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Geological Phases of Soil Erosion Investigation and Control in Nebraska

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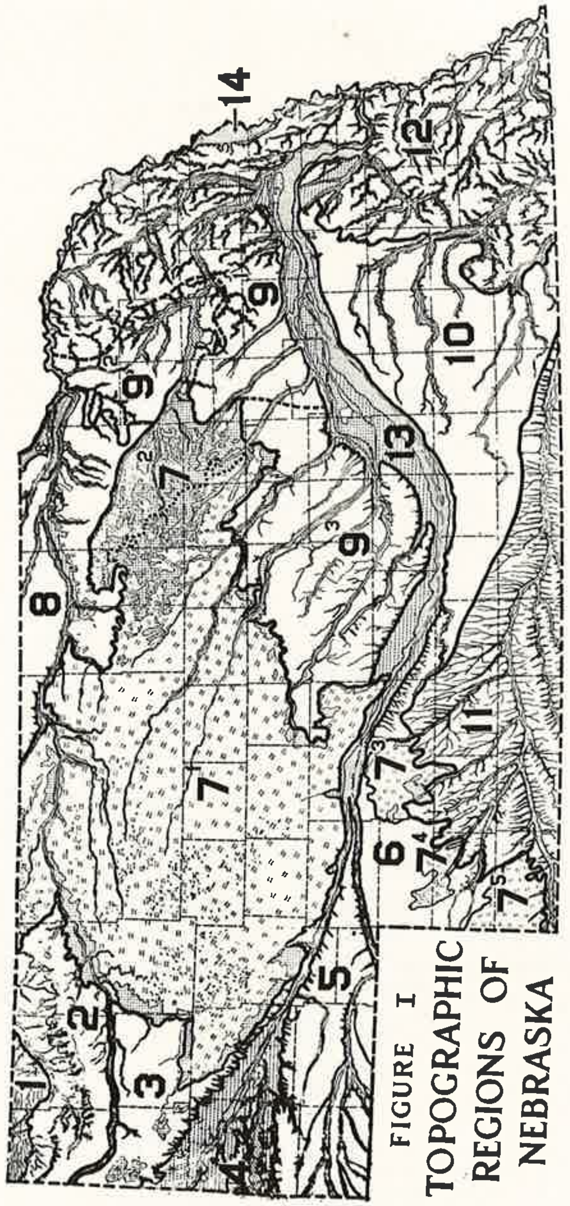

FIGURE 1.—The Topographic Regions of Nebraska: 1, Pierre Plains; 2, Pine Ridge; 3, Box Butte Tableland; 4, Wild Cat Ridge; 5, Cheyenne Tableland; 6, Perkins Tableland; 7^1 to 7^5, Sandhill Region and outliers of which 7^2 is the Prairie Plains area; 8, Northern Tablelands in which 8^1 is the Boyd Plain developed on Pierre Shale; 9^1, 9^2, and 9^3 Loess Hill Region; 10, Loess Plain Region; 11, Republican Valley Region; 12, Drift Hill Region; 13, Platte Valley Lowlands; 14, Missouri River Lowlands.

Geological Phases of Soil Erosion Investigation and Control in Nebraska *

BY G. E. CONDRA

Soil erosion has become a problem in Nebraska and most other states. Its study and solution have reached the proportions of a National Project, engaging the activities of several closely related Federal departments and the cooperation of State agencies.

This paper is based on the writer's study of Nebraska and on the investigations that have been made by the College of Agriculture and departments of the Conservation and Survey Division. It has been prepared in response to a statute that requires the Conservation and Survey Division to investigate and report upon Nebraska's conservation problems, and is a brief review of the geological relations involved in erosion in Nebraska. It recognizes the importance of the erosion control work that is being done by National activities.

State Activity.—The College of Agriculture, State Soil Survey, and the State Geological Survey have cooperated in soil erosion investigation through a period of years. The Agricultural Extension service has emphasized the need for erosion control, and many people of the state are conversant with the erosion hazard.

The State Soil Survey, cooperating with the United States Bureau of Chemistry and Soils, has determined the extent of soil erosion and its unfavorable relations to the agricultural development of the state. Its county maps and reports are now used generally in detailed erosion investigation and in control work.

The State Geological Survey has studied, mapped, and described the topography and the formations on which the soils were developed and where erosion is active. The data obtained by this survey are also of importance in erosion study and control.

Fortunately, maps and bulletins are available for use in the erosion activity of the state, which is not true in most

* Reprint from the Nebraska Blue Book of 1934 with some modifications and the addition of figures.

commonwealths. Then, too, the College of Agriculture and the Conservation and Survey Division are cooperating with the Federal projects in making the erosion service beneficial to Nebraska.

EROSION IN GENERAL

Many persons do not distinguish very clearly between land erosion in general and soil erosion proper. Their tendency is to class all natural erosion as soil erosion, probably not knowing that the soil is only the thin surface layer or layers developed on the mantle rock and bedrock. It must be admitted, however, that all erosion in our state has a relation to the soil either directly or indirectly.

The active agencies of erosion in Nebraska are running water and wind, the effects of each varying with the nature of the land, its exposure, slope and plant cover, and with the amount and character of rainfall. Running water has eroded valleys in the land and reduced large areas of it to hills and valleys. The amount of material so removed from the land is very great, lowering the original surface hundreds of feet in places. The hills, valleys, and rough stony lands are the results of erosion enacted long before our present soils were formed. They were formed from mantlerock and bedrock and not from soil.

The wind has eroded large areas of Nebraska and shaped the debris into sand hills. This change, too, was of the mantlerock and soft bedrock and not of the soil.

ORIGIN OF THE LAND AND ITS TOPOGRAPHY

The origin of our land and its surface features is an interesting story. It has a relation here because the materials of the land and the topography must be taken into account in erosion control. We should especially know the mantlerock formations and the leading kinds of exposed bedrock, and have some knowledge of the principal land forms. The summarized story of the evolution of our bedrock formations and their major topography is as follows:

First.—Far back in geologic time the sea extended over what is now Nebraska, and beds of limestone, shale, and sandstone were deposited in it, after which the sea floor elevated,

forming land. Except along some of our deep valleys, as in the southeastern counties, the old bedrock formations are now deeply buried beneath later deposits and, therefore, do not affect the erosion of this time. It should be observed, also, in passing this part of the story, that the old bedrock formations of Nebraska have been studied closely and that they evidence a number of well defined climatic cycles and periods of erosion.

Second.—After the old bedrock surface was eroded, four thick Tertiary formations of clay, silt, and sand were deposited on it in succession with debris from the Rocky Mountains, Black Hills, and other highlands.* This made a broad tableland in western, central, and northern Nebraska and westward and northwestward to the mountains.

Third.—Near the close of the Tertiary period, the tableland surface was eroded by rivers which extended eastward and southeastward, forming quite large valleys which separated it into regions. The tablelands have not changed greatly since then, yet they have endured continued wind erosion and considerable water erosion. Near the close of the Tertiary their valleys were filled to considerable depths, after which the rivers deepened their channels, making terraces.

EFFECTS OF CLIMATIC CHANGE AND GLACIATION

The most far-reaching effects in the development of eastern and southern Nebraska were caused by glaciation, i.e., by great ice sheets that invaded the Mississippi Basin from the north. There were five advances and retreats of the ice, each accompanied by climate change. Cool, moist climate prevailed here when the glaciers were farthest south, and warmer, dry climate when they retreated farthest north.

Two glaciers crossed eastern Nebraska and three later ones reached into Iowa and Illinois and affected Nebraska indirectly but very definitely. The time when these great glaciers were developing, advancing, and retreating is known as the Pleistocene or Glacial period. The changes made in the land and topography of Nebraska by glaciation are summarized as follows:

* The major subdivisions of the Tertiary deposits are separated by two erosional unconformities.

First.—An ice sheet, called the *Nebraskan,* formed in Canada and moved southward to and across eastern Nebraska. It eroded the country to the north and northeast of our state, ground the softer rock debris to clay, silt and sand, and deposited these materials and hard boulders as a drift sheet (*Nebraskan)* 50 to 100 feet thick in the eastern part of our state, and to variable thickness in northeastern Kansas, northern Missouri, Iowa and some other states to the east.

Some outwash from the glacier was deposited on the old bedrock surface as the ice advanced southward and this became covered by the drift proper. It is now a discontinuous formation under the *Nebraskan* drift.

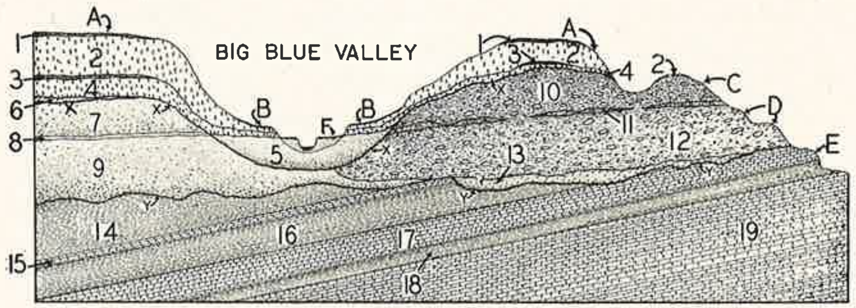

FIGURE 2.—Generalized, East-west Cross-section of the Geological formations in Seward County, in the vicinity of Seward; 1, soil on the *Peorian* loess; 2, *Peorian* loess; 3, old soil on the *Loveland* loess; 4, *Loveland* loess; 5, *alluvium,* old and recent; 6, *Upland* formation; 7, *Grand Island* formation; 8, *Fullerton* formation; 9, *Holdrege* formation; 10, *Kansan* drift; 11, *Aftonian* sand and gravel; 12, *Nebraskan* drift; 13, sand and gravel deposit below the *Nebraskan* drift; 14, *Carlile* shale; 15, *Greenhorn* limestone; 16, *Graneros* shale; 17, upper *Dakota* sandstone; 18, shale in the *Dakota;* 19, lower *Dakota* sandstone. The positions of the main old erosional surfaces shown in the cross-section are at X and Y. The land forms represented in the cross-section are: A, Loess Plain; B, terrace; C, Loess-drift Hill; D, Drift hills; E, rough stony land on the outcrop of the Dakota sandstone and shale; F, floodplain.

The *Nebraskan* glacier became a great dam across the valleys of the Dakotas and Nebraska, causing lakes to form in their lower courses, and turned the drainage southward along its western border. All of the drainage from between Canada on the north and the Black Hills and part of the Rocky Mountain country was then diverted through central

Nebraska by the thick ice sheet. The river sediments, together with outwash from the glacier, then filled the old valleys and spread a sand and gravel deposit (*Holdrege* formation) 40 to 100 feet thick in central Nebraska west of the glacial dam.

Second.—The climate grew warmer, causing the *Nebraskan* glacier to melt northward. This left a nearly level drift plain in eastern Nebraska and a broad sand plain west of it, reaching to the tablelands. During this inter--glacial stage (*Aftonian*) the surface of the drift plain became weathered, forming some soil and a dense claypan-like layer called *gumbotil,* and the *Holdrege* sand plain to the west became covered with a thin, light-gray, loess-like formation which is now known as the *Fullerton* formation. Then the region generally was eroded in places, making small valleys and removing much of the soil and *gumbotil.*

Third.—The climate becoming colder and more humid, a second glacier (*Kansan*) formed and advanced over about the same area as the first. During its advance, outwash from the ice sheet mantled the *Nebraskan* drift unevenly, and this deposit (*Aftonian* sand and gravel) was over-ridden by the glacier when it made the second drift sheet (*Kansas*) and caused a second sand and gravel formation (*Grand Island*) to be deposited west of it, on the *Fullerton* and *Holdrege* formations.

Fourth.—The *Kansas glacier* retreated northward, due to increased temperature, leaving central and eastern Nebraska as a broad plain, on sand and gravel to the west and on glacial drift to the east. During this inter-glacial stage, known as the *Yarmouth,* the surface of the *Kansan* drift plain was weathered and leached to a considerable depth, forming soil and *gumbotil,* and the *Grand Island* sandplain to the west became thinly mantled at places with a grayish, silty, loess-like deposit, which is called the *Upland* formation.

Fifth.—The third glacier (*Illinoian*) advanced into Illinois and Iowa but not into Nebraska. However, the rainfall increased here and caused heavier run-off. The Missouri, Elkhorn, Loup, Republican, and other rivers came into existence in about their present positions. They carved large valleys, and with their tributaries, reduced considerable areas of eastern and southern Nebraska to bold hills, leaving the less eroded areas as upland plains. Intrenchment through the *Nebraskan* and *Kansan* drifts, and at places in the sandplain, uncovered the bedrock formations in the principal valleys.

Sixth.—With the change to a warmer and less humid climate, the *Illinoian* ice sheet retreated northward. This period is known as the *Sangamon* inter-glacial stage, at the beginning of which, the valleys of eastern Nebraska and western Iowa became clogged to considerable depths with gravel, sand, and silt washed in from the eroding upland.

With yet lower rainfall and more wind-erosion, much of the region was mantled with dust (*Loveland* loess) to depths of 5 to 30 feet or more. This redish loess was brought in by wind, from adjacent states, mainly to the west and northwest, and in part from our tablelands, and from the sandhills of Nebraska, which were forming. It is now generally covered by later deposits, but has been exposed in many highway cuts and by erosion in small valleys.

Seventh.—The fourth glacier (*Iowan*) invaded northern Iowa and the rainfall became heavier in the areas bordering it, as in Nebraska. This rainfall resulted in considerable erosion, deepening of valleys, terrace development, and the formation of a deep soil on the *Loveland* loess where the topography was comparatively level. This old soil is now buried as a dark layer beneath later deposits. It is exposed in many highway cuts and small valleys of eastern and southern Nebraska.

Eighth.—The *Iowan* glacier retreated northward to Minnesota and Wisconsin, due to a warmer, dryer period, and a heavy deposit of dust (*Peorian* loess) was spread on the land from Illinois to Colorado. This time is called the *Peorian* inter-glacial period.

The *Peorian* loess is buff-colored, fine textured, and very uniform to an average thickness of 40 feet or more in the southeastern half of Nebraska. It is our top-most mantlerock of the uplands and on the high terraces, and is a rich, soil-forming material. It was derived in about the same manner

as the *Loveland* loess, part of its material coming from the sandhills, where wind erosion was active during this period.

Ninth.—With the re-advance of the *Iowan* glacier, now known as the *Wisconsin ice invasion,* and with the recurrence of more rainfall, the valleys were deepened, forming the lower alluvial terraces of eastern Nebraska. The colluvial slopes began to develop and our deep, fertile soil began to form on the *Peorian* loess of the uplands and terraces.

Tenth.—Since the retreat of the *Wisconsin* glacier, some of the valleys have deepened a few feet, the alluvial slopes have continued to develop, some loess has accumulated, small sandhills have formed locally, soil development has continued, especially on the smoother lands, and wash from the uplands has accumulated on the flood plains in places.

The rivers are now removing much soil and soil-forming material from the state, due to the destruction of the prairie and the cultivation of the land. The soils of the hilly lands are being depleted by sheet erosion and the slope lands are being gullied.

The foregoing review of what seems to have been the sequence in the development of the formations, topography,

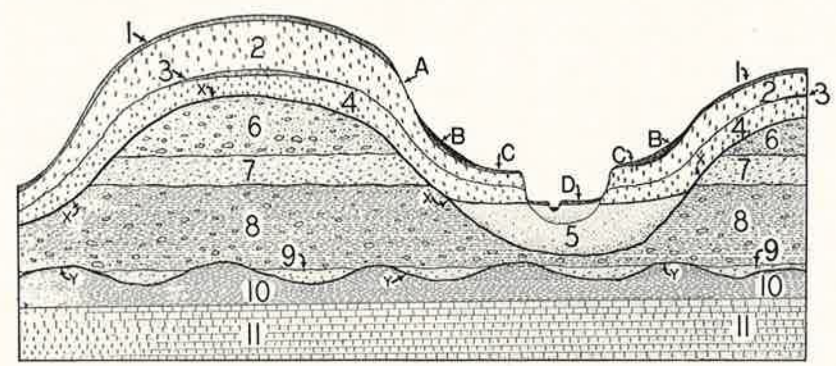

FIGURE 3.—Generalized Cross-section of the Loess Hill Region of northeastern Nebraska: 1, soil on the *Peorian* loess; 2, *Peorian* loess; 3, old soil on the *Loveland* loess; 4, *Loveland* loess; 5, *alluvium,* old and recent; 6, *Kansan* drift; 7, *Aftonian* sand and gravel; 8, *Nebraskan* drift; 9, sand and gravel below the *Nebraskan* drift; 10, *Graneros* shale; 11, *Dakota* sandstone.

The positions of the principal old erosional surfaces are shown by X and Y. The land forms are: A, Loess Hill; B, colluvial slope; C, terraces; D, floodplain.

and periods of erosion in our state was written at the request of persons who are engaged in erosion work in Nebraska. It may be too involved for some readers.

The writer dates stages one to five inclusive of this geological sequence with assurance, and stages six to ten with some reservation. The whole set up is made because it is believed that those who direct the erosion activities should know geological formations, topography, soils, and the erosive process as well as the methods of soil-saving. They must necessarily take into account the nature and occurrence of the geological formations which constitute the land. This requires an acquaintance with the mantlerock and bedrock formations shown in Figures 2, 3, and 4, i.e., *alluvium*, *colluvial* deposits, *Peorian* loess, *Loveland* loess, *Upland* silts and sands, *Grand Island* sands, *Fullerton* silts and sands, *Kansan* drift, *Aftonian* sands, gravels and the gumbotil, *Nebraskan* drift, and the shale, sandstone, and limestone beds where they enter into the problem. The geological conditions affect the percolation and storage of groundwater, relate to the source of materials used in dams, and largely determine the placement and anchorage of dams.

The erosion control work requires a close knowledge of the nature, origin, and occurrence of the following land forms: *Flood plains, terraces, colluvial fans, colluvial slopes, Loess hills, loess bluffs, loess plains, loess canyons, Drift hills, shale hills and slopes, tablelands, bench lands, rough stony land,* and *sand hills.* It also calls for a knowledge of the following series of soils: *Carrington, Shelby, Marshall, Knox, Moody, Crofton, Dickinson, Crete, Hastings, Holdrege, Colby, Keith, Rosebud, Dawes, Pierre, Waukesha, Wabash, Cass, Sarpy, Valentine,* and *Dunesand.*

The method followed in erosion prevention and control relates to the conditions that obtain. It considers such factors as the nature and amount of rainfall, water table depth, geological formations, degree of slope, condition of the soil section, natural vegetative cover, and a plan or setup whereby the best agricultural use can be made of the land without wastage of soil and soil-forming material.

OUR RELATIONS TO GLACIATION

Glaciation changed Nebraska directly and indirectly to a marked degree. It brought materials in from the north, ground them up on the way, and mantled the old eroded bedrock of shale, limestone, chalk, and sandstone with these materials to an average depth of about 100 feet, and, as noted before, caused the deposition of two sand and gravel formations in the central part of the state with a combined thickness of 100 to 200 feet.

The later glaciations that reached Iowa and other states to the east, influenced Nebraska through climatic change, which caused severe land erosion here during the humid periods and valley-filling and extensive loess accumulation during the dryer periods. Soil was formed on the smoother lands when the climate was humid, and sandhills were developed on sandy land when the climate was dry accompanied by wind erosion.

The loess was derived from large areas west and northwest of Nebraska and deposited thickest where there was protective vegetation, as along the borders of the large valleys.

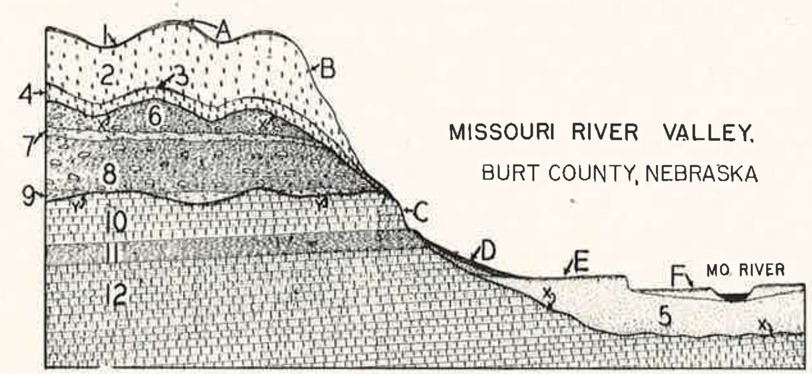

FIGURE 4.—Generalized East-west Cross-section, Burt County, Nebraska: 1, soil on the *Peorian* loess; 2, *Peorian* loess; 3, old soil on the *Loveland* loess; 4, *Loveland* loess; 5, *alluvium*, old and recent; 6, *Kansan* drift; 7, *Aftonian* sand and gravel; 8, *Nebraskan* drift; 9, sand and gravel under the *Nebraskan* drift; 10, upper sandstone of the *Dakota;* 11, shale in the *Dakota;* 12, lower sandstone of the *Dakota.*

The principal old erosion surfaces are at X and Y. The land forms represented are: A, Loess hills; B, Loess bluff; C, stony out crop on sandstone and shale; D, colluvial slope; E, terrace; F, floodplain on recent alluvium.

In places it drifted like snow, accumulating to greatest thickness on the leeward sides of hills.

In general, the glaciers and the winds brought much land debris to our state from the north and west during the Glacial period and finally influenced the development of our present soil. Our problem now is the prevention of the erosion and removal of the soil and soil-forming materials that were developed here during the Glacial period.

PERIODS OF EROSION AND RESULTING LAND FORMS

Geological study shows that there have been eight major and several minor periods of erosion in the area now known as Nebraska, during each of which vast quantities of land were carried to the sea. Of these periods, two were comparatively late in geologic history, i.e., one near the close of the *Teritary* and the other following the *Kansan* glaciation. The latter of these erosions produced the topography on which the loess deposits were laid down and thus shaped the major land forms now found in Nebraska, except in the sandhills and on the tablelands. It made the major valleys of the central and eastern parts of the state, except the middle course of the Platte. It separated the *Grand Island* sand plain into a large plain and many outliers and carved the drift plain into small valleys and hills. Our present upland plains, and hills have about the same form as they had at the end of this period of erosion, except that they were later mantled, protected, and made smoother by the two loess deposits.

The Loess Plain Region is the largest remnant of the *Grand Island* sand plain. The Loess Hill Region is composed of three areas: 1, Eastern, i.e., drift hills thickly mantled with loess; 2, Northwestern, i.e., sandy hills, unevenly mantled with loess; and 3, the Western, i.e., sand plain and sandy hills, thickly mantled with loess.

The Drift Hill Region is largely composed of Drift hills, with a discontinuous mantle of loess. It has many small exposures of bedrock where all of the drift and loess have been eroded, as near Wymore, Du Bois, Humboldt, Falls City, Auburn, Nehawka, and Weeping Water.

The table lands of the state were formed just prior to the Glacial period and the sandhills, as noted above, were developed principally during stages six and eight. Our oldest valleys are those of the table lands, which reach back to the Tertiary period. The Platte Valley (western course) was formed during late Tertiary. The lower course is post-*Kansan* and the middle course is post-*Loveland*. The story of how this valley was finally united as one big trench across Nebraska involves too much geology history to be recited here.

We are now in a period of comparatively active denudation in which the soil and the land materials below it are being eroded and washed to the sea. Fortunately for us, nature developed a natural sod and deep, fertile soils on large areas of our state prior to our cultivation of the land. We have destroyed much of the protective sod, and our methods of farming are contributing to soil wastage and land erosion. In other words, man is a destructive factor in this cycle of erosion in which the future welfare of the state is involved.

WET AND DRY PERIODS

It has been shown in this paper that several wet and dry periods occurred in rather regular order during glacial time with consequent effects on land formation, soil accumulation and land erosion. They were long-time geologic cycles.

There is now much speculation by geographers, meteorologists, and geologists concerning the position we are supposed to occupy in the climatic cycle and the long-time geologic cycle. Some geographers claim that we are approaching a period of greater dryness, and others are equally strong in the opinion that we are soon to enter a period of increased rainfall. Their deductions are based on historical evidence, such as the study of the growth-rings in trees, rainfall records, and the ruins of cultural features. Some of the meteorologists conclude that, on a basis of short-time weather cycles, we are soon to pass into a more humid period, whereas others of them believe that the cyclonic tracts are shifting northward and will give less rainfall in our general area in the future.. Correlating with this latter view, certain geologists hold that a long dry period is ahead, like that which obtained when the *Peorian* loess was formed from dust, to be followed thousands of years hence by glaciation accompanied by lower temperature and higher rainfall, yet it is not certain that cyclic periods are to continue as in the past.

According to the short cyclic occurrence of rainfall, we probably are near a change for the better, and so far as the long geologic cycle is concerned, we need not worry because it is measured by thousands of years and may not be experienced by our posterity. At any rate, our problem now is more tangible and real than mere speculation. It is the prevention and control of soil erosion whereby the rainfall can be used more effectively.

EVIDENCE OF SOIL DEPLETION BY EROSION

Extensive tracts of agricultural land in the older states have gone out of cultivation because of soil erosion, and

FIGURE 5.—View on the Plum Creek Project near Albion, Boone County, showing sheet erosion and rill-washing. Much of the top soil has been removed here. Photo through courtesy of R. L. von Trebra.

there is convincing evidence that some of our land is being destroyed in this manner, as shown by the Soil Survey, by chemical analysis, by general observation, and by the experience of farmers. In places the situation is becoming alarming.

The Soil Survey was started in Nebraska more than twenty years ago, and some of the soils first mapped and described have become thinner and less productive than formerly. For example, the *Carrington silt loam,* which prevails in the Drift Hill Region, is shrinking in total area, due to its erosion.

With the removal of its top soil, as on the steeper hill-sides, this type changes into the *Shelby* soils which are characterized by their thin top soil and exposed subsoil. Similarly the *Marshall* and *Moody* soils of the Loess Hill Region, which

FIGURE 6.—A deep gully on the Plum Creek Project. Photo through courtesy of R. L. von Trebra.

FIGURE 7.—Brush dam in a deep ravine on the Plum Creek Project; view from the downside. Photo by Richard Hufnagle.

are among our most productive types, give way to the *Knox* and *Crofton* soils in which the subsoil is near the surface.

Again, the chemical study that has been made of soils by Professor J. C. Russel and others of the College of Agriculture, shows that the humus content of the soil has been less-

FIGURE 8.—Gully control on the Plum Creek Project. Note the small dams, and that the shoulders of the gully have been shovelled off. This work was done by CCC boys.

ened within recent years because of careless cultivation, and erosion. This conclusion correlates with that of the Soil Survey in showing that soil erosion has become a menace on some of our best land.

FIGURE 9.—The results of a dust storm in Gregory County, South Dakota, 1934. The material was blown from dry shaly soil. Photo through courtesy of F. A. Hayes.

FIGURE 10.—Effects of wind on sandy land planted (listed) to corn. This is typical of the conditions developed by wind on very sandy land under cultivation. Photo through courtesy of F. A. Hayes.

NATURE AND EFFECT OF EROSION

The top soils of the hilly lands and slope lands are being thinned, and in places destroyed by sheet erosion. This decreases their capacity to absorb and hold rainfall, and also reduces their fertility. This type of erosion augments the direct run-off and contributes to rill-washing and gullying.

Sheet erosion is active on the Loess hills and even more so on the Drift hills, especially on slopes of eight degrees or

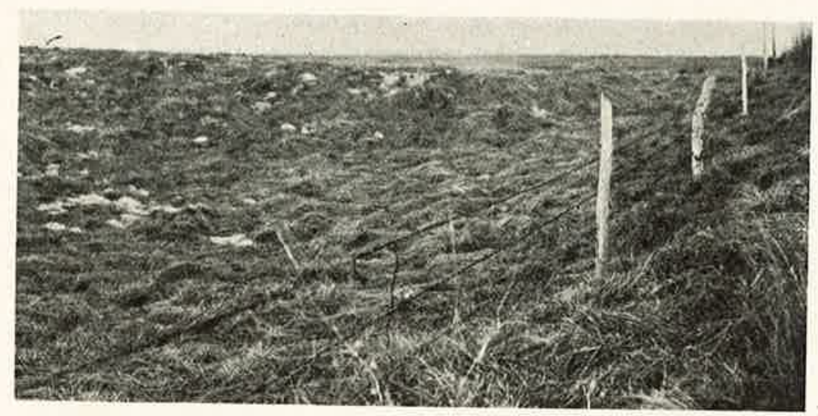

FIGURE 11.—A sandhill blow-out in Cherry County, controlled by a spread of hay and weeds.

FIGURE 12.—A graded, sandhill road of Thomas County, held against wind erosion by a spread of hay and weeds.

more. Gullying is also common in these regions. It frequently extends deep into the mantle rock, breaking the farms into disconnected areas, and interfering with cultivation. Gullying is developing at thousands of places, eating into the hills, terraces, upland plains, and tablelands.

Sheet erosion and gullying remove large quantities of sediment from the uplands and deposit the materials on the lowlands, usually with considerable damage to the bottom land soils. The valuable soil and soil-forming materials overload the streams. Gullying also damages fences, bridges, and highways.

Wind erosion is still active in the sandhills and on other sandy land of the state, especially where such lands are overgrazed or farmed. The worst season for the erosion of sandy ground is early springtime.

This year much shaly land in the Dakotas, and some in Nebraska, was badly damaged by wind. The effects were most destructive where the soil was very dry and where grasshoppers destroyed the vegetation. These conditions made the soil and the shaly bedrock too incoherent to withstand the wind.

FIGURE 13.—Bank erosion of the Missouri River in Burt County. River control work will prevent destructive bank erosion here in the future.

MEANS OF EROSION PREVENTION AND CONTROL

There are many farms in the state on which erosion is stopped at its inception or is prevented by keeping the most erosive land in native grass, planted grass, or forest. Some contour farming and terracing are done by the farmers.

Eroded soils are being reclaimed by seeding to legumes, by the use of barnyard manure, and by reseeding to native grasses. Gullies are being controlled by the use of retards, various kinds of dams, by seeding the slopes to sod-forming grasses, and by planting bushy plants and trees along the gullies.

Less sandy land in the Sandhill Region and along its borders is being cultivated than formerly, and the ground of this kind that has been plowed is being revegetated to native grass. Blow places along the cattle trails, about the ranch buildings and along the public roads are being protected by the application of hay, and other cover materials.

Many farmers of the state are awake to the erosive problem and are using inexpensive methods of control, whereas others, especially those in hard circumstances, hold a negative and sometimes critical attitude on this matter.

NATIONAL POLICY AND PROGRAM

The Federal Govermnent and our State are committed to a policy and program of soil conservation based on the principle that the maintenance of soil fertility is a fundamental requirement in agriculture, and supported by the claim that soil erosion-prevention and control further the absorption of rainfall as soil moisture and ground water. A national program for soil-saving and water conservation has been set up to operate in distinct lines, as follows:

1. Soil Erosion Experiment Stations have been located in several states to investigate the problems of soil erosion in relation to water conservation and land use.
2. Erosion Surveys are being made to determine the extent and types of soil erosion throughout the United States. The results of this work are to be used in erecting a comprehensive program of erosion-prevention and control.
3. Soil Erosion Demonstration projects, as the one in the Plum Creek drainage area near Albion, Nebraska, have been established at 24 places in the United States. These projects employ effective, technical methods for the prevention and control of erosion, and the results are intended to demonstrate what can be accomplished in regions needing erosion control.
4. The CCC camps and the Emergency Relief agencies are doing much erosion control work. There are 25 CCC camps in Nebraska, of which 17 are building soil-saving dams and are doing gully control work.
5. The control work, as on the Missouri, holds the rivers in place and thus prevents the erosion and destruction of soil and land. Although this development is intended primarily for navigation, it has a direct relation to land saving and fits into the national plan.

DISCUSSION

The CCC erosion work has been rushed the past year in order to relieve the unemployment situation and to afford civilian training. With this hurry-up program and the new and comparatively inexperienced personnel, mistakes probably have been made, but with it all, the young men of the camps have been in the open, off the streets and away

from idleness. They have learned how to do some things well and have gained in training and good citizenship.

Some of the relief workers in soil erosion control work probably do not know much about soil, subsoil, and mantle-rock, or how the rainfall is absorbed into the soil, or what causes a portion of it to run-off, yet their purpose is commendable.

The erosion activities of the CCC camps are improving. They were recently reorganized more closely, and we may now expect this set-up to produce effective results.

The Soil Erosion Demonstration projects employ technical men to guide their departmental activities. The project areas are carefully surveyed. Engineers plan the reclamation work. Big machinery is used in terracing and knocking off the humps along the gullies. Trees, bushy plants, and grasses are planted on the most erosive places. Agriculturists and soil scientists study every farm in the project and recommend crop systems suited to the conditions. All of the work is carried on for a common purpose.

No doubt some of the control work done on the Plum Creek Project near Albion, as in other states, may seem unwarranted and expensive, yet we should not overlook the fact that this demonstration project is intended to show what can be accomplished in a representative area of the state, and that the results will be open for inspection and study by farmers and others for their benefit.

Evidently the Federal erosion activities should be more closely coordinated and administered by a centralized department or bureau with close cooperation with the State departments as is done in similar lines of technical investigation and service for public benefit. This would place the work on a firmer footing and make it more effective.

CONCLUSIONS

1. The original prairie was not so erosive as cultivated land.

2. Erosion reduces soil fertility and the capacity of the soil to absorb and hold rainfall.

3. Soils that have been eroded down to the subsoil cause relatively heavy direct run-off, resulting in rill-washing and gullying.

4. Contour farming is an effective means of erosion prevention and in moisture conservation on land with moderate slope.

5. The terracing of farm land with slope of less than 8 degrees seems to be feasible in parts of the state, but not generally.

6. Sheet erosion, rill-washing and gullying should be controlled at the start and not allowed to progress to the point where the soil is impoverished and the land is scarred by deep trenches.

7. The most erosive land should be withdrawn from cultivation and seeded to grass or planted to forest.

8. Every feasible means should be employed to prevent gullying and to efface the ugly gullies from our agricultural lands.

9. Soil erosion work should proceed on a technical basis in order to avoid failure and insure permanent benefit.

10. The erosivity of soils must be taken into account in a program of land utilization.

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