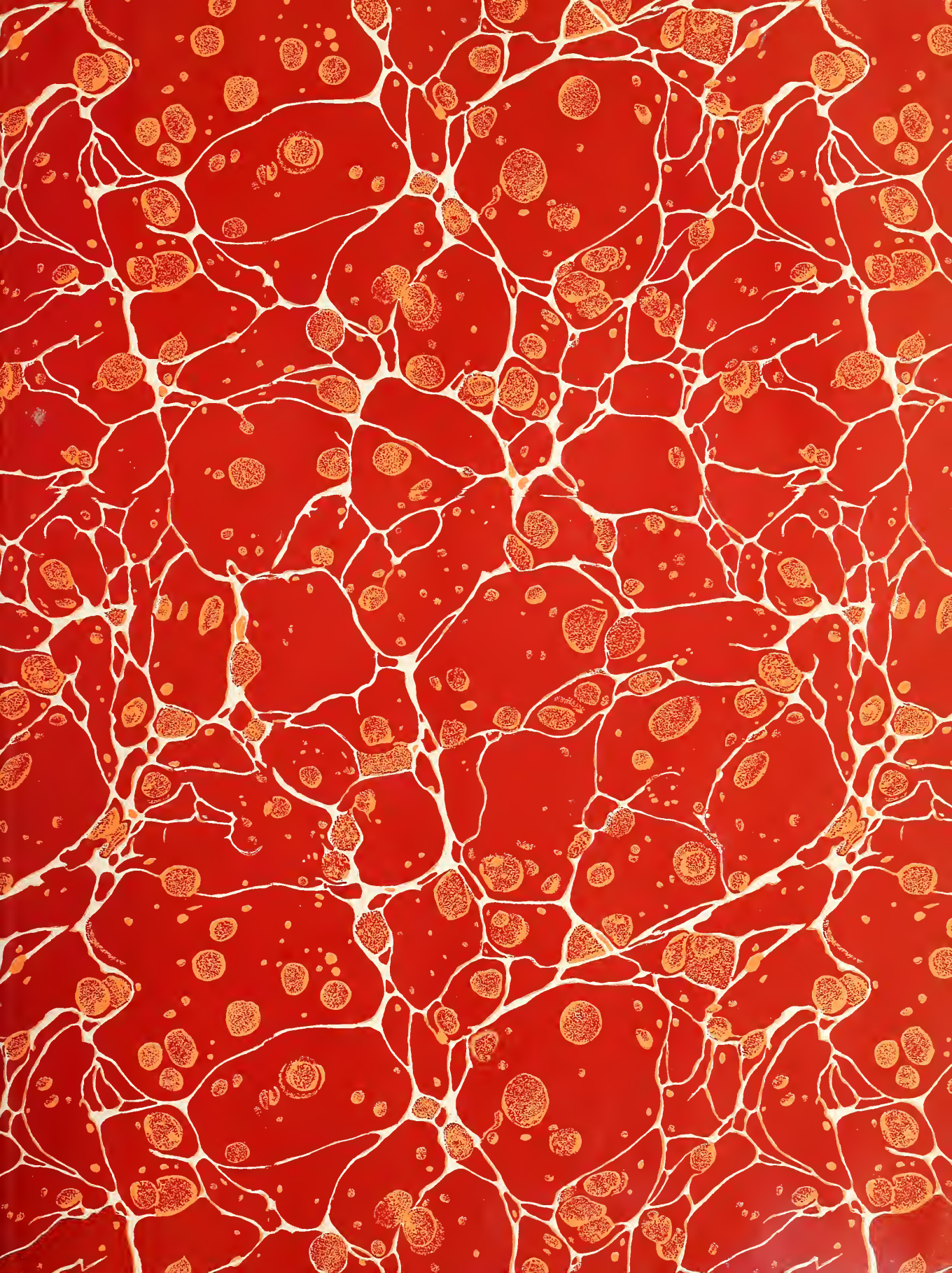
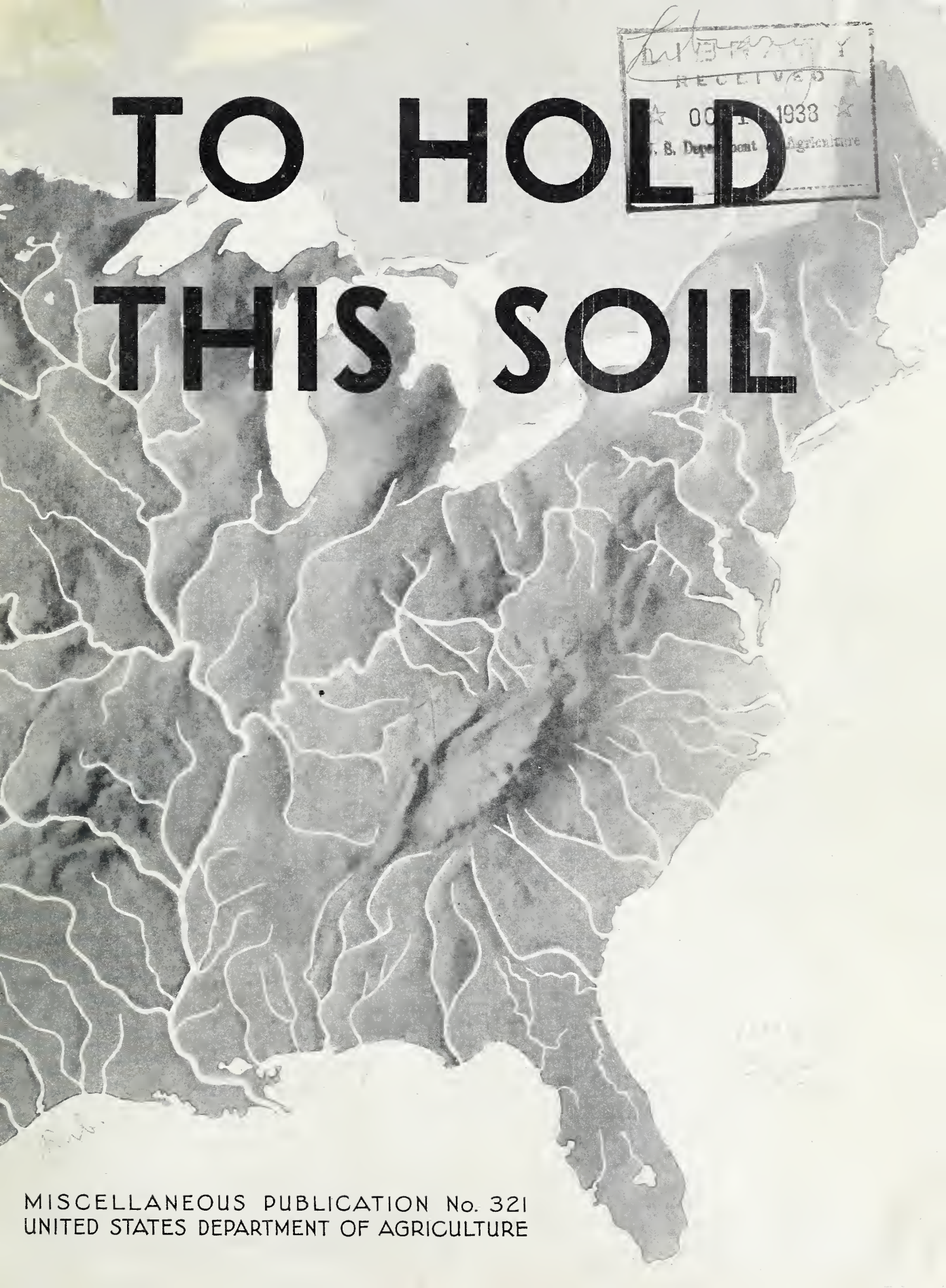
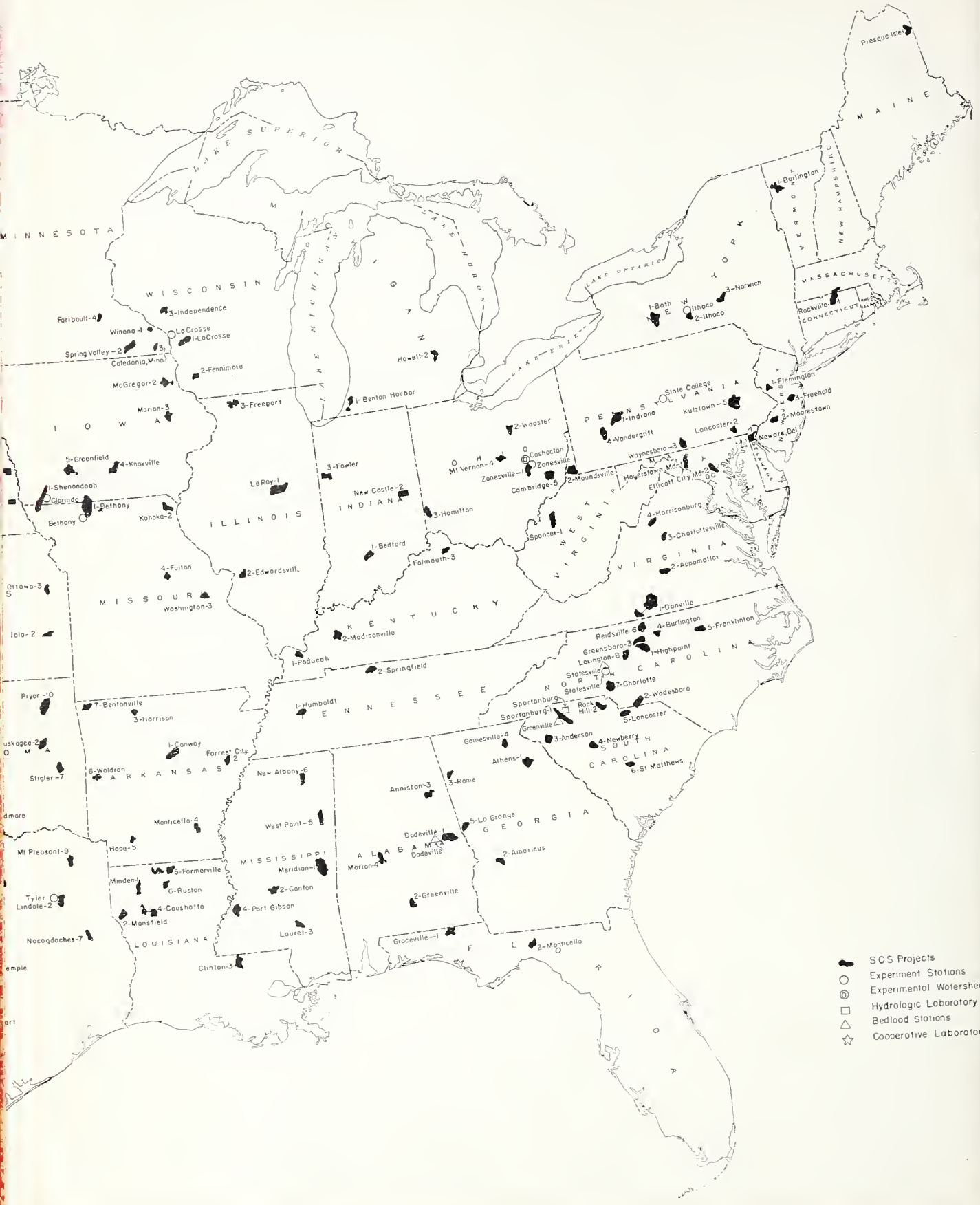


TO HOLD THIS SOIL



MISCELLANEOUS PUBLICATION No. 321
UNITED STATES DEPARTMENT OF AGRICULTURE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LAKE ONTARIO
LAKE ERIE
LAKE SUPERIOR
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Faribault-4
Winona-1
LaCrosse
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Spring Valley-2
Caledonia, Minn.
2-Fennimore
McGregor-2
3-Independence
3-Freeport
Marion-3
IOWA
Howell-2
1-Benton Harbor
2-Wooster
Coshocton
Zonesville
Mt Vernon-4
Zonesville-1
Cambridge-5
2-Moundsville
OHIO
PENNSYLVANIA
State College
1-Indiana
Kutztown-5
Wondergrift
Lancaster-2
Waynesboro-3
Hagerstown, Md-1
Ellicott City, Md-2
Newark, Del
1-Flemington
5-Freehold
2-Moorestown
NEW JERSEY
DELAWARE
MARYLAND
D.C.
5-Greenfield
4-Knoxville
1-Shenandoah
Clarinda
1-Bethany
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Kahoka-2
LeRoy-1
ILLINOIS
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New Castle-2
INDIANA
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1-Bedford
Folmouth-3
Spencer-1
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3-Charlottesville
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2-Edwardsville
Washington-3
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Ottowa-3
Iola-2
KENTUCKY
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1-Danville
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Greensboro-3
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Statesville
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7-Charlotte
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Sportanburg
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Rock Hill-2
5-Loncaster
Greenville
3-Anderson
4-Newberry
SOUTH CAROLINA
6-St Matthews
Gainesville-4
Athens-
Pryor-10
7-Bentonville
3-Harrison
1-Humboldt
TENNESSEE
Muskogee-2
OMA
Stigler-7
1-Conway
Forrest City-2
6-Waldron
ARKANSAS
New Albany-6
Anniston-3
3-Rome
Monticello-4
West Point-5
Dodeville-1
Dodeville
5-Lo Grange
GEORGIA
Mt Pleasont-9
Hope-5
MISSISSIPPI
Meridian-1
Morion-4
ALABAMA
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Minden-1
5-Formerville
6-Ruston
2-Canton
Tyler
Lindale-2
4-Coushotta
4-Port Gibson
2-Greenville
2-Monsfield
Nacogdoches-7
LOUISIANA
Laurel-3
Clinton-3
Graceville-1
2-Monticello
FLORIDA
SCS Projects
Experiment Stations
Experimentol Watersheds
Hydrologic Laboratory
Bedload Stations
Cooperative Laboratory

THE NEW DESIGN.

On this Iowa farm they are getting away from
"square farming in a round country."

To Hold This Soil

by RUSSELL LORD

Soil Conservation Service

MISCELLANEOUS PUBLICATION NO. 321

UNITED STATES DEPARTMENT OF AGRICULTURE

AUGUST 1938

Pictorial relief map on cover

by JOHN J. BRAUND,

Coast and Geodetic Survey,

Washington, D. C.

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Contents

The Midland Is Taken

page 46

The High Plains Are Taken

page 63

Last Wests

page 81

"Back of Yonder"

page 107

The Film of Life

The fabric of human life has been woven on earthen looms. It everywhere smells of the clay . . . Howsoever high the spirit of man may soar . . . it is on [the stomach] that humanity, like an army, ever must advance. Beneath the stomach is vegetation, beneath vegetation the soil, and beneath the soil the ceaseless and varied turmoil of terrestrial forces.—J. H. Bradley. Autobiography of Earth. (1935.)

EVERY SOILED STREAM and dust storm in the United States advances the spectacle of one farm, county, and State moving into another, or out to sea, at a rate for which there is no known precedent, over a country as a whole.

The purpose here is to exhibit conditions and methods of defensive husbandry. But first it is right and practical to stand off a while from the problem, erect a rough frame of time and space around it, and try to view it with some sense of proportion, removed from immediate alarums.

Geographers draw maps flat, inert, with fixed edges. Poets sing of the everlasting hills. Man likes to think of solid ground beneath his feet; but there is no such thing on earth. This world is cast of solid rock, but the weather grinds the surface into little pieces, and the pieces travel. If accurate land maps were scientifically possible they would more nearly resemble something living—bodies of land changing their skin, changing their outlines and positions, squirming with life and change.

This is so of all bodies of land, from the largest continent to the smallest farm. Indeed, no cubic inch of earth's surface remains, most probably, precisely the same in its physical and chemical make-up as it was the second before. If this statement were advanced as to air or water, few would doubt it. Except that the rate of change is by no means as quick or apparent, the same must be true of soil. Physically, the upper, more porous parts of a good, spongy soil are from one-third to one-half air, and from one-tenth to one-fourth water. The pull of gravitation, the beat of sun, rain, and wind are forever at work, and the land moves.

Anyone who has ever bent in old churchyards to trace on the stones the fading names of the dead has seen the weather starting work as a maker of soil. Infinite particles, even of solid granite, have been bitten back into the dust. The tombstone swells with heat, winces under ice and chill, wears down under the stroke of rain and wind. Then the same weathering forces which start soils sort them and move them endlessly.

Whether the exposed rock is a tomb or a mountain, it is subject to the same slow demolition and removal. Once the Blue Ridge Mountains stood 30,000 feet high. They are not one-third that high now at their utmost summits. They have taken on in the course of the centuries the appearance of rounded hills. The soil wash from their eastern slope extends across and beyond the visible coastal plain in a drowned, continuing plain sloping gently eastward for a hundred miles or so under the sea.

Every continent is rimmed by such formations. Debris bibs, continental bibs or aprons, geologists call them; and they estimate that one-twentieth of earth's total surface is covered by these drowned inclines of lost soil. Plenty of buried American soil lies east of Charleston, south of New Orleans, west of San Francisco;

but there is no live soil all the way from there to foreign parts; for soil, like man, must receive the sun and air direct if it is to stay alive and be fruitful.

Terms and Proportions

Land is that part of the earth's surface which stands at a given time above sea level. Soil is the living surface of the land.

Erosion is a coined word of classical origin, like pyrotechnic or photosynthesis. Derived from two words of ancient Greek, years after that civilization had failed and its language had become the plaything of scholars, erosion means gnawing away. Gnawing away at naked rock the weathering agencies—heat and cold, water and air, roots, molds, bacteria, and the remains of all things living—combine to chip and powder earth's rocky crust and to distribute the debris, depositing here and there on land a thin and shifting film of rotted rock with the essence of life's renewal in it, called soil.

Seen at the height of a worm a plowed field is a range of hills. From his own height man sees mountains, and great valleys; but in proportion to the whole bulk of the planet, earth's surface is as smooth as an egg. Between the highest mountain, and the greatest known depth of the sea, off the Philippines, the total difference is 12 miles. That is only about one-six hundred and seventieth of the diameter. Shown to strict scale in relief on a 3-foot globe world 29,000-foot Mount Everest would dwindle to less than the thickness of the paper on which these words are printed, and a depression of the same thickness would be enough to indicate the 6-mile depth of the sea above Swire Deep, the deepest of holes in the Pacific.

If mountains ashore, and the great mountains and valleys under the sea, viewed thus, amount to so little, what may be said of the proportions of living land surface to the inert bulk of the earth? No line could possibly be drawn fine enough to show the relationship of the lithosphere, or rocky core of earth, to life-giving topsoil. The proportion is roughly an inch to a thousand miles, or ultramicroscopic.

On this whirling globe of rock, some 8,000 miles in diameter, topsoil seldom exceeds the depth of a spade. There is more, of course, to a soil than topsoil, but the top inches are the vital part, for here and here only the locked, potential energy of rocks is completely vivified and transformed into living growths. Under the topsoil, which scientists call horizon A, is horizon B, the subsoil, 2 or 3 feet thick, as a rule. Subsoil is soil material in process of creation. A soil in the making, it can hold some water and contains some available plant food, but is not yet rich in organic matter.

Wherever bared to the plow, subsoil is harder to work than mellow topsoil, and less rewarding. It is mean land to handle, more likely to shed than to absorb rainfall; unready, unresponsive, poor. Below the subsoil is a C horizon of raw rock or other soil-forming materials still less digested and less impregnated with life by weathering and the addition of organic remains. Graves are generally dug into this third horizons 6 feet deep. Streams generally cut their way down through the softer upper part of the C horizon, into the harder bedrock beneath.

Below bedrock is the solid frame of earth. You strike bedrock at different depths in different places; but the A, B, and upper C horizons of more or less pulverized rock (laid, as Bradley puts it, like a "loose mantle on the bony framework of the continents"), add up to around 7 or 8 feet deep on the average. Water can penetrate below that, into the solid bedrock, and does, forming "thin shallow oceans beneath the surface of every land mass on the globe." But, Bradley continues: "Percolating waters are held within a relatively superficial zone, their cankerous touch securely barred from the inner depths * * * The deeper shafts of many mines cut through the water-logged zone into rocks that are dry and dusty * * *"

Count in all the outer layers of earth which in any way contribute to the making of a plant or animal—the topsoil; the B horizon, the C horizon, and the deepest rock layers into which living waters penetrate. Count in, too, the few

score miles above ground where (according to guesses of recent balloonists wearing oxygen helmets) air, however thin, may cling to the earth as part of its terrestrial garment; and the living part of earth remains still a tenous habitation.

Out of the Dark, Crops

Drawn by the moon, whipped by the sun and wind, the sea breeds—often in its depths—a life of its own, and buries it deep, and brings it to life again. The sun cannot send warmth as far down into soil as it can into water. Free air cannot penetrate on land as deeply as can air dissolved in the waters of the earth. On land, the miracle of the transformation takes place a few inches underground where air and water move at a creeping pace through a dark, inverted forest of warring roots.

Here is the earthly border line between the quick and dead. Here, through the topsoil's infinite number of rotting rock and organic particles, and through their infinite interspaces, move not only the gases of the atmosphere but gases of the soil's own making, the products of a vast and patient fermentation which never ends. ". . . humus—dead matter—" writes Gove Hambidge, in his book, Enchanted Acre (1933), reflecting upon the mysteries of our present existence, and the mysteries of a garden-compost pile, "must be got into the soil if it is to be fruitful. Out of this death cometh life, out of this corruption, incorruption."

Hambidge continues:

"Air moves in the space as though the earth breathed and supplies the needs of living roots. Water moves in the space . . . The water dissolves many things; others are held in colloidal solution, that is, finely divided and suspended in the water like oil droplets and paprika in a salad dressing, only much more minute . . . It is a caldron of chemical soup on which the roots of plants feed . . . a seething fermenting mass, inert to the eye only, actually a brew bubbling like wine in a vat.

". . . bacteria take part, variously estimated at from 600,000 to 800,000,000 in a gram (less than 1/30 of an ounce) of soil; and not only bacteria but vast numbers of fungi, algae, protozoa also, many of them performing the same or similar functions. And these microscopic beings too are continually dying, decaying, coming to birth . . . The very odor of the soil, the smell beloved by plowman and gardener, is not the odor of soil but of a group of bacteria, the Actinomyces, and of splinters of cellulose, the structural material of plants."

Celestial Dynamics

Blazing hot, 10,000° F. at the surface and enormously hotter within, the sun is earth's immediate source of life. Most sun power goes out to the other heavenly bodies or off into space; only about one two-billionth reaches earth. Even so, the delivered energy averages three-eighths horsepower, day and night, on each square yard of land and sea. At noon, when the rays strike perpendicularly the sun delivers 1½ horsepower to the square yard, upwards of 4½-million horsepower to the square mile, or 7,260 horsepower to the acre.

Windmills run by sun power. If the sun did not heat different parts of earth's surface, and different layers of its water-laden atmosphere unevenly, no winds would blow. Waterpower is sun power. The sun draws surface water up for another run down the face of the continents. It is the pumping heart of the circulatory water system that keeps earth alive.

Winds blow, clouds mount the wind, rain falls, and the lands are replenished. Streams and rivers flash to the sea, clouds form; and the cycle continues. "All the rivers run into the sea; yet the sea is not full; unto the place from whence the rivers come . . . they return . . ."—Ecclesiastes 1: 7.

Sun power drives the weather mill that grinds soil and propels still-secret processes by which in soil, sea, leaf, and flesh, our common ingredients—sun, air, water, and a sprinkling of earthy minerals—combine into all forms of life and energy, including man.

Our power age is a governed explosion of buried sun power. When coal, petroleum, and gasoline are burned they deliver energy the sun stored in plants aeons ago. Farmers plowing, miners digging, Sunday motorists out for an airing, airplane drivers streaking for Europe or South America—all are developing in their various persons and from their subject beast or equipage, sun power previously fixed for use through a film of soil.

Wounded, with their nourishing film of soil and water—their placenta, Shaler calls it—out of working order, powerful civilizations have flicked out of the earthly procession in a few hundred years. Literally, placenta is the enveloping membrane through which the mother transmits sustenance to the new life she carries as part of her being. By his boldly figurative application of this word to earth, Nathaniel Southgate Shaler, a Harvard geologist, pronounced, 30 years ago in his Man and the Earth a neglected warning: Man, and all forms of land life, draw life from sun, clouds, air and earth through a tenuous film of topsoil, indispensable, and if rudely handled, impermanent.

A Matter of Time

Geological erosion is an old story on this planet, older than man, older than the hills. It began when the first air stirred and the first rain fell on the face of the earth. It crept with a mysterious natural balance between soil manufacture and soil transportation through aeons.

Always, water has been the great leveler. Dust storms are dramatic. Water works quietly, most of the time. Look in a stream on a clear day and you can see the hills dwindle to utter flatness.

Actually, such flattening has never quite happened. If it had, the world would be covered by a sea 2 miles deep. A number of times this and other continents have been so leveled by erosion that they were partly flooded by sea water. Our continental interior throughout long stages of its geological development was a shallow inland sea, of salt or brackish water, and many islands. Fully seven-eighths of the United States today is underlain by strata of water-borne and water-deposited rocks. But rivers grow more sluggish as they lower the land they are leveling. Under natural conditions water erosion carries its own brakes. Besides, many students of earth structure believe, the terrific weight of accumulated land sediments on the ocean floor beyond our coast lines upset the balance and buckled major parts of our land area, lifted them higher, and threw back the sea.

Geologists call it isostasy, and do not altogether know how to account for it. Whatever the cause of this buckling and lifting, the thing has happened on this and other continents time and again; and whenever it happened the steeper land slants and higher elevations gave water a fiercely renewed power to tear the landscape down again. These cycles of geological erosion and upheaval offer a neat example of natural checks and balances, but they are entirely beyond human management and proceed so slowly as to be of no immediate concern.

From what has been said it follows that erosion's long-time processes may prove beneficent. That is true. In a manner of speaking, the weather designed this country, molding through the activities of erosion and glaciers countless smooth hills, wide plains, and fertile valleys such as our first white settlers discovered and which we now inherit, somewhat changed. Like fire and other natural phenomena, erosion can produce both comfort and destruction. The trouble comes when man through recklessness or ignorance removes natural curbs, forces the process, and lets it get out of hand.

When this happens the weather can remove in a few years soils which it has taken centuries to build. Then you get what is known as accelerated erosion. Those who take comfort in the thought that erosion has been always with us, and was here, indeed, before we were, ignore the difference between geological erosion under conditions of natural balance and cover,

AN OLD STORY, OLDER THAN MAN, OLDER THAN THE HILLS.

Geological erosion moves at a creeping pace.

MANHANDLED LAND.

Fertile soil goes off by carload lots.

and the accelerated removal which starts when soil is bared and tilled.

"Soil," wrote Shaler, in his Man and the Earth, "is rock material on its way toward the deep." But soils, he added, are "considerably restrained in . . . going by the action of plants which form a mat upon them." Then he made this point:

"The preservation of the food-giving value of the soil as used by civilized man depends on the efficiency of the means by which he keeps the passage of the soil to the sea at a rate no greater than that at which it is restored by the decay of the materials on which it rests."

Manhandled Land

Not erosion, in itself; but a high-powered modern differential between the rate of soil formation, and the rate of its removal, offers the problem here to be considered. Even under natural conditions, with trees or thick grass to break the lash of wind and rain above and with roots undisturbed by tillage or unconfined by row planting spreading a dark, entangling net below, soil creeps and changes. This is not serious. The changes that take place in the soil under the stability of vegetative cover are so slow that they are generally balanced by soil-formative forces and so nearly imperceptible that succeeding generations of man may accommodate themselves to the change and never feel the difference.

But if you take off the cover, rip off trees or sod, pulverize the soil with steel implements, push it too hard, deprive it of the spongy remains of organic growths which help to make soil more absorptive and hold the top of a field together—then you smash the natural balance; and Nature, quite impersonally, starts taking soil away from the top much faster than it grinds, mellows, and builds new soil from below. New soil is chipped and pulverized from parent materials and weathered into being, particle by particle, at the same slow rate as of old. Mature and fertile soil goes off by carload lots with the rain, or leaves on the wind, or both.

That is what has happened, and what is happening, with a menacing, accelerating, and all but incredible speed to this land, the United States. In Rich Land, Poor Land (1936), Stuart Chase states the trouble thus:

"The skin of America has been laid open . . . Geological erosion tends to be static, for soil builds as fast or a little faster than water carries it away. *Man-made erosion is dynamic and cumulative* and has no end save complete destruction (unless it is controlled)."

As an actual instance of erosion's give and take under conditions of slipshod cultivation, consider the reduced condition of a hilltop at the head of a small watershed in the Middle Atlantic States, not far from this writing table. It is what is called a *bald* here, a *gall* in parts more southern, a *scald* to the West. Nearly all the topsoil has been stripped off the top of this hill. The subsoil protrudes, supporting only a fuzzy growth of coarse, thin wiry grasses, weeds, some briers, and a dawning patch of scrub pine.

Down the slope, escaping raindrops, laden with grit, and thrown into slashing ribbons of run-off by converging slopes, have ripped out three nasty-looking gullies, down to bedrock. These gullies the farmer has tended; at least he has exhibited concern. Cornstalks, two old cars, a rusted kitchen range, and a candid display of discarded domestic crockery have been cast into the cuts. Just as the Plains have their dust-storm jokes, this new land's old East is developing a humorous defense against rain wash. It is said in this locality now that the newer sort of streamlined cars don't hold up when it comes to gully-stopping like the old ones did.

In the skinning of this hill, and of many other hills ranging south and west, gullies, however, have played a small and incidental part. No gullies scar the gently arched bald at the hilltop, yet from there, over more than an acre, the topsoil has gone. And the bald is spreading in an irregular design, like a splash of water or an octopus. A penknife is all you need to get through the patchy scurf of remaining topsoil

at many ungullied points between the crest of the field and the gullies.

Killing an Acre

The great harm here has been done by sheet erosion, which strips off topsoil evenly, imperceptibly, grain by grain, layer by layer. Unnoticed, sheet erosion gnaws down the whole surface, keeping it smooth looking but making it more barren all the time. This smooth bald hill in Maryland has been just about killed for farming purposes for generations to come; and it has all been done in 20 years.

Almost the whole farm was in woods which had been but lightly cut over, a century or so before, when the present owner bought it, soon after 1900. He bought it to farm, and counted on the timber to help meet his payments, which it did. A frail man, tired of the city, land hungry, he almost killed himself at the heavy labor of clearing that land, but he did it; and established a dairy farm. His debts drove intertilled row crops (corn, for the cows; tomatoes and sweet corn as summer cash crops for the canneries) too far up the shoulders; but he had a big family; he had to work that land. He plowed and harrowed and laid his rows and intercultivated up and down the slope, as often as not. This was, and is, the general practice. It is equivalent to scratching millions of inviting little channels so that the stirred soil may all the more readily be conveyed downhill to the sea; but that is how most cultivation has always been conducted in the United States.

This farmer wanted to farm right. He bought lime and, in good years, fertilizer. He never realized that he was skinning his land by pushing it too hard with hoof and tooth and steel implements. He does not realize it now. He says he has those gullies just about stopped, and as for the rest of the field, "It's just a little run down; needs a little rest."

Like many farmers he formed in the toil of clearing a feeling of natural enmity toward trees, even in pastures. But the highest crest on the place, the acre which now is bald, he kept in trees, judging the slope below too steep for comfortable plowing, until 1917. In 1917 he cleared and dragged stumps. In 1918 he plowed and put the field in corn, intending to follow with wheat, then grass. War prices may have had something to do with. it. In that period of two-dollar wheat and guaranteed high rewards for corn, meat, and milk, plows crept high; and by the end of the World War millions of acres of good American soil, thousands of miles from the battle front, lay wounded.

Twice put through a 4-year rotation (corn, wheat, then 2 years of timothy and clover), this field developed those gullies toward the bottom and made no hay worth cutting in 1924. In 1925 cultivation was abandoned, and the hill was thrown into permanent pasture, which is what they call it now. The bunchy wisps of timothy and clover provided no permanent cover. No reseeding with a perennial grass was attempted. Small sprawling patches of a dwarf lespedeza, probably seeded from neighboring lands by the cows' droppings, have taken hold here and there in moist spots during the 12 years since. It is an annual that reseeds itself. It is spreading. But the skinned soil shows through the thin grass almost all over.

The owner watches his front pastures, next the road. If the bluegrass sod there shows serious damage from hoof and tooth, he swings a gate and switches his herds to the upland. The carrying capacity of the bald hilltop and its thinned slopes can certainly be no more now than a cow to 10 acres; but it happens that an old apple tree, striking roots into subsoil, has survived there, right at the crest. It offers shade; and the cows incline to bunch there, milling around, striking at flies, stomping, nibbling at any blade resembling grass, during the heat of the day. That is the reason the bald spot is spreading—overgrazing. Way off in the back of the place, and supposed to be at rest and healing, that hill has been heavily overgrazed and has continued to wash, even when removed from cultivation. Deforestation, then unguarded cultivation, then overgrazing, have just about ruined

it as a piece of land to live on or make a living on in 20 years.

There would be no point in fixing attention so closely on this quickly hurt acre or more of the United States, if it were not fairly typical of a vast expanse of American soil. It is only in scattered spots, to be sure, that the rate of soil loss advanced as fast as it has here; yet even more rapid removals could easily be cited on "flat land" in western States and townships first brought under cultivation, as the saying goes, as little as 20 or 30 years ago.

Slow to Form: Quick to Go

"It seems strange," writes H. H. Bennett, Chief of the United States Soil Conservation Service, reporting analyses of crops from eroded land, "that we have paid so little attention to the vital importance of the topsoil, the thin humus layer, charged with decaying vegetable matter, containing the bulk of available plant food and representing the abiding place of incredible hosts of beneficial micro-organism." The top few inches of soil, he continues: "often is higher in content of phosphorus and lime than the layers below; it is neutral or even alkaline where the subsurface material is strongly acid. This is due to basic constituents brought up from below by plant roots and concentrated in this surface layer through the medium of decomposing leaves and grass . . . experiments at the erosion [soil conservation] stations are showing not only large decreases in the productive capacity of land following the washing away of the soil, but even impairment of the quality of some of the products grown. Cotton, for example, has tested much weaker in strength where grown on eroded soil, as compared with that produced on uneroded soil immediately alongside, and the content of oil in the cottonseed much lower—according to results obtained at the Oklahoma erosion station."

Rates of soil formation can only be estimated, in the light of present knowledge; and they vary from soil to soil. Clays, in general, take longer to grind and mellow than sandy soils. The number of centuries required to make an inch of loam falls somewhere in between. Probably it took not less than 500 years to make each inch of the 6 to 8 inches of topsoil of the Shelby loam and similar soils which cover a large part of northern Missouri; yet under conditions of undisturbed natural cover that was fast enough to replace topsoil of that type displaced by geological erosion, and so keep it stabilized. In the southern Piedmont, the topsoil of one of the important types of upland of Fairfield County, S. C., was not less than 600 years to the inch in the making. Doubtless some of it slipped away from under its native forest cover, but it did not slip away any faster than it was being made.

These estimates are Bennett's, who adds: "Over most of the southern Piedmont it probably took nature even longer to build up a topsoil. According to some of the quantitative measurements made at the erosion stations, . . . I would not be in the least surprised if it turned out that not less than 1,000 years at least are required by nature to build an inch of good, rich Piedmont topsoil [over the greater part of the region]."

What it has taken nature thousands of years to give us we have despoiled in two or three centuries at the most, and often in as little as 20 or 40 years, a mere clock tick, in the span of eternity.

Returning for a moment to that nearby hill, scrubbed bald in 20 years: The soil is Chester clay loam. Bennett, inspecting the field, puts the former average depth of its topsoil at 6 or 7 inches and estimates that the rate of its formation from subsoil was certainly no faster than 600 years to the inch. In other words, it took the weather at least 3,600 years to spread and stabilize a 6-inch topsoil blanket on that hilltop; and it took only 20 years of indifferent farming to rend it and remove it. These are approximations; and it may not do to push them too closely; but it is interesting to note that 20 years make 7,300 days, and 7,300 is roughly twice 3,600. *Soil that it took at least*

3,600 years to make went off in about twice as many days.

It follows that as much topsoil as it had taken the weather a year to grind, ran off that crest every 2 days, or so, on the average; and in 20 years it was barren ground, out of production, or nearly so. This happened in a part of the country where accelerated erosion is not yet considered a serious menace.

Other Instances

On a 5-percent slope (a 5-foot fall in 100 feet, horizontally) at the western Kansas station, losses of soil and of rainfall by surface run-off have been recorded since 1930. The first 6 years' results, verified under different cropping arrangements, are fairly typical of findings throughout semiarid sections of the United States, where much of the little rain that they have comes fast, in torrential bursts.

Of rain that fell on protected native grass sod, for the entire 6 years, 99.70 percent was absorbed; only 0.30 percent ran off, taking with it only 0.029 ton of topsoil from each acre each year. But from clean-tilled kafir, 16.2 percent of the rainfall ran off, taking with it 11.74 tons of topsoil to the acre annually.

An acre-inch of soil can be figured to weigh 150 tons, on the average; so this clean-tilled land, on a gentle slope, has lost about one-thirteenth of an inch of topsoil every year. At this rate, an inch of topsoil goes out in 13 years, and 6 inches of topsoil in about 78 years. Native sod on the same slope held back 54 times more of the rainfall than did the clean-tilled kafir; and the soil loss from under the kafir was 400 times as great as the soil loss from the sodded portion of the slopes.

In the humid region of northern Missouri, Shelby loam with a 4-percent slope (4 feet of vertical fall to 100 feet, horizontally), planted to corn year after year, is found to be losing approximately an inch of topsoil every 8 years. Where the slope runs up to 8 percent (8 feet of vertical fall to 100 feet, horizontally), this same soil type, under corn often loses approximately an inch of topsoil in 2 years, and in about 16 years, if cropped to corn repeatedly, the entire 7 inches of topsoil is gone. On recently broken land in this region corn ordinarily makes upwards of 50 bushels to the acre, without fertilizer. On washed-out land the yield drops to 14 bushels or less, and the farm is likely to become a weed farm, abandoned.

These are not extreme instances of accelerated erosion in the United States. On an 8-percent slope of this same Shelby loam, near the Iowa-Missouri line, the measured loss was 19½ tons of topsoil to the acre during a single 1-inch rain. A 16-percent slope in west-central Wisconsin lost 26 tons to the acre in a 1⅘-inch rain. The severest loss of a rich soil ever recorded in this country took place in a bean-growing district of California in 1934. Farms there are remarkably rich and steep; certain of the tilled hillsides slope to 40 percent or more. Beans are planted in rows and intertilled to keep down weeds. One of these bean farms lost 500 tons to the acre—more than 3 inches of topsoil—in one cloudburst.

A 16½-percent slope planted to cotton at the erosion experiment station near Tyler, Tex., in 1936 lost 63 tons of soil per acre from a single rain in May. The adjacent grass plot lost no measurable part of its soil.

In all these States note amazing differences in rate of soil loss between land thatched and gripped by a solid vegetative cover, on the one hand, and land laid bare, or nearly bare, between crop rows, on the other. On the basis of these experiments at the erosion experiment stations W. C. Lowdermilk, Chief of the Division of Research, Soil Conservation Service, estimates:

"It would require 12,000 years to wash away 12 inches of surface soil on the Marshall silt loam of the Missouri Valley, when covered with alfalfa, or more than 100,000 years when covered by native sod; whereas it would require only 29 to 36 years to wash away 1 foot of soil when cultivated to corn on an 8 percent slope."

The United States as a whole is a land of vio-

lent climate. Over most of the country wind and rain are less inclined to caress than to slash, to strike hard, and never harder than in late spring and summer when enormous areas of our soil in cotton and corn, our great row-crop staples, lie cleanly intertilled, powdered, stirred, open to easy removal. When it comes to explaining why these States, as a whole, seem to lead the modern world in accelerated soil erosion, here is a key fact. The farmers of no other great country rip open as much of its soil, bare it, stir it, push it around with implements as vigorously as we do here in the United States. Proportionately, we *expose two and a half times as many acres to the weather in row crops as Europe does.* To state it another way: *Europe exposes only 40 percent as much of her cropland in intertilled row crops as we do;* yet summer weather in western Europe, particularly, is generally gentle weather compared with ours.

"This Mortal Coil"

Some say that only the pinch of time and need may be counted on to change our views and ways. But if simple measurements of our topsoil, taken with a foot rule over most of this country, do not mislead and if almost as simple arithmetical calculations are right, a change of views and ways cannot be safely left to time and luck. Soil troubles here in our violent climates increase so rapidly, soil losses have been so advanced by high-powered overcultivation, that we lack time.

Every tick of a clock testifies to the hard practicality of astronomical calculations. Calendars, almanacs, and other planetary compilations and timetables apply the same information usefully to human concerns. Once no American farmstead seemed complete without an almanac. The same thing might be said about a radio today. Probably this is a sign of progress, but sophistication is not to be had without losses; and there is meaning in the fact that newsstands in New York and other great metropolitan centers still sell thousands of something like the old-time farmers' almanacs to city people homesick for the soil and sun. O. Henry and other American writers have made fun of almanac addicts and their mixed, astonishing learning; but contemplation of the stars in their courses has been known for centuries to sustain in people of all callings the sense of a working relationship with earth and time. A certain amount of what might be called almanac information from modern scientific sources is pertinent to a consideration of accelerated erosion.

F. R. Moulton, an astronomer, tells, for instance, of a marvelous new instrument, the spectroscope. It "separates light into its constituent parts and enables the astronomer to determine whether or not those rays, for example, which iron radiates are being received." By this device—". . . It has been found beyond a shadow of a doubt that the sun contains in enormous quantities such familiar elements as hydrogen, helium, carbon, oxygen, sodium, calcium, iron, nickel, copper, and zinc—in fact, nearly all of the metals known on the earth except a few of the heaviest ones."

In the same book—The Nature of the World and of Man, by scientists of the University of Chicago—H. B. Lemon, a physicist, extends the finding to the universe: ". . . We find this . . . composed, with very few exceptions, of the same materials with which we are familiar in our own atmosphere and soil."

Long before there were spectroscopes men felt it in their bones, and proclaimed it—the chemical and physical oneness of star, clod, cloud, leaf, and man. ". . . the whole creation groaneth and travaileth . . . together."—St. Paul to the Romans 8: 22. "All flesh is grass."—Isaiah 40: 6. The homeless mind of Hamlet, as Shakespeare conceived him, struggles toward like conclusions. Reread, if you have the book, the soliloquies, the conversations with Horatio, the graveyard scene.

According to Bradley, a scientific modern man's greatest problem is "the nature and control of vital energy." And "Solutions," he writes, "depend on an understanding of materials and forces that are essentially the same

in roses, angleworms, and men." Chase, an engineer, and others of his calling have come to regard the body of this continent and the life upon it as a whole. So have Paul Sears, an ecologist, and many others. The half-diminished grasslands, the soiled streams, the wasted power, the fretful, waning faith in the American dream of unending abundance: these are interrelated, ailing parts of a vital mechanism, a piece of land with the beat of the weather on it, a mortal engine "out of joint."

All this suggests that when a piece of land begins to go dead, unproductive, as ours has, its ills are not separate or simple but infinitely linked. Soil, air, water, and protoplasm are all of a part. Kill forests or grass and you kill soil and water sources; or vice versa. No one trouble expresses the derangement of natural processes now plaguing this continent; no one prescription will do. That accelerated soil erosion is flicking from under us a film of sustenance which ought naturally to renew and enrich itself, presents a special but not a separate problem. Soil and water cycles interlock. Excessive erosion tends to derange the continental water system. It lowers or raises ground-water tables, dries up springs and wells, silts up rivers and harbors, kills with the grit of muddy water certain fish, or grinds away their underwater food supply; and grit stops the purr of dynamos.

In recent years drought can be counted on to provide first-page news for the American press in summer almost as certainly as floods can be counted on at other times. To a degree not determined, violent erosion speeds violent alterations of dust and flood. It has filled with lost topsoil and rendered useless in a few decades some of the major reservoirs Americans have built. If our soil keeps running at the present rate, it will fill up the new Boulder Dam in 250 years or less.

To close this chapter: Wounded farm land cannot be partitioned off and considered by various specialists with special cures as a problem exclusively agricultural. Skinned farms, gutted mines, stunted growth where great forests flourished or seas of grass were spread, offer a general and terrible exhibit of lowered national vitality. Farmers are not to be viewed from the comfort of passing parlor and pleasure cars as peculiar offenders. A headlong spoliation of soil, water resources, minerals, forests, game, fish, power, scenic, and human values in the United States has strikingly been all of a piece.

How can a people do such things to their own country—weaken its base, befoul its beauty, darken its future—how can they do such things and seem never to realize what they are doing? How can they countenance and join in a continual defacement and destruction of the body of their land?

New Land

A thousand years in Thy sight are but as yesterday when it is past, and as a watch in the night—Psalms 90:4.

In cosmic discussions scientists rule out decimal points and uneven numbers, throw out odd millions, and reduce their guesses to the sort of rough arithmetic anyone can follow on the fingers of one hand. And for all the elaborate terminology with which they disagree in designations of the untimed past when "the earth was without form or void," their varying geological "days," periods, or eras correspond remarkably, in the end, with the brief account of a pastoral prophet in the first chapter of Genesis.

Hydrologists, or students of water in action, at the California Institute of Technology recently set up on a derricklike crane a moving-picture camera equipped to do work of microscopic accuracy, shooting straight downward. Under the lens are a variety of troughs, filled with soil. The troughs may be lifted or lowered at one end to give various slopes. The purpose is to photograph and study, both in slow motion and by "time-lapse" photography (which shows imperceptible processes speeded up), the action of erosion.

Time lapse is the method by which seeds are shown to sprout, put forth stems, leaves, blossom, and even fruit, all in a few minutes, on the screen. Suppose that you want to study the germination of a corn grain in a sand box. Floodlights are fixed; and the camera is set to take automatically one exposure every 15 seconds, four a minute. At the end of an hour there are 240 exposures. Projected on the screen at the usual rate, 24 frames a second, the film shows an hour's growth in 10 seconds, and a day's growth in 240 seconds, or 4 minutes.

Of other natural phenomena which proceed slowly over longer periods—erosion, for example—it is possible at least to imagine taking one exposure an hour. Let us see how that would figure out. One exposure an hour, normally projected, will show 24 hours' or a day's erosion in a second. It follows that 10 days' erosion will be shown in 10 seconds, 60 days' erosion in 60 seconds, a year's erosion in a little more than 6 minutes, and so on. There might be practical impediments to the making of such a long record, for one, the difficulty of continuously illuminating a stretch of erodible soil; but it does no harm to think about such things.

A Camera on the Moon

Enough has been said now to indicate that it is possible to make time-lapse projections in the mind, and on paper, which go far beyond practical limits of laboratory or field practice. What we are after here is a way of projecting in terms of the clock and the calendar the vast stretch of time during which this land was in the making, in comparison with the short while that men have been living on it and doing things to it.

Suppose, then, that a time switch has been set on an imagined time-lapse moving picture camera to make it take not one shot a minute, or even one an hour, but one a year—in 24 years, 24 exposures, and so on. Projected at the normal rate, such a film would show:

24 years of change in a second.
1,440 years of change in a minute.
86,400 years of change in an hour.
2,073,600 (roughly 2 million) years in a day.
756,935,800 (roughly three-fourths of a billion) years in a year.

Suppose that such a machine, so set, has been on the moon, our satellite, or any convenient star or planet, clicking away, one shot a year,

with its lens turned straight upon our earth, for the past three-quarters of a billion years. That long ago, most geologists agree, the continents, including this one, had formed in something like their present outlines and emerged from the sea. According to Bretz, rock strata at the bottom of the Grand Canyon of the Colorado give evidence of having been washed there, and deposited, grain by grain, at least 700 million years ago.

And now suppose that this time-lapse film is somehow brought to earth for showing in some great hall or planetarium. It will take a full year to show the picture. That is long; but it reenacts the events of 756,864,000 years. Projection starts at midnight on January 1 of a leap year. The film runs day and night without pause or intermission until midnight of December 31, following.

While our scale of time minimization is tremendous, showing everything happening some 757 million times as fast as it actually happened, land in great masses has been made and moved so gradually that little or nothing essential to the record is blurred.

The picture though it soon becomes repetitious is fairly lively at first. The earth writhes and heaves as if in monstrous labor, with no green or living thing in view. Shore lines change. Mountains and uplands rear, sometimes abruptly, sometimes so gradually that rivers upon them hold their general courses and cut down into the land no faster than the land is being raised. But always the land seeks the sea, and always the finer sediments, passing farthest out, lay, on the whole, a heavier weight on the ocean bed than on the coarser continental platforms and their rimming, buried plains or shelves.

Sea Shells on Mountaintops

Beneath the sea the debris of the continents is compressed into sedimentary beds that eventually become rock or compact strata. As time goes on these rocks embrace and preserve sea shells and other skeletons of marine animals, now to be found in delicate traceries in the rocks of our loftiest mountain tops. Sedimentary rocks underlie seven-eighths of the United States today.

Uplift, erosion, deposition; uplift, erosion, deposition. Sea bottom and land masses, pressed into rock strata, strained and tilted, are reared in a rough, uneven seesaw manner to mountains and plains and valleys. The continents repeatedly are crumpled and peaked as cloth is when pushed in from the sides, and then the weather scrubs them down.

Titanic weights are redistributed on earth. New land forms rise, with internal disturbances. Sometimes molten material jets up between sedimented, water-laid rocks, or flows out over the face of the earth as lava, and cooling, forms igneous rocks. The palisades of the Hudson, the San Francisco peaks of Arizona, the Coast Range batholith of British Columbia and Alaska, the vast lava flow of our Northwestern States, thus are formed; but most of North America is made of rocks that grew under water, uplifted, faulted, tilted, and ground into soil.

Day and night the picture grinds on. All through January, February, March. Now the story has advanced to 568 million years ago. On it grinds, day and night, through April, May, June. Every day of the showing advances the story 2 million years; but it is a long, slow picture just the same.

It is not until the second quarter of the showing has ended, on July 1, with the story carried forward to within 360 million years ago, that recognizable forms of vegetation appear, and dying, are taken with primitive animal forms into the skin of earth to form new life.

Balance

Here is an important change. Until now the picture has shown earth naked. Mountains have run like heaps of butter in the sun. Now the earth puts on verdure and is clad. Soils

A GLACIER MOVES; VEGETATION FOLLOWS.

TIME BUILDS SOIL.

Profile of a virgin field in North Dakota.

replace sterile ground-up mineral debris. Organic matter packed as time goes on into soils enables them to receive and hold more water. Run-off and erosion moderate. Vegetation assumes forms more and more recognizable. It develops root systems which clasp in an infinite protective tangle the soil they feed upon and hold on to it for dear life. As soil is thus grasped and held by natural cover we see the headlong vigor of erosion checked. The surface of earth tends to settle down, to become stabilized. Soil movements are reduced to a creep; and new soil forms in most places as fast as old soil creeps away. This is what Lowdermilk calls "the geological norm of erosion," achieved under natural circumstances; and a natural functioning of eternal balance shows throughout the remainder of our picture, up to the last 2 or 3 minutes, when civilized man strides upon the scene.

In 1874 George P. Marsh wrote: "Nature has provided against the absolute destruction of any of her elementary matter, the raw material of her works . . . but she has left it within the power of man irreparably to derange the combinations of inorganic matter and organic life, which through the night of aeons she had been proportioning and balancing to prepare the earth for his habitation . . ."

On with the second half of the picture: Balance is established. Life multiplies on the face of the earth and assumes more intricate forms. The picture begins to take on variety. In July, limbless vertebrates appear in the water. By August (some 300 million years ago) amphibians have come ashore. On grinds the film into the autumn months, reeling off its 2 million years daily. In September we see the first reptiles and primitive insects. At about the same time, some 250 million years in the past, the sea again creeps over the greater part of North America, and retreating, lays under vegetated swamps enormous deposits of carbonized vegetation, now mined in Pennsylvania and elsewhere as coal.

October brings on the dinosaurs and the first mammals. By mid-October birds and flying reptiles appear. Early in November with the story getting along toward only 100 million years from the present time, the dinosaurs degenerate and disappear, and mammals dominate the earthy scene.

The film comes now to December, the last month of its showing, with the story of 62 million years still to be shown. Erosion and mountain making proceed at a more balanced rate. The Himalayas, the Alps, the Rockies, the Andes, and other great ranges are always losing ground; yet under compensating, gradual upheavals they are made, remade, or rejuvenated. Vegetation grips the land. The continents, on the whole, stand higher than at any previous period; and the life upon them works, with marvels of natural adaptation to specialized needs and functions, toward higher forms.

Man

Man first comes into the picture around noon of December 31, a million years in the past. If "dawn stones" are to be taken seriously, they indicate that by this time man was a tool-making animal. Harried and driven over the face of the earth by glaciers and by sweeping climatic changes, primitive man had a hard time of it, and seems to have succeeded in rearing only enough of his kind sparsely to perpetuate the race. For the better part of a million years, until the last few minutes of the picture, marching ice in mountainous masses has pretty much of its way with this world, and with the European and North American Continents especially. About one-fifth of all the land in the world is buried under glaciers like those of the Arctic. They cover 4 million square miles of this continent, the northern half. They override and plane down mountains. They gouge out new valleys. Four times they march on this land, plowing a gigantic tonnage of northern soil before them, churning soils into those heterogeneous mixtures found today in our great glaciated regions, and depositing alluvial patches

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of more nearly sorted soil as they melt and retreat. The last of the great invading glaciers retreats from our land as little, perhaps, as 20,000 years ago. In the last quarter hour of our time film we may see them going.

The final 5 minutes of the picture are projected at the same rate, 1,440 years a minute, which has been used ever since the film started running, almost a year ago. At 11:55, we see the world 7,200 years ago, or at 5264 B. C. At 11:56, events have advanced to 3824 B. C.; at 11:57, to 2384 B. C.; at 11:58, to 944 B. C.; at 11:59, A. D. 496. The last minute of the film ticks off everything that has happened from A. D. 496 to date.

Civilized man—farming, driving herd, making war for wider lands and greener pastures; trading, rearing cities, forever devising new engines and measures, agricultural and industrial, for the earth's conquest—shoulders his way into our picture only in the last 2 or 3 minutes of its run. At 11:56 (3264 B. C.) man is scattered, nomadic, and not populous. By 11:57 (2384 B. C.) advanced specimens on alluvial soils of extraordinary richness have clustered and formed in Asia.

Europe was the ancient West of crowded populations migrating in great numbers; North America was next. Asiatic progenitors of the American Indian are said to have come upon this continent from the west via Bering Straits or perhaps across a land bridge or by raft. But the main tide from Asian cradles of civilization seems to have swept from east to west, first along the shores of the Mediterranean to western Europe; then (after intensive refinements centering in the Mediterranean Basin, and extending throughout Europe, with consequent overcrowding, a certain amount of soil depletion, and a marked decline of opportunity for the ordinary man) the western tide of civilization swept on to this new shore.

Viewed, however briefly, against the long dark span of geological time, all that civilized man (as opposed to the simple Indian) has gained from and done to this new land is startling. The time scale of our film crowds all that we have done into the last few seconds of a year's record. Recall the scale: 1,440 years to the minute, 24 years to the second. The time of civilized man the world over is somewhere between 3 and 4 minutes. The time of American civilization, in these terms, is less than 20 seconds.

Last Part of a Minute

At the rate of 24 years to a second the picture clicks to a close: The first 20 seconds of the film's last minute show the world from A. D. 496 to 952. Barbarian hordes overrun Europe, and are thrown back or assimilated. The Crusades are launched and ended. Boats of the Norsemen and others explore the seas. At the forty-first second (1492) Columbus touches North America, and venturing ships of Spain, England, the Netherlands, then of all Europe follow. At the forty-sixth second (1606) Jamestown is founded; by the fiftieth second (1706) our eastern shore is dotted with settlements, and pioneers are beginning to enter the wilderness and press the Indians back. At the fifty-third second (1776) we fight the British and at the fifty-fifth second (1812) fight them again.

Even this late in the story, with the film only 4 or 5 seconds from its ending, most of the United States still stretches westward, a virgin land, largely untaken, its forests and grassland and prairie unbroken, undeveloped. "In 1790," writes Frank Ernest Hill, in What is American?, "the flood of Americans hung on the western rim of the Alleghenies." He continues:

"Then the human tide broke. It descended and rolled westward, to the north and south alike. Twenty-five years and it had touched the Mississippi. Twenty-five more and two long ribbons of it were thrust across the plains beyond, split this way and that, licked upward through mountain valleys to the north, jetted straight across mountain walls at the center, curled over deserts to the south. So it reached the Pacific . . . Forests went down before its waves; black furrows of farmland spread where their tangled shade had waved. Indians were

pushed aside or engulfed. Prairie grass five feet high shot into cornstalks three feet higher. A thousand towns lifted their more than five million chimneys . . . When in 1890 the Census Bureau announced that free land was practically gone, the Frontier officially ended . . . In a hundred years half an almost empty continent had been filled by fifty million men and women . . .

"Sunless forest, boatmen's song on broad river, sky black with pigeons or plain with buffalo, slug of ax by clearing, howling savages and shrieks of murdered women, cornfield and paintless town that grew as if enraged—this was a physical pageant almost as fantastic as the crusades."

Thus, in a little more than a hundred years—4 or 5 seconds at this showing—the United States is transformed from a pastoral or rural haven to the greatest industrial and commercial power in the world. There has been no comparable transformation in the history of earth or man.

The Land As We Found It

"Always the land was of the same beauty," Columbus wrote, in a prospectus, while returning to report to the court of Spain. He continued: "and the fields [were] very green and full of an infinity of fruits as red as scarlet, and everywhere there was the perfume of flowers, and the singing of birds, very sweet." Even the pigeons, he wrote, "had their crops full of flowers which smelt sweeter than orange blossoms." . . . And: "In all these regions gold is found among the roots of trees, along the banks and among the rocks and stones left by torrents."

The history of North America in its present era of white occupation started as a gold rush. It became a soil rush as soon as the English gained ascendency. The Spaniards sought gold and slaves and converts and fabulous lost cities. The French pioneers were pre-eminently trappers and traders, not farmers. "Are you ignorant," Duquesne demanded of the Iroquois, "of the difference between the King of England and the King of France? See the forts that our king has established. You can still hunt under their very walls . . . The English, on the contrary, are no sooner in possession of a place than the game is driven off. The forest falls before them as they advance and the soil is laid bare."

In the old countries of Europe times were hard. Economic pressure and class distinction reduced able and ambitious people to humble situations and insecurity. A land of the free where a man could stand up again, make his own way, look the world in the eye, became a need not only material, but spiritual. The pressure of religious persecution served to heighten spiritual impulses to live and worship in freedom, and served to sanctify the right of man to earthroom in a brave New World. As for property rights, the Indians seemed to have practically no sense of property or its responsibilites. According to Erl Bates, a Quaker historian of the Iroquois, their first recorded words to the invading whites were: "Welcome! The Great Spirit made a big country. We are all children of the Great Spirit. There is room here for all."

At the end of the sixteenth century, a hundred years or so after Columbus, all of the United States was still the West; and Europe was western mad. In England especially the idea of a New World, boundless space, boundless wealth, beyond the Atlantic became the constant theme of writers and a fad of the people. Drayton scorned "loy'tring hinds who lurk at home with shame," and described Virginia, which he had never seen, as blessed with "the fruitfullest soil on earth." With the Crown pushing expansion, the poets of England piped a tune remarkably resembling some of the loftier compositions of modern realtors. Indians brought as captives to England drew squirming crowds. Virginia Farrar, a lady enthusiast for American colonization, produced in London a map of the new land which put the Pacific just over the Alleghenies. That was a general persuasion. The search for the western passage to India still was on. Not until 300 years after Columbus was the whole country, or even the entire coast line, to be known and mapped with any certainty.

The story of our western surge across this continent has been often told. The purpose here is not to retrace the march of occupation in detail, but only to sketch the original worth of the soil taken and the situation now.

Lowdermilk writes:

"By one of the most remarkable facts of history, the North American continent, as well as South America, was isolated from the Old World during the long and tedious rise of its civilizations and was preserved in pristine beauty and fecundity, awaiting the establishment of new nations and a new civilization." He describes this land as it lay, awaiting occupation—3,000 miles from east to west, and from the frozen wastes of the Arctic to the luxurious forests of the Tropics, some 1,200 miles, up and down. A land of 1,903,216,640 acres covered with primeval forests and nearly a third of the area with broad expanses of grasslands across which roamed herds of buffalo and antelope. "Absolute desert," Lowdermilk estimates, "spread over only 2.5 percent of the area." He continues:

"Streams, abundant in fish, bore oceanward the residue of precipitation waters that flowed gently from drainages of unbroken stands of vegetation. Such streams ran clear except in floods, when channel and bank erosion furnished the major burden of silt. Channel cutting and bank erosion generated soil creep down vegetated slopes and, supplemented by solution, served to sculpture and wear down the land with the leisure of geologic processes.

"Where, however, comparatively rapid differential land uplift had occurred, or within climatic zones too rigorous or too arid to support a complete coverage of vegetation, storm waters swept from unprotected surfaces substantial quantities of erosional debris into drainage streams. Processes of erosion proceeded in these instances at more rapid rates than elsewhere throughout the land. Streams such as the Missouri and the Colorado ran muddy throughout most of the year. The vast extent of soils suited to agriculture, however, had with few exceptions been built up under unbroken mantles of forest, woodland or grass."

Harvest of Fish and Fur

Nameless fishermen—Scandinavians, Portuguese, French, and English—knew the far northern Atlantic shore of this continent long before Columbus made his reconnaissance to the south. Catholic Europe required great stores of fish. Fishermen, then as now, kept their mouths shut about the best places. Cabot, exploring for the English in 1497, discovered fishermen's secrets and gave them wide currency in his letter of report. Our northeastern waters, he said, were "swarming with fish that can be taken not only in the net, but in baskets let down with a stone." In 1534 Cartier, exploring for the French, made similar announcement.

With the courses charted, many more fishing boats came. The first harvests of the Atlantic shore were taken in shoal water; then hunters and trappers pressed into the wilderness. "Fish and furres was then our refuge," wrote Captain John Smith, of the first frightful years at Jamestown. Within 5 years, however, the Virginians had turned principally to clearing land and to planting tobacco under a one-crop, clean-culture plan that ever since has been removing American topsoil and converting its soluble constituents into smoke and ashes the world over.

The heaviest initial killing, to the north, ashore, was not of topsoil or of woodland, but of wildlife. Among the fashionables, male and female, of seventeenth-century Europe, marten fur and beaver hats were in brisk demand. "Fishermen became fur traders, the fur trade led to settlement, and the settlements during their first generation were saved from economic extinction by their exports of furs," writes J. B. Brebner, in his Explorers of North America, a book made mainly from the accounts of the explorers and first settlers. He quotes Governor Bradford of Plymouth: "There was no other means to procure the food (we) so much needed, and cloaths also." The Appalachians held the New England fur traffic within a fairly narrow

shelf of exploitation. Less navigable rivers to the south did the same. But far inreaching watercourses of Canada led French hunters and traders to the heart of the continent. "Thus," says Brebner, "the hat-makers of Europe were transformed into the prime movers of an exchange in America which sucked into the interior the men who followed the ever-retreating 'beaver frontier' across the continent."

Death of the Trees

The line of frontier farming was pushed inland a little more slowly. Before farms could be established, there had to be a tremendous killing of trees. Greater than anywhere else in the temperate zones of the world, the virgin forests of North America covered nearly half of the continent. The redwood and the sequoia, the black walnut and the sugar maple, the tuliptree and the sassafras, the magnolia and the tamarack, the Osage-orange, the locust and the hickory, were new trees to the white settlers. Oak and elms were more familiar forms. If the familiar definition of a weed—a plant out of place—be accepted, most of the trees, from the standpoint of farm-minded frontiersmen, scratching for a living, were weeds. Beautiful or not, that forest wall was a barrier of mainly useless plants opposing the march of the plow. "To the pioneer," remarks Frederick Jackson Turner of Wisconsin, a historian who understood frontier farming and its rude compulsions, "the forest was no friendly resource for posterity, no object of careful economy." In his classic, The Frontier in American History, Turner continues:

"He [the pioneer] must wage a hand-to-hand war upon it [woodland], cutting and burning a little space to let in the light upon a dozen acres of hard-won soil, and year after year expanding the clearing into new woodlands against the stubborn resistance of primeval trunks and matted roots. He made war against the rank fertility of the soil. While new worlds of virgin land lay over just beyond, it was idle to expect the pioneer to stay his hand and turn to scientific farming. Indeed, as Secretary of Agriculture Wilson has said, the pioneer would, in that case, have raised wheat that no one wanted to eat, corn to store on the farm, and cotton not worth the picking."

The settler who loved trees had to kill and burn them, notwithstanding. "Root, hog, or die!" Or root, hog *and* die. Scorn of pioneer prodigality may be somewhat tempered by the fact that hardship and illness killed half of the hundred men and women of Plymouth Colony during the first winter after they landed. And by 1625 in Virginia only 1,095 white persons were living, and more than 4,500 had died.

With a tobacco trade established in the coastal South, things went better there. Tobacco was a crop native to this soil. Taken up by the courtly Raleigh and others, it aroused a fad, then a habitual market overseas, and proved a godsend to the struggling colonists. A mixed godsend; for tobacco is not easy or pleasant to grow, and it draws hard on soil. It may reasonably be imagined that most of the Virginia and Maryland colonists who planted tobacco on their clearings did not want to do so. Even smokers who grow it find it a hard crop to love. But if there is a demanding market for tobacco, and your region becomes a tobacco region, you grow it. You have little or no choice. "Root, hog, or die!"

Economic and ecologic circumstances have combined and clashed in the past to lay out the great crop belts of this country, and to stretch and shift them constantly. The man in the woods, and the man on the land, seem generally, in the light of the record, to have had little choice or sway as to systems and methods. "Root, hog, or die!" is a saying born in backwoods clearings. "Fight your own battles and kill your own snakes" is another, implying sturdy independence and freedom. But freedom of choice as to agricultural and forestry systems and ways proves upon examination to have been largely illusory. The lines of the battle, the weapons, and the immediate strategy were largely imposed by circumstances.

It is estimated that nine-tenths of the original timber stand in the United States was stricken down, or burned, or both, during the march of occupation. By this accounting, only a tenth of the virgin timber remains standing; all other woodland is replacement growth. The total of woodland and woodland pasture in the country runs now to some 615 million acres. Ferdinand Silcox, Chief of the Forest Service, says: "When we settled this country we had approximately 800 million acres of forest land. We have opened up a lot of it for farms. Now . . . land in the Cumberland and in the Piedmont regions of the Carolinas, which has been cultivated and has proved to be rather poor agricultural land is reverting to forests, going back."

Across the South, particularly along the line of the march of tobacco and cotton, are millions of acres of second-growth pine. Much of this piney-woods land still is burned over each spring. The flames freshen the grass, the woods farmers say, and kill rattlers. Oklahoma experiments of the Soil Conservation Service show that 30 times as much rain and 11 times as much soil runs off a burned forest floor as runs off an adjacent forest floor which has not been burned. The Forest Service estimates that 40 million acres of State and private land in the United States are still burned over every year.

The pioneers had little use or market outlet for all that magnificent timber they toiled to fell. They needed some wood, of course, for their habitations, fences, palisades, and fires. Later they had some need of wood for shipbuilding, in places; and of wood products, charcoal and potash, for developing industries. But wood was not their main need. Their main need was space to farm. So down came the wilderness and the greater part of it was offered up in smoke, a vast initial sacrifice to progress. This sacrifice was accomplished with an incredible speed and energy. The electrical violence and swift changes of our climate seem to have entered into the veins of these new inhabitants. Hardship, greed, and wonder made them heedless of discomfort, cruelty, and danger; and they performed miracles of back-breaking toil and plunder.

Harvest of Soil

A slashing pioneer rotation—virgin woodland, wasteland, second-growth woodland, often scrubby—wrought a sorrowful transformation on the coastal plain and foothills, and then on the wooded slopes of the Appalachians, as the march on the soil moved west. In Soil Defense in the Piedmont (Farmers' Bulletin 1767), E. M. Rowalt writes:

"When men came to the Piedmont to farm less than two centuries ago, they settled near the streams . . .". These streams flowed clear and quietly; the upland forests were quite different from the forests of the southern Piedmont today. The principal trees of the uplands were oak, hickory, and chestnut. Trees were large and spaced so widely apart that wagons could pass easily between them. There was little underbrush in the woods; the forest floor was a carpet of grass and peavine. There was plenty of wild turkey, deer, and partridge for the hunting, and wild fruit everywhere.

The original forests of the Piedmont have disappeared, to be replaced in part by patches of scrubby oak and underbrush, or by shortleaf pine, and many of the fertile bottom lands have been covered by an overwash of sterile sand and gravel.

"In pioneer times sandy loams were the dominant soil types in the Piedmont. They lay over the region to a depth of 7 to 15 inches. Held in place by the binding roots of plants, and covered and protected by an absorbent layer of decaying vegetable matter, these soils lay where they had formed from the ancient crystalline rocks which underlie most of the Piedmont Plateau. Nature had worked, in her patient, unhurried way, for thousands of years to form these loamy topsoils. Here and there, in small patches of virgin forest and in level places not subject to excessive soil washing, these loamy soils may still be seen . . . on many slopes that had been cultivated long enough for the stumps to disappear . . . the

ROOT, HOG, OR DIE.

Trees to the settler were weeds and enemies
to be fought with ax and fire.

ROOT, HOG, AND DIE.

Pioneers asked no mercy and received none
in the battle with nature.

original soil . . . had been removed down to, or near to . . . the red clay, by erosion.

Forty Souls to the Section

American antiquarians figure that there must have been somewhere between half a million and a million Indians here in the North America the white man found. In white hands, the United States has been made to support a population of 127,500,000, or about 40 to the square mile. That is close to the world average. But parts of the Nile Valley are being made to support 1,000 persons to the square mile. Each square mile of China, counting in all the washed-out land and the deserts and mountains, supports 299. Germany supports 364 to the square mile; the Netherlands, 659; Belgium, 701; England and Wales, 685. These are estimates of Raymond Pearl of Johns Hopkins University, writing in The Yale Review. Of the world at large he writes:

"Forty persons for every square mile of land in the world, good land, poor land, and utterly impossible land, is a sobering thought if really grasped . . . upwards of 2,074 millions of human beings are right now [in the spring of 1936] struggling, with such powers as within them lie, and by such methods as they can devise, to get a living on this inexpansible earth. Many are making heavy weather of it."

A square mile of land, as western Americans know, is a section, or 640 acres. Forty persons to a section, the world average, equals 10 persons to a quarter section, 160 acres; or 16 acres of land apiece. This may seem earth room and elbowroom enough for all, until you break down the figures and try to get at the amount of yielding soil (apart from the polar caps, the mountaintops, the deserts, the swamps, jungles, all the waste places of sterile soil or forbidding climate and the area occupied by the habitations and works of man) on the face of the earth.

To do this requires estimations admittedly bold and rough. Attempting some 10 years ago to compile a table, Arable Land on Earth, as distinguished from land in general, O. E. Baker of our Department of Agriculture was led to reflect that astronomers on this planet can be more accurate, at present, than economic geographers. Astronomers announce to the last decimal place the mass and density of other planets; but the apparently unique soil supply by which we live on this one has so recently become an object of concern and measurement that men do well to guess within a million square miles of its usable extent.

A million square miles is more than four times the area of France, or about three and a half times the area of Texas. If every dagger (†) in the following type chart is taken to represent a million square miles of the earth's surface, the proportions of ocean area, all land, and our land appear as follows:

SEA ††††††††††††††††††††††††††††
††††††††††††††††††††††††††††
††††††††††††††††††††††††††††
††††††††††††††††††††††††††††
††††††††††††††††††††††††††††
—(139 million square miles)

LAND ††††††††††††††††††††††††††††
††††††††††††††††††††††††††††
††
—(58 million square miles).

U.S.A. †††
—(3 million square miles).

Land is scarce. Usable soil is even scarcer. Baker figures that 52 of earth's 58 million square miles of land lie out from under the polar caps. Climatic factors make 22 of that 52 million square miles plainly unfit for crops, with a large additional area of dubious use. That whittles the 52 million down to 30 million, and requires a guess as to how much of this 30 million square miles of earth might be made ultimately arable under need. He guesses one-third: 10 million square miles, about half of it in the temperate zones, and half in the Tropics.

Now, of the 2,900,000 square miles in the Continental United States, Bennett figures that certainly no more than 953,125 square miles (or 610 million acres), can ever be farmed, even under the utmost pressure. Call it a million

square miles; and the proportions of all land, land agriculturally usable, and *our* share, stand roughly thus:

ALL THE LAND IN THE WORLD
(Exclusive of the Polar Caps)
††††††††††††††††††††††††††††††††††
††††††††††††††††††
—(52 million square miles).

ULTIMATELY ARABLE
††††††††††
—(10 million square miles).

OUR SHARE
†
—(1 million square miles).

Fading Hopes

No one who talks or corresponds with a considerable number of American farmers nowadays can fail to detect a widespread restlessness under physical restrictions relatively new in our history, a cramped feeling, a sense of being denied earth room and an equal chance. Land hunger seems as keen as ever; but relatively little rewarding soil remains easily accessible for it to feed upon.

Gone are the days when our settlers could say, "When you see the smoke of your neighbor's chimney, it's time to move." And sing

Come along; make no delay;
Come from every nation, every way.
Our lands are rich and broad enough.
Don't be alarmed,
For Uncle Sam is rich enough
To give us all a farm!

Parts of the Nile Valley support 1,000, not merely 40, persons to the square mile. But American standards are keyed to a different stride and aim. To the peoples of old, or elderly lands, for centuries accustomed to overcrowding and mass penury, the amount of usable American soil per capita and the degree of opportunity still open to those who want to farm it may seem miraculous. But recognized limits to our soil supply are a new thing in the United States; we chafe under them; we fear and dislike them; and there is reason that we should. For it may be said without exaggeration that after only a few centuries of occupation, with a population relatively sparse in most places, and with prospect of a stationary population by 1950, the people of the United States have already (in the light of their traditional attitudes and expectations) felt a shortage of soil.

It is not yet a physical shortage in terms of produce. As worn and hurt as much of it is, our farm land still produces in a normal year more than we can eat or wear—or pay for—and find paying markets for abroad. If greater harvests seemed to pay, at the moment, American soil could still be whipped or coaxed to roll them forth. But American soil has always meant far more than that to us and to the world. It is not so much of grain and meat that we think when that phrase, "American soil" rings forth, as of a new hope on earth; and it was of this "ultimate crop" that Henry A. Wallace was thinking when, in a recent address he said:

"This country is older now. All of the good land has been taken, and much of it has been worn down. We begin to feel some of the internal pressures which have pinched older nations for many centuries; and the problem of maintaining and governing democratically a land of the free becomes more complicated and challenging. It is perhaps no chance coincidence that Share the Wealth agitations should arise and spread at this time, when we have no longer rich new frontiers to scramble to, when we are just discovering that the United States is not, after all, to remain eternally a place of inexhaustible natural wealth and freebooter opportunity.

"In no spread-eagle sense of the word, but in plain truth, liberty and equality are a natural growth of this soil. If it keeps washing and wearing thinner, what of the ultimate crop? . . . Having played high, wide and handsome with all

our resources, and having in addition lost world trade, we feel the pinch; and an increasing discontent with our modern "relief" equivalents for a piece of land and an equal chance for every one, is widely evident. It would be, of course, a fanatic view to lay all present perplexities to a lack of wise land use and conservation. Our man-made wastelands are only one symptom of the trouble, but an important symptom, for in good times and bad, for all time, the soil is the basic resource.'

"*Decadence*," "*Earth Disease*"

"Soil decadence," said Jacob G. Lipman, president of the Association of Land Grant Colleges, addressing the Farm Chemurgic Council in 1936, "is usually followed by social and political decadence . . . Land wastage in China has found expression in extensive areas of bad lands and in periodic droughts on the one hand, and in destructive floods, on the other. The low yields of cereals in Poland, European Russia, the Balkan countries and the Near East," Dr. Lipman continued, "find their counterpart in the meagre harvests of many areas in South and Central America and even of our own Southeast . . . the effect of soil mining, reinforced by erosion and leaching, is certain to be felt in lower yields and in changed landscapes."

Leached plant food is the part that percolates down through the soil and is lost by way of underground waters. Plant food lost by erosion runs off above ground, on the surface. Erosion is taking more fertility—both in terms of organic matter and of mineral elements—than crops are taking from American soil year by year. Of mineral losses (nitrogen, phosphorus, potash, calcium, magnesium, and sulphur) crops and grazing take off a total of 19,500,000 tons a year, while erosion and leaching whisk away nearly 117,000,000 tons. *The major distinction between erosion and leaching is that erosion removes not only plant food, but the body of the soil itself.* At least 3 billion tons of solid soil materials are washed out of the fields and pastures of the United States each year by water erosion alone. It has been figured that to move such a bulk of American soil on rails would take a train of freight cars 475,000 miles long—long enough to girdle the planet 18 times at the Equator.

Lipman continues: ". . . Serious as is the quantitative phase of soil decadence there is often the no less serious condition of qualitative deterioration. So-called *deficiency diseases* of plants are rather common. Insufficient amounts in the soil of magnesium, manganese, boron, zinc, copper and of other plant nutrients lead to stunted growth and other abnormalities. Not infrequently plant deficiencies give rise to animal deficiencies. We know, for instance, that in some localities in Australia, Africa, and our own Northwest animals wander about the plains looking for bones in order that they might satisfy their craving for phosphorus. Abnormalities in growth and development may arise for lack of calcium, phosphorus, and iodine in the soil. Too large a proportion of undersized animals and humans may occur in some regions because of mineral deficiencies in their food or because of an inadequate supply of food. This may be illustrated by the experience of some of the European nations in the World War.

"For instance, the Rural Report of the [England's] Liberal Land Committee, 1923–1925, contains the following statement: 'The English Army, drawn from a population eighty per cent urban, had a disquietingly high percentage of rejections. Our nation had, it is said, a higher percentage of men unfit for military service than either our opponents or our allies . . . Now (1925) five out of every eight would-be Army recruits are being rejected. Before the war the Navy rejected 30,000 boys to get 5,000 future sailors."

Nitrogen, phosphorus, potash, and calcium are the constituents of most commercial fertilizers and soil conditioners that American farmers buy. The drain on soluble phosphates by escaping waters has already become crucial in the United States. All these plant foods enter as vitally into the making of a sound soil as they

do into the making of a sound livestock and healthy people; but the wash-out of phosphates is especially serious. Bushrod Allin gives four reasons for this:

"1. For most soils phosphorous deficiency imposes a greater limitation than the deficiency of any other mineral element. (2) In relation to need world supplies of recoverable phosphorus are more limited than those of other important soil minerals. (3) A greater proportion of existing phosphorous supplies in the soil is lost by erosion than in the case of any other mineral element. (4) Phosphorus must be applied to many eroded and depleted soils in order to grow legumes which are the best growths for checking further erosion and restoring humus and nitrogen requirements."

The National Resources Board reports, disclosing in a sweeping, initial estimate of what has been given us in this country, and what we have done with it, as follows: "There has been no notable increase in crop yields (on this soil) for several decades . . . a planless, crazy-quilt pattern of land use which has destroyed or impaired a large proportion of the Nation's irreplaceable resources, and wrecked the hopes, aspirations, and the very lives of untold thousands of people."

The first report of 1934, and the supplementary issue, Soil Erosion, in 1936, show that when "a soil runs down," as the saying goes, farmers are not the only sufferers.

That idea is spreading. For instance, after a recent disastrous flood at Cincinnati, a farm-bred shop girl, helping to clean the store and open up again afterwards, wept not so much for all the stained merchandise as to see "so many good, rich farms" swept and flushed by the blasts of fire hose down the sewer.

It is true that a whole country suffers when the soil runs down; and, in the end, it suffers far more than passing crises of swollen floods and buried farms impeding navigation downstream, if the soil keeps running down, more and more. Appearing in March 1936 before a Senate committee, Morris L. Cooke, an engineer, then in charge of the Water Section of the Resources Board's report, said:

"We have been trying to get the water off the land, into the big rivers, and out of the way. We've got to hold it on the fields, or wherever it falls, and do it quickly, if disastrous floods, dust storms, and other calamities are to be stopped. . . .

"Our country is afflicted with earth disease. We are like a man well gone with cancer or tuberculosis . . . As the matter now stands, and with continuance of the manner in which the soil is now being squandered, this country of ours has less than one hundred years of virile national existence. If that represents a reasonably accurate statement, it is vastly more significant that we have probably less than twenty years in which to build up the technique, to recruit the fighting personnel, and most difficult of all, to change the attitude of millions of people who hold that ownership of land carries with it the right to mistreat and even to destroy their land, regardless of the effect on the total national state."

Check-up

If the entire 1,903,000 square miles (or 640-acre sections) of the continental United States were laid out as if it were a 100-acre farm, there would be 19 acres of tilled fields, 37 acres of pasture land, some 32 acres of woodland, about half of it pastured, and some 11 acres given over to wasteland, roads, and buildings.

This, of course, is the same as saying that 19 percent of our land is plowed, etc. The proportions:

Plowland †††††††††††††††††† —(19 percent)

Pasture †††††††††††††††††††††††† ††††††††††††† —(37 percent)

Woodland ††††††††††††††††††††††† ††††††††† —(32 percent)

Other uses †††††††††††
—(11 percent)

Less than a fifth of our land, then, is under the plow; yet a little more than half of it is in farms. Woodland, in farm wood lots or in greater stretches both publicly and privately owned, still occupies a third of our land surface. The report of the National Resources Board (1934) from which these figures are drawn, distinguishes between farmland, including pastures, woods, etc., on the one hand, and range land and forests, publicly and privately owned, on the other. Throughout the report the Board speaks of land not in square miles, but in acres. A square mile is 640 acres. In all the United States has 1,903 million (nearly 2 billion) acres within its continental borders. The Board figures that 974 million acres (51 percent) is in farms—plowland, pasture, wood lots, farmyards, lanes, waste, and fallow—that 163 million acres is in public forests and 294 million acres in private forests; that 329 million acres is range, two-thirds of it publicly owned; and that the remaining 131 million acres of our country are taken up by deserts, cities, towns, roads, parks, and waste land.

On the basis of these figures, Bennett estimates that the United States has 610 million acres either tilled or tillable. On the basis of early returns from this country's first erosion reconnaissance survey started by the Soil Conservation Service in 1934, Bennett adds:

"*Approximately 50 million acres of once fertile land in this country has been essentially ruined for practical cultivation by erosion. Another 50 million acres are in a condition almost as serious.*

"*About 100 million acres still in cultivation has been seriously impoverished by loss of soil; and about 100 million acres more of cultivated land are being depleted of productive soil at an alarming rate.*"

A hundred million acres is as much land as there is in all of Illinois, Ohio, North Carolina, and Maryland, together. It is enough land to provide 1,250,000 families with 80-acre farms. And, as nearly as can be figured from present data, 200 million acres more of American soil (2,500,000 such 80-acre farms), are rapidly passing toward the seriously impoverished or waste land classification, because of accelerated erosion each year.

First Wests

Our lands, as I mentioned in my first letter . . . were originally very good; but use and abuse have made them quite otherwise . . . We ruin the lands that are already cleared, and either cut down more wood, if we have it, or emigrate into the Western country.—George Washington.

The first American West was anywhere a mile or so back from the Atlantic coast. For 300 years it was anywhere on toward the sunset, "back of beyond." Thin and hard, with cool and lovely hills and valleys to be taken only by patient husbandry, New England turned a forbidding face against the rushing sort of easy, one-crop come-and-go exploitation to which the more opulent tidewater soils of Virginia lay open almost at once. Thrown into a picture of cartoonlike simplicity with all exceptions out, we see New Englanders as their soil made them, spare, tight-lipped, cautious, pushing west on small holdings along the lake shores to Ohio's New England Reserve, then to Kansas, a broader New England, and on. Across the more lusty South at a more galloping stride one-crop dominions extend themselves; and one-crop concepts rule.

Our Northeast had its troubles, too, when the great West opened, and the greater product of fresher lands came flooding eastward. There are many abandoned farms in New England, slowly healing under grass and thicket; but nothing to compare in extent and horror with the man-made waste lands in parts of Virginia, Kentucky, the Carolinas, Georgia, Tennessee, Alabama, Mississippi, Texas, Oklahoma, Ohio, Indiana, and Missouri. The parts of this continent that have lasted best, in general, are those on which the first explorers made dubious report.

Primitive New England at the time of its settlement must have been a land to lift the heart; but the general tone of first reports bespoke a calculating glance and determination, rather than rapture. The country bore, Governor Bradford said, "a wild and savage hiew" More soft and slumberous shores to the South aroused in the accounts of nearly all the early navigators and explorers (however matter of fact their style), a sense of mild enchantment, an Arcadian note. Hear John Smith, writing of his Sixt Voyage to Another Part of Virginia, Where Now are Planted our English Colonies Whom God Increase and Preserve:

"There is but one entrance by Sea into this Country, and that is at the mouth of a very goodly bay, 18 or 20 myles wide . . . Within is a country that may have the prerogative over the most pleasant places knowne, for large and navigable rivers. Heaven and earth never agreed better to frame a place for man's habitation, were it fully manured and inhabited by industrious people. . . .

"The Country is not mountainenous, nor yet low, but such pleasant plain hills, and fertile valleys, one prettily crossing another, and watered so conveniently with fresh brooks and streams, no less commodious than delightsome . . ."

Explorers of the coastal shelf and Appalachian slope; nameless hunters, herdsmen and traders, many of them; others, scouts or geographers duly appointed, were active from almost the first years of settlement. A German, John Lederer, appointed by Governor Berkeley of Virginia, failed to find a pass through the mountains to the interior, but was no less convinced, from Indian tales, that "the Indian ocean doth stretch an arm or bay from California into the continent as far as the Apalataean mountains, answerable to the Gulfs of Florida

and Mexico on this side." More soberly, and from the evidence of his own eyes, Col. William Byrd II, heading a surveying party on the line between Virginia and North Carolina in 1728, reported:

"The soil we passed over this day was very good, being clothed with large trees of poplar, hickory, and oak. Another certain token of its fertility is that wild Angelica grown plentifully . . . Charming valleys bring forth like the lands of Egypt without being overflowed once a year. Grass in the river sections grows as high as a man on horseback, and the rivers roll down their waters to the sea as clear as crystal . . . Happy will be the people destined for so wholesome a situation, where they may live to the fullness of days, and, which is much better still, with much content and gaiety of heart."

Colonel Byrd's notes referred principally to the Dan River Valley, before it was cleared and put to growing tobacco and corn by one-crop farmers. Then and later about 85 percent of the Dan River Valley was cleared and cropped. The area cleared and tilled was 1,153,000 acres. Today, fully one-half of that million and a half acres of bounteous land has since been allowed to wash to the point of complete or almost complete disuse, and to go back to a second-growth piney woods.

Out ahead of the farm-land frontier were hunters and trappers, and generally drovers, riding herd. "Very extraordinarily kind of Fellows [these cow-pen men]," wrote an English officer on Braddock's disastrous march through the Potomac uplands, "they drive up their herds on Horseback, and they had need do so, for their Cattle are near as wild as Deer . . . You see, Sir," this visiting Englishman concluded in a letter to a friend back home, "what a wild set of Creatures our English Men grow into, when they lose society . . ." Big rangy cattle, strong enough to climb over the hills to market, and razorback hogs that could, according to Kephart, "run like deer and climb like goats" were being driven to Philadelphia by grass openings and buffalo trails, through the high-flung Cumberland Gap, all the way from far-off Ohio and Kentucky, by the end of the War of 1812. On the western march cowboys, drovers, and shepherds far outran plowmen tending more or less fixed holdings and bloodless, legless crops. Livestock can take itself to market, even when there are no roads.

Yearly round-ups of cliff ponies on certain coastal isles and wastes of the Atlantic shore, gaunt livestock still ranging in piney wastes and the occasional sight of riders with western saddles and a western seat in our eastern highlands—these and other sometimes stagnant pools or back eddies of cow-country influences, are all that is left to remind us that our eastern upland was wild West, a land of free grass and of great drives that followed buffalo trails and roiled raw clay roads, not so long ago. Complaints of early travelers about these "cowbillows" resemble the remarks of pleasure-car drivers over truck-torn roads today.

The Way of the Grass

As early as 1635 overgrazing and overcrowding of pastures had led northern colonists at Newton (now Cambridge), Mass., to appoint "fence-viewers" empowered to impound all cattle feeding out of season, and to pass other regulations "lest cattle should 'damnify the corn and grass'." These were fenced cattle. The first evidence of concern as to overgrazing on open range is noted by Shaler: "An Act to Preserve the Range; that is, the Right of Public Pasture." Together with an act to preserve the breed of horses, and an act to preserve game, this range law was drawn up at Boones Fort (or Boonesboro, Ky.) in May 1775. The text of these acts has not come down to us. They were never enforced. They were drawn for the better governance of "The Colony of Transylvania," which never came off. And by 1800, Boone and his immediate followers, finding Kentucky "too crowded" had passed westward, "back of beyond."

The first great westward trek moved west by south, and to an extent not generally realized, it followed grass. Thousands of northerners made, of course, a direct march west from New England and from upstate New York through the gaps into Ohio's Western Reserve counties, and on through the old Northwest, to Kansas and beyond. Many Pennsylvanians made for the West more or less directly in the sturdy Conestoga wagons they built from the hickories there. But such Yankee advances upon new soil were belated in comparison with the thrust southwestward down the Cumberland Valley of Pennsylvania, across the Potomac River, on down the continuing limestone valley now called the Shenandoah in Virginia and the Tennessee Valley beyond Virginia, and across the Cumberland Plateau on to the bluegrass, the meadowlands of Kentucky, and westward. A staunch line of Presbyterian Church spires marks to this day the west-by-south advance of the Scotch-Irish down from Pennsylvania into the Shenandoah, and on to the "land of western waters."

Crop Domains

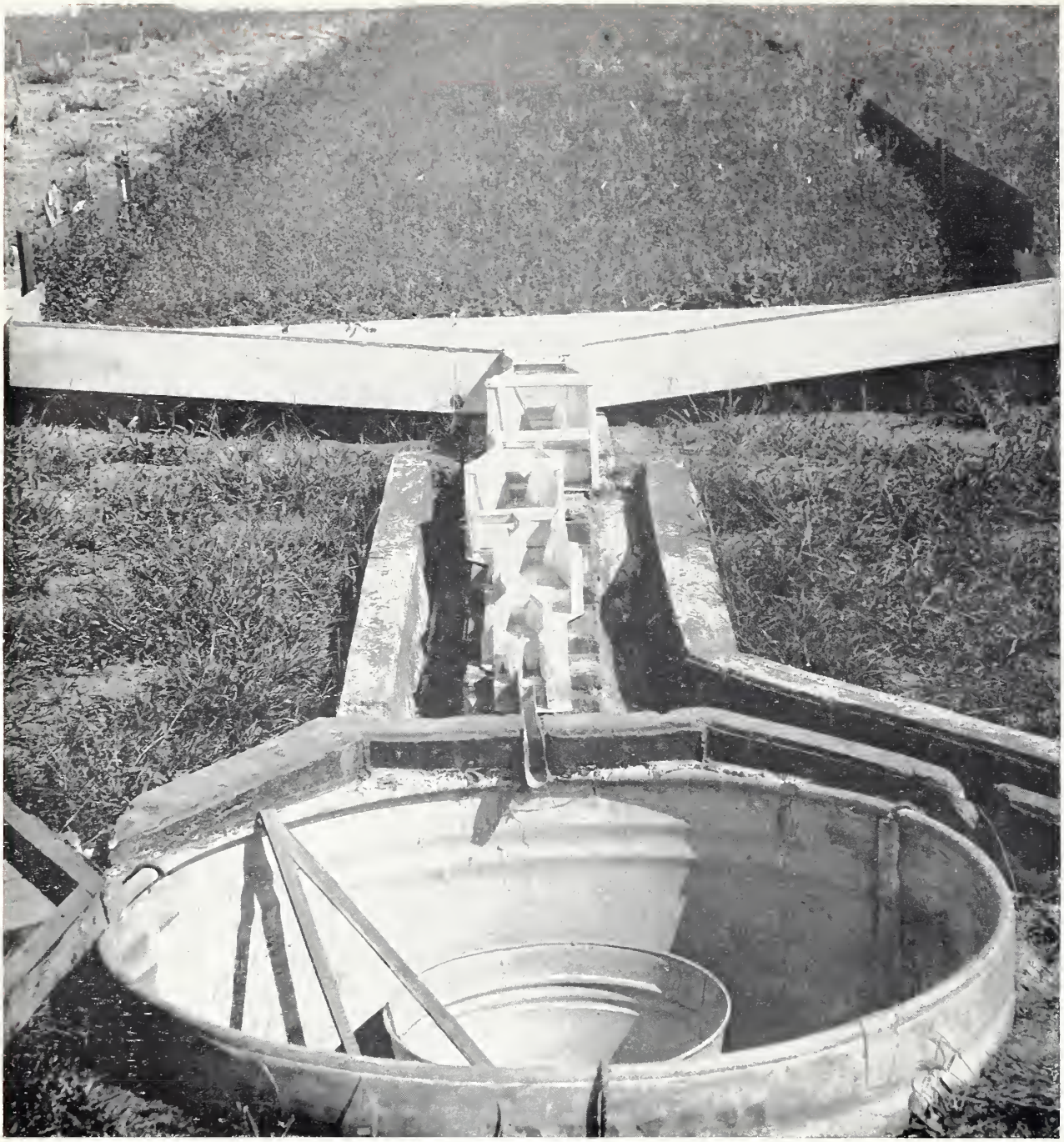
Choice of land went by habitual assumptions, with native vegetation serving as an additional guide. Hickories, walnuts, and blue ash were accounted signs of fruitful soil in various regions; "the devil's-shoe strings," post oak, and black jack grew on land generally accounted second rate, or worse. Any natural growth of hardwoods was good land (hammock land) to the settlers of southwestern Georgia and western Florida. In his Soil: Its Influence on the History of the United States, Archer Butler Hulbert dwells engagingly on the tendency of different races of settlers to follow different soil types, like migrating plants. Thus the Scotch-Irish, fearing from experience in their homeland that limestone soils would be dry and given to heaving, left Lancaster County, Pennsylvania, to the Palatinate Germans, and pushed on. The Pennsylvania Germans had no such soil taboo. A like soil in their native Rhine Valley had proved excellent for wheat; so they planted wheat, and got from 20 to 45 bushels to the acre, with corresponding yields of other small grains, and of corn. Wheat had been tried by the Jamestown colonists, and had failed. Lancaster County became America's first granary, and an important seedbed of diversified farming, with corn, wheat, grass, and livestock. There was also tobacco, but in rotation.

More splotches along the coast to the South, at the time, were spawning beds of one-crop tobacco and cotton systems soon to spread. Tobacco passed as currency in the Virginia and Maryland tidewater; it was a light, compact product, easily hauled, rolled, and shipped; and the demand was insatiable, at first. "Of grain and pulse they (the Virginians) provide commonly no more than they reckon that their families, will require," wrote an English observer of American agriculture in 1697. "The one thing of which they make as much as they can is tobacco there being always a vent for it." Some 75 years later, A. O. Craven, in a paper, Soil Exhaustion in Virginia and Maryland, wrote: "New land is taken up, the best to be had; tobacco is grown on it for 3 or 4 years, and then Indian corn as long as any will come. And in the end if the soil is thoroughly impoverished they begin again with a new piece and go through the rotation." Writing later of Virginia as a source of settlers and of agricultural methods in Kentucky, Shaler describes the same method of "turning back" wounded land to "the healing forest," and remarks: "The compulsion to westward migration then acting upon the Virginia people was something like that which in the olden days drove their remote ancestry from Central Asia over the lands of Europe and to the Atlantic."

There were definite physical reasons, apart from crops and cropping systems, why soil wreckage started first and proceeded fastest to the south. Southern soil does not freeze as deeply in winter; it is therefore more likely to wash all year round. By reason of low inviting

IN RICH LANCASTER.

For generations the shrewd Pennsylvania German farmers of Lancaster County have practiced strip cropping.



HOW LOSSES ARE MEASURED.

From enclosed strips of a field, variously planted and treated, run-off of soil and water may be gaged.

banks, with inreaching tidewater, southern coastal soil was, in general, more accessible, at first. And the march from there inland to "the land of western waters" was not entirely through impenetrable or trackless forest, by any means. Open woods and grass savannas marked the way west by south. Buffalo trails beckoned. In Kentucky first settlers took such trails following contours through woodland, grassy draws to salt licks and water; and found them as wide, in places, as a three-lane highway. In short, southern soil was relatively easy to get at; and to get away from, westward, when it had been slashed and skinned.

Not blind to the waste and ruin, the Governors of the Virginia Colony, and to some extent the proprietors developed schemes and rules to impose general farming upon tenants. "At times," Hulbert notes, "it was ordered that each planter should raise a certain number of acres of grain on penalty of forfeiting all of his crop and being reduced to slavery." Regulations for the planting of mulberry trees were passed. Limits were placed on tobacco exports. By the time of the Revolutionary War, Adam Smith reports in his Wealth of Nations, with disapprobation, Maryland and Virginia tidewater planters had tried one of the world's first allotment plans. They limited themselves to planting so many hills of tobacco for each slave; and are said to have burned standing tobacco when sun and rain made more of a crop than England would pay for handsomely. Whether these early maneuvers toward agricultural adjustment were designed to lift prices or to save soil, little came of them. With new land just over the ridge, and a frontier psychology prevailing, they failed to stand before the march of the single-crop system across the South.

Different crops offer widely different degrees of soil protection. Timber, as a crop properly cared for, and of sufficient age to lay down a complete ground cover of litter, is best in regions well adapted to trees for holding the soil. Grasses in thick stands are as effective; often equally as effective as trees. They have the advantage over timber in that their effectiveness is almost immediate. The clean-tilled crops, with bare earth stirred up between rows to give the crops all the available plant food, to prevent their sharing it with weeds, are the worst offenders. Tobacco, a greedy feeder, has a root system which tends to suck at rather than to grasp and preserve topsoil.

Havoc

Trouble started almost as soon as tobacco took root, in clean-tilled rows, on our eastern coast. In 1685 the first William Byrd of Virginia described a deluge that swept out tobacco hills "with all the top of the manured land." Alarm and agitation, multiplied and reechoed, and nothing much was done about it, as tobacco, cotton, and corn gnawed inland into the heart of the rolling sections of the South—that is the record of the next hundred years or so. Preparing his autobiography, A Maverick American, Maury Maverick, formerly a Congressman, recently visited the ancestral home of a great-great grandfather in South Carolina, near the head of the cotton trail westward, and wrote:

". . . let old General Bob Anderson . . . tell a tale from his grave in South Carolina. Somewhat lonely lie the bones of this fellow they called 'Old Thunder Gusty,' who rose from sergeant to general, who fought the Cherokees, served in the House of Burgesses and then the Legislature, and who farmed the land.

"The weary old soldier was buried in a field one day, and for all anybody knows, what there is of him has washed down to the sea. The slashing and the tearing of the land thereabouts is terrific. The elements of nature have fought around his grave, and everywhere the hand of man has added to the destruction of the land."

From the records of the county, Maverick dug up this warning of a resident, issued throughout the district, in 1818:

"This system, if it may be so called, of perpetual exhaustion, has impoverished our lands to an alarming degree, and if pursued for half a century more, would make this interesting por-

tion of the State [South Carolina] a perfect desert—exhibiting a naked barren surface, spotted here and there by a few patches of broomstraw, or starved shrubbery, and ruined from future recovery by deep-washed gullies, the permanent and accusing witnesses of our apathy and indolence."

George Washington hated corn, as a soil remover, almost as much as he hated tobacco. He wrote to Thomas Jefferson in 1795:

". . . neither my overseers nor manager will attend properly to anything but the crops they have usually cultivated; and, in spite of all I can say, if there is the smallest discretionary power allowed them, they will fill the land with Indian corn, although even to themselves there are the most obvious traces of its baneful effects."

The small grains (wheat, barley, oats, rye) more closely sown, and never intercultivated, are better; but it seldom pays to offer them steep land. As for cotton, this king has been rightly said to offer hardly more protection to the soil it feeds on than would a walking stick thrust into the ground. King Cotton has sucked numerous areas of the old South dry and tossed them back toward piney woods. Cotton has flicked virgin topsoils away. It has carried incalculable quantities of the old and new South's chemical constituents of the region's foundation in fiber and seed products to other regions and continents. How the cotton South would live were its cotton export business to go entirely, no one knows; but that cotton has been, in our South, a tyrannous and destructive crop, is undeniable.

In the eighteenth century a slave required a month to pick the seeds out of a bale, and the Cotton Belt was a narrow crescent hugging the Atlantic shore of Georgia. In 1792 Eli Whitney of Massachusetts, visiting Georgia, invented the cotton gin. By 1800 American cotton production had increased more than two-hundred-and-fifty-fold. By 1821 the cotton frontier had crossed the Mississippi, and was thrusting out a long tongue toward Texas.

Cotton then, was the first major crop to march across this continent in force. Like the bluegrass trail which led men southwest from Pennsylvania, Hulbert notes, the march of cotton tended to follow the piled-up skeletons of old sea forms, deposited. Possessed of a marked ability, as compared with corn, to fold its tent and wait for rain in subhumid climates, cotton in its westward march assumed sovereignty over some of the best land in the United States. And around cotton, as around tobacco, and later, around cattle, there grew up a domain, a civilization, and ways of thought more or less distinct from the thoughts, ways, and aspirations of the rest of the country.

Remembered Names

Letters and records left by both George Washington and Thomas Jefferson provide, curiously, the most detailed observations now available, as to first known measures of soil defense in the United States. In 1787, Washington wrote the English agriculturist, Arthur Young:

"The cultivation of tobacco has been almost the sole object with men of landed property, and consequently a regular course of crops has never been in view. The general custom has been, first to raise a crop of Indian corn (maize), which, according to the mode of cultivation, is a good preparation for wheat; then a crop of wheat; after which the ground is respited (except from weeds, and every trash that can contribute to its foulness), for about eighteen months; and so on, alternately, without any dressing, till the land is exhausted; when it is turned out, without being sown with grass-seeds, or any method taken to restore it; and another piece is ruined in the same manner. No more cattle are raised, than can be supported by lowland meadows, swamps, etc., and the tops and blades of Indian corn; as very few persons have attended to sowing grasses, and connecting cattle with their crops . . . There are several, among whom I may class myself, who are endeavouring to get into your regular and systematic course of cropping, as fast as the nature of the business will admit; so that I hope in the course of a few years we shall make a more re-

spectable figure as farmers, than we have hitherto done."

First Cures

The above was written just before Washington left Mount Vernon to assume the presidency. His letters back home, while president, to his nephew; and the careful memoranda by which he sought to guide farming operations at Mount Vernon, show, again and again, that those eroding fields and dawning gullies weighed forever on his mind. This, to his nephew, George A. Washington, in 1789, suggests sound methods of gully healing:

". . . The gullies in these fields, previous to their being sown with grain and grass-seeds, ought invariably to be filled up. By so doing, and a small sprinkling of manure thereon, they will acquire a green sward, and strength of soil sufficient to preserve them. These are the only means I know of, by which exhausted lands can be recovered, and an estate rescued from destruction. . .

"Save all the honey-locusts you can, of those which belong to me; if more could be obtained, the better. And, in the fall, plant them on the ditches where they are to remain, about six inches apart, one seed from another."

Filling up gullies, prior to attempting their stabilization by close-growing vegetation, is expensive, and may not be necessary; but Washington had slave labor, and was anxious to give it winter occupation. In notes entitled, A View of the Work at the Several Plantations at Mount Vernon, in the Year 1789, and General Directions for the Execution of it," he wrote:

"*Muddy Hole Farm:* . . . there is a work of great importance, if the weather and other circumstances would concur for the execution of it in season. I mean, that of getting up rich mud from the most convenient parts of the creek, and laying it in small heaps, for amelioration, to be carried over the poor parts of No. 5, which will be in corn."

Washington seems no more than most Americans, then and now, to have detected far larger and more subtle soil removal performed by sheet erosion—erosion that strips off all of a topsoil fairly evenly. Sheet erosion, on those gentle round slopes of the Potomac was making, then as now, the greatest changes—but gullies shout ruin to every farmer and passerby. To Arthur Young, again, in 1793, Washington reported:

"A husbandman's wish would not lay the farms more level than they are; and yet some of the fields, but in no great degree, are washed into gullies, from which all of them have not as yet been recovered."

Returning for a moment to his prescriptions for healing gullies, addressed to his nephew and foremen in 1789: The field No. 5 he refers to was 65 acres on the Alexandria Road. The suggested digging and hauling and spreading of washed-down silt back on the field, exceeds in point of expense and care most erosion cures currently practiced in the United States. Older countries have, however, often come to far more expensive and laborious measures. With cheap labor, it is possible; and in the wind-blown areas of our West farmers with power machinery have lately been moving heaped topsoil back from the fence rows with scoops, to put their fields, so far as possible, back where they were. Another Washington letter, written from Mount Vernon to William Strickland in July 1797:

"Your strictures on the agriculture of this country are but too just. It is indeed wretched; but a leading, if not the primary, cause of its being so is, that, instead of improving a little ground well, we attempt much and do it ill. A half, a third, or even a fourth of what we mangle, well wrought and properly dressed, would produce more than the whole under our system of management; yet such is the force of habit, that we cannot depart from it. The consequence of which is, that we ruin the lands that are already cleared, and either cut down more wood, if we have it, or emigrate into the Western country . . ."

On December 10, 1799—4 days before his death—he wrote final instructions to his farm

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overseer, Mr. Anderson, listing erosion control as a major item in the plan of operations: "The washed and gullied parts of (Muddy Hole Farm) ought to be levelled and smoothed, and as far as it can be accomplished, covered with litter, straw, weeds, corn stalks, or any other kind of vegetable rubbish, to bind together, and to prevent the earth from gullying."

He gave similar orders for work on his river farm. Referring to field No. 1, he directed: ". . . part is in meadow, and will remain so; the most broken, washed, and indifferent part is to remain uncultivated, but to be harrowed and smoothed in the spring, and the worst portions, if practicable to be covered with litter, straw, weeds, or any kind of vegetable rubbish, to prevent them from running into gullies."

Field No. 2 on his Union farm, an "indifferent field, washed in some places, gullied in others, and rich in none," was to be "prevented from getting worse, and becoming such eye sores as they now are."

Washington's preoccupation with gully-healing; his insistence upon the virtues of a rough surface with mingled "vegetable rubbish" to help hold topsoil; his practice of withdrawing too-steep land from cultivation; and his insistence above all on cover crops and rotations, as opposed to soil scalping by one-crop methods, suggest in fairly complete outline the curative program of the most modern soil conservators. Contour cultivation, terracing, and strip cropping apparently did not enter into his program. With such gentle slopes as the fields of Mount Vernon present in general; and with erosion troublesome but not ruinous at the time Washington farmed there, terracing would probably not have been justified, anyway. At the time of his death he was following a 7-year crop rotation, admirably adapted to sustain and hold his soil.

A hundred miles southwest, Thomas Jefferson was expressing concern at the devastation ax and plow had wrought on hills his father had cleared and planted. Corresponding with Washington, John Taylor, and other farmers and agriculturists, Jefferson shifted his farming scheme toward a 7-year rotation much like Washington's. At last the agitation about erosion was beginning to take a constructive turn. Edmund Ruffin of Virginia, later of Kentucky, was issuing pamphlets opposing "exhausting agricultural practices" and recommending "calcerous manures," or marl. A traveler in those parts about 1815 reported that, "An angel of destruction had cursed the land; with farm after farm worn out, washed and gullied, so that scarcely an acre could be found in a place fit for cultivation." He saw "dreary and uncultivated wastes, houses falling to decay, fences wind-shaken and delapidated." Lewis C. Gray, in his History of Agriculture in the Southern United States to 1860, writes:

"In the upland areas from Virginia to Georgia the expansion of cotton and tobacco left behind an ever-widening circle of lands suffering from soil exhaustion. Year after year the old lands were depleted until it was no longer profitable to farm them. By 1850 a large proportion of Virginia and Maryland east of the Blue Ridge was a waste of old fields and abandoned lands covered with underbrush and young cedars . . . The first three decades after the introduction of cotton was a period of financial prosperity and rapid development in upper South Carolina and middle Georgia, but by 1820 the uplands first devoted to cotton were gullied and bare of verdure, or covered with a thin growth of broom sedge; and the evil spread progressively over the areas later occupied. By 1825 farmers in middle North Carolina had been forced to occupy the poorer ridge lands, formerly believed not worth cultivation."

Horizontal Plowing

In a letter to Tristram Dalton, dated May 2, 1817, Thomas Jefferson reported as a developing stay against erosion the practice of making every furrow a small terrace, instead of a potential runway for rainfall, by simply plowing along the land's contour, instead of up and down the hill. This practice, Jefferson wrote, had

been employed by his son-in-law, T. N. Randolph on his farms for 12 or 15 years roughly, since 1800, and:

". . . it has already become very general, and has entirely changed and renovated the face of our country. Every rain, before that, while it gave a temporary refreshment, did permanent evil by carrying off our soil and fields were no sooner cleared than washed, at present we . . . lose none of our soil, the rain not absorbed at the moment of its fall being retained in the hollows between the beds until it can be absorbed. Our practice is when we first enter on this process, with a rafter level of 10.f. span, to lay off guide lines conducted horizontally around the hill or valley from one end to the other of the field, and about 30 yards apart. The steps (?) of the level on the ground are marked by a stroke of a hoe, and immediately followed by a plough to preserve the trace. A man or lad, with a level, and two small boys, the one with sticks, the other with the hoe, will do an acre of this in an hour, and when once done it is forever done. We generally level a field the year it is put into Indian corn, laying it into beds . . . until all the fields have been once levelled. The intermediate furrows are run by the eye of the plough-man governed by these guide lines. The inequalities of the declivity in the hill will vary in places the distance of the guide lines and occasion gores which are thrown into short beds. As in ploughing very steep hillside horizontally a common plough can scarcely throw the furrow up hill, Col. Randolph has contrived a very simple alteration of the share, which throws the furrow down hill both going and coming . . . horizontal and deep ploughing with the use of plaster (?) and clover (?) are but beginning to be used here will, as we believe, restore this part of our country to its original fertility, which was exceeded by no upland in the state."

In a prior letter, written in 1810 to William A. Burrell, Jefferson described the most devastating rain within his knowledge and added:

"Mr. Randolph's farm was the only one which has not suffered, as horizontal furrows arrested the water at every step until it was absorbed, or at least had deposited the soil it had taken up. Everybody in this neighborhood is adopting his method of ploughing, except tenants who have no interest in the preservation of the soil."

"By the thirties," writes Frederick Turner, the historian, "the exhaustion of the soil in the South Atlantic States had gone so far that many of the planter class, with their slaves . . . moved in great numbers to the cheap and fertile lands beyond the mountains."

Between a soil collapse, and a collapse of cotton prices, the old South was in no shape to follow seven-crop rotations and the sound but expensive methods urged by Washington and Jefferson. Jefferson lost Monticello, his farm and home, in the end; and died still in residence there only by sufferance of his creditors and a grateful nation. "Root, hog, or die!" was still the law of the wilderness, and of clearing it to farm. Ahead lay El Dorado; behind, a racked and gutted soil.

Soon after the Revolution Patrick Henry said in a speech: "He is the greatest patriot, who stops the most gullies." Speaking to the Virginia House of Delegates in 1832, Thomas Marshall estimated that all the crops of Virginia then were worth less than the State's agricultural export alone had been worth 80 or 90 years before, when it had only one-sixth as many people. Ironically croaking, John Randolph of Roanoke prophesied that masters would shortly run away from their slaves, and would be advertised for by them in the gazettes. The soil rush swept on.

Two Hundred Years Later

The Dust Bowl has caught the attention of the whole Nation: 4 million acres, an area two-thirds the State of Maryland, exclusive of its water surface, practically ruined . . . 60 million more acres going. That is bad. It represents a waste so stupendous that the human mind is incapable of comprehending it. Yet water erosion has ruined eight Marylands . . . and another 300 million acres have been in some part hurt.—Gerald W. Johnson in The Baltimore Evening Sun, July 9, 1936.

From a Maryland Window

THE FIRST of these present-day field notes is written at a farmhouse window overlooking a fair green stretch of hilly grassland, broken with corn and wheatfields, homes and orchards, some 7 miles west, as the planes fly, up from the headwaters of Chesapeake Bay.

The State is Maryland; the county Harford; the slant of these rolling fields varies, within reach of the eye, from less than 10 percent to more than 30 percent (a 30-foot drop in 100 feet, horizontally), and their elevation ranges from 400 to 500 feet. The soil is predominantly a clay loam, with red to yellowish clay subsoil, overlying old crystalline rocks. The darker land is generally the more rewarding and less erosive, but the soils of this county as a whole are rich and durable.

White settlement at the shore line seems to date from 1634. During the 100 years following, these first ranges of foothills were cleared and settled. A Presbyterian Church some 8 miles inland was founded in 1738 by a Scotch-Irish circuit rider who came on horseback from Pennsylvania. Notes gathered by William W. Finney, a member of the present congregation, show that cabins, tobacco patches, grainfields, and a typical pioneer frontier economy were by that time established here. The oldest roads which dip to the Chesapeake tidewater were "rolling roads." Hogsheads of tobacco were prodded down them first by men with poles, drawn down them later by oxen. The first resident pastor of Churchville Presbyterian Church was admonished not for making whisky (for this was the one readily movable and marketable form of grain) but for making and selling bad whisky. This first western swell of land up from the Coastal Plain on the western shore of Maryland maintained many frontier characteristics until about the time of the Revolutionary War.

For the past 200 years or more this part of the country has been pulled and jostled away from thoroughgoing land skinning, and has become, in a general way, middle ground between plow-torn lands of one-crop country southward, and the more diversified and meadowy farming country of the Middle Atlantic and New England coast. Most of the measures adopted to defend this soil were less the result of conscious local choice and virtue than an outgrowth of happy circumstances. Diversified markets and outlets just down the hill, called for a diversity of product. Beyond that, in a manner perhaps only coincidental, but certainly curious, tobacco culture appears to have hastened the clogging of the little river ports, and so cut off early shipping points for tobacco. A hard road strikes now through the site of Joppa, once a tobacco port of this county, on the Bush. It has silted up. Cargo boats cannot get within miles of it. Mixed farming proceeds on the filled-in flats beyond. Only a few yellowed custom receipts, framed on the walls of the old houses, tell of the time when Harford was a tobacco county, and the road to Joppa was a rolling road. Around

a hundred years ago tobacco fields providentially retreated toward the deeper tidewater of the Patapsco and the Potomac, on into southern Maryland, and the nearby Virginia coast.

Up in the mixed-crop country a 100 miles or more to the north, plague specks of gully erosion occasionally appear, but they are rare and not spectacular. Sheet erosion, proceeding imperceptibly, keeps sending year by year to the creek bottoms, the bay, and the sea a great deal more topsoil than is generally realized. But established rotations, a decent respect for grass and cover crops, instinctive care on the part of most plowmen not to reopen gully wounds, and a growing tendency to plow along contours, not up and down hills, have helped to hold this soil. The thing that has helped most of all, perhaps, is what in England would be called a strong county feeling—a proud provincialism, a deepening sense of permanent abode. Land in the family is something to be guarded, husbanded, and kept in the family. All this has helped to guard these rolling hills of Harford and the adjoining counties from sensational transformation, and from man-made waste lands of wide extent.

These are green counties. The traveler sees bare soil only in occasional fields, for a little while each year. Dairying is the specialty; so there is much pasture land, and it has become almost a point of family honor to have a good deal of it permanent pasture, and to say, when asked, that no one knows when that field was last plowed. For cropped land, the traditional local rotation: Corn, "cornstalk wheat," and then 2 years of grass, brings the plow to most fields only once in 4 years; and while the practice of drilling wheat with grass seed in it between the harvested rows of corn shocks is deprecated as slovenly, this crude rotation is a good deal better than no rotation at all. It provides cover most of the time. Semipermanent sowings of alfalfa and, more recently, of lespedeza, represent an advance.

Other changes have come with the years to make this stretch of hill country a natural if inadequate exhibit of common-sense principles in soil defense. A little at a time, permanent pasture is moving up from the bottoms to the higher shoulders of the hills. This goes slow; it is a wrenching departure from the past; for most of the old houses face their lowlands, and a man naturally likes to see his stock there, feeding on sod that has not been broken since the Lord knows when, as he sits on the porch after supper. Nevertheless, the bottoms are being put more and more into row crops, rotated, and the upland shoulders into binding permanent pasture, or woods.

It should be plain by now that the people of Harford and adjacent counties think of themselves as peculiarly provident, especially blessed, and permanently established. And comparatively speaking, they are.

Yet, a small pond behind a 7-foot dam built in 1936 down the slope from this house, is barely 6 feet deep at the dam now, and it has been shallowed by whisked-in topsoil over all its scant area as a whole. All within 2 years. When summer thundergusts and the tearing rains of spring and fall smite these hills, all the streams and creeks—Winter's Run, Bynum's Run, Deer Creek, Octoraro—are densely muddy, and so are the tidewater rivers by which streams from the uplands proceed in more stately manner into the bay. Ten years ago sizable steamers used to come up the Susquehanna and dock at Port Deposit. Skippers who know these waters and their changing shoals may try it; but not as a regular thing; and others, coming occasionally, have learned not to trust the charts. The silt accumulates and shifts too rapidly. Lesser rivers still fairly navigable when men of 60 were youngsters are in even worse shape today.

Silting is simply erosion, afterwards. What the rate of soil wash from these hills has been from year to year, no one knows. Hardly anyone is interested. So there are no measurements or sharply calculated measures of defense. Old residents along the Bush and Gunpowder Rivers, farther south, toward Baltimore, say that when

new bridges were built there, some 25 years ago, piles were sunk from 60 to 70 feet in mud, and still did not find bottom. The transfer from upland to valley and stream bottom proceeds steathily, grain by grain.

Four hundred feet above tidewater, on this shore, a miller on Deer Creek complains that the head of water behind his dam barely suffices now to turn the wheel. Silt. The Pennsylvania Railroad bridge across the Susquehanna has a draw seldom lifted now. Silt. Octoraro Creek, striking down from rich Lancaster County, Pennsylvania, upstream from this idle drawbridge is so muddy most of the time now that mills have been abandoned and people have stopped swimming there. Silt. Yet many Lancaster countians, like these proud farmers just south of the Mason-Dixon line, will tell you that erosion is a bad thing, for other people; a real problem, some place else.

On such a countryside, serene and glowing, one could almost wish for more gullies suddenly to appear, preferably along main-traveled roads, and cry havoc. Few believe in erosion in these parts. Yet it is certain that soil is going out faster, very much faster, than it is being made, and that present defenses are inadequate for a permanent agriculture.

Farm land is being abandoned—a few acres here, and in places entire farms—in Lancaster County, in Harford County, in Baltimore County—with but two centuries of use—that is the theme of this note. If it seems overlong, there are two reasons. (1) A man likes to dwell on delights and troubles in his home country. (2) A century or so longer of trial and error deserves attention, even if, as here, the attempted cures seem only partly adequate.

The country out this window is typical of a considerable area. It has a severe and advancing case of accelerated erosion, and the people here do not know it. The condition extends north, then west, over millions of acres including some of the most productive farm land remaining in the United States. When you get out on the lake-shore plain, and beyond that on to the prairie, where the land looks flat, resistance to belief in the actuality of erosion heightens.

To such lands still rich and peaceful looking few or no experts have been called to determine, to a decimal point, how fast soil is going out. In such country the only data, as a rule, are those of local historians and of a few farmers whose perceptions are unusually acute.

Observations of a Fruit Farmer

Charles E. Bryan came here to Harford County from the neighboring county of Baltimore in 1907. He had made money in business and was tired of it. He wanted to farm. In the 30 years since he has established on the Chesapeake tidewater commercial orchards that in point of yield and profit outdo many modern commercial plantings in the Pacific Northwest. The University of Maryland has cited him as a master farmer, and he is president of the State Horticultural Society.

His farm, Mount Pleasant, is 350 acres on a tall hill facing the bay. The Americans had cannon on that hill when the British burned Havre de Grace in 1813. Mr. Bryan bought and built there because of the view. He knew little about soils when he started farming, 30 years ago. "I found," he now observes, "that it is possible to buy a rather extensive acreage, and not much soil.

"The land was washed and wasted. There were gullies, but gullies were not the main difficulty. Nearly every one knows, or thinks he knows, how to dam and stop a gully. The harder problem is to restore fields stripped evenly of topsoil by sheet erosion.

"Our first orchard was a 6-acre planting of apples on a 40 percent slope west of the house. The soil was a clay loam, washed down to reddish clay subsoil with protruding rocks, and of almost stony hardness when dry. We had to get some sort of a seedbed there before we could put out trees.

"We scattered trash, weeds, and straw manure. We sowed crimson clover. Between the mulch

and the remnants of soil below it caught. We pastured lightly for 3 years and kept sowing clover and vetch. We used any vegetation that would take hold. We welcomed even poison-ivy vines. They helped weave a net to hold the hill. When erosion seemed to be somewhat checked in 1910, we killed off the poison ivy (it's a mouse harbor) and set out apple trees on the contour.

"At the time (and, indeed, until recently), clean cultivation in orchards was supposed to make all the difference between poor fruit and good fruit. As the trees came along, we would break up the sod between the rows with a disc-harrow, working around the contours, and follow that with a 12-foot spring-tooth harrow.

"The harrowed land washed. There was no preventing that. But it did not wash as fast. The soil showed, as it always will in hillside orchards planted along contours, a tendency to bench off levelly between the tree-rows. We encouraged this. We kept spring-tooth harrows moving on the lanes between the trees all summer, leaving only a protective strip of sod, marking the contour from tree to tree. Every fall we tied down the whole orchard with a new cover crop. Every spring we resumed inter-row harrowing. By the time the block of trees came into bearing, the hillside had definitely terraced itself."

This method, extended to lesser slopes as planting progressed, has terraced 250 acres of apple and peach orchards that produce around 100 carloads of fruit a year. The self-made terraces have become sharply defined. They appear as level bands, one above another, around the hills. The joining slopes, like stairsteps, become so sharp that it often is necessary to smooth them with a harrow so that the grass there can be mowed.

But terracing did not make Mount Pleasant permanent. The very readiness with which the hillsides there reshaped themselves suggests that topsoil still was moving. Heavy applications of lime and of manure from the Havre de Grace race track brought thickening stands of winter cover crops. Every spring for more than 20 years these cover crops were turned under. The soil of Mount Pleasant was deepened and enriched. With humus packed in the topsoil and subsoil opened, to 30 inches down, with a knifelike subsoiler, the water-holding capacity of the land was increased greatly.

Yet for all the surrounding safeguards those slopes were too steep to be held by any clean-tilled crop, year upon year. Intertilled orchards do not, of course, move as much soil as intertilled corn, or tobacco, or potatoes, or cotton. The tree lines themselves, as Mr. Bryan has shown, can be made lines of erosion-resistance. But as long as water runs downhill, it will probably remain impossible for man to tear up, year by year, protecting foliage mats, and expose only "clean," powdered, naked soil particles to the downward creep and rush of water, without losing a troubling amount of topsoil.

In the late winter of 1932, Charles Bryan, splashing in boots during thaws and rains along his lower fence lines and observing the run-off, decided that he no longer could afford to follow the traditional dogma that quality fruit growing requires "clean" intertillage. "My land was going away from me too fast," he says.

In 1932, he put his 250 acres of bearing orchards under cover—alfalfa and sweetclover—summer and winter. They have been kept so ever since. Alternate lands are sometimes cultivated when they get weedy or when reseeding is desired. Apart from that, Mr. Bryan's present system leaves no land bare. Cover crops are kept mowed and left as a mulch on the ground. The books for the years 1932 to 1936, inclusive, show larger crops with a higher proportion of top-grade fruit, and a greater average profit than before, even though these years have included two dry ones for Maryland, and a freeze that wiped out his entire peach crop in 1935.

Summarizing the experience for this publication, he writes:

"The quality of the fruit has improved as the soil has improved under cover. The color, size and quantity of our fruit is better than it was under intertillage. The amount of water which

summer grass takes is many times repaid by the greatly increased rain-halting, rain-absorbing capacity of soil under grass.

"Under year-round cover our soil waste has been reduced to negligible proportions. With intertillage we were losing ground. On certain flat holdings intertillage may pay, but most American orchards are planted on hills.

"Every farm is different; but from thirty years' experience on this one we are led to believe that clean culture between fruit trees is a soil-destroying superstition. From work on two different soil types, a stiff Cecil clay and a granular Sassafras soil that washes like sugar, we find that year-round cover is better for the fruit and much better for the farm."

Twenty Miles West

Twenty miles west of this window, the hills of Harford sharpen and climb to nearly 1,000 feet above sea level before entering Pennsylvania, where they join the Blue Ridge. Up-country, gullies announce trouble emphatically. Nearly everyone there is more or less worried about it. To the weekly Bel Air Times of November 13, 1936, W. Lee Linkous, a farmer, wrote:

"We have a CCC camp doing soil erosion control work at Black Horse. I was the ninth farmer to sign a co-operative contract with them. They now have 31 farmers co-operating. On the farms they have planted 177,000 locust trees, 18,000 Scotch pine, 10,000 Norway spruce, 10,000 loblolly pine, 5,000 white pine and several thousand mulberry and caragana for food for the birds. They have built several thousand rods of fence; constructed a number of check dams across gullies; worked considerably in the woods; put on several pasture demonstrations; surveyed the farms; mapped out all the fields on a contour and helped all farmers to figure a rotation that will save the soil; and aided them to get started raising alfalfa.

"On my farm the rotation was corn, soy-beans, wheat and clover. That gave me one-half my land in grain and the remainder in hay. Now I have one-third of the land to plow in the spring and one-sixth in the fall. My fields are laid off in contour strips with every other strip in alfalfa and the remaining strip in grain. They have built for me about 100 rods of fence which divides my pasture into three nearly equal parts. Now I can rotate the pasture. The boys have made terraces in the pasture to hold the water that falls on it. The entire program is to conserve soil and water. I advise other farmers to investigate."

Two Farms

"God in his wisdom having ordered it so," wrote William Penn in 1683, "the advantages of the country (Pennsylvania) are divided, the back lands being generally three to one richer than those that lie by navigable waters."

In 1936 the United States Soil Conservation Service established regional headquarters, No. 1, for the Northeast, at Williamsport, and set up cooperative erosion-control projects on Pennsylvania's rich back lands. It is a country of mixed farming, good and bad. Probably no other region offers such striking examples of soil preservation on one side of a fence, and devastation on the other.

"Here, in northwestern Pennsylvania," Austin L. Patrick, then regional conservator, reported, "are adjoining farms, both of 170 acres, and both cooperating with the Soil Conservation Service. The owner of farm 'A' has carried on for years most of the practices now recommended by the Service. He has plowed and cultivated on the contour and prevented gullying. He has practiced a systematic crop rotation that includes soil-building crops, such as alfalfa and other legumes. He has consistently limed and fertilized every field and practiced pasture management. He is one of the leading cattle and sheep growers of the community.

"Farm 'B' has been kicked around from one owner to another. Pastures have been mismanaged; woodlots badly neglected. Buckwheat, corn and potatoes have been planted in large blocks without regard to contours. In

fact, the crop rows have often been run straight up and down steep hills. The place has large patches abandoned to weeds and briers.

"Farm 'A' yields its owner a substantial income. 'B' has been in the red for the past five years. 'A' produces about 20 percent better yields of all crops than 'B'. 'A' has plenty of good pasture. The pasture on 'B' is of poor quality and low carrying-power.

"In establishing erosion control plans on these two adjoining farms no gully work was required on 'A'. Virtually every field on 'B' required extensive control operations, including the construction of some long diversion ditches.

"On 'A', a few acres of steep land that was not being used was planted to trees. On 'B' it was necessary to plant trees on 40 acres that had formerly been in pasture or cultivated crops. One hillside pasture of about 10 acres was so badly gullied that it was impossible to plow contour furrows for the tree planting. The gullies were so large that the tractor couldn't cross them. There was practically no pasture grass on the entire 10 acres, and hardly a trace of the original topsoil could be found.

"Strip-cropping plans for Farm 'A' fitted easily into the owner's former plans, and few changes in field boundaries were required. Farm 'B,' on the other hand, had to be entirely re-arranged, involving the removal of old fence rows and a complete revision of crop rotation plans."

Potato Plungers

The first erosion-control project established in New England is in Aroostook County, Maine. Its rich strip of cleared potato land, along the Aroostook River, is north of Quebec and so far east that a line dropped south would strike more than 100 miles off the Carolina capes. But this northeasternmost county is in many ways more like western frontier country than any other part of the United States.

Late in the 1830's England reasserted a claim to northern Maine. Ten thousand Maine militiamen in flaming red shirts and pea-green jackets marched north from Bangor in subzero weather to engage in the siege of the Little Madawaska. It was a good war, if ever there was one. The troops sat around and swapped yarns while statesmen wrangled. The total recorded casualties were one: An American soldier engaging in horseplay, fell on the ice and broke his hip.

The siege wore on until warm weather. The idle soldiers noted the luxuriance of that northern burst of foliage. They pawed at the soil that burst through the snow and were good soldiers no longer. They were Americans, and they smelled land. When the boundary dispute was settled in 1842, the western tide from old New England turned partly northeast for a year or so.

From Bangor north to Aroostook it is still nearly 200 miles through woods. The railroad did not strike through until 1895. Extensive, high-powered farming in Aroostook dates from then. Between 1890 and 1900 Aroostook's potato crop rose from 1 million to 2 million bushels. In 1910, it was 20 million bushels. By 1930 it was 40 million bushels. A 50-million-dollar potato crop is shipped out of Aroostook in "good years" now.

A rich strip of rolling land along the Aroostook River accounts for most of it. Thick woods extend for 100 miles to the west. It is not unusual on this northeastern frontier to meet men who went into the wilderness with winter temperatures down to forty below, and hewed out the fields they now are tilling with tractors. Some of these men are still in their early fifties. The papers call them potato kings.

They form a pleasant, rugged community—hard-working people of high character, strictly religious, in the old sense; and in most respects kind and thrifty. But when it comes to growing potatoes they are plungers, and until lately they have taken no more account of soil loss than did the westering pioneers.

On many of their plantings, the rotation is potatoes-potatoes-potatoes. Some years their potatoes bring 11 cents a bushel. One year they brought $4 a bushel. One summer a big

planter will run four big automobiles, and the next summer one little car. Winter travel is by sleigh. The land, a gravelly loam of glacial origin, is plowed in the fall. Snow covers it, as a rule, from October until late in April; and it is protected by hard freezing against erosion for at least 6 months of the year.

But potatoes, intertilled, offer scant summer cover; and this northeasternmost frontier had developed severe cases of erosion on land that was heavily wooded as little as 10, 20, 30, or 40 years ago.

Soiled Streams

Octoraro Creek, striking south from Lancaster County, Pennsylvania, was mentioned in the first note of this section. In 1934 an old log-and-masonry dam at Kings Bridge broke. Engineers of the county's soil conservation project measured the silt that has washed in almost to the brink of the spillway in the 2 years since the dam last had broken. The silt was 11 feet deep. "The total watershed area contributing to this accumulation," reports Charles B. Maits, Jr., "is about 1,200 acres, of which approximately 75 percent is cultivated . . . [By local evidence] the deposits . . . indicate a loss of about 5 tons of soil per cultivated acre per year . . ." This does not include all the silt; much of it, probably the greater part, went over the dam. It is estimated that in the past 80 years one-half of the total topsoil has been lost from the cultivated land within the boundaries of this small watershed.

Three hundred miles south: "This charming valley will bring forth like the lands of Egypt," wrote Colonel Byrd, first surveyor of Virginia's Dan River Valley, in 1728. "The river, about 240 feet wide, always confined within its lofty banks, and rolling down its waters as clear as crystal," he added. Today, a steam electric plant at Danville has to open its condensers every 15 minutes because of the silt; and a proposal to build, with public money, a large hydraulic plant at a site 70 miles away was rejected for the same reason.

From a study of the Valley, P. F. Keil estimates that 85 percent of the Dan's drainage area once was cleared, and that 40 percent has now been abandoned to scrubby second growth. Of the Schoolfield Dam, just above Danville, he notes:

The reservoir was completed in 1904, with an average depth of 17 feet, and an area of 600 acres, including its backwater. "An island has formed, occupying four-fifths of the reservoir, or about 400 acres . . . Only a narrow channel is left where there were once 600 acres of open water. The engineer in charge states that the flood gates have been opened regularly since 1920 in an effort to release some of the silt. This would seem to indicate that the greater part of the silt has been washed down the river. It is estimated that in about 16 years 432 acres of the reservoir have been covered with soil to an average depth of 19 feet. This is the equivalent of 1 foot of soil over 8,208 acres. And this is only one of the many dams along the Dan!"

Recent studies by soil conservation engineers of 56 reservoirs in the southern Piedmont show that 13 reservoirs of major capacity had silted to the top of the dam within an average period of 30 years; and all of them had silted up in fewer than 36 years.

Jefferson's Home Place

This is Shadwell, the farm near Charlottesville, Va., where Thomas Jefferson was born. Peter Jefferson, his father, cleared most of it and planted tobacco, and some corn and wheat here 200 years ago. On a neighboring mountaintop, within sight of both Shadwell and his University of Virginia, Thomas Jefferson built a place of his own, Monticello. An old man, viewing his home country, he wrote hopefully in 1817 of plowing along contours as a stay against erosion.

How widely contour plowing spread upon the hills around Charlottesville, no one now can say exactly; but the country today shows little evidence of systematic care. If the practice was ever followed at Shadwell it proved in itself inadequate. No single device, including

terracing, if unsupported by systematic rotations and cover crops, can hold tilled soil on hills as steep as these. The steeper slopes of Shadwell dip as sharply as 30 or even 40 percent, and the whole place is hilly.

As a farm, Shadwell is practically out of business now. An Episcopal minister lives in the residence, and no longer tries to farm. The 1,000-acre tract that was Peter Jefferson's has been many times divided. A new house where the old one stood, a slave cottage down the hill, some 500 acres of thin pasture, abandoned fields, and a piece of woods, are all that remain of the greater part of Shadwell as a place. Some of the flatter parts of the old fields still have fair soil, rather, a mixture of soil and subsoil.

Cup your hands before you at a natural angle, and you have a rough representation of Shadwell's topography. The residence stands high, about at the juncture of your little fingers. Behind and above the house, on land sloping sharply inward, is a 35-acre block of virgin timber.

Go into that woods with a spade, dig through the vegetative layer of forest duff; and you find from 5 to 6 inches of rich brown topsoil, entirely preserved. Nowhere on this steep wooded slope will you find destructive erosion. Topsoil remains there as rich and probably as deep as it was when Peter Jefferson built his story-and-a-half clapboard home here in the wilderness 200 years ago. An oak recently felled in these woods was more than 300 years old.

The woods dip to a small stream. The opposing slope is of roughly the same extent and dip. Ten acres of it is steep, cleared land, swept bare. All the brown topsoil is gone. Gullies have cut through the red, stiff clay, secondary layer and on through a layer of weather-softened yellowish rock material to bedrock.

The bedrock is of igneous origin. The soil that formed from it over thousands of years classifies as Davidson clay loam, one of the prevailing types in this section. Unlike soils formed from granitic rocks, which are most common in the Piedmont, Davidson soils are derived from rocks that are not acidic; and they contain more lime. They will take more abuse than most soils, and still make crops; they are not naturally so erodible as the other Piedmont soils of similar slope and texture.

Even so, this field has gone with the rain. From the undisturbed soil profile on the wooded slope, you can see what has been lost. Around 6 inches of topsoil, all over; the better part of a 2-foot subsoil; and even part of the chipped rock particles from the surface of the decomposed bedrock—chips that are at least a thousand years from weathered topsoil—all this has been washed away.

Grass might have held this ridge intact. Trees would have held it. But no Piedmont slope that runs between 20 and 35 percent can be safely plowed. Someone, probably long after Jefferson's time, plowed it. And here it is. Its only vegetation now is an occasional wisp of broomsedge toward the top, a few weeds, and here and there in sedimented spots along the gullies, a struggling brier.

Probably the gullies have lowered the water table. The spring at the head of the branch which runs down the cut between the woods and this cleared field goes dry now, from time to time.

From the cleared hilltop you can look beyond the present line fences of Shadwell and see in an almost continuous stretch thousands of acres of cultivated or once-cultivated land in the same condition, or approaching it.

Earthworks

Farmers in our cover-cropped Southeast, where the need of erosion defenses first appeared, evolved from experience earth terracing, one of the important devices now being developed and demonstrated by the Soil Conservation Service there, and in many other parts of the country.

Contour cultivation, rotations, reforestation, improvement of grass stands, terracing, and hillside ditching—none of these measures is

new. Most of them have been known for centuries in other countries. All have been haphazardly discussed and practiced for at least a century on our oldest one-crop farm land, in the Carolinas, Georgia; and to some extent in adjacent States.

Some of the major devices of erosion control remain the same in general principle, but there are hopeful differences between the old South's first drive to hold its soil, which dates roughly from 1800, and the present drive. Implements, engineering knowledge, and farming knowledge in general have greatly advanced. It is possible now to do well what used to be done feebly. Again, and most important: It is recognized now that there can be no simple and single cure-all for erosion. Nearly every farm presents a different case. On no farm can any one defense measure be counted on to do the job, entire. Appropriate measures are used to support one another. The job now is to develop from experience coordinated systems of defense—farm-by-farm, field-by-field, management programs that will preserve the farm and at the same time make that farmer more money.

Natural laws show that until the different kinds of land, dependent on soil character, slope, susceptibility to erosion, climate, and cover, are treated individually according to their needs and adaptabilities, success cannot be obtained with any program for erosion control. These differing parcels of land that go to make up a field, a farm, a watershed, the Nation, call for the use of all the knowledge that science and experience have accumulated, all the practical measures that have been devised. But that is not enough. We do not know enough. Successfully to combat accelerated erosion and waste of rainfall we must have a continuing program of research to discover new methods, to improve old methods.

On two watersheds aggregating 200,000 acres near High Point, N. C., Soil Conservation Service, working with 1,613 individual farm operators on private land, is pushing working combinations of rotated strip fields which sometimes straddle wide, rounded Mangum terraces, and sometimes do not. "The emphasis here," writes Wellington Brink, in a field note to Soil Conservation (March 1936) "is decidedly on vegetative measures, although mechanical structures are given a part in the control program when their cost is justified." Rigid prescriptions are of no account. Soils and slopes are too various. ". . . one farm in this area has 21 different soil types," Brink notes; and adds: "They have tried many promising ideas . . . program of control centering on the thoroughly tested broad-base Mangum terraces, strip cropping, rotation, and supplementary engineering structures, where necessary, for the control of gullies and run-off waters."

These two projects, on the watersheds of Deep River and Brown Creek in North Carolina, are in their third year. But they have far more than 3 years experience to go by. Efforts to stem erosion are almost as old as agriculture. To skip, for the moment, Old World efforts, we have scattered record of a long agitation and divided effort here in the United States. In 1788 the Agricultural Society of Philadelphia offered medals of gold and silver "for the best method within the power of common farmers of recovering old gullied fields to a hearty state." In 1811, the Richmond Agricultural Society sought, by questionnaire, practical data on soil-saving rotations and conservative methods of cultivation. Even earlier, in 1801, James Hall noted destructive erosion near Natchez, Miss.; and in 1813 the Louisiana and Mississippi Almanac urged sheep as a crop less destructive to topsoil than cotton-cotton-cotton.

Out of contour plowing, which failed as a single measure of defense in Virginia and elsewhere, developed "hillside ditching;" and that as a single measure also failed. From hillside ditching earth terracing developed, and became an erosion cure-all dominating southern control efforts, even to date.

European terraces and hillside-drainage systems that returning travelers describe with admiration are permanent, imposing, and costly structures. Along the Mediterranean and the

Rhine, particularly, small farms resemble giant stairways or, where slope of the hill turns inward, amphitheaters. The masonry "risers" are vertical or nearly so. The curving, nearly level bands of soil between are, in effect, small separate fields. The hills of Ireland were thus protected by "stone hedges," with the soil between them leveled, many centuries ago.

Such terraces, faithfully reproduced on a monastery farm in northern Kentucky by French stone workers especially imported for the business a century ago, are found now by Soil Conservation field men to provide almost complete defense against erosion. Similar structures, recently installed, are in successful use on California hills—cliffs, almost—planted in avocado groves.

For highly specialized plantings tended mainly by hand, hand-made notches in hillsides may be all right. But for open-field farming with mechanized methods such terraces are economically implausible. They cost more than most field crops can repay, and they closely restrict the use of modern implements.

American terraces are ingenious and necessary adaptations of Old World models. They are made by team or tractor power from the body of the field itself, of earth. Generally they are so laid off as not to "cut up" the field into separate fields and add to the number of turns and waste motions of cultivation. The evolution of southern terraces from puny ridges to the broad-base Mangum type and the more recent Nichols type may be traced partly by terrace ruins on racked hills, and partly in agricultural publications of the nineteenth century. In general, it went like this:

Under a one-crop system on sloping land, contour plowing proved of itself inadequate. Rain still dashed off and stripped off topsoil. Early in the 1800's some farmers were trying and championing contour "drains," or open ditches, as a supplement to contour plowing. The dirt dug from such drains was thrown up as a casual embankment on the downhill side. By the 1830's "hillside ditching" had a considerable group of champions as the one way out. But more farmers, having tried them, seem to have come to the general finding that the embankment was more important than the ditch.

For one thing, ditches, cut into subsoil which, lacking humus, is generally more erodible than topsoil. To grade a ditch on the level is a delicate business; to conduct one safely around a slope is harder. Above or below ground, on flats or hills, drainage lay-out is a job for engineers. Terraces laid off by guess or with a spirit level are perhaps not as risky as hillside ditches so designed; but they are risky.

Terraces are dams. If they are slenderly made or sharply curved, and badly graded or spaced, the impounded water hammers at the weak spots. The dam breaks. Water tears through with redoubled violence and rips to bedrock the field this slap-dash earthwork was reared to save. That has happened from Virginia to Texas, time and again.

In the face of many failures, farmers kept terracing, with changing designs. Earthworks assumed stronger, more moundlike forms. The general trend was away from choppy earth "breakers," toward long, smooth "swells" of earth. At High Point, and at most of the 165 soil conservation demonstration watersheds throughout the country you see terraced stretches of farmed country that remind you of a calm sea, running in a slow, strong swell.

Most of these are terraces of the Mangum type, named for Priestly Mangum, a North Carolina farmer who, by 1885, had worked out on his farm near Wake Forest the principles of their construction and design. With various regional modifications the Mangum is now the standard terrace on open fields throughout most of the Nation. A recent development is the Nichols terrace, with more of a ditchlike channel and milder gradient on the downhill side of the embankment.

The terraces on the High Point watersheds are Mangums. They are set with vegetation the first year. After that they are worked over with rotated crops in strips. The strip fields

are crop bands around the hills. They overlay the terrace pattern. Thus, contour cultivation, rotation with cover and on the contour, and terraces, are made to supplement one another as measures of defense.

At Spartanburg, S. C., Soil Conservation Service headquarters for the Southeast Region, investigators and fieldmen declare for the Nichols terrace, a modified Mangum, developed in Alabama. This is a low, winding ridge of earth with a distinct notch, or ditch remnant, on the uphill side, and closer conformity with the prevailing slope on the downhill side. They are cheaper to build than Mangums. The dirt is moved downhill, only; not both up and down; and they are cheaper to maintain. Moreover, the ridge is composed more of a mixture of topsoil and subsoil than the regular Mangum, which is built chiefly of topsoil.

All over the country, you will find conservation workers and farmers variously persuaded, by immediate and actual experience, that the notched or the unnotched soil embankment is the thing. This variety of ideas seems to derive reasonably from the nature of local subsoil. If the subsoil can stand a careful scratch, above the terrace, to help carry off the water the terrace gathers, on a careful grade of about 1 to 3 or 4 inches in 100 feet, the distinct water channel may help. The red clay generally underlying Cecil, Davidson, and related soil types in the southern Piedmont is unusually stable; it can take it.

Notched or not, broad-base terraces throw strong, protecting arms around the slopes. Properly reinforced with vegetation and other control measures they slow down run-off, and in some places, permit cultivation on grades up to about 12 percent. The cost of building them varies according to the site, equipment, and soil. As little as $1.50 an acre covers the job occasionally; but in most places, upwards of $5 to $10 an acre can be counted when both outlet and terracing work is thoroughly done.

The cheap and slap-dash way of terracing sought simply to dump the water off the field, and forget it. Thrown off, it tore up highways or some other man's land. Modern terracing systems provide terrace outlet channels which pick up run-off at the terrace ends and ease it safely into a stream, or a piece of absorptive woodland, or a lowland meadow strip, where it soaks in. The terrace outlet channel—t.o.c., soil conservators call it, for short—is meticulously graded and protected against washing. Usually in the southern area vegetation is adequate protective paving for all outlets regardless of slope. The amount of water to be handled is the determining factor and not the degree of slope. In some instances small amounts of water are carried over good Bermuda grass where slopes are as steep as 15 percent. But occasionally, check dams or baffles may be needed. The top of each such low, rough dam is made level with the bottom of the next one uphill. The channel bottom washes and benches off evenly between these breaks. Water descends from level to level by easy stages, and the channel becomes a permanent structure of defense. The technicians of the Soil Conservation Service, however, are depending more and more on vegetative control of terrace outlets.

On Red Hills

The watershed of the South Tyger River, near Spartanburg, S. C., is of 111,000 acres. The Cecil clay loam, prevailing here, is brick red in the subsoil. The original brown top of it has gone or mostly gone from probably more than half the area. These farmers are working the red subsoil. The Tyger, and all the other rivers here run red most of the time.

Local measurements of soil loss by erosion made within the watershed show that plots planted to Bermuda grass in 1935 lost only 262 pounds of topsoil per acre that year. Under lespedeza cover, the loss was less than a ton of soil to the acre. Under corn the loss was 7 tons to the acre. Under cotton it was 18 tons to the acre.

An annual soil loss of 18 tons means about an

COILED FIELDS HUG THE HILLS.

Instead of imposing themselves on the landscape in stiff checkerboard fashion
these South Carolina strip fields have fitted themselves at last
to the lay of the land.

THESE TERRACES BROKE.

Made slapdash, with inadequate knowledge and power,
many of the South's first earthworks redoubled ruin.

inch of soil lost every 8 years, and 6 inches in half a century.

Approximately three-quarters of all cultivated land in the southern Piedmont is planted to cotton or corn now.

If these farmers could cut out corn and cotton and live by grass and woodland culture, they would have no serious increase in erosion from now on; and their torn fields would heal. But that cannot be done. This is cotton and corn country. The problem here in hilly red lands is to grow the cash crops, and at the same time hold on.

It is a hard problem. Much of the country is gullied and most of it is badly eaten into. Yields have declined. "In four townships of Spartanburg County, lying within a few miles of each other," T. S. Buie, the regional conservator, reports, "parts least eroded are found to average 108 bales of cotton, to the square mile, against 34 bales to the square mile from the parts most eroded."

Defense programs on the South Tyger watershed have been taken up by 759 of the farmers there. First, soil conservation engineers and agronomists consult with the farmer and redesign the farm. The steepest and worst-washed parts are retired to woodland or permanent pasture. The remainder is laid off in strips that wrap themselves around the hills.

On steeper slopes that must be farmed these strip fields straddle terraces. On lesser slopes, strip cropping alone proves often adequate.

Flying in a plane over the South Tyger watershed you see alternating field strips (plowed and vegetated), coiled around the hills in various colors, as all hill fields in the United States some day may be. Instead of imposing themselves upon it in stiff checkerboard pattern that defies common sense and the laws of gravity, these fields have fitted themselves at last to the lay of the land.

Such fields bring out the lines of a countryside, and dress it beautifully. But beauty is not the object. The object is to keep that piece of country in production.

Here in the South Tyger watershed is a rounded slope of 35 acres, with four cropped bands around it; and a rotation in practice that provides for a shifting of the crops planted on the bands. The crown and top quarter of the hill are brown. That is cotton. The next band down is green—lespedeza. Then a band of cotton. Then another band of lespedeza.

The owner of the farm says that when it rains he can see muddy water from the cotton strips enter the strips of thick lespedeza, and come out notably cleared of sediment on the other side.

Next year, the grass strips will be contour-plowed and put into cotton. The cotton strips will be put in lespedeza. This is on a hill that slopes fairly evenly around 8 percent, all over. Terraces have thus far proved unnecessary. Here is a new type of rotation, one carried out on the contour rather than by haphazard fields.

Individual treatments, from farm to farm, and from field to field, vary endlessly. On another farm within a mile or so of the place just noted, the cliffs of a gully have been bulldozed down so that teams can get across it. The gully, stabilized with Bermuda grass strips and rock baffles, has been turned into a terrace-outlet channel, discharging run-off from terraces into a nearby woods. The crest of the hill, which is sharp, has been netted down with a permanent strip of Bermuda grass. Below that the band rotation is cotton, then wheat, then lespedeza.

These banded lands vary in width from 15 to 100 feet, according to the severity of the grade, which runs up to 14 percent in some places. Cotton rows, or drilled strips of grass or a legume and small grain march right over the terraces, in turn. Remaining partisans of earthworks as the one sure way to plow hills and keep them doubt the wisdom of working over terraces this way. Such attempts on the South Tyger watershed proceed tentatively, watchfully, but with hope.

First, bands of thick crops there followed terrace lines, 10 feet above, 10 feet below. The next step was to try narrow strip crops between terraces; and next, wider strips over the ter-

races, covering about half of the terrace interval. That is the method most favored on the South Tyger area now.

Here, as on other demonstration watersheds, the tendency is to narrow strips of thick crops to lengthen rotations, and to retire to grass or woodland slopes that do not stand up under guarded cultivation. Professionally terraced and maintained, almost any hill can be made to grow tilled crops for a while; but the cost runs up, and generally if the gradient exceeds about 12 percent, the soil eventually will run off into the streams. Effective terraces cannot be built by everyone, or kept up without extra expenditure and effort. Wherever simpler methods can be made to serve, so much the better. And, above all, the steeper more erodible slopes must go to permanent protective cover.

The rolling, red hills of the southern Piedmont could, for the most part, be safely farmed, if it were a mixed-crop country. Economic pressures concentrated here have pumped topsoil and fertility from the uplands to lowlands—cotton, cotton, cotton. The same pressure has driven still more cotton to the hilltops, to strip them bare, to wipe out or to bury with worthless soil debris the fields below. The pressure continues. The chief hope is that even in an eroded one-crop country, cash crops grown conservatively on the most likely slope and soil, with supplementary crops such as woods and pasture, or game, uphill, can be made, rather quickly, to send more stuff to market, and to make more money than the same farms made when they were plowed haphazardly and mined for cotton, all over.

On cheap land such as this it begins to seem likely that the thing can be done. One of the first increases is in capital value. Property prices fall off sharply on eroding farms in erosion-conscious areas; and rise when the soil is stabilized. Bankers, too, have become erosion-conscious in making loans. Joseph Pearson, a farmer cooperating on the South Tyger project reports to headquarters that he tried to sell his place in 1934 for $2,400, and was offered only $1,800. Now he has been offered $2,400; but he figures that the place, redesigned and stabilized with practical conservative measures, is worth at least $3,500 as an established, money-making concern.

Living on the Leavings

Background studies of accelerated erosion made by Dr. Buie and his associates in the Southeast, lead toward a somewhat paradoxical finding. It is plain that debt and starvation prices have at times driven cultivated crops uphill to thin, steep land, and so have tended to increase soil erosion. But it is equally plain that boom times, with towering prices, have driven farmers and their plows just as hard uphill to the same ending.

A native of South Carolina, and a lifetime student of its agricultural history, Dr. Buie believes that the soil was better cared for, as a whole, under the old plantation system than it has ever been cared for since.

"Talks with very old people," he says, "bring out the fact that most of the old slave plantations were largely self-sufficient. They raised their own living, and took care of their own. With so many people to feed and care for, the oldest places made diverse plantings, and did not put every available acre in cotton."

In that more spacious time, pressure on the land was not as intense. First records show that the main preoccupation was timber, not cotton. Timber was slaughtered, but the plow did not follow far uphill. The practice was to plow the bottoms, wear them down, and move on. Not much steep land was plowed.

The war between the States left marks on southern soil still to be seen. Undermanned and neglected, many farms ran down. On the other hand, some of the land, with a blockade operating, got a rest from cotton, and began with pine and weeds to heal itself.

Worse trouble came after the war. Then brush and old-field pine had to be cut away and wounded fields reopened. The implacable credit system which pushed cotton had passed for the

most part into northern hands. The South owed a huge debt. Its farmers were driven, and its soil suffered. In second-growth piney woods on some of the steepest ridges of the Tyger River country, soil conservation men now find broken remnants of crude terraces—evidence that in the 1870's, 80's, and 90's or even later the very crests were cleared, under pressure of debt and low prices, in a desperate effort to grow a little cotton there.

The earthworks broke. Cultivation was abandoned. Healing pines took hold on those crests again. Southern pines will grow on subsoil, almost on bedrock. They break the smash of rainfall and cover the ground with their needles. Under the needles topsoil returns. Slowly: In a second-growth pinewoods 50 years old, southeastern soil conservators lately measured the topsoil that had formed under the needle coating since 1887. The most they could find anywhere was one-sixteenth of an inch.

To many such brushy wood lots, guarding crests and the lands below, wood cutters and plowmen returned when the cotton line marched uphill again, around 1917. It was no poverty-driven plod, this time, but a boom parade. The same delirium that ran black Iowa praire land up to $400 an acre moved red hills here for as high as $200 an acre; and $1,700 was not considered too big a loan on 150 acres of red hill land.

James Derieux reports in The Country Home the case of a South Carolina hill farmer: "He had been making from 10 to 20 bales of cotton a year, a few hundred bushels of wheat, enough corn and peavine hay to do him." When the drum beat reached his farm, this steady fellow cleared a steep hillside of timber, slapped that and nearly every other piece of land on the place into cotton, ran his production up to 50 bales annually, and ruined his farm.

"World War prices and inflated land valuations," says Dr. Buie, "pushed cotton often to land that had been tried in cotton before and abandoned to timber. An old way of looking at the land came back: Again and again, I heard men say: "The timber will pay for it; and after that it will make some cotton." Later, I heard them say, man after man: "I bought this place in 1918, and made five crops of cotton."

"That was the very game played here in South Carolina after the first settlement. Chop, crop, and get out. For a few years after 1917 we played the same game over, and soon played it out. The consequences this time were more serious. This time we had much less wealth to squander. We pushed higher up the hills to get what we could while the getting seemed good; and hurt even more of our land than we did the first time."

The ebb in cotton price came long before the stock market gave indication, in 1929, that postwar conditions were not eternally rosy. And, after 1929, cotton kept crashing until it hit an all-time low, under 5 cents a pound.

Even so, the crop did not notably retire from the hills—except here and there, where cottoned-out hills refused to support such desperate husbandry. But what to do? You had to try to make twice as much 5-cent cotton as you had of 10-cent cotton, to meet taxes and interest, and to hold your farm. Many farms were lost, not only to mortgage holders who for the most part didn't want them; but to the sea.

Present farm migration in the Piedmont lacks dash and direction. In the hardest-tilled parts to the South, it has mainly come down now to a troubled milling around of small owners and tenants from place to place. Hopeful, hard-working people are promising to pay interest or rent on farms that ought not now be farmed for that much rent or interest; if farmed at all. "You see them pushing out to try it over again on abandoned, skinned red hills," says Dr. Buie, "you see them plowing, planting, toiling failing. It hurts to see it. If you grew up here, as I did, and love this country, it cuts you to the heart."

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The Midland Is Taken

The symbolism of the western journey is tremendous. It has given the commonplace word "frontier" a meaning for Americans that it has for no other people . . . Inseparable from that meaning is the beauty of the land across which the journey passed. Whatever else the word means, it has also meant water flowing in clear rivers, a countryside under clean sun or snow, woods, prairies, mountains of simple loveliness . . . Layer after layer of experience and frustration may come between but at the very base of the American mind an undespoiled country lies open in the sun.—Bernard De Voto in Mark Twain's America.

"*Most Spacious Habitation*"

"ALREADY," said Burke, speaking of the American colonists in Parliament before our Revolution, "they have topped the Appalachian mountains. From thence they behold before them an immense plain, one vast level meadow; a square of 500 square miles."

There was much more to this country than that: A million and a half acres of meadowy bluegrass soil, rich in natural lime, between the Ohio and Tennessee Rivers; and, beyond that, the prairies, and beyond that, 700,000,000 acres of sparse trees or no trees at all—"a pasture country greater than the known world in the days of Homer," says Archibald MacLeish.

With a post-war depression which, after a short period of spotty prosperity, followed the Revolution, the pressure to get over the mountains increased. A million Americans were living west of the mountains by 1800. By 1820, the number had swollen to 2½ millions; and by 1830, according to James Truslow Adams, 3½ millions or "one-third of the American people were 'Men of the Western Waters,' as they loved to call themselves."

To a remarkable extent, the great sweeps of western migration followed panics or business depressions. The Land Offices of the Government proved then our Relief Administration. The western march was in considerable part a relief march of the unemployed and dispossessed. The full tide of immigration from the Atlantic coastal shelf, north and south, and the eastern slope of its highlands, to the western waters did not roll until after the panic of 1819.

A relationship between free land, or land nearly free, and the national slogan "Land of the Free" is evident throughout the eighteenth and nineteenth centuries in American history. Our coastal settlements represented in large part a back-to-the-land movement from Europe; and so did the successive western surges which settled and resettled this country in the following 200 years. It may be, as some historians and essayists point out now, that a nation settled largely by men and women who could not stand and take it where they were, somewhat lacks in its bloodstream the qualities of stolidity and patience. Stolidity and patience do not, indeed, appear to be our strongest points to date. The Chinese are better on that. They have to be. Yet it is not unreasonable to suppose that in the earliest days of settlement Chinese frontiersmen aspired, as ours did here, to stand on their own two legs on their own piece of ground, free and independent, and look any man in the eye, and tell him where to head in. That must be a very old dream of humankind. The Jeffersonian tenet, that the least government is the best government, is probably as old as farming. It was a rude business, the taking of the frontiers. "Old Mis-

sou—good for mules, but hell on women," is a midland frontier saying, true to fact. But an abundant supply of new soil to be taken free or nearly free, sustained for upwards of 200 years an extraordinary degree of equal opportunity in this country, and we miss it now.

In 1828, it is said, Andrew Jackson, standing high up in the Appalachian region, remarked to a friend: "From here out to the Mississippi River there is enough good land—much better than the land to the east of us, with soil richer than the soil of the Nile Valley—to take care of all the population we will have in the United States for the next 700 years."

What actually happened was that in 75 years all the land to the Mississippi was taken. Beyond that, all the prairies, all the high plains, all or nearly all of the intermountain area, were taken. And still beyond, most of the usable land across the Sierras and Cascades, to the Pacific shore—it all was taken in the next 75 years.

De Toqueville, an early French visitor to this shore, accounted, sympathetically, for the frenzy of taking and destroying. He wrote that here in early America, the good and rare things, in most countries secured and held by the few, were abruptly thrown open to the grasp of everyone.

Later visitors from Europe returned to tell without sympathy of lavish waste and carelessness. In 1846, when the main tide of western migration had barely passed from the Land of Western Waters to the great Mississippi Basin, Professor Lyell, an English geologist, reported in a field less than 20 years cleared and cropped, near Milledgeville, Ga., a gully 55 feet wide and 180 feet deep . . . Shaler, a historian native to the region, and one of the first to cry alarm at soil waste, estimated 50 years ago that 4,000,000 acres of Virginia, Tennessee, and Kentucky which had formerly been cultivated had, even then, been destroyed for farming purposes.

All this gives additional point to the famous letter Lord Macaulay of England wrote to an American physician in 1857. He declared in this letter his complete conviction that "institutions purely democratic must, sooner or later, destroy liberty or civilization, or both . . . Your fate I believe to be certain, though it is deferred by a physical cause . . ." By "a physical cause" Macaulay meant the free or abundant land, the occupation and removal of which we are here considering.

Both the corn-and-hog and the Wheat Belt concentrations were clearly outlined in embryo by the 1840's. Then the invention of wheat drills, and, in 1847, the invention of the McCormick reaper, drove the midland wheat rush on with new vigor; and produced in the North and central east, on older soils, apprehensions and troubles not unlike those of the coastal South when the westward rush of cotton on cheaper lands began to hit full stride. The railroads followed.

The great central valley the farming settlers entered toward the beginning of the nineteenth century was of a richness and magnitude that made even the widest and best-watered valleys eastward seem cramped and frugal. A sea of grass with islands of wood, the greater part of the Mississippi Valley reaches in level stretches or in undulating, slowly heaving hills and vales from the western base of the Alleghenies to the eastern slope of the Rockies.

The taking of the midland was accompanied by some danger, hardship, toil, and suffering; but an air of boisterous zest surrounded the business. Boom towns, stomping dances, big talk, hope unlimited, and a veritable explosion of moving, building, and moving kept things lively. The men, at least, seem from most pioneer chronicles to have had a wonderful time. Horse-trading ethics applied, quite generally, to land acquisitions. The records abound in feats of high-hearted chicanery on the part of individuals and corporations, great and small. Tall tales fascinate frontiersmen in general, and they carried that liking into real estate transactions with an infectious enthusiasm. Often they believed their own gorgeous lies. John J. In-

galls wryly described the circular depicting the town of Sumner, which attracted him from Massachusetts to Kansas as "a chromatic triumph of lithographed mendacity." He survived his disillusionment and for 18 years represented Kansas in the Senate. His grandiose oration, Grass, a true warning to the midland and the high plains beyond, hangs framed in many a western farmstead and seed store—a pioneer memento, now that both Senator Ingalls and the native sod are dead and gone.

Indeed, it was a hard country to describe in strict and sober truth, our vast and gleaming midland, in that early day. Spread like a rolling sea of land in calm flats and slow swells, breaking here and there into riffles of rounded foothills; enormous, sleek, abundantly watered; our midland from the Gulf to Canada was land of an all but incredible fatness and beauty. Appraising it soberly, by hindsight, in his Conservation of Our Natural Resources, "Probably," wrote Charles R. Van Hise of the University of Wisconsin, "no equally large area of the world surpassed it in original fertility." James Truslow Adams, as a historian, calls it even now, "the most spacious habitation for human life to be found in the world."

Many implausible tales handed down by the first settlers of Ohio, Indiana, Iowa, Kansas, the Dakotas, and southward, appear in the light of long digging by midland historical scholars, true. Grass stirrup-high was no novelty. In some places native grass stood above the head of the tallest man, dismounted. Children often got lost in it. It was good rich grass. Horses' coats took on a high, sleek shine when you turned them out to grass in the spring. The prairie soil, grass guarded, produced in countless forms a riotous, abounding life. In Illinois, "Beds of wild stawberries came ripe in June and stained horses and cattle crimson to the knees," writes Carl Sandburg in Abraham Lincoln: The Prairie Years.

To break the prairie sod, it took teams of four, six, or even more of the stoutest oxen, in many places; and often the iron plow broke first. So stout and deep a net the native grass had woven, darkly through aeons, to hold this fat and slowly heaving sea of land, the prairie. "I can hear those grass-roots a 'crackin' and a 'poppin' yet," says Edmund Elijah of Iowa, interviewed. A survivor of the breaking in the north of that State, he is nearly 90 years old.

Where Cotton Marched

"If western land spoilers knew how eastern land skinners had skinned their land to death, they would not go on doing just the same thing," wrote Solon Robinson of Indiana. "But they won't know, and, of course, won't do." This is from the first volume of his notes and letters, edited by H. A. Kellar, and published in 1936. Solon Robinson was the founder of Crown Point, Ind., a pioneer prairie agriculturist, and a voluminous writer with little use for the word "perhaps." He had a good eye for land and its prospects. Some of his pronouncements seem downright prophetic now.

Visiting Mississippi plantations, he approved of hillside ditches there: (built as many) "as may be necessary to take up and carry off all the falling water, almost on a level, and winding round till an outlet can be found to discharge it without injury to the land." He saw at once the most important thing about hillside ditches—the new pattern and principle of cultivation they imposed:

"These ditches are laid off by a level, and are intended to remain permanent fixtures; and all the plowing has to conform to their shape . . . as a matter of course, utterly annihilating 'straight rows'."

He praised the South's Bermuda grass, and scorned planters who rejected the tenacious cover it offers for fear of having it spread all over the place. "They . . . prefer," he wrote, "to see their land taking its rapid course down the millions of gullies through which some of the finest soil in the world is sweeping its way rapidly toward the Gulf of Mexico, rather than risk the trouble of getting this grass into their cultivated fields . . . For be it known, this is *the land of gullies*." He wrote this in 1845.

The same thing may be said of other parts of this country now, even of parts settled as little as a generation ago. But our most horrible man-made gulches still appear in greater frequency along the cotton trail westward, and particularly here where the Alleghenies, subsiding, allowed early and easy entrance into the southern midland for cotton planters on the march.

Here where slopes drop southward and inland the land has taken between one and two centuries of punishment from a brutal one-crop system which grew from no one's choice, simply from circumstances. Naturally, the old-time "land of cotton" offers more striking examples of devastation than any other. At the same time, and again naturally, soil defense in the cotton South has been developed more generally and thoroughly than anywhere else in the United States. Most of the measures under development westward and northward stem from here. At the risk, then, of seeming to pick on a part of the country deeply troubled, and not especially to be blamed for its present condition, let us start this middle section of present-day field notes here, where cotton marched, and work inland and up through the midland.

From the Drip of a Barn

Stewart County, Georgia, is on the Alabama border. A line drawn straight north would pass through western Ohio. In 1913, when fieldmen of the Bureau of Soils making the first American soil maps reached Stewart County, they found a greater part of it devastated.

"We mapped," said H. H. Bennett, testifying before a congressional committee in 1935, "70,000 acres formerly cultivated, reduced to largely worthless gullied land. Much of it was the best type of soil in southern Georgia—the Orangeburg, Greenville and Ruston sandy loams. Some of the gullies are the deepest I have ever seen. The largest of them, locally known as Providence Cave, is eight miles west of Lumpkin, Ga. . . .

"Last year I talked with a gentleman who went to school in a schoolhouse that stood in the center of Providence Cave. If the schoolhouse were there now it would be suspended nearly 200 feet in the air. It has toppled into the gully, I was told, and along with it has gone a tenant house, a barn, and part of a graveyard."

All this, and at least 3,000 acres of farm land, the rain has devoured during the past half century or so, in one man-made canyon only, together with its appendages; and this, Providence Cave, named from an early community, keeps eating along with lesser nearby gullies, into more farm land all the time. "Fingering" is the technical name for it. These great raw gulches throw out branching arms and claws. They are like malign living structures, creeping, feeding on soil, on the habitations of the living, on the bodies of the dead. Stuart Chase, who saw Providence gully in 1935, wrote:

"We stood over one of the gully's arms and far down caught a glimpse of the central basin . . . A red gash on a little hill a mile away marked a tip of another tentacle of the same gully.

"The chasm was awful and beautiful. The earth strata changed from red to yellow to brown, mauve, lavender, jade, ochre, orange and chalk white. Pinnacles rose from the gully floor, sometimes with a solitary pine tree on their top at the level of the old land, banded and frescoed with color. Along the banks trees were in all stages of collapse—some just ready to plunge downward, some holding on by their roots with might and main, some leaning crazily outward. . . The good earth had given up the struggle."

Providence gully got its start, according to local information, from the roof drip of a barn it since has swallowed. It dates, as a visible menace from around 1890, as do some of the other great gullies of the vicinity. It is not safe to go up to the edges of any of them. The chalky substrata undercuts. Even where some sort of protective weed or forest cover has formed, the walls keep caving under, eating back. After heavy rains, it is said, you can sometimes hear them crumbling and crashing from considerable dis-

tances. When such a gully throws an arm across a road, that road is gone. When it turns an arm toward a farmstead, that family has cause to consider moving.

One arm of the Providence gully is eating toward a still comfortable-looking farmhouse and lay-out on a crest. Can it be stopped? Are this farm and family past help?

Field and Gully Healers

By the hasty old technique of simply throwing things into gullies or plugging them with little dams, control of deep, branching chasms such as these in Stewart County would be manifestly impossible. You could throw in half a county; still they would grow. Only by treating the watershed that feeds them with thickly vegetated diversion ditches to convey run-off around them safely; and then by lashing the whole job down with thick, quick-growing vegetation, could Providence gully be stabilized, if at all.

Even trenching, then revegetation, might not work there. Heavy equipment could not be used near the gully edges. And while C. C. C. boys and W. P. A. workers enjoy as a rule the adventure of being lowered by rope to make grass, tree, or vine plantings in the clefts of gully ledges, the chalky walls of Providence gully oppose to such operations a double hazard. The plants might not take hold; and workers might be killed in cave-ins. Again, there is always the question of operating cost, in dollars and cents.

So gully-healing operations at the edge of the middle South remain confined, for the time at least, to smaller gashes on farms not so far gone.

At Buena Vista, Ga., a gully 40 feet deep is healing under a planting of kudzu, an oriental vine. On the farm of Luther Nix, a farmer cooperator in the Sandy Creek watershed, around Athens, a four-forked gully 25 years old and around 50 feet deep seems, under a more elaborate treatment, to have been stabilized.

The work here has involved diversion ditches and a careful reset of varied vegetation—willows, locusts, Bermuda grass, anything that could be made to take hold. Soil conservators of the Sandy Creek staff figure that to attain to its present size this gully must have taken an average of 4.54 tons of soil a day during its 25 years of growth. It had ruined 2½ acres for tillage.

Southward, men count heavily on kudzu as a gully mender, and as a restorer of washed-down fields. A leguminous vine, native to Japan, kudzu was first grown in this country as an ornamental covering for porches and arbors. The vines grow from crowns. They accept small soil favors gratefully, and provide pasture and hay high in protein. "On very poor soils setting the crowns in post holes filled with rich soil had been tried successfully," writes Paul Tabor in Georgia State College Bulletin 356. Cows, horses, mules, and hogs eat kudzu eagerly; but if they are allowed to overgraze, they kill the vines. In the North the plant is likely to winterkill; though it grows in Washington, D. C. In the deeper South it sheds its leaves and starts again in the spring. It grows there like honeysuckle and is fed like clover. Given the barest sort of foothold, in that climate, kudzu will sometimes smother out, net down, and stabilize a sizable gully in a year or so. Some farmers are afraid to plant it because it grows and spreads so furiously. On the experiment station farm at Auburn, Ala., kudzu has never given serious trouble. Animals reaching under pasture fences chop neighboring pieces of kudzu back and tillage has thrown it back from cultivated land.

R. Y. Bailey, agronomist of the Southeastern States regional office of the Soil Conservation Service, exhibits on the farm of John Woody, a cooperator on the Dadeville, Ala., erosion-control project, a gully large enough to hold a good-sized house and barn. Two years ago this gully was given engineering treatment and revegetated with kudzu alone. The engineering treatment was a diversion ditch to throw run-off around the head of the old channel, and so keep it from cutting back at that point. Kudzu did the rest, in 2 years. Completely stabilized now, this gully may be counted on soon to provide reserve pasturage, if used with care.

In this warm, far-southern climate, kudzu

FROM THE DRIP OF A BARN.

One arm of Providence Cave, Stewart County, Ga.

KUDZU.

A miracle of restoration.

works miracles of restoration on farmed-down fields. Often it will push out and smother broomsedge, providing fresh, green leguminous forage in a year or two. Here, still in the Dadeville area, is nearly a whole farm under restoration. It is not all gullied land; but the whole cupped hillside has lost all its topsoil and part of its subsoil. It is beyond the stage of sheet erosion, and well into the next phase—rill and gully erosion. Sharp-cut bare rills, an inch deep, then 3 inches, then a foot deep, fork and join, sucking bright red subsoil down to larger bare, red gullies 2 feet to 6 feet deep now, and growing, along the lower slopes, extending upward.

If ever a farm were visibly dying, here it is. The bare, tumbling farmstead at the crest of the hill is empty now. The man who gave the mortgage has it. Another man hanged himself in that house.

It is December, with no green, living thing in view. Yet: "This planting is taking hold just fine," says Bailey, and points to a rope-line vine stem, hugging the ground at his feet. "It must be all of 30 feet long," he says, with some excitement, and paces it off to see.

Looking more closely, you can see that C. C. C. boys have built small dams of trash and rocks along the larger rills, all over the hillside; and back of these dams in dribbles of sediment they have set kudzu crowns. Checking the field over, you will find vines crawling from these dams, beginning to net the whole hill, lash it down. Some have made 10 feet of growth; a few have grown as much as 35 feet this first year.

On a small field nearly as far gone, nearby, kudzu, in its third year, has woven a net that covers the ground completely. You must look closely here, too, for it is winter, and the vines have shed their leaves. But here on the red ground you can see a light, natural mulch and small washes of soil held by clasping ground stems, which serve as millions of little dams. "This field is coming back. It will be green this spring," says Bailey.

Ingleside is Redesigned

Ingleside Plantation, near Jackson, Miss., was cleared from the forest at the beginning of the nineteenth century. In 1848 a mansion replaced the original log house, and the great house was called Annandale, for the Earl of Annandale, an ancestor of the first owner. A Bride of Annandale, whose lover fell on the dueling ground in New Orleans, still figures in histories and legends of ante bellum days, when Ingleside had thousands of acres and hundreds of slaves.

As time went on the soil, overworked, became thin and in places gullied. Efforts to save it appeared in the ruins of sharp, crested terraces, broken by the weather, barely visible now. Small acreages were sold, as need developed; but after the World War when an insurance company took it over by foreclosure, the property was still considerable, 1,079 acres in all. L. E. Brame, a planter and businessman of the locality, bought it from the insurance company for around $10 an acre.

The fields of Ingleside lie within a 144,000-acre watershed that drains to the Gulf through Okatibbee River. In 1935, when the Soil Conservation Service set up cooperative a control project on Okatibbee watershed, Mr. Brame was one of the first to come into the project.

Here as elsewhere, for purposes of quick, cheap mapping, planes flew over the area and photographed the land. Engineers of the project staff came on to the fields of Ingleside and mapped their condition. The survey showed:

On 41 percent of the plantation, from one-half to three-quarters of the topsoil had washed away; 44 percent more had lost half its topsoil, and was gullied; 6 percent had been entirely ruined for tillage by deep gullies.

Besides, 11 percent of the bottom land had been reduced in productive power by debris and subsoil washed from eroded land above; and 119 acres of upland under tillage were adjudged too steep for safe tillage under any practicable system of control.

With this information before them, an agronomist, an engineer, and a forester of the Service staff, drew, jointly, a new land-use map for Ingleside, and put it before Mr. Brame, who accepted it. "The plantation," writes Jerome J. Henry "was wearing an ill-fitting agricultural garment, too long unchanged. The essential job was to get as much of the land as possible covered by a protective mantle of vegetation for as much of the time as possible. . . .

"Thirty acres was retired to forest: on 8 acres, kudzu was put to work stopping gullies: 194 acres of steep land was retired from cultivation to pasture, making a total of 297 acres of pasture, some of it protected from washing by contour furrows, and reseeded with Dallis grass, clover, and lespedeza to give a thicker sod."

The fields were redesigned to hug the hillsides; strip cropping replaced square cropping on cultivated land; and all cultivation was put on a contour basis. Well-built terraces of the Mangum type were made on cultivated slopes, but only where strips and winter cover alone seemed risky, unsupported. "Natural methods of erosion control," Henry continues; "were supplemented with terraces and dams only where mechanical structures could not be dispensed with. On cultivated hillsides it was agreed that a 5-year rotation be followed. The rotation is cotton, corn, oats, and lespedeza, with the lespedeza remaining on the land 2 years.

"This modified form of strip cropping means dividing the field into five equal strips or parts measured out on a contour, and rotating the general farm crops within the five strips in a five-year rotation. It was also agreed that hairy vetch and Austrian winter peas were to be planted in the corn and cotton strips as winter cover and soil-builders.

"The idea behind it all is to get the rain to walk—not run—downhill; and, as it walks, to deposit its load of silt and sink into the ground."

Northward

Headquarters for Region 3 of the Soil Conservation Service is at Dayton, Ohio. The oldest watershed control area is Salt Creek, at Zanesville, on the old National Pike. Region 3 includes five States—Ohio, Indiana, Kentucky, Tennessee, and Michigan. A reconnaissance survey indicates that in these five States over an area comprising 34 million acres, as roughly mapped, most of the land has lost between one-fourth and three-fourths of its topsoil. Thirty-four million acres is more than 10 times the area of Connecticut.

Highway No. 1, which passes through Zanesville, strikes over the eastern mountains through the Cumberland Gap. The first settlement here was a mixture of northerners, who came by the pike, or by pike and river, and of southerners, working northward. Pennsylvania influences—deriving principally, from Germany—are apparent on the face of the better preserved of these steep hills today. You see farms here, as in Pennsylvania, where strip cropping and rotation have been practiced for three generations, where the steepest slopes have been kept in trees, and where intermediate slopes have been lashed down and held for permanent use as meadow or pasture land.

Such green and banded plantings stand, however, as exceptions to the generality. In 1934, when the Salt Creek erosion-control demonstration area was established on a watershed totaling 93,000 acres out from Zanesville, the surveyors found that, except in the bottoms, anywhere from half to all of a topsoil, which originally ran from 8 to 10 inches deep, had washed from these hill farms.

But it was the farmers in the bottoms who came in first to sign up for control demonstrations. This is true on watershed demonstrations throughout the country. Time was, no doubt, when owners of bottom land received thankfully rich deposits of topsoil brought down by the weather from the freshly plowed hills. But today, so much of the stuff that washes down is raw subsoil or worthless rubble, the valley farmers want it stopped. "That fellow up the hill is corning my land to death," they say.

An 80-year-old resident of Zanesville, John Winters, went recently with Service workers

over the Salt Creek area, and identified a thoroughly gullied and wasted field as one he had helped his father clear of forest in 1865. They had sold, he said, little of the timber; there was no paying market; most of the trees were burned. The field was put under a rotation of corn-wheat-grass, and worked thus until 1910, when an attempt was made to get a stand of grass as pasture, with scant success. The field slopes 45 percent. Cropping had washed it out.

Control measures in use on the Zanesville watershed, and on the 15 other erosion-control demonstration watersheds of Region 3, represent, for the most part, simply a concerted development of proven local devices to hold soil. Retirement from tillage of slopes with a high erosion hazard is a first step; but on farms where men must still make a living, this cannot be done sweepingly. Relatively hazardous slopes and soils must sometimes be worked, whether they ought to be or not. Such slopes are given every possible form of protection, with terracing as a last resort. As a general policy, slopes above 40 percent are reforested, slopes above 20 percent are kept in sod, and the lowlands and more tillable slopes are strip cropped, rotated, and contour-tilled.

This part of southern Ohio was natural bluegrass country when the settlers came. Plowing bluegrass land and overgrazing have led to much of the trouble. Pasture improvement, with lime and reseeding, is emphasized both as a control measure and a way to increase farm income. Tree and brush cover on rough land and in gullies is arranged with an eye to restoring wildlife as an auxiliary crop. Given natural feed and cover, game has been thus restored on many farms to the north and west, and farmers there make money by selling or letting shooting rights.

On small farms, some of them mountainous, with no one cash crop to take to market, erosion defenses must be simple and not costly. The leading recommendations in this hilly part of Region 3, are to get away from "square farming in a round country," to redesign holdings and methods so that every stroke of cultivation will oppose run-off, not feed and hasten it; and to get as much year-round cover on the land as possible.

Where To Look

Passing now from the elder East and middle South to States of the middle border and the great prairie, these notes will assume a general understanding of control practices, and take on a more general character. Nearly all known ways to check erosion have now been sketched in action. The reader will know now what is meant by contour cultivation, strip cropping, baffles, and check dams, terraces, terrace outlet channels, and similar technical phrases.

The same devices of control are used nearly everywhere but with endless variations. Strip fields in the Palouse of Oregon are not exactly as wide as in Ohio. Terraces in western dryland Texas follow a different grade from those in Tennessee. In the dry land, many terraces are level. The precise working combination of strips and earthworks, of pasture, tilled land, and woodland, that will do the job for a Maine potato farm will not serve on a ranch in California, nor probably on any other piece of farm land in the United States.

Accelerated erosion can be controlled. The practical and immediate way to do it is to combine the cheapest and most appropriate measures into rearranged management plans, farm by farm. The main idea is so simple that it may be stated in a word: Cover. Control work in Mississippi repeats in effect the work in Pennsylvania, and is again repeated in Ohio, the Dakotas, and Oregon; but with infinite detailed differences, dictated by soil, slope, climate, inherited farming habits, and cash at hand.

This publication is designed for national circulation. It attempts to outline the problem as a whole, to exhibit working combinations of control in different parts of the country, and to emphasize developing principles which seem to strike through local and regional considerations. To try to do more than that here would be of no practical benefit. Boldly to advance

specific prescriptions might sound downright and practical; but when it comes to advising this or that, specifically, for thousands, even millions, of farms, from a desk chair—nothing could be more impractical.

Even suggestions of technicians on the spot must be tempered by the farmer's closer knowledge of his own land, its possibilities and limitations; and his own. To form and fit an erosion-control plan to a given piece of ground is a job that must be done there, on the ground, with the lay of it before your eye, the feel of it under your soles, and an intimate understanding of immediate circumstances. Finally, as with all applications of scientific findings to workaday farming, the thing must be done, in the last analysis, by the farmer himself. Scientists, technicians, even writers may help him; but no one can sit back at a distance and farm for him.

Regional publications and press releases are issued from time to time from regional headquarters of the Soil Conservation Service. These contain suggestions which come more closely home to farmers and other interested persons in that region; but even in these, if the advices are practical, they are not downright. Farmers actively interested in stopping soil wash or blow-off will find their greatest help neither in words, nor in charts nor in photographs, but in visits to the nearest of the many watershed-control projects now under way throughout the United States.

There the story is translated concretely into terms of local use. There it is written not on paper, but on the face of the earth, on the face of more than 50,000 different, working farms up against the problem of holding soil and still doing business. A divided map, East and West, on the endpapers of this book, locates the main soil conservation demonstration areas now at work.

A "Depletion" Experiment

On a field with an average slope of only 4 percent the directors of the Ohio Agricultural Experiment Station at Wooster, started in 1894 to measure the soil-depleting effects of continuous single cropping.

If a man knocked senseless were brought to, here at Wooster, or anywhere for miles around in this part of Ohio, he would hardly know whether he was in northern Ohio, Indiana, Illinois, or Iowa. This wide swell of land, laid off in strict rectangles, with trim houses and great barns announces approach to the prairie. The slightness of the 4-percent slope on which the experiment was conducted can be visualized, by leaning a yardstick on a prop 1½ inches high.

Early records indicate that this was not an erosion experiment. In 1894, it is likely that no one, farmer or scientist, believed that our "flat" midland was seriously subject to erosion. The experiment was established to show how much fertility, not how much soil, is removed by one-crop farming.

Forty-one years' results, announced in 1936, reveal an amazing soil loss. To summarize the findings of the Ohio Agricultural Experiment Station as reported by A. J. Patch, Ohio extension editor: Forty-one consecutive years in corn have removed 8.9 inches of soil, by erosion. Subsoil shows over at least two-thirds of the field. Tile drains set before the experiment started from 28 to 30 inches down are now only 10 inches down, in places. Soil losses from this plot, figured on the average, have been at the rate of 35 tons a year. (An acre-inch of soil weighs, on the average about 150 tons; 6⅔ acre-inches weigh around 1,000 tons, over the country as a whole.)

In a plot kept 41 years in oats, soil losses averaged 19 tons a year. The average loss of topsoil, in inches, has been 5.2 in 42 years.

On a plot of more varied topography, sloping from 1 to 8 percent, and cropped under the rotation corn-oats-wheat-timothy and clover since 1893, soil losses varied rather widely. A low ridge lost 13.4 inches; average loss over a 1-percent grade was 4.5 inches for the 41-year period; and average loss over the plot as a whole, 7.3

inches, since 1894. The rotation, it will be noted, cut soil loss somewhat; but as a single measure of defense crop rotation proved of little use in preventing this mildly sloping midland soil from washing away.

Like findings were diffidently announced in Illinois 20 years ago by Arthur J. Mason, a retired engineer. In 1917, he read a quiet, startling paper before the Chicago Literary Club, to which he belonged. "This paper," he said, "is an attempt to describe five years of effort," and to arrive at "an approximation of the truth.

". . . Our rich lands are slowly being washed into the sea at a rate much faster than the creative agencies which exist for the manufacture of soil can do their work . . . The loss of soil I allude to is not the scouring gullies and obvious wash in the crystalline soils of our Southern States, but the imperceptible loss all over a field . . . With the best part of the land carried off as coloring matter in the runoff . . . Is there any type of agriculture which will retard this slow bleeding to death? . . . The culture of corn and cotton keeps the soil in a defenseless condition. I have tried lately to get from experts some definite measure of the soil loss, but without success. My own observation leads me to state that it will become a very serious matter within fifty years."

In 1920 Mason read to the same club a second paper. "Is the United States a Permanent Country, Like North Europe?" He had in the interim bought an Illinois farm: "160 acres of black corn land, smooth summit land without a ravine or waste place, every inch cultivable, (and) no part 20 feet higher than any other. It has been under cultivation 50 years. Already the soil is gone from the bumps. Almost half the soil has disappeared . . . A fair estimate for the whole countryside is that four or five inches of the mould have gone. The soil and subsoil are very different in color—black the one, yellow the other . . . For thirty years we have been hearing of the wornout lands of the East. Like the ringworm or erysipelas the failing land story creeps West . . . We must shift to a form of culture which keeps the soil bound together and protected by some form of sod."

At an earlier time when the Government was giving out land lavishly, the Illinois Central came into possession of a right-of-way 300 miles long and 200 feet wide. It runs from Chicago south, with virgin sod on both sides of the tracks, most of the way. Mason went out and dug test holes along 35 miles of this right-of-way—"first a hole in the ancient sod, then a hole in adjacent fields, about 50 years under cultivation."

"What have we found? In the first hole, 17 inches of black soil—30 feet away in the field only 9 inches . . . A bad case, not typical. It was a smooth flat piece of land, and we could see no reason for any especial wash. We never found in any test a loss of less than 3 inches. The average of all tests gave a loss of 4 inches of soil . . .

"*One might here announce, agricultural regions with dirty streams are, must be temporary. Agricultural regions with clear streams are, must be permanent* . . .

"Remove the soil from any region and without diminution of rainfall it becomes arid. Without soil there is no local water storage. The rainfall runs off as it does from a slate roof . . .

"The United States is not a permanent country like north Europe; cannot be, unless we . . . make it one by conduct altogether different from present practice. Within a century as we now go, Illinois, from being the envy of the world for its rich lands, will change to a harsh unproductive waste. If we have lost four inches of the best soil in fifty crops, the remainder will disappear in about the same time, for it is a case of unstable equilibrium. The more soil we lose the faster the remainder goes."

Over the Big River

In the same year when Mason read his first paper, 1917, F. L. Duley and M. F. Miller of the Missouri Agricultural Experiment Station staff designed and laid off on the slopes of the station farm, at Columbia, the first erosion check plots, for controlled measurement of soil

and water losses under various crops. Their method, still standard, is to lay off strips of the same slant, partition them each from each with treated wood or metal, plant them variously, catch water and silt in receptables at the foot of each strip, and measure the differences in run-off. In 1923 Duley and Miller published their findings (Research Bulletin No. 63 of the Missouri Station). Their experiments, carried forward and extended, provide the basis for Dr. Lowdermilk's computations on Corn Belt soil longevity, quoted on page 8, and the basis of all such computations at various college and erosion experiment stations throughout the country.

The test plots Duley and Miller laid off sloped 3.68 percent, on the average. The same, for practical purposes as the 4-percent average slope of the Wooster, Ohio, experimental field. The first 5 years' results in Missouri, announced in 1923, showed the following average soil losses to the acre, annually:

Bare soil (a Shelby loam) lost an average of 41 tons of soil a year by washing. Cornland lost 19.7 tons a year. Wheatland lost 10.1 tons a year. (These plots were kept continuously in corn or wheat for the 5 years.) Plots under a good rotation lost only 2.7 tons a year. Plots in continuous bluegrass lost only 0.3 ton of soil a year.

With nearly two-thirds of all American farm land which the National Resources Board rates as grade 1; with more than a quarter of grade 2 farm land; and with nearly a fifth of the farm land the board calls third-, fourth-, and fifth-rate, the upper valley is of all our great farming sectors the most richly endowed. But even here, where our land is richest, best watered, and most abounding, we have somehow jostled and battered out of good working order the whole complex of factors which keep a country rich and its people secure.

Most of our middle farm land here is harder to work than it used to be, and not as much worth working. It does not absorb water for crops as well as it did. The rainfall dashes off. Flood stages in the Mississippi Valley have risen fairly consistently through the period of white occupation, and the whole natural water system of the great valley seems somewhat deranged. The Mississippi Valley report, issued in 1933, goes into these troubles in detail. The water table has fallen alarmingly, in some places as much as 30 feet. Ponds and springs have dried up. By injudicious drainage and farming projects, marshes which served as natural reservoirs have been destroyed; and the level of important headwater lakes has been seriously lowered.

Not one thing, but many things at once, go wrong. Drought, grasshoppers, raging floods, short crops, short pasture: These are old troubles; but they seem to be coming harder and faster of recent years, and getting worse. Citizens of Columbia, Mo., and of other Corn Belt cities who until lately had never seen dust storms blowing in from the West are occasionally troubled by them now, as a nuisance, and as an omen. There, as in the East, people who are living on soils half washed off in a century or so of ill usage raise awed eyes to high, saffron dust clouds passing over, and praise God that they do not live in parts which are blowing away. Actually, rainwash erosion in the United States is more damaging and insidious than wind erosion. The signs of waste and desolation that midwesterners see in the sky are no more menacing than signs becoming each year plainer at their feet.

An Iowan Sees Iowa

Forty years ago Thomas McBride gave a course of lectures on conservation at the University of Iowa. "Here," he said, "nature asks for nothing but defense—only for protection. In this interim of our advance let us teach our people reverence for the silent power and magnificence of nature as she works incessantly for our good." One of those who heard the lectures was Jay N. Darling, who later became the moving spirit behind a study and report, The Iowa Twenty-Five Year Conservation Plan, published in 1933. From the foreword:

"The second century in the development of Iowa will see, not the drama of the occupation and exploitation of the state, but the readjustment of human life to the situation now found here . . . The trend is toward the recovery of a reasonable balance between man-made and nature-made elements in the environment . . . a practical use of land and its treasures." This report reveals, "the waste of Iowa's greatest asset, the soil; the unwise destruction of surface waters by drainage, pollution and silting; the heedless stripping of woodlands; the almost wanton destruction of wild life; the irrational use of funds for recreation in several forms; the patent failure to capitalize the state's fine potentialities all along the line. Only *co-ordinated* planning can fit together these closely interrelated fields."

Dating from 1930, this Iowa survey and report anticipated and marked the way for several present national programs of land use. Other States, notably New York, Minnesota, and Wisconsin, had moved in the same direction; but in no other State did the findings arouse as intense and general a public interest. Jacob L. Crane, Jr., directed the Iowa Survey. Aldo Leopold of Wisconsin did the work on game restoration. Darling, who holds three honorary doctorates as a naturalist and conservator, and signs himself "J. N. Ding," publicized the findings in his *Des Moines Register-Tribune* cartoons and throughout the country. Later, President Roosevelt asked him to head the United States Bureau of Biological Survey. For about a year he served as Chief of that Bureau of the Department of Agriculture. Then he returned to Des Moines and his drawing board. There he continues to raise his voice above polite academic murmurings about conservation, with wide effect. Whether he is drawing or writing, he talks in pictures.

"Look," he says, showing photographs, "Where do you think those were taken? France? Down in the cotton gullies of the South? No. This is what's left of some of the finest natural grass and timberland in Iowa.

"Railroads and highways, seeking easy grades give people passing through the idea that these prairie States are flat country. They're mostly hills. It all slants, and the lower two-thirds of Iowa is broken or rough. A lot of it is not only washing, but washed out, after a century or two of white farming.

"Any one of a number of these southern Iowa counties, down where the Des Moines River strikes into the Mississippi, might be taken as an example. Here's Davis County, on the Missouri Border. The thing that finished Davis County was the War. Prices said, 'Plow!' The Government said, 'Plow!' Against their better judgment the farmers plowed those rolling hills for wheat and corn, especially for wheat. "Food will win the war!" the posters said.

"More woodland was hacked away. More grass was plowed under. The hills washed. The rivers grew muddier. The water table fell. Springs went dry. Game went dry and starved and died.

"Now thousands of acres have been abandoned. The tax situation has been catastrophic. Things are straightening out a little now, but four-fifths of the people in this Iowa farm county had to accept some degree of relief in 1932 and 1933.

"Here are three townships up in the northeast of Davis County. I know them. I used to hunt there. Salt Creek, Soap Creek, and Licking townships—48,000 acres in a block. I saw them again when we surveyed there in 1930. The change was shocking. We made a plan for this 48,000 acres, and for another 200,000 acres we found washed beyond hope of farm use. Under our Iowa plan, if we can work it, we'll buy up all such areas, break them into 3,000-acre tracts with a custodian-family on each tract, and move the other families into 20-acre subsistence homesteads in the valleys, and put them all to work restoring forests, game cover, wild life—healing, resting, restoring that land.

"We figure we could give each man 150 days' work at $2 a day, each year. Income would be

from timber, and prior to that, from shooting fees collected from hunters: 25 cents a bird or, on a bag basis, a dollar a day.

"The first three years we could give every man in the area a full year's work. After that we could give them 150 days—$300—work a year. And they'd have modern homes and gardens, 20 acres for a cow and hens, and any other money they could get, working outside. That's better than most of them do, trying to farm there."

War-torn Hills

As you enter Davis County from Ottumwa the good road ends and a faded chamber of commerce sign announces: "Welcome to Davis County: The Heart of the Bluegrass Country." There were 990 miles of road in the county, and only 60 miles paved, in 1934. The rest are of shiny yellow clay sharply coiling and dipping over as naturally fine a grass and tree country as you could ever hope to see. Such timber as survives is beautiful: Elm, birch, walnut, hickory, black oak, bur oak, red oak, shellbark hickory, cottonwood. Elms and oaks dominate. They stand proudly in field alone, and in groves, with flocks feeding under them. Davis County grazes a tenth of all the sheep in Iowa, and ranks second in the production of soybeans and timothy hay. Bluegrass used to take hold naturally. There used to be great meadows and pastures of it. It is mainly where the sod was broken for upland wheat and corn that the most catastrophic washing has occurred. (Wheat is not intertilled; but it is drilled in rows; and it does not form a solid grasslike mat, below ground or above.)

Less corn and wheat is grown now. The soil so obviously will not stand it, and stay. Under A. A. A.'s first corn-reduction drive, Davis County reduced corn acreage from 11,000 acres to 8,000 acres. Some of the farmers put in adjustment claims to A. A. A. for as little as $6, and were glad to get it. In many of these midwestern hill counties, times were really hard.

You see all kinds of land in Davis County, and much of it still is lovely. Along the river and in creek bottoms good farmsteads stand staunch and serene under high, graceful trees, among rich fields fairly intact. To the south of the county, the soil is a Shelby loam with a gravelly clay subsoil. To the north, where the slopes run steeper, the soil is a stiffer, deeper clay. This is the part that is terribly washed. But even here, in the valleys and on a number of upland plateaus, you find farms with some plowland that will stay there. If the Iowa 25-year plan, stressing game and woodland, is ever put in effect in those three northeastern townships, woodland and cropland game ranges will simply go around such farms.

As an example of what may be done to restore hurt land with woods, game cover and water, C. C. C. boys have built near the county border a 352-acre lake, Lake Wapello, the first of 25 such lakes blueprinted, under the Iowa plan, to dot the map of Iowa. Of irregular shape, with a shore line of 12½ miles, Lake Wapello is stocked with 150,000 game fish—bass, crappie, bluegills, lake bullheads. It was a dirty lake at first but control plantings made by the boys in the watershed have considerably cleared its waters. It is bluish now, most of the time. The worn fields up from the lake shore have been treated to stop rainwash and to bring back game. Wild gooseberry, black locust, St. Johnswort, and buckbrush have been grouped in gully and patch plantings, providing feed, adequate cover, and nesting places for upland birds. Oblong feed patches of about half an acre offer further feed—corn, millet, buckwheat, Kafir—to wildlife.

Fishing has been allowed in the lake since 1935. The catches are generally good, providing sport and food. Erosion has been checked on that small watershed. And for the first time in years (most of the streams around there having filled with silt), the people of Davis and adjacent counties have a good place to gather for family or community picnics, with clean, deep water to swim in, for those who like it.

But in those northeastern townships where the damage perhaps has been heaviest, few of the people are thinking much about picnics and

swimming. For most of them, times remain hard. Many don't know whether to try to hold on, or not. A woodsman-farmer says:

"I get along. I'm more of an old hunter than a farmer. I like the woods. I hate to see them spoiled. There's something funny happened to this part of the country. We got to whittling too big, trying to farm.

"This is wonderful soil if you let it be. Stir it up, crop it, even on the level, it'll go away from you. If anybody told me I had to farm this eighty of mine all over, I'd scat 'til hell wouldn't hold me. I just work a little, and shoot for my meat, and let cows run on the rest. You can't raise enough on most of it to make a wrestling jacket for a mosquito. My taxes here are $56 and I have trouble making it. You can see for yourself: My old lady's been cutting my hair to save a quarter. And I'm not too proud to say I've been down there to the pork house, as they call it, for some of that Government food. Some of the best of us have."

A 38-year-old farmer on 160 acres of fair to good plateau land, somewhat washed, reports: "My father bought in here in 1840. This isn't bad land. It'll carry a few sheep if you watch it. We don't want to move. I have two boys still at home, and they're helping me, and want to stay here. But a lot of the land above us ought to be put back in woods."

A woman farmer. Her husband is a hospital case, probably permanent; a nervous disorder. He paid $100 an acre for 360 acres just when the high tide of land prices was over, in 1922. They took him away. There are four children and a $5,000 mortgage. She is farming the place. She says:

"A third of our 360 acres is still in woods. That's what it's good for. So far as I'm concerned, no grain would be raised here. But you can't pay your bills without it. We plow that half of it that doesn't wash too badly, and keep forty sheep and eighteen cows.

"I don't think most of us around here would want to move. You know, the rougher the country is, the more folks stick to it."

Retreat From Corn

A hundred miles west on the same rolling borderland between Iowa and Missouri, is one of the oldest soil conservation demonstration areas in the Nation. The Big Creek watershed embraces 152,000 acres of Ringold and Decatur Counties, Iowa, and Harrison County, Mo. Work started there in October 1933. Of the some thousand farmers in Big Creek watershed more than 800 have signed soil conservation contracts, and are cooperating with the Service. Project headquarters is at Bethany, Mo.

As planes flew over the area, taking pictures, as engineers worked these "mosaics" into more detailed maps, farm by farm, as foresters, agronomists, and soil technicians drew further plans, with farmers on the ground, for a changed landscape, three agricultural economists of Iowa State College entered upon a special study of "the principal economic and social factors which, in general, tend to hinder or assist erosion control." On the inside cover of their report (Economic Phases of Erosion Control, Bulletin 333, Iowa State College, 1935), the authors—Rainer Schickele, John P. Himmel and Russell M. Hurd—brief their findings, thus:

These Hinder Control	*These Assist Control*
1. Small farms.	1. Large farms.
2. Corn-hog type of farming.	2. Dairy- and beef-cattle type of farming.
3. Farms operated by tenants.	3. Farms operated by owners.
4. Heavy debt burden and high interest rates.	4. Small debt burden and low interest rates.

"The data," they say, "reveal the close correspondence of livestock system and crop system, and of farm type and degree of erosion . . . Expansion of the dairy enterprise would greatly facilitate reduction of corn acreage through establishment of more balanced crop rotations, with a larger proportion of the crop land in soil-protecting grasses and legumes. Physical, economic, and social conditions seem to limit the expansion of dairying which so effectively saved the northeastern section of Iowa from such

devastating erosion as southern Iowa and northern Missouri are experiencing; (yet) . . . there is conclusive evidence that in erodible sections of the Corn Belt soil conditions no longer warrant a highly specialized corn-hog type of farming."

The immediate cost and cash loss of necessary adjustments, farm by farm, region by region, to a changed farming system is actual. Even with technical help and relief labor supplied them free by the Government, for the land's sake; and even with the aid of A. A. A. adjustment checks in the past few years, farmers in the Big Creek watershed who have joined a general retreat from corn to cover have done so, by and large, at the cost of taking less money from their work, year by year, than they might have made, temporarily, from continuing to whip their soil along toward complete sterility.

In 3 years, the 800 cooperating farms on Big Creek watershed have reduced their corn acreage by 46 percent. "This does not mean," the first regional conservator R. E. Uhland, explained, "that corn production will be reduced to this amount, because the steeper land was retired from cultivation and placed in grass, permanent meadow, or trees, thus leaving the better land for growing corn; and since this corn now is grown in rotation, the actual acre yields will be considerably greater than where continuous corn is grown . . .

"Our soils men have found that 50 to 75 percent of the surface soil is gone on more than half of this watershed . . . Prior to starting the project, contour and strip cropping were practically unknown in this area . . . Farmers of the region have always taken pride in making straight rows and many of them felt to run their rows on the contour would take all the pleasure out of their work . . . this fear is being dispelled . . . [on Big Creek watershed] 4,238 acres will be newly strip cropped and 6,189 acres will be newly contour-tilled [in 1936].

". . . Crop rotations have been worked out for 46,386 acres of land; 12,699 acres of erosive land have been taken out of cultivation and seeded to permanent hay and pasture."

The Restoration of Coon Valley

Region 5, directed from headquarters at Des Moines, takes in all of Wisconsin, Minnesota, Iowa, Missouri, and Illinois. A number of major watershed projects have been set going; such as the Big Creek project, crossing the Missouri—down near Bethany, Mo., the one in the Sangamon River Valley, Ill., and the Coon Creek project, on the driftless or unglaciated area, with headquarters at La Crosse, Wis. These are 100,000-acre projects, or larger—as is one of 102,600 acres more recently launched near Shenandoah, Iowa. Twelve smaller projects, averaging around 25,000 acres each, are scattered over the area; and 101 C. C. C. camps have been doing some work with farmers not in demonstration watersheds. In all, control demonstrations have thus far been established on about 10,000 different farms near the headwaters of the Mississippi River, in Region 5 of the Soil Conservation Service.

Throughout the region, control by changed farm lay-outs and practices is preferred above control by earthworks; but terraces are used when slope, soil, and economic pressures require them. The idea is to dismiss preconceptions, to take each piece of ground as you come to it, and to oppose to erosion a flexible, integrated, and if possible inexpensive defense.

Aldo Leopold of the University of Wisconsin, a specialist in wildlife conservation, has spoken for many years for such an approach. Late in 1935 he visited Coon Creek watershed, Soil Conservation Service project area No. 1, and wrote a field note for American Forests, in part as follows:

"Erosion-control is one of those new professions whose personnel has been recruited by the fortuitous interplay of events. Previous to 1933 its work had been to define and propagate an idea, rather than to execute a task . . . the sudden creation of a bureau, with large sums of easy money at its disposal, presented the probability that some one group would prescribe its particular control technique as the panacea for

all the ills of the soil. There was, for example, a group that would save land by building concrete check-dams in gullies, another by terracing fields, another by planting alfalfa or clover, another by planting slopes in alternating strips following the contour, another by curbing cows and sheep, another by planting trees.

". . . the new bureau (the Soil Erosion Service, later changed to Soil Conservation Service) . . . immediately decided to use not one, but all, of these remedial methods. It also perceived from the outset that sound soil conservation implied not merely erosion control, but also the integration of all land crops.

"The first demonstration area to get under way was the Coon Valley watershed, near LaCrosse, in west central Wisconsin, . . . one of the innumerable little units of the Mississippi Valley which collectively fill the national dinner pail. Its particular contribution is butterfat, tobacco, and scenery.

". . . everything was all right because there were more hills than cows, and because the soil still retained the humus which the wilderness vegetation through the centuries had built up. The trout streams ran clear, deep, narrow, and full . . . This is proven by the fact that the first settlers stacked their hay on the creek-banks, a procedure now quite unthinkable. The deep loam of even the steepest fields and pastures showed never a gully, being able to take on any rain as it came, and turn it either upward into crops, or downward into perennial springs. It was a land to please everyone, be he an empire-builder or a poet.

"More cows, more silos to feed them, then machines to milk them, and then more pasture to graze them—this is the epic cycle . . . More pasture was obtainable only on the steep upper slopes, which were timber to begin with, and should have remained so. But pasture they now are, and gone is the humus of the old prairie . . .

"Result: Every rain pours off the ridges as from a roof. The ravines of the grazed slopes are the gutters . . . Great gashing gullies are torn out of the hillside. Each gully dumps its load of hillside rocks upon the fields of the creek bottom, and its muddy waters into the already swollen streams. Coon Valley, in short, is one of the thousand farm communities which, through abuse of its original rich soil, has not only filled the national dinner pail, but has created the Mississippi flood problem, the navigation problem, the overproduction problem, and the problem of its own future continuity.

"The Soil Erosion Service says to each individual farmer in Coon Valley: 'The government wants to prove that your farm can be brought back. We will furnish you free labor, wire, seed, lime, and planting stock, if you will help us reorganize your croping system. You are to give the new system a 5-year trial' . . . half of all the farms in the watershed, have already formally accepted the offer. Hence we now see foregathering at Coon Valley a staff of technicians to figure out what should be done, a C. C. C. camp to perform labor; a nursery, a seed warehouse, a lime quarry, and other needed equipments . . .

"The plan, in a nutshell, proposes to remove all cows and crops from steep slopes, and to use these slopes for timber and wildlife only. More intensive cultivation of the flat lands is to make up for the retirement of the eroding hillsides. Gently sloping fields are to be terraced or strip-cropped . . . contour farming, good crop rotations, and the repair of eroding gullies and stream banks, constitute the technique of soil restoration.

"The first visible evidence of the new order on a Coon Valley farm is a C. C. C. crew stringing a new fence along the contour which marks the beginning of forty percent gradients. This new fence commonly cuts off the upper half of the pasture. Part of this upper half still bears timber, the rest is open sod. The timbered part has been grazed clear of undergrowth, but with protection this will come back to brush and young timber and make range for ruffed grouse. The open part is being planted, largely to conifers—white pine, Norway pine, and Norway spruce for north slopes, Scotch pine

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for south slopes . . . Creek banks and gullies as well as steep slopes, are being fenced and planted . . . In odd spots of good land near each of the new game coverts, the observer will, see a newly enclosed spot of a half-acre each . . . thickly planted to sorghum, kafir, millet, proso, sunflower. These are the food patches to forestall winter starvation in wildlife . . . Such a feeding system, extended over all the farms of Wisconsin, would, I think, double the crop of farm game in a single year."

In the first year of the project, Professor Leopold estimates, quail in Coon Valley doubled and pheasants quadrupled in number. The technique of estimating wildlife units over given areas has been worked out with a remarkable accuracy by game-management men. Research economists of the Coon Valley field staff now are working toward a method by which the entire crop of farms so redesigned can be tallied, in terms of total digestible nutrients produced, and again in terms of farm income; and so compared with the food and cash yield of those farms when they were plowed or pastured to their steepest crests. At the end of 2 years' work, a satisfactory method has still to be evolved, and the basic data are incomplete. By working their best land better and restoring the remainder to natural crops, most of the farmers seem convinced that they are doing better. Certainly, they are feeling better. Prices are better; and a man naturally hates to mine and tear his farm. "This country is healing," an old Norse farmer in Coon Valley says.

The following figures, on the first 413 farms signed and redesigned in Coon Valley, show what was done in shifting field crops in the first 2 years of the project, 1934–35 and 1935–36. Time will tell how it pays:

With 11,853 acres in all, these 413 farmers had cut corn acreage 2 percent by the end of 1935, grain acreage 20 percent, clover and timothy acreage 6 percent. They retired 1,151 acres from tilled crops to permanent pasture. They increased their acreage in alfalfa 32 percent.

Aldo Leopold ends his account of beginnings in Coon Valley, Wis., with a sketch of highly various staff technicians sprawled in office chairs and on desks around the stove at project headquarters late at night, and getting their ideas together for the work to come:

"Not all the sights of Coon Valley are to be seen by day. No less distinctive is the nightly 'bull session' of the technical staff. One may hear a forester expounding to an engineer the basic theory of how organic matter in the soil decreases the per cent of run-off; an economist holds forth on tax rebates as a means to get farmers to install their own erosion control. Underneath the facetious conversation one detects a vein of thought—an attitude toward the common enterprise—which is strangely reminiscent of the early days of the Forest Service. Then, too, a staff of technicians, all under thirty, was faced by a common task so large and so long as to stir the imagination of all but dullards."

GRASS CREEPS BACK.

Bermuda grass is performing the healing mercies
that Solon Robinson predicted in 1845.

TALL GRASS.

Big bluestem guards some of the richest soils
of humid Kansas and Missouri.

A PLANTATION DEFENDED.

Strip crops and terraces hold these slopes like guarding arms.
A grassed terrace—outlet channels ease the run-off.

A FARM DEFENDED.

As a garment cut to measure, crop strips clothe
and protect these Ohio Valley slopes.

The High Plains Are Taken

Because the ground is chapt, for there was no rain in the earth, the plowmen were ashamed, they covered their heads. Yes, the hind also calved in the field and forsook it, because there was no grass. And the wild asses did stand in the high places, they snuffed up the wind like dragons; their eyes did fail, because there was no grass.— Jeremiah 14–6.

WESTWARD, the Mississippi Valley lifts with a slow persistent tilt until on the plains of semiarid western Kansas, toward the base of the Rockies, you stand on what seems to be level land 3,500 feet above the sea. The 5,000-foot contour is generally accepted as the western crest of the High Plains.

As the valley floor climbs from the Mississippi to the Rockies, rainfall tapers off, at first almost imperceptibly, then abruptly, from copious to subhumid, to semiarid. The grass changes character: Tall grass on the humid prairies; short grass in the subhumid high plains; beyond, in the semiarid Southwest, desert grass or mesquite; and in the arid intermountain sections, desert shrubs.

The ninety-eighth meridian marks, roughly, the dividing mark between a humid and dryland or irrigated agriculture. There rainfall eases off, as you go westward, from 30 to 25 inches, then to 20 to 15 to 10, or in desert places, to as little as 5 inches a year. The grass hugs dryer ground more closely. The country and all its products change character. The transition is graduated or spotty; but once you pass this meridian, whether you have grazing or cropping systems, farming must be done with an anxious eye to the sky; and the first need is to save for use where it falls every drop of rain the heavens grant. *Water run-off becomes as important as, or even more important, than soil run-off, from here to the coast.*

Men of New Spain, with a base in Mexico, explored the Great Plains, along with the middle South, considerably before the English were established on the Atlantic shore. Striking in from Florida with a small party, Cabeza de Vaca crossed the continent, touched the rim of the Plains, pressed on to the Pacific, and swung down to Mexico City with fabulous tales. This was within half a century after 1492.

At the same time, Coronado, operating from a Mexican base, traversed the High Plains proper. He and his party saw the Grand Canyon and the Colorado River. Misled by an Indian tale, they penetrated into Kansas to seek plunder from the legendary Seven Cities of Cibola. "It was the Lord's pleasure," wrote Coronado, "that, after having journeyed across these deserts seventy-seven days, I arrived at the province they call Quivira."

The plains were nothing, said Castañeda, but land and sky; no gold, no gems, no slaves. It is hardly credible, as Walter P. Webb points out in his monumental book, The Great Plains, that men from a country with less than 25 inches of rain over most of it, should have been so blind to a deep virgin soil clad with marvelous grass, and often with sufficient rain for dry farming, or occasional sources of irrigation near by. The Spaniards were city hunters, gold hunters, not farmers. The sword, not the plow, was their blade of conquest. Reports they brought in from glittering cavalcades of exploration out of Mexico to the north and east started the myth of the Great American Desert.

Over the Trackless Grass

But even Castañeda, so bored with all this land, and no gold, was moved to exclaim at the

grass. As the historian of Coronado's expedition to Quivira (probably western Kansas) in 1540 he wrote:

"Who could believe that 1,000 horses and 500 of our cows and more than 5,000 rams and ewes and more than 1,500 friendly Indians in travelling over these plains would leave no more trace where they had passed than if nothing had been there—nothing—so that it was necessary to make piles of bones and cow dung now and then, so that the rear guard could follow the army."

The first whites to approach from the East saw little in the high plains to write about. Following rivers, so far as possible, Lewis and Clark largely ignored the plains. Their notes are noncommittal and scanty. Zebulon M. Pike, setting out from St. Louis in 1803, reported that "it might be possible to introduce a limited population."

Cavalry on the march must have an eye for grass. In 1868 Gen. Luther Bradley, commanding troops in the Great Plains region, marveled at the pasturage. He reported to the War Department:

"Good, fine grasses grow evenly all over the country . . . they cure all over the ground without losing any of their nutriment . . . the climate is so mild and genial that stock can range and feed all the winter and keep in excellent condition without artificial shelter or fodder . . . I believe that all the flocks and herds in the world could find ample pasturage on these unoccupied plains and the mountain slopes beyond; and the time is not far distant when the largest flocks and herds in the world will be found here, where the grass grows and ripens untouched from year to year."

The War between the States was fought and ended. The post-war depression came, forcing new tides westward. Then from a straggling start before and during the War, the Cattle Empire (a world to itself, as was the Cotton Empire), sprawled and boomed.

The striking through of the old cattle trails, the rough reunion of East and West in stockyards at the end of racing rails, at Abilene, Kans., and elsewhere; the conquest of the Plains by hard-riding white men, adapting first the Spanish horse, then the six-shooter, then windmills and barbed-wire fence, as devices and implements of agriculture—all this served to open the dry-land western country to agriculture on a rough and spacious basis, with baronial cattlemen contending with meeker but determined sheepmen, and both despising plow farmers as lumpish plodders and wreckers of the grass.

Cow Rush

On an assignment in the Great Plains region, Glenn K. Rule, of the Soil Conservation Service, brought in observations of the cow rush which preceded the crop rush, and of the ripping-up of the Plains surface. In his first letter of report Rule wrote:

"The panic of 1873 made only a pause in the dramatic expansion of the cattle business. By the late 70's cattle were spread over most of the area in 12 States. Resumption of gold payments in 1879 created a boom. England was looking for an investment market. America was ripe and eager. If we remember 1927, 1928, and a part of 1929 perhaps we can form some idea of the scramble to get rich. The cow business became popular, fashionable, and a gamble. Absurd predictions of promoters were accepted as sober fact. Legislatures, newspapers, railroads, chambers of commerce did their part to make the fairy tales seem real . . .

"Every stage and train brought men with money for investment in the cow country. Vast syndicates were formed by investors in the East and in England. Germany and Australia sent men and money. Even the canny Scot bought stock in companies that owned not a single longhorn or an acre of grass.

Collapse of the cow rush in 1885 coincided fairly closely with the first marked decline of the grass. Was this a chance relationship? Or, if there is a definite relationship between price cycles and land misuse, how does it work?

TOO MANY CATTLE.

TOO MANY SHEEP.

Backwards, forwards, or both ends against the middle? Do good times or hard times lead most rapidly to the despoliation of a soil? Thus far in our history it can be shown that in good times we have pushed farming and grazing too hard. It can be shown, with instances that range from the growth of cotton, to wheat, to potatoes, to beans, to livestock, and back again, that fancy prices and heated visions of prices forever fancy have led repeatedly to overplowing and overpasturing, and so to denudation and staggering losses of soil.

But it can also be shown that when happy days have gone to smash, farmers caught in a web of debt, with just so much land, were forced to overwork that land all the harder, killing what was left of the grass, scalping the topsoil, in order to pay taxes, to buy the goods they needed, and to pay interest—none of which charges have a way of smashing down, as a rule, as hard and fast as farm prices do, when the break comes.

Some countries, both kingdoms and republics, in the Old World have excellent records of soil husbandry, as a whole. This was a rich, raw, and somewhat violent country. We thought we had all the land in the world; and the sky, as the saying went, was the limit. They grew up, our pioneers; and moved and had their being, among heady illusions. It was a brave time, and a time to which—however painful the present consequences—few Americans can look back without some understanding and sympathy.

"Perhaps," writes Will C. Barnes, "the stockmen of those pioneer days should not be held to too strict an accountability for their range practices. It was all a new proposition to them. Few of them knew the rudiments of foliage growth or plant requirements. They mostly grew up with the pioneer idea that when the feed in a certain region was gone there was more 'over the range' to which they could move their herds and flocks.

"Certainly they may be forgiven for using such words . . . as 'illimitable', 'never ending', 'boundless', 'inexhaustible', etc. To them, with nothing in the past to guide them in their estimates, these great grassy plains seemed inexhaustible indeed . . ."

This is from Barnes' Story of the Range, issued by the Forest Service, in 1926, with the subhead: "An account of the occupation of the public domain ranges by the pioneer stockman, the effect on the forage and the land of unrestricted grazing, and the attempts that have been made to regulate grazing practices, and perpetuate the great natural forage resources of the open ranges." It remains a trail-blazer among Government publications. Further excerpts:

Overgrazing

"The longhorns from the West met and mingled with the better breeds from the East . . . until finally, about 1895, no open range remained unstocked. Not an acre of grazing land was left unoccupied, and ranges that for permanent and regular use would have been fully stocked with a cow to every 40 acres were loaded until they were carrying one to every 10 acres. Into western Kansas, Nebraska, eastern Colorado, out into the Red Desert country of Wyoming and Utah, up across Montana and the two Dakotas clear to the Canadian line, they pressed in their mad search for grass. No one provided any feed for the winter, the owners preferring to risk the losses. Gradually the native grasses disappeared. As fast as a blade of grass showed above the ground some hungry animal gnawed it off. A few men sounded a note of alarm, but most of the owners declined to realize the approaching disaster and drifted along in their fancied opulence.

"Then came the inevitable. The winter of 1886 saw the almost total extinction of the industry in some of the Northwestern States. Thousands of cattle went into that winter never to see the spring flowers again. Great cattle companies with managers riding back and forth to the frontier towns in coaches and six, drawing princely salaries for doing nothing, went out of existence. Millions of dollars were lost beyond hope of recovery. A few years later,

in 1893, the Southwest went through the same experience, and still greater losses were piled up . . .

". . . Reckless competition could have but one end. The mountains were turned into dust heaps; the old forage plants were gnawed to the roots and so weakened that they failed to grow. Worthless weeds and annuals took their place. The willows along the streams and meadows were eaten down to walking sticks. The meadows, stripped of their green covering, dried out. The forage cover gone, the freshets tore through the meadows leaving great gashes in the sod and soil, which cut down deeper and deeper, draining the land as successfully as any Corn Belt farmer ever drained his water-logged fields with machinery and tiling. Then the areas grew brilliant under purple iris, a sure sign of forage-plant decadence in a mountain meadow, and their value for grazing purposes was almost gone . . . Down in the open plains much the same process was followed . . .

"If overgrazing injured no one but the stockman, this whole subject might perhaps be allowed to continue in its present [1926] unsatisfactory condition . . . Lying as they do at average elevations of over 5,000 feet above sea level, most of these lands may be said to form a goodly part of the roof of this continent. Every drop of rain that falls upon them, the water that runs from each melting snowbank, at once begins its long, devious, often delayed, but nevertheless constant journeying toward either the Gulf of Mexico or one of the two oceans which border this continent.

"Each drop is a potential flood . . . Every rivulet . . . carries small particles of soil in its roiled waters. Joined by other rivulets it grows in size and often becomes a flood that moves mighty masses of earth and stone, fills the clear mountain streams with debris of every kind, chokes the irrigating ditches of settlers in the valleys below, and gaining strength and volume, overwhelms bridges and railroads, and fills the mouths of our great rivers with waste materials that cost millions of dollars each . . . year to keep dredged out sufficiently to allow shipping to enter or leave our harbors."

The Grass Is Wounded

In the 1890's sheepmen began to gain a foothold on the ranges. Antipathies as old as history flared into range wars. Cattle range. Sheep are herded. Cattle are fairly broad-footed. Sheep have hoofs like chisels. Cattle, most western cattlemen tell you, will not eat where sheep have browsed; they despise the smell, sight, and sound of sheep.

All this is somewhat controversial. "Men have died," MacLeish writes darkly, "because sheep have cloven lips." Marsh, in his The Earth as Modified by Human Action (1874), considering overgrazing by goats and camels—browsers, like sheep—in Arabia and Africa, wrote: "I am convinced that forests would soon cover many parts of [these] deserts if man and domestic animals, especially the goat and the camel were banished from them." Marsh does not exempt cattle from his strictures: "Young trees," he continues: "sprout plentifully around the springs and along the winter watercourses of the desert; in the shade of these trees annual grasses and perennial shrubs shoot up, but are mown down by the hungry cattle of the Bedouin as fast as they grow. A few years of undisturbed vegetation would suffice to cover such points with groves, and these would gradually extend themselves over soils where now scarcely any green thing except the bitter colocynth and the poisonous foxglove is ever seen."

In another paper, La Pays de Rirha, published in 1879, Marsh cites the views of a French traveler, Largeau, who "believes the Sahara to have been anciently well-watered, and to have been well wooded, and to have been reduced to its present condition by the folly and improvidence of man."

Some rangers of long experience suggest that, while sheep do slash with their teeth right down to the crowns of the grass, this does not in itself hurt the sod, and may even thicken it.

Close herding of sheep is what kills a sod, they say; if flocks of a reasonable size are permitted to spread out in feeding, the grass survives.

Be that as it may, sheepmen and cattlemen differ instinctively and by type. They incline to be different sorts of people. The spacious and arrogant traditions of old-time American cattle ranching, and the more farmerlike and pastoral tradition of shepherds guarding lonely flocks in the hills where the grass is thin, still clash as of old. When drought smote the land of Canaan, and Joseph took his brothers, who sought help, before the Great Pharaoh of Egypt, he warned them to tell the King that they were cattlemen: "For every shepherd is an abomination to the Egyptians," said Joseph.

Cattle and sheepmen fought for the grass of our West, while their stock wounded it.

Yes, men have died because sheep have cloven lips; and because lords and shepherds of the open range dislike farming. If sheepmen and cowmen ever get together on anything, it is in contending that "overgrazing" is a theory born of the lamp and, worse, of the sundering plow; that farmers, not graziers, have broken the magic circle of the grass under which the high Plains flourished; that there is really no such thing as overgrazing. So complete and violent is many an old-time cattleman's rejection of this baleful word, that James Wilson, Secretary of Agriculture, had to write on a bulletin manuscript on the subject in 1901: "all too true, but not best for us to take a position just now."

By tact and a reiterated demonstration of the facts the United States Forest Service has in the years since won gradual acceptance of the fact that overgrazing does exist, that it ruins both open and woodland range, and that with reasonable measures of restriction, the trouble may be halted. But this view is still not universally accepted. Addressing a group of western stockmen in the Plains soon after disastrous dust storms in 1935, W. C. Lowdermilk, Associate Chief of the Soil Conservation Service, was astonished to have the chairman rise midway in the discourse, and with a chill politeness terminate it. Dr. Lowdermilk had used the word "overgrazing," and the stockmen were offended.

Something must be allowed for that point of view. A rushed plowing of short-grass sod land has probably raised more dust and done more to advertise the plight of wide areas, than has overgrazing.

In terms of total damage, overplowing has probably done more harm than overgrazing. But, in view of larger acreage of Plains and western ranges which has never been plowed, yet has suffered severe erosional losses and a catastrophic decline of herbage, it is certain that overgrazing, alone, has effected a wide and sad transformation.

The Western Range, a Forest Service report issued in 1936, estimates that it takes one-fifth greater acreage of tall-grass range now to feed a cow than it did on the virgin range. On short grass, it takes nearly twice as much range to feed a cow (or five sheep), on the average, as it did when the range was new. On sagebrush-grass range more than three times the former acreage is required. On salt-desert shrub, three and a half times the former acreage is required. "Widespread, continuous, and exhaustive use of the forage," says the report, "has changed the whole character of the virgin range. The outstanding changes have been (1) the passage of much of the land from Federal ownership to other forms of control, (2) a reduction in the area available for range use, (3) a tremendous decrease in the quantity and quality of the forage, and (4) deterioration of the basic resource, the soil itself."

Plows to the Plains

Confronted upon emerging from the woods with a prairie sea of grass, most southerners and Yankees slowed up, hugged the woodsides; but a few made, then and there, a plodding magnificent detour all the way to the Pacific. Thus, from 1840 onward, they stamped out the Oregon Trail and extended the American frontier 2,000 miles in one migration . . . "They travelled," writes M. L. Wilson, "an

almost impossible distance and endured untold difficulties in moving from one forested section to another forested section." Thirty-four thousand pioneers, seventeen to the mile, are said to have died following that trail to the Pacific. A letter from one of those who first got through is, says Turner, "typical." The man who wrote the letter had moved four times: In 1819 from Virginia to Ohio, in 1825 from Ohio to Indiana, in 1835 from Indiana to Wisconsin; and in 1849 he wrote:

"I have reached the Pacific, and yet the sun sets west of me, and my wife positively refuses to go to the Sandwich Islands, and the bark is starting off my rails, and that is longer than I ever allowed myself to remain on one farm . . ."

But the march on the soil had not ended; the rushed acceleration of its final phases had, indeed, hardly begun. On the High Plains and up on the mountain sides, plenty of land remained to surge upon; rewarding land, too, much of it; rich, wide, and in years when the rains came, wonderfully fruitful. Garrisons at forts located to protect overland travel were the first to discover that if touched by water, the soil of the High Plains yields amazingly.

In the sixties and seventies, while the forty-niners of California were getting to be settled men and patriarchs on the western shore, the farmers' main line of western advance still gnawed with plows at the eastern edge of the High Plains, and farm leaders there formed hopeful ideas that a slashing plow-up was rendering the country humid. By 1880, Samuel Aughey of the University of Nebraska was writing that cultivation had increased rainfall, and C. D. Wilber of the same State, accepting this finding, declared that all the deserts of the earth exist only because of man's neglect.

The ninety-eighth meridian strikes up from the lower tip of Texas through eastern Oklahoma, Kansas, Nebraska, and the Dakotas. The one-hundredth meridian, which some Plains authorities accept as more nearly the deadline between humid and dry-land farming, cuts off the western third of Oklahoma and Kansas, and roughly bisects Nebraska and the Dakotas.

On and up into short-grass country, higher up the plains and mountains, the thickening herds were pushed, with constant ruction, by following waves of farmers or "nesters" armed with plows. Thus "the much heralded western march of civilization" proceeded, writes Barnes (a man of range antecedents) wryly. "These fellows from Ohio, Indiana and other northern and western states", an old trail captain, quoted by Webb, exploded,—" 'the bone and sinew of the country', politicians call them . . . I say, damn such bone and sinew: They are the ruin of the country, and have everlastingly, eternally, now and forever, destroyed the best grazing land in the world!"

As the first wave of settlers with plows edged into the dry lands they chanced in many sectors to break land in wet years. This raised the idea that no changes in culture were needed, that anyone who could farm anywhere could farm on the Plains. "Tickle this land with a hoe and it laughs with a harvest"—this and other hopeful, extravagant sayings arose and were borne East, where they stirred new waves and trickles of migration. "The great cattle kings claim that the country is utterly unfit for cultivation." To which, wrote Gen. James Brisbin in The Beef Bonanza (1881), "the farmers reply by plowing up a strip some ten miles wide on its eastern edge each year, and raising good crops."

In all forms of farming west of the Ninety-eighth meridian the need of catch-as-catch-can adjustments has been acute. Windmills, barbed wire, and six-shooters were, as Webb points out, first responses. Cowboy clothes, which some think fanciful, were another hard-handed adaptation to the scene. The scarf at the neck, like the veil of the Arab, can be employed as a simple dust mask; and "chaps" protect the legs of mounted men tearing through mesquite and chaparral, riding herd. Even the low, mournful beat of cowboy melodies may be said to reflect less a sorrowful temperament and outlook among western stockmen than a practical

adaptation to their business: Close-herded stock are soothed, it is thought, by such tunes.

Especially considering the responses of western cattlemen to dry-land conditions, Webb remarks:

"The plains destroyed the old formula of living and demanded a new one . . . East of the Mississippi civilization stood on three legs—land, water and timber; west of the Mississippi not one but two of these legs were withdrawn—water and timber—and civilization was left on one leg—land. It is small wonder that it toppled over in temporary failure . . ."

Rarely as picturesque as adaptations required of cattlemen in their first gaudy scamper over the dry lands, but no less demanding, were adaptations required of farmers who, with corn and the seed of eastern and midland grasses in their saddlebags, followed. Pushing over the dry line, the farmers tried to farm on the Plains just as they had farmed in the midland, or back East. They found, as a rule, that their farms were too small, that existing varieties of corn would not grow in the short-grass country, and that dry-land farming required an almost complete change in method, more expansive thinking, greater patience, and an even more tenacious faith than it takes to make a go of things on costlier, wetter, more crowded soils they had known.

Even before white farmers came here there must have been a considerable outwash of soil. Indians set the grass afire here and there and burned great expanses of the Plains to bareness. Buffalo herds milled up the sod, and stomped it to dust at places where they thronged to drink. The occasional ferocity of the climate here, with swift amazing swings of temperature, and cloudbursts no gulch, arroyo, or natural watercourse can contain, is noted in the accounts of the early explorers. To the south, the Spaniards encountered floods; to the north, years later, Lewis and Clark declared (in their more sober, surveyor manner) that they had never seen such weather.

Lewis relates that, with a Plains shower impending, "Captain Clark" (scouting, with an Indian guide, his wife, and their child, in company), "took refuge in a deep ravine where there were some shelving rocks." It was a dust-dry ravine, and in that shelter not a drop of the cloudburst reached them, directly. But: "The rain seemed to fall in a solid mass, and instantly collecting in the ravine came rolling down in a solid mass, carrying the mud and rocks and everything that opposed it." They leaped to their feet and began to climb, with the captain pushing the Indian woman and her child before him. "So instantaneous was the rise of the water, that before Captain Clark had reached his gun and begun to ascend the bank, the water was up to his waist, and he scarcely could get up faster than it rose, till it reached a height of fifteen feet with a furious current."

Struggling back to camp, they found the remainder of the expedition "in great confusion." For: "The hail," writes Lewis, "was so large and driven so furiously against them by the high wind, that it knocked several of them down . . . Most of them were bleeding freely and complained of being bruised. Willow Run had risen six feet since the rain, and as the plains were so wet they could not proceed, they passed the night at their camp."

When, after 1850, the first tide of settlers crossed the Missouri, or made their way up it in steamboats, they called the river "Old Muddy." Its waters, said Thomas Hart Benton, who later became a senator, were "a little too thick to swim in, and not quite thick enough to walk on."

Stratagems and Schemes

The free-land racket was a grand one while it lasted; and it had its lighter side. Often the grab was made by ingenious little tricks, without violence, in the manner of David Harum, slick. The homestead law required a habitable dwelling on a quarter section before the homesteader could file claim on it as his own. In reports filed for Horace Greeley's Tribune, later gathered into a book, Beyond the Mississippi

(1867) Albert D. Richardson sketches some of the "habitable dwellings" that he saw on pre-emption claims. One was a doll's house which could be carried conveniently under a man's arm, from one claim to another. It was "12 by 14," the deponent swore; that was the legal requirement; and he neglected to add that he meant 12 by 14 inches, not feet. Another fraudulent device was a shed drawn on wheels by oxen, a rude forerunner of the trailer in this land of the restless free. But the neatest dodge of all was nothing but four sticks laid in a square on the ground. Thus with dodges great and small, and some violence—together with patient suffering and stupendous feats of heroism and endurance—the great grasslands of our western country were taken and broken.

A hard country, beautiful and mighty. The sun and wind beat and weather its people. Their eyes squint, the skin of the lids parch and wrinkle early in life, the hands and the face, the neck, and all skin surfaces which men who work afield expose become thickened, tanned, and seamed, rather like leather. And Plains weather exerts other effects upon people, inward effects. They are not sure of as many things as more sheltered people are. Even when they brag, their eyes are generally self-mocking, mildly wise. They do not, as a rule, have much to say, or take long to say it. But the ones who manage to stick it out up here toward the roof of the continent who live on and farm there, through the unpredictable swings from bounteous weather to long spells of punishment and terror, form for this part of the country bonds of affection not unlike the bonds which hold men to the sea.

There is no definite border now between the north and south Plains. It is all one slope of ground, which becomes more northern in crops and character above the Red River, and more definitely so toward, say, the thirty-eighth parallel. Most of Kansas, all Nebraska, the Dakotas, and Montana are distinctly northern, in tradition, attitudes, and temperature. The soil freezes harder and stays frozen longer here than it does to the south; neither dust nor water erosion is quite as severe or general as it is southward. But the north Plains people have seen trouble too; plenty of trouble, and have helped the weather here to scrub and whip the land.

In the drought of 1859–60, "not one good rain," (Everett Dick reports in The Sod-House Frontier) fell on the greater part of Kansas and Nebraska "from late June until November." The winter was open, the spring hot and dry; and with the summer of 1860 the hot winds came. In Nebraska the wind blew from the southwest, "as if the very breath of hell had been released" for 16 days and nights on end. "Claims were abandoned; farms were sold for a song; thirty thousand people left the territory of Kansas temporarily to secure food. Forty thousand stayed . . ."

In 1874, the grasshoppers or "Rocky Mountain locusts" came in such force that their weight broke off the limbs of trees and Union Pacific trains stalled, with spinning wheels, because of the hopper's massed greasy bodies, covering the tracks. "Men with clubs," Professor Dick records, "walked down the corn rows, knocking the hoppers off, but on looking behind them they saw that the insects were as numerous as ever." The hoppers ate pitchfork handles, weatherbeaten boards, trees, field crops, gardens, "and even invaded the house and ate the window curtains in at least one place in Kansas . . . When the insects left the whole country was a scene of vast ruin and desolation." Nebraska and Kansas floated relief bonds. Dakota territory considered doing so also, but took no action. The Federal Government appropriated $150,000 for the relief of the settlers, the Army gave it out as clothing, food, and seed for 1875, the year to come.

Up in the Dakotas, too, the weather hit hard soon after the earliest sweep of settlement. An editorial from The Daily Tribune of Bismarck, dated October 15, 1886:

"The Northern Pacific Company will act upon the advice of its general emigration agent

Colonel P. B. Groat, and all farmers along the line of the road whose crops were a total failure this year (because of drought) will be furnished with good seed wheat for next season. This encouragement to farmers at this time will do an immense amount of good, as many who decided to do but little fall plowing for next spring's seeding will now prepare all the ground possible and make up next season for what has been lost this year."

Of the same drought, 1886, Lauren Dunlap, of the North Dakota State emigration office, said: "Never since the settlement of Dakota began in earnest has drought been so general . . . It is reasonable to suppose that such an experience may not be repeated again in the life of the youngest Dakotan." Digging these observations out of the dusty files of The Tribune in 1937, H. L. Walster, dean of the North Dakota Agricultural College, shows now that Dakotans born in 1886 and still living there, have come through severe droughts in 1893, 1897, 1900, 1910, 1917, 1934, and 1936. Rain returned in some quantity to the greater part of the Dakota dry lands in 1937, but not always when it was most needed; the extreme northwest of North Dakota, like the eastern Montana country just beyond, remained desperately deprived. There are counties in this territory where nine-tenths of the farming people are on relief today.

"*Sharing the Wealth*"

As long as the land lasted, the Government kept giving out land. The Homestead Act of 1862 provided for the entry of 160 acres by citizens and those who had declared their intentions to become citizens. An entry fee of $5, and 5 years' residence was all that was required to obtain title. This quarter-section grant, cut to the measure of more humid regions, proved in time on the Plains a skimpy grant, a grudging invitation to economic suicide; and it was 15 years before a far-away Congress could be moved to see that the Plains are different and to make significant change in land laws. In 1877 the Desert Land Act allowed title of 640 acres to each applicant. It was contemplated that the land would be irrigated.

Between 1870 and 1880 land added to the farms of the Nation was equal in area to France, Germany, England, and Wales combined. No king, however open-handed, ever granted his favorites lands and bounty as lavishly as this free Government, parceling out the country to all comers, great and small. To the railroads the Government gave 158 million acres of land, with all the coal and ore under them and all the timber above them. This domain stretched across the moist prairie as well as upon dry lands westward. By 1871, railroad grants alone amounted to five times the area of Pennsylvania.

In her novel, Cimarron (based on historical records and talks with men and women who have lived in Oklahoma since the days of the opening, in 1889) Edna Ferber writes:

"The militia was lined up at the boundary. No one was allowed to set foot on the new land until noon next day, at the firing of the guns. Two million acres of land were to be given away for the grabbing. Noon was the time . . . April twenty-second [1889], at noon . . ."

Women as well as men were crouched there on the line, set to make the run: ". . . women in mud-caked boots and calico dresses and sunbonnets . . . Good women, with a terrible and rigid goodness that comes of work and self-denial . . ." Yancey Cravat, the hero of the novel, goes on with the story:

"I had planned to try and get a place on the Santa Fe train that was standing, steam up, ready to run into the Nation . . . There wasn't room for a flea. They were hanging on the cow-catcher and swarming all over the engine, and sitting on top of the cars . . . I decided I'd use my Indian pony . . .

"There we stood, by the thousands, all night. Morning, and we began to line up at the Border as near as they'd let us go . . . Ten o'clock, and the crowd was nervous . . . like people starving. I've seen the same look exactly on the faces of men who were ravenous for food . . .

". . . eleven o'clock, and they were crowding and cursing and fighting for places near the Line . . . The sun blazed down . . . The black dust of the burned prairie was over everything . . . Eleven forty-five . . . the soldiers, their guns in one hand, their watches in the other . . . The last minute was an eternity. Twelve o'clock. There went up a roar that drowned the crack of the soldiers' musketry as they fired in the air . . . You could see the puffs of smoke from their guns, but you couldn't hear a sound . . . like water going over a broken dam . . . The thousands surged over the Line . . ."

This was in the spring of 1889. Forty-one years later, in 1930, the Oklahoma Agricultural College completed an erosion survey in Oklahoma. It showed some 16 million acres under cultivation, of which 13 million acres was severely eroded. And: "Of 1,694,000 acres abandoned in the State during the past few years, 359,000 acres," the report estimated, "was abandoned because of erosion."

Some part of this, in western Oklahoma, was wind erosion, but most of the soil loss recorded was from rainfall on the loose.

Pressing On

It is the custom of historians to accept as the end date of the American frontier the year 1890, when the Government first announced that there was no more A 1 free land to be had. But people were pressing on to new sod long after that. Farm settlement (and partial resettlement) of western plains and mountain plateaus dates, in many localities, within the present century. In western Kansas, near the New Mexico line people still are pressing on to short-grass sod and are killing grass with plows. They are living in dugouts, and ripping up thousands of acres with modern power plows on a new cotton frontier in the western Texas Panhandle. They got some rain there in 1937. It was estimated before the farmers there voted compulsory controls upon themselves in the A. A. A. cotton referendum, that another 200,000 acres of sod would be broken in the spring of 1938.

As was true along the eastern edge of the dry-land Plains in the eighties, many of the more recent sodbusters hit, in the middle and western Plains, good years and great harvests, at first. "Indeed", writes M. L. Wilson and Ray Bowden, in their bulletin, Dry Farming in the North Central Montana "Triangle", "the man was a stoic who could not enthuse over the crops of 1915–'16. Wheat on sod without exceptional treatment yielded 50 bushels to the acre and sold for two dollars a bushel . . . [But] beginning in 1917 a drought set in and continued practically unabated until 1931."

Homesteading on the Plains was subsiding, somewhat, when in 1912 Congress passed the Three-Year Homestead Act; then it doubled. The land office at Havre, Mont., for one, had recorded about 3,000 entries for land in 1912; in 1917, it recorded 7,500. Wilson took an occupational tally on a typical group in one Montana township. Of 58 settlers there, less than half had ever farmed. The others included professional wrestlers, a deep-sea diver, two milliners, cowpunchers, bartenders, carpenters, and maiden ladies of no calling, all persuaded that sod breaking and wheat growing would make them rich and happy.

M. L. Wilson is now Undersecretary of Agriculture. His grandfather was born in Pennsylvania; his father was born in Iowa; his own children were born in Montana where, in 1909, he went as a homesteader and took out a dry-land claim. Difficulties developed when the rains failed, from 1917 onward; and the College of Agriculture called him in as a farmer to help work out new cropping systems that would make Montana permanently habitable. The "Triangle" bulletin, written with Bowden, then editor of the college, was issued in 1926, at a time when drought and deflation had seared the region, held the wheat rush there at a standstill, and deprived through tax or mortgage default, nearly half of Montana's wheat farmers of their farms. The remaining half were trying,

of necessity, in the face of everything, to grow each man a greater acreage of wheat than before.

The Wilson-Bowden bulletin carries more than information. It sounds that stoical, yet proud note of stubborn optimism which keeps the surviving farmers going, out there on the high dry land. Most of the material was gathered from working farmers who give from experience methods they consider practical and necessary, if Montana is to remain a farming State. Crop diversification, fallowing, the building up of feed reserves, and—perhaps most important—supplementary irrigation are stressed. As early as 1880 a few Montana farmers had started to convey run-off waters from snow or rain on higher slopes to thirsty land below, holding it there with dikes, soaking it into bottom lands, to make a crop.

A considerable part of this Montana bulletin is made up of encouraging communications of older Plains regions that had gone or still were going through much the same experience. One must serve. William E. Connelley, Secretary of the Kansas State Historical Society, wrote:

"From what you say, you people in Montana are having the same experience that the pioneers in Kansas had . . . In 1860 there was a drought extending throughout the year. Claims were abandoned at that time which are now worth $350 an acre. Western Kansas has been settled and almost depopulated more than once because of climatic conditions. The soil is good and with enough moisture immense crops are raised . . . As people become more familiar with the soil and climate they know what crops to plant and they always have enough feed for their stock. Those who settle down and stay through these vicissitudes of pioneer life win out . . ."

Wheat Rush

In 1926, when this letter was written, the march of wheat on the High Plains of Kansas, Oklahoma, and Texas was still in full stride. In speed and extent there was never in all history another crop rush such as this. "Immediately before the war", said Henry A. Wallace, contemplating staple crop surpluses, in one of his first addresses as Secretary of Agriculture (May 13, 1933), "our agriculture was tending toward a domestic basis of production. The war rushed us out upon the markets of the world. Fifty million acres of Europe, not counting Russia, went out of cultivation. Food prices rose. A new surge of pioneers strode forth on our high and dusty plains, and found they could grow wheat there . . . Throughout the country, sod was broken. Before the surge was over, we had put to the plow a vast new area . . . To replace the 50 million lost acres of Europe, the United States had added 40 million acres to its tilled domain, and thrown its whole farm plant into high gear."

Not all this expansion, of course, was in the Plains area. Grassy hills of humid areas were overplowed; and humid crests were cleared of protecting woods for wheat. But the greatest breaking of grass for wheat was on the Plains. The greatest killing of the grass that had matted and helped to hold this country together for centuries was in our dry lands where native grasses, once destroyed, are slowest to creep back.

Two great new belts of grassland were torn open and sown, with constantly larger machinery, and higher power: (1) The hard winter-wheat area of western Kansas and Oklahoma, which extends also into bordering parts of Texas, Colorado, and Nebraska. (2) The semiarid section of the more northern spring wheat region, from the Missouri west to the Rocky Mountains. By 1924, O. E. Baker notes, mapping the march of wheat, in his Graphic Summary (U. S. Department of Agriculture Miscellaneous Publication No. 105), "grain production had advanced almost across the Great Plains in these two sections." By 1924, the Plains States were growing around 17 million more acres of wheat than they had grown in 1909. By 1928, they were growing 20 million acres more than in 1909; and the rush swept on to a peak in 1931. Prices ranged in

that long period from around $2 to below 25 cents a bushel; yields ranged from bumper proportions to almost nothing. Wheat farmers lost their homes and lands, and diminished in number; but with ever greater machinery, and lower costs, the march swept on, with more sod turned under, and dust storms getting worse.

This burst of new wheatland upon the Plains was accompanied by acreage increases on the Pacific coast and in Idaho, and by a general diminution of wheat sowings to the East. In 1910 Kansas had harvested 60½ million bushels on 5 million acres. In 1931, Kansas harvested 13½ million acres of wheat, and the crop was 252 million bushels. These figures suggest, among other things, the Plains' erratic weather.

In the same years (1910–31) Oklahoma wheatland went from 1½ to 4½ million acres; in Texas, the jump was from three-fourths of a million to 4¼ million acres, harvested. In point both of harvested acreage and yields, 1931 was top year on the Plains.

Roots to the Sky

With no recorded mention of soil conservation, the first major drive for a reduction of American plowland was launched on the Plains against wheat. When the crop of 1931 was as yet unseeded, Alexander Legge, chairman of the Farm Board, and Arthur M. Hyde, then Secretary of Agriculture, stood on platforms in the midst of this vast new belt of grain and pleaded because of a burdening wheat surplus, for a diminished sowing there that fall.

It was a brave attempt, a gallant appeal to reason, launched at a time when deflationary forces driving farming ahead of a general smash forced farmers into unreasonable decisions as to land use and into further frenzied cultivation which many knew, even then, to be unwise.

"The way to handle a surplus is not to grow it," said Secretary Hyde. "We were ridiculed," he wrote later. "We aroused a storm of wrath and resentment. But the trip had its uses. It started thought on new tracks." So it did; but these Government men had nothing to offer except reasons which, while good for all growers, offered neither hope nor comfort to any one grower individually. In its closing report the Farm Board said: "Prices can not be kept at a fair level unless production is adjusted to meet market demands."

The A. A. A. was a developed and desperate response to overplowing during the war. After the war we piled uncollectible post-war loans upon uncollectible war loans abroad, in order to keep up an appearance of traditionally expanding farm acreages and output and of crop surpluses moving overseas. When we had a general panic, in 1929, farm prices, already far below most prices, led a general collapse.

Rude measures of agricultural adjustment had to be undertaken. What we tried to do was a forced continuation of what we had been forced to the edge of doing earlier less by reason than by tightening circumstances throughout all but a little of the civilized world.

It runs against our tradition. Traditionally, we are the great opener, the great skimmer of new soils; the great and cheap provider to elder lands, on a restless, debtor, expansionist basis. Suddenly now, we became the greatest creditor nation on earth. Suddenly we could not collect for the overexpanded plowing, the slaughtered grass, the lost soil, the rusting grain elevators, the overexpanded factory smokestacks, the idle boats, granaries, and warehouses at our ports. Emotionally we were still on an expansionist basis, but the rest of the world, somehow, had shut down on us; and was trying, within national borders, to fend for itself, to stand, country by country, on a stripped-down basis, against the hazard of another World War.

Wheat proved particularly a symbol and symptom of Europe's withdrawal from commerce. All those separate, fear-ridden countries craved with a special ardor bread at hand.

An eastern American writer who traveled to western Kansas soon after the first reduction plea had been delivered there by Legge and Hyde in 1930, rode for 3 days in his first dust

storm, saw 40-horsepower outfits with headlights still extending the wheatland, day and night, and wrote, in some bewilderment:

"Over all this high, parched region of gray, interminable plain a wind blows hot and dirty with a peculiar low, roaring resonance from the south. A strong wind, beating cubic acres of acrid topsoil into clouds that fly low and delicately cut the face. A thin, swift, scorching wind, bringing upon the body no living beat of air—only a hot, dry, constant pressure as a dead world of dust, dried insects, corn husks, kafir fodder and the skeletons of thistle and tumbleweed sweep by.

"Out in this blast of dust, bitten by it, hidden by it, their denims, their hands and faces matted with the grime of it, the men of West Kansas whistle, and go right on sowing wheat. The very life of Kansas, they say, is in its wheatlands. Western Kansas will raise wheat at a hogfeed price to the end of time if need be, say its biggest farmers, and make money and keep the world in bread."

They had little choice. It was not just obstinacy, or local pride, which kept these sodbusters defiantly plowing with their tractor headlights stabbing through dust clouds at noon and midnight. They had cheap land, fit for little else than wheat; they had huge machinery; and they were in debt. If a man has certain debts to meet, and wheat is a dollar a bushel, he will plant enough wheat, allowing a margin of safety, to pay his debts and have some money clear. But if wheat promises to bring at the farm only around 50 cents a bushel, he will probably strain himself to slap in around twice the acreage and pay out. He will not at least be inclined to reduce production.

Amid similar conditions, our Cotton Belt stretched westward. Our national planting of cotton increased from 30 million acres in 1921 to 47 million acres in 1926.

Extremely low prices do not, then, invariably lead in their own good time to an adjusted production. This is particularly true in farming. Very low prices for farm products prevailed in general from 1920 to 1930. Something over 450,000 farmers lost their farms by foreclosure and millions of others moved to town, but those who remained extended their operations over practically as much land as had been tilled in 1919, at the peak.

"*Factories on Wheels*"

Througnout the world the march of wheat and other major crops from lands originally forested to the steppes and prairies, and an attendant passage from a pastoral to a commercial, interdependent, and mechanized agriculture, has been swift. Early in the nineteenth century, when Malthus foresaw starvation, the Hungarian plain was mostly pasture land, the pampas of Argentina was an unmapped wilderness, and our American dry-land Plains were an unknown "desert." But nowhere else in the world was the march of chilled steel, tearing into sod, as thoroughly mechanized as here. Plowing, the Indians say, turns good country upside down. Nowhere else was country turned upside down with as impressive an equipment of warlike wheeled *materiél* as on our Plains.

Farmers of Kansas, Oklahoma, Texas, and Colorado had, between them, 65,594 tractors in 1925. By 1930 they had 142,919 tractors. "The most modern of these wheat outfits," writes Chester C. Davis, "can fairly be called actories on wheels." A 60-horsepower tractor draws 12 plows and seeding equipment. When the wheat is ripe a combined harvester and thresher puts the wheat into trucks, threshed. A bushel of wheat so raised and taken, Davis estimates (Review of Reviews, December 1933) "takes only about three minutes of human labor. A peasant, or an old-time farmer, sowing by hand, harvesting with the cradle, requires about three hours."

Of large-scale experiments in Montana, M. L. Wilson reports: "A 60 horse-power track-laying type of tractor, with its complement of wheat-raising machinery, is capable of operating a wheat farm five or six times larger than the average wheat farm in northern

Montana . . . If all wheat farms were in some magic way to shift to this type of equipment, four families out of five would be eliminated . . ."

The greatest and quickest plow-down of native grass in the world's history was expedited, then, by a marvelous technological development—expedited, and, in a sense, compelled. In years of rain, when you can grow wheat that way on flat, cheap dry land, you get it remarkably cheap, and you save an almost incalculable amounts of back-breaking labor.

Toiling by hand, a Chinaman and his son break, sow, and harvest 5 acres of grain a year. In many areas of the United States, writes Roy F. Hendrickson, in a recent United States Department of Agriculture report, Technology and Agriculture, a farmer and his son, with power equipment, break, sow, and take each year 500 acres of grain. Combines drawn by tractors, crawling giants in the wheat, grow bigger; and, year by year, they move faster. In some places the tractors, with another shift of drivers, have headlights. Hooked on to gang plows and trailer equipment, they push on, break and resow the same ground that night. More and more tractors are being equipped with radios for the distraction of the drivers.

Now this might be all to the good, this farming behind headlights to the strains of night-club music, if instruments and measures of soil holding had developed to anything like the same proportions, or at the same pace. They have not. Leaving out such extreme examples as these high-powered plainsmen—some of them, "suit-case farmers" who put in 6 or 8 weeks making and taking a crop and spend the rest of the year on the coast—we have still in operation over a great part of the United States a point of view, knowledge, and equipment which tears into the topsoil by power-age standards, and defends that soil from blowing or washing by hoe-age standards, or not at all.

If we knew today, one-tenth as much about the fundamental mechanics of soil erosion as we know about the mechanics of the internal-combustion motor (which has served so powerfully to accelerate that trouble) we might learn rather quickly to farm safely on these Plains, and elsewhere. But we have one research man or worker on one side to thousands on the other.

Dust

Soil has moved with the winds since the world began. Even before the earth was clad, and in long-time cycles of weathering and glaciation with alterations of weather and of the plant cloak afterwards, loessial or aeolian soils were laid and relaid. Within the remembered time of man, dust storms are an old trouble. Homer mentions them; Virgil mentions them; and if in the lament for dead grass which opens this chapter mention of the failing eyes of livestock may be taken to mean that the dust was blowing, the Bible mentions dust storms, too. Clouds and showers of volcanic ash have long been recorded; so have sandstorms. But dust storms which carry the finest part of the soil high in the air from one region or country to others far away are a comparatively recent phenomenon, the world over. In 1902 dust clouds originating in Algeria were seen over Italy, Great Britain, Russia, and Denmark. Today, when dust from overgrazed sandy steppes in central Asia, dims the sun in Samara, hundreds of miles away, the peasants, according to Ilin, have a saying: "The Persians are shaking their robes."

E. E. Free of the United States Department of Agriculture summarized existing knowledge on the aeolian transfer of soil materials in a monograph published in 1911. He showed that any soil changes somewhat under stroke of the wind; that moderate transfers may be beneficial; that excessive transfers must be controlled by windbreaks, cover crops, rotations. It was a thorough, quiet publication. Wind erosion was almost nowhere considered a general menace in the United States a quarter century ago.

Ewing Jones of the Soil Conservation Service, having examined explorer and pioneer chron-

PLOWS TO THE PLAINS.

DUST.

DUST OVER DAKOTA.

DUST OVER TEXAS.

icles, finds repeated mention of "brief and local" dust storms on the Plains in the last half of the nineteenth century, and a few reports of bigger and more troublesome dusters that seemed, one traveler wrote, "to come from beyond the rim of the earth." But even the greatest dusters of that time were minor and passing inconvenience as compared with the storms of today.

In The Country Gentleman, March 1936, Ben Hibbs, who was reared on the Plains, answers in a few words, sensibly, and in accord with the prevailing testimony of natives and historians not embroiled in the continuing controversy between plowmen and stockmen, the question: "Who did it?" Hibbs:

"The dirt has blown, to a degree, ever since the first sod was broken on the Great Plains shortly after the Civil War. Even during the era of the fenceless cattle range there were dusty days—in localities which had been overgrazed, and in isolated sandy areas where the soil was too thin to support vegetation. *But such disturbances were minor and local.* The records of the early explorers and the testimony of the older cattlemen bear me out when I say that there was a time when, year in and year out, the wind blew clear and sparkling across the grassy savannas of the West. In two brief generations man has undone Nature's labors of several thousand years . . ."

Nature raised the first dust storms, then established with vegetation a working balance. Man—first stockmen, then plowmen—tore rudely into the established scheme—always maintained at a hair-trigger balance in regions of little rain. Man tore in and "deranged"—to take a phrase from Marsh, who foretold such wreckage in 1874—"derange[d] the combinations of inorganic matter and organic life, which through the night of aeons she [Nature] had been proportioning and balancing to prepare the earth for his habitation."

Waiting for the Rain

Now that we have dust storms, severe and threatening beyond known precedent, "The rain will come back," plainsmen say. In western Kansas they tell you that as far back as 1911, 1912, and 1913, when the wheat advance was but a scattered line of sod houses on the buffalo grass sod out from Hays, the dust was bad. It blew, they say, during those 3 years with hardly a pause, day and night. It would shower hard in the morning and the dust would blow again that afternoon. Crops baked and were blown from the ground. The topsoil of whole counties moved north. Then came steadier rain, the war, less dust, and the greatest wheat crops in the history of Kansas. And then came another cycle of drought and dust, still continuing, but certain (the old-timers believe) to end in 1938, at the latest.

On the Plains, as elsewhere, many believe in 7-year cycles of wet and dry weather. That precipitation cycles exist, most students of weather agree; but neither the 7-year formula, nor any other, appear in the light of present findings to hold. In a 620-page compilation of data, The Western Range, by specialists of the Forest Service, issued in 1936, R. S. Campbell summarizes evidence on climatic fluctuations. Tree-ring studies of A. E. Douglass on California sequoias dating back to 1310 B. C. indicate an 11-year cycle there. (Wet years leave their mark in a greater growth-ring; dry years in a slighter one.) Growth studies on ponderosa pine in Arizona indicate 14- and 21-year cycles, with drought of some severity every half century, and major droughts every 150 years. A similar study in California shows years of poor growth in ponderosa varying from 3 to 14 years between 1630 and 1930. "With such considerable variance," Campbell concludes, ". . . it is not possible to predict the exact rainfall for any single year in the future, although some progress has been made . . ."

People who live and work in biting dust as it streaks across their land for days on end, who live and work under the lash of dirty winds, hot and cold, with blown-out, and scorched-out crops and mounting debts and diminishing reserves; people who go on like this, not only

78021°—38——6

from day to day but from year to year, in the "dry cycles" of the Plains; who go on, half stifled, with dirt in their noses and eyes, in their beds, in their food, and the dirty, moaning wind pushing more dirt, through the tightest chink of the window, day and night,—people who farm thus, who fight it out on this line, live while the dust blows in as nearly a literal hell on earth as can be imagined.

They spit dust and carry on. They make jokes about it. "A drop of water hit a man, and they had to throw two buckets of dirt in his face to bring him to . . . We keep track of the wind by hanging a log chain on a post. If it stands out straight, that's a breeze, but when it gets to whipping around, and links snap off, look out it's likely to be windy by sundown."

News correspondents and other visiting writers have tried to describe "black blizzards" with some success. James Rorty, in his Where Life is Better pictures such a duster sweeping East:

"The wind rises, and suddenly all movement stops; the surface of the land rises, and clouds of dust darken the sky. The people cower in their automobiles; the roadside ditches are drifted level with the concrete; in cities many hundreds of miles away apartment dwellers shut their windows and brush the destroyed fertility of Kansas cornfields from their counterpanes. (The hawks soar higher with bleak cries; this is something new.) . . ."

Plainsmen in general, and their booster bodies call such talk "hysterical." "It'll rain again; it always has," they say. Probably it will. But a wet cycle will heal but temporarily, if at all, the trouble on the Plains. You cannot keep ripping a country up and counting on the rain, when it comes in torrential bursts as it does out there, to heal it. Dust storms, an open form of erosion, inflicting visible damage and intolerable discomfort, are only a part and symptom of the trouble with Plains agriculture.

Unquestionably, the dust menace has been at times exaggerated. Unquestionably, the term "dust bowl" is inept. It suggests fixed confines. A shift in the regions of heaviest dust has already caused those who love the phrase to stretch the imagined "bowl" hundreds of miles north, and somewhat east. Dust bowls are elastic and movable. The north Plains are stirring up their own little sources of dust now, quite apart from the general sweep from the southwest.

All that may be said of drought and dust is likely to be overwrought. Water erosion, really far more serious, arouses slight emotion. But when drought strikes hard, year after year, and your soil rises up to choke and ruin you, its passage strikes in the mind and heart an indescribable note of doom.

Are the Plains Through?

Nearly 4½ million people, the census shows, lived on the Plains in 1930. That would be about a million families. The Great Plains Committee, which early in 1937 submitted a report to the President, estimate that since 1930 some 40,000 families had moved out. Most of them seem to have gone into Idaho, Washington, and Oregon. "To the Coast or Bust" is the motto they chalk on their chugging, overladen, old cars. Reports from relief officials show that 9,000 new farm families, about half of them practically without funds, came into these three northwest States in the year 1936 alone. The 10 counties of the rich Willamette Valley, around Portland, Oreg., received 950 new farm families in 1936. Only five of these families had no need of help; 760 required work or subsistence relief; 185 showed need of farm loans for capital goods.

This worn and ragged exodus from the dust and drought has served usefully to impress the public with the hazard and discomfort of farming on the plains. And news pictures of dust storms have made the Plains appear a vast, intolerable expanse of blighted country, thoroughly done for.

The dust itself has contributed to extreme impressions. It has broken bounds. It has hung a dreadful shroud above eastern cities, even to New York and Washington, and beyond that above ships 200 miles at sea; the great duster of

May 11, 1934, especially. It ripped topsoil off some fields on the Plains to the depth of a plow. Aviators who tried to ride above it say they went up as far as they could and still there was dust. In the Capitol at Washington, Congressmen tasted dust.

Bennett estimates that this one blow moved 300 million tons (around 2,000,000 acre-inches) of soil. It was an immense and terrifying storm, the greatest of its kind in history. If ever soil was sacrificed not entirely uselessly, it was this; for that one blow jolted the United States awake to what is happening to this piece of the earth that we live on; or to a part of it at least.

The wind put on a horrifying show. But it is necessary to examine the omens with a sense of proportion. Rain moves much more soil. In round estimates, one-third of our national area shows no important degree of accelerated erosion. One-third shows scattered loss of from one-quarter to all topsoil by sheet erosion, the work of water. This leaves a third, roughly 33 percent, unaccounted for.

Of that 33 percent, reconnaissance estimates show 6 percent gullied, again the work of water. Some 5 percent of the national area is reported more or less eroded by both wind and water; and 12 percent has lost from one-quarter to all topsoil by wind erosion.

Nothing honest that could be said would be optimistic enough to appease wounded local patriotism, or Plains business interests; but it is only fair to emphasize again that dust storms, in their very nature, overdramatize themselves.

Consequent reports of the death of the Plains as a great agricultural region are greatly exaggerated. The dust does not blow there all the time, by any means; and when it does blow, much soil sticks more or less where it is. A special reconnaissance by Soil Conservation Service field men after heavy blows in the spring of 1936 covered 25,000 square miles in 20 counties of Texas, Kansas, Colorado, and Oklahoma. About half of this southern Plains area showed signs of serious blow-off; the other half did not. The worst blow-off, in general, was from recently abandoned farms, and from farms carelessly tilled under absentee ownership.

Since the dry years came, since American dust began to blow higher and darker, there is apparent an impatient tendency to write of the Plains as an agricultural waste land. Lack of present markets abroad for wheat and cotton, the Plains' great field crops, has sharpened this tendency. The people sticking it out where the dust is thickest, and the gulches driest, resent this; and rightly.

In humid areas American agriculture, with its derived plans and skills from humid Europe, has had from 100 to 300 years or more to work the thing out. Most dry-landers, on the other hand, have been struggling without inherited help, to farm the Plains for less than half of a century.

The Plains cannot so easily be written back into "desert." The land out there is deep and rich over tremendous areas. It is flat. It is cheap. It is not subject to soil acidity. The very dryness and hardness of the Plains' surface offers trackage for field machines of an almost unlimited amplitude and efficiency. Sixty-horsepower tractors are likely to bog down at planting time and again at harvesttime, back East. Corn-harvesting machinery of a size and weight comparable with the combination harvesters and threshers (combines) of the Plains remain all but inconceivable.

An advanced machine technology seems, then, to favor this region, if water enough to make the crops can be stored in the soil. Geneticists, too, are working to make the Plains safe for agriculture. Russian plant breeders report (with a perhaps premature enthusiasm) that they have crossed a relative of quackgrass on wheat, and behold, a perennial plant which mats the soil like grass, keeps growing year after year, and will yield a wheatlike grain as well. Canadian geneticists make a somewhat more cautious announcement, headline as follows in the New York Times, December 27, 1936: "SEED BLEND YIELDS PERENNIAL WHEAT: New Forage Crop Developed to Restore

Drought-Dried Lands of Western Canada; Rooting Binds Topsoil; Crossing of Grass With Cereal Produces Hay and Pasturage but Not a Bread Source."

Geneticists in the United States Department of Agriculture guardedly admit many experiments, for years under way. The thing is not impossible genetically, they say; and break off communication with this, in the Department's 1936 Yearbook: "Should it ever be possible to produce a wheat with a combination of the superior qualities of *Agropyron*, it might revolutionize wheat growing, since many of the hazards would be eliminated and the annual crop could be estimated in advance with certainty not now possible." (P. 196.)

Further along, developing afield now over great acreages of land farmed for a living, are genetic adaptations of sorghum to the need of the Plains.

"The breeders have been signally successful," says the Department's 1936 Yearbook (p. 137), "in producing plants practically to order. Especially, they have made short plants, as in Dwarf Yellow, Double Dwarf, Wheatland, and Beaver milo, that would fit the combine harvester; changed the color of seeds, as in Sooner milo; adapted the plants to new environments, as in Dawn kafir; introduced disease resistance, as in Spur feterita; and produced a dual-purpose plant [grain and forage], as in Atlas sorgo. There are now sorghums that have a productive capacity of 180 bushels of grain to the acre, and sorghums that can produce 16,000 pounds of cured fodder to the acre. Environmental factors keep average production far below these figures."

The combine sorghums especially, offer a potential threat to the Corn Belt. The grain has almost the nutritive value of corn. Sown at a swoop with great machinery, and taken and threshed in another sweeping operation by combine, sorghums bred to bear grain at the height of wheat may make in the years to come vast stores of cheap grain, and provision a livestock-feeding industry on the Plains. Derived, as are all sorghums, from Africa, these new Plains plants, whether bred for grain or forage or both, demand little rainfall. And when sorgo is planted with the rows across prevailing winds it helps rear against blow-off stout lines of defense.

All this looks to the future. What of the Plains now? They are in fearfully bad shape; but never count them out. The graziers and farmers who still are there are, for the most part, wily and adaptable. Otherwise they would not be there now. Their ground costs and overhead are low. Their farm machines are mighty. Any year farmers there can store in their soil, moisture enough to make a crop, they can make that crop, the best of them, cheap. They have as yet no fertilizer bills to meet. Available plant food is by no means as continuously melted out of dry-land soils through leaching, as in humid parts. Less cultivation is necessary for weed control on the Plains; there are fewer disease and insect pests; charges for buildings and equipment are generally less than on lands of greater rainfall; and the amount of hand labor is enormously reduced.

In the rather few places where coordinated management plans of erosion control have thus far been tried over a considerable area, wind erosion appears by no means beyond control.

Given these prospects, the better plainsmen farmers can confront severe disadvantages—erratic weather, limited crop choices, the pestilence of dust, the ruin wrought by sudden, tearing floods, the need of feed reserves and of financial reserves, and distance from markets. They may be able to lay the dust, the best of them, to adapt new crops, to lash their soil down with grass and new methods of culture, continue to make adaptations that look to the soil itself as the great reservoir of rainfall; and hold their land.

Last Wests

If between the lines in this farming summary there appears at times the hint that the story has left its strict purpose, it must be remembered that behind the whole outline of fact and figures is the stirring drama of life itself. Every deserted homestead shack is the key to some unwritten story that strikes deep. Every successful farm is a monument to frontier men and women who have written the story with their lives.—Wilson and Bowden in their "Triangle" bulletin.

We have come, thus, to American soil so lately taken that men and women still living, not their children or grandchildren, or studious writers, may be taken as authorities on the pioneer advance.

Even as far east as Michigan you will find them, farms cleared or broken within the span of a lifetime, and men alive who saw the business done. Speaking in 1932 from the Michigan land that he and his father had cleared and settled, 76-year-old Eugene Davenport, dean emeritus of the Illinois Agricultural College said: "I saw the last of the struggle. I helped clear the last hundred acres of this farm. We felled, then fired, the timber. The flames leaped up for more than seventy-five feet." Not far from Dean Davenport's place, Luther Hall, an 80-year-old fruit farmer, puts a shaking hand on a grand old oak in his farmyard, and tells: "This was the way most of the woods looked when we came here. Under this tree, when I was nine or ten I used to play with the Indian boys."

Travel Note

To easterners venturing west the newness of the greater part of this country remains, even on the twentieth or thirtieth visit, a stimulating shock. Here on newer soil are people bolder, simpler, and less subdued by caste and convention than the people of the East. Over most of the West you still feel a stronger, surviving beat of belief in human equality; and generally the farther west you go, the more you feel it. Far west, where land even lately was to be had for nothing or for very little money, the spirit of democracy is as fresh as new paint. In the Dakotas, in Kansas, in Texas; on farms, ranches, and in towns great and small; in the intermountain area; even, to some extent, in the less publicized and suburbanized expanses of the miraculous coast, you find first settlers who in dress and speech resemble hired men back East, but who are not hired men here.

Here, they hold land of their own, and some have cared for it and made it to flourish and bear. Here, they are first citizens, weathered, wise, and honored. Their names are engraved on the cornerstones of centralized schools. The freshness and vigor of such places, where the shoeshine man calls the judge by his first name, and where bellhops in hotels sufficiently modern to have air conditioning, address the guest as "Buddy" or "Sister", may distress or embarrass the frozen-faced easterner the first time out; but soon it warms the heart. All the United States must have been much like this not so long ago when all this soil was new, and everyone was led to hold himself as good as the next, or better.

It is not, as a rule, until you get to the high country, the plains and the mountains, that you find living pioneers still on their legs and active; but there you find plenty of them: Pioneer farmers such as Darwin Ouderkirk, in his forties, on a mountain plateau 6,000 feet above the sea

near Walsenburg, in southern Colorado, getting along in a region where most veterans of the World War, given grants by a supposedly beneficent Government, suffered and quit. Pioneer farmer-ranchers such as August Dwinell, not far from the Wyoming line in northern Colorado, tacking around cautiously from old-time ranching to putting up hay and laying in reserve feed. He puts up native hay, 10 tons an hour, with a slide and plunger arrangement made from pine poles, and invented locally. He runs just under the number of cattle the grass can stand and flourish: "Taking it along easy; that's what does it. This speculation and plunging, it don't count."

Conservative farming and ranching are gaining in the West—slowly, here and there. In the Texas Panhandle, Virgil Parr is sinking new wells, carefully distributing grazing in immense fenced pastures, and raising great stores of feed and forage with modern machine methods on the bottoms of the Triangle-A Ranch, which he manages for a Midwest company. Parr is not yet 50, a newcomer to Texas as compared with such as A. M. White, a well-established, successful eastern Texas farmer who told Andrew S. Wing of Farm and Fireside in 1928: "I have seen two counties go under the plow. There's an old saying that it takes three moves to settle a country. That was certainly true here. It was desolate here at first with no good roads and only a few farms out of the brush. Very few of the people who settled here when we did stuck. They would try it for a while and then move on . . . Mrs. White was the second white woman to come in. We landed here New Year's Day, 1914."

At the Lip of the Bowl

Muskogee, Okla., is not far from the southeastern lip of what newspapers call the dust bowl. It is on the ninety-fifth meridian, near the Arkansas line. Here in the South, toward the Gulf, the 40-inch rainfall rim extends much farther west than it does up North. Muskogee gets better than 40 inches of rain most years; and in 1935 no less than 72 inches whipped down from Heaven to pare and rack what is left of Muskogee County's soil.

Drive 150 miles west on a mounting terrain and you are out toward Edna Ferber's Cimarron country, with between 25 and 30 inches of rain a year. Drive another 100 miles west, and you are in the Oklahoma and Texas Panhandles, where it's considered a good year when you get from 20 to 25 inches of rain. Extend your western drive to 300 miles, in all, from Muskogee—no distance at all, the way they drive, out in that country: Now you are at Dalhart, Tex., with between 15 and 20 inches of rain. At Dalhart the Soil Conservation Service is demonstrating how to control wind erosion.

Dust from the west sometimes blows over Muskogee; but dust is not the problem here; it is rainwash. On many a farm you see fence rows standing 8, 10, even 12 inches, above the field level. Muskogee is far enough south to be subject to the cotton economy. On the low, round slopes of Pecan Creek watershed, out from Muskogee, many fences stand high because so much tilled topsoil has gone toward the Gulf.

Men gray only at the temples remember when much of this locality was an Indian paradise: Clear creeks with timber, mainly oak; gently rolling prairie deeply sodded with big and little bluestem, switchgrass, native clovers. There were plenty of fish, plenty of birds, plenty of buffalo. Creek Indians, driven north from Mississippi, lived and hunted here until the eighty-niners came. The mass of white settlement and the great plowing date back even less than that, barely 40 years.

The game is nearly gone now. The creeks and the rivers are soiled with outwash of farms and ranches. Crops are not good on the eroded fields. Of corn, 14 bushels to the acre; of cotton, 125 or 130 pounds of lint—that is about the average, once you get out of the river bottoms and second bottoms to the slopes. You can buy land up there for $15 an acre. Yet tenancy runs high.

And the bottoms are by no means as rich or their people as happy as they used to be. Muskogee is on the Arkansas River. When it rains out in the dust-storm country the river, striking down from Pike's Peak and on through western Kansas and Oklahoma, delivers now an inferior deposit. But those bursts of rain on the parched, bare dry land raised the Arkansas River 8 inches at Muskogee in 1936, covered a sand and gravel pit with a worthless 6-inch deposit of mire and rubble, and played havoc with orderly operations on bottom-land farms. Soil Conservation Service technicians at Muskogee say the river water ran close to 50 percent of mud and grit that week; and the parts of Colorado and Kansas which thus moved into Oklahoma were of no help at all.

This continent is all of one body. If one part is wounded, not only the winds spread the trouble, dramatically; but the surface veins and arteries of the Nation, its streams, bear ill. The first thing that strikes a visitor to Muskogee County is that they never seem to get water enough. "We need this," they say, man after man, sloshing around in their boots in the slimy clay; helping each other pull sliding cars out of brimming ditches along rutted clay roads. "We need this," they say, lifting faces, black and white, to the warm drops, gratefully. They never get enough. It is one of the meanest ironies of man-made erosion that the more your soil washes out in the rain,the more rain you need. Hard subsoils do not welcome and absorb rainfall. The rain strikes, bites, bounces off, with grit in its teeth.

As luck would have it, oil strikes kept this humid eastern strip of Oklahoma, bleeding to death agriculturally, feeling fairly prosperous, until the oil excitement dwindled. Awake at last and embattled, farmers and fellow citizens of Muskogee County are trying to do a great deal in a hurry now. The merchants of Muskogee were not much interested until Clyde Haston in charge of the Pecan Creek watershed demonstration, organized a businessman's tour. He put in charge a perceptive merchant he had driven out over the area ahead of time. This Muskogee business man showed Muskogee's immediate hinterland to 40 others of that town. "Twenty years from now, unless we hold what's left, these farms will be goners; and so will our businesses," he said. Now on a convenient small flat mountain overlooking the watershed, farmers and businessmen hold annual rallies to see what has been done.

Muskogee County farmers and businessmen asked for this demonstration area and got it in March 1935. Backed by the townsmen, the farmers have done so much in a hurry on Pecan Creek watershed that Soil Conservation officials in Washington call it one of the most advanced examples of protective field twisting and cover cropping in North America. Here, on a watershed of 36,500 acres, whole blocks of farms have recognized flow lines as something to be dealt with over and above line-fence bickerings. Here you can see adjoining farms on the same slopes, with their fields, terraces, outlet channels, and meadow strips locked into each other with a common design—soil defense.

In places, especially in Negro neighborhoods, fences no longer rim off one farm from another, but follow contours; and the steeper land is grassed and used as a common pasture. Burning and overgrazing, which were killing off the bluestem and natural clover, are curbed now through farm-by-farm understandings and self-government. A third of the cultivated land in the watershed has been put in permanent grass or trees. Most of the slopes are strip-cropped, terraced, or both. Pastures are contour-furrowed, to halt and absorb run-off. These grasslands are ridged like washboards, instead of being left to wash like a roof or cellar door. They are corrugated with level furrows, then matted with renewed vegetation.

Bermuda grass, once fought and scorned, is welcomed now as it weaves its mat on scarred hill pastures, or stabilizes grassed run-off waterways, or anchors terraces. *And 99 percent of all cultivated land in Pecan Creek watershed is worked on the contour now, not up and down the grade.*

The first burst of terracing served usefully to mark the grades and make the natural lay of the land apparent to every passerby. But they are working away from terracing now. Even earthen barricades of such proportions cost too much, in toil and money, to maintain. Strip crops and rows which bend the crops around the grades like guarding arms are the main reliance. Broad-base terraces are used as reinforcements on steeper land; but now in the light of experience they build them differently. At first Muskogee County terraces coiled as much as one-half foot downhill for every 100 feet of their length. Now the fall is only about two-tenths of a foot in 100 feet. To the west, most terraces are level.

It is hard to see the whole area from the ground. The back roads, not good in dry weather, are all but impassable when it rains. But even from a plodding car, squirming and wagging as it roars through mud, you can see places where Pecan Creek used to come over the road often, and does not quite come over it now. The creek used to flash from its bed and bite off roads and bridges during heavy showers. Now, most of it stays within its banks as the rains soak in, uphill.

To see the whole job, mount in a stout old open plane, driven by a World War veteran who makes a special rate to Soil Conservation men, at Muskogee's flying field. A low, westering sun shows the picture best; so it is just before dusk as a rule, that the soil rangers pay $3 from their own pockets to bounce cloud high above the area and see that their work is good.

The new field design of the Pecan Creek Valley and all its watershed is *marbled*. Instead of a grid imposed on a round surface the crops are merged and wrapped around flow lines, like the marking on the "mooney" marbles you may remember from your youth. But marble markings were made in stone by flowing waters aeons past. *Marbled* is too dead a word for the living picture below. Photographs help (one is shown nearby); yet even the best air shots lack in color, life, and movement. The actual picture swings, shines, and lives as the old plane banks, whirls, and side slips.

Ponds flash. Silvery arcs of water flash along terrace lines. Crops gleam, drinking deep of water carefully stored, flourishing, rejoicing in the dying sunlight. It is exciting and beautiful; and it looks *right* the way those crescent rows take endlessly varying form from the long, slow slopes; the way those new-formed fields of varicolored cotton, corn, clover, vetch, Austrian Winter peas, and pasture interlock, hug that soil, protect it, and support each other. Each embracing strip is a rotated garment cut to the lay of the land. The fields do not slavishly embrace contours but belly out where slighter slopes or more stable soils allow. This helps to avoid short rows and slowed-up cultivation. "The whole prairie will have to be farmed this way," says Clyde Haston, in charge of the project.

The change here has been made under grave handicaps: a cotton economy, failing soils and incomes, and tenancy. More than 70 percent of the farmers in Pecan Creek watershed are tenants. Six-tenths of them are 1-year tenants. Unquestionably there is a relationship between erosion and tenancy. It can hardly be doubted that most men with a lifetime hold on a piece of land and the right to will it to their heirs will incline to take better care of that land than will struggling renters or sharecroppers passing through.

Nevertheless, the work at Muskogee, and elsewhere, shows that most men want to farm right. They want to take care of this land. The instinct to do so runs deeper than the instinct to desecrate and plunder. And tenants, when they see that it can be done, and must be done; when, more than that, they see results—a seemly countryside instead of hideous rectangular mats of red earth and gray cotton—"Why, it gives them pride. They take hold, a lot of them, just like that land was *theirs*!" one of the largest landowners around Muskogee says.

It is not to be expected that cooperative soil-defense programs alone will make tenants

happier and more satisfied with their lot as plodding tenders of other men's acres. The long-run effect may be just opposite; it should be. Tenant leases that really give a man a stake in the farm, and its future; a renewal of the American opportunity to work up from hired man to owner; and a gradual abolition of all that remains of the cropper system which succeeded slavery in the South—all this, and more, are necessary, if we are to have a permanent agriculture in the United States.

It will take time. Meantime, it is something to note that in places where the menace of erosion has become most manifest, as around Muskogee, both landlords and tenants have become husbandmen under grave handicaps.

Colored farmers, grouped in a small community of patch farms nearly washed out and abandoned, out from Muskogee, have a saying that if you plow uphill and downhill your springs go dry. This may be a racial memory borne in the blood from Africa, another continent of violent droughts and rains. Or it may be a more modern translation of facts—a deranged water table, dying springs, lost soil. Anyhow, this whole neighborhood of Negro tenants and owners believe it devoutly; so much so, that when one among them plowed on the square uphill and downhill, they sent their pastor to him and made him replow his furrows, back and forth, along the slopes.

Often, in their clean, sagging shack of a church the preachers of this community preach on erosion now. White workers of the Soil Conservation Service and visitors to the Pecan Creek project are welcome. A bench is kept open for them in the rear. Those who go thinking it will be funny leave in a different mood. These people conduct a deeply moving service, right out of the Bible, about soil, wind, and rain.

A tall, black man with a seamed, gentle face starts the preaching quietly. His text is I Kings 18: 21, which tells how Elijah, fed by the ravens in time of great drought and distress, "came unto all the people and said: '*How long halt ye between two opinions*?' " It is a tale of famine and desolation, broken by faith and works; of a punished land with dying grass and livestock, restored to life.

Getting into the story the preacher crouches and whips it up. He describes the dead springs, the dying grass, the wrongdoing which caused all this, the despair and hunger. "Amen!" cry the neat, bent women on the forward benches; and the old gray men there cry, "Amen!" "Amen!" murmur the younger people in the middle and back of the church.

Worn soils, sparse grass, short crops, and suffering are an old story along the frontiers of this world as, continent by continent, its frontiers have been taken. So primitive and eloquent is the black man's memory and expression of the struggle, that whites, far and away the dominant breed around Muskogee, considered getting a Negro preacher in for last summer's field day, held on that flat mountaintop, with a view much like the view you get from a plane—and four planes in a meadow below to take up anyone who wanted to see more.

Up the Dry Land Border

The Great Plains area is larger than Germany, Italy, and Japan put together. Count as its western edge the 5,000-foot contour where the region breaks definitely into sharp mountains; count as the eastern edge the ninety-eighth meridian; and this domain of the Plains contains more than 450,000 square miles—288 million acres.

This traveling account of trouble in the high country will twist northward up from eastern Oklahoma to the Canadian line, then west to Montana, and then strike south toward the juncture of the Oklahoma and Texas Panhandles, from which general locality some of the fiercest dust storms have blown. Over so vast and various an area only quick samplings are possible but major demonstrations of the Soil Conservation Service have been spotted at representative points.

Mankato, Kans., is 150 miles north by west from Muskogee, and almost exactly at the inter-

section of the ninety-eighth meridian and the Kansas-Nebraska line. Limestone Creek watershed, a project of the Service, was established here in December 1933. Since then about two-thirds of the farmers on 212½ square miles have signed cooperative contracts to engage in soil defense.

They are white farmers, about half of them owners, half tenants. They grow grain with some cattle. The peak of settlement dates back only to the grain rush which pushed wheat in quantity to dry land for the World War. Yet much of this raw new stretch of "flat", or gently rolling farms is horribly skinned and torn and the general water table in the area is said to have fallen some 15 feet.

Rainfall runs to the scant side, between 25 and 30 inches a year. Dust blows over and at times makes trouble. A member of the technical staff of the Soil Conservation Service project at Mankato put a dishpan in his back yard recently. When the dust storm had subsided, he had collected 3 solid inches of strange soil from fields of Kansas, Oklahoma, Colorado, and Texas, to the south and west. Blow-in and blow-off are something of a problem at Mankato. But most of the damage here comes from run-off. It is partly limestone soil, and partly of aeolian origin. Savage showers tear it down rapidly, once the short grass, its natural protector, has been destroyed. The soil here does not gully, as a rule, until all the topsoil has been ripped away but there are many ugly gullies in this semiarid area.

Anyone accustomed to hills with a sharp lift may be surprised to see terraces here; or contour furrows to halt run-off from grassland; or grassed run-offs and waterways, stepping water down from small dam to dam between the round notches of barely perceptible slopes. But such devices are hardly less necessary here than on the sharp red slopes of the old Cotton Belt.

West of here, where hills steady down to one long, slow, almost imperceptible western-climbing slope, you have an even harder time trying to account for wash-outs. Out here the rain hits like fury, when it hits. Satisfactory coefficients between slope, length of slope, soil type, and run-off have still to be determined, scientifically. But you have only to recall the time when you took out your sled and coasted, to remember that a slow, long slope sent you tearing downhill as fast, in the end, as a short, sharp one. Out here, the slopes keep creeping higher for miles on end; and the speed and gnawing power of water has increased accordingly. Farms and ranches have washed toward the Gulf, headlong, since white men came and tore this country open to the weather.

The technical staff at Mankato—agronomists, engineers, machinists, foresters, surveyors, map makers, ecologists, and office men—numbers 20. To the work of transforming the landscape with an eye to natural checks and flow lines, the farmers contribute their own labor; but the job is too large and urgent to be done that way, alone. So two work camps, one of veterans, one of C. C. C. boys, have been set up in the watershed; and local relief labor is brought in by truck, according to need. More recently, Works Progress Administration workmen have come in. A soil-defending corps of 150 workers, on the average, is thus made available to the farmers of Limestone Creek watershed during every day of open weather. And there are few days, even in this rough climate, when the camp commanders or W. P. A. foremen judge it too tough to take out the men.

Visitors to Mankato, and to Soil Conservation Service project areas in general, find scant material for jokes about workers seeking relief by leaning on shovels. It becomes, indeed, a cause of wonder on most soil-defense projects how even disillusioned veterans, thrust now into a less romantic role than in 1917, take hold.

It is hard work, with no bands, no reviewing stands, no flags, no crowds, no impulsive kisses from pretty girls, no emotional harangues by elderly men, this time. None of the veterans is as young as he used to be, or as strong. Yet many of them sweat and strain and swear,

OUT FROM MUSKOGEE.

Ninety-nine percent of the land in Pecan Creek watershed
is worked on the contour now.

"WITH ALL THIS LAND TO MEND."

A detail of C. C. C. boys at the end of a day's work.

WAVES ON THE PLAINS.

On grassland, contour furrows to hold run-off band the slopes.

SORGHUM.

Best adapted for protective cover are the sorghums.

but put their backs into it, and show you with pride what they have done.

As for the C. C. C. youngsters, they are grand—far too young and ardent to dawdle and lean on shovels—with all this land to mend. Local relief labor generally toils with less dash and spirit, but steadily and with a deepening interest in the job. It is their own part of the country they are working over to a new design for living, and eating.

F. L. Duley, who set up the Limestone Creek project, then went on to regional work, does not wonder at their willingness to work. "It's an exciting job," he says. It was Duley who, with Miller, improvised those first trough plots to measure soil and water run-off in Missouri, in 1917. Now he has this whole Kansas watershed and the highly specialized problem of helping to work out a new system of agriculture that will allow these short-grass grain farmers to stay there and farm.

The work, the resident staff say, half impatiently, has gone slowly, too slowly. It had, indeed, gone rather more slowly than, for instance, the work at Muskogee. For several reasons: Damage here is not as dramatically apparent as it is southward; and here the tattered banners of a spacious "bonanza" agriculture still lift and flap heroically whenever the region gets a momentary break in the weather.

Farms here still are fairly large; they average more than 200 acres. The farmers here still dream of endless seas of wheat, of great machines and teams, of furrows 7 miles long without a turn. They like to farm "on the square," spaciously; this thing of winding the furrows and rows around the form of the land slows them up, they say; and they speak of "fussy farming."

Waves on the Plains

Still unsubdued to patience Plains farmers, now that they come to conservation, want bold and visible action right away. "Men who have half ruined a stretch of land in 20 years," says one head of a Plains area (not Mankato), "are rarin' now to plunge into reverse and fix up everything in 20 months." This demand to do something striking, something sweeping, something that shows, was met at Mankato, and on other soil conservation projects, in a measure, by an initial burst of broad-base terracing, which probably was pushed too far. Terracing was carried, that is, to lands which probably may be held more cheaply with less obstruction to tillage, and with far less labor of upkeep by simpler methods, in the long run. The technical staff on most of the older watershed projects in the South and West admit, without deep remorse, that they countenanced and sometimes pushed, a certain amount of overterracing at first.

Terracing is the oldest and most obvious soil-defense system known to man. With this in mind, most farmers wanted terracing first of all. They craved action. And action, as a teaching method, beats any amount of talk.

It is mainly with the wisdom of hindsight, to be sure, that most soil conservation fieldmen now have tacked away from too much terracing. But whatever the cost in money and toil, of building embankments which probably will not and should not be maintained, those coiling earthworks embracing the land along its natural contours for leagues on end were manifestly worth their cost. They advertise contours. "We sure woke them up," said Sibley Young, a worker on a Colorado project, nodding familiarly to a considerable mountain side, "when we gave that old lady a permanent wave!"

Back here on the slowly mounting plains of Kansas, west from Mankato, the work crews rolled out two big tractors, 75-horsepower Diesels, of the caterpillar type. They hooked in plows and scrapers and threw up miles of earthworks. The two terracing outfits operated in three shifts of 7 hours each, 21 hours at a stretch, with 3 hours out for conditioning the motors and resting all hands. At night headlights struck through the dark, afield; and at times the headlights burned on into daylight; for dust was blowing, and you could not see the ground with-

out headlights. In the first spring drive on Limestone Creek watershed, 23,000 acres of land were terraced, and the face of the land there was transformed.

Mail and passenger pilots flying over noticed the difference. 'Plane hostesses began to point out such areas, thus to brighten the journey for squirming urban passengers who find the Great Plains dull. Down on earth, the people farming and trading in such places, took hold with a new hope. After a long siege of dry years and dirty winds when nothing seemed to change, nothing to happen, they rejoiced to look upon their land and see something changing, something being done.

Terraces for the cropped land, and on grassland contour furrows—brown bands plowed in sod, along contours, to hold run-off and make it soak in—lift the heart of the plainsman for a special reason: Such contour markings band the slopes with visible strands of water whenever it rains. No one who lives in humid parts can completely share the dry landers' feeling about water—their more than physical thirst for the feel and sight and sound of it. They will gaze into a watering trough, spellbound. The very drip from a creaking windmill pump attracts them. They finger it and let it play on the back of their hands; and they speak in a manner both dreamy and grandiose of how that part of the country will look, once enormous underground seas of cold, fresh water (generally nonexistent), are tapped, lifted, and spread gently upon these thirsting Plains.

This is an old dream. Unquestionably the Great Plains are linked, by cloud, wind, and rain above, and by capillary water and underground streams and reservoirs below, with all the living waters of the earth. The drip from a pump in the Dakotas may go in time to form part of an Arctic ice cap or pass through the gills of a cruising shark off the Bahamas. Even on the Sahara there is really no such thing as "dry land." A veil of water clasps and nets all earth, above ground and below. But when it comes to making desert or semidesert bloom from underground sources, knowledge lags. So does money; and the possibilities seem, at the moment, limited.

The Southwest, in general, has more accessible water underneath than the northern plains have. You can usually strike water somewhere between 40 and 250 feet down; but usually there is not enough for widespread irrigation. Here and there, fairly abundant reservoirs unquestionably lie hidden, but such areas seem limited, and of an uncertain permanence. Nor are these waters always fresh. Oil seekers often bring up salt water, and where fresh water lies locked in rock strata, or flows in dark, burrowing rivers, the cost of finding it, pumping it up, then spreading it over a considerable area, seems generally prohibitive. There are some outstanding exceptions, as in the shallow-water district, near Plainview, Tex.

In the dim light of present knowledge, then, it seems best to do as most plainsmen do. They dream of "mined water" more precious than gold; but keep on farming with an eye to the sky. The sky is still their great source of water, and their soil is their vast reservoir. If more of the rain can be held on and in the ground, they can make crops, most years. This becomes manifest after even a few years' progress toward soil and water conservation in demonstration projects on the Plains. "That's how we'll irrigate, here in the short grass," said one old-timer when the work crews had finished terracing his wheatland and had contour-furrowed the grassed land above. "Lay the whole country out in trenches and let God fill 'em from on high!" he cried.

Some agricultural college technicians and men of the Soil Conservation Service, born on the Plains, have an uneasy feeling about the hopes aroused by this first great spurt of engineering action. This quick banding of the slopes with water-holding earth defenses; this leaping faith that strip cropping, water spreading, and contour cultivation will make the Plains a veritable garden—they distrust it. They have learned to fear Plains optimism and

Plains excesses. They recall a time, not long past, during the first great plow-up, when it was generally believed that the killing of the sod was making the country humid.

Heads of western soil conservation projects find it generally less needful now to whip up enthusiasm for contoured fields or water spreading than to emphasize that no one method will assure a permanent agriculture. Dean H. L. Walster of the North Dakota Agricultural College feels that even strip cropping, if overemphasized, may be seized upon as a sovereign panacea, and lead to the plowing of land which ought to be kept in grass.

Now that the first rush of soil conservation in the West settles into a steadier stride, agronomists, geneticists, and farm-management specialists have caught up with the engineers, who set the pace at first, and naturally; for defense structures can be far more rapidly reared than a clasping vegetative cloak can be restored in a new design. In time, as the new cloak eases into a better fit, and takes hold, it will cover many terraces, obliterate many a contour furrow, allow them gently to crumble into the mold. Log and masonry dams which now step water safely down from the slopes through draws or gullies thus treated by agricultural engineers may be allowed also, in time, to crumble as vegetation takes hold.

Such structures help vegetation to supplant them. Vegetation takes hold most quickly along any of these barriers which have been opposed to run-off. Wherever the water halts, the grass springs green and high, and its roots strike deep, binding. The guiding policy of the Service has been to throw up cheap barriers, to coax back the healing grass to its ancient work of holding open land together. Even in humid parts, farmers have taken, perhaps excessively, to pasture furrowing because, in the dry summers, the grass shows up so green and bright along the furrows.

East or west, as the grass takes hold again, and water is detained, soaking in, reliance upon earth structures lessens. Previous field notes have shown this happening eastward. Out here where grass is the natural cover, and where, in dry years, grass stands out like a banner amid brown desolation, the same change is taking place. Wherever water halts, the grass comes back. It may be course and weedy stuff at first, but it takes hold and creeps back to clothe the earthworks.

Reporting for Region 4, from Fort Worth, Tex., Paul H. Walser of the Soil Conservation Service writes:

"Nature's method of controlling erosion is vegetation. That is the cheapest and most practical method. With this in mind, we have put vegetation first on our program. We use it alone whenever possible, and use it to reinforce mechanical measures, otherwise . . .

"We have extended vegetative treatment to the protection of collective terrace outlets, and find now that we can control run-off from terraced areas as large as 100 acres by pasture or meadow strips, or sodded channels. Throughout Region 4, with the exception of the Black Waxy Prairie of Texas, the use of vegetative means of terrace outlet protection has almost entirely eliminated the need for permanent structures.

"We think this is extremely important, bebecause it makes it practical for individual farmers who come to the areas to go home and duplicate our demonstration program through their own efforts."

To the south Bermuda grass is the great soil binder, with occasional use, by resodding, of native buffalo grass or little bluestem. Up here in Kansas, at Mankato, and at Hays, westward on the ninety-ninth meridian, agronomists are working to find some way other than patchy resodding to bring back the buffalo sod of blessed memory. The Mankato area has an acre of buffalo sod, squat, thick, and beautiful, on a piece of ground that 3 years ago was bare and unprotected as the back of your hand. Crews of C. C. C. boys put it there, bending, digging, poking in bits of sod 3 feet apart, on the square. Even in a desperately dry year,

the sod fragments took hold and spread; but the method is laborious and slow. Improved methods may be found for reestablishing buffalo grass, as by seeding; but no one knows at the moment just how this may be done.

"Back to Grass" How Far Back?

John J. Ingalls described the advertisement which drew him west to pioneer Kansas as "a masterpiece of chromatic mendacity." Massachusetts born, he had the gift of words highly cultivated. He lived to represent Kansas in the Senate. Brought now to the light, his orations may seem overwrought and overwordy; but surely he spoke with tones of prophecy when, in the very first days of the High Plains settlement, he said:

"Our earliest recollections are of grass; and when the fitful fever is ended, and the foolish wrangle of the market and forum is closed, grass heals the scar, . . . and the carpet of the playing infant becomes the blanket of the dead.

"Grass is the forgiveness of nature—her constant benediction . . . Forests decay, harvests perish, flowers vanish, but grass is immortal . . . Its tenacious fibers hold the earth in its place and prevent its soluble components from washing into the wasting sea . . . Unobtrusive and patient, it has immortal vigor and aggression . . . Banished from the thoroughfares and the field, it abides its time to return, and when vigilance is relaxed, or the dynasty has perished, it silently resumes the throne . . ."

Agrostologists, or modern students of grass and its habits, often feel the same way about grass, but are more precise about it, and quieter. They are sun browned men, slightly stooped, some of them, though still in their middle years; and most of them wear spectacles. It is a patient, peering business, this study of the war and drama endlessly under way in the dwarf jungle, sod. It is close work and absorbing, to detect the change and struggle which comes when even a human foot crushes upon grass; or when a hot wind whips the footprints; or when herds of milling, gnawing livestock are turned in.

Sod culture is by no means as well understood, anywhere, as is the culture of row crops or even of forests. In the end, the production of edible feed and food by sod crops, forming a solid mat over civilized countrysides, may prove the most important form of culture, in point of survival.

Europe has made a little headway in this direction; not much, but far more than we have in the United States. Pasture fertilization, meadow culture, and genetic experiments to put more grain feed into close-thatched crops, without ripping the whole land up with "clean culture": These are some of the possibilities peering agrostologists and geneticists describe to engineers, foresters, cash-crop agronomists, and colleagues on their project. Agronomists and engineers wrangle endlessly; but work together; and out of it all comes a hope that a permanent western agriculture and society may still be attained in a larger way than by going back to grass alone, yet with reasonable and measured compromises to the promised mercies of sod.

Observing close-up, for years, the marvelous resilience and tenacity of surviving native grasses, at a very time when the wind was blowing cropped land away, and the rivers were choked with it,—no wonder some scientists have come to believe that the only way to save the Plains is to put the whole sweep of them back in grass and keep them that way.

And in the hardest of recent years the grassmen's sweeping prescription for the Plains' ills has gained a momentary acquiescence among many residents trying to farm. Especially when the dust is blowing, when the skies remain denying, when the hot wind is a torment, then, "The only trouble is, a lot of land has been plowed out here that God Almighty never meant to be plowed," the people say.

Go, however, year after year to the Plains, or month after month; travel, even in a given week, from spots which have been favored with showers to spots which have not; and you will observe that the popularity of "Back to Grass" as a panacea varies inversely to rainfall. Let but a splash of water moisten a locality long de-

prived; then the hardiest will tell you that happy days of 25-bushel wheat yields at big prices are here again, and lay plans accordingly. Even the more moderate incline at such times to turn their thoughts from grass.

It rained spottily but fairly copiously early last spring (1937) over western Kansas and over considerable stretches of the High Plains north and south. Naturally, nearby newspapers played up the break in the drought. A fieldman of the Soil Conservation Service, sent out to estimate probabilities, reported unofficially to his chief at Washington:

"In general, it's the old story: In parts of western Kansas, where no rain alighted, some farmers are refusing at the post offices to receive papers with headlines announcing relief from Heaven. Others on R. F. D. routes are tearing up such papers at their gates. They say let the Indians have the country back, or let's make it a cowboy country like it used to be.

"But where they got rain they are talking about rolling out all the old machinery and slapping in more wheat than ever."

The drought did not break over all the Plains in 1937; but it did break in many places, patchily; and the news reached many an absentee owner and operator as far away as Los Angeles and New York. In Chicago and elsewhere big farm-machinery men heard the news; and naturally they began to push sales in the moister spots. There has been also a considerable burst of resales of sod-busting apparatus reclaimed for debt, resold perhaps, again reclaimed, and now somewhat rusted, but still available for tearing up more land, on easy terms. Expansionism has not ended on the Plains.

Last year Plains people, all but maddened by years of burning drought, ran out into those slashing showers and danced and laughed for joy.

Actually, and paradoxically, that dash of rain threatened their future, and their land's future, more than the punishment of all six "dry years" put together, and this is still the enigma veiling the Plains' permanence as a region of farms. Early in 1938, as the last part of this publication gets written, thousands of plowshares long rusted are being rescoured and sharpened.

But the years may have ground into the plainsmen counsels of greater moderation; and perhaps, still within a democracy, such views may prevail. Back-to-bonanza-wheat; back-to-sod; on-to-an-irrigated-paradise: all such extreme and rigid prescriptions for the Plains' illness, must be subject to certain natural checks and balances. The first of these, in our present economy, is money. Not all businessmen, and certainly not all bankers, are itching to throw great scads of good money after bad. Surely, most American businessmen, along with farmers, must have learned something from past misadventures, and are not eager again to throw their strength headlong behind a widespread slaughter of the remaining grass.

Money considerations and common sense enforce, on the other hand, restraints against an extreme retreat to grass. How can a farming population largely dependent on cash crops, how can a rim of village, town, and city people who trade with such farmers and live in large part by this trade—how can they stay where they are and be fed on grass? This question keeps coming up not only on Plains demonstration areas but on all the other Soil Conservation watersheds throughout the country. Unquestionably, the right grass, properly tended, will put a stay to erosion on almost any soil or slope. But on thinned soil, and in arid, denuded parts, particularly, the first job is often to stop and sink enough water, so that grass will consent to return. Soil defense—once you get beyond paper plans and out on the land—must generally proceed by half measures or less than half measures, sagaciously combined. The treatment must be individual. Every farm is a different piece of land. Every field, indeed, is different in some particulars, from any other piece of land on the face of the earth. Every farmer is a different man, of varying means and capacities. And to tell most farmers that all or

most of their land should be returned to grass is like telling a poor man with stomach trouble to stop work, live easily, and drink the waters at some comfortable resort.

In a reconnaissance memorandum on Plains erosion, Glenn Rule lays stress on what he calls "the clinical approach." "Farmers and members of the medical profession," he says, "work intimately with nature. Medical techniques strike a surprising parallel to methods now being used to save the soil. The best physicians say they can do no more than give nature a chance to do her work.

"Encountering a problem, the physician first seeks facts. That often means a clinical examination. Specialists—X-ray men, bacteriologists, heart specialists, lung specialists, pathologists, to name only a few—may be asked to contribute their special knowledge and skills. The composite report, interpreted to the individual case at hand, suggests the treatment to pursue."

Specialization need not, of course, in the case of soil defense be carried to the point of refinement that it has in medicine. Diagnosis is not as a rule as difficult, nor are the cures as subtle. By earth surgery, with great blunt instruments, engineers can alter flow lines or patch gullies. With vegetation, agronomists can heal the cuts and wounds of earth. But a man has to go on making a living there at the same time.

If there were no new grain and forage crops which are adapted to these Plains, and which may with changed methods be grown safely on large expanses here, the plight of the area might seem at times hopeless. But there are such crops, notably the sorghums; and there are new methods, notably strip cropping, and water spreading, and cultivation deliberately planned to roughen, not smooth and powder, the surface of the land.

Following various and flexible courses toward a new sort of Plains agriculture, the final pattern of which has not been determined, Soil Conservation workers are utilizing knowledge and measures derived from the experience of resident farmers and of agricultural college workers here in the high country, during the past 10 years, especially.

L. E. Call, dean of the State College of Agriculture, at Manhattan, Kans., before the Seventh District Realtors convention at Satanta, May 1926, read a paper entitled "The Future of Southwestern Kansas." He said:

". . . South of the Smoky Hill River, the 20-inch rainfall line marks the boundary of successful wheat farming. Winter wheat is a far from dependable crop here, especially when the crop is grown in the usual manner . . . A safe farming system for southwestern Kansas can be developed best by depending upon the sorghum crops to provide feed and grain for livestock.

"Grassland once destroyed," he warned them, "is difficult to replace in western Kansas." He advised the farmers there to grow enough of forage and grain sorghum for "silage and rough feed to maintain a herd of livestock;" to keep enough pasturage abundantly to carry such a herd; and to turn their money, while the rains were with them, and prices good, into paying debts "instead of expanding operations by increased indebtedness."

Today he says: "It was too much to expect safe land use at a time when disregard of good farming practices was proving so highly remunerative. But if safe established practices had been followed then, much of the destruction from wind erosion in this territory might have been avoided."

Last May, 11 years after his first warning to southwest Kansas, Dean Call made another talk, this time to cattle feeders, and emphasized again the need of working Plains agriculture over from straight cropping toward livestock. The same means which control water erosion, he pointed out, have been found to control wind erosion, and the greatest of these is cover. But fairly constant cover may be kept on the ground without turning the whole Plains country back to sod. "The crops best adapted for growing to provide a protective cover on such lands are the

sorghums. They are planted in the spring, usually by listing, which protects the soil from blowing, and if they are harvested for grain with a combine the major portion of the stover may be left upon the ground to furnish protection to the soil during the winter and spring when most of the blowing usually occurs. Fields handled in this way do not blow."

Soundings and Swerves

Not limited to the fussy, little plots which checker experiment farms in crowded places, the dry-land experiment station at Hays, Kans., is the largest of its kind anywhere. On a flat to slightly rolling expanse of 3,850 acres, new sorghums, new tillage methods, new grasses, and faster hook-ups of mighty machinery are tried, spaciously. The tillage-method test-plots are of 100 acres each. Another 100 acres has been laid off for erosion tests, with measures for actual run-off for the entire area. Troughlike run-off traps, after the manner of Duley and Miller, have been established at Hays since 1929.

More than 25 years of bending and peering in the sun, wind, and dust are behind the 46 pages of Soil Moisture and Winter Wheat, Kansas Bulletin 273, by A. L. Hallsted and O. R. Mathews, associate agronomists of the Bureau of Plant Industry, stationed at Hays. The research had started in 1909. Call made a cautious advance toward anticipating findings in 1915. Not until 1930 did Hallsted feel justified in printing a paper in The Journal of Agricultural Research: Preliminary Report of the Relations Between Yield of Winter Wheat and Moisture in the Soil at Seeding Time. By 1936, when they published their bulletin, Hallsted and Mathews had their whole great mass of material so completely digested and simplified that any Plains farmer who has a soil auger, or if not that, a post-hole digger, or a shovel, can use the findings. From the final section of their bulletin: Summary and Conclusions—

"The depth to which the soil was wet at seeding time has, on the average, borne a very close relationship to the yields obtained. When the comparatively heavy soils at any of the three stations (Hays, Colby, and Garden City, Kans.), were wet to a depth of 3 feet, a good yield has been fairly well assured. . . ."

Since then the findings have been tested on hundreds of working wheat farms, and at other experiment stations have been extended and refined. Most experimenters still set no absolute deadline, but many farmers now say that, unless the soil is wet 2 feet down in the fall, to send out the tractors and teams is to engage in a desperate gamble. A few milling companies, scouting for grain sources, will not back men to make a wheat crop now if the soil 2 feet below the surface is dry. Neither will the Farm Security Administraton. Yet, even last fall, Plains farmers went forth in many places and put seed in soil with less than 1 foot of moisture in it. Often the dust blew over them as they sowed; and they raised more dust, then and later.

Hays gets a little more than 20 inches of rain on the long-time average; but extremes each way vary, within the years of accurate record, from less than 12 to nearly 35½ inches of rain in a year. The year 1936 was not such a good one. Earth soundings that fall showed hard-driven wheatland wet only 15 inches down at most, and in most places moisture had penetrated only 12 inches. Fallowed wheatland showed water stored to a depth of 2½ feet; and in spots, soil so handled was moistened 4 feet below the surface.

The crop came through the winter pretty well. In early spring of 1937 wheat looked promising. On the plots of the experiment station, and around the country, nearly all wheat seemed equally good.

This was in March. Checking their moisture measurements the Hays experimenters knew perfectly well what was going to happen; they have seen it happen many times. The young wheat spurted; then suddenly on land that had not been fallowed, the crop ran out of moisture; the water simply was not there. By May most wheat on unfallowed land stood but 8 inches high, brown, withered. Wheat on the summer-fallowed plots stood 18 inches high, and green.

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From the fallow, a fair crop; from unfallowed land, half a crop to none at all; that was the story in western Kansas again last year and that without going into tables of figures has been the story, many years, in many places on the Plains.

Fallowing leaves land clear of cover, even weeds, as the land gathers and stores water. Unless it is most carefully conducted on new lines, fallow culture may hasten erosion instead of halting it. A variety of new implements which ridge, hump, scoop, clump, and mold the soil itself into low formations for its own defense are in use at Hays, at Huron, S. Dak., at Bottineau, N. Dak., and at other erosion-control stations on the north Plains.

The lister is not a new implement; but newer models, cutting deeper and thrusting up sharper ridges, are proving good first-measure tools in opposing blow-off. In the South they call this type of plow a "middlebuster." It scoops out a trench and throws up ridges on both sides, rather than slicing a furrow and folding it neatly over. Strip listing—swerving occasional shallow trenches with ridged sides at intervals against the sweep of prevailing winds—gives quick temporary defense against wind erosion. When a dust storm attains headlined proportions, when eastern papers predict the Plains' return to eternal desert, when talk mounts in the West of calling out the National Guard to enforce control measures, then the farmers go out in the blinding grit and strip list to hold their land.

In the normal pursuits of soil preparation listing is generally better than plowing on the Plains. It leaves the land rougher, and the newer, deeper thrusting listers get far enough down to bring up clods. Clods, which most farmers have been taught to despise and break, do wonders when it comes to opposing blow-off and causing wind-blown soil particles to gather there. On soil so loose and dry that the lister cannot get down into it for clods, the chisel cultivator does better.

In modern terms of Plains cultivation, a well-tilled field is one that looks like a choppy sea, and the choppier the better. The swerving ground waves oppose the prevailing wind, or follow contours, or effect some compromise between the two. In general, contour furrowing seems to do the business best. It is astonishing, how even a little ground break throws the wind up, or helps quiet torrents; and when a field is worked into a surface displaying millions of such small earth dams, the effect is heartening. Rough, swerving furrows are the rule now on Service projects. They break and lift the wind, catch soil, detain water. To ordinary contour listing which closely bands the fields after heavy rains with lines that look like streams resting, a new implement, the basin lister, adds an improvement. The basin lister throws cross dams of earth at intervals across the contoured furrows; and the water is held in earth enclosures about the size of an old-time narrow bath tub all over the field. "Look at all those little ponds on that old dry field!" said a Nebraska farmer when the first rain fell on his basin-listed cornland. Also, there is a new machine called the hole digger, which pits a field more closely with little ponds.

On the Smoky Hill River project, 225,000 acres of Colorado just beyond the Kansas line, machinists have made over a caterpillar terracer into what they call a range-corrugator or corrugation machine. They took the straight, bladelike cutting bar off the terracer, and rigged it with three shovels, placed 4 feet apart along the bottom of a moldboard. The shovels gouge out corrugations about 5 inches wide and 5 inches deep. Thus grassland is scratched into shallow, parallel corrugations 4 feet apart. The work is done fast and cheaply. On steep slopes the scratches are combined with occasional terraces; but on many a moderate slope the corrugations have proved enough, of themselves, to halt run-off and increase the stand of grass by one-half.

Terraces are unpopular on these worn grass lands, especially among the more modern who herd their stock with automobiles. The whole idea of contour operations was unpopular,

locally, writes George H. Russell, in charge, when the Service started the project in the fall of 1936. "They thought it would be poor advertising for the county," he says. "This attitude has been in part overcome."

The Smoky Hill River area offered other impediments to change. Four-fifths of it is owned by nonresidents. Some of these have never seen their land. Of the entire 225,000 acres only about half is under fence. The other half is a battered survival of "open range." Often when George Russell reported by correspondence to absentee owners whom he located, with considerable trouble, in distant cities, that their land was bare and blowing away, these owners—bankers, widows, building associations, fraternal trust funds, insurance companies, and whatnot—replied that their land had been "resting" since 1927, or thereabouts, and could not possibly be in such condition as described.

Sometimes Russell had to write 50 letters, showing that the land was not "resting"; that as soon as even a sheen of weeds showed there, unfenced, other stockmen drove in herds to devour it. He offered the owners help in fencing their land, under 5-year cooperative contracts with the Service; and help in leasing it to responsible surviving ranchers, also under cooperative contract with the Service not to overuse it. Generally, when owners far away could be reached and impressed with an actual view of what was happening to the holdings, they signed up.

Not earth scratches, but fencing, was the first approach to the problem of laying the dust, holding the rain, and keeping as many as possible of the resident ranchers off relief. After fencing, leasing of fenced range to governed grazing and farming had to be arranged, and quickly. With a living to make there, in the dust, how could anyone expect a settler not to overuse his own section or half section, and overuse, in a general scramble, the open range? Russell made a count and found that most ranchers who had managed to stay off relief were operating anywhere from 5 to 40 sections of land. It was the little fellow, on cramped holdings, who was going under fastest; and in going under, raiding and ruining the open range.

From what he saw of tillage, viewed on a survival basis, Russell estimated that one-tenth of the whole area was plowed; and that one-sixteenth was about all the plowing it could stand, permanently, even with contour tillage and a pick-up in rainfall. "I think," he wrote in a letter of report to Washington, "that a good rule for this area would be 40 acres of cultivated land in a section of 640 acres. If a man wished to summer-fallow, there could be 80 acres of cultivated land in a section.

"Provided good grass was available, and cultivated land was in proper condition, a general standard for an economic unit here on the Smoky Hill River, for the average grower or farmer would be four or five sections: such a unit as that of L. I. Cline, stock grower, located 9 miles South of Cheyenne Wells. He has a unit of four sections, of which a quarter section, 160 acres, is farm land. He has received no relief assistance during the drought.

"The majority of soils in this area are developed on a loess; even moderate erosion exposes the parent material, a floury silt, very difficult to stabilize under cultivation. All severely eroded areas should be retired to native grass by using some emergency tillage operation to roughen the surface and conserve moisture until a protective vegetative cover is established. On slightly eroded fields, continued cultivation should prove profitable if contour tillage, strip cropping and summer fallowing are practiced in combination."

That, roughly, has been the program on Smoky Hill River. "Altogether," reports Russell, "71.3 miles of new fencing has been constructed; 29,440 acres of pasture land which 2 years ago was open range is now enclosed, and in regulated grazing units." Absentee landlords paid for the fencing materials on most of this land; Soil Conservation men laid the fences

out; C. C. C. boys and relief labor built them. The feeling against contour scratching, and against fencing, has in part disappeared. "The best evidence we have of this," says Russell, "is that land buyers already are showing a preference for land within the project area."

On the North Plains

The farm conservation project at Huron, S. Dak., on the ninety-eighth meridian embraces land in three adjoining counties. It is a new project area, about 2 years old, sorely plagued with wind erosion. The wind there blows fairly consistently from the south and southeast in summer and from the northwest in winter. When work was started it was decided to oppose tillage swerves to the wind and so far as possible forget contour levels. With the fields laid out thus, ridged against the wind, there was trouble. Water erosion was aggravated; and blown-in dust gathered in disturbing hummocks, so tillage was swung back on the contour; and now both blow-off and run-off have moderated. Sorgo is used for contour hedges on protecting strips. Native grasses, notably western wheatgrass, are coming back.

This was a badly wind-torn area when conservation demonstration was started, in the growing season of 1935. It looked like a desert, with large areas entirely barren, and the drifting soil destroyed such grass as germinated after rains. Fences were covered with soil drifts. Farms and ranches once valued as high as $15,000 were abandoned. On many fields, as work began, it was necessary first to level the surface with scoops or scrapers.

Shelterbelt planting of trees around holdings was undertaken, in some measure, but shelter bands of field crops in alternate bands,—narrow, bending fields, first of intertilled, then of small-grain crops—came first. This showed results even at the end of the first year, a dry one. The practice is spreading even beyond the area; and the morale of the surviving farmers is manifestly on the upgrade.

"The dust bowl can be saved," says Ben Hibbs writing in The Saturday Evening Post for December 18, 1937. "In 1935, the plight was about as bad as possible. The soil of an area more than twice as large as all New England was on the loose . . . The Soil Conservation Service, a nonpolitical arm of the Department of Agriculture, had just begun work and there was a note of grimness and uncertainty in the talk of its staff . . . During the ensuing two years the Service has done a rather amazing job of demonstrating that fertility still abides in most of the dust-bowl lands. And no one is happier than the conservationists themselves to see their lugubrious estimates of 1935 discredited . . . The greenest, most productive lands I saw in the dust bowl were on Soil Conservation projects."

Much of the more serious wind erosion lies considerably south of the Dakotas; and the eroded lands received during 1937, in general, more rain. The desert-blooming look of things where the rains hit can easily lead to overconfidence, and overplowing. With changed practices introduced as yet to but limited and scattered areas; with 40, 60, and in some counties even 70 percent of the land owned by absentee operators; and with a mounting feeling in parts, that happy days for one-crop farmers are here again, the situation on the Plains is by no means ideal. But, everything considered, there has been, both north and south, a considerable and hopeful improvement in the past 2 years. Up in North Dakota, at Bottineau, only 30 miles from the Canadian line, Service technicians, when they surveyed for a project there in the winter of 1936–37, hit a number of difficulties: deep snows, bitter weather, and winds bearing dust from no particular direction, but from all sides at once, it seemed. The surveying crews worked on snowshoes. It was determined to ignore wind directions and follow contours; but now another difficulty arose. Much of the land was so nearly level, with slopes of 2 percent or less, that contour furrows were too wide apart to break the sweep of the winds. Kay Davis, the project manager, devised an

intermediate strategy. On slopes above 2 percent he followed contours; on lesser slopes he laid his new field design in S-like furrows and strips. The swerve of the S is so calculated that no matter where the wind blows from, it cannot sweep across any treated field in the area without being opposed by a strip or earthwork at least every 500 feet. Tree windbreaks around dwellings and permanent sod strips of western wheatgrass between tilled lands are taking hold at Bottineau, and helping. The tree belts are of Chinese elm, Russian-olive, and caragana. They are grouped in plantings 5 rods wide.

Over the Montana border, at Culbertson, the wind swoops from all sides, too, but particularly from the west and north. Here protection follows contours, with generally helpful effect. Laid off, like the Bottineau area in the fall and winter of 1936–37, the most hopeful sign, at first was the way in which grass shone bright that spring where snowdrifts had made mounds and melted. Elsewhere, junegrass was sparse and brown. With respect to rain and wind, contouring and stripping are inducing the same effect. A distinct difficulty here at Culbertson, and on other wheat areas settled in the past 30 years, is the small size of the farms. A rectangular grant of 160 acres on a semiarid plain is not an economic unit for successful wheat growing in the modern manner; and even where a man has taken title to two quarter sections, 320 acres, his place is much too small. Rain remained scant here in eastern Montana, throughout most of 1937; and these farmers are having a hard time of it. They are making headway, however, in subduing erosion, and in getting some of their wheatland back into pasture for the production of livestock.

Rough Country

Striking southeasterly through Wyoming along the rough, inner rim of the Rockies we find farms and ranches boldly lifted in occasional places 7,000 feet above the sea. On the Black Squirrel Creek watershed, up from Colorado Springs, abandoned bean and potato lands have climbed above the 6,000-foot level. Above that is scrubby range land, and above that a growth of second-growth pine so thin and sparse that slashing gullies strike out of the tree roots there at the crest of a sharp, gigantic mountain watershed. C. C. C. boys have treated these gullies, and below have dug contour furrows by hand in a hard calcareous bedrock only slightly weathered. It was tough work, and the cost ran high; but no plow could be found that would break this crust of impacted sea shells, knit and cemented by aeons of weathering.

This bared, eroding mountain ridge, 7,000 feet up, was sea bottom long ago. Now the dust blows there. And rains hit with such a wallop that geologically hoisted sea bottom is smashed back toward sea bottom at a rate which smothers and drowns in gritty floodwater still fertile land and towns and people down the mountain.

On crest projects of the Service here in Colorado and throughout the Southwest, the cost of protective work on the highest land runs occasionally to as much as the land is worth. This bothers project managers. They have to face sharp queries from the people there, and from Washington. The only answer is that it must be done, not so much for the protection of the crest lands, which are often close to worthless; but for the protection of the farms, the towns, the reservoirs, the rivers, and all the devices and pursuits of civilization below.

With all their bold devices and structures, engineers have to edge their way now and show justification, against a rising swell of vegetation in the lower country; but on the great mountain crests at the headwaters of the continent, the need of structures so clearly announces itself that the engineers still rule the crests, for the most part, and love to work there. Japan, a mountainous country, they will tell you, learned long ago to spend as much as 10 times the value of a piece of crest land to keep it there, and hold back the water. Japan, also, the project man-

ager responds, grumbling, long since passed laws to retire dangerous crest land from culture; and even passed laws to deprive any owner of his land when his handling of it proved a menace to the land as a whole.

So goes the argument on every mountain project; and costs are pared as closely as possible; too closely, some of the engineers feel. The first engineer on this Black Squirrel Creek area was a man with experience on great governmental construction works in Panama. Considering the paltry sums they allowed him here, he was saddened yet stimulated. The riprap work that he planned with wood and stone to keep gulches from crumbling in flood time; his stone buffers and waterways to break, conduct, quiet, and spread run-off, easing it into the ground or down the mountain; the earth-and-log embankment he designed and built, with C. C. C. labor, to prevent the Ayer ranch house from being whisked away—in all this work, John Stoker used native materials and skills. For all his constant and vociferous yearning for something substantial, like concrete reinforced with steel, he did the job. His structures have withstood the beat of the weather beautifully.

"Ayer Ranch, 1882," says the sign at the gate, and it gives the family brand: AYR, with the A written "open," a V inverted, without the bar. Ayer is what they call "an old name" in that region, where old names are rare. Timber slaughter and overgrazing, along with crop booms that pushed plowed land up to the timber line, have led (even with a rainfall which varies capriciously from a scant 10 to 17 inches annually) to periodic bursts of flood water that sweep away soil, bridges, roads, homes, and lives. This has driven most of the early settlers out.

But the Ayers stayed on, doing nicely. Hanging on by their heads they have held the greater part of their land for more than 50 years, and have made money. Through boom and high water they have forested, grazed, and farmed 2,000 acres, not too much, and have built up from the proceeds a country home where life is comfortable, diverting, and dignified.

This thin and heady air, these boundless vistas, and the magnificent violence of Rocky Mountain weather produces in the inhabitants a tendency to state things in the large. If they want to indicate that a dust storm was thick and awful, they say they see gophers a hundred feet up in the air, burrowing. They tell of mountain showers so local and intense that double-barrel shotguns, left outdoors, are found afterwards with one barrel dry and the other one full of water.

A quality of moderation in word and deed distinguishes the Ayers, whose home a company of C. C. C. youngsters barricaded at some cost, against literal and imminent wash-out. "When I think back to this country as I first saw it," says Charles Ayer, mildly, "and see the way we've got it all torn up now, with bean and potato growing and so on, I wonder if what we call progress doesn't actually mean destruction. Greedy farming has been the ruination of a lot of this land. Maybe the Indians can teach us something."

Seventy-six years old, he is one of the cooperating farmers engaged, by agreement with the Government in a 5-year demonstration of soil defending husbandry on this mountain side. At his ridges he has planted more woodland. Steep grassland below is marked by contour furrows coiled on the mountain like mammoth snakes. Indians of mountainous Peru knew about this method of topsoil and water conservation, and were following far more elaborate methods of contour terracing hundreds of years before Columbus sailed.

From section 17 of the Springfield, Colo., area, C. C. C. camp 5–C, proudly reports, "ten contour furrows 3⅘ miles long, without a break. . . ." From the same area B. W. Allred, range examiner, remarks: "Old roadways and trails, following general contours, are more luxuriantly covered with grass than other places. Observing this, we are building small, furrowed ditches on a zero grade around hills to hold tor-

rents that now flow away, depriving pastures of needed moisture, causing destruction downgrade . . . Before a stockman welcomes the ripping out of crooked strips of sod across his pasture he wants to know whether it will work. At Springfield, Colorado, a 1½ inch rain penetrated 19 inches on a treated pasture, while on an adjoining untreated pasture the moisture penetration was only 5 inches and the remainder ran off impervious soils into gullies."

Such reports are general throughout the country that is called the dust bowl. West Texas reports pastures doubled in carrying capacity by contour furrowing in 3 years. Charles Ayer says that maybe he could put twice as many cattle on his furrowed mountain grass; but he won't. "Let it heal; don't rush it," he says.

In 1880, when he rode west, fairly comfortably, with his father in a boxcar containing all their belongings, the upland ranges of these mountains were thickly matted with rich grass. Black Squirrel Creek, on the banks of which the boy Charles built his cabin—with a girl in Niagara Falls, back home, in mind—was so shallow and narrow you could step a horse across it at almost any point. Today it is a dry gully 60 feet wide and 30 feet deep in places, and in flood time it is a raging terror. At the last high water it all but swept away the Ayers' new home; and at every rain thousands of tons of soil roar muddily down this creek, and the gulches which feed it spread and deepen, eating away the range land, bit by bit.

As the gulches have deepened, the water table has lowered. Most of the good, clear, running springs that the Ayers found when they came there are dried up now. The springs have gone, the grass has thinned, whole ranches have been stripped of the greater part of their topsoil, and the floodwater run-off from the sparsely wooded crests of the Black Forest, 7,000 feet up, has become each year more savage and dangerous. Most of the timber is gone. In the early days game abounded. "I saw a fellow named Harper jump a band of eight antelope and get them all," Ayers remembers. "This was an easy country to live in then. If anybody'd said 'erosion' to us, we wouldn't have known what he was talking about."

In 1888, with his cabin built and his fences up, he married Laura Smith from back home; and in 1889 a son, Ralph, was born. "Born just about in time to see this country the way it used to be," says his father—"before we went bean and potato crazy, and tore it up."

The bean rush never reached quite as far up the mountain as Ayers', but the potato rush did. The ghost town of Eastonville 6 miles away, is a desolate reminder of the booming times that followed. It was for a while a roaring little settlement. One of the stores had six clerks; the railroad brought in a branch line from Denver; and the houses spread to four sprawling streets. They are almost all empty houses now, falling to pieces. The end came abruptly, in 1900.

"We'd been putting about 40 acres in potatoes on this place," Charles Ayer recalls. "In 1900, the potato psylla hit us, and we didn't raise enough for a meal. It was the same way all around here. Some of us tried it again the next year, and gave up. It wasn't only the psylla; that wasn't the main thing; the thing that really put us out of business was that we'd unanchored our soil by plowing, and the thin bad land from up above was washing on to and ruining the fields below."

So potatoes went out, but they left scars, miles long and deepening, on the mountains. It would be hard to find anywhere in the world a region where man-made or accelerated erosion has punished land misuse more quickly and savagely than here. It has punished the patient and cautious operator along with the plungers and despoilers. The Ayers have always kept from one-third to one-half of their 2,000 acres in trees. From the day, as a mere boy, when he noticed that places where horses were staked out lost grass and began to wash, Charles Ayer has seen to it that no part of his land is overgrazed. Fifty head of whitefaces (Hereford cattle) is about all the cattle the ranch carries at any one

time. Cultivation has for years been limited to a few acres of small grain, harvested with a mower and used for roughage.

With range land higher up the mountain overgrazed, however; with soils at the crest ripped down to hardpan, so that, even from woods, 70 percent of the rainfall runs off, and comes roaring down Black Squirrel Creek in waves of water 8 feet high, erosion control has become for the Ayers, as for everyone in that area, a question of life or death. "It is terrifying," says Ralph, the son, "to be here when it rains." A quiet and studious man of 49, with a college degree and a taste for nature study, Ralph Ayer does not exaggerate. This is his wife's account of the Memorial Day, 1935, when they really had a mountain-tearing, gully-busting rain. Sitting in the big, book-lined living room of that modern ranch house, with Richard and Persis, her two children, beside her, she said:

"At 4 that morning it clouded over darkly and poured down hail. It covered the ground in places to a depth of four inches. I thought it would flatten the house, it hit so hard. Finally it stopped and a dust cloud blew up. It was so thick we had to eat lunch by lamp light. The electric power was off. The creek was up, plunging and roaring, but you couldn't see it for the dust.

"Early in the afternoon it hailed again—big stones this time, and dirty. Then it rained. There is no describing it. A year's rain in a day, they say. No gage could keep track of it. Some claim to have caught as much as thirty inches in tubs and cisterns.

"The bridge went out like a snapped match, and the creek came over its banks. At 3 o'clock my husband said, 'The house is going. It hasn't a chance.' We got out, wading with the children and whatever we could throw together over to the old cabin, on higher ground. It was like a fire. We took along such things as Persis' doll bed, but forgot to take anything to eat.

"I never expected to see this house again. The water reached it but didn't move it. Below here, things were even worse. The wash from these slopes swept 50 buildings out of the town of Elbert, and drowned some people there and at Colorado Springs."

With the big riprap job the C. C. C. boys did, the Ayers supplying the stone and posts, the house will probably stand. "And we won't lose much land, the way we're fixed now," Charles Ayer believes. "That's more important than not losing the house. The next generation will build new houses anyway; but they can't make new land."

Earth Clouds, Black Snow, Dunes

In the early fall of 1935 when C. C. C. unit 5–C, assigned to soil conservation duty, made camp near Springfield, in the Colorado Rockies, the natives told yarns about "dusters" the boys could not believe. The air there, and the sunlight, were cool, bracing, sparkling—clear. "This weather's just generating electricity," the ranchers said. "Watch out!" And some expressed a belief that dust storms are less the work of man than a sort of diffused explosion of lightning absorbed by earth.

The electrical phenomena which often accompany dust blows are probably a byproduct, not a cause. The effects resemble those of the static electricity which bites your finger in metropolitan edifices when you shuffle your feet on thick carpets and then touch metal, but such pranks of static proceed out of doors on a grander scale. When electricity generated by the friction of billions of flying soil particles begins to play around you in a duster on the great stage of the Plains, with the sky obscured, the wind a roaring blast, and the earth rising to stifle all life, including yours, it's something to remember, and dream of, squirming.

As Thanksgiving approached and the wind bit more sharply, camp 5–C pushed its work, contour-furrowing pasturage, planting brush and trees, building water-spreading embankments, and damming gullies which then were dry as dust. On November 18 the crews arose in pleasant weather. They were at work far afield by 8 o'clock in the morning. "About

ten," wrote H. G. Beehler, the camp superintendent in his routine report to headquarters the day after, "the wind blew hard. At noon I asked the foremen what they thought about going back to work. They said we have worked on worse days than this, which we have, since we have not lost a full day's work in this camp so far."

"About three-thirty the dust was so bad we could not see. Inside the buildings we all put on respirators and goggles. The dust settled over everything. Visibility was so poor you could not see across the room. The static electricity was so bad it was jumping from the stove pipe to the safety-flue, a distance of about one-half inch.

"One foreman came in who had started from the field ahead of the worst part of it. That left four trucks of boys out. Soon another pulled in, the truck motor dying just as they arrived. It could not be started until next morning when we found so much dust in the distributor it would not run. Thinking this had happened to the other trucks I sent the mechanic and a foreman out in another truck to help them. They met them on the road, lights on, just crawling along. They had had trouble starting their engines, and before they could, it was necessary to ground them by dragging a chain or they would go dead. I now have a ground chain on each truck for this purpose.

"The boys stated they didn't mind the dust so much, but when it started large particles of dirt at them, that was too much. The air was so full of dust you could not see the ground you were standing on. This lasted about two hours.

"As soon as the duster had stopped every one was shoveling and sweeping out, cleaning bedding, and making ready for the night. The evening meal was postponed a short while until the dust could be skimmed off the cooking food, and all the dishes washed again.

"We have had many dusters since coming to this area but this was one such as the natives had told us about. We believe they are very honest people down here now."

Dust storms are of many kinds and colors. Some push soil around at a creep or dash it along at a stinging speed close to earth's surface. The heavier particles tend, naturally, to roll or skip, the lighter ones to rise and soar. "Black blizzards" are largely of light particles, intermingled with dark-colored organic particles, humus, flying high. Grays, reds, bronze, saffron dust storms are probably of very fine clay particles and colloidal materials, mixed with humus. Storms that hug the ground are likely to be sand storms, a shifting of heavy and relatively worthless material which gets more like beach sand, more and more worthless for farming with each blow.

The stroke of wind and of water on land accomplish in the end a similar sifting. Sand remains, comparatively speaking, upstream, or up the wind. The lighter, and generally more vital ingredients of soil are carried farthest. Humus from Texas, New Mexico, Colorado, Kansas, Oklahoma—the flaky, organic part of the surface which does most to keep the soil of those parts working as a point of transfer between the quick and the dead—humus and rich fine soil from Texas and Oklahoma and from Colorado, Kansas, and New Mexico passed in the great blow of May 12, 1934, beyond the eastern borders of our land entirely. Gently sifted with a nice precision the finest part of our Plains soil fell upon boat decks and the waves of the Atlantic far at sea. So did saffron colloidal materials, another vital ingredient of any soil. It was a dark-saffron blow as it passed over Maryland. Some of the wind-borne material had been shed upon the midland and the Allegheny's western slope. In Texas, the skim milk—sand; in the midland, median particles; in Ohio, a light, unseen deposit, soon whisked away by water; and overhead, in Maryland the very cream of rich far-western soils blowing out to sea to be drowned and lost.

There have been many other bad blows since. Most of them drive northwest from the Panhandle country, even to Canada. Also, soil has blown south out over the Gulf of Mexico, spread-

ing a delicate rain of light, rich dust upon the lands and waters of the Carribean. Once, when the wind was that way, Plains soil blew west, over the Rockies, into California, and beyond.

Technicians have almost come to the point now where they say they can stop blow-off on a given piece of land of sufficient size and scope. But they cannot stop or check it on bits of land which remain bare and untended. Until blow-off is stopped there, too, the tended land will suffer from blow-in; and the Nation will suffer loss, discomfort, and a diminished vitality.

At dust-country conferences of farmers and soil conservation men, great plans must be keyed of necessity, to a map of the immediate blown area. About half of such a map, as a rule, is marked with irregular blotches—absentee-owned land, or deserted, or both, a veritable crazy-quilt of plague spots, dust breeders. On most of such land there seems to be no one to deal with, no one interested when it comes to lashing the soil down, and keeping it in producing shape. Kansas passed a law permitting threatened communities to go in and tend unguarded holdings, billing the owners, if owners could be found. A State court found this law unconstitutional. Canada has a similar law, operating. Kansas and 21 other States have passed more or less uniform soil conservation district acts now. (The way in which these districts are set up, and how they operate, is explained in Miscellaneous Publication 293 of the Department of Agriculture, entitled Soil Conservation Service Districts for Erosion Control.)

On February 7, 1937, dust blew northwest from the Texas-Oklahoma panhandle country with some ferocity. Snow covered much of our more northern Midwest at the time. It became a black snow as the flaky soil particles descended. Laid thus on a clean blanket, the deposits could be measured and analyzed. In southwestern Iowa, it amounted to more than 200 pounds of dust to the acre. Slighter deposits darkened the snow in Minnesota and on the plains of Manitoba.

Henry A. Wallace, the Secretary of Agriculture, comes from Iowa. So he was especially interested in travelers' reports of this rich black snow, covering so much of his home State. No one, he found, had ever made an analysis of soil blown 500 miles or more in a dust storm. Here was the chance.

Soil conservation fieldmen gathered and analyzed blow deposits at Hays, Kans., at Clarinda, Iowa, at Marquette, Mich. Also, they went out on to the blown soils of the Southwest, where the storm came from, and took samples of virgin land protected under unbroken vegetation. Finally, they took samples of utterly blown-out land there, from sand dunes, the whipped-over material left behind.

Undamaged topsoil protected under grass, down in the Texas Panhandle, was found to contain 1 percent of organic matter, or humus, and less than 80 percent of sand.

Blown-out soils here contained only one-third as much humus, more than 90 percent of sand.

That dust which floated down on the snow of Iowa and northeastward contained more than three times as much humus as the best remaining soil in windy Texas.

With this information before him the Secretary went on the air and spoke at his usual weekly broadcast, of Sand on the March. He gave the results of the mechanical analysis of the blown-out land and of the deposited blow-off. Then he said: "These figures which Hugh Bennett has brought to my office tell the story of a tragedy for the Southwest. Wind has been blowing the heart out of the Southwest. If there is any benefit to Iowa or other States, it is slight, and counterbalanced a thousand times over by the loss.

"The whole process makes you stop and think about the way in which rich soil in moderately dry areas can be converted by overgrazing and overplowing into regions of marching sand dunes. Sand dunes shift from place to place according to the direction of the wind. They march over and destroy farm land which is still fertile, which is being properly farmed, and which would remain fertile if the dunes didn't march in from outside.

BASIN LISTING.

Dams are built at intervals across the contoured furrows making reservoirs to hold the rain.

THE DUNES OF DALHART FROM THE AIR.

"Every little dune so formed represents a small area of desert . . . Some of them are hardly larger than a child's sand pile; some already cover a thousand acres. They grow and move fastest during dry spells. During rainy periods thistles, foxtail and other dryland or near-desert annuals can better be encouraged to hold them down . . . If we cannot stabilize them with some practical covering of vegetation, they will grow larger, join together, smother great areas of now useful land, and perhaps become altogether unmanageable . . . It is disquieting to find in this rich new land of ours conditions which already suggest conditions like those bordering the Sahara . . .

"Fortunately, we are developing defense measures that may preserve us from such waste and ruin. But we have made a late beginning. The need of a wider knowledge of practical erosion control practices is very great. By sandbags and other devices arranged in various ways as wind deflectors, Soil Conservation Service men in Texas are trying to find ways to make the same wind that builds dunes blow them down. Mechanical devices to do this are regarded only as temporary; vegetation is all that can be counted on to lash them down for the long pull . . . We do not know whether we can hold these dunes or not, but we seem to be learning how to go about it."

Laying the Dust

Secretary Wallace described conditions in the spring of 1937. Now, with some aid from Heaven—a little rain at the right time—the tallest and most menacing dunes here in the Dalhart, Tex., area have been somewhat leveled, tied, and even cropped.

Methods have varied according to the changing situations. Generally, as the work has proceeded, experimenters have placed less dependence on bag and other deflectors, and more on a calculated manipulation of the surface. The most precise case history of anchored dunes, to date, is an account of Charles J. Whitfield and Fred C. Newport, field research men of the Service, in the governmental Soil Conservation magazine for January 1938.

The field is of 470 acres, 8 miles north of Dalhart. Ten years ago it had no dunes. When taken over by croppers, private operators, in 1930 it was covered with grama grasses and shrubby clumps of sand sage. The new owners broke it and slapped in row crops 3 years handrunning. They got one crop. Drought bit hard; and the field lay idle, blowing and piling upon itself and the surrounding terrain until 1936.

The Soil Conservation Service leased, and deep listed dunes and all in that great field, in the fall of 1936. They used a 40-horsepower Diesel for power, and gouged in deep enough to throw up clods. The winter winds tended to level off the dunes and spread blow sand in the listed furrows. By March 1937 airplane pictures showed the 57 dunes on this 470 acres more than half blown down, and spread. In March a variety of dust-eating row crops were listed or drilled. Broomcorn and Sudan grass took hold best. By the autumn of 1937, the field had cover all over. Now it resembled a gentle swell instead of a flat sea with humps. And it made better than a fair crop of forage.

Since 1905 rainfall in the Dalhart area has averaged close to 18 inches a year. During the year of this experiment the land received less than 12 inches of rain. Wind blew a little harder than average, from a steady 10 to 12 miles an hour up to a peak of 32 miles. Dust above and sand below moved rather more briskly than usual, even of late, over unprotected lands. Research records at Dalhart show a total of 161 dust storms during the years 1935, 1936, and 1937.

On this duned field of which we are speaking the 57 sand piles, each a bit of desert, ranged from 1 to 9 feet high; they averaged more than 15,000 square feet in area; they were crawling east at a varying rate of from 20 to 150 feet a year, when the fight was started. In a year, they were lashed and halted.

"Wind erosion," the experimenters comment, "differs from water erosion in one primary

essential: When soil is carried away by water it is impractical and often impossible to move it back, whereas the action of wind will often reverse itself and return much of the materials it was instrumental in carrying away." But not the high-flying materials, the humus, the whipped clays, the colloids—the richest components of soil.

On other fields with larger dunes defense maneuvers varied. The dunes could not always be climbed and sown by tillage machinery. If not, the idea was to put in hardy rows of strip crops on the windward side; to loosen the dune tops, helping them to blow; to plant on the leeward side of the blow spot other plants that can stand it dry, but like quieter soil to grow in; and to creep in vegetation from all sides at once.

So they blew the dunes down, and in much the same way they leveled hummocky fields. A fair crop of grain sorghum (desert corn) was grown, and was taken with a combine, in 1937 on somewhat leveled duneland near Dalhart which had no more cover on it in 1936 than a beach or a desert.

Dune binding and dust laying at Dalhart has been accomplished under conditions of subnormal rainfall. This has been noted. But, as Whitfield and Newport also note, there was close to a 2-inch rain late in May 1937, and better than a 1-inch "shower" on the last day of August. The May rain came in a burst just before seeding the cover; *and the ground was in shape to receive and store it.* So with the late August rain; it came and was stored at a time when it helped most powerfully to make an October harvest.

It was a good job, and it got a break, not on total rainfall, but on timing. People who once were sniffish about the ministrations of soil guardians in this territory, look at before-and-after pictures now and say that results are miraculous, no less. Glad of a chance at last to take a bow, Soil Conservation Service technicians in the area take it, absent-mindedly. But in after-hours conversation around the stove they remark worriedly that they did not really "pass a miracle," complete and final, singlehanded. They were given some rain; not much, but at the right time.

Even so, results at Dalhart definitely indicate that even with some 6 inches less than the normal 18 inches of rainfall, the dust can be laid, and crops taken safely in moderation. In 1934 when the project started, 24,000 of the 29,000 acres in the area showed serious damage by wind erosion; and the remainder was starting to blow. At the end of 3 years, H. H. Finnell, in charge of the regional program of soil conservation research, reported all but 3,740 acres completely stabilized, no longer subject to blow-off. There has been some improvement since.

The key to the achievement lies in what the staff at Dalhart have come to call "deposits of moisture." Midway in 1936, Finnell, touring the five-State emergency dust area, located more than 2 million acres of land that had been contour listed before a rainy spell that May. He took moisture soundings, and reported to Washington:

"Contour-listed land is wet slightly more than one foot deeper than land not contour-listed.

"According to determined water usage of this area, this is capable of handling, if efficiently utilized, 3,600,000 bushels of grain to the normal production, and 500 million pounds of additional protective residue for the prevention of wind erosion next spring and winter.

"On the basis of recorded experiments, the surety of crop production has been increased about 75 percent."

"Horizontal plowing" was an old idea even when Thomas Jefferson advocated it for the slopes of the Appalachian foothills—in the piedmont country. There, of course, the idea was to stay soilwash; though Jefferson did note by implication that the practice made more permanent the "refreshment" of the land by rain. To demonstrate the life-and-death importance of such "refreshment" on subhumid soils to the West has become a major function of conservation workers there. In a general way, the facts

were known before; but as long as it rained enough to make crops and cattle, the facts were little regarded. "None of the farming methods introduced by the Soil Conservation Service is new or untried," Finnell points out. "They have been assembled out of the experience of the more progressive farmers in the area, corroborated by Plains experiment stations.

"Failure to recognize the need of a substitute for grass cover, and providing it, has caused most of the trouble. Wind-resistant crops like the small grains and sorghums, and the use of their straw and stubble to protect the soil, offer the most available and at the same time the most effective substitute for natural ground cover. Many unfavorable seasons can be made favorable by better rainfall utilization and timely weed control. And every crop failure avoided is an erosion hazard avoided."

Water Trap

At Spur, in the Panhandle, a substation of the Texas Agricultural and Mechanical College, college research men started run-off measurements as far back as 1926. They measured water run-off first of all. "Not that erosional soil losses are not large," explains a mimeographed progress report issued by the Spur experimenters in February 1934. "But water is our limiting factor of crop production here; water conservation gives immediate returns in crop yields . . . and automatically reduces erosion to a minimum."

Rainfall at Spur averages 20 inches a year. This figure must be read with an eye to differences in the good an inch of rainfall can do a crop, North and South. Long-time records of the Weather Bureau show that here beneath the sun of Texas, surface evaporation proceeds twice as rapidly, in summer, as surface evaporation in cooler Montana. And the water sucked up by the sun is lost to the crop.

Even so, 20 inches of rain here in Texas is enough to make plenty of cotton, Spur station finds, if you can stop the run-off, soak the rains in. Such findings at Spur during the past 10 years have buoyantly raised the hopes of the region to become a permanent crop country; and have reversed, in general, a former practice of the money lenders there.

On the plains of Texas are some 36,000 small "lakes," mainly the accumulation of rainfall in the bottoms. It used to be that, toward spring, the bankers would ride around the country; and the more water they saw in those lakes, the more money they were willing to lend on the cotton crop.

But now they reverse that practice. When the lakes are full, they know that it is run-off and that there is that much less water stored in the soil.

"Farmers from the hill countries," the report continues, "think the station lands are so level that they need no terracing, while farmers from the High Plains country think it is so rolling it should never have been put in cultivation." Surveyors' instruments show that the station farm drops 26 feet in a mile, from west to east, or 6 inches in 100 feet, a slope of only 0.5 percent, on the average.

The Spur station has no irrigation works. The staff workers at Spur dried up their lake entirely when, starting in 1930, they made on the entire slope leading down to it a series of terraces. This held back run-off and soaked it into the ground before it got to where the lake had been.

Above the station farm, which is 400 acres, are 1,200 acres, mostly pasture, all in the same watershed. The run-off from the relatively high land is trapped, guided, and gentled downgrade as it enters the station farm. There the rain from 1,600 acres is soaked into 400 acres. None is wasted. Water caught by roadside ditches is conveyed with the field overflow, impounded against an upland dike, and again, conveyed to the head of the station farm; then it is stepped from terrace level to terrace level down across the fields. The water must travel 6 miles from where it enters the trap to where it is given outlet from the station farm. Little flows out. Almost all of it has soaked in. The water trap was completed in February 1931. Since then, "The entire run-off of this watershed has been used to advantage," says the experi-

menters' report. The greatest increases in yield occur the year after the rain has been stored.

"Too much emphasis cannot be placed on preseasonal storage of water in the soil . . . Results point definitely . . . to a full utilization of rainfall over a large portion of Texas, and a material reduction in the risk of farming," the report concludes.

After showers at Spur, cotton plants on terraced land stand up to their middle for days on end in collected rain water and thrive on it. But the greatest refreshment comes the year following. Spur station made the biggest cotton crop in its history in 1933, a dry year, "on water stored from 1932."

On one field, with the rain left free to run down the cotton rows, the yield for the 8-year period since 1930 has averaged 164 pounds of lint cotton to the acre.

Another field with closed level terraces and water added from the upland made 264 pounds, an even 100 pounds more cotton a year from each acre than was grown on unprotected cotton land, worked up and down the grade, since 1930.

This guiding of rain water or melted snow down from the uplands and spreading it on cultivated bottoms was, it seems, a well-established Indian practice long before whites came bursting into the Southwest. The Indians had no accurate surveying instruments. They had no iron hands by which to move tons of soil at a stroke. But they practiced water spreading on a small scale, modestly. They made small reservoirs uphill, then led the water downhill—or, rather were led by it. They made a weep hole; then following the trickle, made and protected channels with low, guarding mounds, some riprapping and occasional breaks, or benches. With the way thus marked and made ready, their little store of gathered water was eased downhill and spread.

They did not have the means, the machines, or the urge to do the thing on a grand scale. When terrific rains broke the guiding channels and guarding earth structures, these primitive rain-irrigation systems sometimes went to pieces all at once, and all that remained was another mystery for archaeologists to dig up and piece together.

West Texans who understand the findings at Spur and elsewhere sometimes contemplate, as in a vision, the possibility of doing the thing in a big way. It is possible now to make terraces and guiding channels which withstand the smash of any amount of rain. Farm defenses on a Service watershed at Lockhart, Tex., for example, recently stood intact against the heaviest rain there since 1902. For 20 minutes water fell at the rate of 4 inches an hour; in 6 hours 8.38 inches had descended; and the terraces and pasture furrowings held. This was a job of water holding, not of water spreading; but the same technical measures apply. Technically, it is possible now to bring practically all the rain that falls on vast watersheds safely down to refresh the cropped bottoms. This idea is becoming popular in Texas, especially in the cotton country to the west.

When it comes to doing the thing on a big scale, however, impediments arise. The Indians had their troubles but they did not have a patchwork system of private property rights extending from the creekbank to the crests. Line fences now stand as distinct obstacles on most watersheds and bar grand prospects of soaking most of the rain that falls between the divides into a relatively few acres of cropland below. Water holding, with each farm soaking in its own rain, so far as possible, within its own fences, seems generally a more practicable and suitable program in the subhumid Plains.

On a Service demonstration watershed at San Angelo, Tex., no water at all ran off an aggregate treated area of about 8,000 acres during record rains in September 1936; and enough water was stored in the soil of those farms to make a 1937 crop, in any weather. The ground was saturated to a depth of 5 feet; and at least 8,000 acre-feet of water were held back from destructive floods that roared down the Concho River. All the rain which fell on this effectively treated 8,000-acre watershed was held there and used there.

A BLOWN-OUT FIELD IN SOUTH DAKOTA.

Listed on the contour and sown to cane and Sudan grass—

THE SAME FIELD.

It made a crop to anchor soil.

"Back of Yonder"

I have reached the Pacific, and yet the sun sets west of me, and my wife positively refuses to go to the Sandwich Islands, and the bark is starting off my rails, and that is longer than I have ever allowed myself to remain on one farm.—From the letter of a settler, 1849.

One generation can condemn another to a lower standard of living.—W. C. Lowdermilk, 1937.

A HUNDRED MILES WEST by air from the Texas-New Mexico border is Albuquerque, headquarters of Soil Conservation Service operations in Region 8. The Pacific Southwest—California and Nevada—provide another great theater of operations, Region 10. And the Pacific Northwest—Washington, Oregon, and Idaho—is handled as a single and similar expanse of land, Region 11.

Around Albuquerque the expected annual rainfall is no more than 10 inches; and summer evaporation is quick and intense. We are out of the dust bowl now, although there is still wind erosion and dust; and we are beyond limits where it is considered more polite to use the term "subhumid" instead of "semiarid." There arises, to be sure, plenty of dust all over the region; and scattered sand dunes march up mountain sides as the result of overgrazing and patch farming; but the rain, when it comes, does far more evil here than dust and dunes combined.

This is high country, dipping roughly southward and westward, semiarid or arid, yet afflicted with flashing, crashing run-off when it rains. The old Southwest, bordered on the south by ancient Mexico, has special problems to be met in special ways.

Irrigation from mountain waters impounded behind towering structures of modern concrete and steel becomes here an absolute necessity for farming on any large scale. There can be only a pastoral civilization without it. Small structures holding and spreading rainfall will make crops possible on certain areas; their usefulness generally is in increasing the production of grass. Three-quarters of the region lies within the watersheds of the Colorado River, of the Rio Grande, and of the Gila, which feed critically important reservoirs in this part of the country. And the usefulness of every irrigation project in the region, from the great Boulder Dam downward, is threatened by unbelievably rapid silting from above. The first job here is watershed protection, starting at the crests.

More than half of all the land in Region 8 is owned by the Government. Indian reservations, national forests, and range land, public parks and public domain in general—here are millions of acres of public land. But Government control over most of it is far short of absolute, and soil use over the other half of the area is virtually ungoverned. The white people here are not used to being governed. Many of them doubtless came here to get away from it, just as our venerated founding fathers came away from England and other parts of Europe. Some of them do not yield freely to strict governance over land practices. Beyond a certain point, the work lies still within the fields of education and persuasion.

For nearly 30 years men of the Forest Service have been talking against overgrazing here, and pointing out its results. They have done a great job patiently, and have made headway. But despite all the talk, all the pointing to proofs; and in the face of accelerating, increasing, dis-

ruptive demonstrations put on impersonally by Nature—overwhelming floods, silt piling down to fill and choke great reservoirs—overgrazing, denudation of the uplands, continues.

"The situation," Hugh G. Calkins, regional conservator of the Soil Conservation Service, reports in a letter, "has become so serious that not only is the livestock industry here, as a whole, in a precarious condition; but all of the principal irrigation projects are threatened."

He figures, and his associates in the Forest Service and Indian Service agree that: "Present overstocking of the ranges runs from 30 to 75 percent, or even more. There is distinct evidence in many places of far heavier overstocking than in the past. Overuse of ranges here not only is killing off what is left of the livestock industry and choking out farming below; it has also caused widespread damage to the railroads and highways through erosion and floods."

Revegetation of the depleted area is the key to control of the upland wash; and that, in turn, depends on the availability of water. . . Grass can be returned to most upland areas of the old Southwest by adjusting livestock to range capacity, revitalizing the grass through conservation of rainfall and distributing water through spreading devices, etc. This can be accomplished without appreciable reduction of water for irrigation below; and the water sent down is cleaner of silt.

"Additional water delivery on range lands greatly increases both density and volume production of forage. Within 2 years, on one area, vegetative density was doubled and the volume production of forage was increased about ninefold. All of this was done by damming gullies and seeping down water that otherwise would have rushed to destructive use below. The above methods of water distribution increase the carrying capacity of the flats, at the same time relieving the upper, steeper slopes."

On the Navajo

In writing this, Hugh Calkins was thinking most about work at Mexican Springs on the Navajo Reservation, up from Gallup, N. Mex. "Here," wrote a staff man for Fortune when he visited this control demonstration, "the destiny of a nation is at stake." A nomadic, pastoral people, the Navajo Indians did little farming before the white man came. They hunted and got what they needed of corn and squash from small patches wet by the wash from canyons, or in raids on the villages of the more peaceful Pueblos. They defeated Coronado and resisted subjugation until 1864. Then Kit Carson led them on "the great walk" and penned them in Fort Sumner, where more than 1,000 of them died.

In 1868, when they were allotted a reservation, and returned to their own part of the country, 8,000 Navajos survived. Now the tribe has increased to 48,000 people; and this sizable reservation—as large as West Virginia, larger than the Netherlands and Belgium put together—is too small for them. These 16 million acres provide, on paper, an average of 320 acres per capita; but two-thirds of it all is dryland range, torn up, denuded, or nearly so, by overuse. There is at present, hardly an acre of usable cropland per capita, and the soil is rushing out. Much of the range has assumed the appearance of hard-bitten desert. Springs have dried; and the Navajos no longer find enough to keep flocks, themselves, and their civilization going. Unless the grass that used to wave here is brought back, and unless water enough to make some corn and hay is brought down to refresh small farms in the valleys, this people must perish or become a public charge.

Malthus, who predicted that population would overtake food supply, and that famine would decimate civilization, did not, it seems, call the immediate turn correctly for the world as a whole; but the thing has happened repeatedly in parts of China; and here on the Navajo population is pressing hard, desperately hard, upon the food supply. A population jump from 8,000 to 48,000 put a heavy load on this semiarid land. The people had to eat, and be clad; they had to have something to offer in

COOLIDGE DAM.

"The situation has become so serious that all of the principal irrigation projects are threatened"—*Hugh G. Calkins.*

DROUGHT IS NO NEW STORY TO THE NAVAJOS.

trade; that meant more livestock. Too many livestock munched, milled, injured, or killed much of the range.

"All flesh is grass," said the prophet. Navajo grass is food, flesh, and the raw material of the tribe's main industry: weaving woolen rugs and blankets. There might have been grass enough but some of the Navajos went into commercial stock raising expansively, and the result was an overloaded land. Soon this was felt. There could be no running away from the fact. For their last frontiers were determined and set for them when they were put on a reservation and surveyors started ruling lines around them 70 years ago. They have been given several additional grants, and the cry now is for additional acreage, but there seems to be no chance of that.

A nation within our nation, the Navajos have resisted assimilation and rejected the white religion. They scorn our ways. Distrust of most whites is extreme and austere. Drought is no new story to these Indians. Their tribal ceremonies pay eternal obeisance to the Rain God and praise the Frog which lives and croaks only where water has gathered from Heaven. They are used to lean bellies, to death from exposure and malnutrition, to conquest and disease. Whatever comes to confront him in his known world, the Navajo can as a rule stand erect and take it.

By the beginning of the present decade, the tribe had been driven by need to increase flocks until more than 1 million sheep, some 30,000 native cattle, and as many horses were grinding the range to pieces. The good grass, dying, was replaced by a straggling ground cover of non-edible and sometimes poisonous plants. Rainfall which used to soak into the range as into a rug or a blotter, now dashes off as does rain from a tin roof. Water running rampant cut one small stream, the Oraibi, into a twisting gully 80 miles long, and from 20 to 80 feet deep. Other gullies cut back at the head, devouring new acres.

In January 1934 the head men of the Navajos took council and agreed with little faith to let white men show ways, if they could, of making the sick land well. They agreed to turn over to the Soil Conservation Service 50,000 acres of their reservation on which to try their cures.

The demonstration area is 20 miles north of Gallup. Ranging in elevation from 6,000 to 8,000 feet, it gets between 11 and 12 inches of rain a year, and it looked like absolute desert when the Service took their portion of it over, 4 years ago.

The first treatment was fences to keep wandering herds out, to govern the grazing, to rest the cover. Miles of barbwire fence were built. Sheep and cattle were entirely excluded from the thinnest cover, and in most places the load of hungry animals was cut in half.

The second step in the demonstration was more difficult. These Indians have developed their own breed of sheep, and of cattle. No other sheep, they said, make suitable wool for weaving; no other cattle can rustle a living and survive on their rough, dry land. It is true they are tough, these Indian animals. It is true that Navajo blankets must be woven in part of strands which are more like goats hair than sheeps wool. But more efficient units of livestock must be introduced, animals that make far more of wool or of meat to the head. This must be done so that the range can be restocked with fewer hoofs, yet yield more wool, meat, horse flesh, and humans.

Here, at the second step of the ecological equation: (1) More grass (2) to feed fewer head of better stock, and so (3) provision an increased population without again ripping the producing plant to pieces, M. E. Musgrave, then chief of research in the Southwest, took counsel with the best of his friends among the head men of the Navajos, and sought support. He did not get it. Their native sheep, cows, and horses are as much a part of these people's lives as their silver earrings and blankets. The leaders of the tribe told Musgrave that no other animals would serve the Navajo's need.

Musgrave is a working ecologist. A son of white, nomadic pioneers, reared among the

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Klamath Indians of Oregon he learned from them as a boy to think of earth as a hunting ground with one form of life feeding on another to establish a living balance. An old chief told him, when trapping for mink, to set his trap on a gravel bar, explaining: "Salmon lay eggs here. Crawfish like eat salmon eggs. Mink like eat crawfish." "That was ecology," says Musgrave.

"Ecological maladjustments," as this weathered public servant has learned to call them, can be straightened out, if authority is given, by rougher means than are practicable when the maladjustment gets to a point that includes an overweight of undernourished humans on a stretch of land. The job here on the Navajo demonstration and experimental area is essentially to raise, through successive links, the *human* carrying power of 16 million acres; and that requires human consent.

But Musgrave could not get consent. He went ahead, anyway. He knew Indians, so he realized the risk. They liked him, most of them; they thought he knew something; but they were just standing back waiting for those white-faced cattle and Rambouillet sheep to wither and starve. There seemed a fair chance that *any* stock might starve that year; for the drought was long and fearful. Over much of the range, in its first stage of restoration, the animals were munching at thistles to keep alive. Musgrave knew that if his new stock went down under the drought, he would "lose face" with the Indians. That is about as serious as losing face in the Orient; but he went ahead and brought his new stuff in.

Anyone who thinks that an Indian never laughs or has any fun, he says, ought to have been there when that "relief" shipment of 80 Herefords from drought-stricken Texas were unloaded at Mexican Springs. The cattle were of good breeding; but starved, stunted, the runtiest, roughest-looking lot imaginable. They had to lean on each other to stand up, says Musgrave; and so did some of the Navajos, from laughing. He considered sneaking them supplementary food; but the Indians were always watching, and the test was whether these cattle could live on the range, anyway; so he stuck by the terms of the experiment, and went around, a scientist and man of honor, mentally composing a letter giving reasons for request of transfer to another area.

But those Hereford cattle had all kinds of stamina. They lived through a starving time, and then with a spurt of the grass bounced into growth. Rambouillet sheep did well, too, on the whole. The idea is not that white men's sheep can ever replace the native breed on the Navajo, but simply supplement the mutton and wool supply economically. Breeding and feeding operations to increase the efficiency of the native Navajo sheep are also in progress. They used to travel at a high lope to find enough to eat in a day. They take it easier now. The Indians thought their sheep would never consent to eat the summer's yield of forage; but this did not prove true. Indian herds and flocks within an hour's drive of the area have improved notably in the past few years. High in the mountains where lonely Navajo shepherds scatter widely for peace and a livelihood, things remain much the same. But the center of resistance to improved livestock seems to have been broken. The grass has improved greatly. Here, as on other western demonstration areas, it is proven that a five-strand barbwire fence can sometimes stop a wash. Behind those guarding strands the grass thickens, and that piece of ground is stabilized.

Mexican Springs is but one of a dozen demonstration areas scattered over the Navajo Reservation. Vegetative and soil types vary, in detail. So do methods, but in no important particular; and everywhere, where the areas have been established long enough to show results, results are similar.

The thing that has done most to revive the Navajo country and lift the hopes of its people is a return of almost forgotten forms of native grass, hip high or better, to the bottoms, and a vigorous revival of good cornfields and food patches. The effect has been spectacular and

stirring. Following no new procedure, for Indians since time beyond memory have spread floodwater, the Service has simply provided means and technical direction for the Indians, themselves, to do the thing adequately.

Laboring in work crews, with Navajo foremen, at relief wages, they have diverted water out of gullies, around gully heads, guided it down behind tortuous earthen mounds, and soaked it into thirsty soil before it reaches the main watercourse. Three dollars an acre covers the cost, as a rule. Practically all of these gully dams and guiding mounds are earthen structures, reinforced at dangerous places with stone and woven wire.

Rearing these structures the engineers follow a rule-of-thumb formula; figure the maximum possible load, then make the barricade twice that big and strong. The mounds follow a careful grade of from 1 to 3 inches in 100 feet and seek the longest way down. Thus, rainfall gathered from more than 1,000 acres is impounded in a dirt reservoir of a little more than half an acre. More usually, the water from 7½ acres, on the average, is soaked into an acre of ground. The biggest dam, built in 1936, soaks water into nearly 8,000 acres of lowland. It is thought that some 15,000 acres of the Mexican Springs area alone will be thus irrigated from healed gullies before the work is done.

Even at the end of the first year of water spreading, results were apparent. Russian-thistle and poison milkweed began to make way for bluestem, grama, and sacaton. By the end of the second year, there was grass in some of the bottoms higher than the wheels of a car. And good grass; the grass old Navajos remembered from long ago when they were young. On one of the areas wetted with water that had been running to waste, Indian corn of a native variety with low, long brightly colored ears, made a crop of from 40 to 60 bushels an acre; on still another, an Indian put up a good, big stack of native hay, the first in years, and people came from miles around to see that wonder.

The fight to preserve and restore the Navajo country is not over. It is just begun. "Spread of influence"—a phrase of demonstration workers—proceeds slowly among Indians. But in demonstration areas the grass is notably better, the livestock not as lean; and much less of their soil is going down from the Navajo's country to make trouble now in the great basin behind Boulder Dam.

The Maddened Gila

The Gila River squirms west, edging south, from the high borderland of New Mexico and Arizona. Its flow replenishes the San Carlos Reservoir in Arizona, a vital reservoir on arid soil which, irrigated, may yield as much as 2 bales of cotton to the acre. At Yuma the Gila empties into the Colorado River before entering the Gulf of California. It is piling incredible quantities of silt behind Coolidge Dam and pouring millions of tons of southwestern soil into the waters of the Pacific.

Ross Calvin has done a thoroughgoing review of man's use on the upper Gila for the Soil Conservation Service. The first white travelers who made systematic notes on the Gila's headwaters described it, he says, as a bright, meandering stream. Lieutenant Emory, on military reconnaissance in 1846, remarked in his journal on the water's clean sparkle. Of the grass Colonel Cooke, another military scout, noted, the same year, that, "animals (mounts) moderately worked fattened in winter."

It is not to be supposed, of course, that all this undisturbed country was entirely a pastoral haven. The picture was mixed, says Calvin—"desert plains alternating with grass-covered valleys and verdure-filled canyons." But early scouts and explorers agree that natural cases were expansive, fecund, and of breath-taking beauty.

Today the Gila River is a monstrous writhing snake. It runs wild and hits hard. Hydrologists and irrigation technicians are generally cautious men who abhor superlatives. But some who had made flow and silt measurements lately stand ready to argue that the Gila must be the muddiest river on earth.

What the Navajo Indians did to the north because they were penned in and had to, white operators did here under the press of more surging compulsions, casually, grandly, in passing. The land was denuded and beaten down. Railroads extending, needed ties. Copper mines were sunk; that called for timbers. One little mine used a cord every 2 days. Another old-timer who grew up with the country, as the saying goes, tells Ross Calvin that the wood business really was something then. He recalls transactions involving 300 cords of firewood at a single order. More wood was required for charcoal to reduce ore. "Mr. A. A. Anderson of Clifton," writes Calvin, reporting an impartial observer, "says that the tree trunks were first cut and piled, then covered with earth and burned into charcoal. The copper oxides on being heated broke down into free copper and carbon monoxide or dioxide." From such conversations, "One gains the idea," writes Calvin, "that the number of trees sacrificed—junipers, pinons, and oaks—must have been immense. Mr. Anderson says they denuded hills which once were well forested."

The mining rush called for houses, cook stoves, towns, stores; more wood. Down came free cover on the headland. Headlong clearance of the eastern Allegheny slope for progress and civilized occupation repeated itself on this last western slope to the Colorado River just as vigorously, even more ruinously, more than two centuries later.

Some of the earliest military whites, scouting, it seems, with an eye to a manifest destiny beyond the Mexican border, mentioned in their notes an insignificant trickle of water—you could step across it—entering the Gila at a point in the San Simon Valley. In 1872 a merchant named Solomon built a store at the juncture of the creek and the river, and settlers clustered a few homes around about for greater safety from the Apaches. They irrigated farms from small rock and brush dams. The place became known as Solomonville, Ariz. Ranching was restrained for a while by the Apache's warlike ways.

Before he died, a few years ago, Will C. Barnes wrote an account of a ride in the San Simon Valley in 1882 when he was looking for a place to graze a "modest herd" of cattle. You have heard him before in this narrative, commenting as a seasoned, but sensitive rancher, in a publication for the Forest Service (1926), on the progressive despoliation of the High Plains. Hear him again now in this more personal account of a youthful exploration "back of yonder" beyond the Continental Divide:

"An old Army officer who had chased Apaches from one end of Arizona to the other, advised me to look over the San Simon Valley . . . I had heard of the Valley . . . as *Valle de Sauz*, meaning "Willow Valley," because of the willow thickets along the upper reaches. So I set out in that direction, full of hope.

"A ten-day cruise over San Simon . . . My only disappointment was that the willows [along the upper reaches] were gone. The Valley was found to be practically unoccupied, a well watered, well grassed area about sixty miles long and forty miles wide, including the long mountain slopes on each side. It contained, I reckoned, about 750,000 acres of grazing land.

"The stream in the San Simon Valley was an intermittent affair, flowing quietly over the gravelly bottom for a mile or two before becoming lost in the sand only to reappear again farther along. Here and there . . . great "water holes" had been scoured . . . This guaranteed stock water when the streamflow fell away in the dry season.

"On its lower course were many beautiful grassy meadows, spangled with wild flowers of every hue. Great cottonwood trees—the pioneers' best friend—and willow tickets lined its banks. In the widespread branches of the cottonwoods yellow and orange blackbirds, goldfinches and other birds of brilliant plumage made colorful pictures. Farther back, and extending clear to the foot of the mountains mesquite, ironwood, palo verde and other desert trees were plentiful.

"The meadows were covered with soft lush grasses, almost untouched by animals except for

SAN SIMON WASH.

"The meadows were covered with soft lush grass, almost untouched by animals"—*Will C. Barnes, 1882.*

ROCKS FROM THE MOUNTAIN.

Sterile, rocky debris spread by floods on the lowlands makes trouble the country over. In the high country such damage may be rapid and violent. This rock pile is the discharge of one mountain arroyo in New Mexico during a single flood.

the horses and mules of an occasional traveler and the deer and antelope that came to the stream for a drink. Everywhere on the more open areas those fine stock grasses, black, blue, and hairy gramas, grew luxuriantly. Here and there along the wash were tracts of alkili land on which sacaton touched my stirrups. A little farther back large areas were covered with another useful forage plant known to the Mexicans as *galleta*, botanically *hilaria*, one of the earliest to 'green up' in the spring.

"There were then practically no banks to this stream. It simply flowed softly and quietly on top of the ground, except at its lower end where it entered the Gila, a much larger and deeper stream. As I remember it, the banks of the San Simon at the junction were then not over three feet high and the wash itself measured not over twenty feet from bank to bank.

"To an embryo stockman this San Simon Valley was indeed a promised land . . . He [an old stockman in the Valley] told me how the old cows would get down on their knees and crawl under the low overhanging mesquite branches and lick up the long white mesquite beans lying thick on the ground. In later years when feed was scarce, many an old range cow got fat as a seal on these beans.

". . . I picked out a special tract . . . to return . . . claim . . . But alas for the plans of men. Shortly after I left the Valley Apaches from the San Carlos Reservation . . . swept up the Gila Valley leaving behind them a series of burned ranches and murdered settlers. This was something for which I had no desire. Life even in those days was sweet . . . so I decided I did not crave a ranch in their vicinity. I sought farther for a new location."

Will Barnes did not get back to the San Simon until 13 years later, in 1895. By that time 50,000 cattle were grazing in the valley; an obvious overload; the cover had suffered; plainly, it was on the way out. The last time Barnes saw the San Simon country, in 1934, it was much as it is today. "Green meadows," he wrote, "were replaced by wide expanses of drifting sand. Of running water, except during floods, there was almost none." And San Simon Creek had become the infamous San Simon (or Salmonville) Wash.

"The lowering of the bed of the stream," Barnes notes, "began almost at the head of the Valley, and for sixty miles, ending at the Gila River, the flood waters had scoured their way." At the juncture the cut had grown from a width a man could almost jump a horse across in 1882, to a width of more than a hundred feet; and the cut at that point had ripped down more than 30 feet. In other places, the gash sprawls to a width of 1,000 feet, and the wash has gnawed back at the head until its length exceeds 60 miles.

Other tributaries of the Gila have done the same thing, though none quite as speedily as or extensively, to date. The Gila, itself, fed by such excesses, has cut away from 16,000 acres of once rich land. The first settlers say that around 1880 the Gila was between 100 and 150 feet wide. Now its channel averages close to a quarter of a mile wide. Each year it grows larger. The cost of removing silt from the distributaries of the San Carlos irrigation project even now exceeds $100,000 a year. Most of this silt originates from the San Pedro, a Gila tributary entering below Coolidge. All the San Simon and upper Gila contributions of silt go into space designed for water storage in Coolidge Lake.

Over Region 8, as a whole, the Service is undertaking long-range control of some 40 million acres of watershed lands. In the upper Gila basin soil rangers have now about 2 million acres under treatment. The work on the Navajo is only a part of the work on the Colorado watershed. Many of the methods tried there are spreading, and working just as well on land held by whites. In the great Rio Grande watershed above Elephant Butte Dam there are 15 million acres, of which more than 2 million acres are under treatment.

Here in the middle Rio Grande Valley, above Elephant Butte Reservoir, is another

tragic human problem. The rural population of the valley, about 55,000, depends chiefly on subsistence agriculture for a livelihood. Here the Indians and Spanish-American farmers may sell or trade a little chili, a few head of cattle, but most of their products are eaten at home.

In the last half century many of their irrigated fields have become waterlogged and useless, or have been covered by sand and gravel, by floodwater from the Rio Grande. In 1800 about 100,000 acres were irrigated. By 1880 about 125,000 acres had been developed, but by 1934 the cultivated area had shrunk to 40,000 acres. Two-thirds of the irrigated acreage, roughly, had been abandoned in the last 50 years. To eke out a living, many of the families migrated seasonally to the beet and potato fields of Colorado and to the smelters, and labored by the day, but even this opportunity was largely closed to them by depression. The relief load in the valley has been heavy since 1934.

The Far Shore

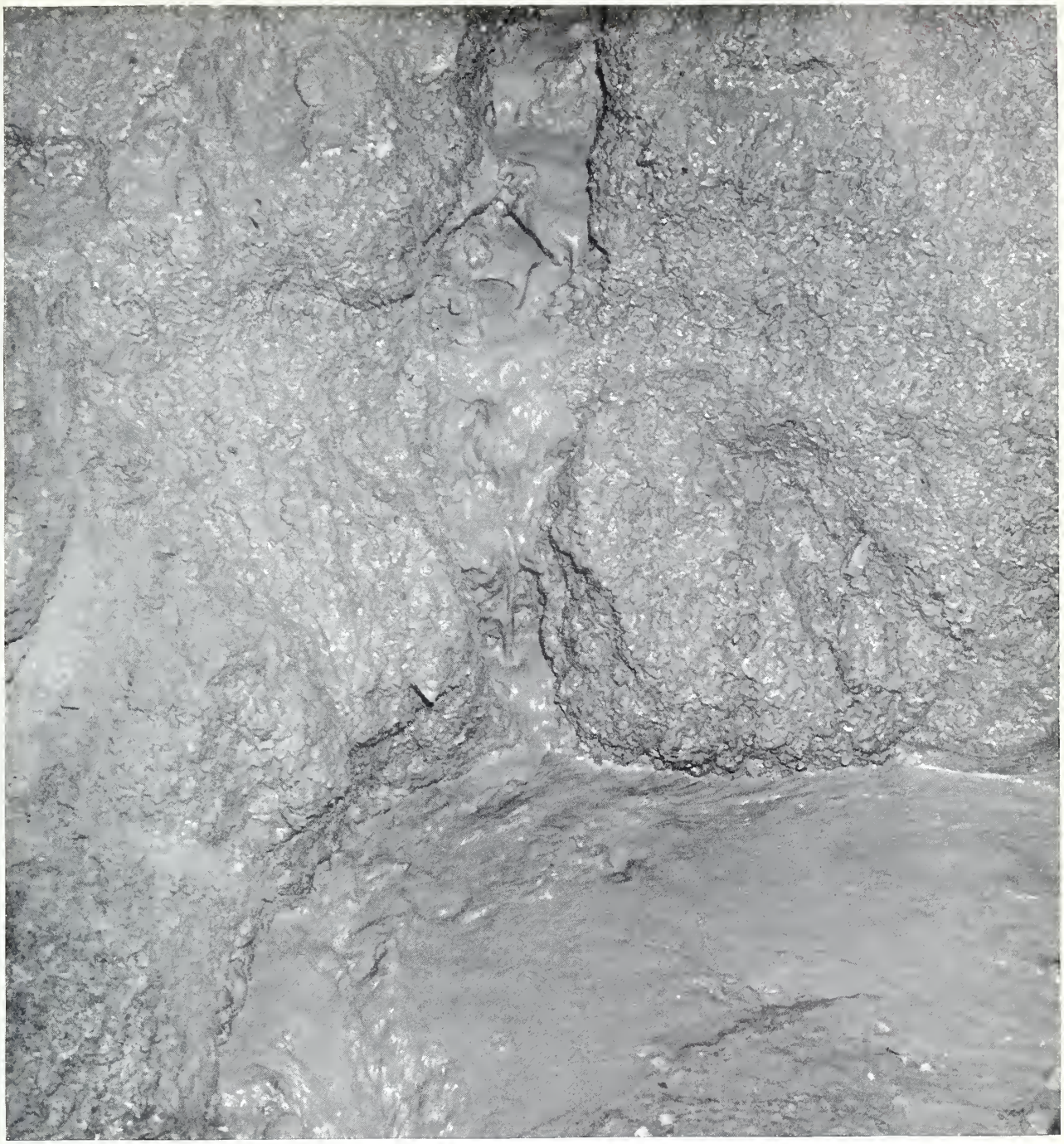
Hydrologists, who examine water in action to learn the rules of its behavior, have undertaken at the California Institute of Technology to get at facts that will help the Soil Conservation Service do its job. The derricklike slow-motion camera, aimed at soil, which led to that dissertation on the agelessness of earth and the brevity of man, at the beginning of this chronicle, is only one of the ingenious devices under development in the institute's hydrological laboratories at Pasadena.

They have made a complete model to strict scale of the terrain of the upper Gila River, and have fitted into the model a precisely reduced replica of a proposed Gila River Dam. By induced flows of an intensity gaged to that of the actual flow of the river, they hope to determine actual stresses and the anticipated rate of silting before making plans for large-scale work on the project.

Delicate instruments have been devised to discover fundamental facts on the mechanics of soil erosion. No one knows exactly how various particles of various soils behave when smitten by water. Some soil particles are so large and coarse you can see them and feel them. Others are so fine they will pass through a mesh of one two-hundredths of an inch. Geological and accelerated erosion proceed from soil to soil at widely different rates. The pick-up or acceleration is subject to so many differences that Bennett can only describe them as "a multiplicity of variables." There has been little basic research; we know next to nothing of the laws of erosion; but here in California and elsewhere men have made a start.

On land between 5,800-foot Sunset Peak and 3,000-foot San Dimas Peak, men of the Forest Service are gathering precise large-scale information on erosion and its ways. They are measuring silt and water run-off from two mountainous watersheds—the San Dimas and the Big Dalton. The area of the experiment exceeds 26 square miles. Rough but adequate structures have been installed to trace, gage, and record the course and disposal of rain water and of every particle of soil that leaves the area. It is a 50-year experiment designed with a magnificent simplicity, and conducted with infinite care and patience as to each detail.

Farm-defense operations on crop and range lands of the Pacific coast country do not differ in principle from operations on the eastern seaboard; but high land values, swift climatic shifts, and variations between a settled and a frontier psychology require various new combinations of tactics. In rich agricultural localities where special produce is raised for a quality market, terraces and other structures incline to be permanent and expensive, but are counted worth the price because of the part they play in protecting high-priced land against erosion. Avocado trees, for instance, are grown in places on strips of soil supported by benched stone terraces on slopes so steep as to be almost cliffs. Irrigated citrus groves planted on contour terraces, and terraced, irrigated cropland in some of the fabled valleys of California are probably as litttle subject to erosion as farm land anywhere.



YOU CAN SEE IT GO.

Rich bean land at the coast invites "clean cultivation."
Some of it is valued at $1,000 an acre—while it lasts.

AT THE END OF THE OREGON TRAIL.

On rich land, barely a generation settled—gullies.

Irrigated farming must always be conducted with an eye to flow lines. Men who must share stored water treasure every drop of it, and guide its spread with care. Dependence on irrigation enforces, moreover, a constant recognition that any piece of land is only a part, an interdependent part, of a watershed, State, or nation and that whatever is done on one piece of land affects the whole. Under all the rumpus about water rights, well-irrigated agricultural regions soon tend to become more civilized in their land-use practices than regions where farmers still like to imagine they can live and farm in absolute independence, apart.

But the farmers of the first wave in pioneer irrigated districts often use water recklessly, with an almost unbelievable lack of observation, care, and sense. In parts of Washington, irrigation from hilltop reservoirs is customarily still conducted by ditches that strike straight down the grade. When the ditch has ripped down to a depth of 3 or 4 feet, as it often does in a year, it is abandoned. A fresh downhill cut is made, only to go in the same way. Productive and beautiful fields have thus been worked to the point of complete abandonment within as little as 5 years.

On irrigated, humid, and dry-land farms alike, once you get up on the hills and shoulders of the Coast Range, the picture is by no means as pretty as in the longer used and sheltered holdings of the shore country below. Nowhere else in the world, probably, has farm land valued at $1,000 an acre on the basis of sheer productivity been destroyed for use more rapidly than on the brown, round hills of the southern California bean district. Plowed and planted to beans, clean-tilled year after year, these farms wash out so fast that you can stand in a heavy rainstorm and literally see the surface ooze away.

Many of these bean planters object to any cover other than beans. All the rain there, they say, is never more than enough to make a good bean crop; why, then share it with weeds? Denying other cover water and earth room they are rapidly ruining their business and their land. They have a pleasant romantic Spanish name for gullies—barranca—in these parts; but this does not make what these men are doing to their country more pleasant to behold. On one bean farm near Santa Paula a ditch so small that it cost only $16 in labor to dig it in 1885 has grown under the abrasive assault of high water from misused hills to a barranca 3 miles long and 100 feet wide. This wash devoured 37 acres of $800-an-acre soil before it was brought under control.

At the End of the Oregon Trail

Oregon, Washington, and Idaho make up Region 11. The Soil Conservation Service has 22 demonstration projects and 3 nurseries for the propagation of protective cover plants established here, on farming country that has been used no longer than from 50 to 75 years in the main; and in many places, no longer than 20 years.

Unusual problems have been put up to soil conservators in this region. One job, up from Pocatello, Idaho, suggests in the results so far apparent how powerfully contoured defense on the upland may serve in the future to reinforce flood-control measures below. Pocatello lies in a pocketed valley below overgrazed and largely denuded mountains. A view of Pocatello from the air shows plainly why, when the snows melt on the mountains, or when summer "waterspouts" strike from the heavens, the city has been flooded. The lay of the land is such that rainfall on the loose has no other course to follow. And to build an effective bypass would be too expensive.

A camp of C. C. C. boys working under the direction of the Soil Conservation Service has closely contour-furrowed 12,000 acres of the watershed above the city. Now the crews are extending the same protection, and renewing vegetation as rapidly as possible in that hard ground. The part of the watershed so protected has absorbed all of the hardest rains that have hit it so far. Little run-off came down from there. But floodwater roared down in punishing quantity from the part as yet undefended.

Farther west, the rich, rolling upland of the Palouse, in southeastern Washington and adjacent parts of Oregon and Idaho, is blanketed, on the whole, with an extremely erodible topsoil. See it from a plane, and you think you are looking at sand hills; actually the soil is predominantly a mellow silt loam. Snow comes to cover it much of the winter, and at times freezing fogs drape every tree, wire fence, farmstead, and telephone line with sparkling ice to enchant the eye. It is beautiful country; but when a warm chinook wind blows in from the Pacific, any time from January to March, it is almost as if a blowtorch had been turned upon it. The ice becomes roaring, grinding water; great snows melt and plunge seaward within half a day. Defensive husbandry was neither generally practiced nor even considered here 6 years ago. The Palouse has been badly defaced and hurt; but in places its transformation for the better, through the use of sound protective measures, is heartening.

On a 100,000-acre watershed of the south Palouse, extending over the Idaho border into southeast Washington, soil defense through more conservative tillage and vegetative practices has noticeably restored and cleared the summer flow of the river. The practice had been to crop the steeper, more vulnerable parts of this fertile watershed with a constant alternation of wheat and summer fallow. There were practically no rotations, and little or no cover except when wheat or wheat stubble covered the ground. When gullies appeared, the farmers of this robust pioneer section plowed the sides of their gullies neatly in before reseeding, and left them thus. This still is done in many places. Great machines do most of the work here. The idea of grading down the sides of the gully-cuts is that thus you may bump machines down in and up on the other side, and so prevent erosion from making a lot of irregular little fields divided by gulches out of one good big field. The treatment aggravates and hastens gully cutting. Failure to defend the fragile soil soon makes the field worthless.

Another practice which hastens land retirement in this still new part of the country is the burning-off of wheat stubble. It does make a nice clean-looking job; and it may, as some of the pea growers insist, cremate bugs which lurk to claim the coming crop; but also it removes surface protection against blowing and washing, burns out binding humus in the topsoil, and kills the land.

Here on the south Palouse most of the farmers on thousands of acres of the less erodible land have agreed to try to farm differently. They crop in rotation now, and burn no more stubble or pea vines, but work such residue with great chisellike tools halfway into the ground. Thus the stems of the crop, half buried, provide a low, continuous bristling hedge of cover on newly broken fields. Trees have been planted at the crests. Protecting meadows of alfalfa, sweetclover, and crested wheatgrass march after wheat or peas on the land, in rotation. In all the area you will find few men who claim they are losing money by farming better; and the south Palouse is a better land to see now, and to live on.

The waters of the south Palouse have cleared of silt, remarkably; and the river seems to have steadied in its flow, now that these farms are better tended. Fierce deviations between raging flood stages and a dustlike dryness of the stream bed in summer have moderated. Summer flow has been in some part restored. It is too early as yet to claim that the south Palouse has been brought back to its normal flow habits; but older people around Pullman, Wash., say that for the past few years the river has certainly become more as it was at the beginning of this century, when it flowed all year round and was clear enough to be full of trout. Soon after the close of the century, its bed lay dry nearly all summer, and was torn with flood and silt during heavy rains, and sudden snow meltings. It became an ugly sluice, a gash, a river in name only. Now it seems to be coming back. Trout from the better watered reaches of the stream or from the north Palouse reappear in its waters. Pullman fishermen are catching them. Behind dams

DUNEGRASSES.
This type takes hold in moving sand.

This type of dunegrass thrives in still or moving sand. Both kinds are used to halt the inland march of Pacific coast dunes.

built to close erosional gullies, ponds have formed, and these have induced wild ducks to winter and nest there. "Ducks are again flying these stream courses where ducks were common from 25 to 50 years ago," writes W. A. Rockie, regional conservator, in a letter of report. "And the large increase of permanent or semipermanent plant cover (tree-plantings, hay, and cover crops, and crops for green manure) have," he adds, "probably increased materially the acreage of land where upland birds can thrive."

The Wildhorse Creek project, out of Pendleton, Oreg., is of 31,360 acres, with 75 farmers under agreement to farm conservatively. One of these farmers, George Sheard, who has been growing wheat there for 20 years, says that the soil began to show plain first signs of wash-out about 1917. Noting this, he stopped burning stubble, rigged his combine with a cutting and spreading device, and scattered the straw as a protecting blanket on the land. This now is general practice in the area, and cultivation aims for a rough, trashy, cloddy surface, not for a "fine dust mulch." Gullies have been graded down and revegetated. Straw has helped here, too. It is country with practically no timber and few stones. Wheat straw twisted as "whiskers," half anchored in the ground, makes "whisker dams" across steep gullies. The dams resemble whisk brooms stuck in a row. They have served well to catch soil, baffle run-off, and give grass a chance. As the grass takes hold whisker dams rot and are covered; but they are no longer needed then.

We come at last to the northwest Pacific coast country. Two generations ago when settlers came here to Clatsop County, Oreg., on the ocean's shore, they found just back from the beaches a rich, thin mantle of soil resting on a subsoil of old wind-blown beach sand. They could see what would happen if their operations broke through the topsoil into that sand. Among the first ordinances of Clatsop County was one that severely limited grazing.

"For almost 40 years," writes E. M. Rowalt, in *Soil and Water Conservation in the Pacific Northwest* (Farmers' Bulletin No. 1773), "the ordinance was respected . . . But new people came into the area. They ignored the ordinance . . . Close grazing soon killed the grass, exposing the sand to the wind . . . The loose sand beneath the protective humus layer, thus exposed, began to blow; it piled into dunes that rolled landward. One of the most damaging dune areas is near Warrenton, south of where the Columbia River empties huge quantities of sand into the Pacific . . . Moved about by ocean currents, much of this sand eventually is swept up on beaches, which extend to the south unbrokenly for 30 miles. Here the properties which lie before the advancing dunes are exceptionally valuable [having a total present valuation of some $35,000,000].

"The problem is to stabilize the dunes by reestablishing vegetation over the entire sand-covered area . . . the first step in stopping the advance of dunes is to build a dune artificially. This man-created fore dune is built parallel to the coast . . . Its purpose is to break the sweep of the ocean winds as they lash inland. A double-line picket fence is driven into the sand where the dune is to be formed. The incoming sands pile over the fence. Each time the picket stakes are covered they are pulled up half their length. This is repeated until the dune attains a height of 8 or 10 feet. The dune is then planted to sand-stilling and sand-catching grasses, such as Holland and American dunegrasses. The vegetation collects more sand, and the dune gradually rises to its ultimate height of 20 or 30 feet.

"Dunegrasses behave peculiarly. For example, Holland grass survives only on barren, moving sand. When organic matter accumulates or when the sands cease to move, it dies out. Even on comparatively still sand the plant loses the bright-green coloring which is its characteristic when growing on mobile sand. Dunegrasses seem to resist any amount of adversity. In the fall of 1935, C. C. C. boys, working under the direction of the Soil Conservation Service, planted to Holland grass an area 100 feet wide

and 8,000 feet long adjacent to the high-tide mark. Two weeks afterwards, a storm whipped up enough sand to cover the new planting 20 inches. Before the winter ended, storms piled on 10 inches more. Yet the following June, 95 percent of the plants had survived.

"A second control step, which is carried on concurrently with the dune building, is the planting of dunegrass species at 18-inch intervals over the blowing areas to the landward side for the fore dune. Later, as a third step, sod-forming and soil-building vegetation is established; and finally in those areas that will support such vegetation, trees and shrubs are planted for further protection. The nature of the permanent vegetation is not yet determined with finality."

In 1929 Congress appropriated to the Department of Agriculture money enough to start a number of erosion experiment stations in various problem areas of the country. These field stations were to measure rate of soil loss under controlled experimental conditions and to develop and test control devices.

In September 1933, $5,000,000 of a Public Works Administration appropriation was marked off abruptly for erosion control, afield. To administer this fund, the Department of the Interior set up a Soil Erosion Service. From the very beginning, this agency held to one fixed idea: Its work ought to be a sensible, elastic, coordinated counter attack against farm and range erosion, employing every known device and developing others, in combination. No two farms ought to be treated exactly alike, since their lands were not alike, nor their needs. The initial impulse from the South, especially, was simply to go out and build still more terraces. But experience had proved this would not do the job. Only good all-round farming, and an appropriate use of land, can curb erosion. And that is a slow, educational process.

On May 12, 1934, dust blown from the Great Plains 2,000 miles away dimmed the sun over the National Capitol at Washington and sifted into the great office buildings of New York. There had been dust storms before in the Plains country, but they were smaller, more local. Never before, since the coming of the white man to North America, had the eastern seaboard seen soil from the Texas-Oklahoma panhandles, swirling in brownish clouds overhead.

"That storm," said Bennett, speaking without notes 2 years later, before a congressional committee considering the value of the work of the Soil Erosion Service and the proposal to make it a permanent agency, "swept from the Great Plains 300 million tons of rich soil. It did another thing. It brought to the consciousness of numerous city people the fact that something was going wrong with our agricultural domain. Soils derived from fields 2,000 miles away gritting against their teeth made erosional wastage a personal experience, not merely a vague problem of remotely situated farmers."

The proposal he argued for at the hearing in 1934 was: To enlarge specific research on erosion, as such, and to extend field operations to new demonstration areas; and to do this in a way that would not duplicate the function of any existing arm or agency of the Government but draw upon all these other agencies for aid. "Erosion of itself seems simple and easy to understand," Bennett has stated: "But the problem of bringing it under control and reestablishing a natural balance under the conditions imposed by a complex civilization, demands knowledge and techniques which touch on many fields of learning, and a coordinated approach to situations as involved and intricate as life itself."

Drawn, of necessity, in broad terms, the Soil Conservation Act (Public, No. 46, 74th Cong.) was passed in 1935. It established, to replace the Soil Erosion Service, the Soil Conservation Service as a permanent bureau of the Department of Agriculture. As such, the Service now draws for facts upon all existing bureaus, offices, and specialists, upon men and women who for years have been probing integrated segments of the agricultural cycle; probing for facts on soil structures; on the vagaries of the weather; on the rooting and ground-knitting habits of grasses.

Explorers for the Bureau of Plant Industry, for instance, now search the face of Asia, South

America, Africa, Australia, Europe, with an eye for cover plants that will hold the soil of the Carolinas, upland Kansas, southern Iowa, the withered range of Arizona, the Palouse of Oregon, and every crucially threatened part of our land's surface.

All sources of possible aid and counsel are employed. From agricultural engineers, help as to terraces, ponds, irrigation, drainage; from animal husbandmen, facts on breeds and types that make the most wool, meat, or leather from the least grass or grain; from plant geneticists, aid in weaving plant germ plasm into needed new designs for the land's protection; from agricultural economists, facts on costs and profits from this crop or that; from sociologists, facts on living standards and human habits as related to the use and condition of land. And so on.

Harmonious working connections between the Soil Conservation Service, the Civilian Conservation Corps, Army engineers, the Forest and Indian Services, and other agencies of the Federal Government as well as of the States, have been made sufficiently evident in the field notes of this publication. The job could hardly have been done without this great surplus of manpower ready and willing to get out and toil at a subsistence wage.

More than 50,000 farmers are working with the Service on watershed demonstrations as this is written. Their farms, put together, would make 8½ million acres of private land. That is approximately 1 percent of all privately owned farm land in the United States, not much of it; but thousands of farmers from outside these areas have come to see and examine the work; and conservation methods are spreading between the demonstration areas. The country shows it.

Since 1936, when the Supreme Court declared the Agricultural Adjustment Act unconstitutional, the Agricultural Adjustment Administration has been giving financial assistance to farmers who follow soil-conserving practices, attempting in this way to level out disparities in farm and industrial income so that farmers generally will be economically able to practice conservation. At first, two organizations operating in the same field, differently, led to some public misunderstanding. This has largely cleared up now as it has become apparent that the Agricultural Adjustment Administration is seeking to relieve a general economic maladjustment through the medium of soil conservation payments, whereas the Soil Conservation Service is engaged in a program of soil conservation action and research. The two agencies supplement and implement each other.

The coordinated attack against land misuse which the Soil Conservation Service, together with allied arms of the Government, is developing, must proceed in the light of facts less explicit, perhaps, than findings derived from test fields and in laboratories; but no less actual and apparent. Facts such as these: (1) The parts of this land most worth farming have become scarcer, and in operation, less rewarding. As land fails in productivity, private means to hold and restore it fail. (2) Our land as a whole is cut up and stitched into a crazy quilt of owned, mortgaged, or repossessed holdings which show hardly anywhere a sensible relationship, or recognition of natural watershed and blow areas. (3) The right of the free American (owner or renter) to stand on his own two legs on his own piece of land and do as he pleases with it cannot be challenged headlong without seeming to deny the very content and essence of the American tradition.

These are some of the difficulties. On the other hand, things are stirring which may help make conservation not a formulated word of vague meaning, but a living creed of conduct. "We have thronged on this land," says M. L. Wilson, "like demanding and thoughtless children. Now we must settle down, and take care of our own, and live as an adult and sensible people should." Given one of the richest and most beautiful pieces of land to tend, we have taken terribly poor care of it. A sense of shame as to what we have done, all of us, begins to be manifest.

And finally, there is this: We seem to have come to a time in our national life when most farmers, and some larger operators, dream of leaving a piece of good land, and a good home, owned and clear, to their heirs; not of scattering their issue away from home soil (as they themselves have scattered), to rend and rob another stretch of country back of yonder.

Early in 1936 the Department of Agriculture decided that while soil conesrvation demonstrations can point the way, no one can make sufficiently rapid headway toward an adequate protection of our agricultural surface unless some means be found to treat whole bodies of land. To build terraces on the shoulders and leave the hilltops bare and unprotected does not accomplish lasting control of erosion. To contour list and lash down with grasses fields or farms here and there in a blow area may operate, in some part, to the advantage of the owners of the treated fields and farms; but it does not stop the blowing and the loss from neighboring unprotected fields. As things are, a few men in any area under treatment can impede stabilization of the soil simply by refusing to have anything to do with an entire area program of control. Sometimes it is an absentee owner, or speculator. Even in the worst of the drought and dust on the high plains, for instance, a few business plungers were buying up blown-out land almost for nothing, betting that some time it will rain again, planning then to go in and whip these tracts for wheat. Also, untended farms that balk and mar control on the Plains and elsewhere are owned by farmers in residence there or nearby who do not want to be told to farm differently by Government men and their neighbors, and who will not stand for it.

This cannot be assailed arbitrarily or overcome by issuing orders. The orders have no force. And the farmer may be right in objecting to a given program of control on his land; the Government specialists and the neighbors may be wrong. Seeking a democratic middle course through or around the obstacle, the Department of Agriculture suggested that the States pass in their legislatures, enabling acts establishing soil conservation districts for erosion control.

A number of States now have passed such enabling acts, and a number of districts have been established. A definite start has been made. Assuming minor variations under the laws as adopted by the respective States, this is how the districts are formed and how they operate:

You are a farmer. A soil conservation districts law has been adopted in your State. You and your neighbors desire to organize for the purpose of pursuing a cooperative erosion-control program.

You petition the State soil conservation committee, asking it to organize a district and to include your land within its boundaries. This petition must bear the signatures of a certain number of land occupiers or landowners. The number varies by States.

After your petition is presented, the State committee holds a public hearing and, guided by the testimony given at the hearing, decides whether a district is needed. If so, the committee defines the boundaries of the district and gives notice of a referendum. It may include all or parts of several counties, or if the problem is localized, the district may be smaller than a single county.

All land occupiers or landowners may vote in the referendum, according to the procedure and conditions laid down in the State law. If a majority vote against creation of a district, that ends it. If a large majority vote in favor, the State committee appoints two supervisors. The appointed supervisors file an application for a certificate of organization with the Secretary of their State. When the certificate is issued, the district comes into being, and an election is held to elect three more supervisors.

The board of five supervisors then studies the problems of the district and formulates a program of erosion-control projects and decides on preventive measures. The committee may call upon the personnel of State and Federal agencies for help with this work.

The supervisors then proceed to carry the program into effect, securing such technical assist-

ance and buying such equipment as their funds permit and the program requires.

Let us say that the community and its supervisors have tried to induce the minority to cooperate and put soil conservation measures into effect, but they have failed. What now? The supervisors turn to their second set of powers, which permits them, as elected representatives of the people of the district, to draw up soil conservation ordinances and submit them to a vote of the people. You vote "yes" or "no". If the vote is against regulations, that ends, or halts, the whole new procedure. But let us say that the vote is close, with a small majority in favor of regulations. If your State law requires only a majority vote, the supervisors may or may not invoke the proposed regulations. They probably will not. But let us say that a large majority favored the regulations. Then, doubtless, your supervisors will declare them in force. Should the hold-outs still refuse to employ the conservation measures called for by the regulations, your supervisors may petition the local court to order the land occupier to observe the soil conservation ordinances. The court order, if issued, may provide that if a land occupier fails to employ the conservation measures the regulations require, then your supervisors may go on his lands, do the necessary work, and collect the costs from the land occupier; or, as in a few States, the court could fine him for committing a misdemeanor.

The laws require that a board of adjustment be established in districts which adopt land-use regulations. This board is authorized to permit exceptions and variances from land-use regulations in cases where the application of the strict letter of the law would result in "great practical difficulties or unnecessary hardship." The decisions of the board of adjustment are, of course, subject to review in the local courts.

It is possible that there will be districts in which the procedures just outlined will prove impractical. The laws therefore provide that after a district has existed for a certain number of years (5 years in most of the State laws), farmers may petition to have the district dissolved. The question of dissolution is then submitted to a referendum. If a sufficient number of the people affected vote to dissolve the district, it is done.

Conclusion

The idea of this publication is not to fix or to direct opinion, but to arouse it. Its major conclusion is this: The soil must be governed, and so far as possible, it should be self-governed. We must change our ways of land use, individually; and where that does not work, enforce change, if the people of localities concerned see the need and recognize the necessity for meeting it, through democratic decision and action. Surely land is vested with a public interest. But that does not mean, necessarily, that we must abolish private ownership to have land better treated. France has not. Nor has Sweden. Nor the Netherlands.

"Change the system!" is the easy answer to everything. But it does not follow that to change the system settles anything. It does not make the spendthrift suddenly thrifty, the careless careful, the sloppy and greedy neat and public spirited. It does not make husbandmen of pioneers or promoters. The essential change comes slowly in the accumulated experiences of men and women. Generally it comes under pinch, or under conditions which impose a reasonable thrift and care.

The purpose here has not been to extol the work of the Soil Conservation Service and its related governmental arms in the battle against erosion. Little enough has been done, as yet, in view of the immensity of the problem. The need of control has so suddenly become so plain and urgent that it hardly is necessary to plead for adequate appropriations. The question of building a staff of well-trained, able, and dedicated people, a staff large enough, strong enough, and sufficiently tireless to meet pressing demands for help throughout the country: That has been more of a problem than getting appropriations; and a relative scarcity of people

so trained and ready is likely to continue for years to come.

There will be no need to puff or advertise workers in soil conservation. The work will grow and attain to the quiet prestige of those professions or callings to which men and women are attracted by the nature of the work, not by the price tag. But it is necessary, in a sense, and proper to advertise this new calling and its needs to young people who now are wondering what to do with their lives. There is work here for you, if you will get the training. It will never make you rich, but it will support you; and it is a decent, vital, and absorbing work.

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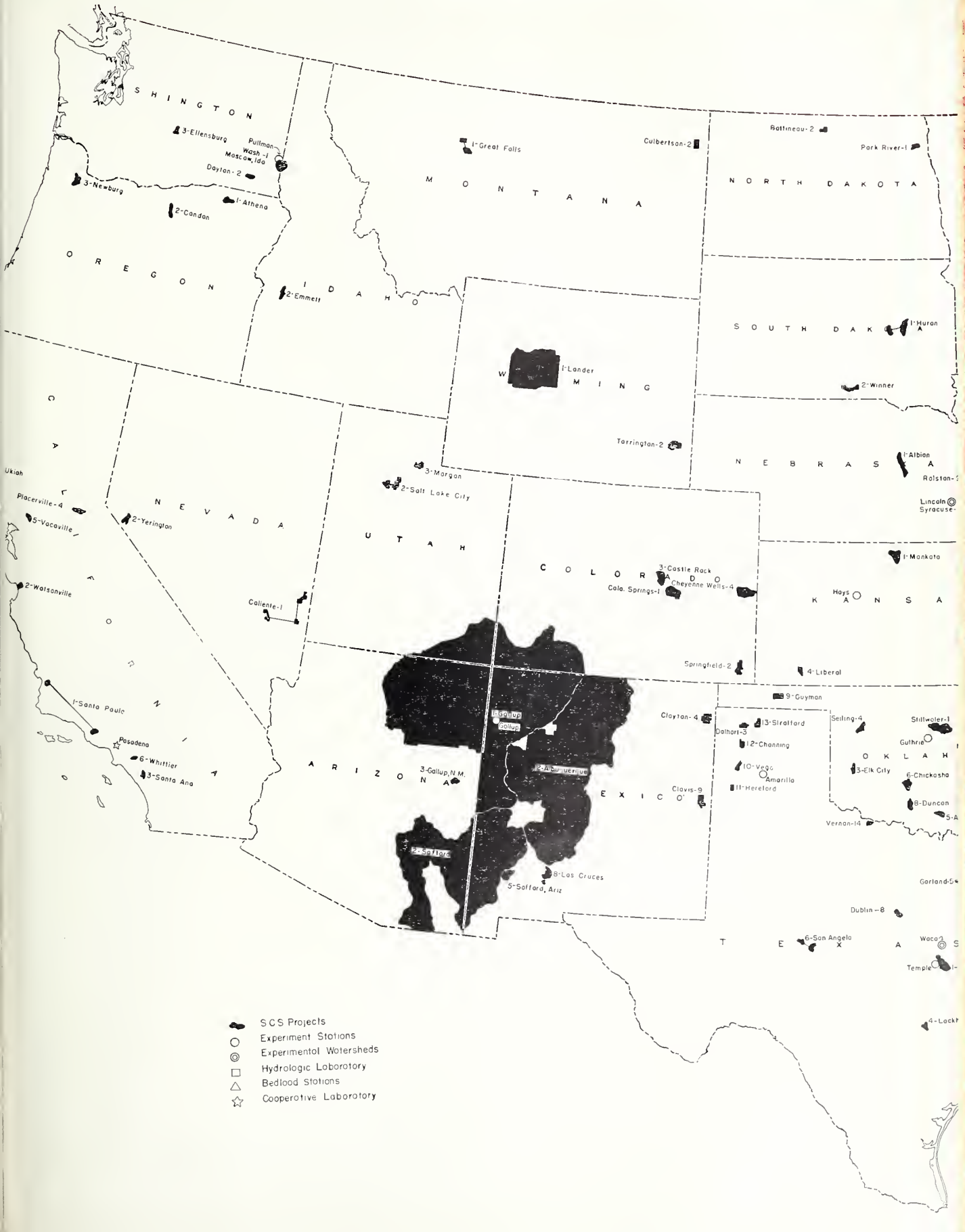
S H I N G T O N
3-Ellensburg
Pullman
Wash.-1
Moscow, Ida
Dayton-2
3-Newburg
1-Athena
2-Condon
O R E G O N
I D A H O
2-Emmett
M O N T A N A
1-Great Falls
Culbertson-2
Battineau-2
Park River-1
N O R T H D A K O T A
S O U T H D A K O T A
1-Huron
2-Winner
W Y O M I N G
1-Lander
Tarrington-2
N E B R A S K A
1-Albion
Ralston-1
Lincoln
Syracuse-
Ukiah
Placerville-4
5-Vacaville
2-Watsonville
N E V A D A
2-Yerington
Caliente-1
U T A H
3-Morgan
2-Salt Lake City
C O L O R A D O
3-Castle Rock
Cheyenne Wells-4
Colo. Springs-1
K A N S A S
Hays
1-Mankato
Springfield-2
4-Liberal
9-Guyman
Clayton-4
13-Stratford
Dalhart-3
12-Channing
10-Vega
Amarillo
11-Hereford
Clovis-9
N E W M E X I C O
A R I Z O N A
3-Gallup, N.M.
2-Albuquerque
Gallup
Gallup
3-Safford
8-Las Cruces
5-Safford, Ariz
Seiling-4
Stillwater-1
Guthrie
O K L A H
3-Elk City
6-Chickasha
8-Duncan
5-A
Vernon-14
1-Santa Paula
Pasadena
6-Whittier
3-Santa Ana
T E X A S
6-San Angelo
Waco-2
Temple-1
Garland-5
Dublin-8
4-Lackl
SCS Projects
Experiment Stations
Experimentol Watersheds
Hydrologic Laborotory
Bedlood Stations
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