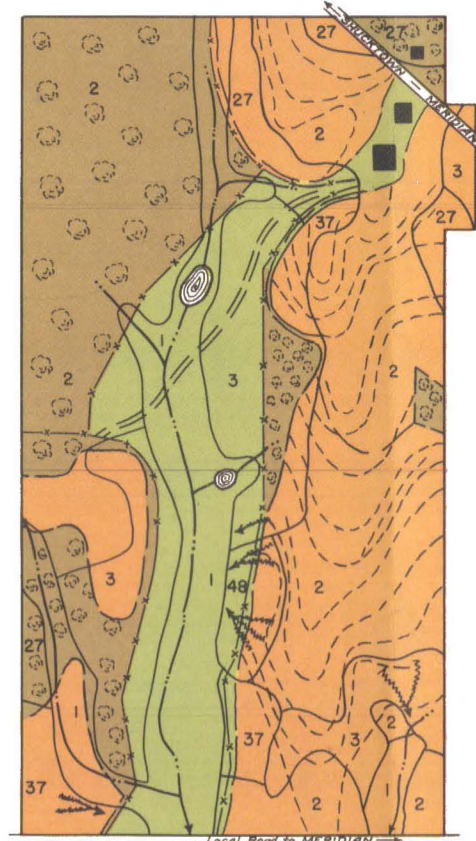
- No apparent erosion
- Slight sheet erosion
- Slight sheet erosion and occasional gullies.
- Moderate sheet erosion and occasional gullies.
- Severe sheet erosion with severe gullying.

- A 0% to 3% Slope
- B 3% to 8% "
- C 8% to 15% "
- D Over 15% "

- Orangeburg and Ruston fine sandy loams.
- Kirvin fine sandy loams
- Caddo fine sandy loam.
- Norfolk fine sandy loam.
- Kalmia and Myatt fine sandy loams.
- Bibb silt loam and fine sandy loam.

- Deep gullies
- Shallow gullies & Waterways
- Lakes and ponds
- Slope boundaries
- Field roads
- Soil boundaries
- Farm buildings and Lots

FIGURE - 16A



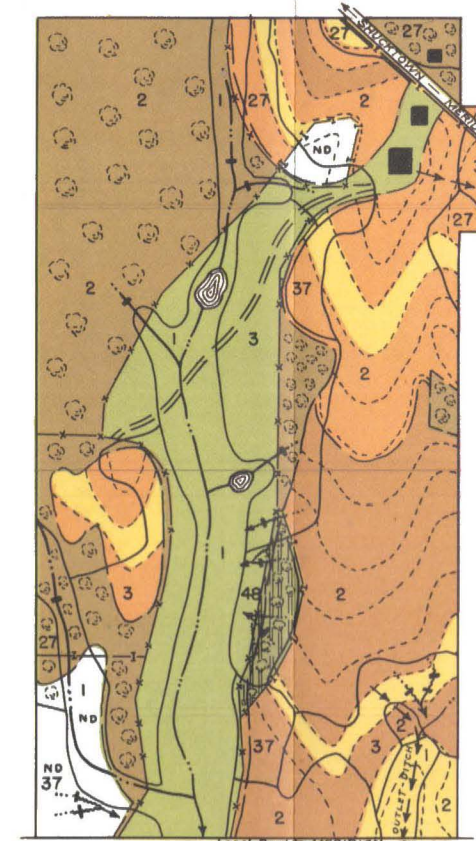
PRECEDING LAND USE

LEGEND

- Clean tilled crops
- Pasture
- Woods

- Fences
- Field boundaries
- Deep gullies
- Shallow gullies and Waterways.
- Outlet ditch
- Lakes and Ponds
- Farm Buildings and Lots
- Erosion boundaries
- Old type terraces
- Field Road

FIGURE - 16B



REORGANIZED LAND USE

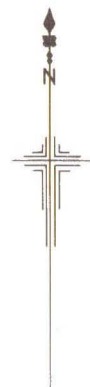
LEGEND

- Strip Cropping
- Clean tilled crops
- Close growing crops
- Hay and Legume crops
- Pasture
- New tree plantings
- New Seeding
- Farm Buildings and Lots

- Woods
- Improved type Terraces
- Check Dams
- Relocated Fences
- Old Fences
- Lakes and Ponds

- 1 No apparent erosion
- 2 Slight sheet erosion
- 27 Slight sheet erosion and occasional gullies.
- 3 Moderate sheet erosion
- 37 Moderate sheet erosion and occasional gullies.
- 48 Severe sheet erosion with severe gullying.

FIGURE - 16C



CONDITION OF FARM BEFORE COOPERATION WITH SOIL CONSERVATION SERVICE

- 1 - Farm 81.46 Acres. Cultivated 42.5 Acres.
- 2 - Sheet erosion becoming serious, gullying severe.
- 3 - No rotation.
- 4 - Crops practically all corn and cotton.
- 5 - Old type terraces improperly constructed and located - severe erosion always results because of this.

REORGANIZED FARM

- 1 - Farm 81.46 Acres. Fields completely reorganized.
- 2 - Strip cropping, terracing and erosion resisting crops used for control. Gullies controlled.
- 3 - Definite rotation with soil building crops.
- 4 - Forage crops and legumes established on 40% of cultivated land in rotation. 12 Acres winter cover crops introduced.
- 5 - Every terrace relocated and new improved types built.

EAST CENTRAL MISSISSIPPI

REPRESENTATIVE FARM, LA

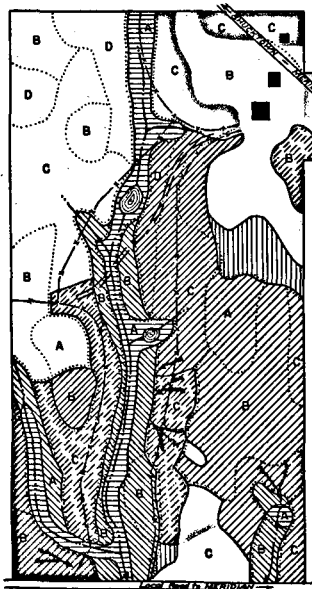


FIGURE-16A

PHYSICAL CONDITION OF LAND

LEGEND

- No apparent erosion
- Slight sheet erosion
- Slight sheet erosion and occasional gullies.
- Moderate sheet erosion
- Moderate sheet erosion and occasional gullies.
- Severe sheet erosion with severe gullying.

- A 0% to 3% Slope
- B 3% to 8% -
- C 8% to 15% -
- D Over 15% -

- Orangeburg and Fuston fine sandy loams.
- Kirvin fine sandy loams
- Caddo fine sandy loam.
- Norfolk fine sandy loam.
- Kalmia and Myatt fine sandy loams.
- Bibb silt loam and fine sandy loam.

- Deep gullies
- Shallow gullies & Waterways
- Lakes and ponds
- Slope boundaries
- Field roads
- Soil boundaries
- Farm buildings and Lots

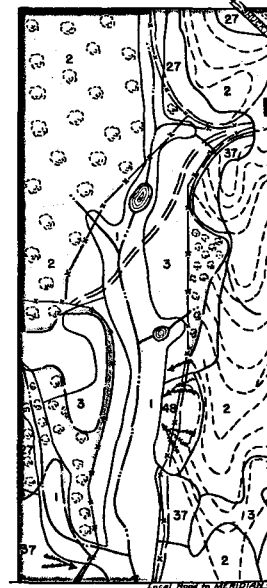


FIGURE-16B



- CONDITION
- COOPERATION WITH SC
- 1 - Farm 8146 Acres. Cultivate
 - 2 - Sheet erosion becoming se
 - 3 - No rotation.
 - 4 - Crops practically all corn
 - 5 - Old type terraces improper severe erosion always r

FIGURE 17

SOUTHEASTERN

OHIO

SALT

CREEK

PROJECT

REPRESENTATIVE FARM - MUSKINGUM COUNTY, OHIO - 150 ACRES

SCALE
0 250 500 750 1000 FT.

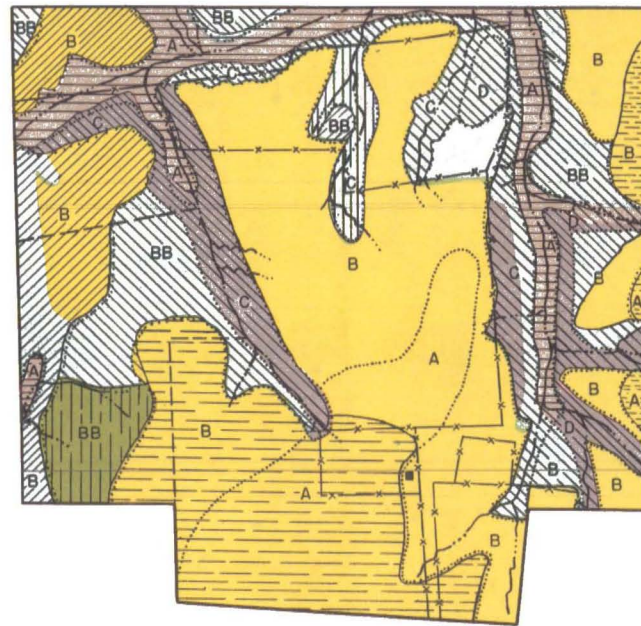


FIGURE - 17A

PHYSICAL CONDITION OF LAND

LEGEND

- | | |
|--|-----------------------|
| No apparent erosion. | Wellston Silt Loam. |
| Slight sheet erosion. | Pope Silt Loam. |
| Moderate sheet erosion. | Zanesville Silt Loam. |
| Moderate sheet erosion and occasional shallow gullies. | Muskingum Loam. |
| Severe sheet erosion. | Muskingum Silt Loam. |
| | Holston Silt Loam. |
| | Atkins Silt Loam. |

- | | |
|------------------|--------------------------|
| A 0% to 5% slope | Streams. |
| B 5% to 12% " | Gullies. |
| BB 12% to 20% " | Fences. |
| C 20% to 30% " | Field Boundaries. |
| D Over 30% " | Slope Boundaries. |
| | Soil Boundaries. |
| | Farm Buildings and Lots. |



FIGURE - 17B

PRECEDING LAND USE

LEGEND

- | | |
|----------------------|----------------------|
| Clean Tilled Crops | Fences |
| Close Growing Crops | Streams |
| Hay and Legume Crops | Gullies |
| Pasture | Field Boundaries |
| Woods | Erosion Boundaries |
| | Farm Building & Lots |

CONDITION OF FARM BEFORE COOPERATION WITH SOIL CONSERVATION SERVICE

- 1 - Farm 150 Acres. Crop land 94 Acres.
- 2 - Sheet erosion serious, 1/4 to all top soils removed on 41% of entire farm.
- 3 - Poor pastures.
- 4 - Gullies serious.
- 5 - Small eroded area unsuited for cropping, 6 Acres.
- 6 - Unorganized farm plan.

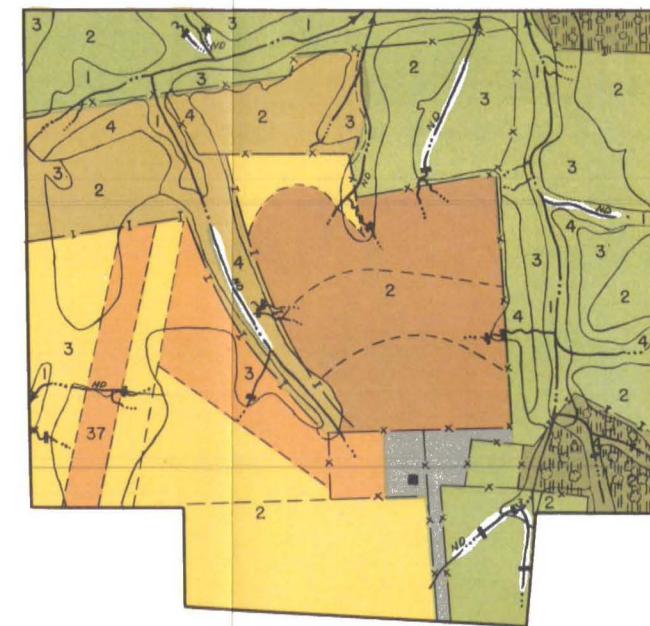


FIGURE - 17C

REORGANIZED LAND USE

LEGEND

- | | |
|----------------------|-------------------------|
| Clean Tilled Crops | Farm Buildings and Lots |
| Close Growing Crops | Gullies |
| Hay and Legume Crops | Old Fences |
| New Pasture | Relocated Fences |
| Strip Cropping | Check Dams |
| New Tree Plantings | Field Boundaries |
| New Seedlings | |
| Old Pasture | |

REORGANIZED FARM

- 1 - Farm 150 Acres. Crop land 62 Acres. Retired from cultivation 32 Acres.
- 2 - Sheet erosion controlled on entire farm by: strip cropping 48A, crop rotation 62A; 76% cultivated land in small grain, hay and legumes; 3A permanent meadows.
- 3 - Old pastures treated. 23A previously cultivated, retired to pasture.
- 4 - Gullies controlled with structures, by seeding, tree and shrub plantings.
- 5 - Planted to trees, 6 Acres.
- 6 - Reorganized plan: Fields rearranged, fences relocated, balanced cropping system, giving erosion control.

SOUTH PROJECT

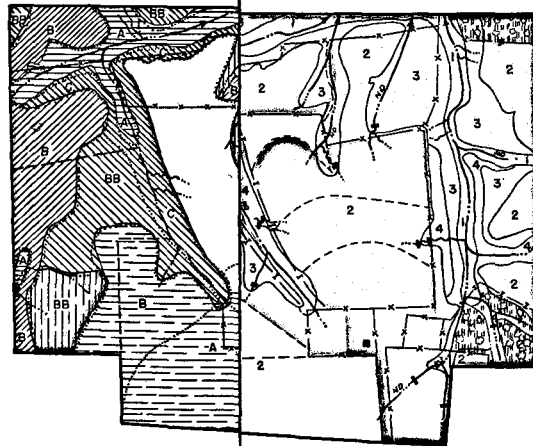


FIGURE - 17C

PHYSICAL CONDITONIZED LAND USE

LEGEND

- | | | |
|--|------------|-------------------------|
| No apparent erosion. | Crops | Farm Buildings and Lots |
| Slight sheet erosion. | Crops | Gullies |
| Moderate sheet erosion. | Fine Crops | Old Fences |
| Moderate sheet erosion and occasional shallow gullies. | Sing | Relocated Fences |
| Severe sheet erosion. | Plantings | Check Dams |
| | | Field Boundaries |

- | | |
|----|----------------|
| A | 0% to 5% slope |
| B | 5% to 12% " |
| BB | 12% to 20% " |
| C | 20% to 30% " |
| D | Over 30% " |

ORGANIZED FARM
 and 62 Acres Retired from cultivation 32 Acres.
 lled on entire farm by strip cropping 48A,
 cultivated land in small grain, hay and legumes;
 23A previously cultivated, retired to pasture.
 structures, by seeding, tree and shrub plantings.
 acres.
 ds rearranged, fences relocated, balanced
 of erosion control.

ush of water over the steeper slopes. These are discharged into sodded waterways, pastures, or into natural drainage channels by terrace outlet structures. Various types of check dams, as brush, rock, wire, wood, and sod, are installed where needed, using those which can be built more economically.

Figures 13, 14, 15, 16, and 17 show actual conditions of five individual farms on Soil Conservation Service

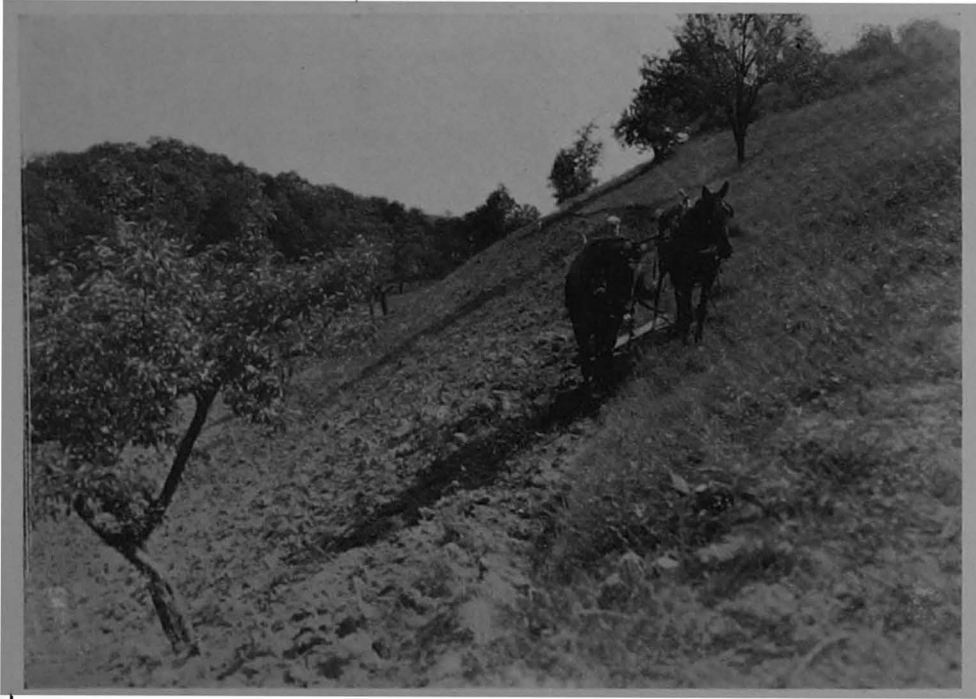
watershed projects in representative parts of the country. On figure 13, the degree of erosion is shown in relationship to soil type and slope; on figure 14 the land use preceding cooperation with the Soil Conservation Service is shown, with the erosion condition resulting from the old system of handling; on figure 15 the reorganized farm plan worked out with the farmer by the soil-erosion specialist is shown with methods of

TABLE XI.—Erosion and treatment on representative farms in the United States

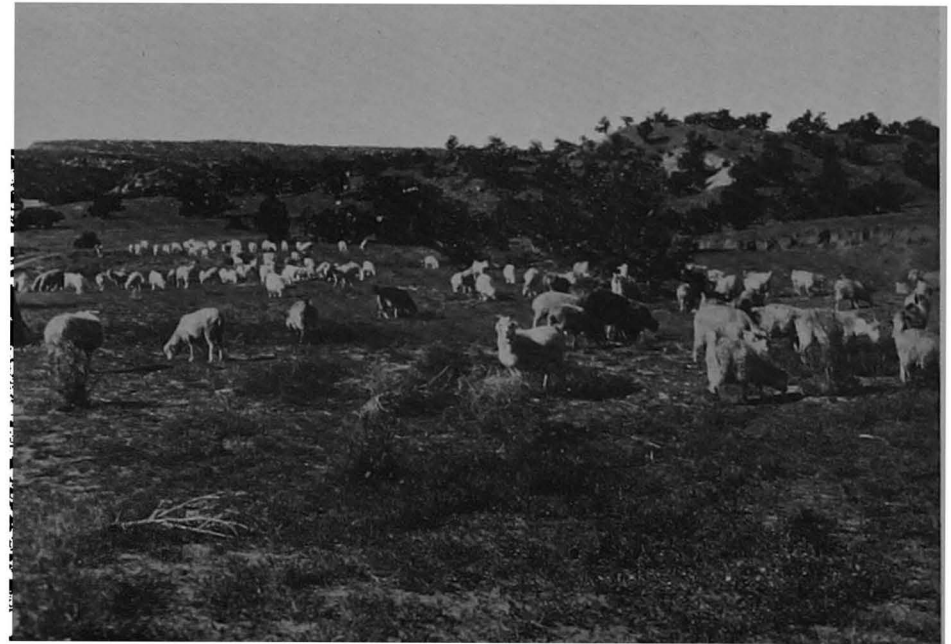
EROSION CLASS	Alabama Buck and Sandy Creek Area, Tallapoosa and Chambers Counties		Arkansas East Cadron Creek Area, Cleburne, White, and Faulkner Counties		California Arroyo Las Posas Area, Ventura County		Illinois Sangamon River Area, McLean and Ford Counties		Kansas Limestone Creek Area, Smith and Jewell Counties		Mississippi Okatibbee River Area, Lauderdale, Kemper, and Neshoba Counties		Missouri and Iowa West Tarkio Creek Area, Montgomery and Page Counties, Iowa and Atchison County, Mo.		Nebraska Plum Creek Area, Boone and Nance Counties	
	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent
Total acreage in selected farms.....	2,029.0		800.0		1,745.0		1,750.0		1,521.0		936.0		1,840.0		1,558.0	
Total acreage treated.....	1,477.0	100.0	390.3	100.0	1,744.6	100.0	1,667.4	100.0	1,318.6	100.0	431.6	100.0	1,572.0	100.0	1,402.7	100.0
No apparent erosion.....	43.6	3.0	8.7	2.2	526.5	30.2	808.3	48.5	264.3	27.6	30.3	7.0	548.1	34.9	403.6	28.8
Slight sheet erosion.....	90.0	6.1	40.3	10.3	645.3	37.0	636.5	39.4	277.2	21.0	182.9	42.4	573.7	36.5	143.4	10.2
Moderate sheet erosion.....	493.7	33.4	268.3	68.7	645.3	37.0	190.3	11.4	428.7	32.5	243.2	56.5	433.4	27.6	337.8	24.1
Severe sheet erosion.....	799.9	54.2	63.1	16.2	572.8	32.8	6.8	.4	243.5	18.5	12.3	2.8	16.8	1.1	517.9	36.9
Deep sheet erosion.....	39.4	2.7					1.7	.1	4.9	.4						
Occasional gullies.....	119.5	8.1	25.4	6.5	56.9	3.3	49.2	3.0	174.4	13.2	180.2	43.8	457.5	29.1	98.0	7.0
Severe gullying.....	77.6	5.3	37.1	9.5	28.8	1.7			32.7	2.5	18.1	4.2			169.6	12.1
Completely destroyed by gullies.....	48.0	3.2					3.8	.2			.4	.1				
TREATMENT BY SOIL CONSERVATION SERVICE																
Total acreage treated.....	1,477.0	100.0	390.3	100.0	1,744.6	100.0	1,667.4	100.0	1,318.6	100.0	431.6	100.0	1,572.0	100.0	1,402.7	100.0
Rotation adopted to check erosion.....	1,080.9	73.2	203.8	52.2	1,031.3	59.1	1,155.0	69.3	1,032.5	78.3	375.5	87.0	14.3	.9	835.0	59.5
Strip cropping and seeding.....	1,075.8	72.8	203.8	52.2	411.3	23.6	229.0	13.7	446.0	33.8	327.0	75.8	448.0	28.5	304.0	21.7
Terraces (improved style).....	1,034.5	70.0	203.8	52.2	762.7	43.7	443.0	26.6	1,017.0	77.1	338.0	78.3	565.5	36.0	698.0	49.8
Contour tillage.....	1,080.9	73.2	203.8	52.2			214.0	12.8	901.0	68.3	40.5	9.4	655.0	54.4	636.0	45.3
Land removed from cultivation.....	74.6	5.1	186.4	47.8	139.3	8.0	239.5	13.8	192.5	14.6	62.5	14.5	61.0	3.9	184.5	13.2
Seeded or planted to sod.....	117.3	7.9	97.8	25.0			274.0	16.4	191.5	14.5	58.5	13.6	82.0	5.2	184.5	13.2
Contour furrowing.....			83.0	21.3	125.6	7.2	93.0	5.6			8.0	1.9			122.5	8.7
New forest.....	177.7	12.0	88.7	22.7			8.5	.5			4.0	.9				
Gully control (area protected).....	474.1	32.1	107.3	27.5	767.9	44.0	1,447.0	86.8	128.0	9.7	35.5	8.2	950.0	60.4	635.0	45.3

EROSION CLASS	Louisiana, Cypress Creek Area, Lincoln Parish		North Carolina and South Carolina, Brown Creek Area, Union and Anson Counties, North Carolina, and Chesterfield County, South Carolina		Ohio, Salt Creek Area, Muskingum County		South Carolina, South Tiger River Area, Greenville and Spartanburg Counties		Texas, Duck Creek Area, Smith County		Virginia, Banister River Area, Pittsylvania County		West Virginia, Reedy Creek Area, Wirt and Roane Counties	
	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent
Total acreage in selected farms.....	1,779.0		3,718.0		345.0		941.0		982.0		1,309.0		3,020.0	
Total acreage treated.....	942.8	100.0	1,566.2	100.0	212.9	100.0	526.7	100.0	797.6	100.0	576.6	100.0	607.9	100.0
No apparent erosion.....	55.3	5.9	181.5	11.6	7.5	3.5	.8	.2	100.78	12.6	5.2	.9	86.4	14.2
Slight sheet erosion.....	96.4	6.2	77.3	36.3	4.65	.9	637.3	79.9	97.3	16.9	97.3	16.9	63.5	10.4
Moderate sheet erosion.....	203.7	31.2	1,087.4	69.4	88.2	41.4	401.0	76.1	59.4	7.4	385.8	66.9	260.8	42.9
Severe sheet erosion.....	593.7	63.0	178.9	11.4	39.9	18.8	118.9	22.6			362.2	62.8	160.0	26.3
Deep sheet erosion.....			22.1	1.4									4.2	.7
Occasional gullies.....	8.0	.9	182.8	11.7	18.6	8.7	881.8	72.5	410.0	51.4	84.6	14.7	108.3	17.8
Severe gullying.....	5.5	.6	5.3	.3	3.4	1.6	5.3	1.0	46.9	5.9	7.7	1.3	86.5	14.2
Completely destroyed by gullies.....					1.6	.8	1.4	.3					2.0	.3
Slips.....													69.5	11.4
TREATMENT BY SOIL CONSERVATION SERVICE														
Total acreage treated.....	942.8	100.0	1,566.2	100.0	212.9	100.0	526.7	100.0	797.6	100.0	576.6	100.0	607.9	100.0
Rotation adopted to check erosion.....	740.8	78.6	1,496.4	95.5	79.3	37.2	449.0	85.2	495.5	62.1	426.9	74.0	132.3	21.8
Strip cropping and seeding.....	487.5	51.7	354.6	22.6			455.0	86.4	503.3	63.1	32.8	5.7	62.3	10.2
Terraces (improved style).....	797.1	84.5	1,407.4	89.9			452.0	85.8	473.9	59.4	356.1	61.8		
Contour tillage.....	763.6	81.0	1,396.2	89.1	56.4	26.5	455.0	86.4	501.6	62.9	411.2	71.3		
Land removed from cultivation.....	118.1	12.5	140.8	9.0	75.4	35.4	26.0	4.9	282.5	35.4	34.5	6.0	340.7	56.0
Seeded or planted to sod.....	50.9	5.4	429.4	27.4	68.2	32.0	44.5	8.4	320.9	40.2	16.9	2.9	246.0	40.5
Contour furrowing.....	50.9	5.4	50.9	3.2					270.9	34.0	174.3	30.2		
New forest.....	43.3	4.6	20.3	1.3	11.4	5.3	28.5	5.4	68.9	8.6	21.3	3.7	216.6	35.6
Gully control (area protected).....	387.5	41.1	409.3	26.1	50.9	23.9	197.0	37.4	203.2	25.5	210.3	36.5		

1 Treatment was not found to be necessary for some parts of the farm which were in woods or permanent pasture.



Suicidal agriculture. Steep slopes such as this should never be cultivated, but should be kept in forests or permanent pasture. West Virginia



Overgrazing, with its almost inevitable accompanying erosion, has been the downfall of much western range land.



Cut-over Wisconsin slopes not only prove an easy prey to erosion, but are flood hazards. Rich valley farms are frequently covered with debris from adjacent slopes such as this.



Formerly a fertile cultivated field, this North Carolina land was abandoned due to erosion. Now it is beginning a new life as a pine forest.

FIGURE 18.

treatment used to establish permanent erosion control and soil conservation on the entire farm. The pertinent facts concerning erosion on these farms and the old and new treatment and land use are set forth on the lower part of the figures.

On the detailed surveys, the conditions of erosion are shown by symbols. Erosion is treated under two major classes, namely, sheet erosion and gully erosion, each classified independently. Sheet erosion, in addition to the expansive plantation normally characterizing the process, includes rill erosion and shallow gully developments which would be obliterated by normal tillage operations. Sheet-erosion conditions are expressed in classes according to the amounts of A horizon, or topsoil, and B horizon, or subsoil, which have been lost, and is expressed in estimated percentages of the depth of the original horizons of the soil profile. When gully development attains such size that it is not obliterated by tillage operations and hence becomes a detriment to tillage, such an incision is classified as to frequency. Areas showing three gullies per acre or less are classified as areas of "occasional gullies", while land containing a larger number is classified as "severely gullied." A third classification covers all land "destroyed by gullying."

The condition of gullying is expressed, in conjunction with the condition of sheet erosion, by a combination symbol, except in the case of land destroyed by gullying.

Following are the erosion classes and their description, as used on the detailed surveys:

Symbol	Description
1.....	No apparent erosion.
2.....	Little sheet erosion; less than 25 percent of A horizon, or topsoil, lost.
3.....	Moderate sheet erosion; 25 to 75 percent of A horizon, or topsoil, lost.
4.....	Severe sheet erosion; over 75 percent of topsoil lost, with consequent exposure and erosion of B horizon.
5.....	Deep sheet erosion; topsoil and subsoil mostly lost, with consequent exposure and erosion of C horizon, or parent material.
7.....	Occasional gullies; not more than three gullies per acre.
8.....	Severe gullying; more than three gullies per acre.
9.....	Destroyed by gullying.

Gully classes 7 and 8 are shown in conjunction with the condition of sheet erosion by a combination of a symbol for sheet erosion with a gully symbol.

The terms for land use appearing on figures 13 to 17 are defined as follows:

Clean-Tilled Crops: Corn, cotton, tobacco and all row crops having clean cultivation.

Close-Growing Crops: Small grains and such crops as afford seasonal ground cover.

Hay and Legume Crops: Farm crops affording maximum protection from erosion as clovers, alfalfa, and timothy.

Strip Cropping: Use of alternate bands or strips of clean-tilled, close-growing, and hay and legume crops.

Contour Farming: Plowing, seeding, and cultivating crops on the land contour, instead of up and down slopes.

Rotations: Planned crop rotations to give erosion control including crops for soil building and winter soil cover.

Terracing: Construction of improved type of terraces. These are restricted to moderate slopes on soils adapted to terracing.

The area seeded or planted to sod is sometimes greater than the area removed from cultivation. This is due to the necessity for seeding old pasture areas in some instances where erosion was active. Elsewhere no control measures have been indicated for land removed from cultivation. In some sections soil and climatic conditions are favorable to the rapid growth of natural vegetation on land left idle for a short time, sufficient to develop a ground cover to check erosion effectively.

The acreage designated with gully control refers to the acreage protected by gully control measures. Such measures include construction of various types of dams, seeding, and planting vines and trees. The construction of dams is usually necessary to stabilize gullies sufficiently to enable suitable vegetation to become established.

The acreage protected by strip cropping is greater than indicated in the table. In some areas the total acreage protected by strip cropping is indicated while other areas reported only the acreage actually included in the alternate strips of close-growing crops.

The percentages of the total area which received the various corrective treatments total more than 100 percent because several treatments were applied to certain areas. Thus, in Alabama 72.8 percent of the total area treated was strip cropped. On the same land terraces were built, contour tillage was employed, and rotations were adopted to assist in controlling erosion.

Summary of Applied Measures to February 28, 1935

Table XII shows the total amount of various measures of control which had been put into effect by the Soil Conservation Service on its 40 projects by February 28, 1935. This work was done in cooperation with the farmers who signed agreements to continue these control measures for a period of 5 years. The number of farms under cooperative agreement varies widely between projects dependent on the period of time each has been organized. Some projects had been operating about 13 months while others were but recently organized. There is a wide range in average size of farm between projects, also, so that the 159 farms in Nebraska or the 216 farms in Mississippi comprise but little more acreage than the 41 farms at Dalhart, Tex.

During the short period of operation over a million and a quarter acres of farm land have been placed under the control of the Soil Conservation Service by the cooperating farmers to check the invasion of this greatest menace to agricultural lands.

Gully Control: Includes construction of various types of dams, seeding grass, planting vines, shrubs, and trees to establish vegetative stabilization.

Erosion conditions and prescribed treatment in 15 regions.

Table XII shows the acreage of the various conditions of erosion found on a number of representative farms on fifteen erosion control projects located in different sections of the United States together with the acreages affected by the various methods of control and farm reorganization adopted to correct those conditions of accelerated erosion.

The first part of the table sets forth the conditions of erosion and the acreage of each condition on these farms. The second part sets forth the corrective measures employed. The total acreage treated is not as great as the total farm areas because on each farm a certain por-

tion was found on which erosion was not active. Such areas may be in woods or in well-sodded pasture where no erosion control measures are required. The percentage refers to the total acreage treated and not to the total farm area.

On the lower part of the table the acreage of land removed from cultivation is shown. This land was removed from cultivation in support of and in cooperation with the Agricultural Adjustment Administration crop reduction program. The land removed from cultivation represents the more severely eroded areas and was planted to grass or trees. Additional control measures were sometimes necessitated to control erosion until trees or grass would stabilize the land. Fertilizers and lime were sometimes furnished to facilitate growth; and contour furrows were used to check runoff and conserve moisture.

TABLE XII.—Control measures effected on Soil Conservation Service demonstration projects to Feb. 28, 1955

Soil Conservation Service demonstration projects	Number of farms under co-operative agreements	Number of acres under co-operative agreements	Cultivated acres on operating	Acres re-tilled from cultivation under co-operative agreements	Acres under contract to strip crop	Increased acreage erosion-resisting crops	Decreased acreage clean-tilled crops	Acres under contract to be contour farmed	Acres under contract to terrace	Acres under contract to adopt erosion-resisting rotation	Total all types dams built	Acres under forest management
Alabama: Buck and Sandy Creek Watershed.....	599	90,800	36,778	8,778	30,000	8,271	3,214	20,000	29,409	30,000	22,973	2,134
Arkansas: East Cadron Creek Watershed.....	345	56,620	29,804	10,525	18,903	10,525	10,524	18,903	18,903	18,903	2,529	11,990
California:												
Arroyo Las Posas Watershed.....	62	13,014	13,014	1,911	1,702	598	555	971	1,018	16	1,005	0
Arroyo Grande Watershed.....	33	1,226	1,226	440	330	26	98	120	400	85	55	0
Corralitos Creek Watershed.....	8	398	368	50	170	0	0	368	0	100	0	0
Georgia: Sandy Creek Watershed.....	556	59,590	32,511	5,286	23,600	6,000	1,200	650	23,560	12,700	13,839	12,705
Illinois: Sangamon River watershed.....	542	95,423	82,699	10,314	473	13,240	5,252	1,607	120	71,468	4,963	0
Kansas: Limestone Creek Watershed.....	391	90,978	43,262	3,797	6,125	5,964	4,566	10,210	31,472	40,000	2,888	15
Louisiana: Cooley Creek and Cypress Creek Watersheds.....	200	36,671	17,030	2,976	2,269	2,269	5,002	3,667	14,370	14,789	1,427	17,348
Minnesota:												
Deer and Bear Creek Watershed.....	7	826	487	55	377	90	14	393	9	129	0	0
Beaver Creek Watershed.....	3	318	170	68	142	3	7	0	0	142	0	0
Gilmore Creek Watershed.....	28	2,903	1,538	491	591	427	46	0	0	1,048	0	0
Mississippi: Okatbee River Watershed.....	216	28,865	9,917	846	7,390	4,080	2,077	9,072	7,390	7,389	770	15,260
Missouri:												
Big Creek Watershed.....	643	92,689	50,731	11,390	3,398	14,000	10,869	5,131	2,760	42,763	1,968	200
West Tarkio River Watershed.....	322	56,079	40,541	4,962	1,164	4,962	4,962	8,694	658	28,377	3,559	0
Nebraska: Plum Creek Watershed.....	159	31,925	20,249	3,948	1,469	3,400	3,400	13,675	15,965	23,227	2,154	0
North Carolina:												
Brown Creek Watershed.....	399	46,779	16,059	549	1,653	3,500	1,500	12,965	13,222	15,510	2,008	2,188
Deep River Watershed.....	1,066	84,509	25,493	2,494	5,078	476	485	22,998	23,787	1,727	1,956	28,019
Reedy Fork Watershed.....	20	1,033	596	49	113	98	98	453	498	419	0	0
Ohio: Salt Creek Watershed.....	330	37,936	13,051	3,700	3,168	2,683	616	3,145	110	5,099	1,572	1,344
Oklahoma: Stillwater Creek Watershed.....	535	70,550	24,717	3,873	22,969	3,300	4,100	22,676	21,144	23,720	5,999	0
South Carolina:												
South Tyger River Watershed.....	652	52,383	30,488	4,906	24,358	5,034	4,672	24,635	10,033	24,635	2,971	22,993
Fishing Creek Watershed.....	48	6,573	4,324	417	2,420	169	673	3,509	3,447	2,747	0	1,742
Texas:												
Jalhart Wind Erosion project.....	41	26,976	22,921	927	19,679	0	0	16,264	16,264	22,921	0	0
Duck Creek Watershed.....	70	5,662	4,280	605	3,272	630	1,368	3,577	1,935	3,521	1,603	2,720
Elm Creek Watershed.....	531	62,189	58,131	770	3,008	322	970	57,861	57,861	44,753	99	0
Virginia: Banister River Watershed.....	581	74,408	29,513	5,139	4,229	8,000	2,500	18,054	20,921	22,138	4,188	40,522
Washington:												
South Palouse River Watershed.....	171	38,069	33,679	5,167	18,504	2,713	0	33,679	0	3,054	3,495	0
Wildhorse Creek Watershed.....	18	4,814	4,347	330	1,591	487	0	2,165	0	3,684	289	0
West Virginia: Reedy Creek Watershed.....	347	53,591	5,296	2,197	848	2,530	98	0	0	6,422	2,661	15
Wisconsin: Coon Creek Watershed.....	387	40,545	17,000	1,154	12,285	4,029	564	12,285	2,242	17,660	805	2,134
Total acres.....	9,400	1,267,353	671,680	98,204	222,709	108,486	69,460	337,129	326,010	489,096	85,593	161,329

SECTION VII

A NATIONAL POLICY OF EROSION CONTROL²

Erosion Control a National Problem

The productive agricultural and other land of the country is being seriously impaired by erosion on a vast scale. The plant nutrients and the soil body itself are relentlessly being removed and this process of degradation is increasing at an accelerated rate. Very little of the soil is being deposited where it can be utilized. The work required to return it is beyond human capabilities. The natural processes for replacing it take hundreds of generations.

A thriving agriculture is the basis for our national prosperity. The world is strewn with ruins of once flourishing civilizations, whose basis of continuance has been destroyed. No greater internal problem than the control of erosion within safe limits confronts the Nation today.

The problem is national in character and scope. The process of soil wastage, now taking place, is seriously impairing the most important of the country's natural resources. The injurious effects of soil erosion touch directly or indirectly the interests of every citizen in the United States. Moreover, on wide-spread areas impoverishment or virtual ruin of the soil is of a permanent character, jeopardizing the well-being of the generations that will follow. The accelerated erosion on our lands is largely due to destructive practices in land use. The problem of prevention of such practices and of checking the erosion now under way is one of great magnitude and complexity, which can be met only by the concerted action of the entire Nation.

The consequences of soil erosion are threefold: First, the fertile top soil is being worn away, thereby impairing the capacity of the Nation's lands for the production of food, forage, and other materials required in industry and in our everyday life.

Second, soil erosion has a direct influence on water-flow and the availability of water for domestic and industrial service. Erosion affects the habits of streams, increasing high-water stages and lowering summer flow. It is a contributing factor in the increase of damaging torrents and floods, in lowering the water table, in the deposition of rock and gravel on valuable land, and in the siltation of streams, canals, and reservoirs. No doubt it adds to the national flood problem.

Third, soil erosion is followed by economic and social consequences that affect not only the owners of land

but the local communities, the States, and the entire Nation. Vast areas of productive land, in the aggregate, are being transformed to the marginal and sub-marginal stages. The result is a lowering of the standard of living of many farmers, reduction of income and purchasing power on a large scale, lowering of land values, increase of tenantry, tax delinquency, land abandonment, bankruptcy, financial embarrassment of local communities, increase of poverty and distress, and creation of problems requiring the direct aid of the Nation for alleviation.

Measures of Control So Far Undertaken

For many years men of science and others have called attention to the menaca of soil erosion and have urged the need of control measures. It is only within a generation that definite action on a substantial scale has been undertaken for the introduction of practical measures of erosion control. The efforts to bring about better methods of land use calculated to check erosion have been largely the result of the leadership of the Federal and State Departments of Agriculture and Forestry and other public and quasi-public agencies. These efforts have been directed in part to private lands and in part to lands owned by the public.

A large amount of research and experiment has been conducted by public agencies, to determine the nature of erosion on different types of soil under varying conditions, the causes of erosion, and the practical methods of control. Public education has in the past been relied upon as the chief instrumentality to induce private owners to adopt field practices designed to check the wasting of the soil. This work has been carried on chiefly through extension teaching by the Federal Government and the States. In some cases cooperative undertakings in control measures have been conducted through the aid of States and counties and through private cooperative organizations. This admirable work has induced a great number of farmers to adopt measures which to a greater or less extent check erosion.

It is estimated, however, that not more than 25 percent of the cultivated land of the country, now exposed to erosion, is adequately protected by preventive measures, and more than 50 percent is still suffering very seriously. In short, only a small beginning has been made in controlling the erosive process which is impairing and in many cases ruining for agriculture the lands now under cultivation.

²This article is incorporated with the consent of Dean Henry S. Graves, author, and the Mississippi Valley Committee.



FIGURE 19.—Terraced field on the Salt Creek Watershed, near Zanesville, Ohio. This picture was taken immediately after the terraces were constructed and before the field was plowed. Crops will be planted on the contour parallel to the terraces, and on top of the terraces.

The public forestry agencies have aided in the control of erosion on private forest lands, first by cooperative aid in planting stands of trees on worn-out and eroding lands, and second through organized protection from fire which is the chief cause of erosion on forest lands. The funds provided for cooperative fire protection still represent only a fraction of what is needed. The result is that many millions of acres in regions where the soil is peculiarly exposed to erosion are entirely without protection. Erosion on forest land is also caused by the excessive grazing of livestock. Efforts to control grazing in private woodlands have been confined to educational work. As yet little progress has been made in this direction.

When the national forests were established, uncontrolled grazing of livestock was causing wide-spread erosion, depleting the productivity of the soil, reducing the carrying capacity of the land for livestock, and increasing the damage by torrents and by siltation of streams, canals, and reservoirs. Erosion on these public reservations is in the process of control through the regulation of grazing and through the reestablishment of vegetative growth.

On the other hand the public domain is without any control of grazing. Already the carrying capacity of the land has been reduced more than 50 percent on account of excess number of animals and faulty methods of handling them. The injury to the vegetative cover is causing extensive erosion by water and wind, with the inevitable consequence to the productiveness of the soil, to water-flow conditions, and to the public and private interests dependent on the ranges.

Within the past year the Federal Government has taken vigorous action to enlarge its efforts in erosion control, both on private and public lands. The establishment of large demonstration areas in various parts of the country within which practically all land is to be brought under control from erosion will render a great service in trying out on a large scale different methods of control and in educating landowners in the

use of practical measures. Funds have also been furnished for the expansion of research and experiment by other agencies. Of special importance also is the work of the Civilian Conservation Corps and other emergency agencies in the building of check dams, in reforestation, and in employment of other control measures on both public and private lands. At the present time there are about 24,000 men engaged in this special work of erosion control.

Need of a National Policy Of Erosion Control

In soil erosion we are dealing with great natural forces which unceasingly operate to wear down rock waste and soil and to level the surface of the land. The mantle of vegetation established by nature retards this process of land degradation and permits the accumulation and enrichment of soil. Disturbance of the vegetative cover exposes the soil to the wearing and scouring action of water and wind. The greatest damage is done by the surface run-off of water on sloping land where the natural checks to soil wash have been removed. The problem is, therefore, to counteract the erosive forces of water and wind by special measures designed to hold the soil in place. These measures are embraced in five broad groups: (1) maintenance of forest or grass vegetation on the steeper slopes; (2) proper tillage and drainage; (3) skillful use of crops; (4) terracing the land; and (5) construction of barriers to check gullying.

These methods, intelligently applied, are effective in controlling erosion, at least to the extent of maintaining the productive service of our soils for an indefinite period. The most urgent and also the most difficult problem of erosion control relates to privately owned lands and particularly to farm lands. It is urgent because much of the land in need of control is highly productive, and the damage touches the interest of a very large number of persons and communities. There is a certain social prestige attached to the ownership of farms. Such owners are entrepreneurs, who proudly resent criticism of their methods. Erosion control requires a modification of traditional methods of tillage and crop management, often involving a special outlay of effort and money. In its early stages the damage by erosion is not apparent. This is the period when preventive measures should be used, and also the period when it is most difficult for farmers to realize the need of changing their methods of operation. An appeal to self interest often falls on deaf ears, and the average land owner is not inclined to adopt special measures on his land in order to safeguard the interests of the general public. There is therefore, a limit to the extent to which farmers by their own efforts will adopt effective measures of erosion control.

It is evident, from the experience in erosion control, that there should be a much larger participation by the public itself than heretofore. The successful combatting of the destructive forces of water and wind on the land is not possible by the efforts of individuals. It requires common effort of all persons concerned, just as is the case with the control of stream flow and prevention of floods. This can be most effectively accomplished through a national policy of erosion control which will serve to bring into coordination the efforts of all agencies and persons.

Such a national policy would set forth definite objectives, would indicate the manner and extent of public participation, would define the relative responsibilities of the different units of government, would provide for the coordination of the efforts of private owners with those of the public agencies, and would make provision for the control of erosion of all publicly owned lands.

Principles of a National Policy Of Erosion Control

Objectives.—The purpose of a national policy of erosion control is to restrict in the largest possible measure the erosive forces that are now depleting the soil resources of the country. Such a policy should aim at the mobilization of all efforts, National, State and local that can logically be directed in early and wide-spread action. A program should be developed to make possible the arresting of sheet erosion, the checking of gullying, and the rehabilitating of badly eroded areas. Such efforts must meet the test of practicability, have popular backing, and solicit the support of public leaders. It is recognized that it is not possible to prevent erosion completely, or fully to reestablish the condition of relative land stability which existed prior to settlement and use of the lands. Any disturbance of the vegetative cover of the land accelerates the natural process of erosion. It is possible, however, by modern techniques in land management to reduce erosion to such an extent that the land may continue to be used almost indefinitely. Public interests in the problem are so great and the problem so urgent that a national policy should aim to initiate within 10 years control measures on all the land now seriously suffering from erosion, to secure reasonable control on these lands within 20 years, and to establish preventive measures on practically all lands in the country within a generation.

Federal Responsibility.—The national character of the problem of erosion control makes necessary both a large participation and also the affirmative leadership of the Federal Government in its solution. Even under the traditional interpretation of the term "Federal interests", the Government has a responsibility in the

control of erosion which, by siltation or otherwise, affects navigation and federally constructed reservoirs. This responsibility has not heretofore been assumed. If flood control should be recognized as appropriate for Federal support, there would be a responsibility in controlling one of the major factors which contribute to freshets, floods, cutting of banks, and siltation. Not only is there a responsibility but from a business viewpoint, would it not be folly to invest millions in flood control and navigation while at the same time failing to move against an important cause of the depreciation of the investments?

In soil erosion the Federal responsibilities extend further than the protection of Federal investments in water improvements. The time has come when this Nation should abandon its negative point of view as to participation in activities which may be classed as paternalistic. It is not proposed here to argue the merits of paternalism nor the classification of erosion control on private lands by the Government as in that category. Suffice to say that in participating in the control of erosion the Government would be taking not only proper but also essential steps in safeguarding the permanent interests of the Nation. This country cannot afford to allow depletion of its soil resources to continue. It must take steps, drastic if need be, to protect its soils from further injury. China has followed a laissez faire policy regarding control of erosion. Large portions of their lands are now eroded beyond use. Japan has at great Government expense assisted its citizens in the protection of their land—even to a point where specific projects could not be justified by even 10 times the land values. Has this not been worthwhile? The problem of soil conservation which confronts this Nation may be compared with that of national defense. No attempt is made to justify the expense based on tangible benefits. The cost of erosion control is often beyond the ability of individual land owners and of the local communities, but this circumstance does not constitute a justification for the Federal Government to decline to take action to meet the situation. The interests of the whole Nation are affected by the injury to its soils. It is only by Federal leadership and liberal expenditure of funds that further serious degradation of the land, with its inevitable injurious consequences, may be prevented.

The recognition of erosion control as a Federal function does not imply that the Government should take over the whole burden of the necessary work. It means rather that the Government would take such action as will actually lead to the introduction on a large scale of preventive and corrective measures for erosion control.

Responsibility of the States.—It may be said that the responsibility for conserving the natural resources rests with the States because they have jurisdiction

over the land, possess the power of taxation and condemnation; and may, if they will, control the use of the land. The States, however, have done little in the way of erosion control beyond research and extension work in cooperation with the Federal Government. There was a similar failure of the States in the protection of forests from fire until the Federal Government offered substantial aid for a systematic protective system to be administered under State direction. It is extremely unlikely that on their own initiative more than a few States will introduce adequate measures of soil control. Unfortunately some States are becoming more and more dependent on Federal aid. This custom has not only developed because of Federal action since the war, but also because of the condition of depression in some commonwealths. Those areas needing erosion control are very likely to be in this class. It is, nevertheless, their responsibility to do their utmost to stimulate immediate interest in corrective measures of such enormous importance and to take part liberally in a joint enterprise, and it is believed that with Federal aid the States would stand ready to contribute a reasonable share of the cost and to administer a program of systematic erosion control, either directly or through the counties or through local conservancy districts organized under State authority.

Responsibility of private owners.—Private ownership of land carries with it the responsibility to refrain from practices which will damage other persons or the general public. There is a certain stewardship attached to land ownership that calls for something opposed to a selfish exploitation and a rapid draining of its resources. Some farmers are among the violators of this trust. The failure of this group and other landowners to employ measures to control the wastage of the soil is jeopardizing large interests of the communities and States where the land is located and of the entire

Nation. There are many reasons—historic, economic, and personal—why destructive methods of soil exploitation have persisted. It is useless to expect most farmers to modify their methods of tillage and cropping without public aid. They should, however, be required to redeem their responsibility as landowners and to use preventive measures of soil conservation, provided the obstacles to better land use practices are lessened or removed.

Public Regulation.—It should be the aim of a policy of erosion control to avoid the necessity for imposing restrictive regulations under the authority of law, on the manner of using land, provided that their purpose may be achieved in some other way. The plan of cooperative public aid, granted with the condition of adoption of constructive measures for erosion control, would be far more effective in practice than direct public regulation. Even with formal regulation, it would doubtless be necessary to provide public aid because the initiation of control measures is beyond the means of many farmers. Resentment against public regulations, difficulties of enforcement, questions of jurisdiction as between the Federal Government and States, great delays or failure of legislation if the method is left to the States, and probable litigation, are among the objections to mandatory legislation, if it can be avoided. Public regulation to prevent destructive methods of land use, should therefore be placed at present in the background as alternative, pending a trial of the principle of cooperative public aid. If the cooperative plan should fail, the public in its own protection would have to resort to regulation.

Cooperative Erosion Control.—A program of Nationwide control of erosion, which would bring into coordination the various public and private agencies concerned, would include the following features:

1. Federal legislation providing for reconnaissance of the lands of the country to determine the areas which are most in need of preventive and corrective measures for the control of soil erosion, the survey to be completed within 5 years. The survey would include also the determination of the character of erosion, the extent of present and prospective damage, and the needed measures for control.

2. State legislation providing for land classification, which would include in greater detail the designation of areas exposed to soil erosion, and which would describe standard measures for controlling erosion.

3. Federal legislation authorizing the annual appropriation by Congress of \$20,000,000 to enable the Federal Government to cooperate, through the States, with owners of land, in the establishment of such measures as may be appropriate for the control of soil



FIGURE 20.—Inexpensive wire and post check dams to curb severe gullying on the Coon Creek Watershed near La Crosse, Wis.

erosion. Where serious situations exist and the States fail to enact legislation in response to the offer of Federal aid, provision should be made for cooperation direct with land owners or responsible local agencies. It should be the policy of the Government ordinarily to expend not more than 50 percent of the cost of the work on a given tract, the balance to be provided by the States or private owners or both. In all cases the farmer should at least contribute his own labor and that of his regular help. Where expensive corrective work in controlling gully erosion is required and large public interests are involved, there should be no rigid limitation to the proportion of Federal contribution. Thus, for example, the work now being performed by the C. C. C. is wholly a Federal expense.

4. Acquisition by the Federal and State Governments of erodible lands unsuited to agriculture and appropriately located for additions to public reservations.

5. Federal legislation for the enlargement of the work of research, experiment, demonstration, and extension teaching now under way.

6. Federal legislation providing for placing the public domain under administration, with funds adequate for the progressive restoration of the vegetation and for other improvements, including those needed in erosion control.

7. State legislation authorizing cooperation with the Federal Government in erosion control.

8. State legislation authorizing the organization of conservancy districts with authority to carry out measures of erosion control as well as for flood control.

9. State legislation providing for erosion-control work, independent of such aid as may be offered by the Federal Government.

10. In addition to Federal participation up to 50 percent of cost, as recommended in "3" above, there should be provisions to lend credit to farmers either direct or through an appropriate agency.

Federal Administration.—An essential element in the success of a national policy of erosion control is efficient administration. At the present time the Federal work in land erosion is chiefly centered in the Departments of Agriculture and Interior. In the former the chief responsibility is carried by the Bureau of Agricultural Engineering, the Bureau of Chemistry and Soils, the Forest Service, and the Extension Service. Most of the other Bureaus in this Department work with these agencies in some features of soil erosion. The newly established Soil Erosion Service is in the Department of the Interior,³ as is also the Geological Survey, which has contributed to the analysis of problems of soil erosion.

³ In March 1935 the Soil Erosion Service was transferred to the Department of Agriculture and became the Soil Conservation Service.

The distribution of the work in soil erosion among a number of bureaus has not so far resulted in unnecessary duplication. Soil erosion cuts across so many aspects of land and water problems, that bureaus dealing with special features of the protection and development of natural resources must of necessity deal with it. If, however, the Nation is to adopt a broad policy of erosion control there should be efficient administrative machinery to insure coordination in planning and in the activities of all bureaus concerned regardless of the executive departments to which they may be assigned. There are many difficulties in undertaking to assemble all work of erosion control in a single department. The problem touches too many lines of endeavor which for other reasons are properly allocated to this one or another department. The same principle applies to other features of governmental work.

The manner of working out this administrative problem will depend on the policy that may be adopted in organizing other work of national planning and the direction of the Federal activities connected with the plans. It is believed that the methods so far used in securing coordination of such undertakings as soil erosion, water conservation and control, public-land administration, land use, and the like, are ineffective. The customary departmental and interdepartmental committee system is only partially successful. Attempts at coordination of effort by the committee plan usually become perfunctory, and they break down when serious differences of opinion arise. In carrying out a national plan there is necessary a centralization of responsibility in an individual or an agency authorized to make decisions. Such an agency should have authority to bring into harmony the plans and activities of all bureaus charged with work connected with soil erosion. In view of the fact that there are similar problems in other lines of public endeavor, it is probable that the coordination of soil erosion would form one of the activities of a Federal agency authorized to exercise general supervision over a broader field of national planning.

State and Local Administration.—The States should establish special agencies or designate existing agencies to cooperate with the Federal Government in a program of erosion control and to perform such functions as may be provided for independently by State legislation. The aim is to organize a State-wide system of erosion control, comparable to the existing system of forest-fire control established as a result of the Weeks' Law of 1911 and the Clark-McNary Law of 1924. Under these laws the Federal Government makes grants to the States for fire protection, to be administered by them through a responsible central agency. The Federal Government then holds the States responsible for the expenditure of Federal funds, and, through the Forest

Service, inspects the work and otherwise cooperates with the State agencies.

In some cases the States may decide to place the responsibility for cooperative erosion control in the hands of local conservancy districts, provided for by State legislation. Federal legislation should provide for this contingency.

Coordination of a Policy of Erosion Control with Other National Policies.—The control of soil erosion is an essential feature in many aspects of national planning, including water conservation, use, and control, agriculture, forestry, grazing, and even in the construction of highways. Large sums of money, both public and private, are involved in working out these problems. The damage resulting from soil erosion may jeopardize these investments; in many cases the expenditures are not justified in the first instance if the land is not protected through adequate control measures. The greatest weakness of national planning, such as has heretofore been undertaken in connection with natural resources, had been the tendency to direct efforts separately toward problems of individual resources, without adequate consideration of coordinate problems of other resources. Coordination of planning for different types of land use has been a cardinal principle in the recent

land-use movement. But there is a singular lack of coordination with problems of stream flow. The flood-control policies have been so far considered with little or no reference to the control of soil erosion. It is obvious that large expenditures in flood control would not be justified if the lands are being so impoverished by erosion that the population to be served is not on a basis of permanence, or if the accelerated erosion would greatly reduce the life and service of the public works themselves. The priority of selection of public works on the streams might be affected by the policies of erosion control and the priority of erosion-control projects be affected by policies of water control and development.

National planning is not new, and definite progress has been made in many national resources. No effective action has been taken to integrate the planning in various features. Thus it will not suffice merely to take erosion into consideration in water control. The planning for both must go hand in hand.

The problem of erosion control is of such a magnitude that it requires a national policy and program. But such a policy and program cuts across the policies and program of water control, forestry, agriculture, etc.; and these, in turn, cut across a broad policy of erosion control.

SECTION VIII

THE FUTURE OF EROSION CONTROL

Control of erosion is the first and most essential step in the direction of correct land utilization on something like 75 percent of the cultivated and cultivable area of the Nation. If the soil is permitted to wash to a condition equivalent to skeletonized land, as already has happened to approximately 50 million acres of formerly cultivated land, with 50 million acres more in about as bad condition, there will be nothing to save insofar as cropping possibilities are concerned, because there can be no sound economic use of such depleted areas, except for trees or permanent grass. Also, if the land is permitted to be stripped of its productive surface layer—the topsoil—as has happened on about 125 million acres of cultivated land, not including the 50 million acres formerly cultivated and now essentially destroyed, the resident farmers are reduced to a condition that frequently, if not generally, amounts to bankrupt farming on submarginal land.

Regardless of our highly successful results with breeding more productive strains of crops and the introduction of new and better species and varieties of crops; in spite of improved cultivation performed with more and better machinery, increased regard for beneficial rotations, and the growing of soil-improving crops, largely increased use of fertilizers and plant disinfectants, and the application of insect control measures; and further, in spite of all the education provided through our agricultural colleges, 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, particularly cotton and corn. 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 1 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 indicates that the comparisons of these 10-year periods are significant.

When it is considered that corn growing has not been pushed onto the marginal and submarginal lands of the

semiarid regions upon any extensive scale, and that the crop has not suffered from any far-reaching, devastating insect or disease scourges, it is impossible to reach any other than the definite conclusion that in a very large way erosion has thwarted our stupendous technical, educational, and practical efforts to increase the yield of this crop.

Results of studies at the soil-erosion experiment stations show decisively that soil wastage under most of the prevailing types of agriculture on erosive soils is going on at rates which menace the future productivity and utility of land for agricultural crops.

The national soil-erosion reconnaissance, as summarized in this report, sets forth the conditions of serious soil wastage over the entire Nation and the need for a national program of soil and moisture conservation.

Since erosion of the soil is an acceleration, and modification in some respects, of the normal process of slow geologic erosion, it is also conditioned by the same major factors of control. These are climate, land gradients in response to diastrophism; parent material, soil formation, vegetation, and the resultants of slope-soil relationships. In a program of soil-erosion control on a national basis, these factors must be related to the susceptibility to erosion of soils when bared by cultivation. The risks to safe use of land must, therefore, be thoroughly evaluated as a basis for determining uses to which land is to be put if soils are to be conserved. Likewise, additional information is required as to methods of erosion prevention and erosion control for all regions of critical soil wastage. Such studies will involve methods of cropping, soil management, and artificial and natural measures of control to be made practicable and applicable to the regions in question.

Together with researches are required effective demonstrations of practices suitable and applicable to the several regions of the country. Such a program of demonstration has been begun by the Soil Conservation Service. Additional demonstration areas are required for unrepresented regions of the country. It is, therefore, recommended that the demonstration program be continued on an adequate basis to meet the needs.

The vital interest of the States and the Nation in the conservative use of soil and moisture resources

requires that the measures discovered and demonstrated, to be effective in erosion prevention and control, be applied generally to cultivated and grazing land subject to wastage. The methods of extending the application of such measures require further study. Provision for general application must recognize the common interest of the landowner, the county, the State, and the Federal Government in the land and its sustained utility and productiveness. This interest suggests an enterprise in which the total cost is shared by the units affected. The ratio of the shared costs is a question to be given thorough examination.

A precedent in the sharing of costs in the protection of private timberland has been established in the Clarke-McNary law. It is probable, however, that a modification of the provisions of this law will be required.

It is recommended that a thorough study be made of the problem of the general application of erosion-control measures to lands in the zones of soil wastage, so as to take advantage of available governmental and State agencies.

Certain it is that there can never be any close approximation of adequate erosion control until all the

land is treated in accordance with the needs and adaptabilities of the different kinds of land. Therefore, a complete, coordinated program of erosion control, as that worked out by the Soil Conservation Service on a demonstrational basis for various representative, sorely affected areas, must be extended to all the land in need of protection. The physical facts involved show that this is an unavoidable fact confronting the American people.

Establishment of the Soil Erosion Service

The Soil Erosion Service was established in October 1933, under the office of the Secretary of the Interior, to administer a grant of \$5,000,000 made by the Federal Emergency Administration of Public Works for erosion work. An additional \$15,000,000 was allocated for the same purpose, of which \$6,000,000 was eventually impounded.

The objectives of the present program of the Soil Erosion Service (now the Soil Conservation Service) are: (1) To demonstrate that the impoverishment and destruction of our remaining areas of good agricultural land, by continuing erosion, can be largely controlled, and (2) to lay the foundation for a permanent national

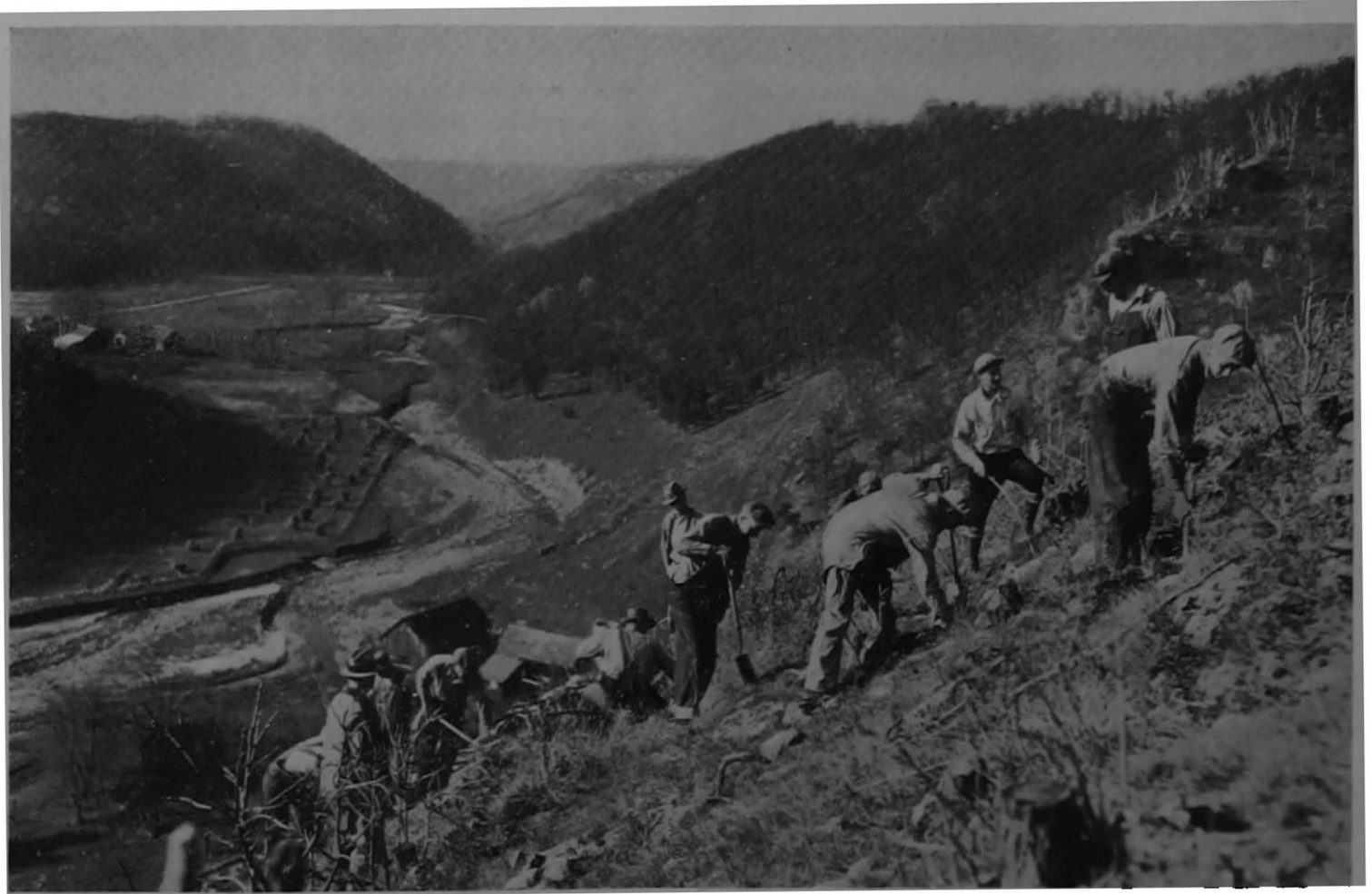


FIGURE 21.—Reforestation—one unit in a coordinated erosion control program. Here a steep hillside is being returned to forests.

erosion-control program of adequate scope to meet the acute land crisis created by wasteful methods of land utilization.

The Problem.—Accelerated soil erosion resulting from improper land-use practices has been manifest since the early settlement of the country. The evil has been speeding up from year to year. It is estimated that the annual cost of erosion amounts to at least \$400,000,000 in directly depreciated soil values, not to count the ultimate cost in terms of land destroyed or impoverished, in the resultant silting of reservoirs, streams and harbors, increased volume and frequency of floods, damage to low-lying fields by overwash of infertile erosional debris, and the impoverishment of farming populations. At least 50,000,000 acres of formerly valuable cultivated land already have been essentially ruined insofar as further practical crop use is concerned; 125,000,000 additional acres, most of them still in cultivation, have been largely stripped of the productive topsoil, with a resultant decline in productivity ranging up to 90 percent. On still other millions of acres of the remaining valuable lands of the Nation, erosion is getting actively underway.

The most conservative estimates, such as leave out of consideration flood damage and the costly problem of silting of reservoirs and streams, indicate that the full value of the land impoverished and destroyed, together with the losses incurred through the creation of stranded populations, already amounts to not less than \$10,000,000,000. Actually, the cost has been much greater than this. It is not possible to calculate the financial equivalent of losses incurred through the destruction of the prosperity of whole regions, the disruption of farming communities, and the scattering of their populations by way of throwing hundreds of thousands of persons upon relief rolls or into a condition of meager subsistence obtained through bankrupt farming on erosion-depleted land. Neither is it possible to calculate the value which the 150,000,000 acres of formerly productive farm land, now either devastated or vastly reduced in value, would have at some future time under conditions of increased population, such as might call for the utilization of every possible productive acre.

Unless the evil is curbed in a far-reaching way, the possible losses from erosion during the next 50 years are obviously enormous. The annual \$400,000,000 direct loss in soil values washed away alone would accumulate to probably not less than \$20,000,000,000. To this would have to be added the values of (1) great reservoirs filled with the products of erosion, (2) the immeasurable cost to the Nation of economic disaster to irrigated areas dependent on such reservoirs, (3) transfer to relief rolls of tremendous farm populations, (4) virtual abandonment of large agricultural sections,

and (5) economic devastation of large western areas dependent on grazing. Furthermore, within something like 50 to 75 years, an estimated area of about 600,000,000 acres of agricultural land (crop and grazing land) will either have been essentially ruined insofar as further important agricultural use is concerned, or will have had its productivity reduced from about 30 to 90 percent. From a future point of view, the value of lands destroyed and impoverished by erosion probably will be measured not so much in terms of the present market value as in terms of the value of the land plus the human values involved. If the evil of unrestrained erosion is permitted to continue, it is possible to predict with a considerable degree of mathematical certainty the time when American standards of living will begin to decline.

Character of the Program.—To meet the threatening situation involved with this wastage of our most basic national resource, the Soil Conservation Service has established a series of representative watershed demonstration areas within the different major geographic and agricultural regions of the country where destructive erosion is prevalent. In each area there has been set up a staff of specialists experienced in the technical aspects of erosion, land, agronomy, and forestry, who have put into effect a practical program of erosion control, seeking not only to protect the land but to increase the absorption of rainfall and to reduce the hazards of floods and silting. This program differs from any other ever undertaken in this country. The plan of procedure is not one of employing single and unsupported implements of attack, but it is definitely one wherein all practical measures of erosion control (which involves control of run-off by increasing absorption of the rainfall) are utilized in a coordinated, correct land-use program. This is not an agronomic program or a soils, forestry, or an engineering program, but a program employing all of these measures in accordance with the needs and adaptability of every acre of land requiring treatment, so coordinated that the integrated activities will support one another to effect complete control of the erosion, flood, and silting problems of entire watersheds.

The procedure followed in the establishment and operation of typical demonstration watershed projects involves the following steps:

(a) The project areas are carefully selected, consideration being given to the representative character of the problems presented therein, their suitability to the application of a unified, well-conceived, effective program of land treatment, and the willingness of the farmers and landowners to cooperate in and help carry out the work. The regional directors are selected on the basis of long experience in related fields of activity, such as executive ability, and knowledge of local soils, agri-

culture, and climatic conditions. Each director is provided with a competent staff of agronomists, soil specialists, agricultural engineers, and other technicians.

(b) The watershed projects, the regional directors, and their staffs having been selected, the next step involves the preparation of a comprehensive practicable plan for control of erosion and reduction of floods and silting over all the lands within the watershed areas. This plan is based on the physical and chemical characteristics of the soils involved, the slopes, the climate, the vegetation, adaptable crops, and the agricultural practices of the area, and applies all known methods of control, chosen for their particular adaptability to the particular situation. In the detailed plans careful consideration is given to the needs of the farm as an economic unit in order that the property owners may not suffer financial loss and that their enthusiastic cooperation may be obtained.

(c) On a basis of carefully prepared land-use plans, 5-year agreements are entered into between the property owners or operators and the Government, whereby the owners or operators agree to carry out the land-use practices advocated by the Soil Conservation Service and to contribute certain labor and materials necessary for construction and installation of control devices, such as check dams, strip crops, terraces, contour furrows, new fences, and relocated fences. In return for these undertakings by the owners or operators the Government agrees to lay out the work, to provide the supplementary labor and material (which the farmer cannot supply) needed to put the cooperatively approved plan into operation, and to furnish seed, trees, and shrubs for the planting of the areas taken out of cultivation because of their highly erosive character and consequent dangerous relation to good lands lying below.

(d) Upon the completion of the cooperative agreements actual field work gets under way and the plans are put into effect as rapidly as it is permitted by the local climatic and agricultural conditions.

An important phase of the program relates to the establishment of practical methods for the utilization of marginal and submarginal lands, since such lands must be retired from cultivation if erosion is to be effectively controlled. When this type of land occurs in a scattered fashion interspersed with productive fields, it is being planted to pasture or trees in such a manner as will make possible the production of supplementary income to replace that which the owners or operators formerly obtained through cropping and other land-use practices that caused exhaustion of their capital-land assets. Where practicable, types of vegetation are utilized which furnish a food supply and coverts for the development of game resources, such as the farmers make profitable use of by disposing of hunting privileges.

A much more difficult land-utilization problem is presented in those regions where marginal and submarginal lands exist in such large blocks that they cannot be profitably operated under private and individual ownership. Where such areas occur, it is the present plan to encourage their purchase by the Federal Government, the States, or the local communities, and to establish thereon State, county, or municipal forest or grazing reserves. These forests, if operated on a perpetual-yield basis, would not only control erosion but would also furnish a stable source of local employment to a considerable percentage of those impoverished farmers now living on the lands which would be purchased.

The object of the erosion-control-demonstration areas is to put into practice those measures of control and correct land use which have been established as effective regional implements of control through experiment and practice. There arise, however, problems and questions which require investigation and special studies if the measures are to be successful to the highest degree. Accordingly, in cooperation with other Federal agencies and with certain non-Federal agencies, the Soil Conservation Service has inaugurated investigations and experiments dealing with (1) the relations between rainfall, stream flow, and water-table levels, on the one hand, and land-use practices on the other; (2) the amount, intensity, and duration of rainfall within the project areas; (3) deposition of eroded material over flood plains and in streams and reservoirs; (4) establishment of geologic norms of erosion; (5) development of new and more economical or efficient methods of controlling erosion; and (6) the effect of soil erosion and erosion-control work on economic and social conditions. It is obvious that adequate information must be obtained on all of these subjects if erosion-control programs are to be carried out on the most practical and economic basis.

Demonstration Watershed Projects.—The 36 erosion-control demonstration projects now under way vary in size for the most part from 25,000 to 200,000 acres, covering a total area of 3,950,000 acres of privately owned land. Each project involves such reorganization of land-use practices and the installation of such measures as are needed to control both wind and water erosion, conserve water, control floods, and place farming on a practical perpetual-yield basis. Approximately 1,380,000 acres have been put under control or 10,000 farms. Out of allotments totaling \$14,000,000 the sum of \$6,751,535 had been spent or obligated February 1, 1935.

Projects on Federally Controlled Land.—Three projects have been established on areas consisting largely or entirely of Federal lands. One on the Navajo Indian Reservation, with an area of 16,000,000 acres; another

comprises the Gila River watershed in Arizona and New Mexico above the Coolidge Dam with an area of 8,200,000 acres; and the third covers the watershed of the Rio Grande River above the Elephant Butte Dam with an area of 11,500,000 acres. The Navajo project is on the lands which contribute vast quantities of silt to Boulder Dam, and involves the preparation and application of comprehensive erosion-control, land-use, and range-control measures. It also involves the reorientation of the entire agricultural-economic system of the 45,000 Navajo Indians. This project has been allotted \$1,600,000 of which \$811,244.82 had been expended or obligated February 1, 1935. The completion of the work will require years and additional funds. The Gila project involves seriously eroded lands which contribute great quantities of silt to the Coolidge Reservoir. The work has been initiated with Civil Works Administration and Emergency Conservation Works labor, under supervision of the Soil Conservation Service. It is estimated that at least \$5,000,000 will be required to complete the stabilization of this important area. The Rio Grande project covers the most densely populated and productive area in New Mexico, now threatened with abandonment because of serious erosion. The Elephant Butte Reservoir subject to rapid silting is also involved.

The Future of the Erosion Control Program

It will be impossible to maintain permanent prosperity over large areas of the United States if the present rapid destruction and impoverishment of our most valuable agricultural lands by accelerated erosion is permitted to continue. This process seriously threatens the welfare of large farming populations and, eventually, will result in the virtual abandonment of large regions and serious impairment of standards of living in other parts of the country, if not vigorously combated without further delay.

These conclusions are not merely expressions of opinion, but rather statements based on physically determined facts. The remedial step that must be inevitably taken is the application of a coordinated land-use and land-protection program applied in accordance with the specific needs and adaptabilities of all valuable land needing treatment. There can be no alternative, and the seeking of one will mean merely the putting off of those things which must be done, with a consequently enlarged and more difficult and costly job pushed off into the future. Whatever may be the wishes or inclinations of the people of the country, this task of fighting increasing land destruction and impairment must continue. This enemy to the continuing welfare of the Nation is out in the open and can never again be driven back into cover by essays, round-table discussions, and the academic opinions of

those who do not know the land, what is taking place on it, and what must be done to save it. Actually the job of control is one of the most difficult that mankind ever undertook, and in America it is by far the most pressing important undertaking standing out ahead of us—one that grows more difficult to handle, as well as more costly, with every succeeding rain heavy enough to cause water to run downhill across unprotected slopes. It can be handled only by pooling the best brains of our specialists, who know the multiplicity of soil conditions stretching across the country, their anatomical constitution, their numerous differing susceptibilities to erosional impairment, and their imminent needs as determined by their physical characteristics. With determined leadership, adequate funds, and national understanding of the importance of overcoming the evil, the battle can be won. Without these things it cannot be won.

The entire problem of erosion control and watershed stabilization is so complex and wide-spread, and the chances for doing ineffective work which would destroy public confidence in the program are so great, it seems evident that the Federal Government must take the initiative in inaugurating and carrying out an adequate national land-use and land-protection program. Furthermore, the problem is interstate in character and its most threatening aspects relate equally as much to national welfare as to the welfare of States, communities, or individuals. Land misuse in the upper Missouri Valley may well contribute to flood damage along the lower reaches of the Mississippi River. Watershed denudation in New Mexico contributes to destructive floods and the silting of Federal reservoirs in Arizona. The creation of stranded farm populations on erosion-depleted land necessitates vast expenditures for relief purposes by the Federal Government. The intensified character of drought damage in the Midwest due to unnecessary loss of rain water through accelerated run-off is reflected in the increased price of foods throughout the entire nation. The Federal Government spends vast sums to reduce crop surpluses, much of which is produced on highly erosive lands that would be removed from cultivation under any intelligent land-use program. Examples of the effect of land misuse on national welfare could be multiplied indefinitely.

The acceptance by the Federal Government of the main responsibility for initiating and carrying out a Nation-wide land-use and erosion-control program, would not in any way imply that the States, their minor subdivisions, and the property owners concerned should not play a highly important part in the work. In fact, it is almost essential that they should play such a part and that they should provide a fair share of the necessary funds. The States in particular would have



FIGURE 22.—Members of the Civilian Conservation Corps building an inexpensive wire and post dam to curb gully erosion, near Minden, La.

to be brought into close cooperation, since in them rests the power to tax and to establish zoning regulations required to control the use and misuse of land. An arrangement will need to be worked out under which the States and the Nation jointly share the responsibility for the program but with the technical control and the general guidance of the work left in the hands of the Federal Government.

To meet the need for a permanent national program of erosion control as outlined above, the Soil Conservation Service has outlined a definite program, both for the fiscal year 1935 and from a long-range point of view. The immediate and long-range plans are outlined hereafter.

Plan for the Fiscal Year 1935

The plan for the Soil Conservation Service program for the fiscal year 1935 involves three distinct fields of operations, namely, erosion-control projects, investigation and surveys, and cooperation with State and Federal agencies. Each of these operations would be directed by the Soil Conservation Service in order that effective coordination and integration of all work will be maintained.

1. *Erosion Control Projects.*—(a) Demonstrational watershed projects. These projects are planned as demonstrational units in agricultural communities. Their purpose is to determine and apply the most effective erosion-control measures that are suitable for the region concerned. It is expected that these demonstrations not only would show methods of erosion control but also determine quite definitely the land-use possibilities of the region. In the first case, the aim would be to apply the policy of prevention in conserving the soil resources. In the latter case, the intention is to furnish definitely satisfactory evidence as to whether or not areas of this nature should be condemned for forestry use, grass lands, or complete abandonment.

The policy is to establish these demonstrational areas in distinct agricultural regions where there is a definite recognition of an erosion problem. The areas for the most part would be approximately 25,000 acres in extent and located, as far as possible, on definite small watersheds. At the present time, many of the States are being zoned into these problem regions. It is intended to place a demonstrational project in each zone as soon as arrangements can be made. In general, the projects should not be less than 100 miles apart. It would then be possible for the farmers in the surrounding territory to visit the areas so that they may carry home with them such methods as they can apply to their own farms.

Although a number of projects are now under way, there are still several agricultural States in which no work is being done. These States would be given priority in the establishment of new projects. On the basis of an expanded program which can be effectively supervised, about 50 general locations for new projects have been tentatively selected. Additional projects could be added should funds be made available. It would require in the neighborhood of 2 to 4 years to effect complete control on each one of these units. The approximate total cost would be from \$200,000 to \$300,000 for each. Some projects should be considerably larger than the average and these would cost more. The benefits of this expenditure would be widely distributed over the country, with each region represented ranging in size from about 2,000 to 5,000 square miles.

(b) Watershed protection: In the western semiarid regions, there are extensive areas where irrigation and grazing are the principal land uses. Erosion here has been very active following severe overgrazing and cultivation of land not suited for agriculture. The greater part of this land lies within the public domain or is under the jurisdiction of the Bureau of Indian Affairs. Erosion both by wind and water now menace these lands as well as the continuity of a satisfactory water supply, and is threatening tremendous Federal investments in reservoirs subject to rapid silting. Many regions must be abandoned in part or in whole unless erosion can be controlled.

The basis of erosion-control work in this part of the United States is that of watershed protection to prevent and check silting of reservoirs, filling of irrigation canals, disastrous gully cutting by torrential rains, and the depletion and destruction of grassland vegetation. Watershed projects are already in operation as described above. It is planned to establish additional projects within the year. Since the lands are largely in Federal ownership or control, practically the entire cost of operations would have to be assumed by the Government. This is in contrast to the demonstrational projects where a large proportion of the cost

of applying control measures will be borne by the landowner himself. Damage resulting from improper agricultural use in these western regions progresses rapidly to land depletion, and it is therefore imperative that proper conservation measures be applied in order that these critical areas may maintain their position of usefulness to the Nation. During the coming year, at least 10 additional large watershed projects are planned for the western arid region. Definite watersheds have been tentatively selected. Each project would require from 5 to 15 years for completion.

(c) Conservancy districts: A demonstration project is already under way in cooperation with the Muskingum Conservancy District of Ohio. The district has now requested the Soil Conservation Service to expand the erosion program to all of the lands under its jurisdiction. The district proposes to bear a substantial share of the costs and to establish regulations protecting permanently any erosion-control work which may be carried out. This would be a highly desirable type of project, since it furnishes a mechanism for an equitable sharing of costs between the Federal Government, the local community, and the landowner. It also would lay the groundwork for a future expansion of the soil-erosion program to all areas needing treatment in cooperation with the States and their subdivisions.

2. *Investigations and Surveys.*—In order that the erosion program may be effective, it will be necessary to make careful investigations concerning the relationships between erosion and the various conditions of soils, slope, climate, and method of land use. In addition, it will be necessary to carry out surveys to furnish an inventory of the present conditions as a basis for future planning.

(a) Erosion and slope survey: During the coming year it is planned to make detailed surveys of each project which may be established, and reconnaissance surveys of larger regions. The detailed survey forms the basis for preparing plans for erosion-control measures on individual farms. The reconnaissance survey would determine the extent and degree of erosion over large areas. These surveys would show not only the degree of erosion, but the slope of the land, the kind of soil, and the present use. They would constitute essential and inseparable parts of any effective program.

(b) Soil and moisture investigations: About 5 years ago the Department of Agriculture established 10 erosion experiment stations in various strategic positions in the United States. These stations have contributed exceedingly valuable information on erosion control. However, a largely expanded program of research must be carried out if the national erosion program is to be carried out most effectively. The Soil Conservation Service plans to carry out such additional research, on the basis of its extensive experience

and knowledge of problems demanding solution. For this purpose an adequate number of experiment stations would be established in representative soil, erosion, and climatic regions. Studies would be made of the rate of erosion under varying soils, slopes, climatic conditions, and land treatments; of water losses under these varying conditions; of the effect on erosion of various field treatments, grazing, land rehabilitation, and reforestation; and of the best types of control measures. The work would be carried out in close cooperation with other Federal agencies and with the States, but the general technical direction should be by the Soil Conservation Service in order that the work may be adapted to its practical needs.

3. *Cooperation with State and Federal Agencies.*—The Soil Conservation Service has been receiving large numbers of requests from other Federal agencies and from State agencies for technical assistance in supervising erosion-control work. These requests have come from both permanent and temporary agencies.

(a) State extension program: Many States have been carrying on for a number of years certain erosion-control activities under the direction of the State extension service. Within the past year, the Soil Conservation Service has established projects in States that had previously been engaged in some phases of erosion work. Many of the States have recognized the difficulties of several agencies working independently on similar problems. They have, therefore, requested the Soil Conservation Service to join with them in a State-wide program of erosion control. Coordination of erosion-control work within the States is essential to provide a harmonious and economical development of this type of undertaking. Men are being trained on the existing projects who have an intimate knowledge of State conditions. These would be available on request to furnish technical assistance to State organizations.

(b) Relief agencies: Within the past 2 years there has been a very decided increase in the development and extension of work relief organizations. These are most generally supported in full by Federal funds. There is now and will be for some time large groups of labor available for constructive work. The present need is to apply this labor under suitable supervision to the type of work which will yield the most permanent benefits to the country.

The Soil Conservation Service is now directing the activities of 51 Emergency Conservation Work camps. Something over five hundred additional E. C. W. camps have been requested. These camps would supplement the work of the demonstrational and watershed-project areas, or they would work at other strategic points.

Another highly important form of relief labor is employed by the State relief administrations. This type

of labor could be very advantageously used for erosion-control work. Throughout the United States there are ample opportunities for the utilization of these people on gully control and the prevention of erosion caused by improperly constructed highways. These people also could be used in connection with labor on demonstration projects. It is essential that careful and adequate supervision be furnished to any work carried out by this relief labor. Many communities have already requested the Soil Conservation Service to furnish such technical supervision. This program should be greatly expanded and the Soil Conservation Service given authority to coordinate and control the work in order that it may be effectively integrated with the national program.

The Long Range Program of the Soil Conservation Service

The long-range program of the Soil Conservation Service would involve the following elements:

1. An adequate expansion of demonstration projects to cover all representative erosion regions and to furnish a satisfactory means of demonstrating and educating farmers in the proper methods of protecting their land from impoverishment.
2. The inauguration and carrying to completion of all erosion work needed on lands owned or controlled by the United States and on watersheds largely composed of such lands draining into Federal reservoirs threatened by premature silting.
3. The carrying out of practical erosion-control measures on large watersheds in the agricultural regions of the United States in cooperation with conservancy districts or other subdivisions of States, and in cooperation with erosion-control associations or similar organizations. This work would be carried out on an equitable cost-sharing basis, under which the Federal Government would provide technical direction and supervision and would establish regulations protecting any erosion-control measures which might be installed. The proportion of the cost borne by the Federal Gov-

ernment, the States, their subdivisions, the associations, and the owners of the land would vary from project to project in each particular instance.

4. An adequate research program would be continued on such a scale as might be necessary to determine the fundamental information upon which effective erosion-control plans are to be based. Such research would of necessity form an integral part of the long-range program. Without it there would be no way of determining in some instances the best measures of control, or even of knowing whether or not under some conditions the measures adopted have been successful.

5. In cooperation with other Federal agencies and with State agencies, the Soil Conservation Service would continue its efforts to educate the public as to the best methods of controlling erosion and as to the need for this type of work. A cooperative effort would be made to carry this important knowledge to the entire country.

6. Should the various types of work relief continue over a period of years, the expanding soil erosion program would offer a rich field of endeavor. No other type of work could be more adaptable to this kind of program, for not only is erosion control essential to the future welfare of the country, but also it furnishes an ever-expanding field of employment to young men who are willing to train themselves as technicians. The Soil Conservation Service would stand ready to supervise such relief work undertakings.

As time goes on, the demonstration program of the Soil Conservation Service would reach its full expansion, and the tendency would be for any additional work to be carried out on the basis outlined in category 3 above. This particular method of procedure, involving work in cooperation with the States, their legal subdivisions, and other qualified organizations, constitutes the best mechanism for carrying control operations to all areas needing treatment, in such manner as would properly distribute the cost of the work and permanently protect the investment of the Government.

SECTION IX
EROSION CONDITIONS BY STATES

**Reconnaissance Erosion
Survey Data by States**

The following tables give a summary of erosion conditions by States, as found by the reconnaissance erosion survey.

The acreages represent areas in which the erosion condition as indicated was found to be the predominating condition, in all cases representing the condition on more than 25 percent of the land so included.

Erosion conditions were expressed by numerical symbols, with 1, 2, and 3 for sheet erosion; 4, 5, and 6 for wind erosion; and 7, 8, and 9 for gully erosion. To express the conditions which were found on any given area, these numerals were used in combination to express the condition of each of the classes found. Following are the individual symbols together with the description of each:

1. Little or no erosion. Less than 25 percent of the topsoil lost.
2. Moderate sheet erosion. Loss of 25 to 75 percent of the topsoil.
3. Severe sheet erosion. More than 75 percent of the topsoil lost. May include losses of subsoil, also.
4. Moderate wind erosion. Small amounts of surface soil removed accompanied by local accumulations.
5. Severe wind erosion. Major amounts of surface soil removed. Usually accompanied by local destructive accumulations.
6. Extreme wind erosion. Soil losses and drifting too severe for cultivation.
7. Occasional gullies.
8. Frequent gullies.
9. Destroyed by gulying.

In the Western States certain geological conditions were found on which specific erosion conditions could not be designated except in a generalized statement. These conditions were classed as follows:

- A. Mesas, canyons, bad lands, rough mountain land.
- R. Barren mountain tops. Areas above timberline.
- W. Scablands, shallow soils with frequent rock outcrop.

A combination of numerals was used to express the prevailing conditions on any given area. Thus 348 indicates that the area has been subjected to severe sheet erosion, to moderate wind erosion, and to frequent or severe gulying.

1. Alabama

TABLE XIII.—Reconnaissance erosion survey of Alabama—acreages within which more than 25 percent of the land has been affected as indicated

	Acres	Percent
Total area (exclusive of large cities and water).....	32,913,588	100.0
Areas with little or no erosion (1) ¹	5,616,861	17.1
Total area affected by sheet erosion.....	25,423,120	77.2
1/4 to 3/4 topsoil lost (2, 27, 28).....	17,182,166	52.2
Over 3/4 topsoil and some subsoil lost (3, 37, 38).....	8,240,954	25.0
Total area affected by gulying.....	22,861,601	69.5
Occasional gullies (17, 37, 37).....	19,908,692	60.5
Severe gulying (18, 28, 38).....	2,947,728	9.0
Destroyed by gullies (9).....	5,181	(?)
Essentially destroyed for tillage (38).....	926,248	2.8

¹ The numbers in parenthesis are symbols for erosion classes. These symbols are explained on pp. 19 to 22.
² Less than 1/10 of 1 percent.

Alabama comprises 32,913,588 acres of land, extending a distance of 330 miles from the Gulf coast north to the Tennessee State line. Of this area 27,296,737 acres, or 82.9 percent, have been damaged by accelerated erosion. Sheet erosion was found to have affected 25,423,120 acres of which 8,240,954 acres have lost practically all of the topsoil and 17,182,166 acres have lost from one-fourth to three-fourths of the topsoil generally.

Gulying was found to prevail on 22,861,601 acres, of which 2,947,728 acres were severely gullied and 5,181 acres were destroyed by gulying.

An area of 926,248 acres was found to have lost practically all of the topsoil and to be so severely gullied that it was destroyed generally for further tillage. This is in addition to the 5,181 acres destroyed by gulying.

The average rainfall is 60 inches on the coast and 50 inches in the northern part of the State. Heavy rains occur frequently, causing large losses of water and soil from the steeper slopes.

Erosion can be best discussed in relation to physiography, soils, and land use. Generally, the greater

the slope, the greater the possibility of erosion. Sandy soils with friable sandy clay subsoils have the capacity to absorb rain-water readily, while the sandy soils with heavy clay subsoils, as well as the clay soils, absorb water slowly and are, therefore, more subject to erosion. A good cover of trees or grass will control erosion on practically any soil; but wherever clean-tilled crops are grown on sloping fields, erosion is almost certain to occur.

In the Limestone Valley province, in the north-western corner of the State, and in a narrow belt extending from Cherokee to Shelby Counties, the soils are mainly heavy in texture, and are subject to severe sheet erosion. Most of these soils occupy smooth topography which accounts for the fact that only about 2 percent has been destroyed by gullying. In many places these soils have lost practically all of the once rich topsoil by sheet erosion, so that the farmers are now cultivating the subsoil. Cotton and corn rows are usually straight which often necessitates plowing up and down the slopes. This practice, together with the continuous growing of clean-tilled crops, such as cotton and corn, on the heavy soils without control of the surface run-off by terraces, contour cultivation, and strip-cropping, has permitted erosion to take a heavy toll.

In the Appalachian Mountain region in the north-eastern corner of the State, most of the soils have friable subsoils and absorb rain water readily. Many of the fields have been terraced and contour cultivation is generally practiced, so that sheet erosion has been retarded and gullying reduced to a minimum on the sandy soils. On the shale and silt loam soils, and on the steep slopes that should never have been cleared of their forest cover, erosion has taken a severe toll. Many of the steep slopes have become badly gullied, washed down to bed rock, and abandoned. Much of the shale soil area is still in forest but even here erosion is very active due to annual burning of the forest litter.

The soils of the Coastal Plains province occupy the largest area of any in the State. They cover the southern half of the State and extend along the western side into Tennessee. The soils are mainly sandy loams underlain by friable sandy clay subsoils. The greater part of these soils have lost from 50 to 75 percent of the topsoil although they have the power to absorb large amounts of water quickly. The great soil losses are due to continuous clean-cultivation of row crops of cotton and corn, and improper handling of the soil. Many deep gullies have been formed, completely destroying much valuable farm land in this soil province by the concentration of excess run-off water and its rush, uncontrolled down the slopes. Not only has much of the valuable upland been stripped of its rich topsoil but thousands of acres of once fertile farm and

pasture lands along the stream bottoms have been covered to various depths by inert soil material. Numerous investigations have shown 6 to 10 feet or more of sands and gravels deposited over the original surface of the first bottom soils in recent years. Many acres of these lands that were once cultivated or in valuable pasture have been abandoned and now support a thick growth of willow, gums, and other water-loving plants. The stream terraces, lying above overflow, have suffered but little from sheet erosion usually, due to the nearly level surface. Included in the Coastal Plain province is an area of soils known as the "Black Belt." This extends across the south central part of the State in an east and west direction and varies in width from about 4 to 20 miles. The soils differ from the other Coastal Plain soils in that they are heavy clays and have or had a black surface soil. The area was named the "Black Belt" by the early settlers because these clay soils had a black surface soil 3 to 6 feet deep. The soils occupy smooth to gently rolling topography favorable to tillage operations and practically all of them have been cultivated. Due to the slowness with which these soils absorb water, the rows were generally run up and down the slope to get rid of the surplus water. This practice greatly accelerated sheet erosion and today this area more nearly represents a "Gray Belt" on account of the exposure of the gray underlying rock from which the black soils were derived. Many landowners now living in this area state that 2 to 3 feet of black soil on some of their fields have washed away within their memory. Up until about 1914, about 90 percent of this area was cultivated, but today only about 10 percent is given to row crops, due mainly to depleted fertility by sheet erosion of the surface soil.

The soils of the Piedmont Plateau in east central Alabama, with the exception of one or two minor series, had in the virgin state a surface covering of 12 to 15 inches of fine sandy loam. The subsoils are mainly heavy clays which absorb water slowly. This, together with the rolling to hilly surface of much of the area, the continuous growing of clean-cultivated crops such as cotton and corn, careless handling of the soil, and cultivation of steep slopes, is responsible for the enormous soil losses, and for the complete destruction for agricultural purposes of numerous fields throughout this soil region by sheet erosion and gullying. Most of these abandoned areas have or will become reseeded to pines, which would stabilize erosion in time were it not for the fact that a high percentage of the woods is burned annually. This not only injures or kills the young trees but speeds up both sheet erosion and gullying by destroying the forest litter. The soil losses and land destruction by sheet erosion and gullying have been so pronounced in the Piedmont soil province that

the Alabama experiment station at Auburn set up an experiment on Cecil clay loam, one of the major soils, to determine the amount of soil loss and to work out methods of erosion control.

The land wastage has been so great in the Piedmont area that the Federal Government, through the Soil Conservation Service, recently established an erosion-control project on 116,000 acres at Dadeville, Tallapoosa County, to demonstrate to farmers in this section the best-known methods of controlling sheet erosion and gullying.

2. Arizona

TABLE XIV.—*Reconnaissance erosion survey of Arizona's acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	72,551,180	100.0
Areas on which erosion conditions were not defined (A).....	37,204,424	51.3
Areas with little or no erosion (1).....	621,349	.9
Total area affected by sheet erosion.....	17,533,280	24.2
1/4 to 3/4 topsoil lost (27, 28, 248, 258).....	15,126,006	20.9
Over 3/4 topsoil and some subsoil lost (38).....	2,407,280	3.3
Total area affected by wind erosion.....	6,523,568	9.0
Moderate wind erosion (4, 47, 48, 248).....	1,320,815	1.8
Severe wind erosion (5, 258).....	4,808,581	6.6
Destroyed by wind erosion (68).....	394,172	.5
Total area affected by gullying.....	32,429,325	44.7
Occasional gullies (17, 27, 47).....	6,632,771	9.1
Severe gullying (18, 28, 38, 48, 249, 258, 68).....	25,796,554	35.6

¹ Include areas with undifferentiated geological erosion.

The total area of Arizona is 72,551,180 acres, of which about half, or 37,204,424 acres, was classed on the reconnaissance erosion survey as rough mountain land, canyons, mesas, scablands, and similar conditions on which erosion conditions were not designated. Included in the erosion class designations for the rest of the State are areas of similar conditions which were too small for separate delineation.

Loss of more than three-fourths of the topsoil was found to be the prevailing condition on 2,407,280 acres, and on another 15,126,006 acres there has been a loss generally of one-fourth to three-fourths of the topsoil.

Gullying was found, in varying degrees of frequency, on 32,429,325 acres, of which 25,796,554 acres were found to be severely gullied generally. However, a considerable proportion of this gullying is normal geological dissection on which accelerated erosion may have been induced by overgrazing or other misuse.

Wind erosion was found to have seriously affected considerable areas. Of the 6,523,568 acres affected by wind erosion in the State, 4,808,581 acres were seriously damaged, and 394,172 acres were essentially destroyed by wind erosion.

Numerous valleys along the major river channels contain belts of soils which are deep water-deposited

sediments. Many rugged buttes and mountain summits border the valleys which have become partly buried by the valley-filling material. These deposits are largely the product of normal geological erosion.

In the northern part of the State, largely within the Colorado River Basin, the region abounds with very extensive mesas, or tablelands, deep box-like gullies, and miles of deep rugged canyons. Sheet erosion is generally moderate, but there are local areas where the surface soil has been entirely removed. Wind erosion is locally active. Gully erosion is severe everywhere except in a long narrow belt lying between the Colorado River and the Mogollan rim.

In the northeastern part of the State there is an elevated, mountainous region which has a protective cover of forest and heavy brush, and where there is a minimum of all forms of erosion. This is the only extensive forested area in the State. South of this body and paralleling it from Phoenix eastward is the Salt River Basin, an intricately eroded region in which tree growth is more scattering, large areas are thinly covered with brush, and both sheet and gully erosion are active and severe.

In the region west of Prescott the mountain descends to the desert plain in a series of sharply rolling hills and low mountains, where the main drainage ways occupy narrow V-shaped canyons. The soils are largely coarse textured, gritty types derived from the igneous formations, and are very susceptible to the action of moving water. The entire region has been heavily overgrazed so that serious sheet and gully erosion are wide-spread.

The remainder of the State, the southwestern portion, is an extensive plain with several north and south trending, narrow, mountain ridges. These ridges are almost devoid of soil mantle. Sheet and wind erosion are generally active on the plain, and gully cutting is serious in many localities.

The Soil Conservation Service has established two erosion-control projects which include parts of Arizona. The Navajo project includes 16,000,000 acres in north-

3. Arkansas

TABLE XV.—*Reconnaissance erosion survey of Arkansas—acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	33,619,407	100.0
Areas with little or no erosion (1).....	17,601,559	52.4
Total area affected by sheet erosion.....	8,940,409	26.6
1/4 to 3/4 topsoil lost (2, 27, 28).....	7,721,625	23.0
Over 3/4 topsoil and some subsoil lost (3, 37, 38).....	1,218,784	3.6
Total area affected by gullying.....	14,894,641	44.3
Occasional gullies (17, 27, 37).....	13,285,144	39.5
Severe gullying (28, 38).....	1,589,573	4.7
Destroyed by gullies (9).....	48,624	.1
Essentially destroyed for further tillage (36).....	990,810	2.9

eastern Arizona, northwestern New Mexico, and southern Utah. The Gila River project embraces 8,200,000 acres in southeastern Arizona and southwestern New Mexico. On these projects, located largely on public lands, efforts are being made to control wide-spread erosion, and to control the silting which threatens the permanence of the large reservoirs, largely by regulating grazing.

The total land area of Arkansas is 33,619,407 acres of which nearly half is suffering from accelerated erosion.

Little or no erosion occurred on 17,601,039 acres, mostly the broad level alluvial or delta lands along the eastern side of the State and the Southern Ozark timbered section.

Gullyng affected an area of 14,894,041 acres and was found with varying degrees of frequency. Part of the gullyng was due to normal geological dissection which was undifferentiated in the mapping. Severe gullyng occurred on 1,580,273 acres generally, and 48,624 acres were destroyed for cultivation.

Of a total of 8,940,409 acres affected by sheet erosion, 7,721,625 acres were found to have lost prevalingly one-fourth to three-fourths of the topsoil. Over three-fourths of the topsoil was removed generally from 1,218,784 acres, which are largely submarginal for the production of clean-tilled crops.

Arkansas lies in four general physiographic regions: (1) the northern Ozark region, (2) the southern Ozark region, (3) the Coastal Plains section, and (4) the flood plains and alluvial deltas which occur along the five principal rivers of the State.

Occasional gullies occur in the northern Ozark section, which is for the most part included in national forest where there is little or no sheet erosion. A few scattered farms are found along the streams. Practically all of the cultivated land in this section is subject to severe erosion.

The southern Ozark section, with a number of small valleys and inter-prairie sections, presents some of the worst erosion in the State. There are a number of small farms where considerable areas of cotton, corn, and truck have been grown, frequently on steep slopes. Many farmers have allowed large portions of their farms to remain idle for a number of years, with the result that erosion has rendered the land unfit for cultivation.

The Coastal Plains region, which consists of the southern third of the State, is characterized by a rolling topography, with reddish colored, friable soils, which are largely silty clay loams and clay loams. The usual annual rainfall is high, normally between 35 and 50 inches. The greater part of this section is covered with pine and oak. Forest fires occur so frequently that gully erosion has gained considerable headway

over much of the timbered section. Much of the farming that is done consists of small fields of cotton and sorghums, which have suffered severe erosion losses generally.

In the eastern part of Arkansas, on a narrow belt of the Coastal Plain known as "Crowleys Ridge", there is probably the most severe erosion in the State. The loessial soils, generally silt loams and clay loams, are subject to extremely severe erosion. This was, at one time, one of the best upland sections of the State, with extensive acreages of cotton and corn, but erosion has destroyed many of the once fertile fields.

The broad alluvial areas of delta lands located principally along the eastern side of the State do not present serious erosion problems.

In the State as a whole, farming of steep slopes and frequent forest fires have been, by far, the most important factors in permitting erosion.

The Soil Conservation Service in 1934 located an erosion-control project of 116,000 acres on the watershed of East Cadron Creek with headquarters in Conway. This project, carried out in cooperation with the farmers, is demonstrating in a practical way the methods of erosion control and moisture conservation. Another similar project involving 32,000 acres has recently been located on Crowleys Ridge.

4. California

TABLE XVI.—*Reconnaissance erosion survey of California*¹—*Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	99,634,672	100.0
Areas on which erosion conditions were not defined (A).....	423,372	.9
Areas with little or no erosion (1).....	52,112,417	52.3
Total area affected by sheet erosion.....	38,020,668	38.1
$\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 25, 27, 28).....	34,914,320	35.0
Over $\frac{3}{4}$ topsoil and some subsoil lost (3, 37, 38).....	3,106,348	3.1
Total area affected by wind erosion.....	1,909,104	2.0
Moderate wind erosion (4, 46).....	33,080	(²)
Severe wind erosion (5, 25, 57, 58).....	1,566,531	1.6
Destroyed by wind erosion (6).....	309,753	.4
Total area affected by gullyng.....	22,659,116	22.7
Occasional gullyng (17, 27, 37, 37).....	15,519,778	15.6
Severe gullyng (18, 28, 38, 48, 56).....	6,824,377	6.8
Destroyed by gullies (9).....	314,461	.3

¹ Includes areas with undifferentiated geological erosion.

² Less than $\frac{1}{10}$ of 1 percent.

The total land area of California is 99,634,672 acres. Little or no man-induced erosion occurs over 52.3 percent of the State, or on 52,112,417 acres. Of this area 19,175,640 acres are in national forests.

In the eroded areas, a loss of from one-fourth to three-fourths of the topsoil was found to be the prevailing condition on 34,914,320 acres, and 3,106,348 acres had lost generally over three-fourths of the topsoil and some subsoil.

Gullyng was prevalent over 22,659,116 acres with varying frequency, of which 6,824,877 acres were severely gullied generally. Much of the gullyng, especially in the more arid sections, is normal geological dissection. Deep, steep-sided, and canyon-like gullies occur. Accelerated erosion was induced in places by partial denudation of vegetation by overgrazing and other misuse.

Wind erosion was found to have affected 1,999,164 acres and was severe on 1,566,331 acres causing considerable damage to young plants; 399,753 acres were found essentially destroyed by wind action.

The southeastern part of the State is a desert plain with mountainous uplifts which have a general east and west trend in the southern part, and a northern trend above Barstow. Both wind and water erosion are active. A considerable portion of this area consists of large mesas of moving sand. The mountain slopes are largely barren, and the run-off from torrential rains is increasing the extent of the gullies and large washes.

The principal argicultural sections of the State are largely confined to the valleys. Many of these limited alluvial plains have fringing belts of gentle slopes which rise from the river valley level to the foot of the steep mountain slope. In these valleys erosion is generally stabilized, but there are localities where, due to careless farming, overgrazing, or fires, great losses of soil and water have occurred with considerable damage to property.

The Sacramento and San Joaquin Valleys have extensive irrigated sections. The soils and slopes of the valleys are not especially subject to erosion, but the many streams which come down into the valleys are frequently highly charged with silt and sand from the overgrazed slopes and mountains above. This material is deposited in the irrigation channels, causing much damage and making upkeep costs excessive. On the extreme northern border of the Sacramento Valley, large industrial smelters have released fumes, killing vegetation on the surrounding territory. This causes rapid run-off of water, severe erosion, and serious menace from floods throughout the lower valleys.

The coastal section has become the most intensive farming region in the State. The level to undulating areas have been much used for row crops and truck, with frequent severe erosion. Much of the southern coastal section is occupied by citrus orchards. If the orchards are laid out and planted on the contour, good control of erosion is possible, but careless arrangement results in heavy losses of soil.

Three erosion control demonstration projects have been located in California by the Soil Conservation Service. These projects involve a total of approximately 123,000 acres on three watersheds in southern California.

The control of erosion is even more necessary in this region where costly reservoirs which supply water for irrigation are threatened with rapid silting.

5. Colorado

TABLE XVII.—*Reconnaissance erosion survey of Colorado*¹—*Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	66,401,445	100.0
Areas on which erosion conditions were not defined (A, W, B).....	12,871,768	19.4
Areas with little or no erosion (1).....	257,068	.4
Total area affected by sheet erosion.....	13,467,612	20.3
14 to 34 topsoil lost (2, 27, 28, 257, 258, 247).....	6,664,258	10.0
Over 34 topsoil and some subsoil lost (3, 27, 28, 348).....	6,803,354	10.2
Total area affected by wind erosion.....	29,335,723	44.2
Moderate wind erosion (4, 47, 48, 247, 348).....	20,551,511	31.0
Severe wind erosion (5, 37, 58, 227, 228).....	8,986,132	13.1
Destroyed by wind erosion (6).....	85,080	.1
Total area affected by gullyng.....	39,382,532	59.3
Occasional gullies (17, 27, 37, 47, 247, 57, 257).....	22,791,327	35.6
Severe gullyng (18, 28, 38, 48, 248, 258, 58).....	15,516,594	23.4
Destroyed by gullies (9).....	74,131	.1

¹ Includes areas with undifferentiated geological erosion.

The total area of Colorado is 66,401,445 acres on less than 1 percent of which little or no erosion was found. However, on the reconnaissance erosion survey, 12,871,768 acres, or 19.4 percent of the State, were classed as rough mountain land, barren mountain tops, canyons, mesas, scablands, and similar conditions on which erosion conditions were not designated. Included in the erosion class designations for the rest of the State are areas of similar conditions which were too small for separate delineation.

Severe sheet erosion was found to have removed more than three-fourths of the original topsoil generally from 6,803,354 acres, and one-fourth to three-fourths of the topsoil has been lost from an additional area of 6,664,258 acres.

Gullyng was found, in varying degrees of frequency, to prevail generally on 39,382,532 acres, of which 15,516,594 acres were severely gullied.

Wind erosion was found to have affected 29,335,723 acres generally. Of this area 8,686,132 acres were seriously eroded and 88,080 acres were essentially destroyed by wind erosion.

The eastern one-third of Colorado which lies east of the Rocky Mountains is suffering from wind erosion. The annual rainfall in this semiarid section is less than 15 inches. The soils of the broad open plains are fine sandy loams, principally, derived from the Tertiary outwash material. Extensive overgrazing has caused the grass cover to become sparse, permitting wind erosion to become severe. In the southern portion of this area, large acreages have been planted to wheat since the development of modern power machinery. The lack of a surface covering on these areas during

the winter and spring months has permitted enormous losses of soil by both wind and water erosion. As the organic matter became depleted, water was absorbed less readily, and blowing became more severe. Great clouds of dust and soil are common over this entire area during and after each windy day.

Dry-farming methods have permitted increased losses of soil by the agencies of water erosion. On these shallow soils with a loose, open structure, rapid run-off with attendant severe losses of soil are common after a sudden downpour of rain. The run-off waters become concentrated, producing numerous small gullies, a condition which is common throughout the eastern and northern portion of this area. Large areas of the broad ranges have had the surface soil almost completely removed by wind and water erosion.

The western half of the State, which lies in the western mountains and intermountain basin region, is to a large extent subject to normal geological erosion. With over 13,000,000 acres of this State in national forest, the problem of accelerated erosion over the major portion of this protected area is minimized. In many of the interbasin sections where the only precipitation is in the form of winter snows, freezing, and thawing have caused considerable erosion, which has been increased in some places by destructive farming or overcutting of the timber.

The Soil Conservation Service has recently established a demonstration soil erosion control project on 328,000 acres in eastern Colorado, where every practical method will be used to control both wind and water erosion on the cooperating farms.

6. Connecticut

TABLE XVIII.—*Reconnaissance erosion survey of Connecticut—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	3,084,800	100.0
Areas with little or no erosion (1).....	2,899,643	94.0
Total area affected by sheet erosion: $\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 27).....	184,376	6.0
Total area affected by gullyng: Occasional gullies (17, 27).....	1,562	.1

Erosion is not an extensive problem on the land area of 3,084,800 acres of Connecticut. This is due to the fact that much of the land is maintained in forest, and a considerable portion of the farm land is used for pasture or grass. An area of 184,376 acres, or 6 percent of the State, was found to be affected by moderate sheet erosion, by which one-fourth to three-fourths of the original topsoil has been removed generally. Of this area, 1,562 acres have occasional gullies.

Most of the erosion occurs on the red soils in central Connecticut, and in the limestone valleys of the

western part of the State. Some of the sandy soils in the Connecticut Valley are subject to wind erosion, although no areas were observed which were sufficiently large to be shown on the reconnaissance map.

7. Delaware

TABLE XIX.—*Reconnaissance erosion survey of Delaware—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	1,255,452	100.0
Areas with little or no erosion (1).....	1,172,951	93.4
Total area affected by sheet erosion: $\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 27).....	82,501	6.6
Total area affected by gullyng: Occasional gullies (27).....	40,000	3.2

The reconnaissance erosion survey revealed that 1,172,951 acres, or 93.4 percent of the total land area of 1,255,452 acres in Delaware were not subject to noticeable erosion, due primarily to the level topography and open porous nature of the soil.

In the northern part of the State, a loss of one-fourth to three-fourths of the topsoil was found to be the prevailing condition on 82,501 acres, on the rolling lands where clean-tilled crops have been grown with tillage lengthwise of the fields, irrespective of direction of slope. Nearly half of this land, or 40,653 acres, was found to be moderately gullied also.

8. Florida

TABLE XX.—*Reconnaissance erosion survey of Florida acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	35,451,177	100.0
Areas with little or no erosion (1).....	33,190,962	93.6
Total area affected by sheet erosion: $\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 27, 28).....	2,246,664	6.3
Total area affected by gullyng.....	827,006	2.3
Occasional gullies (17, 27).....	817,041	2.3
Severe gullyng (18, 28).....	9,964	(¹)

¹ Less than $\frac{1}{16}$ of 1 percent.

The reconnaissance erosion survey covered 35,451,177 acres in Florida. Little or no erosion was found on 33,190,962 acres, or 93.6 percent of the State. Moderate sheet erosion with a loss of from one-fourth to three-fourths of the topsoil was observed on 2,246,664 acres; occasional gullies were found on 817,041 acres and 9,964 acres were severely gullied.

Florida has a warm climate and a high rainfall. The average annual rainfall is 60 inches in the northern part of the State where the eroded area occurs. Heavy downpours are common, as much as 13 inches in 24 hours having been recorded at Pensacola in the summer of 1934. These heavy rains cause severe erosion on the cultivated slopes where the fields are not properly terraced and protected by thick-growing crops.

Erosion is not serious over the State as a whole but is confined mainly to the cultivated soils in the north-western part of the State. Over most of the State the topography is smooth and the greater part of the land is wooded. Moreover, most of the soils are sandy and absorb large amounts of moisture readily.

In the counties bordering the Alabama and Georgia State lines, sheet erosion has caused a loss of 25 to 75 percent of the surface soil on much of the sloping land that is cultivated; scattering gullies develop with sheet erosion, but severe gulying is not common. The most serious erosion observed in the State was in the north-western part of Jackson County.

No extensive experiments or demonstrations of soil-erosion control have yet been located in Florida.

9. Georgia

TABLE XXI.—*Reconnaissance erosion survey of Georgia—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	37,568,324	100.0
Areas with little or no erosion (1).....	14,932,708	39.7
Total area affected by sheet erosion.....	22,128,263	58.9
14 to 24 topsoil lost (2, 27, 28).....	15,905,598	42.3
Over 24 topsoil and some subsoil lost (3, 27, 28).....	6,222,655	16.6
Total area affected by gulying.....	20,132,288	53.6
Occasional gullies (17, 27, 27).....	17,436,924	46.4
Severe gulying (28, 28).....	2,263,403	6.0
Destroyed by gullies (9).....	231,961	.6
Essentially destroyed for tillage (38).....	1,607,092	4.3

The reconnaissance erosion survey covered 37,568,324 acres in Georgia, on 14,932,708 acres, or 39.7 percent, of which there was little or no erosion. Sheet and gully erosion were found to be wide-spread. Over three-fourths of the topsoil was found to have been lost generally from 6,222,655 acres, and a loss of one-fourth to three-fourths of the topsoil was found to be the prevailing condition on 15,905,598 acres more. Gulying, in varied degrees of frequency, was found to have affected nearly all of the land that was subject to sheet erosion. An area of 231,961 acres was completely destroyed by gulying, and 2,263,403 acres more were severely gullyed. A total area of 2,139,053 acres has been essentially destroyed for further cultivation generally by the combined action of sheet and gully erosion.

Erosion conditions in Georgia are closely related to the soil, slope, and land-use factors, which in turn are closely associated with the four major physiographic regions of the State. The southern three-fifths of the State is in the Atlantic and Gulf Coastal Plain; the Piedmont Plateau comprises about one-fifth of the State north of the Coastal Plain; the Appalachian Mountains occupy the northeastern corner; and the Limestone Valleys are in the northwestern corner.

The lower or seaward portion of the Coastal Plain occupies nearly level or gently undulating topography on which erosion is unimportant generally.

The middle Coastal Plain occupies undulating to moderately rolling topography with sands and sandy loam soils which have friable sandy clay subsoils predominating. In this region serious erosion is localized in widely scattered small areas which are subject generally to sheet erosion and occasional gulying.

The upper Coastal Plain borders the Piedmont Plateau across the State, being very narrow at the eastern side but extending from the Piedmont Plateau to Florida on the western side. The soils are predominantly sandy loams with friable red sandy clay subsoils and include some of the most desirable soils in the State. The topography varies from nearly level to steeply hilly. Erosion has been severe on the hilly lands which have been cultivated. In many sections the subsoils are underlain at 6 to 10 feet by loose sands. When gullies penetrate through the soil and subsoil into these underlying, loose sands, the rate and size of growth increases greatly. By some careless farm practice, gullies have been started which have grown to 100 feet and more in depth, and have developed radiating prongs which have engulfed and ruined the major part of the farm in a period of about 50 years. This is especially significant in that land ruined by these gullies includes some of the most productive and most desirable lands in the State. Although certain sections of the upper Coastal Plain present major problems of erosion control and some of the most difficult to solve, the land is some of the most valuable for agriculture. Active erosion on the destroyed lands should be stabilized to protect the adjacent agricultural lands.

The Fall Line Hills consists of a narrow irregular belt extending across the State at the junctions of the Coastal Plain with the Piedmont Plateau. It comprises a series of ridges and hills, deeply dissected, where the soils are predominantly Coastal Plain sands and sandy loams intermixed with residual clays. Although much of this land is not productive and is not well adapted to cultivated crops, severe erosion has been induced by frequent fires on the forested lands and by ill-advised attempts at cultivation on scattered steep areas.

The Piedmont Plateau has gently rolling to steeply hilly topography which is intricately dissected, generally, by drainage ways. The soils are sandy loams, clay loams, and clays, with hard brittle subsoils, generally. Under the original forest conditions probably the major portion of this area had sandy loam surface soils, but due to destructive erosion incident to tillage, a large part of the sandy loams have become eroded clay loams and clays.

Severe erosion is wide-spread in this part of Georgia, although contour cultivation and terracing have been

practiced 40 years or more. Slopes have been cultivated which were too steep, and much land has been cleared which should have been left in forest. Erosion has been rapid and severe in the hilly parts of this section since initial cultivation due to high rainfall and to soils which have relatively impervious or slowly pervious subsoils. Nearly all of the forested land in the hilly sections supports second-growth forest which has grown on fields that were abandoned due to erosion.

In the Appalachian Mountains of northeastern Georgia erosion generally is not severe. Most of the land is forested, especially the strip land. Cultivation is restricted to the valley bottoms and lower slopes. Occasional small patches have been cultivated on slopes so steep that they have become ruined by erosion, especially gullying.

The Limestone Valley section of northwestern Georgia is characterized by flat-topped high ridges or mountains, and relatively wide valleys. Although many steep slopes and rough hilly sections of the valley bottoms have been cultivated in the past, most have been abandoned due to severe washing and are now covered with second-growth forest which has stabilized the erosion generally. Present cultivation is confined mainly to the smoother valley bottoms where erosion is serious only on the hills and knolls.

The seriousness of the erosion problem in Georgia had been recognized for some years, but no agency had made any worth-while attempt to combat it until erosion-control projects were established near Athens in the Piedmont Plateau section and near Americus in the upper Coastal Plain to demonstrate efficient methods of proper land use for erosion control upon every farm within the 132,000 acres in the projects.

10. Idaho

TABLE XXII.—*Reconnaissance erosion survey of Idaho*¹—*Acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	53,285,767	100.0
Areas on which erosion conditions were not defined (A, W, R).....	4,412,016	8.3
Areas with little or no erosion (I).....	21,045,762	39.5
Total area affected by sheet erosion.....	27,207,836	51.0
1/4 to 3/4 topsoil lost (27,20, 24, 247, 25).....	19,940,564	37.4
Over 3/4 topsoil and some subsoil lost (27, 38, 347, 348).....	7,267,272	13.6
Total area affected by wind erosion.....	7,922,498	14.9
Moderate wind erosion (24, 247, 247, 348).....	6,094,547	12.6
Severe wind erosion (25).....	807,798	1.1
Destroyed by wind erosion (4).....	620,153	1.2
Total area affected by gullying.....	26,294,744	49.3
Occasional gullies (27, 37, 247, 347).....	13,372,356	25.1
Severe gullying (28, 38, 348).....	12,922,388	24.2

¹ Includes areas with undifferentiated geological erosion.

The total area of Idaho comprises 53,285,767 acres of which nearly half, or 21,045,762 acres, was found

to have little or no erosion problem. In addition to this area with little or no erosion, 4,412,016 acres more were classed on the reconnaissance erosion survey as rough mountainous land, canyons, mesas, scablands, and similar conditions on which erosion conditions were not designated. These represent areas of normal geologic erosion. Scattering areas with similar geologic conditions which were too small for separate delineation are included also in the 27,827,989 acres on which erosion problems were found in the State.

Over 19,000,000 acres in the rugged mountainous sections of the State are included in national forests. Grazing regulations within these forests are strict, and, insofar as possible, fires are kept out. However, wherever burning has been severe, erosion has been severe and destructive on the steep mountain sides.

About 9,300,000 acres are included in farm lands, comprising about 17 percent of the area of the State. Of this land in farms almost 2,000,000 acres are irrigated lands in the Snake River Plains.

A total area of 27,207,836 acres, or 51.0 percent of the State, was found to have been affected by sheet erosion. Of this area, 7,267,272 acres were found to have lost generally more than three-fourths of the topsoil and on an additional area of 19,940,564 acres the prevailing condition was a loss of one-fourth to three-fourths of the topsoil.

Gullying was extensive and occurred on nearly all of the sheet eroded lands. Severe gullying was found to prevail on 12,922,388 acres of the total area of 26,294,744 acres subjected to gullying.

Wind erosion was found to have affected 7,922,498 acres of which 620,153 acres were essentially destroyed, and 607,798 acres were severely affected.

The annual rainfall of the State varies from 9 or 10 inches in the Snake River Plains areas in the southern part of the State to over 25 inches in the northern or Panhandle section. A large proportion of the precipitation, particularly in the Palouse section in the Panhandle, falls between the months of September and May.

Because of the extremely variable topography in the State there are many different types of erosion. The natural forces of geological erosion are accelerated in the unprotected forested areas by fires and by overgrazing because of the reduction of protective vegetative cover. Uncontrolled grazing is carried on over the public domain. Attempted dry farming in some areas is now known to be futile in the lower rainfall belts.

The general erosional conditions within the State may be divided between the Snake River Plains in the southern part and the central and northern mountainous region. In the first area, a broad plain borders the Snake River for nearly the entire distance across the State, and, with some increase in elevation, extends

for several miles back from the stream. A considerable number of low mountain elevations are scattered across the southern portion of the plain. Within the smoother areas surface erosion is of slight to moderate intensity, but wind erosion has been severe on about 600,000 acres. In the rolling districts paralleling the plain, gully erosion is moderate to severe. Considerable areas of shallow soils or "scabland" are present within the plains areas, which consist of basalt rock which is bare or thinly covered with loessial material. This condition is present along many of the stream valleys.

North of the plains smooth valley lands are of limited extent and the topography ranges from rolling plains in the Palouse region to rugged, high, steep mountains and deep canyons. Throughout a large part of this region, erosion is not serious, due, mainly, to an effective vegetative cover, but the rolling Palouse region has undergone severe losses of surface soil, with active gully cutting, due, in a large part, to the system of fallowing land for the dry farming of wheat.

11. Illinois

TABLE XXIII.—*Reconnaissance erosion survey of Illinois—Acreages within which more than 85 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	35,875,638	100.0
Areas with little or no erosion (1).....	21,496,526	59.9
Total area affected by sheet erosion.....	14,084,976	39.3
4 to 34 topsoil lost (2, 27, 36).....	13,241,233	36.9
Over 34 topsoil and some subsoil lost (38).....	843,743	2.4
Total area affected by wind erosion.....	294,136	.8
Moderate wind erosion (4).....	131,126	.4
Severe wind erosion (5).....	163,010	.4
Total area affected by gullying.....	13,666,490	38.1
Occasional gullies (27).....	8,067,175	22.5
Severe gullying (28, 30).....	5,599,315	15.6
Essentially destroyed for tillage (38).....	843,743	2.4

The land area of Illinois covered by the reconnaissance erosion survey is 35,875,638 acres. Erosion was found to be wide-spread but was most severe in the southern part of the State and along the Mississippi River and its larger tributaries. Erosion is slight or inactive in 60.2 percent of the State on the broad, level to gently undulating interstream divides extending from north to south through the central and eastern portions.

Sheet erosion was found to have affected 14,084,976 acres generally, of which 13,241,233 acres have lost one-fourth to three-fourths of the topsoil and 843,743 acres have lost over three-fourths of the topsoil. This latter area is also severely gullied, rendering the land submarginal for agricultural use. Gullying was found to be severe generally on an area of 5,599,315 acres, out of a total area of 13,666,490 acres on which gullying was observed.

Wind erosion is of minor importance in the State, although its effects were observed on 294,136 acres, of which 163,010 acres were seriously affected. Wind erosion is confined mainly to river-bottom lands and terrace positions.

The most severe sheet erosion and severe gullying occurs in the southern tip of the State which has been unglaciated. This territory is covered with a rather thin layer of loess over residual limestone. This area has extremely rough topography. It was originally mostly forested, which has been cut over and cleared. This area has been so badly eroded and gullied that reforestation is probably the most feasible way of handling much of the land.

The loess soils, which border the Mississippi and the Illinois Rivers, are classified as more than 100 inches thick, and while sheet erosion is quite severe it is less than one would ordinarily expect upon the rolling topography. The porous character of the soil material which allows deep percolation and absorption of the moisture explains in part this condition. Much of this region is a general farming area rather than an intensively cultivated area and this has assisted in holding the soil. Gully erosion, however, is becoming serious. Deep canyons develop that are very difficult to control.

On some of the more gently rolling areas that are underlaid by a tight clay subsoil or in those areas that are underlaid by an impermeable calcareous drift, sheet erosion is more important than gullying. Under these conditions the surface layers become saturated and virtually layers of topsoil begin to move down slopes of 3 percent or more. This type of erosion goes on unnoticed until clay points have become plainly evident.

The areas suffering most from wind are largely dune sand. They vary considerably in organic matter content and resistance to wind erosion. Where these light sandy soils are cultivated frequent windbreaks or controlling vegetation are necessary. The principal centers of wind erosion are in Mason, Kankakee, and Whiteside Counties.

An erosion control demonstration project was started in 1934 along the Sangamon River watershed consisting of 140,000 acres. This area is one in which sheet erosion has been an important factor in reducing yields of crops. An attempt is being made to introduce farm practices that will reduce washing and thus save the very valuable topsoil.

The total land area of Indiana is 23,068,800 acres, of which 13,235,900 acres or 57.4 percent showed little or no erosion.

Sheet erosion was found on 9,193,401 acres or 39.9 percent of the State. From one-fourth to three-fourths of the topsoil was removed from 7,668,043 acres generally, while 1,525,358 acres have lost prevalingly over three-fourths of the topsoil and some subsoil.

12. Indiana

TABLE XXIV.—*Reconnaissance erosion survey of Indiana—acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	23,068,800	100.0
Areas with little or no erosion (1).....	13,235,900	57.4
Total area affected by sheet erosion.....	9,193,401	39.9
$\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2-27-28-247).....	7,668,043	33.2
Over $\frac{3}{4}$ topsoil and some subsoil lost (2-37-38).....	1,525,358	6.6
Total area affected by wind erosion.....	643,467	2.8
Moderate wind erosion (4-247).....	613,317	2.7
Severe wind erosion (5).....	21,819	.1
Destroyed by wind erosion (9).....	8,331	(1)
Total area affected by gullyng.....	7,091,622	30.7
Occasional gullies (27-37-247).....	4,502,680	19.5
Severe gullyng (28-38).....	2,588,942	11.2
Essentially destroyed for tillage (38).....	1,442,445	6.3

¹ Less than $\frac{1}{10}$ of 1 percent.

Gullyng occurred on 7,091,622 acres with more or less frequency, being severe on 2,588,942 acres of this area. On 1,442,445 acres in the southern part of the State, severe sheet erosion and gullyng had essentially destroyed most of the land for cultivation.

Wind erosion was found on 643,467 acres, of which 21,819 acres have been seriously affected and another 8,331 acres were destroyed for cultivation. Wind erosion, found mostly in the northern and northwestern parts of the State on the sandier soil types, has caused the formation often of dunes and low ridges. Many of these low, dune-like deposits of sandy soils are now fairly well stabilized by sparse vegetation and scrub oaks. In the upper two-thirds of the State, lack of erosion has been due, to a large extent, to a predominately undulating to flat topography, although on several extensive areas and on smaller localized acreages both sheet erosion and gullyng have developed on gently rolling to strongly rolling lands. Sheet erosion in the northern half of the State is confined to the more rolling lands, usually along stream courses or the slopes of glacial moraines. Sandy soils are frequent in these locations and, where the surface soil is underlain by a heavy, tight, impervious subsoil, erosion is more serious. Generally, one-fourth to three-fourths of the original topsoil has been lost from the eroded areas although there are a few small areas which have lost more than three-fourths of the topsoil. Occasional gullyng occurs on about 50 percent of the land suffering from sheet erosion in this section and is most common on slopes adjacent to or near streams. A few small areas in Porter and Huntington Counties, totaling 46,232 acres, are severely gullied.

Sheet and gully erosion were found to be more active over the southern half of the State due to the more rolling topography, to a longer period of cultivation, and to the practice of clearing steep slopes of timber and

utilizing them for clean-tilled crops. Corn is an important crop but is often planted on slopes that should be maintained in permanent grass.

Moderate sheet erosion, with loss of one-fourth to three-fourths of the original topsoil generally, was found to be active over the southwestern quarter of the State. Severe sheet erosion, with the loss generally of over three-fourths of the surface soil and frequently some subsoil, was found in the southeastern quarter, especially in Switzerland, Ohio, Dearborn, and Franklin Counties. Considerable severe gullyng and severe sheet erosion occurred over comparatively large areas in the southeastern, south central, and southern parts of the State. Occasional gullyng is common on most of the other areas affected by sheet erosion in this section.

13. Iowa

TABLE XXV.—*Reconnaissance erosion survey of Iowa—acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	35,575,040	100.0
Areas with little or no erosion (1).....	15,045,658	42.3
Total area affected by sheet erosion.....	20,193,217	56.8
$\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 27, 28).....	16,916,101	47.6
Over $\frac{3}{4}$ topsoil and some subsoil lost (27, 28).....	3,277,116	9.2
Total area affected by wind erosion: Moderate wind erosion (4).....	3,190	(1)
Total area affected by gullyng.....	20,072,339	56.4
Occasional gullies (17, 27, 37).....	13,784,354	38.7
Severe gullyng (28, 38).....	6,287,985	17.7

¹ Less than $\frac{1}{10}$ of 1 percent.

The total area of Iowa is 35,575,040 acres, of which less than half, or 15,045,658 acres, was found with little or no erosion. Sheet erosion was found to have affected 20,193,217 acres, most of which have lost generally one-fourth to three-fourths of the topsoil. However, 3,277,116 acres additional have lost generally more than three-fourths of the topsoil.

Gullyng was found on most of the areas affected by sheet erosion. Gullyng was found to be the predominating condition generally on 20,072,339 acres, of which area 6,287,985 acres were severely gullied.

Thousands of acres of formerly productive farm lands have been made marginal for cropping or have been destroyed for cultivation by serious erosion. Only on the flat or gently undulating uplands of the Wisconsin and Iowa drift areas extending across the northern part of the State and southward to Des Moines, and in the southern, south central, and eastern parts of the State has there been little or no erosion.

The character and severity of erosion within the State varies to a large extent with topography or lay of the land and with the erosiveness of the various soil types. The State is divided into five large soil areas:

(1) Missouri loess area of western Iowa, (2) Mississippi loess area of central and eastern Iowa, (3) southern loessial and glacial area, (4) Iowan drift area of the northeastern part of the State, and (5) Wisconsin drift area of the north central part of the State.

The severity of erosion in the western part of the State on the Missouri loess area is correlated very closely with the degree of slope and the percent of land used for clean-cultivated crops. The Missouri loess area consists of approximately 7,700,000 acres, with a rolling to steeply rolling topography which favors washing. The continuous growing of very large acreages of corn in this area has favored relatively severe sheet erosion. Over 1,500,000 acres have lost more than three-fourths of their original dark-colored surface soil and are also severely gullied. Except for the bottom lands all of the remaining territory has been moderately to severely eroded. As the physical character of these soils is so excellent, such that they may be comparatively easily built up with the use of good soil-building farming systems, it cannot be said that they have been reduced to marginality, but they are being seriously depleted and will become worse unless conservation measures are adopted to preserve them in their present condition.

The glacial soils of the southern Iowa loess area, when severely washed and gullied, are reduced to submarginal farming conditions in many respects. In this area over 750,000 acres were found to have been reduced to this condition by severe sheet erosion and severe gullyng. Except for the level soil area in Washington, Henry, and Des Moines Counties in the southeastern corner of the State, all of this territory was found to be moderately to severely sheet eroded and also moderately to severely gullied. The glacial soils never did have a deep dark surface soil as once existed in the loess area, and, furthermore, their subsoils are relatively impervious, heavy, rather than infertile clays. In order that they may be improved and erosion controlled they should be largely taken out of cultivation and seeded to some close-growing crop such as grass or planted to trees.

A relatively small percent of central and eastern Iowa in the Mississippi loess area has been severely eroded. However, in Clayton County bordering the Volga River, the land is steeply rolling and more severely eroded.

In the north central part of the State, in the Wisconsin and Iowan drift area, the topography varies from level to gently rolling. Most of this area has been subject to little or no erosion, although the southern border has been subject to moderate sheet erosion and moderate gullyng. For the most part, this area does not represent an immediate problem. However, the use of farming practices which are conducive to erosion

control should be encouraged in the interest of conservation.

The seriousness of erosion in the western and southern parts of the State had been recognized and efforts by the Federal and State Governments to experiment and demonstrate the various methods of erosion control were started in 1931 with the establishment of an experimental farm at Clarinda, Iowa.

Demonstrations along the West Tarkio Creek watershed from Red Oak, Iowa, to Tarkio, Mo., and along Big Creek watershed from Kellerton, Iowa, to Bethany, Mo., were started early in 1934 by the Soil Conservation Service to initiate erosion control methods on each farm.

14. Kansas

TABLE XXVI. Reconnaissance erosion survey of Kansas—Acreages within which more than 25 percent of the land has been affected as indicated

	Acres	Percent
Total area (exclusive of large cities and water).....	52,520,949	100.0
Areas with little or no erosion (1).....	8,848,351	16.8
Total area affected by sheet erosion.....	31,916,779	60.8
1/4 to 3/4 top soil lost (2, 27, 28, 24, 25, 267).....	24,288,812	46.3
Over 3/4 topsoil and some subsoil lost (3, 37, 38).....	7,627,967	14.5
Total area affected by wind erosion.....	14,634,590	27.9
Moderate wind erosion (4, 24, 47).....	8,837,188	16.8
Severe wind erosion (5, 25, 37, 257).....	5,386,092	10.3
Destroyed by wind erosion (6).....	411,310	.8
Total area affected by gullyng.....	29,472,836	56.1
Occasional gullies (17, 27, 37, 47, 57, 257).....	25,968,223	49.5
Severe gullyng (28, 38).....	3,474,613	6.6
Essentially destroyed for tillage (38).....	2,623,696	5.0

Of the total land area of Kansas, comprising 52,520,949 acres, on 8,848,351 acres there was little or no erosion. Wind and water erosion have affected 43,672,598 acres, or 83.2 percent of the State.

Sheet erosion has been more or less severe on 31,916,779 acres, or 60.8 percent of the State as shown by the reconnaissance erosion survey. The loss of three-fourths of the topsoil and some of the subsoil was the prevailing condition on 7,627,967 acres, and on another 24,288,812 acres there was a loss generally of one-fourth to three-fourths of the topsoil.

Gullyng was prevalent with varying frequency on 29,472,836 acres, or 56.1 percent of the area. Overgrazing and lack of proper adaptation of the land have caused enormous soil losses with attendant gullyng. Severe gullyng was found on 3,474,613 acres generally.

Wind erosion has affected a total of 14,634,590 acres, with 5,386,092 acres mapped as seriously affected. An area of 2,623,696 acres, or 5 percent of the entire State, has been essentially destroyed generally for further tillage by the combination of severe sheet erosion and gullyng, and 411,310 acres have been essentially destroyed by wind erosion.

Wind erosion is most serious in the broad, level, high plains region of the western and southwestern third of the State, where the annual rainfall is less than 20 inches. The soils in this region are principally fine sandy loams, loamy fine sands, and sands which have been derived from Tertiary outwash material from the Rocky Mountains. During the last 1 or 2 decades the natural prairie sod of buffalo grass has been plowed to make way for extensive acreages of wheat. With vast areas of loose soil exposed during the fall and winter months, wind erosion has become more and more active. During recent years great dust storms of increasing severity have caused wide-spread alarm over this and adjoining areas.

In the Red Plains sections of south central Kansas, both wind and water erosion are common. The topography is rolling. Erosion has been active because of the failure to use soil-saving measures, such as contour cultivation, strip farming, and terracing.

In the northern and eastern sections, moderate sheet erosion predominates, with gullies occurring with more or less frequency. The topography is rather gently rolling, but clean-cultivation of row crops on the erodible limestone and loess soils has permitted considerable washing. On many of the steeper slopes in small local areas, which were impossible to show on the reconnaissance map, erosion is very serious. This is largely the result of growing clean-cultivated crops in rows, parallel to fence lines, regardless of soil or slope.

Large areas with slight sheet erosion and occasional gullies occur in the south central part of the State in the section known as the "Flint Hills" where there are extensive areas of overgrazed natural grasslands. Here overgrazing and burning of the grassland has started local areas to erode very rapidly.

Little or no erosion is evident in the broad, level plains sections of the southern and southeastern Kansas. This is due to the level topography and to the soil conditions which are not so conducive to erosion. The broad alluvial bottoms of the lower Arkansas River Valley and the Kansas River show little or no erosion. Soil deposition after severe floods causes much damage. On many small tributary streams of both watersheds the bottom lands suffer considerable erosive damage through stream cutting and the deposition of sand and silt from the adjacent cultivated slope lands on rich farm lands.

Soil erosion has been recognized for some time in Kansas as a very great menace to the extensive agricultural sections of the State. In 1929 the Bureau of Chemistry and Soils of the Department of Agriculture located a soil-erosion experiment station at Fort Hays in cooperation with the dry-farming experiment station there. This station has shown the importance and necessity of soil and water conservation for the

production of crops and of vegetative cover as a means of soil protection from the severe exposure to the winds.

In 1934 the Soil Conservation Service located a soil erosion demonstration project on the watershed of Limestone Creek in northern Kansas with headquarters at Mankato. The project, which involves 114,000 acres, has engaged in checking soil and water losses on the farms of this watershed in cooperation with the farmers by utilizing every practical method of erosion control. The program includes crop-rotation systems, contour farming, strip cropping, terracing, and gully control.

15. Kentucky

TABLE XXVII.—*Reconnaissance erosion survey of Kentucky—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	25,701,698	100.0
Areas with little or no erosion (1).....	1,363,860	5.3
Total area affected by sheet erosion.....	18,939,790	73.7
1/4 to 3/4 topsoil lost (2, 27, 28).....	7,230,599	28.1
Over 3/4 topsoil and some subsoil lost (3, 37, 38).....	11,709,191	45.6
Total area affected by gullying.....	22,369,771	87.0
Occasional gullies (17, 27, 37).....	10,635,275	41.4
Severe gullying (28, 38).....	2,718,952	10.6
Destroyed by gullies (9).....	15,744	(^c)
Essentially destroyed for tillage (38).....	2,679,495	10.4

^c Less than 1/10 of 1 percent.

Accelerated erosion is active over most of the State of Kentucky, which has a land area of 25,701,698 acres. Only on 1,363,860 acres, or 5.3 percent of the State, is there little or no erosion, embracing a few level uplands and the flood plains and terraces along the stream valleys.

The total area affected by sheet erosion was 18,939,790 acres, of which 11,709,191 acres, comprising 45.6 percent of the State land area, were severely eroded, having lost generally over three-fourths of the topsoil and some subsoil. A loss of one-fourth to three-fourths of the topsoil was found to prevail on 7,230,599 acres more.

Gullying was more wide-spread than sheet erosion, occurring with more or less frequency on 22,369,771 acres, or 87 percent of the total area. Severe gullying was found generally on 2,718,952 acres of this area.

Kentucky extends from the Mississippi River on the west into the Appalachian Highlands on the east, thus including several physiographic regions with different soil, topographic, and land-use conditions. An abundance of rainfall evenly distributed throughout the year and frequent freezing and thawing during the winter months also make conditions favorable for erosion.

Three distinct erosion conditions exist in the Appalachian Highlands in the eastern part of the State,

which as a whole is not suited to agriculture. The soils are of low natural fertility, being derived from sandstone and shale and the topography is strongly rolling to mountainous. Severe sheet erosion with a loss of over three-fourths of the original topsoil generally was found on a large percentage of the land which has been cleared and cropped to corn or tobacco in the northeastern part.

In the central part of the Appalachian Highlands, erosion has been less severe because a smaller portion of the land had been cleared and utilized for clean-tilled crops.

The southern part of the highlands area was found to be subject to occasional gullying with little or no sheet erosion. Cultivation is confined to a few small cornfields around scattered dwellings, usually in narrow valleys, but sometimes it extends up the steep slopes where the land is subject to severe sheet erosion. However, these fields represent a very small percentage of the total area.

The inner Blue Grass region in the north central part, west of the Appalachian Highlands, was found to have moderate to serious sheet erosion with widespread loss of one-fourth to three-fourths of the original topsoil. Although the soils are derived from limestone and the region has rolling topography, the losses from sheet erosion are not severe generally due to the maintenance of a large percentage of the area in blue-grass sod.

Immediately surrounding the Blue Grass region is a relatively narrow belt with soils derived from impure limestone, sandstone, and shales. The topography is hilly and rugged and the valleys are steep-sided. Clean tillage of corn and tobacco on these steep slopes has led to severe sheet and gully erosion, which has forced the abandonment of many farms.

The severity of erosion in the Highland Rim area which includes the remainder of the State west to the Tennessee River, exclusive of the western coal fields, is influenced by the topography of the land. In the southwestern part where the topography is gently rolling, erosion is usually moderate with a loss of one-fourth to three-fourths of the original surface soil. Farther north toward the Ohio River, the topography becomes rolling to hilly and a large percentage of the land has suffered from severe sheet erosion by which it has lost over three-fourths of the original topsoil, and some subsoil. Occasional gullying accompanied sheet erosion in all this region except in Hardin, Breckinridge, and Grayson Counties where gullying is severe generally.

The predominating erosion condition in the western coal fields is severe gullying with severe sheet erosion. The factors causing this erosion are much the same as those in the eastern highlands: soils are of low natural

fertility and much steep land has been cropped that is not adapted to clean-tillage.

The remaining division of the State is known as the "Purchase area" and includes all of the counties between the Tennessee and Mississippi Rivers. It is covered by a mantle of loess varying from several feet to 40 or 50 feet in depth and occupies gently rolling to almost level topography. A large portion of the land has been cleared and maintained in continuous cultivation year after year without efforts of soil conservation. This practice has resulted in a depletion of the organic matter which induced acceleration of erosion on the sloping areas until considerable acreages have lost one-fourth to three-fourths of the topsoil and equally large areas have lost more than three-fourths of the topsoil.

The seriousness of the erosion problem is recognized, and a demonstration project is now being set up in western Kentucky by the Soil Conservation Service at the urgent request of citizens of that region.

16. Louisiana

TABLE XXVIII.—*Reconnaissance erosion survey of Louisiana—acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	28,877,785	100.0
Areas with little or no erosion (1).....	20,768,763	71.9
Total area affected by sheet erosion.....	1,635,275	5.7
1/4 to 3/4 topsoil lost (2, 27, 28).....	1,633,681	5.7
Over 3/4 topsoil and some subsoil lost (28).....	1,594	(1)
Total area affected by gullying.....	7,528,327	26.1
Occasional gullies (17, 27).....	7,512,581	26.0
Severe gullying (28, 36).....	14,746	.1
Essentially destroyed for tillage (38).....	1,594	(1)

¹ Less than 1/4 of 1 percent.

Louisiana has a total land area of 28,877,785 acres. There is little or no erosion on 20,768,763 acres or 71.9 percent of the State, because of the large aggregate of essentially flat lands in the Coastal Prairie, Mississippi Delta, and the interior flatwoods country.

The surface relief of Louisiana is moderate with elevations ranging from sea level on the coast to 400 feet in the north central part. The average annual rainfall is 60 inches on the coast and 45 inches in the northern part of the State.

Four soil regions may be recognized, each with characteristic conditions of erosion; (1) the coastal prairies; (2) the Mississippi bottoms or delta lands; (3) the interior flatwoods; and (4) the inner Coastal Plain.

The total area affected by sheet erosion was 1,635,275 acres of which 1,594 acres had lost prevailing over three-fourths of the topsoil and some of the subsoil, the remainder having moderate sheet erosion on which

one-fourth to three-fourths of the topsoil was removed generally. Moderate gullying occurs on the sloping area of cleared lands in the coastal prairies and interior flatwoods region covering 7,528,327 acres or 26.1 percent of the State. Gullying occurred with varying frequency usually without much sheet erosion. Only 14,746 acres were severely gullied while 1,594 acres were destroyed for tillage.

On the gentle slopes of the coastal prairies and interior flatwoods, a limited amount of erosion occurred on cleared lands. On the Mississippi bottoms or delta lands and on the nearly level areas of the interior flatwoods and coastal prairies, little or no erosion was found.

Most of the eroded lands were found on the rolling sections of the inner Coastal Plain. This region includes the northwestern part of the State, and a few small areas bordering the Mississippi State line in the southeastern part. Much of this area is in forest or cut-over land. Large areas of forest lands are burned over annually, causing both sheet erosion and gullying.

On many cultivated fields on sloping land in the inner Coastal Plain, clean-tilled crops have been grown continuously, with little or no protection against washing. Tenant farmers in many cases have not been interested in protecting the land from erosion. The most severe erosion in the State is found on the divides of the Red River and its tributaries, where many of the cultivated slopes are too steep for safe tillage, and should never have been cleared of the protective forest cover.

The Soil Conservation Service has established a soil erosion control project of 100,000 acres near Minden. On this project the best methods of erosion control and correct land use are being demonstrated.

17. Maine

TABLE XXIX.—*Reconnaissance erosion survey of Maine—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total areas (exclusive of large cities and water).....	19,132,800	100.0
Areas with little or no erosion (1).....	17,357,210	90.7
Total area affected by sheet erosion.....	1,013,421	5.3
$\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 27, 28).....	1,013,037	5.3
Over $\frac{3}{4}$ topsoil and some subsoil lost (37).....	384	(1)
Total area affected by wind erosion: Moderate wind erosion (4).....	11,489	.1
Total area affected by gullying.....	1,374,590	7.2
Occasional gullies (17, 27, 37).....	1,368,079	7.2
Severe gullying (28).....	6,511	(1)

(1) Less than $\frac{1}{4}$ of 1 percent.

Maine comprises a land area of 19,132,800 acres exclusive of large urban areas, on 17,357,210 acres or 90.7 percent of which there was little or no accelerated erosion.

Accelerated erosion was found to be a problem on 1,775,590 acres which occurred, for the most part, along the Atlantic coastal section in Aroostook County in the northeastern corner of the State in areas of most intensive agriculture. A large proportion of the State is in forest or wooded areas on which erosion is inactive generally.

Loss of one-fourth to three-fourths of the topsoil was found to be the prevailing condition on 1,013,037 acres, more than half of which, or 612,581 acres, was found in Aroostook County, where the principal crop is potatoes which require clean cultivation. Frequently the potato rows are parallel to fence lines on rolling to hilly topography, irrespective of direction of slope. This practice has induced severe soil losses by both sheet erosion and gullying.

Gullying was found to be more wide-spread than sheet erosion since it was found to prevail generally on 1,374,590 acres, of which more than half, or 750,680 acres, was found on land which showed little or no sheet erosion. This condition of gully development in advance of sheet erosion may be due to several causes such as fires and destructive logging operations, and concentrating run-off waters from cultivated fields upon wooded slopes.

Wind erosion was found to have affected 11,489 acres in Franklin and Cumberland Counties in the coastal sections but not enough was severely affected to be delineated by the survey.

18. Maryland

TABLE XXX.—*Reconnaissance erosion survey of Maryland—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	6,290,414	100.0
Areas with little or no erosion (1).....	4,111,904	65.4
Total area affected by sheet erosion.....	2,155,394	34.3
$\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 27, 28).....	1,914,865	30.5
Over $\frac{3}{4}$ topsoil and some subsoil lost (37, 38).....	240,729	3.8
Total area affected by gullying.....	1,436,797	22.8
Occasional gullies (27, 37).....	1,111,176	17.6
Severe gullying (28, 38).....	302,505	4.8
Destroyed by gullies (9).....	23,116	.4
Essentially destroyed for tillage (38).....	121,162	1.9

Maryland has a total land area of 6,290,414 acres of which 4,111,904 acres, or 65.4 percent of the State area, suffer little or no erosion losses. The level to gently undulating Coastal Plain areas, with sandy soils capable of absorbing much rainfall, and well forested mountain slopes comprise the slightly eroded and uneroded section principally.

Sheet erosion occurred on a total of 2,155,394 acres, mostly moderate, with one-fourth to three-fourths of the topsoil removed generally. Severe sheet erosion was the prevailing condition on 240,729 acres where

more than three-fourths of the topsoil and some subsoil were removed.

Gullyng occurred with more or less frequency on 1,436,797 acres. Severe gullyng was found generally on 302,505 acres, and another 23,116 acres had been destroyed by gullyng. Sheet erosion and gullyng, combined, essentially destroyed 121,162 acres for further tillage.

Maryland extends from the Appalachian Highlands through the Limestone Valley, Piedmont Plateau, and Coastal Plain sections, and thus presents a wide variety of soil conditions, land-cover types, and topographic phases, each of which influences to some extent the amount of erosion.

Through the western part of the State, moderate erosion with one-fourth to three-fourths of the topsoil removed generally was found along the valleys and on the more gently rolling lands which are utilized for crops. Some mountainous slopes, which had been cleared and utilized for pasture or remained in woods but were subjected to logging or severe burning, also show moderate sheet erosion. Carrol, Baltimore, Hartford, and Frederick Counties have considerable areas influenced by moderate sheet erosion. The topography of these counties is gently rolling to rolling, and a very large percentage of the land is utilized for crops, with no attention given to erosion control. The coastal plain south of Washington shows large areas of land which have lost generally one-fourth to three-fourths of the topsoil. This occurs on rolling topography where sandy clay subsoils retard the downward percolation of water. In Kent County, on the eastern shore, moderate erosion prevails.

Severe gullyng occurs, with both moderate and severe sheet erosion, on over 300,000 acres south of Washington. Here the topography is rolling, and the soils contain relatively impervious subsoil layers which allow very slow percolation, with attendant rapid runoff resulting in severe accelerated erosion.

19. Massachusetts

TABLE XXXI.—*Reconnaissance erosion survey of Massachusetts—Acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	5,103,114	100.0
Areas with little or no erosion (1).....	4,808,979	94.2
Total area affected by sheet erosion: $\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 27, 24, 26).....	128,546	2.5
Total area affected by wind erosion.....	88,081	1.7
Moderate wind erosion (4, 24).....	43,044	.8
Severe wind erosion (25).....	19,928	.4
Destroyed by wind erosion (6).....	25,109	.5
Total area affected by gullyng: Occasional gullies (17, 27).....	181,053	3.0

The reconnaissance erosion survey covered 5,103,114 acres in Massachusetts and found that erosion is not

very extensive. A major part of the State, or 4,808,979 acres, has little or no apparent erosion. What erosion was found occurred chiefly on sloping lands that are cropped.

Much of the land with little or no erosion is covered by second-growth timber, the result of land abandonment many years ago. This land abandonment was due to industrial changes and not soil destruction.

One-fourth to three-fourths of the topsoil has been lost generally from 125,546 acres. Of this eroded land 80,110 acres occur in Berkshire, Hampshire, and Hampden Counties, where there is considerable cropping of sloping lands. Where slopes are maintained in forest or good pasture cover there is little or no sheet erosion. The remainder of this moderate sheet erosion occurs in scattered small areas over the State.

Occasional gullyng was found on 151,053 acres, occurring chiefly in connection with sheet erosion, although on 115,980 acres there is occasional gullyng with little or no sheet erosion, chiefly in Berkshire County. Here the gullies originate in small patches of crop land and continue down through wooded or pasture lands.

Wind erosion was found to have affected 88,081 acres, of which 25,109 acres, mostly in Barnstable County, were essentially destroyed and 19,928 acres more, also mostly in Barnstable County, were severely affected.

20. Michigan

TABLE XXXII.—*Reconnaissance erosion survey of Michigan—Acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	36,630,503	100.0
Areas with little or no erosion (1).....	29,652,583	81.0
Total area affected by sheet erosion.....	4,467,816	12.2
$\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 27, 28, 24, 247, 25, 257, 258).....	4,465,026	12.2
Over $\frac{3}{4}$ topsoil and some subsoil lost (3).....	2,790	(¹)
Total area affected by wind erosion.....	3,034,207	8.3
Moderate wind erosion (4, 24, 47, 247).....	2,417,641	6.6
Severe wind erosion (5, 25, 257, 258).....	578,704	1.6
Destroyed by wind erosion (6).....	37,852	.1
Total area affected by gullyng.....	2,041,006	5.6
Occasional gullies (17, 27, 47, 247, 257).....	1,975,642	5.4
Severe gullyng (28, 33).....	65,364	.2
Essentially destroyed for tillage (38).....	2,790	(¹)

¹ Less than $\frac{1}{10}$ of 1 percent.

The total land area of Michigan is 36,630,503 acres, of which 29,652,583 acres have suffered little or no erosion.

The reconnaissance survey showed 6,977,920 acres of land affected by accelerated erosion. While this area is less than one-fifth of the land area of the State, it constitutes more than one-third of the land in farms. In general, most of this eroded region occupies undulating to strongly rolling topography in the intensively farmed areas of the Lower Peninsula.

Sheet erosion was active on 4,467,816 acres. A loss of one-fourth to three-fourths of the topsoil was the prevailing condition on all of this area except for 2,790 acres which had more than three-fourths of the topsoil and some subsoil removed. Moderate sheet erosion, with the loss of one-fourth to three-fourths of the original topsoil, generally occurs over 4,465,026 acres, of which 118,948 acres occur in the Upper Peninsula. In the Lower Peninsula most of the erosion occurs in two zones. One zone is arc-shaped and extends from Berrien County, in the extreme southwest corner of the State, through Montcalm and Grand Traverse Counties and on to the Straits of Mackinac. The other general area extends from Hillsdale to Tuscola County. The characteristic topography is low rolling to hilly. Hills seldom rise above 100 feet in height and frequently have short, steep slopes. The land is sectionized, and fields are laid out rectangularly. This means that cultivated rows often run up and down the slopes, thus increasing the amount of erosion.

Probably the greater portion of material removed by sheet and gully erosion in Michigan does not move far. It is usually deposited in swales and depressions adjacent to the eroding areas. Frequently considerable valuable land is buried in this manner. Probably, the major amounts of soil material carried away by streams is soil which slumps into the streams due to bank cutting and soil removed by erosion from slopes adjacent to the streams.

Gullying was found with varying degrees of frequency on 1,975,642 acres. These gullies were usually on the longer slopes of cultivated sandy soils. Severely gullied areas comprised 65,364 acres. Such areas usually occupy steep slopes and have sandy clay subsoils which prevent rapid absorption of excessive rainfall. This class of erosion occurs predominately in Cass, Allegan, Kent, Washtenaw, and Oakland Counties.

Wind erosion was found to be active on the sandy soils in the western part of the State, on some of the sandy soils of the eastern part, especially Saginaw County, and on the Upper Peninsula in Marquette County. Moderate wind erosion was found on 3,034,207 acres or 8.3 percent of the State. Of this area, 578,704 acres were severely affected and 37,862 acres were destroyed generally for agricultural use. The areas of most severe wind erosion occurred mostly on dunes along the shore of Lake Michigan. Sparse growth of vegetation and trees allows more or less constant shifting of the sands. Areas of moderate wind erosion occur in the jack-pine forest belt centering around Wexford County where the removal of timber and subsequent frequent burning have prevented development of vegetative cover. Moderate wind erosion occurs principally, however, through the orchard belt along the western side of the Lower Penin-

sula. Erosion induced by cultivation of sandy areas has resulted in the destruction of considerable orchard land and trees.

On the lands where little or no erosion occurs, there are three general conditions: (1) Land on which erosion will never be a serious problem. This land, due to its characteristic flat or very gently undulating topography and to the nature of the predominating soils, has little tendency to erode. Most of the Lake Plain which constitutes the eastern fringe of the lower peninsula, and the flat and gently undulating glacial till and outwash plains in Saginaw, Bay, Gratiot, Tuscola, and other counties, are included in this division. (2) Land on which sheet and gully erosion is severe in small local spots but where the area as a whole is subject to but slight erosion. The topography is gently undulating with a few steep slopes and depressions where erosion is severe on clay knobs and on the slopes adjacent to depressions. Although erosion of this type is not spectacular and the individual areas are small, the aggregate of these small areas represents destruction of considerable valuable farm land. This condition exists in Eaton, Ionia, and Clinton Counties, and in the southern part of the State between Berrien and Hillsdale Counties. (3) Land which is characterized by steep slopes that would erode severely if the present vegetative cover were destroyed. This condition is most common in the northern part of the lower peninsula and in the upper peninsula. The major portion of the upper peninsula is covered by trees and is protected from erosion.

21. Minnesota

TABLE XXXIII.—*Reconnaissance erosion survey of Minnesota—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acre	Percent
Total area (exclusive of large cities and water).....	51,452,394	100.0
Areas with little or no erosion (1).....	27,951,147	54.3
Total area affected by sheet erosion: $\frac{3}{4}$ to $\frac{3}{8}$ topsoil lost (2, 27, 28, 257, 247, 248).....	10,083,066	19.6
Total area affected by wind erosion.....	12,092,812	23.5
Moderate wind erosion (4, 247, 47, 248).....	9,256,097	18.0
Severe wind erosion (5, 57, 257).....	3,421,262	6.6
Destroyed by wind erosion (6).....	15,543	(1)
Total area affected by gullying.....	7,804,518	15.2
Occasional gullies (17, 27, 47, 247, 57, 257).....	7,293,170	14.2
Severe gullying (28, 248).....	511,348	1.0

¹ Less than $\frac{1}{16}$ of 1 percent.

The land area of Minnesota comprises 51,452,394 acres, on more than half of which, or 27,951,147 acres, there is at present no erosion problem. Of the remaining 23,501,247 acres, sheet erosion was found to have removed one-fourth to three-fourths of the topsoil generally from 10,083,066 acres.

Gullying was found to occur generally on 7,804,518 acres but only 511,348 acres were severely gullied.

Wind erosion was found to be most wide-spread and the most destructive form of erosion in the State, having been found to have affected 12,692,812 acres, of which 15,543 acres were destroyed and 3,421,202 acres were seriously damaged. It is a serious problem in the better farming sections of the State.

Rainfall is rather uniform over the State, although it is lowest in the north and west and highest in the southeastern corner where the mean annual rainfall has been about 32 inches. About 21 inches of rainfall is received in Lake of the Woods County in the extreme northern portion, 25 inches in Wadena County in the north central part, and 24 inches in Lac qui Parle County in the western portion.

The major areas with little or no erosion are located in the northern half, and in the central and south-western parts of the State and include large bodies of forest land that are well protected and also the more level nonerosive prairie lands. Over 1,000,000 acres are included in national forests.

The areas of water erosion may be accounted for mainly on the basis of topography and land use. More than 10,000,000 acres, or about one-fifth of the State, are affected to some degree. The major area of sheet erosion accompanied by gullying extends from Wright County to the southeastern corner of the State, bordering the Mississippi River. Severe gullying is prevalent in this region. While a large portion of this area was formerly timbered, much of it has been cleared and farmed except the very steep slopes which still remain in timber. However, many of the remaining timbered areas have been abused by excessive grazing and annual burning which have caused serious accelerated erosion. The topography of this section varies from gently rolling to steeply rolling. The loessial soils of the southeastern driftless area have slopes greater than 10 percent.

Many areas scattered over the southern half of the State have lost one-fourth to three-fourths of the surface soil through sheet erosion and are also moderately gullied. Although these areas do not seem to present a pressing problem at present, continued misuse will soon affect them seriously. They are worth conserving and, to this end, effective conservative land-use policies should be adopted here as well as on the more seriously eroded lands.

Moderate sheet erosion with little or no gullying was noted in the central and northern parts of the State, mainly in Douglas, Stearns, Morrison, Todd, and Pope Counties. In most cases less than half of the topsoil has been lost, although many rounded knolls in this glacial topography have the topsoil exposed in spots.

About one-fourth of the State, or 12,692,812 acres, has a tendency to drift with the wind. Wind erosion is serious and needs immediate attention on 3,421,202

acres. The tendency of the soil to drift has been particularly noticeable during the past 2 or 3 years, during which the rainfall has been far below normal, particularly on the cultivated areas that are more or less sandy and droughty. On the old beach line at the border of former glacial Lake Agassiz, it was particularly noticeable. A belt varying from 40 to 60 miles wide extending north and south along the western side of the State nearly to the Iowa State line is affected slightly to moderately by wind erosion with occasional severely affected areas. Moderate wind erosion is found also extending down the Mississippi River Valley. Many scattered areas, mostly sandy lands bordering glacial lakes, have been reworked by wind, particularly on cultivated fields. In Sherburne, Isanti, Chisago, and Anoka Counties located north of Minneapolis and St. Paul, the sandy soils, particularly those cleared, have been seriously affected. It is probable that some reforestation will be necessary to stabilize some of these areas.

The seriousness of water erosion in the southeastern part of the State has been recognized and erosion-control demonstration projects covering about 150,000 acres have been set up within the Root River watershed, by the Soil Conservation Service.

22. Mississippi

TABLE XXXIV.—*Reconnaissance erosion survey of Mississippi—acres within which more than 25 percent of the land has been affected as indicated*

	Acrea	Percent
Total area (exclusive of large cities and water).....	29,671,680	100.0
Areas with little or no erosion (1).....	10,230,444	34.5
Total area affected by sheet erosion.....	18,892,306	63.7
1/4 to 3/4 topsoil lost (2, 27, 28).....	15,855,889	53.4
Over 3/4 topsoil and some subsoil lost (3, 37, 38).....	3,036,417	10.2
Total area affected by gullying.....	13,966,672	47.1
Occasional gullies (17, 27, 37).....	9,601,766	32.4
Severe gullying (28, 36).....	3,922,638	13.2
Destroyed by gullies (4).....	441,188	1.5
Essentially destroyed for tillage (38).....	1,696,194	5.7

The area of Mississippi covered by the reconnaissance erosion survey is 29,671,680 acres. On 10,230,444 acres, or 34.5 percent, there is little or no erosion. Moderate sheet erosion with the loss of one-fourth to three-fourths of the surface soil is the prevailing condition on 15,855,889 acres. Severe sheet erosion, characterized by the loss of three-fourths or more of the topsoil, was found generally on 3,036,417 acres. Occasional gullies were observed on 9,601,766 acres, and severe gullying on 3,922,638 acres. A total area of 2,137,362 acres, or 7.2 percent of the State, has been essentially ruined for cultivation by severe sheet erosion and gullying.

The annual rainfall is 60 inches on the coast and 50 inches in the northern part of the State. Torrential

rains occur frequently, and cause serious erosion on sloping lands that are not protected.

The northeastern part of Mississippi, extending from Alcorn County south to Noxubee County, is a section with rather rough topography, on the Appalachian border. Sheet and gully erosion have progressed to such an extent on those areas which have been farmed that the greater part of this region is now unfit for cultivation. The strong relief, erodible soils, clean tillage, and careless soil management have permitted enormous losses from erosion.

A low-lying body of land known as the "Black Prairie Belt" extends about half of the length of the State, from Alcorn County in the northeast, southward to Kemper County. The soils in this belt are heavy clays which absorb water slowly. Clean-cultivated crops have been grown extensively since the region was first settled. Consequently, sheet erosion has taken a heavy toll, despite the nearly level or gently undulating topography. In many localities the entire soil profile has been removed, exposing the unproductive gray chalklike parent material. Gullying is not very pronounced on these soils.

West of the Black Prairies is a small wedge-shaped region of highlands, consisting of a ridge more than 500 feet high, bordered by rugged broken hills. The sandy soils have been severely damaged by both sheet erosion and gullying. Continuous clean tillage on slopes too steep to be cultivated has permitted the destruction for agricultural purposes of nearly 50 percent of the land once cultivated in parts of this region.

A narrow band of low flat land lies west of the ridge just described, extending from Tippah County on the southern border to Kemper County on the east, where the land is mainly wooded and the surface is so nearly level that erosion is not a serious problem.

West of the flat land, extending from Union County to Clark County in the east-central part of the State, there is an area known as the "Clay Hills." These hills are largely too steep and stony for cultivation, but erosion is serious on much of the land. Fires destroy the forest litter over large areas annually, leaving the soil exposed and subject to washing.

In the southeastern and southern parts of Mississippi there is an area of uneven topography called the "Long Leaf Pine Hills." Sheet erosion is active throughout the entire region, and gullying has affected nearly three-fourths of the land. Considerable land in Clarke, Jasper, Covington, and Smith Counties has been destroyed for agricultural use. Clean cultivation on sloping fields, without adequate provision for the control of excess run-off, has permitted erosion to become active. Gullies develop slowly until the cutting reaches the loose material under the fairly resistant subsoil; but when this stage is reached, the loose material is

removed easily to undermine the soil and allow it to cave in, and the rate of growth of the gully becomes very rapid.

Erosion is not active in the Flatwoods section bordering the Gulf or on the bottom lands along the Mississippi River.

The loess region, a broad belt of uplands bordering the Mississippi River bottoms, has some of the worst erosion in the State. The silty soils are particularly susceptible to both sheet and gully erosion. The topography ranges from gently or moderately rolling to very hilly. Large areas are encountered where the surface has been so eroded that the once gently rolling topography now presents a billowy aspect, with occasional to numerous gullies.

The Soil Conservation Service has located a demonstration erosion control project on 144,000 acres near Meridian, Miss., where the best-known methods of erosion control are put into practice on all the cooperating farms.

23. Missouri

TABLE XXXV.—*Reconnaissance erosion survey of Missouri—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	43,985,280	100.0
Areas with little or no erosion (1).....	6,684,835	15.2
Total area affected by sheet erosion.....	34,466,120	78.4
$\frac{3}{4}$ to $\frac{1}{4}$ topsoil lost (2, 27, 28).....	32,678,682	74.1
Over $\frac{3}{4}$ topsoil and some subsoil lost (38).....	1,887,438	4.3
Total area affected by gullying.....	37,300,049	84.8
Occasional gullies (17, 27).....	22,412,817	51.0
Severe gullying (28, 38).....	14,866,242	33.8
Destroyed by gullies (9).....	20,960	(1)
Essentially destroyed for tillage (38).....	21,124	(1)

¹ Less than $\frac{1}{10}$ of 1 percent.

The total land area of Missouri is 43,985,280 acres, of which 6,684,835 acres showed little or no erosion. This condition is found mainly on bottom lands and terraces.

Sheet erosion affected 34,466,120 acres, or 78.4 percent of the State. Severe sheet erosion, where prevalingly three-fourths of the topsoil and some subsoil were lost, occurred on 1,887,438 acres. Much severe gullying was found scattered over the area affected by severe sheet erosion, which had reduced many local areas to a submarginal status for cultivation.

Gullying was wide-spread, occurring with more or less frequency on 37,300,049 acres, or 84.8 percent of the total land area. Of this, 14,866,242 acres were gullied severely. Gullying was more extensive than sheet erosion due to gullying in the forested areas, mainly in southern Missouri, where little or no erosion was found. Here forest fires removed protective grasses and forest litter, and vegetation was not

reestablished quickly enough to prevent the formation of occasional gullies.

There is much variation in soils, topography, and the character and amount of rainfall annually over the State, all of which have an important bearing on the kind and degree of erosion. The soils range from open porous sands to impervious clay and the topography from flat upland prairies and alluvial lands to steep rocky mountain ranges. The mean annual rainfall of the State ranges from 34 inches in the northwest to 50 inches in the southwest. In the spring and fall heavy rains of torrential proportions sometimes occur, causing severe damage to unprotected fields.

In considering the erosion conditions within the State and their agricultural significance five physiographic regions are important: (1) The Missouri loess, (2) the mixed glacial and loessial, (3) the west Missouri prairie, (4) the Ozarks, and (5) the southeast lowland.

The Missouri loess area consists of about 4,000,000 acres in the northwestern part of the State. The soils of this area were originally 5 feet to 50 feet or more in depth, the darkened surface layer or topsoil varying from 16 to 20 inches in thickness originally. The practice of growing clean-tilled crops, mainly corn, on the rolling topography for many years in succession has resulted in severe erosion, by which three-fourths of the surface soil and some subsoil have been removed by sheet washing from large areas exposing the whitest or pale yellow subsoils, with severe gullying widespread. Moderate to severe erosion occurs on virtually all of the remaining uplands of this area. It is only in the more gently rolling areas and in regions where large acreages of pasture, hay, and small grains are grown, as in Lafayette, Saline, and Platte Counties, that erosion has been moderate. Because of the natural fertility and excellent physical character, probably no other group of soils responds to or shows the influence of good farming methods as do the loessial soils of this region, comprising the Marshall and Knox series.

The mixed glacial and loessial region comprises roughly 14 to 15 million acres north of the Missouri River. This area varies from undulating to gently rolling prairie lands to steeply rolling timbered lands largely of glacial origin, the Shelby and Lindley soils forming the slope lands largely. This region as a whole is completely dissected with natural drainage ways and gullies. The more level loessial Putnam and Grundy soils, occurring on the flat to undulating inter-stream divides, have lost less topsoil generally and are less severely gullied than the more rolling Shelby and Lindley soils. Nearly all of the severely eroded and severely gullied land is found in the northern glaciated region. The commonly impervious subsoils of this region are an important factor, however, in the limited moisture-absorbing capacity of the soils. During a

heavy rain the relatively shallow surface layer soon becomes saturated and subsequent run-off carries with it large amounts of soil. The practice of ridging corn and soybeans up and down the slope to facilitate surface drainage materially increases the soil losses even on rather gentle gradients.

Topographically, the west Missouri prairie is the smoothest part of the State and it is here that erosion is less severe than in other portions. The Cherokee and Oswago soils are generally flat to undulating. It is only in this region that areas of upland having little or no erosion were found, although they are of relatively small extent. It was noted also that large acreage of pasture, hay, and small grains were grown which are excellent crops for controlling erosion.

About two-thirds of southern Missouri, or nearly 15,000,000 acres, may be considered as the general Ozark region. For the most part, the soils of the Ozarks have been derived from limestones and some sandstones, shale, and granites. Because of the stony character of the major portion of the area the absorption of moisture is fairly rapid so that gullying is for the most part moderate. However, 85 to 90 percent of the area has undergone moderate sheet erosion which has removed one-fourth to three-fourths of the surface soil generally. Varying percentages of the territory still remain in timber, although much of it has been cut over and burned, causing accelerated erosion. Farming in this region is quite patchy and scattered as far as cultivated land is concerned. Pasture improvement and reforestation to prevent floods are problems of major consideration.

The southeast lowland represents the largest single area of alluvial soils. There are, however, in the aggregate extensive areas of alluvial soils bordering the Missouri River and its tributaries. It has been estimated by the Soils Department of the University of Missouri that there are nearly 10,000,000 acres of valley land which constitute about 25 percent of the State. The alluvial lands represent areas of deposition rather than erosion. With the partial denudation of much of the timberlands in the Ozarks, considerable outwash of gravel and sand from the hills has virtually destroyed many scattered areas of good bottom land along the smaller stream courses.

The seriousness of erosion problems in the Shelby and Marshall soil areas of southern Iowa and northern Missouri has been recognized for some time. An erosion experiment station was started at Bethany, Mo., by the United States Department of Agriculture in cooperation with the University of Missouri in 1930. A similar experiment station was established at Clarinda, Iowa, in 1931.

An erosion-control demonstration area consisting of 186,000 acres has been established by the Soil Conservation Service on the Big Creek watershed extending

from Bethany north into Iowa. A similar project area has been established on 106,000 acres along the West Tarkio Creek watershed, extending from Tarkio, Mo., north to Red Oak, Iowa.

24. Montana

TABLE XXXVI.—*Reconnaissance erosion survey of Montana*¹—*Acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	93,523,840	100.0
Area on which erosion conditions were not defined (A. R.).....	8,428,501	9.0
Areas with little or no erosion (1).....	17,987,388	19.2
Total area affected by sheet erosion.....	54,184,169	57.9
1/4 to 3/4 topsoil lost (2, 27, 28, 24, 247, 248, 249).....	53,895,684	57.6
Over 3/4 topsoil and some subsoil lost (37).....	318,485	.3
Total area affected by wind erosion.....	46,960,974	50.2
Moderate wind erosion (4, 24, 47, 247, 248).....	42,833,208	45.8
Severe wind erosion (5, 26, 57).....	4,108,586	4.4
Destroyed by wind erosion (6).....	21,180	(*)
Total area affected by gullying.....	52,057,142	55.7
Occasional gullies (27, 37, 47, 247, 57).....	37,544,463	40.1
Severe gullying (28, 248).....	14,512,679	15.6

¹ Includes areas with undifferentiated geological erosion.
* Less than 1/10 of 1 percent.

The land area of Montana comprises 93,523,840 acres about one-third of which is mountainous and two-thirds plains. Little or no erosion was found on 17,987,388 acres and another 8,428,501 acres were classed as mesas, canyons, scablands, barren mountain tops, and similar conditions of geological erosion on which no accelerated erosion was classified. Striking examples of badlands and badland topography were found bordering the Missouri, lower Musselshell, and Yellowstone Rivers. Similar areas of geological erosion too small to be delineated upon the reconnaissance map were included with the classes of accelerated erosion shown throughout the rest of the State. Included in these areas are about 17,000,000 acres of national forests and national parks, in the mountainous sections of the State. Within the mountain region, accelerated erosion is not a problem except locally, as where large streams have been diverted for irrigation purposes.

Less than half of the State is in farm and ranch holdings. A large area still remains in public lands. Accelerated sheet erosion was found to be a problem on 54,184,169 acres where the removal of one-fourth to three-fourths of the topsoil was the prevailing condition, although on 318,485 acres of this area three-fourths to all of the topsoil has been lost generally.

Gullying was found with more or less frequency on 52,057,142 acres, of which 14,512,679 acres were severely gullied. A considerable portion of this severe gullying is normal geological dissection on which accelerated erosion has been induced, frequently, by overgrazing, denudation of timbered slopes, and other misuse.

Wind erosion was found to have affected nearly as much of the State as water erosion, affecting 46,960,974 acres. Moderate wind erosion was noted as the pre-

vailing condition, although 4,106,586 acres were found to be severely eroded by wind and 21,180 acres were essentially destroyed. Many local areas were destroyed by wind which were too small to show on the reconnaissance map.

In the plains area, wind is the dominant cause of erosion, particularly in the dry-land farming areas of the northern glaciated area and in the Judith Basin. South of the Missouri River through the Musselshell Valley and also over the major portion of the Yellowstone watershed, at least 5,000,000 acres of farm lands have been abandoned due to erosion. These areas are mostly barren of vegetation except weeds because of the destruction of the original vegetation by plowing. Abandonment of scattered farms and serious overgrazing of the rolling lands have favored a combination of wind and water erosion.

Comparatively few authentic weather records are available for this large area. Precipitation during the growing season is a very important factor to be considered both from the standpoint of agricultural possibilities and from the erosion standpoint because it is a highly variable factor. The mean annual rainfall may vary from as little as 7 or 8 inches in the central lower portion of the State to 20 inches in the higher mountain sections. The distribution of the summer showers and their intensity are extremely variable. Run-off may be heavy during a short period. During the past 5 years, the rainfall has been continuously below normal over many parts of the State, which has allowed wind erosion to become the dominant noticeable factor over a large portion of the State.

In northern Montana, the plains area was glaciated by great masses of ice from the north which rounded, smoothed, or wholly eliminated hills and filled valleys in their paths. Glaciation was responsible for the change of the course of the Missouri River. The former channels are now filled with loose sandy soils, particularly north of Virgelle and in the Medicine Lake region of Sheridan County. Both of these areas are subject to rather severe wind erosion.

Natural geological erosion has been responsible for the major topographic configuration of the northern plains area, particularly the nonglaciated part. In Montana, this area is one of broad-featured topography comprising tabular uplands having smooth to rolling eastward-sloping plain surfaces broken here and there by mountain masses and elsewhere diversified by buttes, extended escarpments, breaks, and badlands. Successive periods of uplift and erosion have made possible the development of secondary plains at different levels below the original plain until today the region is marked by a series of terraces or remnants of these plains. Old terraces now exist 250 to 300 feet above the Yellowstone Valley.

From the standpoint of erosion the plains area may be divided into two sections: (1) The northern glaciated area mainly north of the Missouri and Sun Rivers and (2) the residual plains area south of the Missouri River, including the Musselshell and Yellowstone drainage systems.

The northern glaciated area consists of approximately 23,500,000 acres, of which about 65 percent was found to be affected by wind erosion. The farming system of alternate fallow and spring wheat has favored the destruction of the original organic fiber that once held the soil firmly in place. During extremely dry periods all soils, including the heaviest clays, have blown badly. Extensive wheat growing sections are found north of the Highwood Mountains, west of Havre, on the northern foothills of the Bearpaw and Little Rocky Mountains, on Turner Bench in northern Blaine and Phillips Counties, and on the Flaxville benches of northeastern Montana.

The badlands, found between the Milk and Missouri Rivers, are mainly steeply rolling alkaline clayhills having a sparse vegetation. They were found to be subject generally to moderate sheet erosion but were badly gullied.

The southern residual section of the plains area comprises approximately 35,000,000 acres. The major extensive farming sections are located in the vicinity of Great Falls and in the Judith Basin. Scattered wheat-growing sections border the Yellowstone Valley and are also found in Big Horn, Wibaux, and Fallon Counties. Alternate fallow and growing of small grains favor breaking down of the organic fiber which, together with considerable cultivation to maintain the fallow, induces severe wind blowing on the bare ground. Extensive areas of land that have been farmed for a few years and are now abandoned were found throughout the Musselshell Basin and in southern and eastern Montana. It has been estimated that at least 5,000,000 acres are now practically worthless, even from the grazing standpoint, due to lack of vegetation. Revegetation is a major problem in this area.

In the western mountainous section of the State wind erosion was found to be a factor of importance in the Flathead Valley both north and south of Flathead Lake where sandy soils were found; and also in the northern and western portions of the Gallatin Valley on the old lake bed, silty soils where dry-land-farming has been practiced for 20 to 30 years.

25. Nebraska

The State of Nebraska comprises an area of 49,291,829 acres. Two types of erosion, water and wind, in varying intensities and combinations, are prevalent. Practically all of the varying degrees of erosion exist in this meeting ground of the humid and semiarid territory.

TABLE XXXVII.—Reconnaissance erosion survey of Nebraska—acres within which more than 25 percent of the land has been affected as indicated

	Acres	Percent
Total area (exclusive of large cities and water).....	49,291,829	100.0
Areas on which erosion conditions were not defined (A, W).....	1,288,132	2.6
Areas with little or no erosion (1).....	11,844,617	23.6
Total area affected by sheet erosion.....	16,736,963	34.0
1/4 to 3/4 topsoil lost (2, 27, 28, 24, 247, 248).....	13,670,872	27.7
Over 3/4 topsoil and some subsoil lost (3, 37, 38).....	3,066,091	6.2
Total area affected by wind erosion.....	20,238,682	41.1
Moderate wind erosion (4, 24, 47, 247, 248).....	16,780,013	34.0
Severe wind erosion (6).....	3,458,669	7.0
Total area affected by gulying.....	16,485,077	33.4
Occasional gullies (17, 37, 37, 47, 247).....	8,266,453	16.8
Severe gulying (23, 38, 248).....	7,207,088	14.6
Destroyed by gullies (9).....	1,011,536	2.1
Essentially destroyed for tillage (38).....	2,728,116	5.5

Wind erosion affects to some degree some 20,238,682 acres or approximately 41 percent of the State, principally in the western, central, and northern portions. Another 35 percent, largely in the eastern one-third of the State, is affected by moderate to severe water erosion, leaving only 23.6 percent having no immediate erosion problem.

These erosion conditions may be rather definitely correlated with (1) the mean annual rainfall, which gradually decreases from 30 inches in the east to 18 or 19 inches in the west; (2) soil types; (3) topography; and (4) the various intensities of land use. Moderate to severe sheet erosion accompanied by gulying is prevalent on the rolling to steeply rolling topography bordering the major stream courses and varies with the amount of land remaining in grass or close-growing crops. The silty loess soils of original high fertility have been used or farmed more intensively and have suffered from uncontrolled erosion.

Severe sheet erosion, with over 75 percent of the topsoil removed, and severe gulying are prevalent generally on 3,066,091 acres, located largely in Custer, Valley, and Greeley Counties of the central part and Hayes and Frontier Counties of the southwest. The Colby soils in particular are very erosive and are thoroughly dissected, the topography being rolling to hilly. Scattered area totalling 1,011,536 acres have been destroyed for cultivation by gulying. Severe gulying was noted on nearly 7,207,088 additional acres, most of which have also moderate to severe sheet erosion, located largely in the eastern and southeastern areas which have a rolling topography. These areas present a problem of immediate conservation or complete destruction will soon follow.

An area of 8,266,453 acres has moderate to severe sheet erosion but to date this land has been only moderately gullied. Severe gulying may follow if steps are not taken to control this menace.

With the gradual change to the lighter rainfall belts particularly in the region of the lighter sandy soil types, wind erosion becomes a factor of considerable importance. About 20,238,682 acres have been affected to some degree by wind erosion. It has been extremely severe on 3,458,669 acres, which have been seriously damaged, largely in the Sand Hill and Dunesand areas of the northwestern part of the State. Locally, even the sandy bottom soils along the Platte River and other valleys are subject to blowing. Moderate wind erosion has affected about 16,780,013 acres. Scattering blow outs were found to be active in areas that, on the whole, were only slightly affected.

Cultivation, particularly the growing of wheat under clean summer fallow methods, which leaves the soil bare during practically a whole season, destroys much of the organic root fiber which formerly held the soil in place. Serious overgrazing is another factor that has contributed or favored a vast amount of wind blowing. The problem of controlling wind erosion is largely a problem of securing and maintaining a vegetative cover, which has a sufficient root system to bind the soil and hold it in place.

In portions of the western part of the State both water and wind erosion are prevalent, particularly on land which is somewhat sandy and rolling in topography.

An erosion control demonstration project of 70,000 acres was started in 1934 by the Soil Conservation Service in cooperation with the farmers along the Plum Creek watershed near Albion, Nebr. In this area all of the farm practices designed to conserve moisture as well as prevent washing and gullying are being used. These are strip and contour cropping, terracing, and the seeding down of such areas as are badly eroded and too steep for cultivation.

26. Nevada

TABLE XXXVIII.—*Reconnaissance erosion survey of Nevada*¹—*Acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	70,286,188	100.0
Areas on which erosion conditions were not defined (A).....	10,656,369	14.3
Areas with little or no erosion (1).....	235,547	.3
Total area affected by sheet erosion.....	49,784,854	70.8
1/4 to 3/4 topsoil lost (2, 27, 28, 247, 258).....	31,377,934	44.6
Over 3/4 topsoil and some subsoil lost (38).....	18,406,920	26.2
Total area affected by wind erosion.....	4,665,030	6.7
Moderate wind erosion (247).....	13,649	(1)
Severe wind erosion (38, 258, 50).....	4,101,146	5.9
Destroyed by wind erosion (0).....	569,935	.8
Total area affected by gullying.....	57,273,736	81.5
Occasional gullies (17, 27, 247).....	11,268,382	16.0
Severe gullying (18, 28, 38, 258, 50).....	46,005,344	65.5

¹ Includes areas with undifferentiated geological erosion.
² Less than 1/4 of 1 percent.

On the reconnaissance survey, many areas were found in Nevada on which, due to lack of time, it was impos-

sible to differentiate accelerated erosion from normal geological erosion. This must be taken into consideration in connection with the following discussion.

The total area of Nevada is 70,286,188 acres. Moderate sheet erosion with the wide-spread loss of one-fourth to three-fourths of the original surface soil, was found to be the prevailing condition on an area of 31,377,934 acres, or 44.6 percent of the entire State, while severe sheet erosion with a loss of three-fourths or more of the surface soil has been general on 18,406,920 acres more. Occasional gullies were found on 11,268,382 acres, and 46,005,344 acres more were found to be severely gullied generally. Severe wind erosion was found to have been active on 4,101,146 acres.

Much of Nevada is mountainous, with steep, rugged mesas of igneous and metamorphic rocks, on which a comparatively thin mantle of soil has developed. If vegetation becomes thin, the shallow soil is soon removed by erosion. On the lower slopes there are alluvial fans, moderately to steeply sloping, which in turn give way to the smooth, nearly level floors of the intervening valleys and desert plains. The soils on the alluvial fans vary somewhat, depending on the character of the material and the method of formation, but as a rule they are porous and well-drained. Sheet and gully erosion are most severe on the lower slopes, where large amounts of water concentrate during run-off.

True desert conditions prevail in the southern half of the State. The great desert plains are broken only by lone parallel ranges of mountains trending north and south. Streams of great length are rare, but the run-off from higher elevations becomes impounded in land-locked depressions. The largest of these sinks occur in the Tahoe, Carson, Humboldt, and Walbur Rivers. Gully erosion is active practically everywhere, and sheet erosion is prevalent on many of the mountain slopes. On the plains the erosion varies greatly with local conditions, but sheet erosion and gullying are generally severe.

Throughout the northern part of the State a cover of sagebrush is fairly well distributed, but the stand has become seriously affected by overgrazing, and erosion is generally severe. Wind erosion is active in the northeastern corner of the State.

27. New Hampshire

TABLE XXXIX.—*Reconnaissance erosion survey of New Hampshire*—*Acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	5,770,286	100.0
Areas with little or no erosion (1).....	5,364,565	92.0
Total area affected by sheet erosion: 1/4 to 3/4 topsoil lost (2, 27).....	46,622	.8
Total area affected by wind erosion: Moderate wind erosion (4, 47).....	48,220	.8
Total area affected by gullying: Occasional gullies (17, 27, 47).....	349,536	6.1

The reconnaissance erosion survey covered 5,770,295 acres in New Hampshire and found 405,732 acres which has been affected by accelerated erosion.

Sheet erosion with the loss of one-fourth to three-fourths of the surface soil was found on 48,623 acres, of which 30,290 acres were in Cheshire and Merrimack Counties. The remainder of this class of erosion occurred in smaller areas in Belknap and Strafford Counties. In Strafford County, occasional gullying accompanied the moderate to serious sheet erosion on 9,964 acres. Sheet erosion, generally, was found to occur on the more rolling topography where there is a relatively high percentage of cleared land that is used for clean-tilled crops.

Occasional gullying was found on 349,536 acres, of which 308,883 acres occurred on land with little or no sheet erosion. This type of erosion was found along stream valleys where there were small patches of cleared lands on upper slopes from which run-off waters concentrated to develop gullies across lower wooded or pastured areas.

Wind erosion affected 48,228 areas on the sand plains, both along the coast and in the interior. Occasional gullies are also found on 30,689 acres of the land subject to movement by wind. The topography and soils of New Hampshire are such that erosion would be a serious menace if the land were cleared and utilized for clean-tilled crops. That erosion is no more serious than it is, is due to the very large percentage of the State that is covered by forests.

28. New Jersey

TABLE XL.—Reconnaissance erosion survey of New Jersey—
Acres within which more than 25 percent of the land has been
affected as indicated

	Acres	Percent
Total area (exclusive of large cities and water).....	4,818,546	100.0
Areas with little or no erosion (1).....	3,852,443	80.0
Total area affected by sheet erosion.....	939,001	19.5
1/4 to 3/4 topsoil lost (2, 27, 29, 247, 248).....	910,305	18.9
Over 3/4 topsoil and some subsoil lost (28).....	28,696	.6
Total area affected by wind erosion: Moderate wind erosion (4, 247, 248).....	268,163	5.9
Total area affected by gullying.....	666,641	13.4
Occasional gullies (27, 247).....	497,002	10.3
Severe gullying (28, 28, 248).....	99,639	2.1
Essentially destroyed by tillage (28).....	28,696	.6

The reconnaissance erosion survey shows 966,103 acres of 4,818,546 acres of land in New Jersey to be affected by accelerated erosion. Much of this erosion is in the northwestern part of the State, although there are some areas of serious erosion in the coastal plains in the southwestern part. Moderate sheet erosion with the loss of one-fourth to three-fourths of the original topsoil is the prevailing condition on 910,305

acres. The largest areas of this erosion condition are in Hunterdon County, and in a strip through Warren and Sussex Counties. The practice of growing clean-tilled crops with cultivation lengthwise of the fields on sloping lands is largely responsible for this soil loss.

In the southern part of the State moderate sheet erosion was found to have affected 318,845 acres. This erosion occurs on sloping lands that are used intensively for truck crops, or are used for orchards where clean tillage is practiced. Numerous small areas of moderate sheet erosion too small to map were found on cultivated lands through much of the intensively cropped lands of southern New Jersey.

Severe sheet erosion where over three-fourths of the topsoil has been removed occurs on 28,696 acres, mainly in Somerset County. This section has been subjected to severe land-use practices with little effort being made to protect or conserve the soil. Severe gullying accompanies this sheet erosion in this section and occurs also on areas in Monmouth and Gloucester Counties where sloping lands are used extensively for clean-tilled crops.

Occasional gullies were found generally on 497,002 acres. This includes all lands affected by moderate sheet erosion except those in Warren, Sussex, and Monmouth Counties, and are the result of advanced stages of sheet erosion.

Moderate wind erosion was found to have affected 286,163 acres. A narrow strip along the Delaware River, north of Camden, showed slight damage from this type of erosion, and wind erosion was found to accompany moderate sheet erosion on the sandy soils in the southern part of New Jersey.

The 3,852,443 acres on which there was little or no erosion have three different land conditions: (1) Flat lands that will never be affected by erosion. These occur on the outer Coastal Plains region south of Asbury Park; (2) gently rolling lands which have a small amount of erosion but are capable of absorbing large quantities of water and are naturally nonerosive. This condition exists over much of the Coastal Plains region; (3) rolling to hilly lands which are now protected from erosion by a good vegetative cover. This condition exists in much of the northern end of the State.

The importance of controlling erosion has been recognized and late in 1934 the Soil Conservation Service established a demonstration erosion control project on the Raritan River watershed with headquarters at Flemington. This project is to demonstrate the best and most practical means of controlling erosion on the different kinds of soil in this region.

29. New Mexico

The total area of New Mexico is 77,588,536 acres, on 85.2 percent of which both wind and water erosion

TABLE XLI.—*Reconnaissance erosion survey of New Mexico*¹—*Acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	77,588,536	100.0
Areas on which erosion conditions were not defined (A, B).....	10,510,728	13.5
Areas with little or no erosion (1).....	1,027,478	1.3
Total area affected by sheet erosion.....	45,799,290	59.0
$\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 27, 28, 24, 247, 248, 257, 258).....	23,282,058	30.0
Over $\frac{3}{4}$ topsoil and some subsoil lost (3, 37, 38, 347, 358).....	22,517,232	29.0
Total area affected by wind erosion.....	14,448,458	18.6
Moderate wind erosion (4, 24, 47, 48, 247, 248, 347).....	5,315,918	8.1
Severe wind erosion (5, 57, 257, 258, 358).....	7,837,609	10.1
Destroyed by wind erosion (6).....	294,931	.4
Total area affected by gullying.....	58,599,720	75.5
Occasional gullies (17, 27, 37, 47, 247, 347, 57, 257).....	17,850,461	22.7
Severe gullying (18, 28, 38, 48, 248, 258, 358).....	40,949,259	52.8

¹ Includes areas with undifferentiated geological erosion.

were found to be active. Areas were mapped on the reconnaissance survey, however, on which accelerated or man-induced erosion was not differentiated from normal geologic erosion. Large areas, aggregating 10,510,728 acres, were designated as mesas, canyons, barren mountain tops, and similar conditions where such areas were large enough to be shown, without designating specific conditions of erosion. In addition to that area, similar conditions in areas too small to be shown separately have been included in the erosion classes as described below.

A loss of three-fourths or more of the topsoil was found to be the prevailing conditions on 22,517,232 acres and on an additional 23,282,058 acres there has been a loss, generally, of one-fourth to three-fourths of the topsoil.

Gullying was found in more or less frequency on 58,599,720 acres of which area 40,949,259 acres were found to be severely gullied. However, an undetermined amount of this gullying is normal geologic dissection which, in some cases, has been accelerated due to overgrazing or other misuse.

Wind erosion was found to have affected 14,448,458 acres, sometimes acting alone and sometimes in conjunction with water erosion of variable severity. Severe wind erosion has affected 7,837,609 acres generally, and 294,931 acres more have been destroyed by wind.

The northwestern part of the State is largely mesas and canyons, where there is considerable erosion, although not much of it has been man-induced.

Slight sheet erosion is prevalent in a belt around the upper limits of the Gila River watershed in the southeastern part of the State, in the alluvial areas of the Rio Grande Valley in the central part, and in the long plain east of the Argan and Franklin Mountains and northwest of Clovis in the eastern part of the State.

The eastern one-third of New Mexico, a continuation of the High Plains, is by far the most important

agricultural section. Both wind and water erosion have become active throughout this area.

The desert-mountain section of western New Mexico represents a timbered transition between the mountains and the southwestern desert plains. The higher portions have a fair to good forest cover which becomes thinner at decreasing elevations, until on the fringe of the desert plains there is a thin cover typical of the very arid regions. There is considerable wind erosion, and gully erosion is also active and generally serious.

In 1934 the Soil Conservation Service established erosion control projects on the Navajo Indian lands, in northwestern New Mexico, and on the Gila River watershed in southwestern New Mexico. This land has suffered wide-spread destruction following overgrazing by goats and sheep. Conservation measures are necessary if the productivity of the land is to be preserved or grazing restored. More recently a similar erosion control project has been established on 11,500,000 acres in the Rio Grande watershed in central New Mexico, comprising the watershed of the Elephant Butte Reservoir. It has been reported that the storage capacity of this reservoir was reduced nearly 10 percent by silting during a period of less than 11 years. Silting constitutes a major problem in connection with all of the large water reservoirs in the Southwestern States.

30. New York

TABLE XLII.—*Reconnaissance erosion survey of New York*—*Acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	30,329,333	100.0
Areas with little or no erosion (1).....	19,890,342	65.6
Total area affected by sheet erosion.....	9,797,714	32.3
$\frac{1}{2}$ to $\frac{3}{4}$ topsoil lost (2, 27, 28, 24, 247, 25, 257).....	9,154,116	30.1
Over $\frac{3}{4}$ topsoil and some subsoil lost (3, 27, 28, 257).....	663,598	2.2
Total area affected by wind erosion.....	967,153	3.0
Moderate wind erosion (4, 24, 47, 247).....	463,124	1.5
Severe wind erosion (5, 25, 257, 357).....	477,724	1.4
Destroyed by wind erosion (6).....	26,305	.1
Total area affected by gullying.....	3,872,776	12.8
Occasional gullies (17, 27, 37, 47, 247, 257, 357).....	3,819,398	12.6
Severe gullying (28, 38).....	47,528	.2
Destroyed by gullies (8).....	5,860	(1)
Essentially destroyed for tillage (38).....	28,696	.1

¹ Less than $\frac{1}{16}$ of 1 percent.

The area of New York covered by the reconnaissance erosion survey comprised 30,329,333 acres, of which 19,890,342 acres were found with little or no erosion. This uneroded condition occurred generally on three land conditions: (1) Level lands that are not subject to erosion, such as stream bottoms and flat ridge tops; (2) lands on which small areas of erosion may occur but where the total area so affected was too small to show on the reconnaissance maps; and (3) lands which are

steep and mountainous but on which erosion is stabilized by forest cover, such as exists in the Catskill and Adirondack Mountains.

Accelerated erosion of one form or another was found to have influenced 10,438,991 acres, or 34.4 percent, of the State. The major portion of this erosion may be described as occurring in two general belts. The first is a north and south belt, lying between the Hudson River and the eastern State line. It reaches west of the river in places and extends from southern Dutchess County as far north as Lake George. The other belt is irregular in shape but extends roughly westward up the Mohawk Valley from Schenectady County to Lake Erie, southwest to Binghamton and westward along the Pennsylvania State line, and northwest to St. Lawrence County.

Sheet erosion was found to have affected 9,797,714 acres, of which 663,598 acres were found to have lost practically all of the topsoil and 9,134,116 acres more have lost one-fourth to three-fourths of the topsoil generally.

Gullying was found to be associated with much of the sheet erosion, being found on a total of 3,872,776 acres, of which 47,828 acres were severely gullied and 5,580 acres were destroyed by gullying. An area of 28,696 acres was found which had been subjected to such severe sheet erosion and gullying that they were essentially destroyed for further tillage.

Wind erosion was found to have affected 897,153 acres. In many cases wind erosion acted in conjunction with water erosion, while elsewhere wind erosion was the dominant factor. Severe wind erosion was found to have affected 407,724 acres generally, and 26,305 acres were essentially destroyed. Wind erosion occurs on sandy soils along the south shore of Long Island and in scattered areas through the northern part of the State, especially in the vicinity of Lake Ontario and Lake Champlain. Sandy soils that contain little clay material blow readily unless the surface is well protected by vegetation. Frequently a small break in vegetation will permit the start of a "blow-out" which will destroy considerable land. Areas of such land not properly protected by windbreaks are subject to wind erosion.

The seriousness of the erosion problem in New York has recently been recognized, and the Soil Conservation Service, in cooperation with Cornell University, has established an experiment station to investigate erosion-control measures. The Soil Conservation Service also has established on the Cohocton River watershed an area of 150,000 acres to demonstrate the best-known control measures upon each farm within the area.

31. North Carolina

Accelerated erosion was found to be active generally on 12,191,035 acres, or 39 percent, of the total area of

TABLE XLIII.—*Reconnaissance erosion survey of North Carolina—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	31,276,299	100.0
Areas with little or no erosion (1).....	19,086,264	61.0
Total area affected by sheet erosion.....	12,187,448	39.0
$\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 27, 28).....	9,368,469	30.0
Over $\frac{3}{4}$ topsoil and some subsoil lost (6, 37, 38).....	2,818,989	9.0
Total area affected by gullying.....	5,647,540	18.1
Occasional gullies (27, 37).....	4,219,513	13.5
Severe gullying (28, 38).....	1,424,440	4.6
Destroyed by gullies (9).....	3,587	(1)
Essentially destroyed for tillage (38).....	1,410,400	4.5

¹ Less than $\frac{1}{4}$ of 1 percent.

31,276,299 acres in North Carolina. Sheet erosion occurs on practically all of this eroded area, or on 12,187,448 acres. From 2,818,989 acres of this area, three-fourths or more of the original topsoil has been lost generally. A total of 5,647,540 acres has been affected by gullying of which 1,424,440 acres are severely gullied generally. Severe sheet erosion accompanied by severe gullying was found to be the prevailing condition on 1,414,077 acres, which means that most of that land is essentially destroyed for further tillage. Erosion is severe on all of the arable lands, except on the Coastal Plain in the eastern one-third of the State.

North Carolina may be divided into three broad divisions: (1) The Appalachian Mountains and valleys in the western one-fifth, (2) the Piedmont Plateau region in the central and west-central sections, (3) the Coastal Plain in the eastern part.

The annual rainfall is 60 to 65 inches on the coast, 45 to 50 inches in the central section, and about 60 inches in the mountains.

The Appalachian region of North Carolina is characterized by a series of parallel mountain ranges, with sharp, narrow ridges and peaks, and with narrow valleys. The elevations range from about 1,000 to 5,000 feet or more above sea level.

The mountains generally are too steep for cultivation and are subject to little or no erosion, except where fires are set occasionally, which burn the forest litter. Then erosion is active until the forest floor is again covered by the protective litter. Some of the smoother mountain tops are safely tilled; but many patches have been cleared on slopes too steep for tillage, which are soon abandoned on account of sheet erosion and gullying. These abandoned fields are conspicuous throughout the region.

The valley soils can, as a rule, be safely tilled, but careless cultural methods have caused many of the slopes to lose practically all of the original surface soil with gullying active in some areas.

The most serious accelerated erosion in the Appalachian regions is found in Cherokee and Macon Counties

in the southern, Haywood and Madison Counties in the central, and Ashe and Wilkes Counties in the northern part of this soil region.

The Piedmont Plateau occupies the central part of North Carolina and comprises 35 percent of the land area of the State. The elevations range from about 300 feet on the eastern border to 1,200 or 1,500 feet above sea level at the foot of the mountains on the western side. The streams have cut rather deep valleys and tributaries have dissected the area resulting in a rolling to hilly topography with excessive drainage.

The extensive Cecil soils originally had a surface layer of sandy loam 12 to 14 inches thick, underlain by 2 to 6 feet of heavy clay. On large areas practically the entire surface soil has been removed, and erosion is now active on the remaining clay or clay-loam subsoil. Much land has been destroyed for agricultural use by severe gullying. Some of these areas have reverted to forests, which provide satisfactory stabilization of erosion except where the forest litter is destroyed by fire.

Erosion is generally not severe on the Coastal Plain of North Carolina, which consists of a low plain with elevations ranging from sea level in the tidewater section to 300 or 400 feet above sea level where the western side of the Coastal Plain borders the Piedmont Plateau. Practically all of the soils are sandy and absorb water readily, and usually occupy level to gently sloping topography.

Investigations of soil erosion have been conducted on a few plots at the North Carolina Experiment Station at Raleigh for several years. In 1930 the United States Department of Agriculture established a soil-erosion experiment station at Statesville in the Piedmont Plateau. The Soil Conservation Service is now conducting three soil-erosion control demonstration projects, at High Point, Wadesboro, and Greensboro, to demonstrate on 247,000 acres of land the best methods by which erosion can be controlled.

32. North Dakota

TABLE XLIV.—*Reconnaissance erosion survey of North Dakota—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	44,948,773	100.0
Areas on which erosion conditions were not defined (A).....	1,972,454	4.4
Areas with little or no erosion (1).....	28,696	.1
Total area affected by sheet erosion: $\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2,247).....	419,283	.9
Total area affected by wind erosion.....	42,725,228	95.1
Moderate wind erosion (4, 47, 247).....	33,616,624	74.8
Severe wind erosion (5).....	9,026,501	20.1
Destroyed by wind erosion (6).....	82,102	.2
Total area affected by gullying: Occasional gullies (17, 47, 247).....	467,110	1.0

Erosion in North Dakota is caused largely by wind. Of the 44,948,773 acres comprising the State's land

area, 42,725,228 acres were mapped on the reconnaissance erosion survey as being affected by wind erosion.

Evidences of slight to moderate wind erosion were found on about 75 percent of the State. This comprises some of the best farm and grazing lands. On 9,026,501 acres, or approximately 20 percent, of the State wind erosion is severe, causing much drifting and crop damage. These seriously affected areas are widely scattered over the entire State. The damage has been so severe in many cases that locally much land has been made unfit for further cultivation.

In the southwestern and western parts of the State, large areas of badly dissected and eroded lands are found. Gullying here is largely normal geological dissection where accelerated erosion has become active because of overgrazing or misuse. Erosion is moderate to severe over these areas, which support only a sparse vegetation.

The extent to which wind erosion has affected the lands of North Dakota varies to a considerable degree with the amount of rainfall received, the texture of the soils, and the type of land use.

The rainfall in the western half of the State is extremely variable, not only in the growing season but in successive years. Variations as much as 10 to 15 inches from the wettest years to the driest years have occurred. With mean annual rainfall varying from 25 to less than 14 or 15 inches, subnormal rainfall may spell failure for any crop. During the past 4 or 5 years subnormal rainfall has been continuous.

The sandy soils formerly intensively cropped and consequently reduced in organic matter are subject to drifting. Vast acreages of North Dakota prairies have been used for wheat growing, much of it being summer fallowed. This has a tendency to break up the soil aggregates as well as to leave the soil bare, thus allowing the wind to have full sway. Even the fine clays will blow badly when thoroughly dried out.

Much of the State has been glaciated, which modified the topography to a great extent in filling up valleys and in smoothing out rough hills. However, in the nonglaciated sections of the southwestern part of the State stream cutting through the sandstones and shales has left a very rough badland topography.

Throughout the western part of the State the establishment of grass over the abandoned farm lands and the judicious control of grazing is of utmost importance in controlling erosion.

33. Ohio

Ohio has a land area of 26,073,600 acres, of which 13,502,318 acres showed little or no erosion generally.

Erosion is a serious problem, however, on 12,567,323 acres or 48.2 percent of the State, of which 4,164,300 acres are severely eroded, over three-fourths of the topsoil and some subsoil having been removed generally.

TABLE XLV.—*Reconnaissance erosion survey of Ohio—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	26,073,600	100.0
Areas with little or no erosion (1).....	13,502,318	51.8
Total area affected by sheet erosion.....	12,567,323	48.2
$\frac{1}{2}$ to $\frac{3}{4}$ topsoil lost (2, 27, 26).....	8,403,023	32.2
Over $\frac{3}{4}$ topsoil and some subsoil lost (3, 37, 38).....	4,164,300	16.0
Total area affected by gullying.....	8,980,166	34.5
Occasional gullies (17, 27, 37).....	7,394,406	28.4
Severe gullying (28, 38).....	1,585,760	6.1
Essentially destroyed for tillage (38).....	1,004,262	3.9

Of this area 1,004,262 acres were destroyed for cultivation by sheet erosion and gullying. Moderate sheet erosion with the loss of one-fourth to three-fourths of the topsoil was the prevailing condition on 8,403,023 acres.

Gullying was found with more or less frequency on 8,980,166 acres, of which 1,585,760 acres were predominantly severely gullied. The most severe sheet erosion and gullying occurs in the southeastern and southwestern parts of the State.

Ohio, including parts of both the Appalachian Mountain region and the Central Plains presents a wide variety of topographic conditions, soil types, and land use, each of which influences the amount of erosion. The even distribution of rainfall throughout the year and the frequent freezing and thawing during the winter months help to make conditions favorable for the loss of soil from unprotected land. The acreages of erosion conditions reported here represent the area over which these conditions are dominant, rather than the actual acreage in each erosion class.

The area with little or no erosion, including 51.8 percent of the State, is practically confined to northern and western Ohio, where glacial action has left a nearly level topography. In the northwestern counties on the flat lake plains, run-off water moves slowly and there is very little erosion. In the northeastern part of the State there is also a large area of nearly level land where erosion is negligible. On the more rolling lands, sheet erosion has removed one-fourth to three-fourths of the topsoil generally on large areas in Ashland, Wayne, Starke, Carroll, Columbiana, Cuyahoga, Knox, and Morrow Counties. The open porous nature of the Wooster and related soils occurring on rolling uplands has helped to prevent rapid run-off and erosion.

In southwestern Ohio the topography is generally rolling with deep, steep-sided valleys near the Ohio River. This part of the State has been influenced by moderate to severe sheet erosion largely. However, the steep valley sides (largely Fairmount soils), are severely eroded and gullied generally. These soils produce a good quality of tobacco. Frequently a steep slope is cleared, planted to tobacco for a few years,

and then left idle for several seasons, which result in much surface soil being washed away. If the fields were allowed to remain in grass or woods, erosion could be satisfactorily controlled.

Southeastern Ohio has by far the greatest area of erosion. The slopes are steep, and the soil only moderately fertile. In Belmont, Carroll, Coshocton, Guernsey, Harrison, Holmes, Jefferson, Muskingum, Noble, and Tuscarawas Counties, much severe sheet erosion occurred with the loss prevailing of more than three-fourths of the topsoil and some subsoil. Much land throughout this section has been used for clean-tilled crops, resulting in destructive washing. This in turn has reduced the fertility to a low level, causing the abandonment of fields for both cropping and pasturage. The amount of abandoned land ranges generally from 10 to 20 percent, but in some sections has reached 40 percent of the area. Farther south, in Athens, Gallia, Jackson, Lawrence, Meigs, and Washington Counties, erosion has been only a little less severe, one-fourth to three-fourths of the surface soil having been removed generally. The topography of this region is rolling to hilly and erosion is active wherever the land is cultivated. The abandonment of coal and iron industries more than thirty years ago lessened the demand for cash crops, with the result that the farmers changed to livestock farming and confined their crop land to small acreages. This left the steeper slopes in pasture or woodland, which has checked active erosion largely.

In southeastern Ohio much severe gullying was found, being most pronounced on the Meigs, Upshur, and Belmont soils, derived from clay-shale or shale. These heavy, highly plastic soils impede percolation of water, causing increased run-off and severe erosion.

The heavy timber on the steep slopes in Scioto, Pike, and Ross Counties provides good protection from erosion. Whenever this timber is removed or destroyed, especially if the land is planted to crops, erosion soon becomes a serious problem.

Erosion conditions in southeastern Ohio have been the subject of investigations since 1932, when an erosion experiment station was established at Zanesville by the United States Department of Agriculture. This station is measuring soil losses under different conditions of slopes and land use, and studying the effectiveness of different control measures such as cropping systems and terraces.

The Soil Conservation Service has located a demonstration area of 93,000 acres on the Salt Creek Watershed in eastern Muskingum County, where erosion-control measures are being demonstrated on a large scale cooperatively on individual farms. This demonstration area includes the principal types of soil, topography, land use, and erosion conditions representative

of southeastern Ohio. The project is of vital interest not only to farmers, but also to conservancy districts in the State, of which there are now three—the Miami, the Scioto-Sandusky, and the Muskingum River systems. These conservancy districts are interested in erosion control from the standpoint of flood control and the silting of reservoirs. The Muskingum Conservancy District is particularly interested because of the large amount of severe erosion within its bounds.

The importance of erosion control for the success of water-storage reservoirs is demonstrated by a survey made on the O'Shaughnessey Dam, the water storage supply for the city of Columbus. Nearly 98 percent of the watershed draining into this reservoir has been mapped as having little or no erosion, yet in 10 years the capacity of this reservoir has been reduced 10 percent by the deposition of silt eroded from the uplands.

34. Oklahoma

TABLE XLVI.—*Reconnaissance erosion survey of Oklahoma—acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	44,586,881	100.0
Areas on which erosion conditions were not defined (A).....	854,507	1.9
Areas with little or no erosion (1).....	8,319,859	18.7
Total area affected by sheet erosion.....	26,102,194	63.0
14 to 34 topsoil lost (2, 27, 28, 24, 247, 25, 257).....	8,313,484	18.6
Over 34 topsoil and some subsoil lost (3, 37, 38, 35, 357, 358).....	19,788,710	44.4
Total area affected by wind erosion.....	7,014,990	15.7
Moderate wind erosion (4, 24, 48, 247).....	320,430	7
Severe wind erosion (5, 25, 35, 57, 58, 257, 357, 358).....	4,736,046	10.6
Destroyed by wind erosion (6, 68).....	1,958,505	4.4
Total area affected by gullying.....	25,225,815	56.6
Occasional gullies (17, 27, 37, 247, 57, 257, 357).....	12,467,230	28.0
Severe gullying (13, 23, 33, 43, 358, 53, 63).....	12,754,599	28.6
Destroyed by gullies (9).....	3,988	(*)
Essentially destroyed for tillage (38).....	11,788,496	26.4

* Less than 1/10 of 1 percent.

Oklahoma is a southern Great Plains State with an area of 44,586,881 acres, of which 81 percent, or 36,267,022 acres, was found to be suffering from accelerated erosion generally. Included in this area are 854,507 acres classified as mesas, canyons, badlands, and similar conditions on which erosion conditions were not designated.

The State has been seriously affected by erosion. Sheet erosion has removed more than three-fourths of the topsoil generally from 19,788,710 acres, or 44.4 percent of the area of the State, and one-fourth to three-fourths of the topsoil has been removed from an additional area of 8,313,484 acres.

Gullying was found to be prevalent generally on 25,225,815 acres, of which 12,754,599 acres were severely gullied.

Western Oklahoma lies in that section of the United States where damage from wind erosion has been most

severe. In this portion of the State 7,014,990 acres were found to be affected by wind erosion, of which area 4,736,046 acres were seriously affected and 1,958,505 acres were essentially destroyed by wind erosion.

Wind erosion in Oklahoma is most serious in the panhandle, or high plains section, where the annual rainfall is less than 20 inches. An extensive acreage has been in cultivation during recent years, with wheat as the predominant crop. The dry-farming methods have left the soils unprotected for considerable periods. The loose, friable soils, derived from late Tertiary outwash material from the Rocky Mountains, are blown about readily if they are left dry and unprotected. With this combination of circumstances, the strong winds which prevail during the fall and spring months have caused severe erosion. This condition has been accentuated by the recent reductions in wheat acreage which have left much unprotected land.

The area with outstanding wind erosion merges gradually into the red plains section, where water erosion is also an important factor. The red plains section occupies most of the western half of Oklahoma, exclusive of the Panhandle. The soils, derived from the Permian Red Beds, vary widely in texture, and include clays, clay loams, silty clay loams, fine sandy loams, loamy fine sands, and sands. The fine-textured soils with heavy subsoils are particularly susceptible to both wind and water erosion. In the western red plains, the annual rainfall is between 20 and 30 inches. The principal cash crops are cotton in the southern two-thirds of the region and wheat in the northern third. Continuous cropping with clean-cultivated cotton with rows parallel to fence lines regardless of soil or slope, and the burning of wheat stubble following harvest, have prepared the stage for unusual damage from erosion. Farther east in the red plains, wind erosion is less serious, but water erosion takes a heavy annual toll. The red soil material is highly charged with soluble salts which develop alkali spots in many of the soil areas. Here the subsoils are generally impervious to water, and the vegetation is sparse, which is conducive to serious gully erosion.

This region was opened to settlement in 1889. Farmers came in from other States and followed their native agricultural methods, regardless of local conditions. Cotton or wheat were grown continuously until a field became so badly depleted of soil that abandonment was necessary. Many of the farmers actually encouraged sheet erosion, believing that a new soil was thus provided each year. Some of the older farmers have prided themselves on the number of farms they have worn out during their lifetime.

In the southeastern cross-timbers section, erosion is a major problem. Sheet erosion and gullying are so severe that many fields have been completely

abandoned. The natural post oak timber of this section has been cut to satisfy the needs of farms and industries. In the development of oil fields and coal mines, many of the fields and woods have been burned or cut over. On the productive farm lands, cotton, oats, and sorghum have been grown extensively. The rows of clean-cultivated crops are laid out parallel to fences, up and down hill, encouraging the loss of topsoil. Many fields have been completely denuded of surface soil, and in many places the subsoil has been removed, leaving only clay and sandstone. Many of the farms in this section once produced an average of one-half to three-quarters of a bale of cotton per acre, but now the average is far below that figure.

The northeastern prairie section is not as severely eroded and gullied as the other parts of the state, largely because of the natural grass cover. There are extensive farming sections, but these are located largely on gently rolling topography, where sheet erosion is not very active. There are, however, gullies throughout this area, which are accelerated by the periodic burning-off of grass land.

The Ozark region, which includes the northeastern and southeastern corners of Oklahoma, is largely forested and hence not extensively eroded. However, when the slopes are exposed, either by clearing or burning the forest, erosion quickly becomes active. Some small farms have been cleared and completely abandoned due to erosion within a few years' time.

The tremendous amount of erosion in Oklahoma affects the rivers as well as the farm lands. Many of the streams are red in color, indicating their tremendous silt load, and their channels are nearly full. The dangers from floods are thereby greatly increased.

The seriousness of erosion is becoming recognized. In 1929 the United States Department of Agriculture, in cooperation with the Oklahoma A. and M. College, established an erosion experiment station near Guthrie. This station is making definite measurements of the losses from erosion, and is investigating methods of control. The Soil Conservation Service located a demonstration project on the Stillwater Creek Watershed in November 1933. Here, working in cooperation with landowners, every known means of erosion control is utilized, including crop rotation, contour farming, strip cropping, terracing, protection of grassland from fires and overgrazing, reforestation or rededication of unutilized land to grassland, and other methods of complete soil protection and conservation.

35. Oregon

The total land area of Oregon comprises 61,443,019 acres, of which slightly more than 25 percent is in farms. Little or no erosion was found on 17,299,330 acres, most of which lies in the forest areas along the

TABLE XLVII.—*Reconnaissance erosion survey of Oregon*—*Acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	61,443,019	100.0
Areas on which erosion conditions were not defined (W, R).....	1,102,806	1.8
Areas with little or no erosion (1).....	17,299,330	28.2
Total area affected by sheet erosion.....	43,126,798	68.6
$\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 27, 28, 24, 247, 25, 257).....	35,776,402	58.2
Over $\frac{3}{4}$ topsoil and some subsoil lost (37, 38, 347).....	6,349,396	10.4
Total area affected by wind erosion.....	6,752,339	11.0
Moderate wind erosion (4, 24, 247, 347).....	5,138,186	8.3
Severe wind erosion (5, 36, 327).....	1,577,486	2.6
Destroyed by wind erosion (6).....	36,667	.1
Total area affected by gullying.....	40,327,512	65.6
Occasional gullies (17, 27, 37, 247, 347, 257).....	32,966,189	53.6
Severe gullying (28, 38).....	7,361,332	12.0

¹ Includes areas with undifferentiated geological erosion.

western side of the State. Mesas, canyons, scablands, and rough mountain lands were mapped on 1,102,806 acres, on which erosion conditions were not designated. Many areas of a similar nature existing in the other parts of the State were too small for separate delineation, and are included with other erosion classes.

Both water and wind erosion are active and nearly 75 percent of the total land area of the State has been affected. The loss of one-fourth to three-fourths of the topsoil was the prevailing condition on 35,776,402 acres. More severe sheet erosion was found on 6,349,396 acres additional, on which three-fourths or more of the topsoil and some subsoil has been removed generally. Much of this area is now submarginal for cropping purposes.

Gullying is wide-spread, occurring with varying degrees of frequency on 40,327,512 acres, or 65.6 percent of the total area. Severe gullying occurred generally over 7,361,332 acres. A considerable portion of this gullying is normal geological dissection, on which accelerated erosion may have been induced by overgrazing and other misuse.

Wind erosion was found to have affected 6,752,339 acres generally, of which 1,577,486 acres were found to be severely eroded. Areas completely destroyed for further cultivation generally comprised 36,667 acres.

The topographic relief of the State varies from sea level to high mountains. The relatively low coastal range is adjacent and parallel to the Pacific Ocean. Between the coastal range and the Cascade Mountains to the east lies the Willamette Valley. East of the Cascades the topographic relief consists of mountains with intervening valleys.

The rainfall is much heavier west of the Cascade Mountains than in the eastern two-thirds of the state, varying from 13 inches in the eastern part to over 50 inches in the northwestern part. Most of the precipitation comes during the fall, winter, and spring for the majority of the area.

Erosion in the forested mountainous areas of the coast and Cascade Ranges is fairly well stabilized because of the protective cover, except where there has been severe fire damage. There is little or no erosion in the valley bottoms of the Willamette River. The upper slopes of the valley, however, are subject to moderate sheet erosion and to moderate to severe gullying depending upon the degree of slope and land use.

East of the Cascade Range, the country is rather dry, but due to attempts at dry-land farming and to the reduction of plant cover by grazing, erosion has been greatly accelerated. Sheet erosion during rainy periods and wind erosion during the dry summer months have resulted in large soil losses. Gullying is also severe over the more rolling lands.

36. Pennsylvania

TABLE XLVIII.—*Reconnaissance erosion survey of Pennsylvania—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	28,784,516	100.0
Areas with little or no erosion (1).....	14,079,392	48.9
Total area affected by sheet erosion.....	14,650,123	50.9
1/4 to 3/4 topsoil lost (2, 27, 28).....	14,222,871	49.4
Over 3/4 topsoil and some subsoil lost (3, 37, 38).....	427,252	1.5
Total area affected by gullying.....	9,093,855	31.6
Occasional gullies (17, 27, 37).....	8,861,496	30.8
Severe gullying (28, 38).....	230,765	(1) .8
Destroyed by gullies (9).....	1,594	
Essentially destroyed for tillage (38).....	41,450	.1

¹ Less than 1/16 of 1 percent.

More than half of the land of Pennsylvania, or 14,705,124 acres, of the State's total of 28,784,516 acres, has been damaged by erosion. On 14,079,392 acres consisting largely of forest, and including the rough mountain sides where cultivation has never been attempted, little or no erosion was found.

Sheet erosion affected a total area of 14,650,123 acres, of which 14,222,871 acres had lost one-fourth to three-fourths of the topsoil generally. There was a widespread loss of more than three-fourths of the topsoil and some subsoil on 427,252 acres, of which 41,450 acres were destroyed for cultivation.

Gullying was found with more or less frequency on 9,093,855 acres, severe gullying occurring on 230,765 acres, mostly in the ridge and valley section where clean cultivation is practiced on the many steep slopes permitting rapid run-off with attendant gullying. Gullies frequently develop following an advanced stage of sheet erosion particularly on abandoned land. Occasional gullies were found on 8,861,496 acres over the State. There is very little gullying in the southeastern, northeastern, and northwestern corners, where the topog-

raphy is not so steep or where large acreages are kept in grass.

In southwestern Pennsylvania on the Westmoreland soils in Greene, Washington, Fayette, Westmoreland, and Allegheny Counties moderate erosion prevails, one-fourth to three-fourths of the surface soil having been generally lost. Slopes are very steep, frequently 40 percent or more, and much of the land, especially in Greene and Washington Counties, has been cleared and used for pasture. Satisfactory pastures can be maintained on these lands with good management. However, the common practice of using no fertilizer, but plowing when the grass becomes thin, cropping 1 or 2 years, and reseeding frequently leads to destructive erosion.

In the west central counties the topography is rugged, and the soils belong largely to the Dekalb, Gilpin, and related series. There has been more general farming here than in the southwestern counties. Many of the steep slopes have been plowed and cropped, resulting in much sheet erosion, the effect of severe sheet erosion being visible on much of the cultivated land.

In the ridge and valley region, a belt extending from Bedford to Carbon and Luzerne Counties, erosion is confined mainly to the lower slopes and valley floors. This region of steep-sided mountain ridges is covered with timber, cultivation being confined to the narrow rolling valleys. In these valleys a general grain and livestock system of farming prevails. The predominating crops are corn, oats, wheat, and clover. Grass usually occupies but 1 year in the rotation. The plowing under of grass after the first year of harvest is a practice brought about during the last 2 decades, due to the failure of a ready market for hay in the nearby cities. As a result erosion has been proceeding at a much more rapid pace within recent years than it did formerly when grass remained on the land for several years before plowing under. Much of the surface soil has been lost by sheet erosion on the predominating soil types, the Hagerstown, Berks, and Gilpin series. Blocks of considerable areas of formerly rich soil have been abandoned, especially where the shale soils (Berks) predominate.

The southeastern corner of the State shows a considerable acreage with moderate sheet erosion. The topography of the section varies from nearly level to rolling. Soils are variable, being derived from sandstone, shale, limestone, and crystalline rocks. Penn and Lansdale are the predominating soils from sandstones and shales. These soils erode very rapidly on slopes, even though the slope may be only slight. Large areas of fairly level land are found on the ridge tops of the divides lying between the valleys. In the section where these soils occupy very rolling lands,

erosion is severe. The soils of crystalline origin, particularly the Manor soils are subject to erosion where the farmers plant large fields in one crop. In the years corn and potatoes are planted, erosion is active. This is one of the oldest and most intensively developed agricultural areas of the State. That erosion is no more severe is due to the good land management practices and to maintaining in sod those areas susceptible to gullyng.

Moderate erosion also occurs in northeastern and northwestern Pennsylvania. In the northeastern section the farmers are primarily interested in producing milk and consequently a large portion of this area is kept in permanent pasture grasses. The more gently rolling land is used for cultivated crops. The common rotation includes several years of grass, which has tended to reduce soil losses by erosion.

In the northwestern section glacial action has left a topography that varies from level to rolling. Little erosion occurs on the level areas but considerable erosion is evident on the rolling lands. However, the open texture and stony character of many of the soils on the rolling lands, the prevalence of livestock farming, and the extensive growing of hay and grass crops helps to keep erosion under control.

In north central Pennsylvania and also in the counties of Clearfield, Cambria, and Somerset, the topography varies from a gently rolling plateau to steep rugged hillsides. Cut-over forest occupies much of the land, particularly in the northern counties, and there is little or no erosion generally. When cleared and cultivated the steep slopes soon become seriously eroded.

In Pennsylvania erosion had not been recognized as a serious problem until recently. During 1934 detailed surveys were made in various sections of the State and at the same time some experimental work was initiated by the Soil Conservation Service in cooperation with the Pennsylvania State College to show the efficiency of various control measures. Also, a demonstration project of 135,000 acres was established on the Crooked Creek Watershed at Indiana, Pa. This project will demonstrate the most practical means of controlling erosion in that region.

37. Rhode Island

TABLE XLIX.—Reconnaissance erosion survey of Rhode Island—Acreages within which more than 25 percent of the land has been affected as indicated

	Acres	Percent
Total area (exclusive of large cities and water).....	673,162	100.0
Areas with little or no erosion (1).....	532,907	94.0
Total area affected by sheet erosion: $\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (27).....	20,726	3.1
Total area affected by wind erosion: Moderate wind erosion (4).....	19,529	2.9
Total area affected by gullyng: Occasional gullies (27).....	20,726	3.1

Erosion is neither extensive nor severe in Rhode Island. The reconnaissance erosion survey covered a total of 673,162 acres of which 20,726 acres were found which showed moderate sheet erosion with the loss generally of one-fourth to three-fourths of the topsoil. All of this eroded area was found to be subject to occasional gullyng. This erosion occurs on clean-tilled areas of moderate slope where no effort is made to cultivate along the contour.

Moderate wind erosion affected 19,529 acres, mostly along the coastal region in Washington and Kent Counties.

Erosion constitutes a threat to land in this State only on the more rolling slopes. Inasmuch as most of these are now wooded or retained in pasture, erosion is not a serious menace, except in local areas.

38. South Carolina

TABLE L.—Reconnaissance erosion survey of South Carolina—Acreages within which more than 25 percent of the land has been affected as indicated

	Acres	Percent
Total area (exclusive of large cities and water).....	19,516,800	100.0
Areas with little or no erosion (1).....	12,823,083	65.7
Total area affected by sheet erosion.....	5,979,165	30.6
$\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 27, 28).....	3,631,411	18.6
Over $\frac{3}{4}$ topsoil and some subsoil lost (27, 28).....	2,347,754	12.0
Total area affected by gullyng.....	5,649,039	28.9
Occasional gullies (27, 27).....	4,337,245	22.2
Severe gullyng (28, 28).....	597,242	3.1
Destroyed by gullies (9).....	714,552	3.6
Essentially destroyed for tillage (28).....	330,920	1.7

The total land area of South Carolina covered by the reconnaissance erosion survey was 19,516,800 acres. Little or no erosion was found on 12,823,083 acres which are mostly in the coastal flatwoods and the nearly level portion of the inner Coastal Plain.

Sheet erosion affected 5,979,165 acres or 30 percent of the State. Of this, 2,347,754 acres had lost over three-fourths of the topsoils and some subsoil generally, and the removal of one-fourth to three-fourths of the topsoil was found to be the prevailing condition on 3,631,411 acres more.

Gullyng, wide-spread on 5,649,039 acres, was found mostly on the cropped lands and on formerly cultivated areas and fields now idle or abandoned. Severe gullyng occurred on 597,242 acres while another 714,552 acres were essentially destroyed by gullyng and sheet erosion.

South Carolina may be divided into three major soil provinces with variations of topography and erosion conditions: (1) The coastal flatwoods; (2) the inner Coastal Plain; and (3) the Piedmont Plateau. About 1 percent of the State, the extreme northwestern corner, belongs to the Appalachian Mountains. The

most serious erosion occurs in the Piedmont and in the inner Coastal Plain.

The flatwoods area borders the Atlantic Ocean and has a width of about 60 to 100 miles or more. Erosion is not pronounced here due to the nearly level surface and the absorptive capacity of the soils.

The topography of the inner Coastal Plain is nearly level to gently rolling in the southeastern part, and hilly along and near the Piedmont Plateau border on the northwest. The soils are mainly light-textured surface soils, 12 to 14 inches deep, underlain by 4 to 6 feet of friable sandy clay. They have the power to absorb large amounts of rain water readily. This accounts for the small amount of serious erosion on the gentle slopes. On the steep slopes erosion is very active and many small areas have been destroyed for agricultural use by gullies.

Erosion has taken a very heavy toll of the soils in the Piedmont Plateau region, where 717,440 acres have been destroyed for tillage. This region occurs in the northwestern part of the State and comprises about one-third of the entire land area. The surface relief ranges from gently rolling to hilly.

It was formerly the practice to cultivate up and down the slopes in this region, which greatly accelerated sheet erosion. Terracing and contour cultivation began to be practiced about 40 years ago which, to some extent, checked erosion. However, terraces often failed due to faulty construction and improper location, the concentration of water causing breaks which developed often into deep gullies.

The soils in the region have heavy subsoils and absorb water slowly. This, coupled with the heavy annual rainfall of 50 inches which often falls in heavy downpours, cultivation of clean-tilled crops, inefficient management, and ill-advised use of the slopes, is responsible for this enormous soil wastage. Many slopes have been cleared of the protective forest cover that are so steep that sheet erosion cannot be controlled under clean tillage. Gullying, once started, quickly destroys the land. On the Cecil soils especially, after gullies cut through the upper heavy subsoils of an average of 5 feet in depth, a loose micaceous sandy clay subsoil is encountered which literally flows away under water action. Steep gullied hillsides are conspicuous throughout the Piedmont region. The silting of reservoirs and ponds is a major problem throughout the Piedmont Plateau. The Spartanburg Reservoir has had its original storage capacity of 2,700 acre-feet reduced more than 17 percent in a period of 8 years.

Land destruction by erosion in this soil region has reached such an enormous acreage that the Federal Government has been asked to take action in stopping this wastage. An erosion control demonstration project was recently established by the Soil Conservation

Service at Spartanburg to demonstrate on two areas with a total of 163,000 acres the best methods of erosion control.

39. South Dakota

TABLE LI.—*Reconnaissance erosion survey of South Dakota—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	49,011,262	100.0
Areas on which erosion conditions were not defined (A).....	685,116	1.4
Areas with little or no erosion (1).....	496,709	.1
Total area affected by sheet erosion.....	5,808,660	11.9
$\frac{1}{4}$ to $\frac{3}{4}$ topsoil lost (2, 27, 28, 247, 248).....	5,800,687	11.9
Over $\frac{3}{4}$ topsoil and some subsoil lost (38).....	7,973	(1)
Total area affected by wind erosion.....	45,588,861	93.0
Moderate wind erosion (4, 47, 48, 247, 248).....	41,559,452	84.8
Severe wind erosion (5).....	4,020,641	8.2
Destroyed by wind erosion (6).....	8,798	(1)
Total area affected by gullying.....	8,099,461	16.5
Occasional gullies (17, 27, 47, 247).....	5,259,348	10.7
Severe gullying (18, 28, 38, 48, 248).....	2,830,946	5.8
Destroyed by gullies (9).....	9,167	(1)
Essentially destroyed for tillage (38).....	7,973	(1)

¹ Less than $\frac{1}{10}$ of 1 percent.

The total area of South Dakota comprises 49,011,262 acres. In South Dakota 36,470,083 acres are included in farm holdings, and over 1,000,000 acres are in national forests and parks. Gullying to some degree in combination with sheet and wind erosion is prevalent on 16.5 percent of the State. Severe gullying was found on 2,830,946 acres. Wind is by far the most active erosion agency, wind erosion being present to some degree in 93 percent of the total area. Serious wind erosion that very definitely indicates the need of attention exists on 4,020,641 acres.

The factors contributing to or influencing the various types of erosion are (1) the rainfall, (2) the farm practices, (3) soil texture, and (4) topography.

The annual rainfall over the State decreases from the southeast where it is 25 inches annually to the northwest where the annual precipitation is around 15 inches, except in the Black Hills region where the annual rainfall is about 20 inches. A marginal rainfall belt is encountered in which the farm practices are much the same as in the more humid States of Iowa, Minnesota, and Wisconsin. Erosion conditions are also influenced to a considerable extent in the James River Valley by the soils which are low in clay content, and high in silt and the very fine sands.

The above-mentioned factors undoubtedly are responsible for the existence of the general belt of serious wind erosion which extends down the James River Valley southwest into Tripp, Lyman, Brule, Sully, and Hand Counties.

Gullying is associated with rolling to steep slopes where the rainfall is not readily absorbed so that rapid run-off occurs. Severe gullying in combination with sheet erosion which has removed one-fourth to three-

fourths of the topsoil occurs in the southeastern part of the State and is confined mainly to soils derived from loess. Here occasional gullying with sheet erosion occurs on 215,619 acres and severe gullying on 224,786 acres in this region of highest rainfall.

Gullying is also associated with wind and sheet erosion along the breaks bordering the major stream courses such as the Missouri, White, Bad, Cheyenne, Moreau, and Grand Rivers. This gully development is largely a geological process that has been accelerated by land-use practices. Severe gullying was found on 2,830,946 acres and occasional gullies occurred on 5,259,348 additional acres.

The Black Hills territory presents a somewhat different picture. This is an elevated mountainous dome which is forested to a large extent and receives a somewhat higher rainfall than the surrounding country. Much of it is confined within a national forest and is protected and fairly well stabilized. The gullying that exists is largely that of natural geological development. The northern portion of this region is more severely gullied than the main body.

In recognition of the wind-erosion problem of the Northern Great Plains States, two demonstration wind-erosion-control projects are being started near Huron, S. Dak., with a total area of 180,000 acres.

40. Tennessee

TABLE LII.—Reconnaissance erosion survey of Tennessee—
Acreages within which more than 25 percent of the land has
been affected as indicated

	Acres	Percent
Total area (exclusive of large cities and water).....	26,679,680	100.0
Areas with little or no erosion (1).....	3,656,314	13.7
Total area affected by sheet erosion.....	17,034,677	63.8
1/4 to 3/4 topsoil lost (3, 37, 38).....	6,120,664	22.9
Over 3/4 topsoil and some subsoil lost (3, 37, 38).....	10,913,913	40.9
Total area affected by gullying.....	21,520,520	80.7
Occasional gullies (17, 27, 37).....	18,582,851	69.7
Severe gullying (28, 38).....	2,833,816	10.6
Destroyed by gullies (6).....	103,753	.4
Essentially destroyed for tillage (38).....	2,085,761	7.8

On the reconnaissance survey of Tennessee, erosion was found to have affected 86.3 percent of the total area of 26,679,680 acres comprising the State. Only 3,656,314 acres were found to have little or no erosion, occurring mainly in the bottomland areas and on forested mountains which have been protected from fires.

The loss of three-fourths of all of the topsoil was found to be the prevailing condition on 10,913,913 acres, and on another 6,120,664 acres there has been a loss generally of one-fourth to three-fourths of the topsoil.

Gullying was found to be more extensive than sheet erosion, having been found on 21,520,520 acres. Severe gullying was found to prevail on 2,833,816 acres of this land, and 103,753 acres more were destroyed by gullying.

Sheet erosion and severe gully erosion combined were found to have rendered 2,085,761 acres generally unsuited to further tillage.

Erosive soils, slopes varying from gentle to extreme for cultivation, a long period of generally careless land use, and a relatively high annual rainfall have induced active water erosion over all but the most level and most heavily forested areas. The present erosion problem is acute in a State thickly settled with a dependent agricultural population and interested in enormous water-power development.

Tennessee embraces in the eastern section part of the Appalachian Mountain region; in the western section the region of loess soils; and, in the central part some of the limestone valley and upland province soils. The State thus presents an extremely wide variety of soil conditions, land-cover types, and topographic conditions.

In the extreme eastern and southeastern corner of the State where greatest relief occurs there is very little accelerated erosion. The mountains are so rugged that there is very little land which lends itself to agriculture, but rather the mountains are well forested.

Directly west of this is a folded region extending from the southeastern boundary of Virginia through the State to the northern boundary of Georgia. The limestone soils in the valleys of this region have been subjected to very severe sheet erosion and generally are severely gullied. These soils have been cultivated for a long time, the principal cash crop on the limestone soil being tobacco. The ground lies bare and unfrozen during a good portion of the winter, which prolongs the period during which erosion may be active. In many cases steep hillsides have been cleared and tobacco has been grown on the slopes which range as high as 75 to 80 percent. Much of this land has lost all of its native fertility and practically all of the topsoil as a result of erosion. These hillsides are farmed as long as a crop can be grown; they are then abandoned to grow up to weeds and brush and a new section of land adjacent to the abandoned one is cleared and the same practices are repeated. Most of these hillsides should never have been put into cultivation at all since they use practically all of the soil and often much of the subsoil in a period of 2 or 3 years.

West of this belt and roughly paralleling it from northeast to southwest is a band of sandstone and shale which gives rise to a very rugged and mountainous section where there is very little agricultural land. In this section the mountaineer type of agriculture prevails where the farmers have cleared off small patches for corn and an occasional tobacco field. Wherever this land has been cleared, erosion has reduced it rapidly to a very unproductive state. The northern part of this belt occupies a rather smooth

plateau covered by a fairly uniform growth of timber, and there has been little erosion.

Adjacent to this belt and surrounding the central basin or limestone section is the section known as the "Highland Rim." This section is intricately dissected, consisting of short steep ridges with narrow valleys and narrow ridge tops. Much of this land has been cleared and farmed at some time or other and has lost the major portion of the surface soil. However, gullying is not as frequent as one might expect in this section due probably to the large amount of rock and chert fragments present in and on the soil.

The central basin of Tennessee, lying within the Highland Rim, comprises an area made up largely of limestone soils, with undulating to rolling topography. On the broader more level areas, erosion is not serious. In some sections of this central basin, especially in Wilson and Rutherford Counties phosphatic limestone lies very close to the surface and has given rise to shallow soils which are covered with the sparse growth of cedars and bluegrass, and is used chiefly as pasture on which there is very little accelerated erosion. The remainder of the central basin is good agricultural land but it has lost generally a moderate amount of topsoil.

Directly west of this central basin is the characteristic Highland Rim topography and agriculture. This flattens out toward the Tennessee River to a section where there is more agricultural land. The soils are quite variable but are fairly productive for most farm crops including tobacco. However, much of the land is seriously eroded by sheet erosion and gullies.

West of the Tennessee River there is a band of soils which are derived from Coastal Plain material. This band runs north and south and is about 60 miles wide, with gently rolling to undulating topography. The section has been subjected to very severe sheet erosion and gully erosion. Practically all of this land has been used for cultivation of tobacco and cotton which leave the soil exposed and subject to erosion throughout the year. Some of this land has been terraced and where the terraces have not been properly constructed and maintained large areas have been completely destroyed by deep gullies.

West of and parallel to the Coastal Plain soils belt is a belt of soils about 25 miles wide derived from loessial deposits. These soils have been used for the production of cotton for a long time. Much of the original topsoil has been lost and large areas have been destroyed by gullies.

The bottoms along the Mississippi River have suffered very little from erosion with the exception that the river has cut channels during flood periods.

41. Texas

The total area of Texas is 169,326,465 acres. There has been little or no erosion on 38,597,844 acres, or 22.8

TABLE LIII.—Reconnaissance erosion survey of Texas—Acreages within which more than 25 percent of the land has been affected as indicated

	Acres	Percent
Total area (exclusive of large cities and water).....	169,326,465	100.0
Areas on which erosion conditions were not defined (A, W).....	19,724,698	11.6
Areas with little or no erosion (1).....	38,597,844	22.8
Total area affected by sheet erosion.....	92,430,413	54.6
4 to 34 topsoil lost (2, 27, 28, 24, 247, 248, 25, 257).....	78,175,311	46.2
Over 34 topsoil and some subsoil lost (3, 37, 38, 347, 35, 357).....	14,255,102	8.4
Total area affected by wind erosion.....	21,405,624	12.6
Moderate wind erosion (4, 24, 248, 347, 247).....	13,327,963	7.9
Severe wind erosion (5, 25, 35, 257, 357).....	6,814,825	4.0
Destroyed by wind erosion (6, 67, 68).....	1,263,736	.7
Total area affected by gullying.....	78,027,402	46.1
Occasional gullies (17, 27, 37, 247, 347, 257, 357, 67).....	45,341,417	26.8
Severe gullying (18, 28, 38, 68, 248).....	31,592,282	18.7
Destroyed by gullies (9).....	1,093,703	.6

¹ Includes areas with undifferentiated geological erosion.

percent of the entire State. The reconnaissance erosion survey found that there has been a loss of one-fourth to three-fourths of the original topsoil generally from 78,175,311 acres and more than three-fourths of the surface soil has been removed generally from 14,255,102 acres more. Occasional gullies were found on 45,341,417 acres; an additional area of 31,592,282 acres has been affected by severe gullying generally; and 1,093,703 acres have been destroyed by gullying. Wind erosion was found to have affected 21,405,624 acres, of which 6,814,825 acres were severely affected, and 1,263,736 acres were destroyed by wind erosion. A total of 9,122,837 acres have been essentially ruined generally by the combination of severe sheet erosion and severe gullying, in addition to the 1,263,736 acres which have been essentially destroyed by wind erosion.

In the high plains of the western Panhandle section, wind erosion is quite general. The annual rainfall is less than 20 inches, and the loose friable soils blow about easily if the vegetative cover is destroyed. In the northern part of the high-plains section large acreages have been planted to wheat, which leaves the soil exposed and subject to wind erosion during the winter months. The southern part is an extensive grazing and farming section, with severe wind erosion on the farm lands and the overgrazed pastures. Sheet erosion by the action of water is also common over a large part of this area. Intense showers occur at irregular intervals, causing the loss of considerable amounts of soil. Gullying is not active on much of the land, due to the smooth topography.

The mountains and basins section of the extreme western portion of Texas, which consists predominantly of pastures and range lands, presents very serious problems of both sheet and gully erosion. The steep slopes and rough lands with shallow soils and generally scant vegetation are very conducive to erosion. Practically all of the annual rainfall occurs in the form of sudden dashing rains during the summer season,

when the topmost inch or two of the soil is loose but the soil underneath is hard and packed.

The Edwards Plateau section which lies east of the mountains and basins contains a considerable amount of severe sheet erosion and severe gullying. The greater portion of this area is devoted to the pasturing of goats and sheep, which are able to survive on the woody forage plants; much of the land has been severely overgrazed and trampled, resulting in severe erosion.

In the rolling plains north of the Edwards Plateau, the severe wind erosion which is characteristic of the High Plateau merges gradually into a combination of wind and water. In the greater part of this area where the annual rainfall is between 20 and 30 inches, both types of erosion exist. The topography varies from nearly level to strongly rolling.

The soils derived from the Permian red beds vary widely in texture and are usually subject to erosion. At the Spur station, there are large losses of soil from land having as little as 1 percent slope. The extensive growing of cotton as a cash crop without contour cultivation, strip cropping, or adequate terracing has resulted in serious sheet erosion. Overgrazing and burning have destroyed the cover on large areas of grassland, with subsequent serious losses of soil and water. The Vernon rough broken lands of the rolling plains have been subject to such severe erosion that much of the land is no longer fit for cultivation.

The west cross timber section, which lies east of the rolling plains, is seriously eroded and has occasional gullies. The annual rainfall is approximately 30 inches. The soils, generally loose, fine sandy loams, were covered originally with a growth of scrub oak. Destructive farming methods including the plowing of steep slopes have induced much severe erosion. The pasture land, which comprises nearly 60 percent of this area, is usually severely gullied.

The eastern and grand prairie section, which includes the black waxy belt, is suffering from very severe erosion. The annual rainfall in this section is about 35 inches. The black, heavy soils absorb water slowly and are very erosive, even on a gentle slope. More than 60 percent of the land is in cultivation, with cotton as the predominant crop. Rows have been run in straight lines, regardless of soil or slope, which leads to the development of small gullies between cotton rows. Practically no pasture land has received adequate protection from erosion. In the 40 to 60 years that most of this land has been under cultivation, in many fields a large part of the rich black topsoil has been washed away, and frequently the subsoil has been removed also, leaving raw chalk or marl exposed and the field almost completely impoverished.

The east Texas timbered section, which occupies the northwestern corner of the State, is characterized by

undulating and rolling timbered areas with friable soils. The annual rainfall is 45 to 60 inches. Both sheet and gully erosion are very active, and in many places the fields have been completely destroyed. In many localities great gullies have formed which are increasing rapidly in length and depth. Many farmers are making efforts to control these losses, but the work needs to be better directed and coordinated.

The broad Rio Grande plain and the coastal prairie section, as well as the large river bottoms and alluvial areas, do not have serious soil erosion. These level to gently rolling areas do not have sufficient slope to cause appreciable rapid run-off and erosion, and the soils are more absorptive.

The problems of soil erosion have been recognized in Texas for some time. Measurements of soil erosion have been conducted at the Spur station in western Texas since 1925. The United States Department of Agriculture established an erosion experiment station at Temple, and another at Tyler, in 1930.

The Soil Conservation Service now has three demonstration erosion-control projects in Texas: one of 207,000 acres on the Elm Creek Watershed near Temple; one of 25,000 acres on the Duck Creek watershed at Lindale; and a third, a wind-erosion-control project, involving 126,000 acres in the Panhandle area near Dalhart. On these three projects the best and most practical methods of controlling erosion are being put into effect in cooperation with the local landowners and operators.

Most of the reservoirs in Texas and in the southwestern States are being rapidly filled by the accumulation of silt which is removed from the uplands by erosion. The municipal reservoir at Rogers, Tex., has accumulated 37.5 acre-feet of silt in 12 years, reducing its capacity by more than one-fifth. The silting process threatens the life of a great many reservoirs in Texas and the States to the west.

42. Utah

TABLE LIV.—*Reconnaissance erosion survey of Utah*—Acre-ages within which more than 25 percent of the land has been affected as indicated

	Acres	Percent
Total area (exclusive of large cities and water).....	82,865,688	100.0
Areas on which erosion conditions were not defined (A).....	23,788,225	45.0
Areas with little or no erosion (1).....	205,656	.4
Total area affected by sheet erosion.....	20,547,568	38.9
1/4 to 3/4 topsoil lost (27, 25, 28, 24, 258).....	13,719,901	26.0
Over 3/4 topsoil and some subsoil lost (37, 35, 348)....	6,827,667	12.9
Total area affected by wind erosion.....	4,218,933	8.0
Moderate wind erosion (24, 348, 47).....	648,856	1.3
Severe wind erosion (5, 25, 258).....	3,570,077	6.7
Destroyed by wind erosion (6).....	39,457	(*)
Total area affected by gullying.....	25,345,383	47.9
Occasional gullies (17, 27, 37, 47).....	6,927,301	13.1
Severe gullying (18, 28, 38, 348, 258).....	18,418,082	34.8

* Includes areas with undifferentiated geological erosion.
 † Less than 1/10 of 1 percent

The area of Utah comprises 52,865,688 acres, of which nearly half or 23,788,225 acres were classified on the reconnaissance erosion survey as rough mountain land, barren mountain tops, canyons, mesas, scablands, and similar conditions on which erosion conditions were not designated. Included in the erosion classes for the rest of the State are areas of similar conditions which were too small for separate delineation.

The loss of more than three-fourths of the topsoil was found to be the prevailing condition on 6,827,667 acres and on an additional 13,719,901 acres there has been a loss of one-fourth to three-fourths of the topsoil.

Gullying was found on 25,345,383 acres generally, of which 18,418,082 acres were severely gullied. However some of this gullying is normal geological dissection on which accelerated erosion may have been induced incident to overgrazing or to other causes.

Wind erosion was found to be serious on much of the land. It was found to have affected, in all, 4,213,933 acres, of which 3,527,620 acres are severely eroded generally and 39,457 acres have been essentially destroyed by wind.

Utah lies wholly within the western mountains and intermountain basins region. Most of the eastern part of the State, except the northeastern corner, consists of mesas, canyons, and rough mountainous land where erosion is generally moderate to severe but erosion in this area and on much of the nonagricultural land must be considered as largely normal or geological erosion, which has not been especially accelerated as a result of the acts of man. Wherever erosion has been increased following cultivation, grazing, lumbering, or forest fires, it is accelerated or man-made erosion. Time did not permit differentiation of the conditions during the reconnaissance survey.

In the western part of the State there are large areas of severely eroded and gullied soils. The region has rather low mountains, with long narrow intervening valleys. The normal plant cover is thin and present erosion conditions are the result of uncontrolled grazing extended over a long period of time. The soil is usually light-textured and loose, and is easily transported by moving water. The greatest run-off and erosion occur following heavy snows. Areas of this type are adapted only to well-supervised grazing.

Small areas of severe wind erosion also occur throughout the western part of the State. These include areas where the surface soil has been removed, and areas of accumulation around plants, along fence lines, or as small dunes.

The mountains generally have moderately to steeply sloping sides, covered with comparatively thin mantles of soil. If the protective cover of vegetation is removed the soils disappear rapidly and many of the slopes are nearly or entirely barren. At lower elevations the

rock masses are buried by moderately to steeply sloping alluvial fans, and these in turn give way to the smooth floors of the intervening valleys. The soils on the alluvial fans are as a rule deep, porous, and well-drained, but local exceptions, especially in the northern part of the State, include districts with poor drainage and impervious soils. Throughout much of this region sheet erosion is dominant.

The Soil Conservation Service has established an erosion-control project which includes 16,000,000 acres on the Navajo Reservation, in New Mexico, Arizona, and the southern and southeastern extremity of Utah.

43. Vermont

TABLE LV.—Reconnaissance erosion survey of Vermont—Acreages within which more than 25 percent of the land has been affected as indicated

	Acres	Percent
Total area (exclusive of large cities and water).....	5,839,360	100.0
Areas with little or no erosion (1).....	5,073,383	86.9
Total area affected by sheet erosion: ¼ to ¾ topsoil lost (2, 27, 28).....	506,476	8.7
Total area affected by gullying.....	681,825	11.7
Occasional gullies (17, 27).....	679,085	11.6
Severe gullying (28).....	2,740	(1)

¹ Less than ¼ of 1 percent.

Vermont comprises an area of 5,839,360 acres, or 86.9 percent of which there is little or no erosion. Much of the State has a steep, rough topography, a large part of which is in forest or in permanent grass cover. Only a small proportion of the acreage is devoted to clean-tilled crops. However, on 765,977 acres, accelerated erosion was found to be a problem generally. On 506,476 acres loss of one-fourth to three-fourths of the topsoil was found to be the prevailing condition, of which 422,324 acres were also gullied occasionally.

Gullying, in a varied degree, was found on a total of 681,825 acres, of which only 2,740 acres occurring in Franklin County, were severely gullied. The severe gullying in Franklin County was found on soils which are underlain by heavy impervious clays. Since rainfall cannot percolate readily through the soil, severe gullying has been induced by the rapid run-off, under the prevailing conditions of land use. Of the land on which occasional gullies were found, 259,501 acres comprised land on which there was practically no sheet erosion in conjunction with the gullying. Such conditions were found more often in narrow belts along stream valleys, especially in the Connecticut River Valley.

44. Virginia

Virginia has a total land area of 25,392,410 acres of which 9,351,320 acres were found on the reconnaissance

TABLE LVI.—*Reconnaissance erosion survey of Virginia—Acreages within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	25,892,410	100.0
Areas with little or no erosion (1).....	9,351,320	36.3
Total area affected by sheet erosion.....	15,758,912	62.1
14 to 24 topsoil lost (2, 27, 28).....	14,748,971	58.1
Over 24 topsoil and some subsoil lost (27, 28).....	1,009,941	4.0
Total area affected by gullying.....	14,354,188	58.5
Occasional gullies (17, 27, 27).....	14,374,725	56.6
Severe gullying (18, 28, 28).....	479,463	1.9
Essentially destroyed for tillage (28).....	851,925	1.4

erosion survey to have little or no erosion. The relatively uneroded portion includes the coastal flatwoods and forested mountain areas principally.

The total area found to be affected by sheet erosion was 15,758,912 acres or 62.1 percent of the entire State. Of this, 14,748,971 acres had lost generally one-fourth to three-fourths of the topsoil. A wide-spread loss of more than three-fourths of the topsoil with some subsoil occurred on 1,009,941 acres, of which 351,925 acres were destroyed for further tillage by sheet and gully erosion. Other small areas of formerly cultivated land now abandoned because of erosion are not shown on the reconnaissance map because of their limited acreage.

Gullying had developed on 14,854,188 acres with varying degrees of frequency and depth. Over this gullied area, 479,463 acres were seriously affected, small acreages locally being destroyed for cropping.

The physiography of Virginia is quite varied. Elevations range from sea level on the coast to 4,000 feet in the western part. There are five distinct soil divisions: (1) The flatwoods; (2) the Chesapeake Bay region; (3) the Middle Coastal Plain; (4) the Piedmont Plateau; and (5) the Appalachian Mountains and valleys.

In the flatwoods section in the southeastern part of the State there is very little erosion because of the comparatively level topography.

The Chesapeake Bay region and the inner Coastal Plain have a topography that is undulating to gently rolling or hilly, the soils being generally sandy, with friable subsoils. They absorb water readily and with proper handling erosion can be controlled, except on the steeper slopes. However, many rolling or steep areas have been cleared and used for clean-tilled crops without adequate protection by terraces, strip cropping, or other erosion control methods to slow down the velocity of running water. Consequently, sheet erosion has done wide-spread damage, and gullying is conspicuous in some localities. The greatest amount of erosion in this region is in the central part, and in King George and Westmoreland Counties bordering the State of Maryland.

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The Piedmont Plateau is the most extensive soil region in Virginia. The surface is rolling to hilly, and in places semimountainous. The soils have heavy clay subsoils that absorb water slowly, giving a heavy-run-off. Many slopes, too steep for safe tillage, have been cleared and used for clean-tilled crops without adequate erosion protective methods. As a result of this, sheet and gully erosion have been especially active.

The Appalachian Mountain system extends in a northeast-southwest direction across the western part of Virginia. This region is marked by a series of parallel mountain ranges with intervening ridges and narrow valleys. The mountain sides are too steep for cultivation but there are areas of fairly level lands, saddles, slopes, and valleys that constitute good farm lands and can be safely farmed. The ridges and mountain slopes are forested but here and there many slopes, too steep for safe tillage, have been cleared of the protective forest cover and within a period of 3 or 4 years have become so eroded and cut by gullies that they have had to be abandoned.

The valley lands included in the Appalachian province range from narrow stream bottoms to the broad limestone Shenandoah Valley 20 to 30 miles wide extending northeast and southwest across the State. The valley floor proper is undulating to gently rolling, but is marked here and there by both low and high ridges, whose sides are generally too steep for safe tillage. Sheet erosion is active on the gentle slopes of the valley floor. The soils are used for clean-tilled crops, and are not generally plowed on the contour. There is no protection by strip cropping or terracing from the erosive action of accumulated water. On the associated ridges many slopes too steep for safe tillage have been cleared and many abandoned fields stand out as erosion scars on the hillsides.

The serious erosion problem in Virginia, particularly in the Piedmont Plateau, is becoming recognized. A demonstration project of the Soil Conservation Service is located on 175,000 acres of the Bannister and Sandy River watersheds near Chatham. This project is putting into practice the best-known methods of erosion control and correct land use.

45. Washington

The land area of the State of Washington comprises 42,431,484 acres of which slightly less than one-third is in farms. Little or no erosion occurs on 12,197,011 acres, most of which are the extensively forested areas of western and flat valley lands of central and eastern Washington. About 500,000 acres are irrigated, located largely in the drier section of eastern Washington. Mesas, rough mountain lands, scablands, barren rocky mountain tops, canyons, and lands of a similar nature constituted 6,077,980 acres and were not

TABLE LVII.—*Reconnaissance erosion survey of Washington*¹—*Acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	42,431,484	100.0
Areas on which erosion conditions were not defined (W, R).....	6,077,980	14.3
Areas with little or no erosion (1).....	12,197,011	28.7
Total areas affected by sheet erosion.....	21,282,505	50.2
1/4 to 3/4 topsoil lost (2, 27, 28, 24, 247, 248, 25, 257, 258).....	20,301,261	47.5
Over 3/4 topsoil and some subsoil lost (38).....	981,244	2.4
Total areas affected by wind erosion.....	6,182,005	14.6
Moderate wind erosion (24, 47, 248, 247).....	1,779,554	4.2
Severe wind erosion (25, 257, 258).....	1,631,689	3.9
Destroyed by wind erosion (6).....	2,770,762	6.5
Total area affected by gullying.....	19,626,903	46.2
Occasional gullies (17, 27, 47, 247, 257).....	14,234,430	33.5
Severe gullying (28, 38, 248, 258).....	5,392,464	12.7

¹ Includes areas with undifferentiated geological erosion.

classified as to erosion. Other areas of similar character too small to delineate separately, occurring over the rest of the State, were included in classified erosion areas.

Sheet erosion has affected 21,282,505 acres or 50.2 percent, of the total area. A loss of more than three-fourths of the topsoil and some subsoil was the prevailing condition on 981,244 acres and on another 20,301,261 acres one-fourth to three-fourths of the topsoil generally was removed.

Wind erosion occurred on 6,182,005 acres, of which 1,631,689 acres suffered severely, and 2,770,762 acres were essentially ruined for cropping purposes.

Gullying has affected 19,626,903 acres or almost as large an area as sheet erosion. Of this area, 5,392,464 acres were severely gullied generally. The gully classes include some normal geological dissection on which accelerated erosion may have been induced by grazing.

The erosion conditions within the State may be broadly separated to coincide with the two fairly distinct rainfall belts. West of the Cascade Mountains the winds coming from the Pacific Ocean are heavily laden with moisture but before they can cross the mountains a large percent is dropped. Precipitation varies from 40 to over 100 inches annually. East of the Cascades the rainfall is very much less, varying from 5 or 6 inches in the Great Bend region to 18 to 20 inches in the Palouse section.

The topography of the State also influences the type and the severity of erosion because of the difference in gradients over which the moisture not readily absorbed must pass.

In the central part of the State, locally known both as the "Columbia Basin" area and the "Great Bend" region, the soils are of light texture and loose structure and are readily moved by both wind and water when not protected by vegetation. This is a region of light rainfall. Most of the original grass and brush cover has been removed in utilizing the land for dry-farming operations and the entire region has suffered heavily

from the effects of both wind and water. In some areas wind erosion is the outstanding factor with a total of 1,631,689 acres seriously damaged by wind erosion. Considerable areas have been abandoned.

Scablands or shallow soils overlying basalt rock are wide-spread in the upper part of the Columbia Basin area.

In the Palouse area the steeply rolling, highly erosive, silty soils have suffered moderate to severe sheet erosion as well as extensive gullying.

The northern part of the State is generally mountainous with a number of prominent river valleys. Logging operations, grazing, and fires have greatly reduced the density and character of the native vegetation, and gully cutting is becoming increasingly serious.

In the flat lands surrounding Puget Sound there is little evidence of soil loss. Much of the poorly drained areas remain in timber. Throughout the mountain areas of the western part of the State, particularly in the regions of heavy rainfall, the tree and brush cover is normally dense and extensive areas show little or no evidence of active erosion. Bordering the lowland or valley areas some of the steeper slopes have been cleared. Slight to severe gullying, accompanied by more or less sheet erosion, has developed. Fires and logging operations are also conducive to accelerated erosion.

One of the erosion experiment stations of the United States Department of Agriculture is located in southeastern Washington near Pullman. The Soil Conservation Service is conducting a demonstration project in soil-erosion control on 130,000 acres on the Wildhorse Creek and the South Palouse River watersheds.

46. West Virginia

TABLE LVIII.—*Reconnaissance erosion survey of West Virginia*—*Acres within which more than 25 percent of the land has been affected as indicated*

	Acres	Percent
Total area (exclusive of large cities and water).....	15,333,648	100.0
Areas with little or no erosion (1).....	1,477,050	9.6
Total area affected by sheet erosion.....	13,768,516	89.8
1/4 to 3/4 topsoil lost (2, 27, 28).....	9,736,325	63.5
Over 3/4 topsoil and some subsoil lost (3, 37, 38).....	4,032,191	26.3
Total area affected by gullying.....	8,370,873	54.6
Occasional gullies (17, 27, 37).....	7,640,357	51.2
Severe gullying (28, 38).....	481,058	3.1
Destroyed by gullies (9).....	249,458	1.6
Essentially destroyed for tillage (38).....	245,150	1.6

Although most of West Virginia occupies rough mountainous topography and is largely timbered, erosion was found to be active on 13,768,516 acres, or 89.8 percent, of the State's total land area of 15,333,648 acres. Little or no sheet erosion was found on 1,477,050 acres, most of which is restricted to the heavily wooded

mountain slopes in the eastern part of the State, and along the numerous level flood plains of stream and river valleys.

A loss of over three-fourths of the topsoil and some subsoil was the prevailing condition on 4,032,191 acres, or 26.3 percent, of the State. Less severe erosion occurred on 9,736,325 acres more where one-fourth to three-fourths of the topsoil was removed generally. Land destroyed by sheet erosion and gullying for further tillage generally was found to be 345,150 acres and another 39,458 acres were destroyed by gullying alone. Many small scattered acreages which could not be shown on a reconnaissance map were found abandoned and essentially ruined for cropping. Gullying was widespread, occurring more or less frequently on 8,370,873 acres, of which 481,058 acres were severely gullied.

The prevalence of erosion on the forested lands is due primarily to the destructive methods employed in logging operations. Close grazing of cut-over and forested lands has contributed also in some sections. Another practice which has proven severely destructive has been that of clearing steep mountain slopes, cultivating the land for 2 or 3 years, and then, when the topsoil is gone, abandoning the land to grow up to weedy pastures of poor quality or to brush and inferior types of forest. On the more gentle slopes which are cultivated, a wide variety of conditions was found. Some cultivated lands have been well protected by restricting cultivation to more gentle slopes and maintaining the steeper parts in permanent grass. Cultivation of steep slopes has induced severe sheet erosion and gullying.

Severe erosion was noted in practically all counties in the western part of the State where a loss of over three-fourths of the surface soil accompanied by occasional gullying prevails.

It has been a common practice to clear a few acres of forest each year, on which corn is grown for a short time, or until all the topsoil is gone, and then allow the land to grow up in grass for pasture. Brush grows quickly on the eroded pastures which are burned over often in an attempt to improve them. This naturally results in acceleration of severe erosion. Much severe erosion exists in Hardy, Berkeley, and Harrison Counties, where destructive practices of cutting mine timber on the forest land and continuous clean cultivation of crop land have destroyed considerable areas.

On the forested area through the central part of the State moderate sheet erosion with practically no gullying was the predominating condition. Numerous fires and a small amount of cultivation have contributed much to the prevalence of sheet washing.

Because of the severity of erosion in West Virginia, an erosion control demonstrational project was established by the Soil Conservation Service on the Reedy

Creek watershed of 87,000 acres with headquarters at Spencer, W. Va. The best-known methods of erosion control and proper land use are being put into successful practice on each farm.

47. Wisconsin

TABLE LIX. Reconnaissance erosion survey of Wisconsin—Acreages within which more than 25 percent of the land has been affected as indicated

	Acres	Percent
Total area (exclusive of large cities and water).....	35,363,840	100.0
Area with little or no erosion (1).....	19,353,832	54.7
Total area affected by sheet erosion: $\frac{3}{4}$ to $\frac{1}{4}$ topsoil lost (2, 27, 29).....	11,219,017	31.7
Total area affected by wind erosion.....	3,242,747	9.2
Moderate wind erosion (4, 47, 48).....	1,339,363	3.8
Severe wind erosion (3).....	1,895,467	5.4
Destroyed by wind erosion (6).....	7,927	(1)
Total area affected by gullying.....	12,695,120	35.9
Occasional gullies (17, 27, 47).....	9,040,138	25.6
Severe gullying (18, 28, 48).....	3,654,984	10.3

¹ Less than $\frac{1}{16}$ of 1 percent.

The land area of Wisconsin amounts to 35,363,840 acres of which more than half, or 19,353,832 acres, has little or no erosion. The remaining area of 16,010,008 acres was found to be affected by both wind and water erosion. Loss of one-fourth to three-fourths of the topsoil was found to be the prevailing condition on 11,219,017 acres. Practically all of this sheet erosion area was found to be gullied to a variable extent. Gullying was found to be more wide-spread than sheet erosion since 1,548,244 acres were found on which there was little or no sheet erosion but on which gullying had developed due to misuse of that land or adjacent land. Gullying was observed generally on a total area of 12,695,120 acres, of which 3,654,984 acres were severely gullied.

Wind erosion was found to have affected 3,242,747 acres. Of this area, 7,927 acres have been destroyed and 1,895,467 acres more have been seriously damaged by wind erosion.

The records indicate a very equable distribution of rainfall of 30 inches or more over the State. It is said that a 2-inch rainfall during a 24-hour period is very rare in occurrence.

The most serious erosion exists in the so-called "Driftless area" of the southwestern part of the State mainly in Buffalo, Trempealeau, La Cross, Monroe, Vernon, Crawford, Richland, and Iowa Counties. About 3 million acres in this section have lost one-fourth to three-fourths of the topsoil, most of which are also severely gullied. The rolling to steeply rolling topography favors a rapid run-off of the moisture not readily absorbed. Much of this land was originally forested; and some areas, particularly the steep slopes, remain in timber. Excessive grazing of the timbered areas and the cultivation of very steep slopes have induced accelerated erosion.

In the western and southern portions of the State from Polk County south and east about 7,500,000 acres have lost from one-fourth to three-fourths of the surface soil through sheet erosion, but are only moderately gullied. The glacial topography consists in part of very rolling moraines, eskers, and outwashes, the slopes of which are quite steep.

In the extreme northern portion of the State, on the Superior Clay soils, about a million acres more show the effects of moderate sheet erosion with occasional gully-ing. This condition has been aggravated by the clearing of the ravines of their trees, as well as by excessive grazing. Moderate gully-ing also occurs in Marathon and Clark Counties. While erosion in these areas is not an immediate problem, poor farm management may soon bring about a serious condition.

Wind erosion is most serious in the Sand Plain section of the State in Juneau, Adams, Marquette, Waushara, Wood, and Jackson Counties, where about 1,900,000 acres are seriously affected. Much of this land has been cleared and cultivated until the organic matter has become depleted to such an extent that the wind now easily picks up the finer soil and shifts it to other regions. Much of the land has been abandoned and is slowly reverting to a wooded condition.

On the sandy soils in the northwestern part of the State, moderate wind erosion has affected about 1,000,000 acres more. On much of this land the timber has been cut off and jack pine trees are now being planted.

The seriousness of erosion in the Driftless Area is recognized. The United States Department of Agriculture established an erosion experiment station at La Crosse in 1931 and the Soil Conservation Service has now established a demonstration area on 93,000 acres in the Coon Creek watershed to cooperate with the farmers of the district in demonstrating practical measures of erosion control.

48. Wyoming

TABLE LX.—*Reconnaissance erosion survey of Wyoming*—
Acres within which more than 25 percent of the land has been affected as indicated

	Acres	Percent
Total area (exclusive of large cities and water).....	62,369,259	100.0
Areas on which erosion conditions were not defined (A).....	4,926,949	7.9
Areas with little or no erosion (1).....	9,077,115	14.6
Total area affected by sheet erosion.....	41,159,297	66.0
1/4 to 3/4 topsoil lost (2, 27, 28, 24, 247, 248, 258).....	33,442,851	53.6
Over 3/4 topsoil and some subsoil lost (38, 348).....	7,716,446	12.4
Total area affected by wind erosion.....	20,288,903	32.5
Moderate wind erosion (4, 24, 47, 48, 247, 248, 248)....	18,910,694	30.3
Severe wind erosion (57, 258).....	1,357,446	2.0
Destroyed by wind erosion (6).....	120,763	.2
Total area affected by gully-ing.....	47,152,288	75.6
Occasional gullies (17, 27, 47, 247, 57).....	16,530,119	26.5
Severe gully-ing (18, 26, 38, 348, 48, 248, 258).....	30,622,269	49.1

Includes areas with undifferentiated geological erosion.

The area of Wyoming comprises 62,369,259 acres, of which 9,077,115 acres were found to have little or no erosion and 4,926,949 acres were classed as rough mountain lands, canyons, mesas, scablands, and similar conditions on which erosion conditions were not designated. These represent areas with normal geological erosion on which accelerated erosion may or may not be active. Scattering areas with similar geological conditions which were too small for separate delineation, are included in the 48,365,195 acres on which accelerated erosion was found by the survey.

Accelerated erosion was found to be slight if present at all in the northwestern part of the State in Yellowstone Park, in the national-forest areas, and in a large area north of Laramie. There are about 8,500,000 acres in national forests in the State.

About half of the State's area is included in farms and ranches, of which 1,256,155 acres are irrigated, as reported by the census in 1929. Because of the low rainfall, 15 inches or less, dry farming is not extensive. Rather, Wyoming is a vast range country with the raising of livestock the most important agricultural industry.

Sheet erosion was found to have affected 41,159,297 acres, of which 7,716,446 acres have lost more than three-fourths of the topsoil. Gully-ing was found generally on 47,152,388 acres, of which 30,622,269 acres were severely gullied. However, part of this gully-ing was normal geological dissection on which accelerated erosion may have been induced by overgrazing or other causes.

Wind erosion was found to have affected 20,288,903 acres, of which 120,763 acres were destroyed and 1,257,446 acres were seriously damaged. Wind erosion was found to be most severe in the plains area in the eastern part of the State.

Outside of the forested areas, conditions are serious generally, and in places have reached a stage where the land is practically ruined by the removal of most of the surface soil and by deep gully-ing. More than 4,600,000 acres of land, largely south and east of Cody, have a badland topography with sparse vegetation. Over 5,000,000 acres have but little surface soil left and are so severely gullied that the land is of slight value even for grazing purposes. Many years of protection will be necessary to produce even a stabilizing vegetation.

Moderate to severe sheet erosion in combination with some wind erosion is prevalent and much of the land affected in this way is also seriously gullied. Such areas are scattered over all parts of the State outside of the forested mountainous areas.

The topography of the State of Wyoming varies from extremely rugged mountains, rough broken badlands, and steep escarpments to fairly level high

benches and plains areas. With the exception of the irrigated valleys and foothills bordering the mountains, very little of the State may be said to be suitable for general farming. The grazing of livestock over the public domain has been largely uncontrolled, except in the national forests. This has greatly reduced the stand of natural vegetation, thus making it possible for the wind and occasional hard dashing showers to move rather large quantities of soil. The stabilization of erosion in this dry region will require adequately controlled grazing practices over the entire area.

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SECTION X

ENGINEERING ASPECTS OF EROSION CONTROL¹

Soil erosion is the loss of the soil by the action of wind or water. The cutting of our trees on the sloping land, without a program of reforestation, and the extensive use of sloping, erodible soils for the production of cultivated crops, without adequate protection by terraces, contours, and cover planting, have made the soils susceptible to the erosive action of water.

A statement of the extent and distribution of soil erosion in the United States is set forth in the contribution to this report by the Soil Conservation Service. Although this section of this report is devoted to the engineering aspects of the problem of controlling soil erosion caused by water run-off, it should be clearly understood that the success of any program of erosion control in farming areas is dependent on the employment of a good system of farming. Soil-erosion control should be clearly recognized as a problem having agricultural, forestry, and engineering phases.

From an engineering point of view the problem of soil-erosion control is one of providing a type of surface drainage that will so control run-off as to reduce erosion to a minimum. The solution of the problem is dependent largely on reducing the rate of flow and increasing the absorption of surface water. The destructiveness of surface drainage or run-off in eroding land is dependent on both quantity and rate of run-off. The rate of run-off is more dependent on the amount of rainfall that occurs during a short period than on the total amount of rain that falls during a month or a year. The amount and rate of run-off and of erosion are also dependent on the topography, the degree of saturation of the soil, the soil type, its treatment, the cultural practices, and the vegetative cover on the land.

In considering the problem of erosion control we should be interested first in the causes of erosion and the conditions that make the soil susceptible to erosion, and then in developing remedies that will control the cause and make the soil less susceptible to erosion. The rapid movement of water over the soil surface is the cause of erosion. If all the rainfall and other precipitation were absorbed by the ground upon which it falls there would be no erosion. The water that is not absorbed by the soil is the cause of all water erosion. The movement of this water is slow at first without power to do much damage, but as it proceeds down the

slope it gains momentum and power to tear away the soil, resulting in sheet erosion and finally producing gullies of increasing size.

The erosive power of water is dependent upon its velocity and the load of eroded material; the velocity of the water in turn depends upon the slope of the land, the roughness of the surface, the depth of flow, and the resistance offered by cover crops. Erosion is, therefore, more pronounced on steep slopes than on gentle slopes, because the run-off water attains higher velocities and, therefore, can remove more soil. For instance, if the slope is increased four times, the velocity of the water is about doubled and the power of the water to carry away soil is greatly increased. Water flowing down a land slope tends to concentrate in small depressions in the surface, forming streams that grow larger in volume as they approach the foot of the slope.

We often hear the idea expressed that "the present condition of our poor denuded field soils is a result of the soil being washed away and not a result of cropping." The fact remains that the serious erosion of millions of acres of crop land began when the land was first plowed, whether it was land cleared from the forest or the original sodded slopes of the prairie country. Plowing and cultivating are fundamental to the operation of growing crops. The cropping of these soils made them susceptible to erosion.

Methods of Erosion Control

On most erodible soils used for row crops the amount of erosion can be greatly reduced by terracing. The consensus of opinion among agricultural workers upon erosion-control problems is, broadly speaking, that forests effect the most satisfactory protection for steep slopes; that permanent hay lands and pastures are very effective on moderate slopes; that in every agricultural area there is a rather definite limit to the steepness of slopes for economic use under cultivation; that cultivated fields with slopes of 2 to 10 percent require terracing, contour farming, and erosion-resistant and soil-improvement crops; and that nearly level lands may be protected with suitable cropping practices.

Of these typical methods of erosion control, those to be used upon sloping cultivated fields are of greatest interest in reference to land use because a large part of all the cultivated land in the United States shows

¹ Prepared by E. W. Lehmann, Bureau of Agricultural Engineering, United States Department of Agriculture.

visible evidence of erosion losses that are depleting the soil fertility far faster than does the use of plant food by the crops grown. Measurements of soil losses from sloping cultivated fields show that 40 tons per acre of the most fertile topsoil is not an uncommon annual loss. Six inches or more of topsoil have been washed off many cultivated fields in a generation.

Factors Causing Erosion

The application of particular erosion-control methods cannot be made indiscriminately. In a program of land use all methods that contribute to soil-erosion control should be considered, as it has been noted that there are many conditions affecting the degree of erosion and several factors that cause erosion.

The factors causing erosion over which we have little or no control are largely climatic. The chief cause of erosion is rainfall and other precipitation resulting in run-off, which varies throughout the country; in the South 50 to 60 inches, in the Southwest 15 to 30 inches, and in the East 30 to 40 inches. The occasional torrential downpour is the cause of the greatest damage.

In the United States as a whole and in certain areas in particular, erosion is more serious than in northern Europe and more serious than in some of the older countries, due in part to greater rainfall, but due more to the great intensity of rainfall at certain seasons of the year when the soil has little cover to protect it and to the fact that the soil is naturally more erodible. Although the British Isles cover a small area and are surrounded by water, the annual rainfall in England is only about two-thirds that of our North Central States. The distribution throughout the growing season, however, is more uniform and results in a larger percentage being absorbed. Therefore, little if any erosion takes place, and the country is free from drought. To suffer from drought where the rainfall is much greater than in a country where drought is not in evidence is one of our paradoxes. We need to consider not only the problem of erosion control, but also the problem of water conservation.

Throughout the country where vast areas of erodible lands are devoted to cultivated crops, 10 to 20 inches depth of water runs off the surface each year. The problem of erosion is further aggravated in most of these areas by the intense rainstorms that occur during the months of May, June, July, and August, when the soil surface in our fields of corn, cotton, tobacco, and other cultivated crops is kept clean by tillage, greatly increasing the susceptibility to erosion and increasing the damage done by surface run-off.

Row crops must continue to be grown on erodible land. Much of such land is of high value and must continue to be used for the production of row crops that are adapted to the area. Farm management

studies show that the more financially successful farmers, from a standpoint of a profitable cropping system, are generally those who have a large portion of their farms in the crops that require the land to be plowed each year in preparation of a seed bed. In an effort to make the individual farm more profitable the tendency is to grow those crops from which the greatest profit can be made, even at the expense of the soil. Part of the erosion can be attributed to misuse of the land in an effort to make a profit.

The fact is definitely established that if more of our erodible soils could be kept in pasture or cover crops our erosion problem would be greatly reduced. However, the problem is a practical one and must be solved largely on individual farms. The farmer who has sloping land that is erodible cannot be expected to use the land for grasses and pasture to a large degree just because those are better suited in a soil-erosion-control program than the more profitable crops. Provision must be made for protecting the erodible soils so they may continue to be used for growing cultivated crops.

Other climatic factors causing erosion are temperature changes, degree of humidity, and degree of wind.

Factors and conditions which affect or determine the degree of erosion over which we have some control include the following: The soil, the topography, the cropping system, and the planting and tillage practices. The soil can be made more resistant to erosion by making it more absorptive. The topography, in effect, may be changed by the use of terraces or contour rows. The system of cropping may be changed to provide adequate cover a greater percent of the time and to provide additional organic matter. The tillage practices may be changed so that all plowing, planting, and cultivating are done across the slope.

According to the soil scientists of the Missouri Agricultural Experiment Station, in Bulletin 211:

The soils of Missouri have become gradually less fertile during the last hundred years due in large measure to the excessive cultivation of rolling fields. Many of the most fertile soils in the rolling prairies and timberlands of this State have been kept in corn until the clay spots are evident on nearly every hillside. So much soil has been lost from even the more gently rolling parts of the fields that yields are far below those obtained when the land was brought into cultivation. Erosion of cultivated fields is taking place at such a rate that it is calling for a decided change in our system of soil management. If we are to maintain profitable yields, we must make every reasonable effort to reduce the amount of soil fertility that is carried off during heavy rains.

This statement of the condition in Missouri will apply to a large part of the sloping lands throughout the Mississippi Valley, as well as other sections of the country where row crops are grown on erodible soils.

The plowing and cultivating of unprotected sloping soil on an extensive basis is generally recognized as

resulting in soil wastage. Our modern methods of farming have encouraged the use of less productive land for crop production. According to Prof. N. S. Shaler, of Harvard University, in a paper written on soil erosion more than 30 years ago:

Each extension of civilization has widened the field of devastation until nearly one-half of the land is subject to its ravages.

Dr. Shaler stated further:

It is now a question whether human culture, which rests upon the use of the soil, can devise and enforce ways of dealing with the earth, which will preserve this source of life so that it can support the men of the ages to come.

When a gully or an eroded area is noted, the question should be definitely answered as to what change in condition has taken place which made the soil less resistant to run-off and resulted in erosion. The installation of a culvert at the roadside, without a drop inlet; the deepening of a drainage ditch without considering the drains emptying in it; a broken tile, permitting the surface drainage to enter; a tile filled with roots, causing a greater flow on the surface; the concentration of surface water on a slope, without checking its velocity; all of these represent conditions that make the land less resistant to erosion.

The practical solution of the problem of soil erosion to the satisfaction of the farmer who uses the land is dependent on correcting those conditions which make the soil less resistant to the forces of erosion without disturbing too greatly the established farming practices that are most profitable.

Soil Protection Should Precede Soil Building

Attempts to fertilize crops or to restore fertility on sloping fields affected by erosion are only temporarily and partially effective, and are usually wasteful of the investment or effort expended unless accompanied by erosion-protection practices that will check the flow of surface water. This waste occurs because the most essential processes of crop production, plowing and cultivation, are most conducive to rapid erosion. Crops that require ground breaking or other thorough tillage as a preparation for seeding or planting leave the soil exceptionally vulnerable to erosion for a long period each year, often at a season when water or wind erosion is most destructive. Crops that require row cultivation extend this period of exceptional erosion losses through the growing season, when in most good crop-producing areas the rainfall is both intense and abundant.

Since it is essential that cultivated crops be grown on much of the land subject to erosion, practices of control such as terracing and contour farming, must be used that will not hinder crop growth. For several generations the value of contour farming and terracing has been demonstrated by the better farmers in the rolling and hill land of the Southern States. Failures

with this type of soil protection and conservation have occurred, but they were largely due to a lack of skill in construction and to a lack of knowledge of the basic principles of surface drainage.

Terracing

Terracing as it has been developed to suit modern farm practice is a system of drainage and water control. It should be regarded as one of the essential field practices on sloping, erodible land, and not as an optional or alternate method of erosion control comparable to a change in rotation or use of a cover crop. When an open ditch is used as a means of surface drainage in a field, it is recognized as a "necessary evil." No one likes to have his farm cut up with open ditches. The same is true of terraces. Terraces to a certain extent hinder the use of modern machinery. However, their use is preferable to having the topsoil removed, gullies formed, and the productivity of the soil destroyed. The interference with field operations can be largely eliminated by following contours in plowing, planting, and cultivating.

Soil Losses on Terraced and Unterraced Land

During the past 5 years the Bureau of Agricultural Engineering has obtained considerable data concerning the rates of erosion in different areas and the holding ability of terraces constructed on different grades and of different lengths. These data indicate that slight modification of terrace design is necessary to control erosion effectively on different slopes and on different soil types. Studies have been made in the red land regions of Oklahoma and northern Texas, the black land region of central Texas, the dark prairie lands of east central Kansas, the gray lands of northern Missouri and southern Iowa, the piedmont lands of the Carolinas, the volcanic-ash soils of the Northwest, the Missouri Valley loess soils of northwestern Missouri and southwestern Iowa, the unglaciated soils of the upper Mississippi Valley region in southern Wisconsin, and the silt clay soils of southern Ohio.

Results obtained on the relative losses of soil by erosion from terraced and unterraced lands demonstrate conclusively the great value of terraces as conservers of the soil. The longest record supporting the above statement has been obtained at the Guthrie, Okla., station where a full 3 years' record has been obtained. This record shows an annual loss for a 3-year period of 64.1 tons of soil per acre as compared with an average of 2.2 tons per acre from a terraced area, the loss from the terraced land being only 3.4 percent of that from the unterraced land. The soil and slope were practically the same on both areas; they were cropped essentially the same, and the average rainfall for the 3-year period was about normal. In table LXI

these and similar results are indicated for other stations where reliable data have been collected. In addition, this table gives the percent of the rainfall that ran off from terraced and unterraced land. The results show that terraced fields are more effective in conserving the rainfall than unterraced land. For the stations in the Middle West the run-off from unterraced land ranges from about 3 percent more for the Bethany station to about 82 percent more for the La Crosse station than from terraced land during periods of 1 to 3 years. At the Pullman station in Washington the run-off is nearly 200 percent more from the unterraced than from the terraced land.

Saving Water With Terraces

In humid areas in years of normal rainfall the value of saving water by means of terraces is not generally recognized and is ordinarily considered as of no great consequence. However, during periods of limited rainfall, in humid areas as well as in semiarid regions, the conservation of water is very important. The amount of water held by terraces can be governed largely by the terrace design. On certain types of soils the absorption is greater and terraces of slight grade can be used, resulting in low run-off.

At the Spur, Tex., substation a decided advantage of the terraces was credited to their ability to conserve water. This conservation of water resulted in a marked increase in crop yield.

Soil Losses with Uncultivated Crops

The soil losses over a 2-year period on the Bethany, Mo., station for terraced wheat land were only approximately 11 percent less than from corn land, indicating

that terraces are needed nearly as much on wheat land as on corn land. The loss in tons per acre on terraced alfalfa land at the same station was 1.5, while the loss in tons of soil per acre on unterraced alfalfa was 10.7, or 7 times as much. This was the first year that the land was in alfalfa. One of the greatest difficulties experienced on many farms is to get a good stand of alfalfa, or other legume, on sloping land, due to excessive soil washing during the season the crop is planted. In many unterraced alfalfa fields small gullies develop which interfere with hay-harvesting operations.

Relation of Strip Cropping to Terracing

In many sections where strip cropping is practiced it is considered a temporary practice until a system of terraces can be constructed. Where terraces are to be constructed later, strips of early-maturing crops planted along the lines laid off for terraces can be harvested early enough to provide for summer terracing, conveniently in the calendar of farming operations. Strips of drilled or broadcast crops have long been used as a cover when planted on top of terraces to get them established and to reduce the movement of soil between terraces. In this latter use they have the same effect as any broadcast crop proportional to the area covered. While strip cropping is a good farm practice, and can be used to good advantage in taking up point rows, and in supplementing the terraces, it cannot be considered a substitute for terracing.

Value of Terraces in Pastures

Ordinarily the use of the terrace is considered practical only in fields used for growing cultivated crops. It has been demonstrated that a modified type of terrace is of special value in pastures. A number of

TABLE LXI.—Run-off and soil losses from terraced and unterraced land at several soil erosion experiment stations

Experiment station	Number of terrace or watershed	Period (years)	Annual soil losses (tons per acre)			Annual run-off in percent of rainfall		Average slope of land in feet per 100 feet		Crops	Annual rainfall (inches)
			Terraced	Un-terraced	Terraced in percent of un-terraced	Terraced	Un-terraced	Terraced	Un-terraced		
Outhrie.....	Watershed 13, terrace 6-C....	1931	1.25	48.90	2.8	10.7	22.7	5.5	5.1	Young oats, ¹ mature cow-peas, fallow.	27.5
Do.....	do.....	1932	4.05	38.05	4.6	23.3	30.9	5.5	5.1	Fallow, cotton, winter wheat	35.2
Do.....	do.....	1933	1.33	61.39	2.3	21.9	14.1	4.8	5.1	Winter wheat, cotton, later grass in cotton.	30.4
	Average annual.....		2.21	64.12	3.4	18.6	22.5				31.3
Tyler.....	Watershed 4, terrace 7-C....	1933	4.55	*41.03	11.1	14.0	16.5	5.8	7.5	Cotton followed by fall oats.	45.7
LaCrosse.....	Unterraced, cultivated watershed, terraces 3-C to 4-C.	1933	2.28	31.70	7.0	4.9	8.9	12.7	13.1	Barley followed by clover...	26.8
Bethany.....	Watershed D3, terrace 3-H....	1933	3.19	27.09	11.8	13.7	19.2	3.3	6.7	Corn followed by sweet clover, winter wheat following peas.	31.7
Pullman.....	Watershed 4, terraces 5, 7, and 17.	1932	2.55	22.53	12.6	10.0	24.5	*20.0	*20.0	Winter wheat, winter wheat stubble.	24.4
Do.....	do.....	1933	3.53	11.26	31.3	12.4	37.3	*20.0	*20.0	Winter wheat stubble, fallow, winter wheat.	28.5
	Average annual.....		3.19	16.90	18.9	11.3	21.0				26.6

¹ Crops are given for terraced area. Crops for unterraced area are winter rye, mature cowpeas, and winter wheat.
² Gullies and watercourse protected by brush dams.
³ Approximate.

experiments have shown that erosion on well-sodded permanent pastures is very slight; however, the benefit, according to the director of the Mississippi substation at McNeill, Miss., is because of the influence of terraces on other factors beside erosion.

The following statement is quoted from a report by the director of the Mississippi substation at McNeill before the twenty-fourth annual meeting of the American Society of Animal Production:

On even moderate grades, especially with porous soils, the run-off and leaching is so rapid that the soil moisture may become deficient for pasture growth even in short periods of drought or during seasons of periodically light rainfall * * *.

At the McNeill Experiment Station over a period of 27 years the average annual rainfall was 63 inches with 3 inches for November the least for any month of the year. In spite of this heavy and well-distributed rainfall, hill pastures frequently become dry in late summer and fall * * *.

No detailed comparative figures for terraced and natural slope pastures have yet been obtained, but it is obvious that more forage is being produced per acre on the terraced pastures. It is also obvious that the cattle have preferred the growth of pasture plants on the terraces to that of an unterraced corner of about 5 acres.

In addition to conserving moisture and preventing erosion until the pasture sod is established, the level terraces have another very important use in hill pastures where annual legumes are used as a part of the pasture mixture. The closely spaced terraces reduce the velocity of the surface water and what seed is moved from place is stopped at the first terrace instead of being washed completely off the pasture. With the rapid spread of adapted varieties of lespedeza into areas farther north this is a problem that will have to be considered.

A level terrace in a clover and timothy meadow at the Missouri station had a loss of 134 pounds of soil per acre as compared with a loss of 2,540 pounds from an unterraced bluegrass sod.

Terraces an Advantage During Drought

In a report from the Wisconsin station, where the water loss on cultivated unterraced land is approximately twice as great as terraced, it is stated:

In a year of drought like the current one, when the clover hay crop is a complete failure, the terraced land is producing over one-half ton per acre. Unterraced corn land near the farm shows drought damage while terraced corn at the station is in good condition and will produce a much better yield.

Effect of Terracing on Yields

Records at the Oklahoma station show that new land will yield 30 to 150 percent more cash crop than the same sort of land which has just reached the gully stage of erosion. The decrease in cotton yields in the black lands of Texas, over a period of 20 years, is no doubt due largely to erosion. Terraces with proper cropping practices would have preserved the original productivity of these soils and retained the manure applied, prevented the leeching out of fertilizers and

cover crops, thus preventing the decrease of crop yields. Terraces do not add fertility to the soil but they do check the wastage, stop the decline of yields, and make possible an effective program of soil improvement.

Thousands of farmers throughout the country have secured increased yields of crops by the use of terraces. The following are some examples reported by the Extension Service:

A 25-acre field on a farm in Wabash County, Ill., was so badly gullied that the owner had difficulty in hauling the silage corn from it. He tried stopping the washes with straw and brush, but they were ineffective. Finally one fall he laid out three terraces about 100 feet apart. In the following spring the field was planted to soybeans. When they were removed wheat was sown. It made 15 bushels an acre, or 125 bushels more than before the field was terraced.

A farmer of Childress County, Tex., states that in 1931 he purchased a farm of 90 acres at \$8 an acre. In the fall he put in high, wide terraces. In 1932 the farm produced \$9 more an acre than in any previous year, which gain is \$1 more an acre than the purchase price. In 1933 the farm produced the first bale of cotton in the county. Because his land was terraced, this farmer received \$2 more an acre during the cotton plow-up campaign than his neighbors whose lands were not terraced. His fields averaged 400 pounds of lint as compared with a county average of 250 pounds.

A landowner of Crawford, Okla., has just an average upland farm, which was terraced during the winter of 1923-24. Instead of this land decreasing in production, as the surrounding farms have, it has been gradually increasing until, according to the owner's estimate, at the present time it is worth approximately 100 percent more than it was before the terraces were built. In 1933, in spite of the dry weather, it produced 30 bushels of yellow milo per acre, and the 50 acres of cotton produced approximately 1,200 pounds of seed cotton per acre. Farms just over the fence are harvesting from 15 to 20 bushels of yellow milo per acre, using the same kind of seed, and the cotton is yielding from 400 to 500 pounds of seed cotton per acre.

A farmer of Cyrene, Mo., claims that by not first building terraces he lost 78 tons of ground limestone, 15 bushels of sweet clover seed, and about 4 inches of soil from 26 acres. He now has 118 acres terraced.

Farmers know that erosion control upon their fields is their most serious soil problem. They appreciate their fertility losses and desire to effect a control. They have tried liming, fertilizing, cover crops, and rotations, but year after year the erosion continues and in many cases becomes increasingly difficult to control. Terracing effects the continuous control which makes the application of lime and fertilizer and the rotation of soil-building crops paying investments.

Progress in Terracing By Extension Workers

Extension workers realize the importance of terracing and have encouraged the practice for many years.

In the 19 years of records which the Extension Service has kept on erosion control by means of terraces and soil-saving dams, over 18,000,000 acres have been reported as protected by these structures, of which over 16,000,000 acres were protected by the terracing of cultivated land, accompanied almost invariably by contour farming and the use of soil-improving rotations, usually including legumes as cover crops.

Since farmers desire to protect their cultivated lands from erosion by means of terracing, and the cost of terracing is comparable to that of plowing (for example, from \$1.25 to \$2.50 an acre is the prevailing custom charge at present) it may well be asked, Why is not terracing being done more rapidly? Strangely, the reasons are the same everywhere, but the immediate cause of delay is not the same everywhere simultaneously. First of all, inaugurating erosion control upon cultivated land involves the changing of field practices and even touches the farmer's pride in straight rows, which practices, nevertheless, effectively rob him of his wealth. Most farms lose all or the best part of the top soil before the farmer is willing to improve what he has previously considered up-to-date farming practice. Terracing then is usually resorted to as the initial step in a soil-rebuilding program rather than as the soil-conservation measure which it should be.

Recommended Practices in Construction of Terraces

Practically all land classified as erodible that is used for cultivated crops in the Mississippi Valley watershed in central United States should be terraced. The cultivated areas in the Southwest and Southeast where the slopes are greater than 2 or 3 percent and up to 10 or 12 percent can be benefited by terraces supplemented by contour farming and other soil-erosion-control practices. Lands that have eroded to the gully state should be used for forests or pasture lands. Cultivated lands less than 10 percent of which are not badly gullied, but which do not profitably produce a crop due to erosion, should be terraced and their productivity brought back by proper use of cover crops such as legumes, or put into permanent pasture.

Where the cropping system does not adequately prevent erosion, slopes as little as 1 percent should be terraced. In the extreme northwestern part of the United States terraces have been used effectively in saving soil on slopes up to 25 percent. It is difficult to use grain-harvesting equipment on this land that has been terraced where the slopes exceed 20 percent.

There are several kinds of terraces that are being successfully used, all of which are designed to retard

the flow of water, to allow more of it to be absorbed, to reduce its eroding power, and to permit the planting, growing, and harvesting of crops without great inconvenience. The following are specific recommendations:

1. In laying off terraces, the recommendations for vertical spacing to use for various land slopes and soils found in Farmers' Bulletin No. 1669, Farm Terracing, should be followed in the Southern States where rains of high intensity are more frequent and where erosion occurs practically throughout the entire year as compared with the Northern States where rains of high intensity are less frequent, the soils are not so badly eroded, and the soil is frozen part of the year, during which period no erosion occurs. From results of experiments on the soil erosion experiment stations it has been found that the spacing of terraces recommended in the Farmers' Bulletin can be increased in the Northern States from about 10 percent on a land slope of 2 percent and gradually increasing to 30 percent for a land slope of 15 percent. These recommendations are based on safe hydraulic principles and where used have given general satisfaction.

2. It is recommended that under general conditions the practice be followed of giving terraces a variable grade from level to a maximum of 4 inches per 100 feet, the grade being changed at regular intervals of 300 feet along the terrace. The grade should be increased 1 inch per 100 feet for each 300 feet of length and the terrace should preferably be limited to a length of 1,500 feet. When this length is exceeded the terrace should either be built higher for the additional length or the spacing should be reduced.

3. Short terraces should be used wherever the controlling conditions permit. A greater volume of water in the terrace channels of the longer terraces causes more erosion and carries away more of the soil. Safe length of terraces depends on local conditions. On soils that are not highly erodible terraces 1,200 to 1,500 feet long can be safely used. Where it is necessary to have terraces longer than this, it is best to have outlets at both ends of the terrace; or if this cannot be done at a reasonable expense then it is necessary to either increase the height for the additional length or reduce the spacing.

4. Terraces should be constructed with an effective width of 15 to 30 feet and about 18 inches high, depending largely upon the slope of the land and the type of farming practiced. On slopes up to 6 percent the terraces can be constructed by moving the dirt equally from both sides; above 6 percent slope and under 10 percent most of the dirt can be best moved from the upper side; above 10 percent it is more economical to move all of the soil from the upper side. It has been found desirable, even on steep slopes, to make one cut on the lower side, which tends to prevent the soil from moving too far down the

slope. When any of the soil is moved from the lower side it is important to smooth the edge of the cut on that side so it will not collect water, which would flow out at the low point and start a wash that would extend from one terrace to the next.

5. It is recommended that special attention be given to providing suitable outlets. Cooperation among adjacent landowners often make possible good outlets. Outlets and ditches should be designed and constructed to reduce erosion to a minimum. Well sodded natural watercourses make the best outlets, and it is recommended that such be used for outlets in preference to using a road ditch or a ditch built directly down a slope along a fence line. Natural watercourses usually have less fall than road or fence line ditches and, therefore, are not so difficult to control by means of check dams or vegetation.

6. It is recommended that row crops grown in terraced fields be planted with the rows parallel to the terraces. Since the terraces, as a rule, are not parallel, this means that fields will have a number of point rows which are objectionable but which must be endured, at least during the first year or so, until the terrace ridge has had an opportunity to become thoroughly settled. After settlement has occurred, it may be practical on moderate slopes to start the rows parallel with the center terrace, crossing the other terraces at a small angle, thus cutting out all point rows except those at the edge of the field.

7. It is recommended that terraces be carefully maintained for the best results. Where crop rows run parallel to them, the terraces can be maintained in the usual plowing operations; but when the rows cross them, special maintenance work is generally required to maintain satisfactory terrace heights.

Gully Erosion

There are several types of gully erosion resulting from different conditions which make the soil susceptible to washing. In order to solve the problem it is essential that the causes of gullying be accurately determined.

The more common type of gullying is a direct result of sheet washing on sloping land. This type of gullying is sometimes referred to as headwater erosion. It usually starts some distance down the slope, or at any point where a quantity of water accumulates as it flows down the slopes. The damage is done not only to the sidehill but much of the eroded material is usually deposited on the bottom land at the base of the slope. Headwater also occurs in draws and low places along slopes where the water naturally accumulates. A seepy spot in a draw on a slope will keep the soil saturated and often start washing.

Another type of gullying is commonly referred to as overfall erosion, which occurs at the outlet of a surface

drain into a ditch or stream and works back into the field. The depth and width of the gully depend on local conditions. Such erosion is responsible not only for some of the worst gullies but also for destroying more good land than the gullies formed on hills by headwater because many such gullies are formed across valuable bottom land that normally is not considered erodible. While the type of soil and the quantity of water are important factors in overfall washing, the factor which must be given consideration is the drop or the difference in gradient of the outlet ditch or stream and the surface over which the water flows to the outlet. It is this drop or overfall which makes the soil susceptible to cutting back, or caving. A common condition resulting in overfall erosion is the change of gradient, or drop where a new culvert or bridge is constructed across a road.

Another condition resulting in overfall gully erosion is where a tile is broken and the surface water starts a gully. This overfall gully may follow the line of tile or along the line of natural surface drainage where the greatest quantity of water flows. Where surface water flows into an open ditch and there is a decided drop, undercutting usually occurs, and a gully is started.

Another type of gully erosion is that which occurs along the banks of ditches and streams. The condition which makes the banks erode is usually some obstruction which diverts the flow of water. It may be debris or sediment.

National Program of Erosion Control Essential

It must be recognized in a program of land use that there are not enough flat lands available for the growing of cultivated crops. A large portion of the people prefer to make their homes on the sloping land or among the hills. They prefer to farm such land instead of moving onto land less erodible, even if it were available. The control of erosion is fundamental to successful agriculture on such land. This applies to a large part of the area of cultivated crops in the United States.

Dr. A. G. McCall, Bureau of Chemistry and Soils, United States Department of Agriculture, stated before an annual meeting of the Kansas State Board of Agriculture:

Probably not less than 10,000,000 acres of land formerly cultivated has been permanently destroyed by rain wash. Much of this could have been saved by timely terracing. A considerable part consists of land that should never have been plowed in the first place, because of its susceptibility to erosion.

Dr. McCall stated further:

In the southeastern part of the United States, chiefly in the old Cotton Belt whose methods of farming have generally

been held up as examples of what should not be done on a farm, is found the only part of the Nation where a widespread and sensible practice of soil conservation by terracing sloping lands has been practiced for any considerable length of time. Recently terracing has spread to Texas, Oklahoma, and Arkansas, where it is rapidly gaining favor among farmers of many localities. Beyond these regions terraces are conspicuously absent; but not because they are not needed.

Later estimates indicate that over 20,000,000 acres have been permanently destroyed by erosion. Many more millions of acres will be destroyed in the near future if present farming practices are continued. The public interest requires that such terrific land losses be stopped, for in the final analysis the vitality of a nation depends on the productivity of its lands. A national effort must be made to encourage soil-erosion control through all existing research, educational, and extension agencies.

Retiring lands from cultivation and using them for forest and pasture is effective, but the method is distinctly limited. If all erodible lands were used for pasture and forest the remaining cultivated areas probably would not be half large enough to support the present population with American standards of living and farming. Therefore, a large area of erodible land must be continued in cultivation and must be protected by erosion-control methods.

Terracing has been demonstrated as an effective method of erosion control on sloping, cultivated lands. Terracing, therefore, must be extensively used on cultivated lands as the first step in erosion control. It must be supplemented with proper control of outlet ditches and usually with contour farming. With these practices established, soil losses are reduced to a nominal figure regardless of the crops or fertilizers employed. Without them, the fertile topsoil will be washed away very rapidly on sloping, cultivated lands. Therefore, in the preliminary stages of an erosion-control program great emphasis must be placed on terracing because it is the first step toward retaining and building up the productivity of cultivated soils.

Gully Control Practices Recommended

Gully-control practices are recommended for the protection of terrace outlet channels and also for the reclamation of abandoned or otherwise unprotected gullied lands. United States Department of Agriculture Farmers' Bulletin No. 1234, *Gullies—How to Control and Reclaim Them*, describes a wide variety of gully-control works using materials suitable to the many sizes and locations of gullies encountered in field work; also a mimeographed paper on *Brief Instructions on Gully Control*, issued by the Bureau of Agricultural Engineering, contains detailed information on the structural and hydraulic design of gully-

control structures. Principles to be remembered in constructing gully-control works are:

1. The foundation of gully-control dams should extend far enough below the bottom of the gully, and the ends should extend far enough into the banks, to prevent the hydraulic pressure from forcing water under the bottom or around the ends of the dam.

2. The capacity of the spillway must accommodate flood stages of the watershed without overtopping the structure or side-cutting the embankments.

3. The reduction in cross section area of the gully by erosion-control works should not be so great as to cause the run-off water to overflow the banks of the gully and thereby cause erosion around the ends of the dam or the development of a new parallel gully down the slope.

4. The apron must absorb the energy of the waterfall, releasing the water at a low velocity at the foot of the drop so as to prevent undermining.

5. Successive gully-control dams in the same channel must be so located with reference to one another that the velocity in the gully between them is materially reduced, and that the deposits of soil above the spillway of each will extend to the apron of the dam above. Ordinarily, the best results are obtained when the crest of the spillway is at the same level as the apron on the dam above; the fill will usually assume a slope of 6 to 12 inches per 100 feet. With vegetation in the gully the fill will assume a much steeper gradient, depending upon the density and nature of vegetation.

6. Temporary types of structures must be protected by suitable plantings which will assure a more permanent control of the erosive forces. Suitable vegetative covering is also necessary in connection with permanent types of checks or dams to prevent further erosion of side embankments. Bermuda grass, kudzu vine, willow, poplar, and locust trees, and similar erosion-resistant perennial plantings that will grow in the area are suggested for this purpose.

Need of an Educational Program on Soil-Erosion Control

There is great need of developing a public consciousness of the necessity for soil-erosion control in the areas of high-value land. Much has been accomplished in the South through the activities of the agricultural extension workers. As a result, thousands of farmers are putting into practice soil-erosion control measures, and millions of acres have been terraced. Public interest is now being focused on the problem through the large-scale demonstrations of the Soil Erosion Service, and the work of the Emergency Conservation Corps.

Soil-erosion control is a basic problem that every agricultural agent and vocational agricultural teacher should recognize before advocating the application of lime and manure on erodible land. Agricultural agents

have been known to remark, "When I get my fertility program established, I will be ready to start a program of erosion control." The lack of an erosion-control program has destroyed many such promising fertility programs. Erosion control by terracing is a highly specialized type of field work, in which the vocational agricultural teacher and the agents should be especially trained.

The great need at present is to assist and to train individual farmers to terrace and to practice other erosion-control measures on their own farms. This can be best and most economically accomplished through the agricultural extension agencies now established. Throughout the seriously eroded areas of the South many agricultural agents are well qualified to do this work. In many of the northern counties the seriousness of the problem would justify employing additional special agents trained in erosion control whose job would be to supervise terracing, to design erosion-control structures when necessary, and to assist farmers in working out a well-rounded erosion-control program. Prof. E. R. Jones, of the University of Wisconsin, recently stated that there was need for an engineer in each of the 20 western counties in Wisconsin. The work of these men would be supplemented by the regular agricultural program on soil treatment and management as conducted by the regular agent. This educational work on erosion control should be done with interested farmers who are ready to go ahead with the program on their own farms at their own expense. Such a procedure would result in sustained interest, better maintenance, and permanent results. The lack of such a program is delaying the protection of vast areas of our most productive land.

One southeastern State increased its rate of terracing in 7 years from 25,000 to 221,000 acres annually by increasing the terracing specialist's service from two-thirds of 1 man's time approximately to twice that amount of time expended by 2 men, with more than a corresponding amount of terracing activity among county agricultural agents. Unfortunately, at the peak of this activity both specialists became engaged in other employment and the rate of terracing in that State dropped in one year to 86,000 acres annually. This drop of almost 60 percent was due to the lack of specialized educational extension aid, as the record for the entire country showed an increase in terracing.

However, with the need for terracing as a whole recognized by the farmer and the State extension service furnishing special technical training in terracing technique, two important factors still delay the actual terracing of farms; the most important of these is the need for local men well trained and experienced in the technique of terracing, and the other factor is the need for surveying and terracing equipment.

The training of local terracing workers is the most essential need, as terracing is such an important land improvement affecting farm operations that other farmers will not undertake it without the advice and assistance of a person experienced in the technique. During the 3 years of the depression the influence of the 18 extension specialists activating the terracing program of county agricultural agents held the rate of terracing consistently above 1,800,000 acres of cultivated land annually. In no other way can a Government expenditure be used as efficiently to reach all farmers with equal assistance to effect control of erosion upon cultivated fields, where without question the most vital national problem of erosion destruction exists.

Need for Equipment and Financial Aid

The lack of adequate equipment is an important factor in hindering the progress of terrace construction in many sections. While terraces may be built with equipment constructed on the farm, the labor requirements under such conditions are much greater and discourage the work even though there is little or no actual outlay of cash.

The States of Texas, Oklahoma, Kansas, and Alabama have met this situation by granting farmers the use of road equipment, at cost, for terracing their farm lands. In some counties in Texas the charges were reported as ranging from 75 cents to \$1.25 per acre. Millions of acres in Texas and Oklahoma have been terraced under such favorable conditions, but too frequently the road equipment is unsuitable for terracing or is not available.

Recently the county commissioners of Tallapoosa County, Ala., recognized that furnishing terracing machinery and equipment was of at least equal importance to the county as road maintenance, and since the farmers were willing to pay the costs, the commissioners bought a tractor and terracing grader to do terracing work exclusively. The plan was so successful that subsequently four more outfits were purchased, and over 6,000 acres were terraced under adequate supervision within a year. Several other counties in Alabama and Georgia have since followed this plan. In Georgia, however, and in most other States the county commissioners cannot use publicly owned equipment for this purpose without legislative action, even though the farmers pay all the cost.

Production credit loans have been suggested as a feasible source of cash for group purchases of terracing equipment. The contribution of each farmer would be in proportion to his acreage, and the total cost could be spread over an acreage which the equipment could reasonably be expected to terrace in 3 years' time.

Need for Further Research on Soil Erosion Control

The research on soil erosion now in progress is being conducted on soils of comparatively low productivity. A study of soil and fertility losses and methods of control are even more important in areas of high productivity on comparatively slight slopes. Quantitative studies in such areas would determine accurately the need for applying different erosion-control measures. Such studies should cover: (1) Terrace design and requirement—as to length and spacing for different soil types, for cultivated and noncultivated crops, for orchards, and for pasture; (2) terrace costs and maintenance under different conditions; (3) machinery operations in terraced fields; (4) the most effective structures to use in gully control; and (5) the value and cost of tile drainage as a means of controlling soil erosion.

Summary

Soil erosion in one of the most serious problems facing American agriculture, and its satisfactory control will have a distinct influence on land use of the future. The most difficult problem is to get the individual land-owners to appreciate its importance and to get them to put into practice those methods of soil-erosion control that are thoroughly established. In humid areas with the best farming practices established, soil-erosion control becomes a problem of surface water run-off control.

Terracing, supplemented by the best farming practices, is effective in erosion control; in a long-time land-use program it is the initial step in a soil-conservation and rebuilding program, because it—

1. Retards sheet erosion.
2. Controls the flow of water by conveying it across the slope at low velocities, thereby preventing the formation of gullies.
3. Makes it possible for fields to be farmed as a unit because the gullies are eliminated.
4. Protects the land during rains of unusually high intensity, particularly during seasons of clean cultivation, and during periods of fallow.
5. Prevents excessive run-off across flatter fields which frequently washes out stands of crops or leaves sterile deposits.
6. Simplifies the practice of contour farming.

This makes possible a sound program of soil conservation, maintenance, and improvement with increased yields.

While terracing is a means of protecting, conserving, maintaining, and improving the soil productivity, gully-control structures are primarily for reclamation and for protection against further gully damage and

usually protect relatively small areas. Gully-control structures are needed under special conditions to—

1. Prevent the destruction of good land.
2. Hold the soil in destructively eroded areas to make it possible to grow trees and other vegetative cover and to prevent further filling of stream channels and damage to low lands.
3. Check headwater erosion and make possible the filling and reclamation of gullies for cultivation or pasture.
4. Enable the crossing of gullies with teams and farm implements.
5. Stop overfall erosion to prevent the gullies from eating back into good land, undermining culverts and bridges, or extending through a farmstead and undermining farm buildings.
6. Prevent the silting up of reservoirs and drainage channels, often dredged at great expense.
7. Prevent sand wasted from the hills from being deposited on rich bottomlands, making them unproductive.
8. Improve unsightly appearance of a farm, increasing its market value.

Recommendations²

Educational.—Erosion control is of sufficient national importance in a sound land use and conservation program that a special fund for expanding the agricultural educational program on soil-erosion control through the Agricultural Extension Service is justified. This fund should be made available for soil-erosion-control educational work where an equal amount is provided by the States concerned.

It is recommended that the Agricultural Extension Service be charged with the administration of all funds provided for extending the program of education in soil-erosion work. In areas where there is need and the land value justifies the expenditures, a county or district erosion specialist should be employed. This specialist should have sufficient technical training to be able to establish and supervise the construction of terraces, to design and supervise the construction of terrace outlets and other soil-erosion structures, and be qualified to assist the county agricultural agent in working out a satisfactory agricultural program for the area that will have as its ultimate objective the control of erosion. It is recognized that the ultimate success of a program of soil-erosion control is dependent on proper maintenance of terraces and other surface drain-

² These recommendations were formulated before establishment of the Soil Conservation Service in the Department of Agriculture, superseding the Soil Erosion Service in the Department of the Interior. Under act of Congress approved April 27, 1935, the Soil Conservation Service in preparing to accomplish the general objective of these recommendations by methods not unlike some of those herein suggested, including extended cooperation with the Agricultural Extension Service.

age or run-off control structures. An important phase of a county erosion specialist's duty would be to emphasize maintenance work.

Research.—Soil-erosion research has been started in 10 areas where experiment stations have been established by the United States Department of Agriculture. Studies are being made in these areas to determine soil losses under different conditions and the relative effectiveness of different methods of erosion control. This work should be extended into many other areas where soil erosion is a serious problem.

Recognizing the facts that the soil is a national resource and that the individual owner has no right to exploit or destroy it, studies should also be made to (1) develop a plan for the protection of entire watershed areas, with special reference to run-off, water conservation, soil erosion, and flood control; (2) determine the practicability of removing lands that are being destructively eroded by present methods of farming from private ownership, perfect a zoning ordinance that will prevent the use of such lands for purposes that result in destructive erosion, and limit public expenditures for roads, schools, etc., in such areas; and (3) work out a land policy which does not apply an economic yard-stick to the land-planning program, but which recognizes land-use planning as a complex problem of civilization.

Legislation.—To put the above recommendations into general effect will require additional legislation, which should cover also the following points:

1. Require road-building agencies to protect adjacent farm land from washing due to—

- a. Changes in gradient at culverts and bridges.
 - b. Changes in road location, resulting in cuts and fills affecting farm drainage.
 - c. Poorly designed road ditches.
2. Make some provision for roadside terrace outlets, whereby county and farmer would cooperate in controlling erosion in such outlets.
 3. Provide a basis for cooperation in establishing terrace outlets where two or more landowners are involved.
 4. Permit farmers to use county-owned equipment for terracing at actual operating expense.
 5. Make some provision for a plan by which a group of farmers in a watershed area can organize a soil-erosion district for simplifying the provision of outlets; for making available adequate equipment for construction and maintenance; for financing the project; and for securing technical assistance for staking out terraces, designing structures, and supervision of construction and maintenance.

Financial aid to landowners in controlling soil erosion.—Since soil erosion is a national problem, and since it is desirable that landowners be encouraged to construct terraces and other erosion-control structures and put into practice systems of farming that will result in erosion prevention, the Federal Government should provide some financial aid. This can probably be done by one or more of the following methods: A system of bonuses, long-time loans, the provision of equipment, supervision, and the use of unemployed labor, a part of which is to be paid for by the Government.

SECTION XI

FARM ORGANIZATION AND RELATED DATA FOR SELECTED AREAS IN EROSIIVE REGIONS¹

From a special tabulation of 1930 census data,² it has been possible to calculate the average farm organization and related data for some selected areas in highly erosive regions. The type-of-farming map of the United States as published by the Bureau of the Census was compared with maps showing those regions having the most serious erosion losses. Similar type-of-farming areas were combined to give larger areas with which to work (fig. 23). Type-of-farming boundary lines did not always coincide with erosion-region boundary lines; however, this discrepancy is not great. No effort was made to include all erosion regions. Only those areas most commonly considered highly erosive were studied.

Selected Areas in the Old Cotton Belt.

Table LXII includes data on average farm organization as indicated above for six selected areas in the Old Cotton Belt. One of the facts to be noted in this table is the similarity in crop acreages in each area and the small amount of harvested crop land per farm. In this connection it must be kept in mind that census enumerators include the land operated by each cropper as a separate farm. It is readily apparent that a cropping system such as these figures indicate, with around 90 percent of the total harvested crop land devoted to intertilled crops, is conducive to all types of soil depletion.

The idle crop land, which amounts to 10 to 20 percent of the total crop land, is for the most part a product of this destructive cropping system. It is land worn out in crop production and left idle to recuperate if possible. Plowable pasture amounting to 3 to 9 acres per farm, while available for rotation with crop production, is probably changed quite infrequently.

A peculiar feature of the agriculture in these areas is that although intertilled crops make up almost the entire crop acreage, they represent only a little over a third of the total farm area. Another point to be kept in mind is the large amount of land in these areas reported by the census as not in farms. The percentage of total land in farms varies from 50 in the hilly

sections of Alabama to 67 in the Mississippi silt loam uplands area and the southern Piedmont. As a matter of fact, the proportion of total land in these areas in intertilled crops is very low—not over 23 percent in any area.

The number of livestock per farm is very small. The common practice, as these data indicate, is to clear a field, crop it as long as yields are fairly satisfactory, or until they get around to clear another field, then "turn out" the depleted field and start the destructive process on the new land. Legumes and grasses, which are essential both for livestock production and soil maintenance, have but a small place in the present systems of farming in these areas.

It is apparent that a type of agricultural production providing for soil maintenance in these areas, in addition to including such mechanical erosion-prevention measures as terracing, strip cropping, and contour farming, must include a rotation of crops including legumes, winter cover crops, and grasses. Such a change in the agriculture in these regions would not require any great reduction in the present basic crops, corn and cotton, except as the total national requirements for such crops indicate a desirable reduction. Usually the legumes and winter cover crops would be in addition to the present crop acreage per farm. This can be accomplished, for winter cover crops represent a second crop following corn or cotton and are to be plowed under the following spring. Additional land needed to make possible increased acreages of legumes can be obtained by bringing into production some of the better lands not now in farms (or land now in farms but not in crops).

Selected Areas in the Western Cotton Belt

Five areas were selected in the Cotton Belt west of the Mississippi River for which farm organization and related data are shown in table LXIII. These areas do not present the same uniformity as those discussed in the Old Cotton Belt. The area in the red plains cotton and general farming area of central Oklahoma and Texas, including over 19,000,000 acres, is characterized by fairly large farms and large acreages of low-yielding cotton. The area in the red plains cotton and ranching area differs from it only in having more pasture and waste land in proportion to the crop land.

¹ Prepared by W. W. Wilcox, Land Policy Section, Agricultural Adjustment Administration.
² Made by the Production Planning Section, Division of Program Planning, Agricultural Adjustment.

The average acreage of cotton per farm is 60 acres for the first area and 55 for the second.

Lack of rainfall makes it necessary for the farmers in these areas to depend on grain sorghums for hay and grain, very little corn or hay other than sorghum being grown. Oats do not yield well and are found in small acreages on a minority of the farms. Wheat does well and is important in the western and northern parts of the areas.

It is quite evident from a consideration of the acreage of the various crops per farm in these two areas that the rotation being followed does not meet the

essential requirements from a soil-maintenance standpoint. Such a cropping system has been not only largely responsible for the erosion losses described by soil-erosion specialists but also makes no provision for the maintenance of organic matter.

The solution of this problem is particularly difficult because of the lack of legume and grass crops adapted to the short rainfall conditions found here. Livestock numbers are relatively small—enough cattle are kept to utilize the range pasture, but tame grasses and legumes and livestock production based on their utilization are absent.

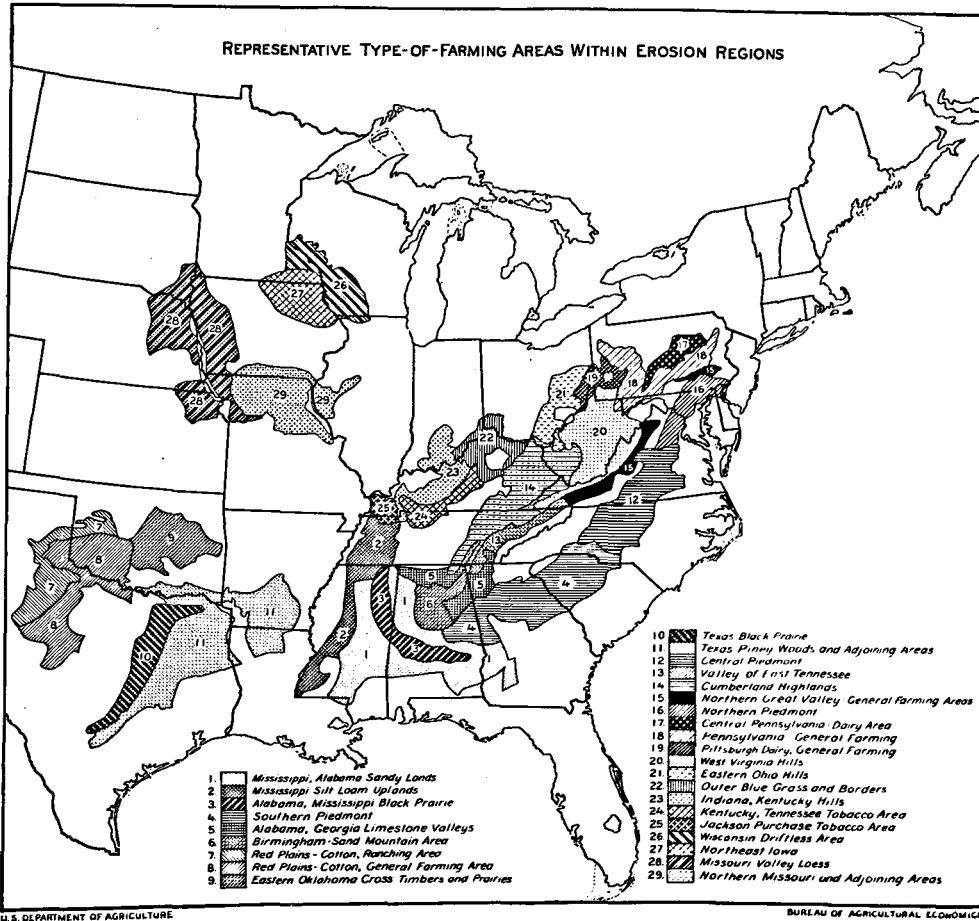


FIGURE 28.—Representative type-of-farming areas having erosion problems. Similar type-of-farming areas, as shown in "Types of Farming in the United States", by F. P. Elliott, Fifteenth Census of the United States, were combined to give larger and more representative areas.

The eastern Oklahoma cross timbers and prairies area and the Piney Woods section of Texas and adjoining areas more nearly resemble the cotton-producing areas east of the Mississippi River than those in the Red plains; the rainfall is higher, the farms are smaller, and the acreage of corn per farm is larger.

TABLE LXII.—Farm organization and related data for certain erosive areas in the Old Cotton Belt

[Computed from 1930 census data]

Item	Alabama-Mississippi sandy lands	Mississippi silt loam uplands	Alabama-Mississippi black prairie
Approximate land area..... acres.	25,386,240	10,704,640	8,285,600
Number of farms.....	190,728	117,411	89,224
Farm population per farm.....	5.1	4.4	4.6
Value of all farm products.....	\$799	\$840	\$746
Value of all farm products exclusive of family living.....	\$611	\$686	\$590
Acres per farm:			
Cotton.....	13	12	13
Corn.....	11	8	8
Peanuts.....	2	2	2
Hay.....	1	1	1
Miscellaneous crops.....	1	1	1
Total crop land harvested.....	27	23	24
Crop failures and idle crop land.....	5	4	3
Plowable pasture.....	5	7	9
Other pasture.....	15	11	11
Woods and waste.....	22	16	12
Total land in farms.....	77	61	59
Percent of all land in farms.....	58	67	62
Percent of all land in intertilled crops.....	20	22	23
Yield per acre:			
Cotton..... pounds.....	178	210	166
Corn..... bushels.....	14	19	17
Number of livestock per farm:			
All cattle.....	3.3	3.8	4.7
Cows kept for milk.....	1.4	1.4	1.9
Cows kept for beef.....	2	2.4	2.8
All swine.....	3.6	3.3	2.5
Sows and gilts.....	.3	.3	.2
Sheep and lambs.....	.1	.3	.2
Chickens over 3 months.....	20	20	18
Horses and mules.....	1.5	1.8	1.7

Item	Southern piedmont	Alabama-Georgia limestone valleys	Birmingham sand mountain areas
Approximate land area..... acres.	21,728,640	7,976,960	3,557,780
Number of farms.....	216,285	80,178	29,422
Farm population per farm.....	5.3	5.2	5.3
Value of all farm products.....	\$848	\$910	\$902
Value of all farm products exclusive of family living.....	\$675	\$710	\$699
Acres per farm:			
Cotton.....	18	14	10
Corn.....	8	9	9
Wheat.....	1	2	1
Hay.....	1	2	1
Miscellaneous crops.....	2	2	2
Total crop land harvested.....	26	27	22
Crop failures and idle crop land.....	6	6	4
Plowable pasture.....	4	4	3
Other pasture.....	10	7	9
Woods and waste.....	22	20	22
Total land in farms.....	67	64	60
Percent of all land in farms.....	67	65	59
Percent of all land in intertilled crops.....	30	28	23
Yield per acre:			
Cotton..... pounds.....	119	109	120
Corn..... bushels.....	18	14	13
Wheat..... do.....	21	23	21
Hay..... do.....	10	11	11
Number of livestock per farm:			
All cattle.....	2.3	2.3	2.5
Cows kept for milk.....	1.2	1.2	1.3
Cows kept for beef.....	1.1	1.1	1.2
All swine.....	1.5	1.5	1.2
Sows and gilts.....	.1	.1	.1
Sheep and lambs.....	.1	.1	.1
Chickens over 3 months.....	21	24	25
Horses and mules.....	1.4	1.9	1.4

Cotton yields in these areas are lower than in the eastern Cotton Belt, however, partly because less fertilizer is used, and the acreage of cotton per family is from 50 to 100 percent greater than in the areas east of the Mississippi. Miscellaneous crops are also more generally grown.

Here again the prevailing cropping practice, depending primarily on cotton and corn, is conducive to all types of soil depletion.

The black waxy prairie area in Texas is similar to the better sections of the Corn Belt in natural soil fertility and topography. Rainfall averages 30 to 40 inches a year, and with this favorable combination of factors a higher proportion of the total land area is devoted to intertilled crops than in any of the other 10 selected areas in the Cotton Belt. Most of the land is in farms and about two-thirds of the farm land is in crops. With an average of 68 acres of total crop land plus plowable pasture, 51 acres are devoted to corn and cotton. Clearly, such a cropping system does not provide for soil maintenance. It should be

TABLE LXIII.—Farm organization and related data for erosive areas in the Cotton Belt west of the Mississippi River

[Computed from 1930 census data]

Item	Red plains cotton and general farming area	Red plains cotton and ranching area	Eastern Oklahoma cross timbers and prairies	Piney woods and adjacent areas	Texas black prairie
Approximate land area..... acres.	19,745,280	7,822,720	9,514,240	26,285,040	12,006,960
Number of farms.....	79,993	17,360	63,937	198,744	106,300
Farm population per farm.....	5.1	4.8	5.3	4.6	4.7
Value of all farm products.....	\$1,921	\$2,079	\$1,029	\$815	\$1,472
Value of all farm products exclusive of family living.....	\$1,719	\$1,858	\$921	\$654	\$1,310
Acres per farm:					
Cotton.....	60	55	18	21	40
Corn.....	4	9	16	9	11
Oats.....	3	1	3	1	4
Wheat.....	8	19	1	1	1
Peanuts.....	1	1	1	1	1
Miscellaneous crops.....	2	2	4	1	1
Hay.....	2	2	4	1	1
Sorghum for grain.....	8	16	2	2	2
Sorghum for hay.....	10	12	2	2	2
Total crop land harvested.....	97	114	48	33	59
Idle crop land and crop failures.....	7	10	8	5	4
Plowable pasture.....	15	33	9	6	5
Other pasture.....	92	228	34	23	24
Woods and waste.....	6	7	8	12	8
Total land in farms.....	217	389	107	76	95
Percent of all land in farms.....	87	86	72	69	84
Percent of all land in intertilled crops.....	30	18	28	23	45
Yield per acre:					
Cotton..... pounds.....	119	109	120	120	134
Corn..... bushels.....	18	14	16	13	20
Oats..... do.....	21	23	20	21	25
Wheat..... do.....	10	11	11	11	12
Number of livestock per farm:					
All cattle.....	11.4	21.9	6.7	4.4	4.2
Cows kept for milk.....	2.7	3.2	2.4	1.6	1.6
Cows kept for beef.....	2.2	6.4	.5	.4	.4
Swine.....	2.4	4.6	8.1	2.2	2.2
Sows and gilts.....	.2	.4	.4	.3	.1
Sheep and lambs.....	5.3	2.3	.3	.2	1.8
Chickens over 3 months.....	53	57	48	27	40
Horses and mules.....	4.5	5.2	3.2	2.2	2.1

pointed out, however, that farmers have followed this destructive system of cropping throughout the Cotton Belt not entirely through ignorance or willful exploitation but to a large extent because legumes, winter cover crops, and other soil maintenance crops represent a cost to the farmers for which they are not reimbursed in a reasonably short period of time. This is especially true in those areas west of the Mississippi where the rainfall is not sufficient to produce good stands of the common soil-building crops and the price of new land has been less than the cost of maintaining the fertility and physical structure of the land being cropped.

The credit and tenure system has also been conducive to these destructive cropping practices, especially in the old Cotton Belt.

Selected Areas in Tennessee and Adjoining States

Six areas in Tennessee and adjoining States have been grouped together and farm organization and related facts are shown for them in table LXIV. These areas bordering the Cotton Belt on the north vary greatly in topography. They also differ markedly in cropping systems as compared with the areas discussed in the Cotton Belt. The Central Piedmont, where much tobacco is grown, and the Cumberland Highlands, where the topography is so rough that only small

TABLE LXIV.—Farm organization and related data for certain erosive areas in east Tennessee and adjoining areas

[Computed from 1930 census data]

Item	Central piedmont	Valley of east Tennessee	Northern Great Valley general farming	Cumberland Highlands
Approximate land area.....acres.	10,407,040	6,768,000	4,170,090	12,999,680
Number of farms.....	42,451	103,978	56,744	93,161
Farm population per farm.....	5.5	5.6	5.4	5.7
Value of all farm products.....	\$970	\$905	\$1,747	\$566
Value of all farm products exclusive of family living.....	\$733	\$635	\$1,456	\$290
Acres per farm:				
Tobacco.....	4	10	9	8
Corn.....	7	10	9	8
Oats, barley, and rye.....	1	1	3	1
Wheat.....	2	2	11	1
Truck crops and potatoes.....	1	7	10	3
Hay.....	2	1	1	1
Miscellaneous crops.....	1	1	1	1
Orchard.....	1	1	2	1
Total crop land harvested.....	19	22	37	13
Idle crop land and crop failure.....	8	6	4	6
Plowable pasture.....	4	17	23	13
Other pasture.....	8	11	15	11
Woods and waste.....	37	23	22	30
Total land in farms.....	78	79	101	73
Percent of all land in farms.....	75	67	64	52
Percent of all land in intertilled crops.....	13	8	6	6
Yield per acre:				
Corn.....bushels.	19	23	34	20
Cotton.....pounds.	238	11	15	1
Wheat.....bushels.	11	10	15	1
Hay.....tons.	1.1	1.0	1.3	1.0
Number of livestock per farm:				
All cattle.....	2.0	5.7	8.9	3.3
Cows kept for milk.....	1.2	2.1	3.3	1.4
Cows kept for beef.....	1	2	3	1
All swine.....	1	2.9	6.2	2.4
Sows and gilts.....	1	2	5	2
Sheep and lambs.....	2	3.0	9.3	1.2
Chickens over 3 months.....	24	43	30	30
Horses and mules.....	1.4	1.5	2.0	1.2

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patches can be cultivated, are the only areas where over half the crop land is in intertilled crops. If idle crop land and plowable pasture are taken into consideration, intertilled crops do not account for as much as

TABLE LXV.—Farm organization and related data for certain erosive areas in the Eastern States
[Computed from 1930 census data]

Item	Northern piedmont	Central Pennsylvania dairy area	Pittsburgh dairy and general farming
Approximate land area.....acres.	5,634,095	2,591,686	2,945,372
Number of farms.....	46,111	11,027	22,090
Farm population per farm.....	5.4	4.8	6.0
Value of all farm products.....	\$2,580	\$1,833	\$1,239
Value of all farm products exclusive of family living.....	\$2,246	\$1,510	\$967
Acres per farm:			
Tobacco.....	1	10	6
Corn.....	12	10	4
Oats and barley.....	2	11	4
Wheat.....	12	10	4
Truck crops and potatoes.....	2	1	1
Hay.....	12	15	14
Miscellaneous crops.....	2	1	2
Orchard.....	2	1	2
Total crop land harvested.....	43	49	29
Idle crop land and crop failure.....	4	7	8
Plowable pasture.....	17	8	21
Other pasture.....	10	13	18
Woods and waste.....	18	25	15
Total land in farms.....	93	102	91
Percent of all land in farms.....	76	43	68
Percent of all land in intertilled crops.....	12	5	5
Yield per acre:			
Corn.....bushels.	39	36	36
Oats.....do.	29	27	28
Wheat.....do.	20	17	16
Hay.....tons.	1.4	1.2	1.2
Number of livestock per farm:			
All cattle.....	10.3	9.3	8.0
Cows kept for milk.....	5.1	4.7	3.7
Cows kept for beef.....	1	1	1
All swine.....	5.4	5.9	3.1
Sows and gilts.....	4	4	3
Sheep and lambs.....	2.7	1.5	9.8
Chickens over 3 months.....	113	83	66
Horses and mules.....	2.8	2.3	1.7

Item	West Virginia hills	East Ohio hills	Pennsylvania general farming
Approximate land area.....acres.	13,759,590	5,069,200	7,300,220
Number of farms.....	71,493	42,430	37,256
Farm population per farm.....	5.4	4.6	5.2
Value of all farm products.....	\$1,024	\$1,075	\$1,503
Value of all farm products exclusive of family living.....	\$600	\$332	\$1,182
Acres per farm:			
Tobacco.....	5	8	6
Corn.....	1	2	6
Oats and barley.....	1	3	4
Wheat.....	1	1	2
Truck crops and potatoes.....	11	11	14
Hay.....	1	1	2
Miscellaneous crops.....	2	2	1
Orchard.....	2	2	1
Total crop land harvested.....	21	27	37
Idle crop land and crop failure.....	2	5	8
Plowable pasture.....	25	23	10
Other pasture.....	36	31	18
Woods and waste.....	27	18	25
Total land in farms.....	111	104	98
Percent of all land in farms.....	56	78	50
Percent of all land in intertilled crops.....	3	7	4
Yield per acre:			
Corn.....bushels.	29	34	36
Oats.....do.	28	22	26
Wheat.....do.	14	16	16
Hay.....tons.	1.1	1.1	1.1
Number of livestock per farm:			
All cattle.....	7.7	7.2	7.6
Cows kept for milk.....	2.4	2.8	3.5
Cows kept for beef.....	4	2	1
All swine.....	2.7	3.8	3.8
Sows and gilts.....	2	3	3
Sheep and lambs.....	15.7	12.7	2.8
Chickens over 3 months.....	44	63	74
Horses and mules.....	1.5	1.7	1.9

half the plowable land in any area. The percentage of all land in intertilled crops varies from 5 to 13. On the whole, this is a very small proportion of the land in intertilled crops and represents a rational adjustment on the part of the users of the land to its fitness for various types of production. In areas such as the Cumberland Highlands perhaps even 5 to 6 percent of the total land area is not sufficiently level to permit crop production without serious erosion losses. Here, however, the crop acreage per family is so limited and the land so generally unsuited to crop production that large areas have been recommended for retirement from production by Government purchase.

Farm organization and related data for six areas including the northern Piedmont and parts of Pennsylvania, West Virginia, and Ohio are shown in table LXV.

Selected Areas in Eastern States

The selected areas in Eastern States are grouped together in table LXV; these areas, like those in table LXIV, vary in topography and natural fertility. They do have several things in common, however, which contrast them with the other areas previously considered. In all of these areas the acres in hay equal or exceed those in corn. Hay varies from 11 acres per farm in the West Virginia and Ohio hills to 15 acres in central Pennsylvania, as compared with a range from 5 acres of corn per farm in the West Virginia hills to 12 acres in the northern Piedmont. In no case do intertilled crops account for more than 25 percent of the plowable land. In some cases the percentage is as low as 10. As a proportion of all land in the areas, intertilled crops vary from 3 percent in the West Virginia hills to 12 percent in the northern Piedmont. The trends in crop yields have been generally upward in these States, which would indicate that the present cropping system as supplemented by commercial fertilizers are adequate, on the average, to provide for soil maintenance. This does not mean, of course, that each individual farm is following a soil-maintenance system of farming. No doubt many farms are continuing to deplete their soil; and even though the proportion of land in intertilled crops on many farms is adjusted to the soil resources, much could be done to minimize erosion through damming of gullies, contour cultivation, and similar farm practices.

Tobacco Areas

Four areas in Tennessee, Kentucky, Indiana, and Ohio where tobacco is the chief source of income have been grouped together, and farm organization and related facts are presented in table LXVI. These areas resemble those previously considered in the

TABLE LXVI.—Farm organization and related data for erosive areas in the tobacco growing section, Kentucky, Indiana, and Ohio

[Computed from 1920 census data]

Item	Jackson Purchase tobacco area	Indiana-Kentucky hills	Outer bluegrass and borders	Kentucky-Tennessee tobacco area
Approximate land area.....acres	2,305,620	5,330,560	6,623,360	5,644,160
Number of farms.....	26,476	40,202	68,566	54,994
Farm population per farm.....	4.4	4.7	4.3	4.5
Value of all farm products.....	\$894	\$860	\$1,317	\$1,004
Value of all farm products exclusive of family living.....	\$690	\$634	\$1,088	\$785
Acres per farm:				
Tobacco.....	2	1	2	3
Corn.....	13	15	10	13
Oats and barley.....	4	2	1	1
Wheat.....	1	3	2	1
Truck crops and potatoes.....	1	1	1	1
Cotton.....	2	1	1	1
Hay.....	7	8	8	6
Miscellaneous crops.....	2	1	1	1
Orchard.....	1	1	1	1
Total crop land harvested.....	27	31	24	25
Idle crop land and crop failure.....	9	10	5	9
Plowable pasture.....	15	18	26	20
Other pasture.....	6	18	18	9
Woods and waste.....	16	26	10	21
Total land in farms.....	73	104	83	84
Percent of all land in farms.....	80	78	86	82
Percent of all land in intertilled crops.....	19	12	12	16
Yield per acre:				
Corn.....bushels.....	25	22	27	26
Oats.....do.....	19	19	16	17
Wheat.....do.....	12	10	15	11
Hay.....tons.....	1.0	1.0	1.2	1.0
Number of livestock per farm:				
All cattle.....	4.2	5.1	6.4	4.1
Cows kept for milk.....	2.0	2.3	3.1	1.8
Cows kept for beef.....	2.2	2.8	3.3	2.3
All swine.....	5.0	5.2	5.6	4.5
Sows and gilts.....	0.4	0.5	0.5	0.4
Sheep and lambs.....	1.3	2.1	12.9	3.2
Chickens over 3 months.....	31	51	51	35
Horses and mules.....	2.3	2.4	2.0	2.1

Cotton Belt. The proportion of total crop land in intertilled crops is high. Considerable crop land is idle, the average acreage of hay per farm is low, and the total acreage of crop land harvested is small. A careful study of the average acreage of each crop for each area indicates that the essentials of a good rotation are not met in these areas. The reasons for the failure of these farmers to follow a cropping system that will prevent or minimize soil depletion are probably similar to those mentioned when discussing the Cotton Belt problems. As in the case of the Cotton Belt, the prevention of soil depletion in these areas is a major problem and includes soil-erosion control as one of its most important elements.

Selected Areas in the Middle West

Four areas in the Middle West—including southwest Wisconsin, northeast Iowa, the Missouri Valley loess area, and the southern Iowa, northern Missouri, and western Illinois hills—have been grouped together and farm organization and related data are presented for them in table LXVII.

Here intertilled crops account for from one-fourth to a little over one-half of the total harvested crop

land. On the basis of total plowable land the proportion of intertilled crops is smaller, being somewhat less than one-half in the Missouri Valley loess, which is the highest of the four areas. The percent of all land in intertilled crops varies from 10 in southwest Wisconsin to 35 in the Missouri Valley loess. Yields per acre are uniformly high, with the exception of the hilly area in northern Missouri, southern Iowa, and western Illinois. These yields are below their 5-year average in 1929, due, no doubt, to unfavorable weather conditions.

TABLE LXVII.—Farm organization and related data for erosive areas in the Middle West

[Computed from 1930 census data]

Item	Wisconsin Driftless Area	Northeast Iowa	Missouri Valley loess	Northern Missouri and adjoining areas
Approximate land area.....acres..	6,608,000	10,371,200	26,003,200	16,852,480
Number of farms.....	41,108	61,323	140,689	101,868
Farm population per farm.....	4.8	4.6	4.6	4.0
Value of all farm products.....	\$2,569	\$2,739	\$3,525	\$1,814
Value of all farm products exclusive of family living.....	\$2,251	\$2,414	\$3,207	\$1,566
Acres per farm:				
Corn.....	15	35	65	28
Oats and barley.....	26	33	30	12
Wheat.....	1	1	7	6
Truck crops and potatoes.....	1	1	1	1
Hay.....	22	23	16	20
Miscellaneous crops.....	1	1	1	2
Total crop land harvested.....	66	93	119	68
Idle crop land and crop failure.....	3	2	5	9
Plowable pasture.....	16	20	23	26
Other pasture.....	47	34	19	28
Woods and waste.....	15	10	8	8
Total land in farms.....	146	159	176	149
Percent of all land in farms.....	91	94	95	90
Percent of all land in intertilled crops.....	10	21	35	17
Yield per acre:				
Corn.....bushels..	37	38	35	27
Oats.....do.....	32	33	34	23
Wheat.....do.....	20	15	15	11
Hay.....tons.....	1.9	1.6	1.5	1.0
Number of livestock per farm:				
All cattle.....	23.7	23.6	18.6	13.2
Cows kept for milk.....	11.5	9.1	4.7	3.4
Cows kept for beef.....	2	8	1.9	2.1
All swine.....	16.0	36.0	51.4	23.3
Sows and gilts.....	2.9	7.0	8.8	2.7
Sheep and lambs.....	6.1	5.7	4.5	13.8
Chickens over 3 months.....	89	135	130	130
Horses and mules.....	3.6	4.3	5.3	3.8

Both southwest Wisconsin and northeast Iowa not only have a reasonably low percentage of their crop land in corn but they have a large amount of livestock—mostly dairy cattle. An analysis of acre yields by counties in these areas indicates a horizontal or upward trend, especially if the late drought years are omitted.

These facts indicate that, for the areas taken as a whole, the users of land have developed a reasonably conservative system of land use—much more so, at least, than in the Cotton Belt.

Selected Areas in the Missouri Valley

The Missouri Valley, with its rich loess soil, has too high a proportion of corn and too low a proportion of hay to meet the essentials of a good rotation. Yields are being maintained in the area, with this cropping system because of the large supply of fertile topsoil. It seems certain that unless some plan for the more general encouragement of soil maintenance is developed for this area, users of the land in the not far distant future will have an inferior or mediocre soil with which to work, as compared with the farmers of yesterday and today.

Small grains do not yield as well in the hilly area of southern Iowa, northern Missouri, and western Illinois as they do farther north. As a result, farmers have to depend more on corn for feed concentrates. Corn and hay are the principal crops in this area. The average figures presented in table LXVII suggest that on the whole the agriculture in the area is not as well adapted to minimize soil depletion as is the case in northeast Iowa and southwest Wisconsin, but better adapted than the agriculture in the Missouri Valley. The acreage and yield per acre of corn have maintained approximately a horizontal trend since 1905. This would suggest that present maladjustments in the cropping systems are not as great as in some other areas.

A careful study of the data presented in tables LXII to LXVII, covering 29 selected areas and a total land surface of almost 300,000,000 acres, leads to the inescapable conclusion that because of differences in economic and physical factors the prevention of soil depletion, both from the individual and the social points of view, presents not one but a series of problems varying both in importance with regard to soil resources endangered and in difficulty of solution. These differences and the variations in the magnitude of the conservation program needed in each area must be taken into consideration in any comprehensive soil-conservation program that is both highly effective and economical.