Issued June 16, 1913.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS—MILTON WHITNEY, Chief.

RECONNOISSANCE SURVEY OF WESTERN NEBRASKA.

BY

T. D. RICE AND PARTY.

[Advance Sheets—Field Operations of the Bureau of Soils, 1911.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., October 3, 1912.

SIR: During the field season of 1911 the soil reconnoissance of the Great Plains region was continued by mapping the western half of Nebraska. Mr. Thomas D. Rice was in immediate charge of the field work. He was assisted by Messrs. Allen L. Higgins, Risden T. Allen, William G. Smith, Grove B. Jones, L. C. Holmes, J. W. Nelson, Gustavus B. Maynadier, Howard C. Smith, and Ewing Scott.

I have the honor to transmit herewith the manuscript report and map covering this work and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1911, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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RECONNOISSANCE SURVEY OF WESTERN NEBRASKA.

By T. D. RICE and Party.

GENERAL DESCRIPTION OF THE AREA.

LOCATION.

The soil survey of western Nebraska covers an area of 53,064 square miles, or 33,960,960 acres. Fifty-two counties make up the area, of

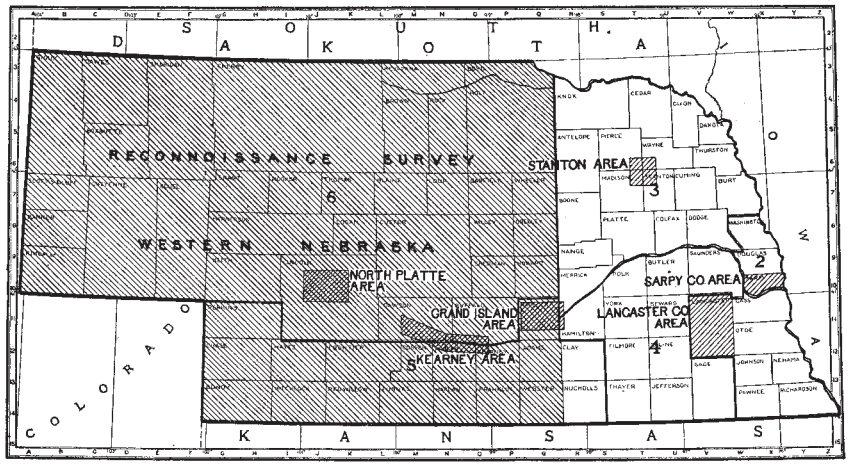

FIG. 1.—Sketch map showing areas surveyed in Nebraska.

which the tier composed of Boyd, Holt, Wheeler, Greeley, Howard, Hall, Adams, and Webster form the eastern boundary.

SURFACE FEATURES.

The physiographic province known as the Great Plains, of which the entire State of Nebraska forms a part, is a vast plateau sloping away from the Rocky Mountains. Its deeper lying formations antedate the Rocky Mountain uplift and consist of ancient deposits of Cretaceous and early Tertiary age. Its surface formations, except where they have been removed by erosion, are made up of sediments brought down from the elevated region to the west during and since late Tertiary time and deposited by the streams in thick strata or fan-like aprons, so that it may be regarded as the outwash débris removed from the Rocky Mountains. There is an eastward slope in the whole of the Great Plains region, which is due partly to earth movements

and partly to the natural slope of the constructional surface of the ancient fanlike aprons. In the part of the Plains covered by this survey the eastward inclination is at an average rate of nearly 12 feet per mile, descending from an altitude of more than 5,300 feet in the western part to about 1,600 feet in the east, but the rate of inclination is more rapid in the west.

The region is composed of strata of varying degrees of hardness and greater or less resistance to erosion, in which the present relief, comprising all variations of topography from nearly level plains to rugged buttes and canyons, has been developed by dissection of the plateau since its formation and by the deposition over the surface of loosened material by the agencies of wind and water. In Nebraska wind has been a more active agent of soil formation than water, and the vast sandhills and the loess owe their extensive deposition to this force.

In early Pleistocene times, western Nebraska was a broad, relatively smooth plateau sloping gently toward the east. Since that time drainage channels have been established, valleys have been eroded and widened, and tributary drainage ways developed, so that in the eastern part of the State practically none of the original plateau remains intact. In the extreme western portion of the State remnants of the ancient tableland, which have escaped the widespread degradation of the country, may be seen in the broad divides, of which the most extensive are the Cheyenne Table in the southwestern part of the State, south of the North Platte River, and the Boxbutte Table, lying principally in Boxbutte County. On these plateaus the surface is level or gently undulating, being broken only by small drainage channels barely sufficient to dispose of the water after occasional heavy rains.

Where running water has been the principal agent of erosion the extent and character of the local surface sculpturing in any part of the area has been determined by the amount of rainfall in that particular locality. In the eastern part, where the rainfall is adequate for the purpose, erosion has smoothed the hills and given the pleasing rounded contours characteristic of the humid regions, but in the western portion, where the rainfall is less abundant, the cutting of the watercourses has been more abrupt, and deeply cut valleys, sharp hills, and deep gorges are characteristic features of the landscape, culminating in the extreme western part of the State in the true badland topography, such as may be seen in the vicinity of Scotts Bluff or in the bold, rugged outlines of Pine Ridge.

That the irregular rolling areas differ so widely in appearance in different parts of the State is due entirely to an adjustment of the agencies of erosion to the superficial geologic formations, with their varying degrees of hardness and resistance to degradation. Recog-

nizing these factors in the formation of the prominent surface features, the State is usually divided for purposes of convenience into three physiographic provinces: the loess region, the Sand Hills, and the Plains, the latter including in this report the excessively eroded portion called the Bad Lands, which is sometimes treated as a separate physiographic province.

The loess region occupies more than one-third of the area, including the greater part of the southeastern corner and irregular patches to the west and northward along the eastern boundary. It is characterized by a topography ranging from hilly and rolling to level and gently undulating. There is little of the badly dissected type of the bad-lands character, but much of it is very sharply rolling, particularly on the northern slope of the Platte Valley. Precipitous stream slopes are rarely found in the pure loess, as they are well grassed over, but along the deeper valleys, where the streams have cut through the loess and exposed the rocks of the harder formations, strips of rough, stony land have been produced. In the extreme southeastern part of the area the underlying drift is usually exposed on hillsides and the slopes are covered with sandy or gravelly soils of little agricultural value. Over the greater part of the true loess region, however, the hills are smoothed and have the pleasing contours characteristic of this material wherever it occurs in a humid region and has not been exposed to excessive erosion. Drainage channels have been established more thickly than is the case in the western part of the State, and there are no extensive areas that are not eroded by streams so as to give some variety to the topography.

The loess region in Nebraska is characterized by broad belts of alluvium along the larger streams. The Republican River, in the southern part, has a broad bottom of uniform width along its entire extent. The bottom of the Platte River is wider and varies more, attaining its greatest width of 18 miles near Grand Island.

The main body of the Sand Hills occupies a vast region in the north-central part of the area surveyed. There are outlying areas of considerable size, some of which differ somewhat in the composition of their sandy soil, but have a similar topography. The sand-hill region is a monotonous succession of rounded or choppy hills and irregular ridges, often capped by drifting sand and pitted by blowouts. The outlets of the valleys are often obstructed by the drifting sand, so that lakes and narrow marshy tracts are a common feature of the country. A few large streams succeed in traversing the Sand Hills, but the small watercourses are obliterated at intervals by the porous drifting sand. Naturally no extensive valleys can be formed and kept open under these conditions, and the ancient valleys now have the form of a chain of lakes and meadow tracts, usually lying in an east and west direction.

Where the sand has been stationary for a long time, as is the case along the outer edge of the main body and over some of the sandy loam soils, the hills are well grassed over, but the topography is that of the true dunes.

The topography of the Plains has greater variety than that of the other provinces. In the northwestern part of the State, around the southern extension of the Black Hills uplift, the older sedimentary strata have been tilted and subsequently removed by erosion, giving a topography more varied than on the High Plains. So rapidly have these rocks succumbed to erosion that this region of their outcrop is now on an average more than 700 feet below the level of the main portion of the High Plains, which is protected by more recent strata. The oldest formation in this part of the State is the Pierre clay, which has produced a sharply rolling country, dissected by numerous drainage channels. Bordering it on the south is a band of the Chadron formation and above it one of the Brule formation, both of which are so readily eroded that their surface exposures are characterized by a very rolling and broken landscape, with occasional areas of incipient bad lands. This region has been eroded by White River and its tributaries, except a small section toward the western part of the State, which is drained by Hat Creek.

South of these formations, with their characteristic topography, lies the Pine Ridge escarpment, constituting probably the most striking surface feature of western Nebraska. It is the northern edge of the High Plains; the steep slope from their higher surface to the lower surface of the lowlands to the north. It enters the State from Wyoming about 30 miles a little north of west from Crawford and runs approximately parallel with the Niobrara River crossing the State line into South Dakota north of Rushville. It rises to a height of 500 to 800 feet above the lowlands to the north and 300 to 600 feet above Niobrara River. This escarpment presents its steepest face toward the White River Valley to the south.

The Niobrara enters the State south of Pine Ridge and flows in an almost eastern direction throughout the area. The topography of the valley of this stream varies in different parts of its course. In the western part of the State it drains the northern slopes of the Boxbutte Table and the southern slope of Pine Ridge, which consists of a rolling country, broken in many places by patches of Bad Lands. In this region the bottom lands are narrow and cut by many incoming streams. Where the Niobrara enters the great sand-hills region the flood plains are almost overwhelmed by the constantly encroaching sand, so that there is left only a narrow flood plain that is kept scoured out by the stream. Few tributaries enter the river in this region and for some distance there is actually a loss of the water from its drainage basin into the porous sand. Before it leaves the

Sand Hills this loss is more than regained by the accretion from the seepage of the sheet water that underlies the hills. Thoughout its course from the point at which it enters the Sand Hills to the eastern edge of the area the river has cut down into the indurated strata of the Arickaree formation, producing a gorge-like channel with areas of Rough broken land along the slopes. The flood plain is a narrow band, usually less than one-fourth mile wide. The bottoms widen out toward the Missouri, but the soils are sandy, owing to the large quantity of material brought from the Sand Hills.

South of the Niobrara, in the western part of the State, there is again an elevated country in the form of a vast plateau, which is commonly known as the High Plains. The term "High Plains" as used in this report includes that part of the State where the rocks of the original plateau stand high above the dissected country and have not been covered by a mantle of loess or drifting sand. This plateau, with its eroded flanks, covers nearly all of the State west of the loess and south and west of the Sand Hills, together with a narrow fringe through the northern part of the State. In this region a number of the newer and more resistant strata have been exposed, and they have withstood erosion to a greater degree than the older rocks to the north. The areas least disturbed by erosion are two extensive table-lands, one on each side of North Platte River—Boxbutte Table, which covers the greater part of Boxbutte County and portions of Sioux and Sheridan, and Cheyenne Table. lying between North Platte River and Lodgepole Creek, in the counties of Cheyenne, Kimball, and Deuel. These plateaus are high, gently undulating, or nearly level plains, upon which drainage channels have not yet been well established.

These table-lands are separated by the valleys of North Platte River and Lodgepole Creek. The North Platte Valley includes a strip of alluvium several miles in width, which rises in a series of terraces above the river flood plain proper. The bordering valley has a mixed topography, consisting of gentle slopes and nearly level country, with patches of very rough land where the streams have cut through the easily eroded formations. Above this are the high bluffs and hills of varied height and rugged outline, representing the comb of the ridge between North Platte River and Pumpkin Seed Creek.

The Bad Lands, which are such a striking feature of the landscape in the western part of Nebraska, are the result of the erosion of soft rocks under partly arid conditions. This topography is developed in only a few ragged, irregular areas in Scotts Bluff, Sioux, and Dawes Counties. The formation that breaks down most readily under erosion to produce such an irregular topography is the Brule formation. It is a soft silty clay that melts away rapidly under the action of water; the streams sink into it to produce deep gulleys,

and soon the entire surface is dissected. Wherever the Brule formation is capped by a protecting stratum of the Arickaree or any of the other harder formations, buttes with steep walls are produced, between which the Brule formation on any exposed portion is rapidly removed and deep gorges and ravines are produced.

The principal areas of the Brule formation outcrop on each side of the North Platte River in the vicinity of Scotts Bluff and in the valley of White River between Crawford and Chadron. There are also numerous small patches of this excessively eroded land in Lodgepole Creek Valley and in nearly all parts of the Brule outcrop. In all of these areas the ground is nearly bare of vegetation, not only on account of the rapid erosion, but also because of the natural infertility of the soils of the Brule formation, which is due to their high percentage of soluble salts and to their deficiency of organic matter when they are first exposed to weathering. In Lodgepole Valley, where the Brule formation outcrops, there are tracts of land bare of vegetation, but the surface is not washed and gullied to produce the typical Bad Lands.

REGIONAL DRAINAGE.

The entire State of Nebraska lies within the drainage basin of the Missouri River. With the exception of the drainage carried by a few small streams, the rainfall of the area surveyed is carried to the Missouri by three tributaries—the Niobrara, which skirts the northern part of the State; the Platte, which flows through the central part; and the Republican, which touches the southern border. Of these systems, that of the Platte carries the greater part of the drainage. The Missouri itself touches the northeastern corner of the area, but receives practically no direct local drainage. The main tributaries of the Missouri River flow in a general easterly direction, and the feeder streams have an eastward trend, with a slight convergence toward the main channels.

The Niobrara River extends along the northern part of the area from its northwestern corner to its northeastern. It is a comparatively small stream when it enters the State and derives a considerable portion of its flow from the slopes of the High Plains. After it enters the Sand Hills in Sheridan County it gains but little lateral drainage and loses some of its flow by seepage and evaporation. In the western part of Cherry County there is an accession to its volume from the underflow of the Sand Hills section, and from this point eastward several creeks of steady flow empty into it, and its volume is steadily increased until it forms a junction with the Missouri.

Platte River is formed by the junction of the North Platte and the South Platte about half way across the area and near the town of

North Platte. The North Platte enters the State on its western boundary about one-third the distance from its northwestern corner and flows in a southeastern direction to its junction with the South Platte. The South Platte enters the State from the northeastern corner of Colorado and flows nearly due east to the junction. Both of these branches receive numerous important creeks, but the surface flow in each gradually diminishes as the streams sink into the mass of sand and gravel that makes up its immediate flood plain.

The Platte flows in a southeast direction to within a short distance of the town of Kearney, then turns north and leaves the area through Hall County. From the south it receives but little local drainage, but it gathers a large volume of water from the extensive region of the Sand Hills to the north. This accession is acquired chiefly through the Loup River and its tributaries. Before these streams emerge from the Sand Hills their courses are much choked by the drifting sands, and at intervals they are entirely swallowed up. The rain that falls on the Sand Hills sinks immediately into the ground and little is lost by evaporation, and eventually this underground water emerges and adds to the volume of the creeks. After these streams escape from the hills they add to their flow the drainage of the well-watered, loess-covered region in the eastern part of the area. In spite of the addition by tributary creeks and seepage, the volume of the surface flow of the Platte diminishes toward the east as the water sinks into the gravelly, porous bed and finds its way eastward as an underflow. East of Kearney it is only when the river is much swollen that the flow appears on the surface, and west as far as North Platte the bed of the river is frequently dry. For this reason the water of the Platte is not available for irrigation, except when wells are dug and it is pumped to the surface.

The Republican River enters the State from Kansas and flows along the southern border of the State to the southeastern corner of the area. It receives a number of swiftly flowing tributaries. As the land drained is hilly and the surface soils hard and impervious, there is a rapid run-off of the rainfall, so that the Republican is quickly swollen after heavy rains and much damage is frequently done to crops and property on the alluvial land.

POPULATION.

The population of western Nebraska is greater per square mile in the eastern part of the area and diminishes gradually toward the west in proportion to rainfall and average crop production. The time of most rapid increase in population was in the decade between 1880 and 1890. The loss of settlers during the dry years that fol-

lowed was so severe that for the whole of the decade between 1890 and 1900 the eastern counties made very slight gains and many of the western counties sustained losses. In the last decade there has been a steady increase in the number of inhabitants in all parts of the State, and nearly all counties have more than regained their former population.

The following table has been compiled to show the changes in population in the area surveyed during the last 20 years. To indicate more effectively the changes that have taken place in different parts of the area on account of the greater severity of the drought toward the western part three groups have been made, comprising, respectively, 18 eastern counties of the area, 16 central, and 17 western, and the total populations for these groups are given for 1890, 1900, and 1910.

Changes in population, 1890 to 1910.

	1910	1900	1890
Eastern counties	187,097	164,464	159,213
Central counties	127,697	102,274	102,158
Western counties	71,053	42,425	56,821

Towns have been established and have increased in size in proportion to the increase of the rural population and in relation to the needs of the farmers for markets and shipping facilities. The tendency of the early days to boom towns without regard to natural advantages or to the needs of the surrounding country, which must ultimately limit the size of towns in this region, has long since passed away, and the towns at the present time are of reasonable size and have a healthy, steady growth. Grand Island is the only town of the area that has a population in excess of 10,000, but Hastings falls but little short of that figure. Nearly every county has for its county seat a town of from 1,000 to 3,000 people. In addition, there have grown up at railroad points in each county small towns and villages which serve as trading points for the surrounding country and supply shipping facilities for the agricultural products.

It is probable that a larger proportion of the farmers of Nebraska are native born than in any other Western State. The early settlers were drawn from all parts of the United States, many of them locating first in Iowa or Missouri and later coming farther West as agriculture gradually spread in this direction. At the present time homeseekers coming to the western part of the State have been drawn from the older, thickly settled agricultural communities, such as Illinois, Iowa, and the eastern part of Nebraska, where the high price of land has tempted the owners to part with their holdings in those sections to seek homes in the cheaper lands of the West.

The population of western Nebraska will probably continue to increase for many years to come, with fluctuations from time to time, due to droughts and crop failures following years of unusual productiveness. There is a total area of many thousands of square miles in the western part of the State that is not now utilized for the most extensive system of farming or even for stock raising. No part of the State can be said to be thickly settled at the present time. The best land of the eastern part of the State offers little inducement to the usual type of new settler, but there will be a gradual growth of the farming population due to natural increase and the subdivision of the farms. The more arid portion of the State can never be as thickly settled as the eastern, but the number of people that can finally be supported is hard to estimate. It will always be a region of extensive farming, and the probable development along agricultural lines will be a system combining farming and stock raising, and such utilization of the land will not support a very dense population. It is safe to say that if the land were used to advantage in this way a population much in excess of that now resident in the region could be supported. The irrigated districts will in the future have the largest increases in settlement, and it is probable that the irrigated valley of the North Platte will eventually have the densest rural population of any part of the area.

MARKETS.

Grand Island, with a population of 10,326 in 1910, is the largest town in the area and an important railroad, milling, and shipping center. It is noted as a horse market, and three large firms of breeders and importers have sale stables there. There are three greenhouses in the town, and more flowers are shipped from here than from any other town in the State. Hastings ranks next to Grand Island in size, having a population of 9,338 by the last census. It is the center of a large farming and dairying section and supports numerous important mercantile and manufacturing enterprises. Kearney, North Platte, Alliance, Sidney, Crawford, and Valentine are all centers of retail trade, and furnish markets and shipping facilities for the agricultural products of the surrounding country.

The surplus products of the area, consisting principally of wheat, corn, hay, and cattle, with some potatoes and dairy products, are marketed in Omaha and Chicago. Some of the wheat is ground at the flour mills found in every town of any size in the area. The product of these mills finds a local market. Grain is nearly all handled at the elevators, where it may be sold at once or stored until the price is satisfactory. Some of the elevators are owned and operated by nonresident capitalists, but many of them are owned

by the farmers of the community and operated on a cooperative plan. Some of the cattle in the ranching districts are sold on the range to speculators, but usually the rancher ships his cattle to Omaha or Chicago, where they are sold for him by commission houses. Potatoes are usually taken by buyers f. o. b. in carload lots and shipped to Chicago, Omaha, and other outside markets. The sugar-beet crop finds a market at factories in Grand Island, North Platte, and Scotts Bluff.

TRANSPORTATION FACILITIES.

The eastern part of the area surveyed is well supplied with railroad facilities, and the southeastern part is covered by a network of branches of the Union Pacific and the Chicago, Burlington & Quincy systems. Three lines of the latter extend nearly across the area from east to west, and a main line from Denver to the Black Hills runs in a north and south direction through the western part of the State. The Chicago & Northwestern has a main line across the northern part of the State. The main transcontinental line of the Union Pacific extends across the State, following the course of the Platte River to North Platte and thence along the South Platte and Lodgepole Creek.

Portions of the sand-hills district are the only large stretches of country in the State distant from any railroad. The Chicago, Burlington & Quincy passes through the center of this vast region, but there are great stretches of country on both sides of this line that are far from railroad facilities, and the small farming communities are retarded in their development by this cause.

FORESTS.

The uplands of the Plains were originally in a treeless condition and the only timber was a sparse fringe of water-loving trees along some of the larger streams and a scattering growth of dry-land trees over some of the rough country in the western part of the State. The tree growth on the alluvial belt consisted principally of cottonwood, box elder, ash, and elm. These trees were distributed as scattered individuals at intervals in the bends of some of the larger streams or occurred in bodies of a square mile or more. The greater part of this timber has been cut over and very few valuable trees now remain. The timber of the rough, broken country consists of a sparse growth of pine and cedar. The shelter afforded by the rough land and the soil conditions seem to have been favorable to these species. The cedar has proved very useful to the settlers for posts and for small building timber, but the pine was usually too small to be of service except as fuel. The best of these trees have also been cut by the settlers. These trees are of exceedingly slow growth and it will take a long time to reforest the hills.

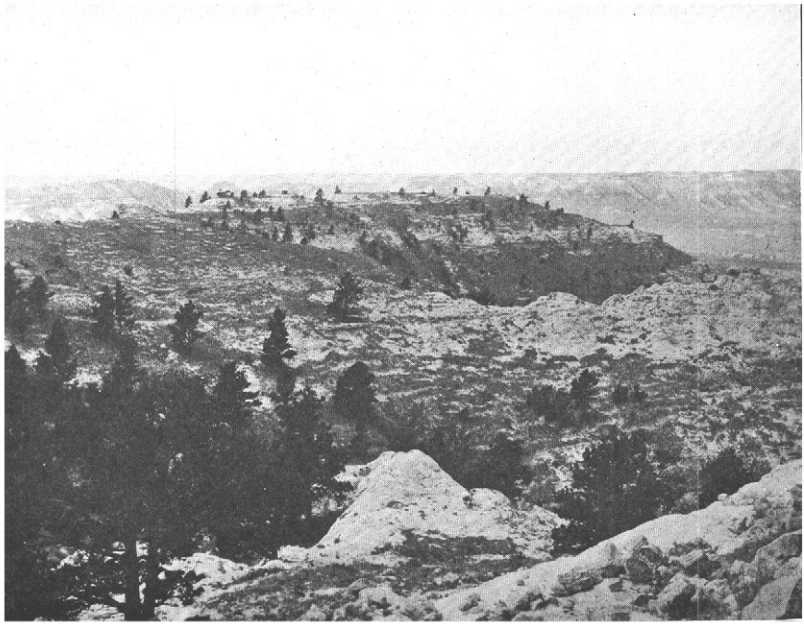

FIG. 1.—TYPICAL SCENERY IN THE AREAS OF ROUGH BROKEN LAND.

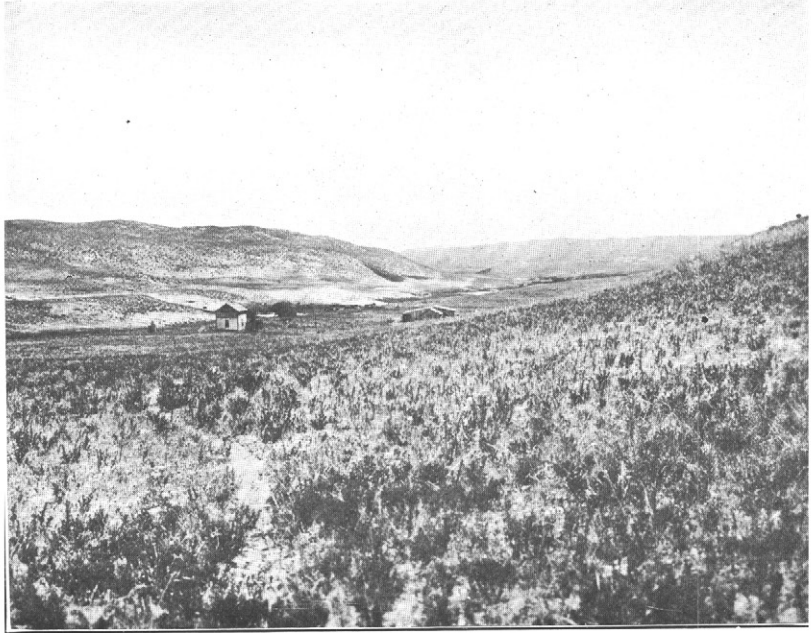

FIG. 2.—SMALL RANCH IN THE SANDHILLS.

On the uplands, particularly toward the eastern part of the area, groves of several acres in extent are often seen around the farms, and it is seldom that there has not been some attempt to plant trees around the house and farm. This can be done without much difficulty in the entire eastern half of the area, but west of this it is more difficult to get trees started, and the number of species that can be grown under the semiarid conditions steadily decreases as the western boundary of the State is approached. In many parts of the State groves of 10 acres were at one time planted in order to conform to the requirements for obtaining land under the desert-land act. In the east and in the wet meadow land in the Sand Hills section these groves have been successful, and the trees, though usually the less useful cottonwood, have value for use around the farms. The groves also break the force of the winds and furnish shade for the cattle.

Several reserves have been established by the Forest Service in the sand-hill region with the view of experimenting in tree culture, but little progress has as yet been made in the actual work of foresting these areas.

CLIMATE.

Two factors, soils and climate, determine the adaptability of a region for any particular system of agriculture. With the exception of comparatively small areas of drifting sand and strips of Bad Lands, the soils of Nebraska are of high average fertility and capable of producing large crops under the proper conditions of moisture, so we have only to consider the variable element of climate in estimating the agricultural possibilities of the region. In the past the development has been held in check by climatic conditions and the future must be judged by this experience. In this report not only the successes and failures of the farmers have been taken into consideration in estimating the prospects for the future, but also the records of the Weather Bureau which have accumulated since the region was first settled. The observations taken at several points in the State furnish reliable data for so long a period that an average may be computed which will represent the permanent climatic condition.

The climatic features considered in this report are temperature, precipitation, evaporation, and winds.

TEMPERATURE.

The tables given below show the highest, lowest, and mean monthly and annual temperature at points in different parts of the area. It will be seen from this table that this section, like other parts of the

Great Plains, is characterized by a wide range of monthly and annual extremes of temperature. The annual mean varies in different parts of the area from 46.7° at Fort Robinson to 51.8° at Red Cloud. The extremes range from an absolute maximum of 107° F., as recorded at North Platte, to an absolute minimum of —37° F. at Fort Robinson. The extremely low temperatures occur as cold waves or blizzards, accompanied in the beginning by high wind and usually lasting from three days to a week. It is generally conceded that the dryness of the atmosphere on the plains renders the severe cold more endurable than the same temperatures would be in the humid East. The blizzards, once so destructive to range cattle, now seldom cause much loss, as the animals are better protected and fed.

The average snowfall is less than 25 inches, being heaviest in the eastern part of the area and gradually diminishing toward the west. Cattle are seldom prevented from grazing by the snow, as the winds remove the snow from the more exposed land as fast as it falls.

The periods of high temperature in the summer may last a week or more, the mercury rising to 100° F. or above during the day and often not dropping much below 90° F. during the night.

Absolute maximum, absolute minimum, and average temperatures.

Month.	Fort Robinson.			Kimball.			North Platte.			Red Cloud.		
	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
January	74	—28	23.1	73	—33	27.3	70	—35	22.9	67	—25	26.9
February	72	—37	23.1	73	—30	26.9	74	—35	26.0	76	—16	27.8
March	89	—25	33.5	82	—17	34.4	86	—14	36.1	98	—18	39.6
April	89	3	46.4	89	6	46.1	93	2	49.0	98	10	52.4
May	96	7	55.2	97	8	55.0	97	20	58.8	102	21	62.1
June	104	32	65.0	102	32	65.0	102	33	68.0	106	38	72.3
July	106	35	71.1	106	39	70.9	107	42	73.2	106	48	76.9
August	103	31	70.3	104	35	69.9	103	40	71.6	104	43	75.8
September	100	9	61.0	97	19	60.9	103	21	63.4	100	25	66.8
October	94	6	48.4	91	4	48.1	94	9	50.3	90	16	53.4
November	81	—11	35.4	87	—21	35.8	81	—25	35.2	78	— 7	38.6
December	68	—28	28.3	68	—24	31.0	72	—30	28.0	68	—14	28.6
Year	106	—37	46.7	106	—33	47.6	107	—35	47.4	106	—25	51.8

FROSTS.

The interval between the probable dates of the last killing frost in the spring and the first in the fall ranges from 130 days in the northern part of the area to 162 days in the southern.

The table shows the average dates of frost at stations in different parts of the area.

Average dates of killing frosts.

Stations.	Length of record years.	Last killing frost in spring.	First killing frost in autumn.
Fort Robinson	17	May 13	Sept. 21
Kimball	18	May 15	Sept. 21
North Platte	34	May 1	Sept. 29
O'Neill	16	May 2	Sept. 25
Ravenna	24	May 10	Sept. 30
Red Cloud	12	Apr. 24	Oct. 4

PRECIPITATION.

The question of rainfall is of vital importance throughout the Great Plains region, because the average precipitation is so near the minimum required for profitable agriculture. Even in the humid portions of the United States the yield of crops is curtailed almost every year by drought and at rare intervals there is a total failure from this cause, but in the semiarid regions failures are much more frequent, as a very slight falling off in the normal precipitation brings the moisture in the soil below the requirements of successful crop production. In estimating for any section the supply of moisture available for the use of plants, other factors than the total annual rainfall must be taken into account. The prospective settlers too often note only the rainfall for one or for a short series of years without taking into consideration the seasonal distribution, rate of falling, run-off, evaporation, and other factors. The first step should be to ascertain the average annual precipitation and its probable distribution as shown by the most complete records that can be obtained. When these records are favorable there is still an element of uncertainty, since the summer rains usually come as local showers and a particular locality may be passed by for several years and have crop failures, while near-by communities may have unusually large crops. The areas of failure, however, are exceptional, and as a rule the agricultural prosperity in different parts of the State is directly proportional to the average annual rainfall. The seasonal distribution is also fairly constant in different sections and well suited to the needs of the farmer of the semiarid region, as three-fourths of the rain comes during the six months of the growing season.

There is a steady decrease in the amount of precipitation in this area from the eastern to the western part, the rate being much more rapid in a given distance along the southern border of the State than along the northern. Some writers have included the entire area covered by this report in the so-called semiarid region, but there has

never been a definite boundary established for the semiarid region nor any exact definition of what the term should include. It would certainly be misleading to include that portion of Nebraska that has an annual precipitation of over 20 inches, in which farming has been practiced with great success for over 30 years. In this report all discussions of semiarid conditions will apply to that portion of the State west of the precipitation line of 20 inches of rainfall annually.

The following table gives the monthly and annual mean precipitation for several points representative of conditions over the region:

Monthly and annual mean precipitation.

Month.	Fort Robinson.	Alliance.	Valentine.	O'Neill.	Kimball.	Grant.	North Platte.	Beaver City.	Grand Island.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January		0.62	0.56	0.42	0.45	0.37	0.43	0.42	0.52
February		.42	.64	.61	.66	.62	.46	.71	.84
March		.77	1.38	1.15	1.09	1.04	.80	.96	1.12
April		1.98	2.36	3.11	2.08	1.99	2.08	2.75	3.21
May		2.97	2.61	3.06	2.70	2.57	2.88	3.71	4.92
June		2.83	3.42	4.15	2.12	3.80	3.35	3.94	5.11
July		2.69	3.22	3.13	2.71	2.47	2.83	4.00	4.25
August		1.80	2.42	2.74	1.43	2.27	2.41	2.72	3.93
September		.74	1.17	2.05	.91	.89	1.49	1.79	2.68
October		.83	1.11	1.30	.63	.86	1.13	1.54	2.63
November		.35	.58	.47	.42	.35	.40	.60	.79
December		.39	.52	.64	.54	.39	.48	.62	.63
Year	16.91	16.39	19.99	22.83	15.74	17.62	18.74	23.76	30.63

The portion of Nebraska covered by this report may be divided into belts based upon the decrease in rainfall from east to west and upon the effect of this variation as shown by crop yields and the degree of soil weathering. (See fig. 2.[1]) The changes in production due to differences in rainfall are so gradual and so influenced by the texture of the soil that any boundary lines drawn for these belts are purely arbitrary as to position. The most humid division, as indicated by the sketch map, includes the country that has an annual rainfall in excess of 20 inches, or the greater part of the State east of the one hundredth meridian. Here failures from drought are rare, and a wide range of crops may be grown. Corn is a profitable crop, and alfalfa, though confined to the subirrigated valleys, makes heavy yields. An indication of the agricultural prosperity of this region is afforded by the price of land, which ranges from $25 to $50 for the upland and $50 to $125 for the valleys. The country was originally prairie, but trees of many species have been grown without difficulty, and fruit trees, particularly apple, are grown to

[1] Annual Report Nebr. State Board of Agr., 1909, p. 281.

some extent. Other trees are planted chiefly for posts, and of these the catalpa is the most valuable. The soils in this region are more deeply weathered and have accumulated a greater percentage of organic matter, which gives the darker color to the soils of the eastern part of the State. There is a smaller proportion of lime and soluble salts in the soils, but in no place is the amount deficient.

The second belt lies approximately between the lines of 18 and 20 inches of rainfall. In this section crop yields are more uncertain by reason of droughts that occasionally cause partial or total failures. The average crop, however, is profitable, and the product from the cultivated land is sufficient to support the population now resident in this belt. Corn is grown extensively, and it is considered a profit-

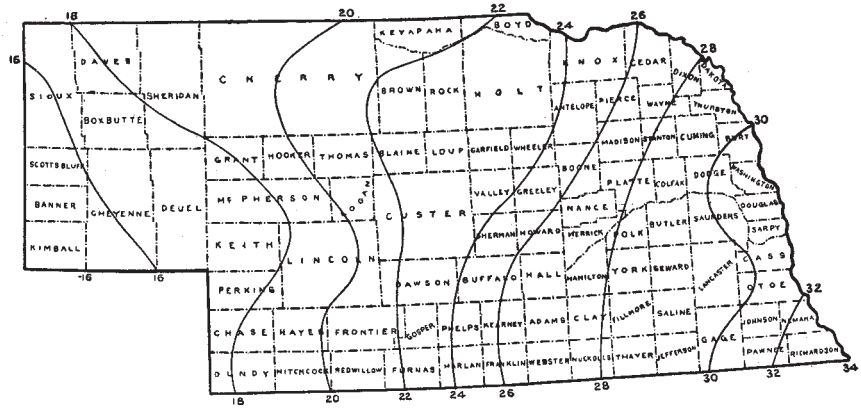

FIG. 2.—Diagram showing decrease in annual precipitation from east to west across the State.

able crop, and small grains are profitable when average yields are considered. Alfalfa is confined to the subirrigated stream valleys. Millets and sorghums are widely grown for forage and the yields are fair. Trees are of few species, and while they will grow on the upland, it is more difficult to keep them alive in the early stages of growth. Apple and other fruit trees are not profitable, except in favored localities. The soils in this section are not leached as in the eastern section, and are richer in the soluble salts, but there are no dangerous accumulations of alkali as in the arid regions.

The third division includes that portion of the State that has less than 18 inches of rainfall. In this section early settlement failed and the country was at one time almost depopulated. Settlement has again taken place to the extreme western edge of the State, but farming may be regarded as precarious, as the average crop is barely profitable. Farming is successful with the class of farmers who make use of the best methods of conserving moisture. In this section of the State the crops on unirrigated land are principally small

grains and the sorghums, and on the sandy land corn is grown. The native timber grows near the streams, and on the uplands it is very difficult to grow any except the most hardy and drought-resistant species. The soils in this section present marked differences from those of the eastern part of the State. They are not weathered so deeply, and in most places there is a lack of the black organic matter. The soluble salts have not been leached out as in soils of the more humid belt, and in valleys and depressions of restricted drainage excessive accumulations of alkali have resulted. The land that has been brought under irrigation in the Platte Valley and along other streams has these characteristics to a marked degree, the soil being so deficient in humus that for several years crops show the need of this material, and the alkali salts being present in such quantities as to constitute a menace to farming in the future. In the sandy soils of the upland alkali is removed so readily where the drainage is good that it is not a source of danger.

EVAPORATION.

Evaporation is as important as precipitation in determining the amount of moisture that can be retained in the soil for the use of plants, and it also determines the amount of water that must pass through the plant in order to support a proper growth. The amount of water that must pass through a plant in this region is far in excess of that required in humid regions and countries of less wind action. For this reason the rainfall is not as effective as in the country farther north, but much more so than in the regions to the south. In Montana and North Dakota 16 inches of rain is equal in its effect on plant growth to 20 inches in Nebraska and 23 in western Texas. How great this excessive evaporation is may be seen when it is noted that at Williston, N. Dak., the evaporation from an open tank during six months of the year was 30 inches, while at Hays, Kans., it was 45 inches and at Garden City nearly 60 inches. Though the rate of evaporation from various soils may differ, the average loss from the wet soil is approximately that from the surface of an exposed tank. The loss decreases as the soil becomes drier.[1]

It will be seen how difficult is the retention of 20 inches of rainfall in a region where excessive evaporation is favored by the low relative humidity, the almost continuous sunshine, and the prevalence of strong and often hot winds.

In addition to the loss from the soil, excessive transpiration from the plant itself requires a supply of moisture far greater than is required in the more humid regions, where the relative humidity of

[1] Dry Farming in Relation to Rainfall and Evaporation. Bul. 188, Bureau of Plant Industry, U. S. Dept. of Agriculture.

the atmosphere is greater and the wind velocity is less. How great this transpiration is has not been determined for this section, but it probably corresponds to the rate of evaporation from an open water surface.

WINDS.

Winds of high velocity and frequency during a greater part of the year characterize the climate of the Great Plains. The winds are of value to the farmer in pumping water and running small farm machinery, and the value of the pastures of the region for winter grazing are due in large part to the work of the wind in curing the grasses into hay on the ground, but these services are far overbalanced by the injurious effect in accelerating the rate of evaporation from the soil and from the plants themselves.

The conservation of moisture in the soil would be a difficult problem on the Plains if the atmosphere were still, but here the difficulty is increased by the wind movement. Not only do the hot, dry winds so prevalent during the summer months accelerate the removal of moisture by evaporation, but they prevent the employment of the dust mulch so desirable in any system of dry farming. They are therefore a source of danger from the time the land is broken for planting until the crop is matured.

CHANGE OF CLIMATE.

In many portions of the semiarid plains the belief is held that a permanent change has taken place in the climate, resulting in an increase in the rainfall, but this fallacy is not held to any extent in Nebraska, though before the two dry years which the country has just experienced the belief was quite general. In most places the increase in rainfall was ascribed to the effect of breaking up vast areas of the prairie land. It is not necessary to discuss this fallacy here, except to call attention to its utter lack of foundation in theory or in the weather history of the region. The official records, as well as the experience of the farmers, dispose of any such contention and demonstrate clearly that no perceptible change of climate has taken place within human experience, and that any recent changes in either direction should be considered as mere temporary oscillations. Nearly all farmers recognize the deficiencies of the climate and hold no unwarranted theories as to the future betterment of natural conditions.

AGRICULTURE.

EARLY HISTORY.

Nebraska early became one of the best-known States of the Great Plains, as lines of communication toward the region of hostilities during the Indian wars were established across the State, and later

the Union Pacific Railroad was constructed. This railroad was the first to penetrate the Great Plains, and the towns of Grand Island, Kearney, and Sidney became the trading posts for a vast outlying territory. Sidney was for many years the western terminus of the railroad and the point of supply for the mining population of the Black Hills, and later for the extensive cattle country on all sides.

The first settlers to make use of the agricultural resources of Nebraska were the cattlemen. This portion of the State was very favorable to the industry, as there was a great variety of nutritious grasses, and the country was as a whole better watered than any other part of the Great Plains. Winter losses, though heavy at times, were probably less than in other parts of the plains, and this is especially true of the great sand-hill district, where grazing could not be depended upon to furnish sufficient food for the cattle, so that hay was cut in the meadows to carry stock through the hard winters. This was expensive, but in the end proved more profitable for the average rancher, and it is to this extra care that the success of stock raising in the Sand Hills is due.

Ranching was soon replaced by farming in all the eastern part of the State, where conditions were favorable. In 1854 less than 1 square mile of land was under cultivation in the entire Territory,[1] but from that time there was a steady influx of farmers. Settlement began in the extreme eastern portion, extended westward along the lines of travel, and later spread out from the railroads.

For more than 40 years the settlement of farmers in Nebraska has been one of advancement and recession. Periods of a few years of good crops have resulted in rapid settlement, while the subsequent periods of drought have caused abandonment and retreat, with little regard for the real agricultural possibilities of the country. Each wave of settlement, however, has left behind a small proportion of permanent settlers scattered over the region.

The first farmers engaged in supplying provisions and horse feed for the Army, and for this purpose raised wheat, corn, and oats, and as soon as the supply of buffalo meat became scarce they began to furnish the soldiers and adventurers of the region with beef. By 1880 there had drifted into the region a sparse population even to the western part of the State, and the eastern part of this area was well settled. A few years of good crops occurred after this, followed by the exceptionally large crop of 1891, and immigration was so stimulated that within a short time the western part of the State had a population that was later partly lost and has not been regained until within recent years, and some of the counties have never recovered their former population. After these fortunate years followed some of the worst droughts the region has ever experienced, culminating

[1] Report Sec. Nebr. State Board of Agr., 1905.

in the extremely dry years of 1893 and 1894. Total failures of all crops resulted and the new settlers were so impoverished that they left the country in large numbers, and the western part of the State was for a time almost depopulated.

These droughts, although severe, would not have checked the development of western Nebraska so seriously if there had not been contributing causes. The new settlers themselves were not fitted by experience to overcome the difficulties of a semiarid country, nor were they supplied with the means with which to maintain themselves during the first years of failure. They had no knowledge of the crops best adapted to the semiarid belt, and the seed planted had been bred in the humid regions and was not adapted to the climate of the Plains. The so-called drought-resistant crops and varieties now in common use were then unknown. The elementary principles of moisture conservation by proper cultivation, now understood and practiced to some extent by the farmers, had not been emphasized, and under the system of cultivation then practiced periods of dry weather did more damage than much longer droughts would do at the present time.

Added to the local difficulties that beset the farmers of the newly settled region was the general financial depression then prevailing over the entire country and the consequent low prices of all agricultural products. This combination of misfortunes caused an abandonment of the farms over a large part of the State and the greater part of the land was again left to the cattlemen or to those who made a living by combined farming and stock raising.

The depression was naturally most severe in the extreme western portion of the State, decreasing in its effects toward the east. In the eastern half of the State, though there was some loss of population, the country was soon resettled. In the western counties it has required many years to bring the farming population to its former figure.

Beginning about the year 1898 and continuing until within the last two years, there was a period of well-distributed rainfall over the greater part of the plains section, and the advance of population was resumed. The present settlement promises to be more permanent than the first. The farmers are now much more conservative in their expectations of the country than were the early pioneers, and they are also bringing with them knowledge of scientific agriculture applicable to the plains. With drought-resistant crops and capital to withstand several failures, if necessary, they stand a much better chance to succeed. The farmers who will experience the most severe hardships will be those who have taken up the public land of low agricultural value, where a living can not be made from cultivated crops. In recent years much land has been homesteaded under

the provisions of the Kinkaid Act, by which the settler could take 640 acres. This has tempted many people with no knowledge of land or of climatic conditions to take land in rough sections or in the Sand Hills that is practically worthless except for pasture. Those who have settled on the loose, drifting Sand Hills with the intention of farming will be compelled to leave and sell their land to the cattlemen at any price they can get. This does not apply to those who were so fortunate as to secure some of the loamy valley land or some of the wet meadows, which, in connection with the grazing land, will enable them to raise cattle on a small scale for beef or dairying.

In the eastern part of the area agricultural methods have been worked out and few problems confront the farmer, but in the western part an adjustment of farm methods to meet the climatic and economic conditions is taking place. Until within the last few years the comparatively level land had been taken by farmers, and the rough land was used by the cattlemen, but the change in the public-land law allowing 640 acres to be taken as a homestead has brought into the country a class of settlers who have not adapted themselves to conditions. It has been very difficult for most of them to make a profitable use of their 640-acre tracts. They have in most places attempted to grow wheat, corn, and potatoes for the market regardless of the distance these products must be hauled or the unsuitable local conditions. The public land has for a long time been well picked, and the homesteads now being taken are hardly productive enough to support a family even in 640-acre tracts. These farms are located either in the Sand Hills or in the rough, hilly country. There is usually a small proportion of land that may be farmed, and the remainder is suitable only for pasture. A sufficient number of cattle to support a family can not be grazed on a 640-acre tract unless there is a good hay meadow or enough farming land to furnish winter feed and supplement the grazing. The best system of farm management for these settlers is one of combined farming and stock raising, or, better, dairying, where the latter industry is practicable. Conditions in the sand-hill section have forced the adoption of this system, and it might well be extended to the areas of heavy land in the western part of the State. In the Sand Hills as many dual-purpose cows are kept as the land will support, and the products sold are butter and cream. Most farmers keep a small herd of horses, as they are quite profitable and do not require much feed during the winter. A large flock of poultry should always be kept, as the climate is very favorable to poultry raising and the industry is not affected by dry weather. The principal work of the farmer in this section is to procure feed for his stock. The native mowing lands are the best source of hay, and where they have a good growth of grass they should never be broken up for farming unless alfalfa can be grown. The mowings may be improved by the introduction of better grasses,

timothy being the most valuable for this purpose. Wherever alfalfa can be grown in the better water flats or stream valleys persistent efforts should be made to get it started.

On the Plains the nearly level land that has become too high priced to use for stock raising may be devoted to cultivated crops, though it might in the end be more profitable to practice stock farming. Here the best practice for the new settler is to grow as great a diversity of crops as is practicable under his conditions and to keep cows, horses, and chickens in sufficient number at least to supply home needs.

PRINCIPAL AGRICULTURAL PRODUCTS.

Among the great variety of crops grown in western Nebraska the most important are corn, wheat, hay, oats, barley, rye, emmer, sorghum, potatoes, and sugar beets.

CORN.

Corn is the principal crop of Nebraska and it holds first place over the area covered by this survey, except in the extreme western counties. The distribution of corn is determined by variations in soil, climate, and topography. The climatic conditions in the western part of the State are not favorable to the production of the same varieties of corn that thrive best in the eastern part, but the sandy lands are better adapted to corn than to the small grains, so that it is the dominant crop in the counties where sandy soils prevail, as in Chase, Perkins, and Dundy. On the heavy loess soils in the southeastern part of the area the acreage of corn is said to be decreasing proportionately, on account of the greater profit now derived from winter wheat. The usefulness of corn in connection with alfalfa in any system of stock farming, dairying, or feeding causes its cultivation on valley lands, where other crops might be grown with more profit. It is also grown in some of the western counties on account of its convenience as feed on ranches, though the average yields are low and the crop would be unprofitable if grown for market.

The suitableness of varieties is determined by the altitude, the amount of rainfall, and the length of the growing season. An early maturing corn is a necessity in the western part of the State, where the growing season is limited to about four months and the high altitude is not favorable to some of the varieties grown in the eastern part of the State. In the extreme western and northwestern counties, where the early maturing varieties are required, Pride of the North, Minnesota Pride, White Cap, Squaw, and Flint are usually planted. In the central and eastern counties Reids Yellow Dent is the variety in most common use, but Hogues Yellow Dent, Golden Beauty, Boone County White, and Nebraska White Prize are also grown to some extent.

WHEAT.

Wheat stands second among the crops of Nebraska in acreage and value and the State is fourth among the States of the Union in wheat production. It is a favorite money crop wherever an extensive system of farming prevails, for the reason that one man can handle so large an acreage and some return can be secured with the minimum amount of labor. In the area of this survey it is likely that the acreage in wheat will increase rather than diminish as new settlers come and the soils of heavier texture, which are better suited to this crop than to corn, are gradually brought under cultivation.

The areas devoted to wheat are more limited by the character of the soil than any other factor. Heavy wheat production is confined to the hard loessial soils of the southeastern part of the State and to the heavier silt soils of the western part. The intervening region, including the sand-hills section and many areas of sandy soils, has a very small acreage in this crop. This is due to the fact that the sandy soils are easier to handle when in cultivated crops like corn and the returns are relatively larger. One important consideration in growing wheat on the sandy soils is the danger of drifting. The entire surface of the fields is liable to be carried away by the hard winds in the autumn and spring. Corn is more profitable on the sandy land than on the heavy silt loams, because it is easier to maintain the loose mulch on the surface.

The area is about equally divided between the belts of winter and spring wheat. The winter wheat prevails over the southeastern part of the area, while spring wheats still maintain their hold over the northern and western parts of the State. The early settlers tried winter wheats, but the varieties then in use were not sufficiently hardy to withstand the winters in this section, and spring wheats were for many years grown exclusively. The Turkey Red wheat was introduced into this country from Russia about 25 years ago, but it was some time before it was widely distributed and its ability to withstand the winters, and thereby replace the spring wheats, was demonstrated. The larger yields of this variety, amounting in most places to a 50 to 100 per cent increase over the spring wheats, has caused it to displace spring wheat almost entirely over the southeastern part of the area, and there seems to be no reason why it should not drive the latter variety out of the State entirely. That it has not done so on the sandy soils is due to the fact that the farmers have not been compelled to grow the winter varieties, as the spring crop has suffered less on this land. The United States Department of Agriculture has brought several hundred varieties from Russia, Siberia, and other countries, and they have been tested by the various State experiment stations, but so far the only variety

that could replace the Turkey Red is another Russian wheat, the Kharkof, which seems to have a slight superiority over it.

The conditions that favor the Turkey Red are a deep, mellow soil, with firm subsoil, a fair amount of rainfall, and a level topography.

Two varieties of spring wheat are grown, the Northern and the macaroni. In the northwestern part of the State both are grown, but in the sandy soils of the southwestern portion the macaroni predominates. The latter, one of the so-called drought resisting types, is suited to the semiarid conditions, and does not thrive outside the region of deficient rainfall. This wheat has its place in the agriculture of the region, which it has held for many years in spite of the fact that it is discriminated against by the millers at the rate of 5 to 10 cents a bushel. Wheat can not be said to be drought resistant in the sense that the sorghums are by remaining dormant in periods of dry weather and resuming their growth when conditions are more favorable, but certain varieties, including the macaroni, seem to be in some way more hardy than the others, and make larger average yields in semiarid climates. It has been the experience of the farmers that in good seasons the common varieties are more profitable than the macaroni, but the latter will sometimes make a fair crop in very dry years when the others are a total failure.

The average yields of wheat in Nebraska decrease from the eastern part of the State to the western in almost direct proportion to the decrease of the average rainfall. In this area the average yields range from 9 to 14 bushels.

Oats.

Nebraska holds fourth place among the oat-producing States of the Union, but in the part of the State covered by this survey the crop is of minor importance. It is only in the southeastern part that oats are regularly grown, and here only for farm use and not as a market crop. The average farmer does not consider oats a profitable crop, but they are needed for horse feed and they fit in well with any plan of crop rotation. The crop is not as profitable on the sandy land as corn, and it does not withstand drought as well as the other small grains. On the irrigated lands oats do well and make a useful step in the crop rotation for these lands. On the Scotts Bluff irrigation projects they are grown to some extent for shipment.

Sorghum.

Nebraska seems to be north of the line of profitable production of kafir and milo, both of which are important crops in Kansas and the States to the south, but sorghum is extensively grown in nearly all parts of the area. This crop is truly drought resisting, as it belongs to that class of plants that remain dormant in dry seasons and

resume their growth when moisture is again supplied. In the western part of the State, where the rainfall is more likely to be scanty, the crop is planted in rows and cultivated like corn, but in the east it is sown thickly broadcast or drilled thickly in rows.

The principal objections to sorghum are that it has the reputation of exhausting the land and decreasing its productiveness for all kinds of crops and that it takes the water from the soil so completely that succeeding crops can not get started, and that for this reason it can not be used in a rotation. Its value as a stock feed where other forage can not be grown to advantage makes it a popular crop, and the acreage is probably increasing.

Barley.

Barley was once a more important crop than at the present time. It is now grown extensively only in Red Willow, Hitchcock, and the eastern half of Dundy Counties. In the other parts of the area, where the rainfall is deficient, barley seems to be more hardy than oats, and it is frequently used as a substitute for that crop and cut for hay.

Rye.

Rye is grown on a small scale in nearly all parts of the area. It is usually sown in the fall or early spring to furnish green feed when nothing else is available. To a much less extent it is a grain crop. It produces better on the sandy soils than the other small grains and on these soils it is more needed as a forage crop, so that outside of Hitchcock, which is the leading county in the production of rye, the crop is nearly confined to the sands and sandy loams.

Alfalfa.

Of all forage crops alfalfa is by far the most valuable wherever it can be grown to advantage. In nearly all parts of the area it is confined to the stream valleys, where the land is irrigated or the water table near enough to the surface to be reached by the roots. Extensive areas in the valley of the Platte, Loup, and other streams in the eastern part of the area are adapted to the growth of alfalfa without irrigation. As the valleys become narrower and water scarcer toward the west the acreage of alfalfa decreases and the crop becomes more confined to the irrigated districts. The larger proportion of the alfalfa crop is grown in the eastern part of the area, which is also well adapted to corn, and the two make a useful combination for general farming, dairying, and stock feeding. The yield of hay cut in the eastern counties is about 4 tons to the acre, but toward the west the average is about 2 tons, except in the best irrigated land, on which the average is about 3 tons to the acre.

Alfalfa is not grown on all the land where it might produce well, as many farmers consider it less profitable than some of the other crops. It is doubtful, however, if it is not better in the long run for a farmer to have at least a part of his farm in alfalfa, even if other crops in good years seem to be more profitable.

AGRICULTURAL METHODS.

The principal question involved in tillage on the Great Plains is that of the conservation of moisture in the soil. While much attention is being given to the selection of varieties suited to the semiarid belt, it is doubtful if any crop will succeed in extremely dry years. Some varieties are more hardy and drought resisting, but no plant will grow if the moisture in the soil is reduced below a certain point. It is on thorough cultivation, therefore, that the farmer of western Nebraska must rely for success. In seasons of more than the usual rainfall crops will yield well with only ordinary care, while in very dry years the best methods are unavailing. This fact has seemed to discourage some farmers from employing the best methods, as they reason that the careless preparation of the land being cheaper, a greater acreage may be cultivated and the profits will be greater in the long run. All careful experiments, however, have demonstrated that the better preparation of the land is profitable. The problem in this section is not to be decided by the results obtained in good or in bad years, but success must be attained by bringing up the average crop to exceed the average cost. This can only be done by a reasonable amount of care in the preparation of the land to conserve the soil moisture.

There is no hard and fast method of so-called dry farming that may be applied in all seasons and on every kind of land, but there are general principles of moisture conservation that may serve as a guide. The farmer himself must constantly study the conditions that confront him and familiarize himself with the peculiarities of his soil. In no section of the country is a study of the soil of more importance.

There are many variations in the so-called dry-farming methods, but in all of them the essential features are thorough preparation of the land and the maintenance, as far as conditions permit, of the dust mulch on the surface. On sandy lands deep plowing is not necessary, as the soil is naturally porous. Sometimes it needs to be compacted rather than loosened, especially for small grains. These soils often drift badly and it is well to leave the surface rough and to run the rows east and west, at right angles to the course of the prevailing winds. If weeds are kept down there is usually sufficient shifting of the surface material to form a mulch, so that cultivation is not so necessary

as on the heavier soils. In case of the latter soils, deep plowing, loosening the subsoil, thus enabling the rainfall to enter, is very essential. A rather rough surface is advantageous here also to prevent the water from running off during heavy rains. A crust usually forms on these heavy soils and cultivation after rains to maintain a mulch is necessary. The soil, however, should not be pulverized too fine or drifting will ensue and rains will puddle the surface and cause a larger percentage of the water to drain off.

It is claimed by practically all the farmers that the sandy lands withstand dry weather better than the heavier soils, which seems very peculiar to one accustomed to humid conditions. There are several reasons why this is true. The sandy soils are much more porous and a much larger percentage of the rainfall therefore enters the soil than is the case in the silt loams and other heavier soils. This emphasizes the importance of loosening the heavier soils so that the rainfall can easily penetrate them. The heavier soils also require a larger amount of rainfall than sandy soils to wet them to the same depth, while the crop can not take out as large a percentage of the moisture from soils of fine texture as from those of coarse texture. These and other reasons make crops more certain on the sandy soils.

It is well to emphasize the fact that in nearly all parts of this area the seed bed should not be made too mellow and loose, for two reasons: (1) Because there should be a firm stratum of earth below the seed to maintain capillarity with the moisture below, and (2) because if the soil is brought into too loose condition it is liable to be blown away by the spring winds.

BEET-SUGAR INDUSTRY.

The beet-sugar industry was established in this area in 1890, when the first factory was erected at Grand Island. This factory is still in operation and draws its supply of beets principally from the valley of the Platte as far west as the town of North Platte. Recently a factory has been built at Scotts Bluff which will take the product of 10,000 acres of land in the irrigation project.

The sugar companies have experienced the usual difficulty in procuring a sufficient supply of beets and in keeping up the quality. A portion of the land devoted to the crop is now controlled by the companies and the tenants usually pay one-fifth of the beets as rent. If other crops are grown on the land the rental is usually one-half of the alfalfa and small grains. When land owners grow beets contracts are made in advance and the farmer must comply with the instructions of the manufacturers. The company furnishes seed at a reasonable price and tries to provide labor for the farmer in the busy season. They also send out an expert who has supervision of the farmers' methods. As abundant water will produce a large tonnage

of beets with low sugar content, the company objects to frequent irrigation, and if the rainfall is sufficient to make a moderate tonnage it is not considered advisable to irrigate. The yield of beets ranges from 5 to 20 tons to the acre, with an average of less than 10 tons, with a sugar content of 13 to 16 per cent. Beets are sold to the factory at a fixed price, regardless of quality. The price ranges in different seasons from $4.25 to $5 a ton.

TENURE AND SIZE OF FARMS.

With the exception of tracts of Rough broken land and Sand Hills, the public land was homesteaded and patented many years ago. In the eastern part of this area a large proportion of the land has remained in the ownership of the original settlers, but in the western part many changes have taken place in land titles. In periods of drought the original quarter sections of the early homesteaders were consolidated into the large holding of cattlemen and loan companies. During subsequent good crop years settlers again came in and the land was split up into smaller farms. In most localities in the western part of the State several of these fluctuations in the size of land holdings have taken place. The occupation of the public land was extended until all tracts of 160 acres on which a living could be made had been taken up. There was left a vast area of Rough broken land and Sand Hills, used by the ranchers as public pasture. Since the passage of the Kinkaid Act, which permitted the acquisition of 640 acres of this land, much of it has been settled. Nearly all of the Rough broken land has been occupied and the most desirable tracts in the sand-hill section. There still remain large areas of drifting sand dunes which can not be utilized in 640-acre tracts, and it will be a long time before they pass into private ownership.

The tendency at the present time in all parts of the State is toward a decrease in the size of farms. In the sand-hill region some of the new settlers, who have taken up nearly worthless tracts, will be obliged to sell, after they obtain title, to the cattlemen, but on the other hand the large ranches of mixed hay and grazing land are being broken up as land becomes more valuable. The small stockman and dairyman can afford to offer a price for land higher than that at which cattlemen can afford to use it in large holdings, so that the tendency is toward a reduction into small stock farms.

In the extreme western part of the State the resident farmers usually hold large tracts, and the remainder of the smooth land is held by nonresident loan companies and speculators, and the rough portions are included in ranches.

The average acreage in all parts of the State is sufficient to support the resident population in comfort. The average acreage per capita

for the actual residents ranges from 17 to 50 acres in the southeastern part of the area to 300 to 500 in the most thinly settled counties of the sand-hill region.

The greater part of the farming land now in cultivation is farmed by the owner. In Grand Island, Hastings, Kearney, and a few other towns there are a small number of retired farmers who have rented their land in the surrounding country to tenants.

LABOR.

There is usually a scarcity of labor during the busy seasons of the summer over the whole of this area. The farmers of the eastern section, who do general farming and dairying, have need of labor at all times, and many keep men hired by the month; others keep no regular help, but do their own work and hire extra labor in the busiest seasons. In the central and western counties grain harvesting and haying come at the same time and more hands are usually needed than are available. Daily wages of $2 to $2.50, with board, are aften paid for harvesting, thrashing, and haying. The ranchers in the remote Sand Hills district were formerly short of help during the haying season, but for several years the homesteaders in that region have worked for the ranchers during the summer and relieved the scarcity to some extent.

The farm and ranch labor is usually of fair efficiency. The workers are mostly from the farms where work is not pressing, or from the towns in which many men are familiar with farm work. In the sugar-beet districts labor is sometimes very scarce, and Mexicans and other foreigners are brought in to do the work of growing and harvesting the beets.

RANCHING.

Ranching was once the principal occupation of the inhabitants of the western part of the State, and, though the industry in the more level sections has given way to farming, it is still of considerable importance over the extensive areas not suited for cultivation. Cattle and horses are now raised in a combined system of farming and stock raising over a large percentage of the western part of the State, where strips of farming land are interspersed over tracts of rough land. Over the greater part of the sand-hill region ranching is done exclusively, as the tillable land and the meadows are barely sufficient to supply feed for the cattle that range the hills and can best be used for that purpose (see Pl. I, fig. 2). At an early date it was appreciated by the cattlemen that control of the wet meadows that dot the Sand Hills and produce their never-failing supply of hay was the means of controlling the surrounding valuable dry range of the Sand Hills. The rigorous winters of the locality necessitate the

winter feeding of range stock to insure success in the ranching business. The most desirable of the scattering wet meadows, limited in extent and so striking in their grass growth as contrasted with the prevalent dunesand, were immediately occupied and held under the old homestead law. In this manner title to hay meadows gradually passed to individuals. Divided ownership of single meadows or groups of meadows soon afterwards gave way to large holdings wherein individuals or companies gained control of vast areas of dunesand range through ownership of the intervening meadows. Very little endeavor was made to gain title to the range proper, since ownership of the winter feed supply prohibited all except a hazardous competition. The public land was fenced by common consent into blocks in proportion to the hay yielding ability of the inclosed meadows. In some cases large and small outfits ranged cattle together in numbers beyond their ability to provide winter feed and trusted to the precarious chance of open winters. Under these conditions heavy losses were frequent.

The size of herds in the Sand Hills varied from a few hundred head of cattle to many thousand. One firm is said to have had over 40,000 head at one time, but this was exceptional, the usual herd ranging in size from 1,000 to 3,000 head.

After settlers were allowed to take homesteads of 640 acres all unclaimed meadow and much of the better range land was promptly taken. For a time the ranches were demoralized and many were forced to reduce their herds. In many places, however, the newly acquired land has been bought by the ranchers or the settler has himself gone into the cattle business in a small way, so that most of this region is now or soon will be primarily interested in stock raising.

On the heavy soils of the plains of the western part of the State and on the Rough broken land winter grazing is afforded by the buffalo, grama, and other grasses, but it is the practice of the better class of ranchers to feed some of their cattle nearly every winter and to be prepared to carry them through any winter however severe. A ranch in this section usually consists of several sections of rough land fit only for grazing and some fairly level tracts, usually meadow or alluvial land along some creek on which feed can be grown. By this system a much larger number of cattle can be supported than where grazing is depended upon to carry cattle through the winter. Horses can be carried with less regard to winter feed, as it is rarely that they need to be fed. On nearly every ranch some horses and mules are raised, if not for the market, to supply the needed work animals. A few ranchers in the Sand Hills and several in the southern part of the State range horses exclusively.

The range cattle are usually Herefords of fair grade. Of late years the Angers cattle have been introduced, and it is likely that as

conditions become better and more like those of the farm that breed will come more into favor.

The old method of extensive grazing is not practiced to any extent at the present time, as most of the land has come under private ownership, but the use of fenced ranges in a system of ranching on a moderate scale or of combined ranching and farming will continue for a long time.

IRRIGATION.

Irrigation plays a minor part in the agriculture of Nebraska, when the total acreage in crops is considered. The water supply is insufficient to irrigate more than a very small proportion of the arable land. Irrigation is important, however, in that it gives limited areas where production is sure, thereby providing an element of stability to the agriculture of the region and adding to the list of crops that may be grown.

There are a number of small streams in different parts of the area that have been diverted to irrigate small tracts of land. Republican, Elkhorn, and Niobrara Rivers and Hat and Lodgepole Creeks are the minor streams most utilized for this purpose. The chief source of irrigation water is North Platte River, which supplies the several irrigation projects extending from the Wyoming-Nebraska line to some distance below the town of North Platte. The United States Reclamation Service contemplates the irrigation of an area of more than 107,000 acres in the State of Nebraska, the greater part of which lies in the vicinity of Scotts Bluff. In order to supplement the normal flow of North Platte River, the Pathfinder Dam was constructed in Wyoming, by means of which the supply of water in rainy seasons can be conserved and distributed later as needed in the irrigated districts. Some of the older projects near Scottsbluff have been in successful operation for many years, while others have not given satisfaction. For the last few years the irrigated districts have made rapid advancement and are fast becoming prosperous agricultural communities. It is not improbable that the valley near Scotts Bluff will become the most thickly settled farming district in the State.

ALKALI.

In all arid and partly arid regions soluble salts are released from disintegrating rocks faster than they can be removed through leaching with a scanty rainfall, and there is danger in localities where conditions are favorable that alkali may be concentrated in quantities dangerous to plant growth. In western Nebraska this takes place only where drainage is restricted and there is a rapid concentration of the salts as a residue from the evaporation of salt-laden waters,

or on irrigated tracts where the seepage from higher lands accelerates the accumulation. The process of alkali concentration is simple. When water passes through a material containing alkali it takes a portion of the soluble material into solution, and when this water is brought to the surface by seepage or by capillarity and evaporated the salts are left behind. The most notable alkali areas in Nebraska are along North Platte River and comprise the low flats near the river, which have received seepage waters from the higher irrigated lands. Many square miles are now marshy from seepage and are fast becoming impregnated with alkali. This condition will follow in many other low areas when irrigation is extended along the higher levels.

The only practicable remedy is adequate drainage so planned as to cut off the seepage water from the hills and to provide an outlet downward through the soil for the alkali water.

SOILS.

GENERAL DISCUSSION.

Soil may in a general way be defined as the loosely consolidated upper layer of the earth's surface, which may serve as a medium for the growth of plants. It has a complex composition, the solid portion consisting of particles of mineral matter derived by weathering from rocks mixed with organic substances made up of partially decayed plant and animal remains. This report deals more particularly with the physical properties of the soil and its crop-producing power, and the chemical composition is not minutely considered except where these physical properties are directly affected, as the color of the soil by the form of the organic matter or its productiveness by the presence of alkali.

The mineral portion of the soil having been derived from the rock formations by processes of weathering, its character will vary according to differences in the original material and the nature of the processes of decomposition. It is therefore essential in a study of the soils of Nebraska to know the character of the original formations and by a study of the geologic history of the region to understand the processes by which they have been brought to their present positions in the form of cultivable soils.

RELATIONS OF SOILS TO GEOLOGICAL FORMATIONS.

As a rule, a soil map and a geologic map do not coincide, since formations of the same age may give different soils, while those of different ages may weather into similar soils. In Nebraska, however, there are fewer discrepancies between the soil map and the geologic map than are usually found, as the soils from the older formations

follow closely the areal geology, and a large part of the State is covered by the recent aeolian and alluvial deposits.

The older Cretaceous formations are not extensively exposed in western Nebraska. The Carlisle formation outcrops in the valley of the Republican River, but the exposures are so narrow that no true soil is derived from them. The Niobrara is more extensively exposed on the upland in Webster, Franklin, and Harlan Counties south of the Republican River, and the soils of the Summit series are derived from this formation.

The Pierre shale is the only Cretaceous formation that produces a characteristic series of tillable soils. It outcrops in the extreme northwestern part of the State, where the Black Hills uplift has been planed away by erosion and the other newer formations removed, exposing the Pierre shale. The formation also outcrops in the northeastern part of the area, where it comes near the surface and is reached by the valleys of the Niobrara and other streams. In the southern part of the area it is exposed in very narrow areas along the Republican River, but no considerable bodies of soil are produced. The formation consists of dark to slate colored shales of rather uniform character, which have weathered into a group of clay and clay loam soils, called in this report the Pierre series.

The formation overlying the Pierre shale and outcropping in a narrow band around it is the Chadron formation. This material when unweathered is usually a sandy silty clay of light greenish-gray color. Some of the beds are of a strong dark-red color, particularly in the vicinity of Adelia. The only soils distinctive of this formation is the group mapped as Orella clay loams and silty clay loams, which occurs in a small area near Adelia, and is derived from the highly colored beds mentioned above. The more sandy parts of this formation enter into the composition of the soils of the Dawes series.

The Brule, the next highest formation, constitutes one of the most important soil-forming materials in the western part of the State. It outcrops around the southern border of the Black Hills uplift in a band from 3 to 6 miles wide. In the valley of North Platte River, on the western boundary of the State, it forms the surface in a belt more than 40 miles wide, narrowing gradually toward the east. It is also exposed in a strip from 1 to 2 miles wide in the valley of Lodgepole Creek. This material consists usually of a silty clay containing much fine sand. It has a characteristic whitish-pink or pale flesh color, which changes through weathering into soil of a light buff that gradually darkens as organic matter is acquired. The characteristic soil of this formation has been called the Epping silt loam. The wash from the Brule formation enters into the composition of the alluvial soils of North Platte Valley and largely into the soils of the Tripp series on the terraces of the North Platte.

Two formations of Tertiary age, the Arickaree and the Ogallala, furnish the soil material for the most extensive residual soils in this area. Owing to the method of their formation, the Tertiary deposits of the Great Plains usually consist of irregular areas of interbedded marls or lentils of sands and gravels indiscriminately mixed. Any particular horizon, however, may be quite uniform over a considerable portion of its outcrop, and this we find to be the case with the upper strata which form the top of the High Plains plateau. The formations have weathered into vast areas of uniform soil on the comparatively level plain, but on the slopes and eroded land, where a series of beds are exposed, there is a greater range in the texture of the soils.

The older Arickaree formation outcrops south of the Black Hills uplift and covers the High Plains from the western part of the State north of the North Platte, and extends eastward until it is covered by the material forming Sand Hills. It consists in its unweathered state of a series of sands of gray color and soft, sandy, calcareous shales. It weathers into a group of gray soils ranging in texture from a fine sand to heavy silt loam. A characteristic feature of these soils is the finely divided, white, calcareous material that occurs in the subsoil and frequently outcrops in the surface in the more hilly portions. The soils from this formation have been grouped in the Rosebud series.

The Ogallala formation outcrops in the southeastern part of the State and contributes to the composition of vast areas of uniform soil. In its typical development it is a soft limestone or calcareous grit, containing interbedded clay and sand springled through it locally and in many places a basal bed of conglomerate. Streaks and nodules of lime in a matrix of clay make up this material in other places. The pebbles through the mass appear to be fragments of many kinds of crystalline rocks, which have been brought from the Rocky Mountains. The name "Mortar Beds," or Tertiary grit, has been applied to this formation in other places where it outcrops. In this area it weathers into a series of silty loams and sandy loams, usually containing a greater or less quantity of gravel and underlain by a characteristic silty, calcareous subsoil, with a varying percentage of gravel. The typical soils have been grouped into what is known as the Sidney series. It is probable that the formation also furnished the sand for many of the areas of sandy loams and the dunesands of the southern part of the State.

The greater part of Nebraska is covered by unconsolidated materials transported principally by the wind. The part of the State included in this survey is so nearly covered by wind-blown sands and silts that only a rim on the western and northern border is left exposed, and even there accumulations of sand often many square miles

in extent have been heaped up by the wind. The total of such deposits make up probably one-fourth of this comparatively narrow strip.

The great loess sheet, that constitutes the surface of a large area in the eastern part of Nebraska and the adjoining States to the south and east, extends into the southeastern part of this area and covers nearly one-third of the total surface. The typical loess is a light buff-colored, fine-grained material, composed principally of silt and clay, loosely cemented by carbonate of lime and stained by a small proportion of iron oxide. It has a coherent nature where undisturbed, but grinds up readily into a loose, floury, silty dust. There is a tendency to erode in steep, vertical bluffs where exposed to running water, but in Nebraska this form of erosion is seen only along some of the stream valleys in the very hilly regions and there are no large tracts excessively eroded and gullied, as in some of the loess-covered areas of the Mississippi Valley. The changes that take place in the exposed surface of the loess seem to be along the line of a decomposition of the finer material into clay and an accumulation of organic matter in the surface soil. The finer material tends to accumulate in a zone from 6 to 10 inches below the surface and on some of the more level areas it is so compact as to have the nature of a hardpan.

The origin of the loess has been a matter of much dispute among geologists. Some have held that it was wind blown, others that it was wholly or in part deposited by low-grade streams. It is generally conceded that it was laid down at the close of the Pleistocene after the retreat of the great ice sheet. The theory of its formation most generally accepted is that it represents the finer material assorted from the outwash of the glacier and that both wind and water have been agencies in its distribution, the work of the former having been more effective in the territory covered by this survey.

The only soil derived entirely from this material has been called the Colby silt loam.

Toward the eastern part of the area the loess is underlain by a comparatively thin sheet of sands and gravels, crossbedded and indiscriminately mixed. The material itself and the manner of its distribution indicates that it is a glacial drift and a product of the Kansas stage of the Glacial epoch, when the ice sheet extended to the Kansas River.

In this area the drift is exposed only in deeply eroded country in the northeastern part of the area and in stream valleys in the southeastern part. The O'Neill gravelly loam is the product of the true drift. It occurs in the valleys in both sections where the material is exposed, but the areas are usually only a few square miles in extent. A more important type in the northeastern part of the area

is the O'Neill loam, which represents the drift modified by loess and other materials that have been distributed over the surface.

Northwest of the loess lies the vast sand-hill region of Nebraska. It occupies the north-central part of the State from the Platte River to the South Dakota-Nebraska line and covers about 24,000 square miles. The sand in this region is blown up into a seemingly endless succession of hills and ridges, broken occasionally by valleys of varying size, some of which contain wet grasslands and lakes. Besides this main body of sand, there are local accumulations of lesser extent along the valley of the Platte, along Loup River north of Grand Island, and in Chase, Perkins, and Lincoln Counties, and other parts of the area.

The chief material of the Sand Hills in a fine sand so loose and incoherent that, although it may be temporarily grassed over, it is likely to begin drifting at any time if the surface is disturbed.

The origin of these sands is not determined. On the borders of the loess it is evident that the finer sands are simply an extension of the loessial material, in most cases mixed with the somewhat coarser sands of local derivation. Some of the smaller areas along the streams in the southern part of the State have derived their material from the beds of the streams. The vast deposits of the great sand-hill region and many of the outlying areas could hardly have been derived from the neighboring rivers. It is more probable that they have been built up of sand released by weathering from the more sandy strata of the Tertiary.

Weathering acts very slowly upon these sands. Some of the dunes that have been stationary for a long time have a somewhat loamy texture, which may be due wholly or in part to the decomposition of their feldspathic materials. Besides the loosest, most incoherent sand, which has been described in this report as Dunesand, there have been established in the wind-blown sands a number of sandy and very sandy loam types, grouped into the Richfield series.

The river valleys in Nebraska are wide and deeply covered by beds of recent alluvium. The Platte has a strip of alluvium which attains a width of 18 miles near Grand Island. The Republican, Loup, Elkhorn, and Niobrara Rivers carry alluvial deposits of considerable width, ranging in most places from 1 to 3 miles. The various deposits of these streams will be taken up in detail under the descriptions of the soils which they produce.

SOILS IN RELATION TO CLIMATE.

A consideration of the influence of the climatic conditions peculiar to the Great Plains region is of the utmost importance in a study of the formation and distribution of the soils of western Nebraska. Not

only has this influence been exerted in comparatively recent times, but the structure of the hundreds of feet of ancient sediments of which the Plains are built shows evidence of deposition under conditions somewhat similar to those prevailing at the present time. The mass of sands and gravels brought down from the Rocky Mountains and spread out in fanlike beds undoubtedly represents deposition by rivers of diminishing current that finally became choked by their own sediments, a condition that prevails only in arid or partly arid regions.

Strong winds have probably always characterized the climate of the Great Plains and played an important part in the assorting and distributing of the materials brought down by the streams. The work of the wind in disintegrating the rock formations and in transporting the soil materials in recent geological times and even at the present time is too obvious to call for discussion here. It is the most active agent of soil transportation, and besides the vast areas, comprising more than four-fifths of the area, which are completely covered by wind-blown silts and sands, there is not a type of soil in the State that has not been modified to a marked degree by the addition of wind-blown materials.

The intensity of the agencies of weathering that are everywhere breaking down the rock formations and reducing them to arable soils is dependent especially upon the amount of precipitation. The variation in rainfall in western Nebraska from more than 26 inches to less than 16 inches, as one passes from east to west, is reflected by a corresponding change in the composition of the soils. This is most apparent in those soils derived from the same original material, but weathered under different conditions of humidity. The change from humid to arid conditions is shown by differences in texture, color, and to a marked degree by the different soluble salt contents of the soils. Textural differences are due to the fact that rocks in a semiarid region are broken down to a greater extent by disintegration than by chemical decomposition, so that particles of calcium carbonate and other soluble substances are not removed from the soil, as would be the case in a more humid region. In an arid region decomposition of the rocks has not been as thorough, the zone of weathering is not so deep, and the line between soil and subsoil is not so sharply marked. There are also conditions peculiar to the structure of these soils, especially as regards imperviousness and compactness, that are as yet not fully understood.

One of the most striking differences in the appearance of humid and arid soils is in the color. A dark color generally indicates the presence of the black form of organic matter, and the accumulation of the latter is greatly influenced by the amount of lime in the soils. A large percentage of lime in the presence of a certain amount of

moisture favors the retention of organic matter and its conversion into the humus which gives the prairie soils their dark color and affects so favorably the growth of plants. In this area the soils are as a rule well supplied with lime, but the necessary moisture gradually decreases toward the west, resulting in a lighter color of the surface soils. This change of color is most noticeable in the case of the Colby silt loam, a uniform material originally, which now has a considerable range in color in its extension from east to west through the southern part of the area.

Some of the effects of the accumulation of the soluble salts in a soil under dry climatic conditions are involved in the variation of the properties already described. In an arid region the soluble salts tend to accumulate, as they are not removed as fast as they are released from the rocks by weathering, and the excessive amount is in many places a source of danger to crops. In irrigated districts this danger is greater, as the accumulation of the salts near the surface is favored by the movement of the soil water in dissolving these salts and leaving them on the surface by evaporation. This condition prevails in a few localities along the Platte River and in several other valleys and depressions on the upland, where drainage conditions are unfavorable to a removal of the salts.

CLASSIFICATION.

In the course of this survey a number of soil types were recognized and mapped, their differentiation being based upon differences in their physical properties, the character of the underlying rock, the process of their formation and subsequent modification, and their crop-producing power. For convenience in the study of the relationships that exist between the various types they have been broadly divided into groups based upon differences in the material from which they were derived and the method of their formation: (1) Those derived from sandstones and shales, (2) those derived from unconsolidated calcareous deposits, (3) those derived from unconsolidated water-laid deposits, (4) those of aeolian origin, (5) those of river terraces, (6) those of glacial origin, and (7) those of alluvial origin.

A second grouping of the soils may be made by a closer observation of their characteristics. Where soil types are similar in regard to origin, mode of formation, relation to agriculture, and other general characteristics except texture, they have been grouped into series and given a place name. A complete series would include types of all grades of texture from sands to clays, but usually only a few members are present, and often only one.

The subdivision into types based principally upon differences in texture is of special importance in the semiarid region, since average

productiveness and the adaptability of a soil to any system of dry farming is dependent upon texture, which determines the possibility of keeping a loose mulch on the surface to conserve the moisture.

On the map which accompanies this report the soil types are indicated in colors, and the relationship between them may be seen by reference to the legend. It must be kept in mind that in preliminary work of this kind it was necessary to throw into one type areas that in more detailed work and on a map of larger scale would have been separated into a number of types. Also in many places the boundary lines separating the various types are necessarily arbitrary, as two types or classes of material sometimes merge so gradually that it is impossible in a survey of this kind to make a sharp separation.

The following table shows the classification and area of the different soils mapped in this survey:

Classification and area of the different soils mapped in this survey.

Soil groups and types.	Total area of type.	Proportion of total area.
Soils from sandstones and shales:		
Summit series—	*Acres.*	*Per cent.*
Summit silt loam and silty clay loam	152,064	0.4
Pierre series—		
Pierre loams and clay loams	152,064	.4
Pierre clays	497,664	1.5
Soils from calcareous deposits:		
Rosebud series—		
Rosebud silt loam	1,292,544	3.8
Rosebud fine sandy loam	790,272	2.3
Rosebud loamy fine sand	101,376	.3
Sidney series—		
Sidney silt loam	1,405,440	4.2
Sidney loam	705,024	2.1
Sidney sandy loam	292,608	.9
Sidney gravelly sandy loam	343,296	1.0
Miscellaneous types—		
Rough broken land	797,184	2.4
Benton stony loam	11,520	.1
Soils from unconsolidated water-laid deposits:		
Richfield series—		
Richfield sands and sandy loams	967,680	2.9
Richfield fine sandy loam	794,880	2.3
Valentine series—		
Valentine sand	154,368	.5
Valentine fine sandy loam	725,760	2.1
Valentine loamy sand	177,408	.5
Epping series—		
Epping silt loam	313,344	.9
Miscellaneous types—		
Orella clay loams and silty clay loams	18,432	.1
Dawes fine sandy loams and silt loams	317,952	1.0

Classification and area of the different soils mapped in this survey—Continued.

Soil groups and types.	Total area of type.	Proportion of total area.
Soils from wind-laid deposits:		
Colby series—	*Acres.*	*Per cent.*
Colby silt loam	7,513,344	22.1
Miscellaneous types—		
Dunesand	11,672,064	34.4
Gannett fine sand	725,760	2.1
Canyon loam	78,336	.2
River terrace soils:		
Tripp series—		
Tripp loam	87,552	.3
Tripp very fine sandy loam	304,128	.9
Tripp loamy fine sand	92,944	.2
Tripp silt loam	43,776	.1
Soils from glacial deposits:		
O'Neill series—		
O'Neill loam	138,240	.4
O'Neill gravelly loam	211,968	.6
Alluvial soils:		
Lincoln series—Types undifferentiated	1,287,936	3.8
Laurel series—Types undifferentiated	585,216	1.7
Arkansas series (mainly sandy types)	317,952	.9
Miscellaneous types—		
Alluvial soils—Types undifferentiated	721,152	2.1
Riverwash	115,200	.3
Bassett silty clay	64,512	.2
Total	33,960,960	.....

SOILS FROM SANDSTONES AND SHALES.

Summit Series.

The Summit series comprises a group of silty upland soils derived from Cretaceous rocks. As a rule the original rocks are calcareous shales or fine-grained sandstones, having a white to light-brown color. They first break up into a light-colored silty material resembling the unweathered loess very closely, but when further weathering has taken place they change to dark-gray silt loams and silty clay loams. The close resemblance of these weathered products to the soils derived from the loess makes their separation extremely difficult where they come in contact. In this area the separation was made more difficult by the presence of thin sheets of loess spread over the surface or incorporated into these soils. It was only by the appearance of the soils in deep cuts that they could be identified, and where such exposures are not found an arbitrary boundary line was drawn on the map. In this area one grouping was made of the soils of this series, including silt loams and silty clay loams, but in a more detailed survey the two types might be separated.

SUMMIT SILT LOAM AND SILTY CLAY LOAM.

Description.—The Summit silt loam and silty clay loam resemble the Colby silt loam very closely in all their physical properties, and its separation has been based principally upon origin. The surface soil is a dark-gray to brown silty loam to silty clay loam, containing only the finest grades of sand. The silt content is high and the clay ranges from 10 to 20 per cent. The dark color of the soil depends upon the extent of the weathering to some degree, but more upon the content of black organic matter that has accumulated at the surface. The soil on the more level plains ranges in depth from 8 to 18 inches, with an average depth of about 12 inches. In this State the greater proportion of the type is eroded and the soil is much shallower than on the level land. The subsoil is a heavy, compact silty clay loam or clay, which becomes more friable at 30 inches. The silt content of the subsoil is usually about the same as that of the soil, but the percentage of clay is greater.

This type when in sod is tough and hard to break, but once broken it may be brought into a good state of tilth if worked when moisture conditions are best. When plowed too wet or too dry it is apt to clod and be very hard to handle. In some parts of Kansas, where this type covers a large area, there are tracts that have a hard, compact subsoil or hardpan. Spots of this hardpan are found in this area, but they are not extensive and do not give the farmers much trouble. It seems to be due to a compact structure of the clay rather than to lime or iron cementation.

The close resemblance of this type to the Colby silt loam makes it very difficult to draw a boundary line between them, and the division made must always be regarded as arbitrary. To add to the difficulty of separating the types on account of their similar composition, there are numerous patches and thin layers of loess scattered over the surface of this type. Along the stream slopes, where good sections of the soil can be observed, the loess may be easily traced where it lies over the stratified rocks, but on the divides, where the superficial deposits are deeper and intermixed, it is difficult to separate two silty types that resemble each other so closely. The deep subsoil of the Summit silty clay loam distinguishes it from the loess types, as below 3 feet it is more compact and has a slightly drab color as compared with the lighter-textured floury loess.

The lime content of the type is usually much less than that of the loess soils, but the amount varies in different localities, depending probably upon the concentration in the original rock.

Location.—The Summit silt loam and silty clay loam occur only in the southeastern part of the area, principally in Webster, Franklin, and Harlan Counties, where the sandstones and shales of Cretaceous

age are exposed along the Republican River. The largest area is south of the river, extending from the Kansas-Nebraska line to the alluvial lands. There are also small areas north of the river. The soil is not continuous over the entire surface of the areas mapped, but it is the prevailing type and was mapped as uniform, as it was not practicable to separate the very small areas of other types included.

Topography.—In Nebraska practically all of the type has a rolling topography, becoming very hilly near the stream courses. In the deeply cut valleys strips of the shales have been exposed and ledges and rock-strewn slopes occur near the streams.

Origin.—The type is derived by weathering from Cretaceous rocks, of which the most widely exposed is the Niobrara formation. These rocks consist largely of fine-grained sand shales, which break down under weathering first into a light-colored soil, scarcely to be distinguished from the loess, and later into a heavier soil which accumulates organic matter. On account of the rapid removal of weathered material from the slopes, the soil in this area is largely of silty texture and often contains fragments of the partially weathered rock.

Utilization.—The Summit silt loam and silty clay loam are well adapted to all crops suited to the upland of this section. The area lies well within the region of rainfall sufficient to render farming profitable in normal years. On account of the rolling topography of the type, the land is not so valuable as on the level stretches in Kansas. There are, however, small tracts of valuable farming land. Wheat, corn, and sorghum are the principal crops grown. The average yield of wheat taken for a series of years lies between 13 and 15 bushels per acre, depending upon the character of the land. Corn ordinarily yields from 20 to 25 bushels.

Pierre Series.

In the northwestern part of the State the erosion and removal of the newer rocks on the southern flank of the great Black Hills uplift has exposed strata of dark-gray to slate-colored, heavy clayey shales, which have weathered to form the group of soils included in the Pierre series. These shales also outcrop and produce their characteristic soils along the deeper stream channels in the northeastern part of the area.

The soils of the Pierre series consist of dark-brown to yellowish-brown and sometimes slaty-colored loam and clay loams, underlain by clay loam and clay subsoils. It was impossible in this survey to map all variations in texture, but two type groups were established. one to include the loams and clay loams, the other the heavier clays. The characteristic features of the soils of this series, besides their peculiar brown slaty color, is their extremely sticky nature, which is

in strong contrast with the light texture of the surrounding soils and gives them the local name of "gumbo" wherever they are found.

PIERRE LOAMS AND CLAY LOAMS.

Description.—Under the term Pierre loams and clay loams are included all soils derived wholly or in large part from the dark-colored Pierre shales, except the uniform areas of heavy clay. The variations in textures, which range from a silt loam to a heavy clay loam, are due either to differences in the composition of the parent rock or to the incorporation of materials from thin beds of other formations which have weathered over the surface. The most usual texture is that of a heavy loam or silt loam, underlain by a heavy clay loam. The depth of the top soil ranges from 6 to 12 inches, depending upon the topography and the extent of the weathering. All the heavier loams and clay loams possess the characteristic sticky property of the Pierre clay or gumbo. The more clayey soils are unctuous when moist and the roads become very slippery in wet weather and when thoroughly wet become tenacious and stick to the wheels of vehicles and make traveling very difficult. The surface soils vary in color from a rusty brown to grayish or yellowish brown. The color usually becomes darker as the clay content increases and approaches in places the dark-slaty color of portions of the Pierre clay. The rusty color noted in many places is due to the decomposition of thin beds of iron pyrites. This color usually occurs in spots and streaks, but in some localities the entire soil is given a rusty tinge by the iron oxide. The color of the subsoil is usually lighter than that of the soil, except in rare cases where the dark shale is encountered. As a rule the underlying shale is found at a depth of 4 to 6 feet on the ridges and at a greater depth in the lower slopes and in the valleys.

The surface of many small knolls in this type is covered by fragmentary silicious concretions and silicified wood, and occasionally gravel is found in considerable quantities.

Location.—These types occupy one area which is located in the extreme northwestern part of the State. It is the southern fringe of the great body of these types that covers a large area in South Dakota. It is mostly confined to the northern part of Sioux County.

Topography.—These soils lie in the valley of Hat Creek and this stream and its numerous tributaries have given the whole of its surface a rolling topography. As a rule the hills are not as sharply rolling as those in the Pierre clay areas and only a small proportion is unfit for tillage.

Origin.—The outcrop of Pierre shale from which these types were derived lies on the southern flank of the Black Hills uplift. The tilting and the subsequent erosion of newer strata has exposed the thick Pierre shales over an extensive area south of the Black Hills. The

original rock was a dark slaty colored shale, which usually weathers into a clay, slightly lighter in color and often of a reddish or rusty color, due to the ready oxidation of small quantities of iron pyrites. Gypsum crystals are common in the unaltered shale, but they do not greatly influence the weathered product. In some places, particularly toward the southern part of the area covered by these soils, thin beds of the newer formations have weathered on the surface and their products have influenced the composition of the soil, usually imparting more silt and fine sand and making the texture more loamy.

Utilization.—The cultivation of the heavier soils is usually difficult if they are at all wet, but if plowed in the right stage of moisture they break up into a granular condition. As a rule, however, on account of the difficulty of proper cultivation, as well as other physical deficiencies, these soils are not well adapted to dry farming. They are more retentive of moisture than the Pierre clay, but less effective in this respect than the more sandy and silty soils of other series. A very small proportion is under cultivation, the remainder being generally utilized for grazing. In wet seasons abundant grass of high feeding value grows on these types, but in dry years the grasses die quickly, as the unbroken land has a very weak power of retaining moisture.

Wheat, corn, and oats are the principal farm crops. Fair yields are secured in years of average rainfall, but in years of deficiency almost total failure results.

PIERRE CLAYS.

Description.—The Pierre clays are the heaviest soils derived from the heavy, dark-colored shales that outcrop in the northwestern part of the State. They are locally known as "gumbo," on account of their heavy, sticky nature. This tenacity of the clay is one of the most constant features of these soils, whatever variations may take place in color or texture. Under this classification there may be a range in texture of the surface soil from a silty clay loam to heavy clay. The top soil extends to a depth of 6 to 10 inches, being deeper on the more level areas, where weathering has taken place to a greater depth. There is a very small sand content, composed of the finest grades. A large percentage of silt is usually present, exceeding the clay in quantity, but it is not noticeable in the soil on account of the very sticky character of the clay, which gives the soil the properties of an almost pure clay. The color is usually a yellowish brown to dark brown, and in some places it is a dark-drab or slaty color, approaching the color of the parent rock.

The subsoil is a silty clay to heavy clay, usually slightly heavier in texture than the surface soil. It has a somewhat lighter color in some places, but in many localities there is but little change in color

to a depth of 3 feet. The undecomposed shale is found at a depth of 1 to 4 feet on the ridges, but on the level land and gentle valley slopes the soil has a much greater depth.

The Pierre clays are very difficult to till when in a moist condition, on account of the tenacious nature of the clay, and when dry the soil becomes too hard to be broken. When moisture conditions are favorable, however, the surface may be reduced to a mellow, granular condition. A characteristic feature of these types is the cracking of the soil over unbroken areas during dry weather. These cracks are larger and deeper on the heavier textured phases and often extend to a depth of several feet. This tendency to crack is detrimental to the pasture lands in that it permits of more rapid loss of the soil moisture, but on the cultivated lands it helps to granulate the soil and enables the farmer to keep the surface in a looser condition. On the virgin prairie the strong capillarity of the clay and the deep cracking rapidly rob the soil of its moisture, and for this reason grass is more quickly injured during droughts on this type than on any other soil of the region. When cultivated it is retentive of moisture, but the structure of the soil and its tendency to run together into a compact mass when it is wet greatly decrease its value for dry-farming purposes.

Location.—The Pierre clays occupy a relatively small area in the northwestern part of Nebraska. This area begins on the north side of White River and extends north, widening out and crossing the State line into South Dakota, where it covers a vast region. It occupies the eastern side of the lobe of Pierre soils that extends down into Nebraska and lies east of the Chicago, Burlington & Quincy Railway. There has been no attempt to separate the different phases of clay and clay loams that constitute these soils, nor the small areas of lighter type that sometimes occur. There is a gradual change in texture, the soil becoming loamier toward the west until it gradually merges into the areas of Pierre loams or clay loams. The Pierre clays closely confined to the valley of White River, while the Pierre loams and clay loams lie in the drainage basin of Hat Creek.

Topography.—The Pierre clays cover a succession of gently to steeply rolling hills and ridges, with narrow valleys. The entire surface has been carved by the numerous stream channels that traverse it, and there is practically no level or gently undulating land, though on the other hand there is only a small proportion of the country that is too rough to farm. In the more silty areas erosion has been quite rapid, and in some localities there are small areas badly gullied and with the shale exposed.

Native vegetation.—The more loamy portions of the type do not differ in their plant growth from the other heavy soils of the region. Buffalo and grama grass are predominant, but on the heavier por-

tions wheat grass is very common, and in years of heavy rainfall this valuable grass may be cut for hay over large portions of these types. In the lower areas there is sometimes an alkali accumulation, and such plants as greasewood and alkali grass are found.

Utilization.—A small percentage of the area of the Pierre clays is cultivated, the remainder being used for pasture or hay land. The soils cultivated are the lighter phases and the crops grown are corn and the small grains.

The Pierre clays are naturally very productive soils under favorable moisture conditions, but the difficulties of cultivation make them less desirable than soils of lighter texture. The most careful tillage is required to keep the surface in the mellow condition necessary in a dry-farming system to retain the soil moisture. The careful farmer can bring the soil to this condition by plowing and cultivation when the moisture conditions are at their best, as then the soil will break up into small granules and allow the formation of a mulch. The average farmer, however, does not give the proper thought to this matter, and his crops suffer more than those on the sandy and silty soils.

Yields for any particular year are of little value as an indication of the productiveness of the type, since there is such a wide variation with the season. In good years the yield of wheat will range from 12 to 20 bushels, oats 25 to 40, and corn 20 to 25 bushels per acre, but the averages taken year in and year out are below the minimum given above.

SOILS FROM CALCAREOUS DEPOSITS.

Rosebud Series.

The extensive exposures of the Arickaree formations of Tertiary age have weathered into a distinct series of soils that have been classified with the Rosebud series. The parent rock consists in most places of loosely consolidated, fine-grained calcareous sandstones. The resulting soils are principally fine sands, sandy loams, and silt loams having a light gray color. The subsoil is characterized by a light color and a high lime content. The calcareous portion is usually finely divided and increases in quantity with depth to 3 feet or more. At greater depths the material passes into the light gray or buff color of the original rock. These soils are easily eroded, and in the hilly areas white bare spots are a feature of the landscape.

The classification of the types is based principally upon texture and covers a range from loose sands to heavy silt loams. The silt loam is the most extensive type, occupying almost the whole of the High Plains or table-lands. The sandier soils cover the slopes and eroded hilly country, and wind has had a large part in their assortment and distribution.

ROSEBUD SILT LOAM.

Description.—The surface soil of the Rosebud silt loam, to a depth of 10 to 18 inches, is a silty loam containing varying proportions of fine and very fine sand. The depth of the soil varies with topography, being deeper on the more level areas, but the average depth for the type is about 12 inches. In color the soil ranges in different localities from a light ashy gray to a dark gray or brown, depending upon the quantity and character of the organic matter present. The subsoil, to a depth of 2 to 3 feet, is a light-gray or light-brown silty loam. In structure it appears lighter, more silty, floury, and incoherent than the soil, and by analysis it usually contains more silt and clay. Below this is a white, light-pink, or buff silty and sandy material that extends to a depth of many feet. In some places the middle zone is absent and the white floury or pinkish silt is found at 10 inches.

The type has large areas that are remarkably uniform in texture and other physical properties, but gradual changes take place, so that there is a considerable difference in widely separated bodies of the type. There is an increase in the sand content along the borders of the type, particularly toward the south. In the southern parts of Sioux and Boxbutte Counties and in the northern parts of Morrill and Deuel it closely approaches a fine sandy loam. In some localities the increased proportion of sand is probably due to the sandy character of the original rocks or to assortment in the processes of erosion, and in others the soil, like all others of this region, has been modified by wind-blown material.

The heavier phases of the type are found on the level plains, where restricted drainage has favored deep and thorough weathering. In depressed areas in the northern part of Sheridan County the soil has a much darker color than is usual with the type, and the subsoil is a hard, compact silt loam, and in rare cases a silty clay loam. Many of these areas would be mapped as separate types in a more detailed survey, but in this reconnoissance it was not practicable to make the separations. One of the largest bodies of this phase, and with unusually heavy texture, occupies a depression north of Rushville.

The phase that has the least agricultural value occurs on the high table between Alliance and Hemingford, where it occurs thickly in spots over several square miles. In this region the white, calcareous stratum approaches the surface and is so indurated that plant roots do not readily penetrate it. Under a portion of it there is a bed of water-worn gravel, which further decreases its agricultural value. Over small tracts the lime rock outcrops at frequent intervals, and on the intervening land the soil is so shallow as to be practically

worthless. Over all areas where the hard material approaches within 2 feet of the surface crops suffer in droughts of even short duration.

The surface of the typical Rosebud silt loam is loose and friable and may be easily kept in a good state of tillage. For this reason it is adapted to dry farming, though for the careless farmer it is not so safe as the more sandy soils of this series. On the rolling areas of this type the principal difficulty of handling the land is to prevent washing. When erosion has once started the silty material melts away rapidly under the action of running water and hillsides are soon gullied and ruined for farming. The incipient Bad Lands and the Rough broken land along Pine Ridge present the effect of erosion of this material. On the level or gently rolling country it is not difficult to prevent washing, but on the steeper slopes gullies must never be allowed to start.

In common with most soil farmed under semiarid conditions, the Rosebud silt loam has a large percentage of soluble salts. In a few localities there are noticeable accumulations of alkali, but over the greater portion of the type there will never be any dangerous concentration of the salts.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Rosebud silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370746	Soil	0.0	1.7	3.8	19.9	33.7	28.9	11.9
370747	Subsoil	.0	.0	.9	3.6	28.4	44.6	22.2

The following sample contained more than one-half of 1 per cent Calcium carbonate ($CaCO_3$): No. 370747, 9.20 per cent.

Location.—The Rosebud silt loam occupies vast unbroken areas, often remarkably uniform over many miles. The two principal bodies of the type in the northwestern part of the State are confined to the higher portions of the great Boxbutte Table. One begins in Cherry County, extends southwest across and covers the northern half of Sheridan and the southern part of Dawes County, and terminates in irregular lobes in the central part of Sioux County. The divide which it follows is a fragment of the great High Plains plateau. South of this soil area the plateau is broken for a few miles by the valley of the Niobrara, but rises again in the Boxbutte Table. Again, the Rosebud silt loam is one of the prevailing soils and covers more than half of Boxbutte County. There are also numerous irregular-shaped outlying areas to the south of these extensive bodies and to the east in Cherry, Boyd, and Keyapaha Counties, but in all these

the soil lacks the uniformity of texture, topography, and agricultural value that characterizes the type on the High Plains.

Topography.—As already stated, the Rosebud silt loam occupies the top of broad table-lands or plateaus that have escaped erosion in the degradation of the High Plains. The surface is either almost level or gently rolling or undulating. There is usually sufficient slope to carry away the rainfall, even on the more level areas, before it can injure the crops. In the central part of Sioux County the most broken and dissected areas of this type are found. Where the surface is excessively eroded the country has been mapped as rough stony land, regardless of the texture of the soil.

Origin.—This type is the partly weathered product of certain beds of the White River group of the Tertiary, but principally of the Arickaree formation. The original materials consist of very loosely consolidated calcareous sandstones and sandy shales. The low average rainfall over the type has restricted weathering along certain lines. The rocks have been decomposed, but the salts have not been removed as rapidly as they were released, so that the amount of soluble materials has been increased. A marked change that takes place in the undisturbed surface soil is the accumulation of a large quantity of organic matter, though this is not always indicated by a dark color.

In the southern part of its area there seems to be a remnant of the newer Ogallala formation over the surface, which has influenced the composition of the soil to some extent, but the materials have become so intermixed that it was not practicable to outline the areas. The gravelly areas of the Rosebud silt loam are formed by the exposure of red stream channels in the Arickaree, filled with a coarse conglomerate. Thin beds of volcanic ash are common throughout the Arickaree strata, but their effect on the weathered soil is noticeable in only a few small areas.

The fine-grained, long, cylindrical masses known as pipe concretions, common through the Arickaree, are left in the soil when the inclosing material has weathered, but rarely in sufficient numbers to affect the agricultural value.

Native vegetation.—There are no native trees on the areas of the thin Rosebud silt loam and very few shrubs, except on the margins of the bluffs. Most of the grasses are short species and have a shallow root development, conforming to the prevailing moisture supply and general climatic condition. Grama, buffalo, wire grass, and black root are the most common.

Utilization.—This type of soil was generally taken up by homesteaders, and nearly all of it has passed into private ownership. In Boxbutte County it was extensively settled in the early development of the country, but suffered a severe decrease of population during

the dry years that followed. At the present time it is as well settled as any of the soils of this part of the State. In Sheridan and a portion of Boxbutte County the farmers have been very successful for a number of years. In the northern part of Sheridan potatoes have been grown with profit for several years. Corn, wheat, oats, barley, flax, and potatoes are the principal crops. Wheat is probably the best small grain for this region, the yields ranging from 10 to 20 bushels per acre, with an average of about 13 bushels. Corn is a useful but not very profitable crop, the yields ranging from 16 to 22 bushels per acre. The soil is suited to potatoes, and the crop fits in well in a dry farming system. The average yields range from 65 to 75 bushels, but good farmers get a yield of 85 bushels per acre. The most successful varieties are Early Ohio, Prairie Queen, and White Elephant. The Early Ohio does best in dry years, but the Prairie Queen is the heaviest producer in years of fair rainfall.

ROSEBUD FINE SANDY LOAM.

Description.—The Rosebud fine sandy loam consists of a dark-gray or brown fine sandy loam to a depth of 10 to 24 inches. The sand is composed of the very finest grades and there is usually a large percentage of silt, but not enough clay to give this type the coherent structure of the soils of the Valentine series. The dark color of the soil varies with the quantity of humus present, the darker phases occurring on the more level areas, where conditions have favored the accumulation of organic matter and its conversion into the black humus. There is but little difference in texture of the soil and subsoil, but the color becomes lighter as the organic matter decreases below the surface. A characteristic feature of this type is the presence at a depth of 2 to 4 feet of a white, calcareous material, which occurs in all forms from a white silty powder to fragments of hard, limy rock. The former is far more prevalent. At lower depths it passes into the pinkish-white or buff-colored silty clay characteristic of so large a portion of the unweathered Arickaree formation. The soil is easily tilled after the prairie sod is once broken, but the loose, incoherent nature of surface soil favors drifting when plowed. There has been a constant shifting of the type by the wind and the depth of the surface soil in different parts of its area is largely the result of wind action. Occasional hills and ridges of dunelike appearance, heaped up by the wind, are found in nearly all portions of the area covered by this type. In other places, particularly in Sioux County, patches of white, calcareous rock and stony ledges have been exposed by the wind. In nearly all portions of the type the loose sand has been washed or blown away on the slopes and the white, silty, calcareous material exposed, giving the characteristic white spots that fleck the hillsides. Along the streams and

ravines precipitous banks of limy earth occur at intervals, capped by layers of fine-grained concretionary sandstone. From the surface throughout the entire depth of this formation are numerous irregular, oblong, and roundish, limy, fine-grained sandstone concretions. They are frequently exposed and in some places cover the surface, having the appearance of numerous round pipes lying side by side, partly covered by earth. These cylindrical masses, called pipe concretions, vary in diameter from a few inches to several feet and when exposed in the roads make traveling very rough. As a rule, the lime content in the deeper portions of this type is not so high as in the Rosebud silt loam, indicating a more thorough leaching in the process of weathering.

Average results of mechanical analyses of samples of the soil are given below:

Mechanical analyses of Rosebud fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370741–370742.....	Soil.....	0.2	0.9	1.3	8.8	63.0	15.6	10.1

Location.—The Rosebud fine sandy loam occurs in large areas of irregular shape, usually bordering the large streams or covering the eroded slopes, where the High Plains or table-lands begin to break away toward the river valleys. In Sioux County it occupies a considerable part of the rough hilly country between the Niobrara and North Platte Rivers. In this region reworking and shifting by the wind have given much of the country a dunelike topography. The type extends in irregular areas along the Niobrara in the southern part of Dawes and the northern part of Boxbutte Counties. Detached areas of irregular shape and size occur in the northern portions of Cherry, Keyapaha, and Boyd Counties. The largest and most uniform area of the type is found in the southwestern part of Boxbutte County, where a large proportion of it has a gently rolling topography.

Origin.—The Rosebud fine sandy loam is derived by weathering from sandy strata of the Arickaree formation. The high sand content is, no doubt, due in part to an accumulation at the surface through a removal of the finer particles in the process of weathering. There has also been in many places an accession of sand from the wind-blown material.

Native vegetation.—The native vegetation varies according to the quantity of sand in the soil. Over the heavier portions of the type buffalo and grama grass predominate, but in the sandier phases the sand grasses and yucca are more common. In Sioux and Dawes

Counties the predominant grass is black root, which, though not confined to this soil, seems to thrive best on it and is very abundant. In many places it makes a hard, compact sod and excludes all other grasses.

Utilization.—A very small proportion of the type is cultivated at the present time. In Sioux and Dawes Counties the land has recently been homesteaded, and there has not been time to show the value of the type. It is probable that the more level areas that are not too sandy will carry a crop through a drought better than the Rosebud silt loam. It is well adapted by texture to the growth of general farm crops, but potatoes, corn, and vegetables will be more successful than the small grains.

ROSEBUD LOAMY FINE SAND.

Description.—The Rosebud loamy fine sand, while not as important agriculturally as some other soils in the area, has a rather large development in the western part of Sioux County. It represents a gradation between the Rosebud fine sandy loam and the Dunesand and would not have been separated ordinarily from them in a reconnoissance survey. But it occurs in fairly large areas, and the approximate boundaries are relatively easy to define and its difference in agricultural value made separation desirable. The soil to 36 inches consists of a light-gray fine loamy sand, with very little change with depth, except that the color is somewhat lighter and the structure more loose and incoherent. In some places the material is very loose and sandy and approaches the Dunesand type very closely, but nowhere is it drifting at the present time. On the other hand, many places are found where it is heavier and is very little different from the Rosebud fine sandy loam.

Location.—Practically all of this type occurs in the western part of Sioux County, where it is usually associated with the Sand Hills.

Topography.—The topography varies from slightly rolling to hilly and broken, with the greater part too rolling to be well adapted to agriculture. This does not detract from its value as grazing land, as the grasses are fully as good, and the rough land furnishes shelter for stock during bad storms. Outcrops of gray sandstone are frequent in the more rolling areas, especially to the east of Sheep Creek and toward the heads of the Spotted-tail Creeks.

Origin.—The material of this soil has weathered from a gray sandstone of the Arickaree formation similar to that from which the fine sandy loam is derived, and its more sandy character may be due to a difference in the rock from which derived, though more probably to the washing out of the fine particles or to their removal by the wind.

Native vegetation.—The native vegetation gives a good index to this soil type, and its separation from the fine sandy loam was

dependent largely on differences in vegetation. The same grasses—buffalo, grama, blackroot, and coarse sand grass—are found as upon the fine sandy loam, with the difference that here the coarse sand grasses predominate, and in addition some sagebrush is found.

Utilization.—Very little agriculture is practiced upon this type, as the light sandy character of the soil favors drifting. On the small area under cultivation fairly good yields are obtained in favorable seasons, but the best use for the type at present is grazing. As grazing land it ranks with the fine sandy loam and is slightly better than the sand-hills land.

Sidney Series.

The Ogallala formation of the Tertiary is widely exposed on the High Plains in the southwestern part of the State and its surface has weathered into a group of characteristic soils called the Sidney series. The rock, so widely exposed in Nebraska and the Great Plains region to the south, is usually a calcareous conglomerate, consisting of sand and gravel loosely cemented with soft limestone, interbedded with silt and clay. The soils range in texture from rather coarse sandy and gravelly loams to heavy silt loams, and the types are usually continuous and uniform over considerable areas. The characteristic feature of these types is their brown color and the white, calcareous silty subsoil. A varying quantity of gravel is always found in the subsoil and often in the surface soil. The almost white, floury, silty, calcareous subsoil of this type distinguishes it from all other soils derived from the Tertiary of the Great Plains.

Sidney silt loam.

Description.—The surface soil of the Sidney silt loam varies in texture from a fine sandy loam containing a large quantity of silt to almost a typical silt loam, the latter phase being predominant over all the level and gently undulating areas of the type. The depth of the soil ranges from 12 inches over the rolling country to 18 inches on the more level tables, but the average for the type is about 16 inches. The prevailing color, a pronounced brown, is remarkably uniform over large bodies of the type. In some localities it has a slightly reddish tinge, which is especially noticeable in recently plowed fields. On slopes, where the soil is less deeply weathered and the white, calcareous material is mingled in the surface soil, the typical color gives place to a grayish-brown. A common feature in some localities, though it is not essentially characteristic of the type, is a small quantity of coarse sand and gravel and calcareous fragments. There may be a sparse sprinkling of this material scattered through the soil over several square miles, with occasional patches from 20 to 60 feet across, consisting of masses of gravelly loam which

would be shown with the Sidney gravelly sandy loam were the areas larger. Over vast areas of the level table-land, however, there is none of the coarser material and the soil is of a uniform silt loam texture.

The subsoil of the Sidney silt loam is characteristic. It consists of a light-gray to almost pure white silty material, with a depth of more than 3 feet. The white color is imparted to the subsoil by the large content of lime, which greatly exceeds in quantity that carried by the soil. The whitest portion of this material is locally known as "magnesia," and in some places it is so compact as to injuriously affect the crops. The usual texture, however, is that of a loose, floury silty loam, with occasional gravel and small calcareous fragments. In some places there are granular particles composed of the silty calcareous material, but they are readily crushed in the hand and reduced to a loose silty powder. At depths of several feet and in rare instances near the surface this material becomes more compact and passes into unweathered Tertiary marl or Mortar Beds.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Sidney silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370758	Soil	0.8	2.1	2.2	5.1	20.9	38.9	30.1
370759	Subsoil	1.0	1.7	1.5	3.4	21.1	50.6	20.6

The following sample contained more than one-half of 1 per cent Calcium carbonate ($CaCO_3$): No. 370759, 10.11 per cent.

Location.—The Sidney silt loam is one of the most extensive and uniform soil types in the western part of the State. Its most uniform and typical area is found on the broad divide known as the Cheyenne Table, lying between the North Platte River and Lodgepole Creek. Beginning with a few detached areas in Kimball County, it extends eastward, covering the whole of Cheyenne County, with the exception of the Lodgepole Valley and a few square miles of rough land in the northern part, and all of Deuel County, except the valleys, and stretches northward into the southern portion of Garden County. South of Lodgepole Creek a continuation of the same table-land extends along the southern part of Cheyenne and Deuel Counties to the State line. East of these uniform and extensive areas the type is broken by soils of the South Platte Valley. It begins again in the southern part of Keith and, extending southward in irregular areas, covers more than one-half of Perkins County, but this development is neither so continuous

nor so uniform in texture as the area to the west. The material from which it was derived seems to have been coarser and less uniform in composition, so that the soil, as a rule, contains more sand and gravel. Local variations are more numerous, and this type and the Sidney loam are so intimately mixed that pure areas of either are seldom found. In addition, this area of the type has been invaded by the drifting sands from other formations, so that it is frequently broken by areas of sandy loams and sand-hill land. Toward the south the texture of the soil gradually becomes coarser and passes imperceptibly into the loam type of the same series. The line between the two has been drawn through the southern part of Perkins County, but it must be regarded as arbitrary in most places, as the two types merge into each other so gradually and overlap each other in small areas to such an extent that it is impossible to draw a sharp line of demarcation between them.

Topography.—Throughout its entire extent the Sidney silt loam has a slightly undulating or very gently rolling surface admirably adapted to farming. The vast stretch northeast of Sidney, constitutes one of the most beautiful prairie landscapes in the State. The general level permits one to see for long distances, but the gentle, undulating swell to the surface is sufficient to insure good drainage. Over the areas of the type in Keith and Perkins Counties the landscape is broken by sand ridges and the areas of Sidney silt loam take the form of apparently level flats winding around among the sandy soils of wind formation. Although drainage channels have not been well established in the type, the natural roll of the surface is sufficient to dispose of the rainfall.

Origin.—The Sidney silt loam is the weathered product of one of the late Tertiary deposits, which has been given the distinctive name of the Ogallala formation. It is widely exposed over Kansas and Nebraska, and has been called "Mortar Beds," "Tertiary Grit," and other names of more local significance. In its unweathered state it is usually a calcareous grit or soft limestone interbedded with silt and clay, with a greater or less quantity of gravel and calcareous nodules. In many places it is interspersed with beds of hard calcareous conglomerate, containing pebbles of crystalline rocks of various kinds, similar to those now found in the Rocky Mountains. The vast outcrop of the Ogallala formation in this section over a nearly level plain undisturbed by erosion has allowed weathering to go on to an extent not found in the more hilly country, and the Sidney silt loam represents the deeper weathering of the more calcareous and less gravelly portions of the formation. The most marked feature of the weathering has been the removal of nearly all the lime from the surface soil, which contrasts sharply in this respect with the extremely calcareous nature of the subsoil.

Utilization.—In every respect, except the matter of moisture, the Sidney silt loam is a nearly perfect soil for general farming. It is friable, well drained, and contains an abundance of lime and organic matter. If it were situated in a more humid region it would be one of the most valuable soils of the country, but here its productiveness is impaired by the general deficiency of rainfall. It lies well within the belt of less than 18 inches of annual precipitation, within which farming is regarded as precarious, and it requires the utmost care to insure success. The soil itself, while of excellent properties otherwise, is not so well adapted to the retention of moisture as the more sandy soils, and it is for this reason that in Perkins and Keith Counties this type of soil is not so well settled and the farmers are not as a rule so prosperous as on the sandy types. The area in Cheyenne County is more thickly settled, because in late years farmers in this section have been more fortunate in the occurrence of local showers and have made a succession of good crops. This has been a matter of chance, but the farmers are now so well established that they are in a position to withstand droughts and maintain settlement in the country.

The principal crops are those common to the upland types of this section. The main dependence of the farmer is upon the small grains. Large yields of wheat, to which this soil is well adapted, are sometimes obtained, but the average yields are not high. It is probable that, taking one year with another, not more than 12 bushels per acre is secured in the section around Sidney, and in Perkins County, where droughts have been more severe, the average yields for many communities have not been within the limit of profit. Oats are grown to some extent, and the average yield is about 20 bushels. Corn is not a staple crop, but many farmers grow it. The ordinary yield is probably between 15 and 20 bushels.

In Perkins County much of this type is held by nonresidents and is leased for grazing. No large ranches are to be found, but many cattlemen control from 1 to 10 sections each. Buffalo and grama grasses make a good growth on the unbroken sod and furnish excellent pasture both in winter and summer. Ten acres are usually considered sufficient for one animal, but if the grass is supplemented by feed the number of cattle can be greatly increased.

SIDNEY LOAM.

Description.—The surface soil of the Sidney loam consists of a loam 10 to 16 inches deep, containing a large percentage of silt and some medium and fine sand and small gravel scattered through the soil. The color is usually a brown, though where much organic matter is present the soil is a dark gray in the fields. In some locali-

ties the color is a slightly reddish brown, and the red color is very noticeable in plowed fields. The surface is compact and the type is classed by the farmers with the group of heavier soils known as "hard land" to distinguish it from the sandy soils of loose surface. The subsoil is characteristic of the types of the Sidney series. It is usually a silty, white, unconsolidated, calcareous material to a depth of many feet. As elsewhere in these types, this substance is locally known as "magnesia." There is always present an admixture of coarse materials in the subsoil, consisting of coarse sand and small gravel, with occasional calcareous nodules. The composition of the material may range from a loose, floury, silty powder to a rather compact mass of gravel cemented by lime, or an unconsolidated bed containing a small percentage of coarse material, but the first phase is much more common. The color is always a light gray to almost white.

There are small areas, particularly on hillsides or on small knolls, where the white calcareous rock is exposed or approaches the surface. In such places the agricultural value of the land is seriously impaired. This condition prevails over some of the flat areas in Perkins and Chase Counties and the droughty condition of the soil is there due to this cause. A compact form of the underlying rock at 2 feet or less is injurious on account of the lessened space for the storage of soil moisture in dry seasons. The rather compact nature of the surface soil renders this type naturally less fitted to retain moisture, on account of the increased capillary power and the greater difficulty experienced by the farmer in producing a dust mulch on the surface. Careful cultivation will obviate these difficulties, but the increased labor necessary to keep the land well tilled gives this soil a low relative value in comparison with the easily worked sandy soils.

Mechanical analyses of samples of the soil and subsoil of the Sidney loam gave the following results:

Mechanical analyses of Sidney loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370731	Soil	1.0	7.0	5.3	9.3	24.5	36.0	16.9
370732	Subsoil	2.4	5.7	4.4	7.3	24.1	29.9	26.5

The following sample contained more than one-half of 1 per cent Calcium carbonate ($CaCO_3$): No. 370732, .93 per cent.

Location.—The Sidney loam occurs in the southwestern part of this area, confined principally to Chase and Perkins Counties, with small areas in Dundy, Hitchcock, and Hayes Counties. In the first two counties mentioned the areas are extensive, being broken only by belts of the sandier soils of this series. In the other counties the

type occurs chiefly in narrow bands along the borders of sandy areas or on stream slopes, where the Ogallala formation has been exposed by erosion.

Topography.—The usual topography covered by the Sidney loam varies from rolling to gently undulating. The most level portions are found in the northwestern part of Chase County, where flats of several square miles seem almost perfectly level. The narrow strips that follow the streams in Chase and Hayes Counties are exceptionally rough, consisting of steep, broken slopes of "Mortar Beds" exposure, with narrow strips of tillable land higher up on the plains.

Origin.—This type, like the other members of the Sidney series, has been derived by weathering from the Ogallala formation of Tertiary age. The depth of the soil depends largely upon the depth to which weathering has taken place. The subsoil represents the partially decomposed original rock, which was a calcareous grit or conglomerate, probably containing less gravel and sand than the parent material of the Sidney silt loam. The percentage of gravel varies in proportion to the quantity of coarser materials in the original rock.

Native vegetation.—As is the case with the soils of heavier texture on the Plains, the most abundant native grasses are such species as the buffalo and grama. On the level flats in Chase County these very short grasses are predominant. The land is always well covered by these grasses and furnishes good grazing, being particularly well suited for sheep pasture. On the more sandy and gravelly portions more of the coarser sand grasses may be seen. Over all portions of the type the droughty nature of the soil cuts short the grazing capacity of the land in dry seasons.

Utilization.—Only a small proportion of the total area of this type is under cultivation at the present time. The land has not been more generally brought under cultivation by the farmer because the surrounding sandy soils were more desirable for dry farming. A considerable part of the type in Chase County has passed into nonresident ownership, and much of it is not used, except to a small extent for public grazing. The more rolling sections and those with the calcareous rock at a shallow depth below the surface will probably never be farmed with success, but the deeper soils will be fairly productive if properly handled. Careful preparation of the land and the maintenance of a loose surface on cultivated fields will to a large extent counterbalance the deficiencies of the soil in regard to moisture conservation. Some farmers have tried summer fallowing every second or third year and claim it is a good practice. Wheat is the principal crop, but the average yield is low, probably less than the average for this part of the State. Corn does not yield as well as on the sandier soils, and the average yields for several years have

not proved to be a profitable crop, though careful farmers have done well. Where there is a thin, sandy stratum over the surface corn does better. Sorghum is a much more certain crop, and it is grown to some extent in connection with stock raising.

All of the type is now under private ownership. The selling price varies widely. As so much of it is used for grazing, its selling price in many places is governed by its value for this purpose. Very little of the grazing land can be bought for less than $5 an acre, and the farming land may be valued at $20 an acre or more if situated near towns and railroads.

Sidney loam, gravelly phase—Description.—A gravelly phase of the Sidney loam occurs throughout the areas of the Sidney silt loam in patches too small to indicate on a map of small scale, but west of the main bodies of that type it is extensively developed. The soil of this phase is a brown, somewhat silty loam, with a varying quantity of sand and gravel. The usual brown color varies in shade, having in places a slightly reddish tinge. The subsoil is a light-gray to slightly yellowish gray loam to silt loam, containing some coarse sand and gravel, and does not differ greatly from the subsoil of the Sidney silt loam. In the areas in the northern part of Kimball County there are included within the boundaries of this type numerous bodies of the silt loam sufficient to make up a considerable percentage of the whole. But as a rule the typical areas are small in extent and the gravelly phase predominates. In like manner many patches of the gravelly phase are found throughout the areas of Sidney silt loam, particularly to the south and east of Sidney. Over this phase, particularly in Kimball County, there are small buttes that are usually covered by a more gravelly soil and in some cases are composed of a mass of gravel.

The gravel in this phase is similar to that found in all of the Tertiary deposits commonly known as "Mortar Beds." It consists of waterworn pebbles of a number of crystalline rocks, which give evidence of their origin in the Rocky Mountains, and a lesser proportion of calcareous nodules and concretions. The quantity of gravel varies widely in different parts of the type, ranging from almost pure gravel beds on the knobs to a soil having a small percentage of gravel like that which covers a large part of Kimball County.

Location.—The small unmapped areas of this phase are found throughout nearly all parts of the Sidney silt loam, being most common in the southern part of Cheyenne County, and at intervals in the areas of Sidney loam in Chase County. The large uniform areas of the phase are found in Kimball County and the western part of Cheyenne County. In the former county a large body lies on each

side of Lodgepole Creek, the two comprising more than one-half the total area of the county.

Topography.—The topography of the gravelly phase varies from undulating to sharply rolling. Some portions cover a level plain, not more rolling than the areas of Sidney silt loam, but the topography varies from this to very broken land, so that on an average the surface is much more rolling. As already stated, knolls and mounds are a common feature of the landscape. Near Sidney they are small, ranging from 1 to 3 feet in height and 10 to 50 feet in diameter, but toward the west there are hills and buttes of considerable size. The knolls contain a large percentage of sand and gravel and frequently outcroppings of the partly altered, white, calcareous conglomerate is a feature of the hills.

Utilization.—The native grasses comprise the same species as grow on the Sidney silt loam, but the plants are not as thick and the native sod is not so heavy. The proportion of rank weeds and sand grass is greater, particularly on the more sandy phases and on the Rough broken land. Less farming is done and poorer yields are obtained than on the silty soils.

SIDNEY GRAVELLY SANDY LOAM.

Description.—The usual upper soil section of the Sidney gravelly sandy loam is a brown coarse sandy and gravelly loam. There is no apparent textural difference between the soil and subsoil, but below 18 inches the material is usually lighter in color, owing to the absence of organic matter, which darkens the soil proper, and to the less advanced state of weathering. The gravel ranges in amount from a small percentage over most of the type to beds of almost pure gravel in small areas. The latter are usually found on slopes and on the tops of small knolls. Local variations in texture occur in parts of the type. In some areas, as in that along Rush Creek, there is almost a pure sand; in other places both the soil and the subsoil are quite loamy. These differences in texture may be due to variations in the original rock to the extent of the weathering or to the amount of reworking and shifting that has taken place. Below 3 feet the white, silty, calcareous material characteristic of the subsoil of the Sidney series is found.

There has been included with this type the gravelly phase bordering North Platte River. These gravelly materials were probably derived originally from the same source as the typical Sidney gravelly sandy loam, but they have been reworked more or less by the streams. This phase is usually composed of coarse sands and gravels, with a small proportion of brown sandy loam. It occurs as

ridges skirting the alluvial lands of the valleys or as rounded gravel-covered knolls and hills in the upland. As this phase is not widely different in composition from the true type, and often rests upon outcrops of the Ogallala formation, it was mapped with the Sidney gravelly sandy loam.

This phase is of small value as farm land, being useful only for grazing. Soap weed (yucca), sagebrush, and various sand grasses make up the native vegetation.

Location.—The Sidney gravelly sandy loam stretches in long, narrow areas along Lodgepole Creek from the point at which it enters Kimball County southeastward to the Nebraska-Colorado line. East of this it occurs for a few miles in ragged areas along South Platte River. There are also scattering areas in different parts of Kimball and Cheyenne Counties.

Topography.—This soil covers a rough, broken country, comprising steep, winding ridges and deep valley slopes cut across by numerous intermittent streams. At a distance from the streams, nearing the upland plains, there has been mapped in this type strips of rolling and hilly land, including mixed agricultural and grazing land. Very rough and particularly sandy areas occur on each side of Rush Creek, in the northeastern part of Cheyenne County.

Utilization.—Only small areas of this land are under cultivation, as the greater part of it is too hilly and droughty for successful tillage, except in seasons of unusual rainfall. It supports no timber, but is covered on the sandiest knolls with yucca, sagebrush, and grasses. The common species of grass are grama and buffalo, with sand grasses on the more sandy areas. Blackroot produces a heavy, matted growth of roots, making a tough and durable sod.

The greater part of this type has been taken by homesteaders during the last few years under the provisions of the Kincaid Act and is used for pasture. The sandy phases blow badly and should be used only for grazing. Overgrazing is to be avoided, as blow-outs are likely to start wherever the grass has been destroyed and the surface loosened by tramping of animals. Small tracts in the more level country are farmed to corn, oats, and wheat. Average yields for this type are slightly below the average for this section.

SIDNEY SANDY LOAM.

Description.—The Sidney sandy loam includes all the sandy loams of this series, and the top soil has a range in texture from a rather heavy sandy loam to a loamy sand. The average and most extensive phase is a light-brown to dark reddish brown sandy loam, underlain at an average depth of 16 inches by a lighter colored sandy loam. The sand in both soil and subsoil is of various grades, but the fine and medium grades usually predominate. A characteristic feature

of the type is the loamy, slightly sticky character that is imparted by the presence of a small quantity of finely divided clay. This material does not make the surface soil compact, but gives it sufficient adhesiveness to impede its removal by the wind. The top soil of cultivated fields works up into the loose, mellow condition so desirable in dry farming. The subsoil is usually heavier in texture than the soil, and in restricted areas it may be a mass of clayey sand and gravel. At a depth of 2 to 3 feet on the level portions of this type and at a greater depth on the hills there is a white calcareous material locally known as "magnesia." It is the partially weathered product of the "Mortar Beds" of the Ogallala formation and is very similar to the calcareous stratum underlying the Sidney silt loam.

The depth of the unconsolidated upper portion of this type varies widely in different localities. Where weathering is not far advanced or where the loose weathered material has been removed by the wind, the white calcareous material is so near the surface as to affect seriously the agricultural value of the land, while in other places where the wind has heaped up the sand the white material is at a depth of several feet below the surface.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Sidney sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370715	Soil	1.7	17.3	17.2	28.9	17.9	9.0	8.2
370716	Subsoil	1.0	10.0	11.0	22.7	19.0	17.5	19.0

Location.—The greater proportion of the areas occupied by this type are located in the southern and eastern parts of Perkins County. There are also small areas in Keith, Chase, and Lincoln Counties. Its usual occurrence is in the form of irregular areas winding among the bodies of Sidney silt loam and broken at intervals by that type or by sand dunes. There are numerous areas too small to indicate on the map, interspersed over the low sand-hill region in Lincoln County. In the southern extension of the type into Chase County it comes into contact with the sandy soils of the Richfield series, and the dividing line is very difficult to draw. The soils merge so gradually into each other and are so intermixed by wind action that the lines of separation are in most cases purely arbitrary.

Topography.—The Sidney sandy loam has been mapped as occurring in two distinct topographic provinces—the almost level plain on which the more loamy phase is prevalent and the hilly lands on which the very sandy loam is found. Over much of the low hilly

land the surface has a true dune topography, though the hills are not now in motion, and weathering has advanced until the soil has a more loamy texture than the drifting sand dunes.

Origin.—This type, like the Sidney silt loam, has been derived by weathering from the extensive beds of the Ogallala. In its unweathered state the Ogallala formation is a white, calcareous grit or conglomerate varying widely in composition, but usually consisting of gravel, sand, and lime nodules in different proportions, cemented by calcium carbonate. The loose surface soil represents the weathered product of sandy members of the formation, loosened by weathering and wind action and shifted to and fro by the wind. In addition, there has been, as is the case with nearly all soils of western Nebraska, a considerable accretion of foreign materials gathered up by the wind in areas of other types and scattered over the surface. The sands are thought to be largely derived from the Ogallala formation on account of their heavy, sticky nature and the presence of a large proportion of feldspar and minerals other than quartz.

Utilization.—The Sidney sandy loam is the best soil of the semiarid belt for dry farming. The texture is favorable to the retention of moisture, since the surface pulverizes readily to form a mulch and at the same time it is not so loose and incoherent as to be blown away by the wind. The soil itself is naturally productive, and as a result of these advantages the type is better suited to the growth of corn, sorghum, and other feed crops than any other soil of the western part of the State if average yields are considered. In years of sufficient rainfall the heavier or "hard-land" soil will give larger yields, but the Sidney sandy loam will give a much higher average for a series of years and total failures will rarely occur. Corn for several years has made good average yields for this section, though some of the seasons have not been very favorable. The average yield has ranged between 20 and 25 bushels per acre. Wheat and small grains do not do so well as a rule, as the surface soil is likely to drift in the fall and spring, the seasons of hardest wind, when the surface is unprotected by vegetation. In sheltered valleys wheat yields 20 bushels or more, but the average is probably about 12 bushels per acre.

MISCELLANEOUS TYPES.

ROUGH BROKEN LAND.

Description.—The term Rough broken land has been applied to extensive strips of badly eroded stream slopes and bluffs in the western part of the area. It varies from sharply rolling stony land to bare dissected escarpments that in places closely approach a true bad-land topography.

The hilly stream slopes are found for the most part along the north side of North Platte River above the terrace soils and on the ascent to the table-lands formed by the Arickaree formation. The greater portion of the rough land has been carved from the Arickaree formation, which is readily broken into such a topography where there is active stream erosion. The only farming land within these areas is confined to the relatively level stream valleys and a few areas of small extent that have escaped excessive erosion. The soil is thin and usually sandy in texture, as the finer components of the original material have been removed by weathering. There is a low humus content on account of conditions unfavorable to its accumulation. There is usually present a considerable quantity of white, calcareous sandstone, representing uneroded fragments of the Arickaree formation. Near the streams there may be a considerable quantity of gravel and in some places the proportion of gravel unfits the land for farming. The type includes many areas that would in some places be called Rough stony land, but here it was not practicable to make a separation.

The blufflike phase is extensively developed along Pine Ridge and at Scotts Bluff and vicinity. (Plate I, fig. 1.) In the former locality the type occurs where a narrow table-land of the Arickaree formation has been left between the Niobrara and White Rivers, and the rapid erosion of these streams has gradually worn away the plateau and reduced the country to its present topography. Steep slopes have been formed and precipitous bluffs are common. It is rare that extensive strata of indurated rocks are exposed, the usual arrangement being alternate beds of sandy shale and silty clays. It is where the more silty strata are capped and protected by hard rock that we find the steeper cliffs and more abruptly broken country. Scotts Bluff and similar hills in the vicinity are formed by the erosion of the soft Brule and Chardron formation, where they have been partially protected by cappings of the Arickaree sandstone. Immediately below the cap rock there is an abrupt drop forming a bluff with bare slopes. At the foot of the bluff there is an apron of débris forming small areas in some cases of arable soil. When erosion has extended out from the footslopes small areas of well-developed Bad Lands are formed, such as may be seen on the slope between Scotts Bluff and North Platte River.

There is a similarity in appearance in all parts of the bluff region. On the more rolling portion the soil is so thin and drought-stricken that its value for farming purposes may be disregarded. Fragments of stone are thickly scattered through the soil and over the surface of the higher portions where the Arickaree sandstone has been broken up by erosion. On the more stable soils there is a sparse growth of grasses and on the slopes grasses and weeds suited to a droughty soil.

A characteristic feature of the sharply rolling slopes and of any land where trees can get a foothold is the scattering growth of cedar and pine of the species suited to mountainous and arid conditions.

Location.—As noted before, the Rough broken land occurs in many irregular areas in the western part of the State. The Northern escarpment breaking away from the Boxbutte Table includes the sharply dissected Pine Ridge. It begins in the northern part of Sioux County, swings in a northeastern direction through the center of Dawes County, and terminates against the valley of White River in the northwestern part of Sheridan County. It varies in width from 1 to 10 miles and has a descent of 500 to 800 feet measured from the edge of Boxbutte Table to White River.

The areas of this type north of North Platte River are characterized by sharply rolling hills, usually treeless and covered with stone fragments and, in places, coarse gravel. This belt flanks the areas of soils of the Rosebud series and occurs on the sharpest descent from table-lands of the Arickaree formation. This phase continues eastward along the North Platte into Keith County.

Topography.—The landscape of Scotts Bluff and hilly lands of similar topography in the vicinity resembles that of Pine Ridge, except that here the silty material of the Brule formation has weathered more rapidly, so that the slopes are steeper and bare of vegetation, and the true bad-land topography is more often developed.

In the southern part of Scotts Bluff County, the northeastern part of Kimball, and the southern part of Garden the surface features and other characteristics of the type are similar to those areas along the North Platte. The extensive area in the northeastern part of Kimball is more gravelly than the areas farther north and this condition prevails in all the detached areas along the streams of the southern parts of these counties.

Utilization.—With the exception of small, uneroded areas scattered throughout the Rough broken land, none of the type is farmed. Its principal use at the present time is for pasture. The steeply rolling areas are well grassed over and make very desirable grazing land. In Dawes and Sheridan Counties the land has nearly all passed into private ownership and is utilized to its capacity for stock raising. In some places there was originally a fair growth of timber which was valuable for fence posts. The better trees have now been cut and little timber of any value is left. As the growth of the trees suited to this type is so slow, it is not likely that the land will be used for growing trees, but the present growth, if protected, will in a few years be large enough for posts.

In a few sheltered localities fruits may be grown. Of the apples the Wealthy, Ben Davis, Gano, and Early Harvest, and crab apples do best, and bush fruits thrive on the deeper soil of the foot slopes.

BENTON STONY LOAM.

Description.—The term Benton stony loam is applied to areas of rough land adjacent to streams, which have cut their channels into the shales and limestones of the Benton and Niobrara groups, and where the weathered products of these rocks have entered into the composition of the soil. The type is of small extent in this area and is of minor value from an agricultural standpoint. The usual surface soil consists of 3 to 12 inches of a light-brown to grayish silty loam, often interspersed with shale and limestone fragments. The subsoil becomes lighter in color and is more nearly made up of the partially decomposed shale and limestone. On account of the porous, chalky nature of the subsoil, the rainfall sinks to lower depths and is not retained near the surface for the use of crops.

Location.—The Benton stony loam occurs in only a few small bodies in the southeastern part of the area. It is confined to valley slopes along small streams that enter Republican River from the south. It covers the immediate slope very closely and extends back upon the more gently sloping ridges.

Topography.—The topography varies from rolling to very steep and broken, with few intervening tracts level enough for farming purposes.

Utilization.—The greater part of the land covered by this type is devoted exclusively to pasture, to which it is well adapted, an abundance of native grass being found upon it. The type is well adapted to stock raising in connection with the areas of more level prairie, as the draws furnish protection for the cattle during the winter and the grass on the slopes furnishes pasturage during the greater part of the year.

SOILS FROM UNCONSOLIDATED WATER-LAID DEPOSITS.

RICHFIELD SERIES.

The Richfield series includes gray and brown soils composed of the weathered products of the Tertiary formation, modified to a greater or less degree by wind-blown materials. The latter are derived principally from the loess deposits and contribute much silt to some areas of these soils. All of these soils have been shifted and reworked by the wind to such an extent that the source of the original material is difficult to ascertain. As the proportions of the original materials vary, the soil types differ in texture and color, but each is fairly uniform over its area. In texture they cover a wide range, from sandy to a heavy, silty fine sandy loam. Only two separations have been made in this survey, one including the sands and sandy loams, the other the fine sandy loam member of the series.

RICHFIELD SANDS AND SANDY LOAMS.

Description.—There are included under this classification sands and sandy loams which have been derived partly from the sandy strata of the Tertiary and partly from wind-blown materials from the loess region. The soils usually occur in association with the loess, either on its borders or included within its area. The western extension of the loess becomes more and more sandy and its materials become mixed with locally derived sands to form these types. Occurring as they do over a vast stretch of country, and weathering under different climatic conditions, the Richfield sands and sandy loams necessarily have a wide range of texture. They have in this survey been made to include all gradations between the very silty sandy loams on the flanks of the loess to loose sands, including small areas of Dunesand. Ordinarily the Dunesand would have been separated, but in some areas of these types, as in the western part of Dundy County and in Lincoln County, south of North Platte, areas of sand-hill material in small knolls and ridges occur in such frequency and are so widely distributed over the bodies of sandy loam that a separation is not feasible in a reconnoissance survey.

The soil of the sandy loams consists of a fine sandy loam 10 inches deep, having a gray to dark-brown color. There is sufficient silt or clay in the surface to make it slightly coherent when wet. The silt content varies widely in different parts of the area. Near the areas of Colby silt loam toward the east and bordering the Sidney loam on the west there is an increase in the silt content. Where the soil has been reworked and shifted by the wind the finer materials are less abundant. The usual distribution is for the sandy loam phase to occur in flats and valleys between hills and ridges of sand. The subsoil of the sandy loam is slightly heavier than the soil, the silt content being greater near the areas of heavier soils. It is slightly lighter in color than the soil. Toward the western part of the area, where the type is in association with the soils of the Sidney series, the fine material becomes more abundant as the depth increases, and below 36 inches there may be the calcareous silty subsoil, locally known as "magnesia," similar to that which underlies the soils of the Sidney series.

The greater proportion of the areas of Richfield sands covers low, choppy hills of typical dune contour. The soil is more sandy than on the areas of sandy loam, being usually a loamy sand closely approaching a pure sand. There are interspersed over these soils the areas of Dunesand already mentioned. The texture of the soils of the dunelike hills seems to depend either upon the extent to which the fine materials have been removed by the wind or upon the amount of weathering that has taken place since the dunes became stationary.

Only a small proportion of these hills are being moved by the wind at the present time, but care must be taken in breaking the land to prevent the starting of local "blowouts."

The large area of low Sand Hills in Lincoln County south of South Platte River have been included with these soils. In some respects they resemble the Sand Hills north of the river, but differ in certain features. As a rule these hills do not have the sharply rolling, dunelike topography of the great sand-hill areas to the north, but consist of low, rounded hills that have lost their dune shape to some extent. They contain more fine material and more organic matter, so that the soil is bound together more firmly. The underlying material is more compact, and the roads through this section are much better than those through the true Dunesand region. The surface soil is a light yellowish gray color, and the texture ranges from medium to very fine sand, with enough finer material to give it a slightly sticky nature when wet. At lower depths the sand usually has less of the cementing material and the color is lighter.

There are numerous areas, either nearly level or gently rolling, where the type resembles the Sidney sandy loam, but differs from it in that it does not possess a heavy subsoil, nor is it underlain by the calcareous deposit.

Somewhat similar soils and topography are found in the western part of Dundy County, except that the areas of drifting dunes make up a much larger proportion of the surface.

In Greeley and Valley Counties areas of this type lie between the loess-covered plain and the sand-hill region. Much of it closely resembles the sand-hills material, into which it gradually merges. In this section the topography is that of the dunes. The soils are somewhat loamier than Dunesand and have a higher agricultural value. Here is found the loamier texture, owing to the weathering of the dunes and to the admixture of fine material blown from the great loess belt to the east.

Location.—There are two large areas in the southwestern part of the State, one in Lincoln County, including the low sand-hill country already described, the other in the western part of Dundy County, of large extent as mapped, but really including numerous small areas of Dunesand. There are also several areas of the type occurring as strips on the border of the loess soils. Farther east and throughout the areas of the loess there are strips of various sizes, many too small to map, which represent sands blown from the stream beds and mixed with more or less silt from the loess. North of Platte River the types occur in association with the loess, usually intervening between the loess and the dunes.

Topography.—The topography varies from nearly level to rolling. The sharply rolling hills which make up the greater part of the areas are the result of wind action. There is only a small proportion of

the type that does not show some evidence of such force in shaping the contours of the hills. The dunelike topography is especially marked in the large area in Dundy County and in the numerous small areas in the loess region. The largest area of the type in Lincoln County, as already stated, has low, rounded hills, with intervening flats and valleys. In the eastern part of the area surveyed the more level land is found on gentle slopes toward the streams.

Native vegetation.—The native vegetation consists of many species of grasses. The most common are bunch grass or sand grass, blue stem, and a small proportion of buffalo and grama grasses, yucca, and various weeds. The large number of grasses insures grazing in all seasons and gives the variety so much desired by the stockmen.

Utilization.—Though only a small proportion of the area of these types is cultivated, they are by no means without value. As pasture they are not surpassed by any other soils, as they hold their moisture and furnish good grazing during droughts, when grasses on the "hard land" are worthless. The greatest obstacle to cultivation is the tendency to drift whenever the sod is broken. In the western part of the State it is best to cultivate only the more loamy areas or the sandy areas that have some natural protection. The most successful crops are corn and sorghum.

RICHFIELD FINE SANDY LOAM.

Description.—The soil of the Richfield fine sandy loam consists of a very light brown to gray very fine sandy loam. The depth ranges from 6 to 16 inches, with an average of about 12 inches. There is not usually any marked difference between the soil and the subsoil, except the usual decrease in the humus content below the surface. There is a considerable variation in the composition of this type in different parts of its area, but it was not practicable to make a separation in this survey. In the portion of its area north of Holdrege the soil is a fine loamy sand or fine sandy loam with sufficient silt and clay to cause a slight crust to form on the surface. For this reason the section where it occurs is locally known as the "clay hills."

Location.—The most extensive area of this type extends as a strip from 3 to 5 miles wide from a point near the center of Phelps County through Kearney and into Hall and Adams Counties. There are several smaller areas scattered through the loess region, usually occurring on the border between the loess and the more sandy materials. Areas of several square miles occur south of North Platte, where it was mapped in the survey of the North Platte area as the Finney fine sandy loam. It also occurs along the extreme western edge of the loess where it merges into the Sidney sandy loam.

Topography.—The areas covered by this soil usually present a more or less rolling topography. Where the type covers the slopes toward the streams, particularly in the more silty areas, it erodes almost as readily as the loess, and a very hilly topography results, with occasional bare slopes and bluffs. Wind has nearly everywhere had a part in shaping the surface features. In the area north of Holdrege the type occupies a series of peculiar rounded knolls that rise abruptly from the level silt-covered plain and show unmistakably their formation by wind action. In other parts of the areas occupied by the type there are small knolls heaped up by the wind, but there is no active movement of the sand at the present time.

Origin.—The Richfield fine sandy loam owes its present position to wind action. The material of which it is composed has been accumulated either by assortment from the loess or from sands gathered up in the stream channels. In most places there is a mixture of materials from each of these sources. The color is usually a lighter gray than that of the sands derived from the Tertiary formations, and this, with the more silty texture, indicates the presence of materials brought from the loess deposits. The position of the areas and the high sand content indicate that some of the sand has been gathered either from the Ogallala or other Tertiary formations or from the reworked sands of the stream beds.

Utilization.—The more loamy and level areas of this type are under cultivation, but the sharply rolling hills are used only for pasture. The soil supports a good growth of native grasses, including not only the species found on the sandy soils, but also the grama and buffalo grasses.

Toward the western part of the area covered by this type, where moisture conservation is of principal importance, the type has a higher relative value. Corn and sorghum are the most common crops. Yields in different parts of the area depend upon the amount of rainfall and upon the topography of the land. In the area in Phelps and Kearney Counties small grains are grown to some extent, but yields are not high. Winter wheat is not very successful on this type. Corn yields an average of about 20 bushels per acre in the western areas of the type, but the yield increases to about 30 bushels toward the east.

VALENTINE SERIES.

In the northern part of Nebraska the sandy strata of the Tertiary have weathered into a number of soil types, with certain common characteristics, which have been grouped into the Valentine series. These soils are closely associated with the extensive sand dunes, occurring among them or along their borders, and it is very probable

that they have a similar origin. The members of this series range in texture from sandy loams to sands approaching the Dunesand in texture and in coherency. The distinguishing features of the soils of this series is the brown color and their sticky nature, which is imparted by varying quantities of fine clay. The exact origin of these soils and the processes of their formation is not easily ascertained. The heavier texture may be due to the nature of the material from which they have weathered, or in the flats and valleys it may be imparted by fine material assorted from the sands that have gone to build up the dunes. The extent of the action of wind in their formation is not easily calculated, but it is apparent that wind-blown materials have modified these soils to greater or less extent in all localities. Toward the eastern edge of the area fine materials blown from the loess region have contributed to the loamy portions of the soils.

VALENTINE SAND.

Description.—Although similar in some respects to the soil material of the sand dunes, it differs from it in color, topography, and humus content. The soil of the Valentine sand consists of a medium to fine sand, slightly darker in color than the typical dune sand, having a depth of 6 to 12 inches. Below this the dark color due to the organic matter decreases and the subsoil gradually becomes lighter with increase of depth. Below 36 inches is found a loose, yellow, incoherent sand, resembling that of the true dunes. When it occurs contiguous to bodies of the Gannett fine sand or along strips of alluvial land it has been more or less influenced by the addition of transported material, and two phases of the type were noted that could not be separated on a map of small scale. The first consists of a variation from the true type caused by the intermingling of the fine sands, silts, and organic matter of the lowlands, giving a silty fine sand. The second phase consists of a lighter colored material, carrying more or less coarse sand and fine gravel, giving a coarse sand of gray color. These variations usually cover only small areas, and the greater part of the Valentine sand is true to type.

A mechanical analysis of a sample of soil gave the following results:

Mechanical analysis of Valentine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370709	Soil	0.3	5.3	12.9	62.4	10.8	4.1	4.0

Topography.—The Valentine sand occupies country of level to undulating topography, occasionally broken by small hills and ridges

of Dunesand, seldom more than 12 feet in height. In practically all instances this soil occurs between the areas of Gannett fine sand and the Dunesand. The somewhat level flats upon which it occurs have the appearance of terraces lying between the dunes and the lowlands.

Origin.—The Valentine sand probably has an origin similar to that of the other soils of this series, as it is no doubt derived in part from the weathering of a sandy strata of the Tertiary. The original material, however, has been greatly modified by the addition of finer material from the Sand Hills and in the extreme eastern part to wind-blown silt and fine sand from the loess areas.

Utilization.—On account of its topographic position, this soil has, as a rule, excellent drainage. The porous character of the material of which it is composed allows the free internal movement of water, and excess of seepage which occurs along the river and smaller creeks can easily be removed by open ditches.

This soil is easily tilled and one of its chief advantages is the fact that tillage and grazing immediately after rains have no serious effect upon the physical condition. At present the greater area is devoted to hay, on account of the excellent growth of grasses usually found. Corn is grown to some extent and yields are fair. Alfalfa does well on restricted areas where the underground water conditions are favorable.

VALENTINE FINE SANDY LOAM.

Description.—The surface soil of the Valentine fine sandy loam varies widely in texture in different parts of the area. Usually it consists of a light-brown fine sandy loam with an average depth of 14 inches, but there is a range from very fine sandy loam to loam. The sandier phases are found in the rolling country and near the boundaries of the Dunesand it passes gradually into a loose, incoherent sand, having a depth of 24 inches. The small, isolated areas of the type that occur in the western part of the sand-hill region, constituting the farming land in that country, have a deeper soil, with finer textured sands and silts, and lack the sandy clay subsoil of the typical areas. In Brown, Rock, and Holt Counties the soil has a variable and rapidly changing texture, but the average is a sandy loam of a more decided brown color than elsewhere.

The typical subsoil consists of a layer 12 to 24 inches in thickness of a lighter colored sandy loam, with a clay content gradually increasing with depth. The clay is very fine and gives the material its characteristic sticky nature. In some places, though the clay content is really small, the subsoil has the attributes of a sandy clay. Below this layer is a mass of pale-gray or whitish-gray somewhat silty loam to fine sandy loam, containing in some localities, particularly southeast of Cody in Cherry County, a rather high percentage of the coarse-grade sands and occasionally small gravel.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Valentine fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370702	Soil	0.0	4.9	11.8	36.5	24.9	13.9	7.7
370703	Subsoil	.0	2.4	5.7	29.6	29.5	17.7	15.1

Location and topography.—The Valentine fine sandy loam occupies usually the level areas called flats, but considerable areas have a rolling topography. Low, gently rolling hills and ridges are covered by the more sandy phases of the type. Near the streams the areas of the soil are badly eroded and cut by drainage channels. The most level portions of the type are found on the terrace-like flats along the larger streams, and here the soil of heaviest texture is found.

Origin.—The origin of the Valentine fine sandy loam, like that of the other soils of the series, is hard to determine. Its formation can hardly be ascribed to any one agency, but its position would indicate that usually it has been derived by weathering from sandy strata of the Tertiary formations where they have been exposed in the deeper valleys and on the outer slopes of sand hills. To the weathered products of the rocks there has in almost every instance been added the washed out finer materials of the adjacent sand hills and also some fine wind-blown material. The sand of which this type is so largely composed contains a large proportion of feldspar, which weathers rapidly, and much of the finer material may have come from this source. The position of the type has favored the accumulation of more organic matter than is found in the more sandy soils of the same region. This in itself has made the soil more loamy.

Utilization.—The Valentine fine sandy loam is a valuable farming soil, ranking next to the Rosebud soils. Besides its natural productiveness, it has a texture particularly suiting it to cultivation under the local climatic conditions. Its loose, porous structure permits the rainfall to enter and makes easy the cultivation necessary to retain moisture in the soil. The principal field products are corn, potatoes, and forage crops. Corn is a profitable crop, though yields vary widely, ranging in different seasons from 10 to 40 bushels per acre. Wheat is not extensively grown, though fair yields are obtained. Oats are grown to some extent, yielding well in normal seasons. Potatoes have for several years been one of the most profitable crops, the yield ranging from 75 to 150 bushels per acre. The average is about 85 bushels and the price ranges from 50 to 90 cents a bushel.

VALENTINE LOAMY SAND.

Description.—Throughout the sand-hill region there are numerous areas of depressed topography which have a loamy sandy soil, with a large percentage of organic matter. The soil is usually quite variable over these flats, having a range in texture between the Valentine sand and the Valentine fine sandy loam. This type, which has been called the Valentine loamy sand, covers two main kinds of topography. The largest single areas are found on the flats between the Dunesand and the alluvial lands along Niobrara River and Elkhorn River, but by far the greater total acreage is included by the phase locally known as "dry meadow," comprising the shut-in valleys and basins that occur over nearly all of the sand-hill region.

The usual soil of the river-valley phase consists of a medium to fine sand that has a somewhat loamy nature, owing to a small percentage of clay, silt, and finely divided organic matter. In color it ranges from dark gray to dark brown, in many places slightly darker than the other soils of the Valentine series. The subsoil gradually passes into a lighter colored sand at 24 inches, more loose and incoherent than the soil, and below 36 inches, except in some of the lower lying areas of Cherry County, the subsoil is hardly to be distinguished from the subsoil of the Dunesand, being a fine to medium yellow sand.

The soil is easily tilled, and the loosened surface is not so readily removed by the wind as some other more sandy soils, though this danger always threatens to some extent.

There are several minor phases that depart from the typical areas in some respects. Near the breaks of Niobrara River the wash from areas of Pierre clay has in some places influenced the texture of the soil, and along the boundary of the two soils the Valentine loamy sand has in some small areas a dark-gray sandy clay subsoil. Other areas have been modified by wind-blown sand, which often covers the surface to a shallow depth. To the north of Page, in Holt County, a phase is encountered that has a higher percentage of coarse sand than the typical soil and occasionally carries rounded quartz gravel.

A mechanical analysis of a sample of soil gave the following results:

Mechanical analysis of Valentine loamy sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370708.....	Soil.....	0.2	3.8	11.1	48.3	20.8	9.0	6.7

Location.—The largest areas of this river-valley phase of the type are located along Niobrara River, in Cherry and Holt Counties, and

along Elkhorn River, in Holt County. It occupies strips following the course of the stream along the Niobrara, where the valley is well defined, but in the Elkhorn River Valley, which is wider, the areas are more irregular in their occurrence.

Topography.—The topography occupied is that of depressed areas along the valleys at the footslopes of the Sand Hills. The bodies of the type in Cherry County along the Niobrara lie from 50 to 100 feet above the river and have the appearance of terraces. On the Elkhorn the areas are nearer the stream level and have more the appearance of flats of partly colluvial material in a valley of restricted drainage. The type usually has a level to gently undulating surface, broken by small ridges and knolls composed of sand brought down from the dunes.

Origin.—The Valentine loamy sand is composed of sands originally released by weathering from Tertiary rocks, but it has been so shifted by wind and water redeposited and subsequently weathered that it is not possible to make any positive classification in regard to origin. The greater proportion of the type appears to be partly colluvial material deposited in depressed and well-watered areas where the accumulation of organic matter has been favored. The clay content is probably due in part to the weathering of the feldspathic materials in the sand.

Utilization.—The loamy texture and the large amount of organic matter in the soil gives this type a preeminent position over the other sandy types of the area. Its general use is for the production of corn, sorghum, and potatoes for the ranchmen on the borders of the Sand Hills. On the areas in Cherry County there are prosperous farmers and stockmen who have used this soil for growing corn and in late years for the production of potatoes as a money crop.

Valentine loamy sand, basin phase.—The lands locally called "dry meadows" have been mapped as the Valentine loamy sand, basin phase. Areas of this type are widely distributed over the sand-hill region. The largest of these have been indicated on the map, but only a comparatively few are of sufficient size to be shown. In shape and topography they resemble the "wet meadows" or areas of Gannett fine sand, but they are of shallower depth and do not enter the sheet of ground water that produces the lakes and meadows. They occur in two shapes—irregular depressions resembling lake basins and long, narrow valleys that are evidently restricted stream channels.

The soil of this phase of the Valentine loamy sand as found in these areas is variable in texture. In spots and strips in the center of the depressions there is often a very loamy soil, closely approach-

ing a sandy loam in texture, but toward the outer edges the soil becomes more sandy and gradually merges into the true Dunesand. This condition is common in the series of long, narrow valleys, including Survey Valley, in the southwestern part of Cherry County. The usual soil, however, is a brown, loamy, fine to medium sand, 6 to 18 inches deep, containing a large percentage of organic matter, but less than is present in the "wet-meadow" soils. The subsoil is a sand of similar texture, but of lighter color, and at lower depths it closely resembles the material of the dunes.

The surface soil is coherent and not easily moved by the wind when it is first brought under cultivation, but it becomes more unstable under cultivation.

Location.—The largest areas of this type are distributed over the entire sand-hill region, but are most numerous in southern Cherry, and central McPherson Counties. In southern Cherry County they take the form of long, narrow valleys having a west to east course parallel to the numerous "wet meadows" on the north.

Origin.—The soils owe their origin to reworked and reweathered Tertiary sands deposited in valleys and flats of restricted drainage formed from old valleys choked by drifting sand.

Utilization.—The underground water, though not close enough to the surface to form lakes or cause a marshy condition, has a marked effect upon the growth of vegetation, and many of the areas support a heavy growth of grass, which is an important source of hay. Ranching is made possible by the "dry meadows" in many sections where the "wet meadows" do not exist. The higher valleys, where the grass is not so rank, form the part of the type cultivated. In McPherson, Logan, Custer, and the southern part of Cherry Counties these areas are used for growing corn and small grains. In these valleys crops are more likely to suffer in droughts and yields are not much higher than on other sandy soils of this region. It is not advisable to break a good sod on this type in order to grow cultivated crops.

Epping Series.

The formation known to geologists as Brule clay is exposed in the western part of the State in several localities. It outcrops in a band around the southern slope of the Black Hills uplift, where it has been tilted and partly eroded. It is also extensively exposed in the North Platte Valley and a narrow part follows Lodgepole Creek.

The material of this formation after being reworked and assorted by wind and water enters into the composition of several soils, the

terrace and alluvial soils of North Platte River being modified by it as well as the Dawes fine sandy loams and silt loams. The pure material of this formation produces a series of very fine sandy loams and silt loams, which might have been separated in a more detailed survey, but in this reconnoissance only the predominant type, called the Epping silt loam, has been recognized.

EPPING SILT LOAM.

Description.—The Epping silt loam as mapped is rather variable in texture, but it has certain characteristics that are comparatively constant. The typical soil is a light yellowish gray or buff-colored silt loam, having a depth of 12 to 20 inches. The soil is not friable when first worked, but improves under tillage. The sand content varies in different parts of the area, but is usually sufficient to give the soil a gritty feel. There is little difference between the soil and subsoil in the cultivated areas, except in content of organic matter, which is greater in the soil. In the uncultivated portions of the type there is so little organic matter in the soil that this difference is not apparent. The erosion of the material has gone on very rapidly, so that in many places the loose soil is only a few inches deep and rests upon the unweathered Brule clay, a compact silty material locally known where it approaches the surface as hardpan. In the large body of the type found south of Morrill this compact stratum is near the surface over extensive areas. Here wind and water have carried away the soil nearly as fast as it has been formed. The same condition also prevails in the valleys of Kiowa, Owl, and Horse Creeks. From the topography and general surface features of these valleys their floors would be considered alluvium, but close examination shows very little upbuilding of alluvial material. In all such areas there may be found bare spots and patches of incipient bad-lands topography, where the weathered soil has been entirely removed and the unproductive Brule formation left bare. South of Scotts Bluff and along the northern part of Scotts Bluff County and in the southwestern part of Sioux County the soil is deeper and more variable in composition. Here weathering has gone on more thoroughly and there have been accretions of material from the higher lying areas of the Epping silt loam, so that the soil is deeper and the original material can rarely be found at a depth of less than 3 feet. In this section a larger percentage of sand and gravel is found in spots over the soil. This has been derived from material brought down from the Arickaree formation. These sandier areas are so small and so indiscriminately distributed through the true silt-loam areas that it was not practicable to separate them.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Epping silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370749	Soil	0.0	0.2	0.2	5.6	27.5	50.9	15.6
370750	Subsoil	.0	.0	1.0	4.3	10.4	69.6	14.7

The following samples contain more than one-half of 1 per cent Calcium carbonate ($CaCO_3$): No. 370749, 5.70 per cent; No. 370750, 6.70 per cent.

Location.—The Epping silt loam is always found between the alluvial valleys and the higher rough broken land of the Arikaree formation. There is a large area of the type lying in this position south of the North Platte River, extending from the bottom lands to the steep bluffs that flank the valley on the south and winding among the hills that are capped by the harder formations. In a similar position there are smaller bodies of the type along the slopes of Pumpkin Seed Creek Valley. On the north side of the North Platte River there are strips of the type extending from the escarpment on the north toward the river, and in some places down to the old river terraces.

Topography.—The Epping silt loam has a topography ranging from the bad-lands type to long, gentle slopes and almost level flats. On the tracts with generally level surface there are often local interruptions, such as washes and gullies. There is always sufficient slope to give adequate drainage.

Origin.—The Brule clay from which this type is derived outcrops in deeply cut valleys, where it lies below the Chadron and the Arikaree formations. In this section the material is comparatively thin, not averaging over 300 feet in thickness. It is a silty material which, though somewhat compact and impervious, is easily weathered when exposed. Where protection is afforded by the cappings of harder material, slopes of the Brule clay rise abruptly from the plains. The many bluffs and bad-land formations of the rough country in the vicinity of Scotts Bluff are due to irregular weathering of the partially protected areas of the Brule formation.

Native vegetation.—The native growth on this type of soil consists mainly of buffalo and grama grass, but they do not furnish as good pasturage as the Sidney silt loam or the Tripp loam, on account of the droughty character of the soil.

Utilization.—Under the dry-farming system the deeper phases of this type give nearly as large crop yields as any other soil of the

area, but the shallower phases are not suitable for use without irrigation. Where water is available good yields of alfalfa, wheat, barley, and potatoes are obtained. The greatest deficiency of this type is its lack of organic matter. In level areas, where the content of organic matter is greater or where the land has been under cultivation for some time, good crops are grown.

This soil contains some alkali, derived from the parent rock. Where dry farming is followed the crops are not likely to suffer from an excess of injurious salts, but under irrigation, unless means are taken to prevent these accumulations at the surface, injury will probably result.

Miscellaneous Types.

Orella clay loams and silty clay loams.

Description.—The usual soil mapped in the group of Orella clay loams and silty clay loams consists of a grayish-brown to light yellowish brown clay loam, the texture ranging from medium to heavy, depending upon the proportion of silt present. Its depth is very variable, ranging from a few inches to 3 feet or more. The characteristic feature of the type is the appearance of the subsoil, which consists of a clay varying in color from a light greenish gray in some places to a deep red and yellow in others. Over much of the area the soil extends to a depth of more than 3 feet and often the highly colored subsoil is lacking, particularly near the areas of Pierre clays. The soil resembles that of the Pierre clay loams in some respects, but is usually of a lighter color and lacks the extreme stickiness of the Pierre soils. The subsoil is distinctly different and serves to identify these types wherever found.

The land is difficult to break, on account of the compact nature of the soil, but after a few years of tillage the surface becomes quite loose and friable and the type is retentive of moisture when properly handled.

A mechanical analysis of Orella clay loam gave the following results:

Mechanical analysis of Orella clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370745.....	Soil.....	0.0	0.0	0.3	1.1	19.7	53.9	25.0

The following sample contained more than one-half of 1 per cent Calcium carbonate ($CaCO_3$): No. 370745, 8.88 per cent.

Location.—These soils are not extensively developed, consisting of only a few square miles. They are confined to a single area in the vicinity of Orella, lying partly in Sioux and partly in Dawes County.

Origin.—These Orella soils are the only types that have been derived wholly from the Chadron formation. The original material is described by Darton as predominantly a sandy clay of light greenish-gray color, usually with coarser beds at the bottom, including deposits of gravel. The beds above the gravel are often of pronounced dark-red color.

Utilization.—The agriculture suited to these types is the same as that followed on the Pierre clays. These types are preferred, however, on account of the more loose and friable structure of the soil. Corn, small grains, and potatoes, the last to a small extent, are the crops grown. A farm system that includes stock raising and dairying is best suited to these soils. The principal occupation of the farmer should be to grow feed for his stock.

DAWES FINE SANDY LOAMS AND SILT LOAMS.

Description.—The group of soils mapped as Dawes fine sandy loams and silt loams vary in texture over different parts of the area from rather heavy silt loams to fine very sandy loams. As these soils occupy a position below the gray silty and sandy soils of the Rosebud series and the buff-colored silt loams of the Brule formation, they partake of the characteristics of each of these series and are also greatly modified by accumulations of wind-blown sands. On the ridges the usual surface soil is an ashy gray to light-brown silty loam having an average depth of 10 inches. The subsoil to a depth of many feet consists of a pinkish-white silt loam. The surface soil resembles that of the Rosebud silt loam, while the subsoil is more like that of the Epping silt loam. On the slopes and lower areas the surface soil is much deeper and is a brownish gray to a depth of several feet. In places where the surface soil is shallow the Brule clay formation is found beneath, but usually that formation is deeply covered by wash from the Arickaree formation that has been mixed with it to produce silty and fine sandy loams.

The soil is friable and easily cultivated. A surface mulch can easily be formed to conserve moisture, but one that is not so easily removed by the winds as on the more sandy types.

Topography.—The greater portion of these soils cover moderately rolling ridges and slopes. It is also found less typically developed over wind-formed ridges and rough broken country closely approaching Bad Lands. There are within the areas of these types small ridges and knolls of typical Dunesand, usually too small to indicate on the map, and also small areas of true Bad Lands on the steeper slopes.

Location.—These soils occupy a long, irregular area, extending around the southern border of the Black Hills uplift through the counties of Sioux, Dawes, and Sheridan. They are separated from

the High Plains to the south by the rough, broken slopes of the Pine Ridge escarpment and from the soils of the Pierre clay formation to the north by White River.

Origin.—The group of soils under this classification may be regarded as a mixture of materials derived from various sources. The several rock formations outcrop in such narrow irregular areas and their weathered products have become so intermixed that no considerable areas could be placed with other established types, and this group has been made to include the entire series. The weathered product of the Arickaree formation is in most places the chief constituent of the soil, but the buff or flesh-colored silt of the Brule clay formation is often present in the subsoil. Over all the lower slopes and valleys both colluvial wash and wind-blown materials have greatly modified the surface soils.

Utilization.—These soils rank somewhat higher in agricultural value than the sandier soils of the Rosebud series. The valleys and gentle slopes in the country surrounding the towns of Crawford and Chadron are extensively cultivated, but the area of the types as a whole is thinly settled. The soil is adapted to the general crops of this section and particularly to the truck crops. Of the latter only potatoes are grown for shipment to outside markets.

As grazing land these soils rank with the best types of the section. The native grasses include practically all the species of the heavy silt loams and in addition variety is given to the pasturage by the weeds and shrubs of valley lands.

SOILS FROM WIND-LAID DEPOSITS.

Colby Series.

The Colby series includes the weathered products of the extensive loess deposit that covers the southeastern part of the area. The series was established to cover the soils of the western extension of the loess, which have weathered under partly arid conditions and in consequence are lighter in color and have other properties differing from the loess soils of the more humid regions.

COLBY SILT LOAM.

Description.—The Colby silt loam stretches nearly across the southern part of the area, where there is a gradual variation, as we pass from east to west, from 27 to 17 inches of rainfall, and the type, on account of the changes in moisture conditions, has many phases of color, texture, and topography. These changes in the character of the soil take place very gradually, but the differences between the soils of the extreme eastern and the extreme western portions af the area are quite marked. There are, however, common characteristics of the type wherever found, and in some respects it is remarkably uniform.

The surface soil is usually quite constant in texture, consisting of a silt loam with a small proportion of very fine sand and sufficient clay to give a slightly compact structure. The color is more variable than the texture, since it depends upon the extent of the weathering and the quantity of organic matter present, and both of these factors are determined largely by the amount of rainfall. In the western part of the State the soil is a light ashy gray or light brown, and the color gradually becomes darker toward the east, passing into a dark gray or dark brownish gray. The depth of the soil varies with the state of weathering and the amount of erosion from 6 to 24 inches, but the usual depth is from 12 to 18 inches.

In the eastern part of the area there are usually two distinct zones of the subsoil, the upper consisting of heavy weathered material and the lower of loose, mealy loess. The heavy stratum beneath the silty top soil is often a silty clay loam or heavy silt loam having a brown color and a compact structure. It varies in thickness from 2 to 6 inches in the sections of most advanced weathering. Where the heavy stratum is very hard and compact, it is called "hardpan" by the farmers, but it rarely affects the agricultural value of the land. Toward the western part of the State, where weathering is less advanced, the heavy zone is entirely lacking or is very slightly developed.

Below this zone to a depth of more than 36 inches is the less weathered loess, which is everywhere characteristic of the type. It consists of a light-yellow to yellowish-brown very silty loam, closely approaching a pure silt in its properties. It is loose or very slightly cemented in structure and has the smooth, mealy feel characteristic of the unweathered loess in the Mississippi Valley.

The depth at which this less-weathered loess is found varies according to the amount of rainfall and the character of the topography. The weathered top soils are deepest on the broad, level divide in Adams, Kearney, and Phelps Counties and shallowest on the eroded areas in the southwestern part of the State.

The virgin sod on the Colby silt loam is hard and compact and the first breaking is difficult, but when under cultivation tillage is not difficult. With the proper moisture content the soil breaks into a mellow seed bed; when dry it is hard to plow and if broken in this condition it is cloddy and difficult to handle.

When conditions are favorable and the soil is thoroughly prepared it retains moisture fairly well. While not so efficient in this respect as the more sandy soils, it has this advantage, that the surface soil is not so easily drifted, as it can be broken into granular clods, small enough to form a fairly effective mulch and too heavy to be moved by ordinary winds.

Location.—The Colby silt loam may be said in a broad way to cover the southeastern corner of the area. Along the southern border it extends in an unbroken body from near the central part of Chase County to the eastern border of the area. Northward along the eastern border it extends more than one-half the distance across the State, touching the counties of Garfield and Wheeler. To the southwest various lobes of the type extend into Custer, Lincoln, and Perkins Counties. The largest unbroken area and the most uniform in composition is that south of Platte River in Adams, Kearney, and Phelps Counties. Other portions of the type are broken by strips of alluvial land or by encroaching sand dunes.

The variations from the usual type in this soil occur principally on the borders. There is a gradual increase in the proportion of fine sand in the soil toward the west and on some of the extreme lobes it passes gradually into a fine sandy loam. On its northern border, touching the great sand-hill region, there has been added a large percentage of medium and fine sand of the true sanddune type. Over the more level divides covered by the Colby silt loam there are numerous small depressions which are now or were formerly subject to standing water in wet seasons. The soils are usually darker in color and heavier in texture and in some places consist of heavy clays to a depth of several feet. These soils would have been separated from the Colby silt loam if a map of larger scale had been used. In a few of these depressions, mostly in Gosper and Phelps Counties, alkali has accumulated near the surface and in some cases has proved injurious to crops.

Topography.—The type has a topography ranging from sharply rolling to almost level, depending upon the progress made by erosion in the dissection of the loess mantle that originally covered the plains. The least eroded section is that including a large part of the counties of Gosper, Phelps, Kearney, and Adams. In all other parts of the type erosion has been active and the land is more or less hilly. In some parts of Custer, Buffalo, and Dawson Counties a sharply rolling and often broken topography has been produced and along some of the slopes toward Platte River the land is so rough that its value for farming is seriously lessened.

Origin.—The Colby silt loam is derived through weathering from the loess that covers the southeastern part of Nebraska and a large area in adjoining States. Originally it covered the entire surface beyond the region where it now extends, but it has been cut through by the larger streams and areas of drifting sand have encroached upon it, particularly on the borders near the great sand-hill region. The typical loess is characterized by its even-grained, silty texture, porous structure, light-buff color, and the presence of a weak calcareous cement. On the higher plains the material has a depth of

about 100 feet, but thins out toward the edges.[1] It generally lies, particularly toward the east, upon a mass of gravel, which has been identified as glacial drift. In the western part of its area it overlies the older formation and in some places merges gradually into the sandy materials.

As before stated, the loess has weathered in some places more than in others, but everywhere there has been some alteration in the material. Naturally where erosion has been less active and on level areas where the surface has been more subject to standing water weathering has gone on more rapidly and the resultant soils are heavier in texture and darker in color.

Native vegetation.—In its original state the Colby silt loam was covered by a thick growth of buffalo, grama, and other short grasses. No trees originally grew on the type, but trees of several species are now grown around the farmhouses in the eastern part of the area.

Utilization.—In this area the Colby silt loam lies for the most part in the belt of adequate rainfall. In the two eastern tiers of counties the average rainfall is sufficient to make good crops and failures rarely occur. In the narrow strips of this type farther west the rainfall gradually decreases to less than 18 inches and here agriculture on the type is subject to the climatic deficiencies of that region. The texture of soil and subsoil in all parts of the areas of Colby silt loam is favorable to the retention of moisture if the land is prepared in time to receive the rainfall of the summer and autumn months. Wheat and corn are the principal crops on this type in Nebraska, but oats, sorghum, and barley are grown to some extent.

The average yield per acre of wheat varies from 10 bushels in the western part of the State to about 14 bushels in the eastern part. The average for corn ranges from 18 to 30 bushels. The price of the Colby silt loam probably averages higher than that of any other upland soil. In the western counties it is held at $10 to $20 an acre, but in the east, particularly in Hall and Adams Counties, it brings from $30 to $60 an acre.

Miscellaneous Types.

DUNESAND.

Description.—The Dunesand covers practically all of that extensive region widely known as the Sand Hills. It consists of a yellowish-gray or brownish-gray sand, of smooth and uniform fine to medium texture, with small percentages of silt or clay. The material extends to great depths. The structure is always very incoherent, with little variation from soil to subsoil. Slightly greater percentages of organic matter usually occur in the surface few inches, but there is never sufficient to hold the soil against drifting when the

[1] Water Supply and Irrigation Paper No. 216, U. S. Geol. Sur.

native grasses are destroyed. It is rather unusually retentive of moisture, considering its loose structure. All rainfall is immediately absorbed and rarely does run-off occur, even upon the steepest slopes.

There is little variation from the typical description in different areas. However, between the great ridges of the type and in numerous small basins occur bodies of soil locally known as "dry valleys." They are most often only a few acres in extent, but in other cases are developed as long, narrow swales, very gentle slopes or irregular, dune-choked, valleylike depressions. The total extent of areas of this nature is relatively small, but they are widely distributed. The greatest occurrence coincides with the general localities where the "wet meadows" are most frequent, the dry-valleys phase often surrounding or occupying the breaks between a succession of meadows. Such areas represent an intermediate condition between the more elevated typical Dunesand and the depressed swampy "wet meadows." The soil material of these places is sometimes a slightly finer grade of sand, assorted by wind action and influenced by a higher content of organic matter. Even in such instances destruction of the native sod is followed by considerable damage to the surface by wind erosion. Where the "dry-meadow" areas were large enough they were mapped as a distinct soil, but the small areas are included with the Dunesand.

A mechanical analysis of Dunesand gave the following results:

Mechanical analysis of Dunesand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370701	Soil	0.0	0.7	7.7	73.7	15.2	0.7	1.9

Location.—The Dunesand comprises 18,237 square miles of the western Nebraska survey and constitutes over two-thirds of the area north of the Platte River. A continuation of this vast area was also encountered in the survey of western South Dakota. It will also be found in a smaller way in eastern Wyoming and Colorado.

Topography.—Wind action has been the controlling influence in forming the monotonous topographical features of the Dunesand. The surface is sharply rolling, ridged, and heaped into dunes, varying from 30 to 100 feet in height. In a broader view it is noted that the minor hills and swells are grouped so that the region is composed of greater general ridges having a southeasterly and more rarely an easterly trend. It is between these greater ridges that low elevations are reached with moisture conditions giving the characteristic "wet meadows." Steep slopes abound, and altogether the topography is very discouraging to agriculture, irrespective of adverse soil and

moisture conditions. Small hummocks of wind-lodged sand, hollows, and "blow-outs" are of constant occurrence and vary the otherwise billowy appearance of the landscape. A negligible amount of the type is at present under active wind erosion. Patches or slashes along old roads and limited localities here and there where the wind has had an opportunity to work upon a bare surface shows plainly the disastrous effects of disturbing the soil-binding roots. As mentioned before, the slight rainfall is speedily absorbed by this porous type. Although the locality has a considerable fall to the south and east, no continuous waterways have been opened through the main body of the type. Intrusion of cross dunes has no doubt hindered the development of drainageways. In addition to the rainfall upon the type, considerable run-off enters its porous locality from the high plains of the Alliance region. This vast reservoir is relieved of its accumulated subsurface water principally by the Dismal and Loup Rivers. These streams break suddenly from the lower edge of the Dunesand and are fed entirely by gushing springs. They gather great quantities of water in short distances and relieve the regions along their upper courses, so that moist valleys similar to those of the region farther west are not developed.

Origin.—The material comprising the Dunesand was probably derived from the disintegration of loosely cemented sandy beds of the Arikaree formation.

Native vegetation.—The Dunesand is treeless and shrubless. The native vegetation consists of a great number of species of grasses, of which the following are most common on the tops and sides of the ridges: Long-leafed reed-grass (*Calamovilfa longifolia*), redfieldia (*Redfieldia flexuosa*), Halls beard-grass (*Andropogon halii*), little bluestem (*Andropogon scoparius*), western stipa (*Stipa comata*), and hairlike eragrostis (*Eragrostis trichoides*). Besides these grasses there are several species of Psoralea and Euphorbia.[1] During the spring and summer these grasses furnish excellent pasture, but in the winter they are killed by frost and can not be depended upon for winter grazing.

The surface is usually well sodded, it being the general opinion of cattlemen that the grass has materially improved during recent years. This is no doubt due to the increased ability of the larger population to control the frequent fires which formerly swept the region during late fall and early spring. The valuable grama grass and bluestem are becoming widely distributed over the eastern part of the type, where the rainfall is a little greater. The preservation and utilization of the native grasses on this type are the foundation

[1] Forage Crops for the Sand-hill Section of Nebraska. U. S. Dept. of Agr., Bureau of Plant Industry, Circular No. 80.

of its only industry. Cattlemen are keenly conscious of this fact, and all strive against destructive fires and too close grazing.

Utilization.—The Dunesand was occupied by cattlemen years ago in the development of the extensive range-stock industries. It was known that the nonagricultural character of their range land made 160-acre homesteads impossible, and it was not believed that the law would be so amended as to permit larger filings. The demand for more free land, however, resulted a few years ago in the passage of the Kinkaid Act permitting the homesteading by settlers of the Dunesand region in tracts of 640 acres. The Government land which remained has all been taken under that act, and a radical readjustment of conditions is now under way. The "Kinkaiders," as they are known, have fenced their claims and so completely occupied the once free range that all the old cattlemen are restricted or forced to sell out, according to the condition of their individual holdings. The newcomers are stocking their places with cattle and horses and endeavoring to supplement their scant hay production by the growth of corn and grain. The different homesteaders vary greatly in their ability to make a success of such operations. The dry valleys and similar depressions in sand-hill topography are being tilled with varying but more often minimum success. The soil at all times is incoherent and rather loses than gains in stability with continued cultivation, the more favorable phases of the type in the eastern extremity of its development yielding more satisfactory crops, largely as the result of a greater rainfall. Whether or not a living can be made on these homesteads is the measure by which future readjustments will be made. Many of the claims are incapable of supporting a family, and this fact is now generally recognized. The sand-hill region as a whole, with its hay production, is capable of maintaining between 32 and 38 head of live stock to the section, or 640 acres. There are many of the claims now occupied by families incapable of reaching the average and without agricultural land sufficient to grow appreciable crops. Other claims exceed the average considerably and in addition can be made to produce patches of potatoes, grain, and corn. It must never be forgotten that the production of live stock, with few exceptions, measures the efficiency of a landholding in the Dunesand. The remoteness of many of the claims from the railroad and unfavorable roads make the marketing of dairy products difficult. This, together with scant feed during cold weather, makes dairying rather limited, at best to the short summer season. Many of the more prosperous newcomers are already leasing adjoining claims and acquiring a firmer hold. The cattlemen of longer residence are forced to do likewise. The next step will be the purchase of newly acquired titles until a size of holdings is

reached intermediate between the very extensive free-range condition and the present restricted ranch of 640 acres. The region will then be more fully and economically utilized than ever before. It will always be rather sparsely settled and market nearly all ranch products as live stock. No attempt has been made to cultivate the dunes proper, and such attempts can meet with nothing but disaster. The National Government is carrying on extensive investigations and experiments as to the feasibility of forestation. A measure of hope is entertained that success will be reached.

Roads are very heavy, and in the absence of building or surfacing materials can not be improved. This condition, with the uneven topography and small amount of traffic, make fenced or established roads impracticable. Travel is laborious and follows constantly shifting trails with gates on all property lines.

Water for all ordinary purposes is abundant and exceptionally good. The sand-hill region on the whole is healthful and remarkably free from infectious or contagious diseases.

GANNETT FINE SAND.

Description.—The Gannett fine sand comprises those areas of soil known throughout the sand-hill region as "wet valleys" or "wet meadows." Typically the soil consists of from 10 to 24 inches of very dark gray or black material, composed of fine to very fine sand and well-decayed organic matter, with a spongy structure and appreciably light weight. The content of organic matter varies considerably, but where conditions for plant growth and decay are most favorable a product closely resembling Muck is the result. It is boggy and poorly drained, with marshes and small lakes of frequent occurrence. The soil grades rather sharply at an average depth of about 18 inches into an incoherent grayish-white sand of fine texture. This subsoil carries small quantities of organic material, but lacks the porous, compressible nature of the surface soil. It continues to great depths, and from about 4 feet downward is similar to the subsoil of the Dunesand.

Location.—The Gannett fine sand is a widely distributed type, its region of occurrence being coextensive with that of the Dunesand. It usually occupies inextensive bodies of a rounded or elongated outline. They often lie in chains and are separated by ridges of typical Dunesand. In Cherry, Hooker, Thomas, Blaine, and Loup Counties the type is of infrequent occurrence, because of the better outlet for seeping drainage afforded the Dunesand by the Dismal and Loup Rivers.

Topography.—The type has a flat surface. Its bodies are always surrounded by the Dunesand which borders it in great ridges or hills,

but within the type little irregularity occurs. The lowest part of the area is occupied by a shallow lake or marsh. The northern boundary of these low-lying bodies of Gannett fine sand is usually a very steep dune slope, while a more gentle ascent marks the southern side.

Origin.—The Gannett fine sand is formed of the same material as the Dunesand, or of the finer wind-assorted particles thereof much modified by the growth, decay, and incorporation of organic matter. A shallow water table, permitting the heavy meadow grasses to make rank growths, characterizes the Gannett fine sand in all its bodies. Favorable water conditions for the formation of this type have occurred in times past when old valleys and waterways were choked by drifting sand. The soil is also developed in pockets or swales between the large sand ridges which traverse the region. The Gannett fine sand was developed, in fact, wherever the surface of the incoherent sand was lowered to approximately the level of the vast sheet of water underlying the Sand Hills. Thin layers of almost pure organic matter are often encountered throughout the Dunesand area, marking the site of an ancient meadow which lost its primary water condition either by a change in water level or the drifting in of sand.

Native vegetation.—The most valuable native grasses of the Gannett fine sand are big bluestem (*Andropogon furcatus*), switch-grass (*Panicum virgatum*), western wheat-grass (*Agropyron smithii*), Indian grass (*Sorghastrum nutans*), wild timothy (*Muhlenbergia racemosa*), porcupine grass (*Stipa spartea*), and nodding wild rye (*Elymus canadensis*).[1] These are water-loving grasses which yield the principal part of the annual crop of hay, so necessary to the successful wintering of cattle in the sand-hill region. The hay is very nutritious, growing thickly with fine stems from a water-laden, spongy sod. Heavy growths of sedges and rushes replace the hay grasses in the lakes and marshes. This native vegetation ends sharply around the edges of the meadows, where a greater elevation and a deeper water table mark the beginning of the Dunesand.

Utilization.—The Gannett fine sand is the most thoroughly utilized soil in western Nebraska. It was sought out many years ago by the early cattlemen and title was secured from the Government under the old homestead act. The ownership of these hay meadows, with their almost indispensable annual crop, controlled the surrounding sand-hill range. The enactment of the Kinkaid homestead law affected but little of this type yet in Government ownership. Its present utilization will continue indefinitely. Some alfalfa has been sown, and upon portions where the water table is slightly too deep for the native grasses, yet sufficient for alfalfa, good results have been secured. A small effort has been made to grow intertilled crops,

[1] Circ. 80, Bureau of Plant Industry, U. S. Dept. of Agr.

but their extensive production is out of the question. The soil drifts and blows badly when the original sod is thoroughly decomposed. Patches of potatoes for ranch use and some small areas in grain are perhaps to be advised, but the production of winter feed for cattle is its principal use for this type. Hay is cut annually, with an average yield of about three-fourths ton per acre. It is possible that some of the leguminous crops can be more generally grown, but with the ultimate aim at all times of securing more forage for winter feeding of cattle.

CANYON LOAM.

Description.—The Canyon loam is a type of minor importance in western Nebraska. It occupies a topographic position between the Colby silt loam and the sandy soils of the Tertiary, and resembles all these soils in some respects. The soil varies widely, but the usual surface material to a depth of 6 inches is a light-brown loam, with a noticeable proportion of fine sand, which gives it the appearance of a sandy loam in the roads. The subsoil to a depth of more than 36 inches is a yellowish-gray silt loam, containing fine sand. Fragments of the Mortar Beds formation, which is a sandy, calcareous conglomerate, are present in the soil or scattered over the surface. The greater part of the soil material, however, is derived from the loess. The more sandy areas indicate a greater proportion of the materials derived from the sandy strata of the Tertiary, and perhaps in some cases from the gravelly glacial drift at the base of the loess.

Location.—The type is found in small, irregular areas in the southern part of the State along Republican River and its tributaries. The areas mapped are nearly all on the southern side of this river, but there are numerous strips of the type along the northern tributaries that are too small to map. The type is found in close association with the Colby silt loam and does not occur except within areas of that type.

Topography.—As the type occurs along the stream slopes on the descent from the loess-covered plains to the lower valleys, the topography is hilly and there are no considerable areas of level or undulating land. On account of the rapid erosion of the slopes, the calcareous rocks are frequently exposed or broken up and scattered over the surface.

Origin.—As already stated, this soil has been formed by erosion and weathering of the loess and the lower-lying calcareous Tertiary material. More or less of the loess has been washed down and distributed over the exposed Mortar Beds on the slopes and the resultant soil is a mixture of the weathered products of both in varying proportions.

Utilization.—Very little of this type is cultivated, on account of its hilly character. The cultivated portions are those where the soil is formed mainly from the loess. Corn and sorghum are the principal crops. The greater part of the areas are better suited for pasture and are generally used for this purpose.

RIVER TERRACE SOILS.

TRIPP SERIES.[1]

Terraces more or less distinct occur along North Platte River and Pumpkin Seed Creek at various elevations. These terraces were built up, at different stages of the history of the streams, of sediments brought down and deposited by floods. The surface covering of these terraces did not vary as widely as might be expected of deposits of this kind, the range being in most places from fine sands to silty clays. In process of weathering the surface soils have been greatly modified by colluvial wash brought down from the surrounding river slopes and by wind-blown sands gathered up from stream channels or brought from the extensive tracts of sandy loams to the north of the valley. These more recently transported materials were also principally fine sands and silts. The colluvial addition is largely wash from the areas of Epping silt loam and it has added to the silt content of these soils and contributed to their lighter color.

The soils of this series, called the Tripp series, may be characterized as terrace soils of gray color and a high fine sand and silt content. Four types—a loam, a silt loam, a very fine sandy loam, and a loamy fine sand—have been mapped.

TRIPP LOAM.

Description.—The surface soil of the Tripp loam consists of 14 to 16 inches of a light-brown loam, containing a relatively large proportion of very fine sand, the content of the latter being larger in rolling areas or on slight knolls. The texture varies considerably from the type description and often is more nearly a fine sandy loam than silt loam, but even in such areas there is enough material finer than silt to give the soil in the field the workable characteristics of a silt loam.

The subsoil differs but little from the soil in texture, but becomes somewhat lighter in color, being a light brown, shading into yellow in many places. In some localities there is slightly more sand in the subsoil than in the soil, but as a rule there is little change apparent in the texture to a depth of 36 inches.

[1] The Tripp loamy fine sand, very fine sandy loam, and loam, all of which occur within a few miles of the Platte River, are not typical. They occur as more or less well defined terraces and isolated upland areas, while the true Tripp soils are alluvial soils. In future detailed mapping alluvial soils only will be included in the series.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Tripp loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370717	Soil	1.2	4.6	3.6	7.7	36.1	29.2	17.6
370718	Subsoil	1.4	6.4	4.7	8.6	20.6	38.1	19.9

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 370718, 1.36 per cent.

Location.—The largest areas of this type are found in Scotts Bluff County north of the belt of alluvial land that follows the North Platte River. It occurs in irregular bodies from the eastern edge of the county to a few miles northwest of Scotts Bluff. There is also an important area near Hull, in Pumpkin Seed Creek Valley, and a smaller body near Spring Canyon.

Topography.—The Tripp loam has a gently undulating topography, sufficient to give good drainage and yet requiring only very little leveling to prepare the land for irrigation. So far the type has been dry-farmed, but nearly all of the areas along the North Platte River will eventually be irrigated, as they lie within the irrigation projects. The areas in Pumpkin Seed Valley can not be irrigated, as there is no supply of water available for the purpose.

Origin.—This type was originally alluvial in origin, but it now lies outside the belt of distinctly new alluvium that follows the North Platte River. It represents an ancient deposit of sedimentary material laid down by the river when its flood plain was at a higher level than it is to-day. The indications are that much of the surface soil has been transported and reworked by the wind since its original deposition.

Native vegetation.—The native vegetation on this type consists of grasses, among which buffalo and the grama grass are more abundant than on any other soil of the area. Needle grass is a common species on the more sandy phases of the type.

Utilization.—The Tripp loam is well suited to the production of the entire range of crops grown in Nebraska. It is easily cultivated, does not drift as does the fine sandy loam of the series, and is well adapted texturally to irrigation. Under dry farming the yields are curtailed by lack of moisture. With the semiarid conditions of the region where this type occurs the average yields are slightly above the average for other productive soils of the region. The yield of wheat through good and poor years is probably not far from 13 bushels. Corn is grown under the additional disadvantages of un-

favorable temperatures and too great an altitude, and average yields are scarcely above the limit of profit. Potatoes are grown successfully, though only for home and local use and not on a commercial scale.

In case of irrigated areas the yields are increasing as the land is brought into better condition and the methods of irrigating it have been improved. Yields of 40 to 50 bushels of wheat per acre have been secured, and the average yield is probably more than double what it was under dry farming. Oats are grown to some extent, 40 bushels per acre being about the average yield. The texture of the soil adapts it to a wide range of truck and garden crops, but as these industries are dependent upon markets, they have not been developed on a commercial scale. Sugar beets are grown to some extent on this type, but it is not the principal beet soil of the area. Yields of beets range as high as 20 tons per acre, with the average less than half this amount. At the present time the most profitable irrigated crop is alfalfa. The growing season ordinarily limits the crop to three cuttings, but each cutting averages more than 1 ton per acre.

TRIPP VERY FINE SANDY LOAM.

Description.—The Tripp very fine sandy loam, though it closely approximates the Tripp loam in texture in many places and gradually merges into it on the borders, is distinctly different in several important characteristics. The typical surface is a slightly yellowish brown fine sandy loam, with an average depth of 16 inches. The sand content, which is of the finer grades, varies in quantity so widely as to give the soil a range in texture from heavy sandy loam to loamy fine sand. The larger sand content is more noticable in the cultivated fields, where the surface, if left unprotected, is often drifted by hard winds.

The subsoil is slightly more sandy than the soil and has a more pronounced yellowish tinge. The sand content is apparently greater, but this may be due to the lack of organic matter, which makes the soil more loamy. In a few localities the subsoil is heavier than the soil, but such areas are of small extent and exceptional.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Tripp very fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370723	Soil	0.6	1.5	1.8	24.2	53.2	10.6	8.0
370724	Subsoil	.6	2.0	2.1	25.5	44.9	13.5	11.2

Location.—This type occurs in several irregular areas scattered over the slopes and terraces of North Platte River and in Pumpkin Seed Creek Valley. The largest and most important area along the North Platte Valley lies north of Morrill, occupying what is known as the Dutch Flats. There is a small area in Sioux County near the Nebraska-Wyoming line in the vicinity of the Sturdivant ranch.

Topography.—The topography varies from nearly level on the Dutch Flats to rolling and sloping on the higher ground. The surface configuration favors drainage and irrigation.

Origin.—The Tripp very fine sandy loam probably represents remnants of an old terrace built up by the North Platte River when that stream stood at a higher level than it does at the present time. The original deposits have no doubt been greatly modified in many places by colluvial wash from the higher lands brought down during torrential rains by many small streams. The yellowish color so pronounced in some parts of the type is probably ascribable to addition in this manner of wash from the surrounding areas of the Epping silt loam. The level portions of the type appear to be weathered surface materials of the ancient terrace, but in the more rolling areas the soil has been more largely composed of the colluvial wash, though there is little difference in the physical properties of the two. In all parts of the type the soil has been more or less influenced by the deposition of wind-blown silts and sands.

Native vegetation.—The native vegetation includes besides the grama and buffalo grasses, needle grass, which is more abundant on the sandier phases, coarse sand grass, bunch grass, and occasionally sagebrush. As pasture, the virgin prairie is not as valuable as the Tripp loam, because of the smaller proportion of buffalo and grama grasses and other nutritious species.

Utilization.—This soil is adapted to the production of nearly all the crops of this region, including wheat, oats, barley, potatoes, and alfalfa. The most profitable crops are potatoes and alfalfa. Sugar beets and to a less extent small grains are likely to be injured by the drifting of the sandy surface soil. In common with nearly all other soils of this semiarid region, the type lacks humus.

TRIPP LOAMY FINE SAND.

Description.—The Tripp loamy fine sand consists of an admixture of the finer grades of sand with enough silt and clay and organic matter to give it a loamy character. The texture of the sand is nearly the same as that of the Dunesand, but it has been separated from that type on account of its more level topography and its greater stability. The color is a yellowish gray, with very little change to a depth of more than 36 inches. The principal variation noted in this type was a heavier subsoil in some small areas. The

soil is loose and easily stirred, but care must be taken when the surface is made too loose to prevent drifting. There is less danger of this under irrigation if the soil is kept moist.

Location.—The largest bodies of this type are found north of the North Platte Valley and west of the town of Morrill. There are also small areas east of Mitchell, covering several square miles. South of the river there is a small area due south of Morrill and numerous irregular bodies of the type in the Pumpkin Seed Creek Valley. One of these of considerable size extends along the valley to the State line and over into Wyoming.

Topography.—The topography is level to gently undulating, with occasional small hummocks heaped up by the wind, but no dunes of any considerable size. The topography is suited to irrigation, except in the hummocky areas. The texture, however, is so loose and porous that difficulty is experienced in getting water over the land, and the loss by seepage is excessive.

Origin.—Like the other types of this series, the loamy fine sand is composed of ancient deposits laid down by the river and creeks when the floor of the valley stood at a higher level than at present. Since its original deposition, however, the material has been shifted and reworked to such an extent by the wind that it may now be regarded as more a wind-formed than a water-formed soil.

Native vegetation.—The native vegetation differs markedly from that on the other types of the series and gives a fairly accurate indication of its limits in the field. Although small patches of grama and buffalo grass may be found, the principal and typical growth consists of coarse and sand grasses and sagebrush. In the Pumpkin Seed Creek Valley, where the land is not irrigated, the type is valued for grazing, as it supports a variety of grasses that withstand drought well.

Utilization.—The same crops are grown as on the other Tripp types. The yields are fairly satisfactory in the better areas, if the land is handled in the right manner. The lack of humus causes the yields to be very low during the first few years of cultivation. If a good stand of alfalfa can be obtained, fairly good yields can be secured, but as a rule it is hard to get a stand that will make a profitable crop. The first essential in getting this soil in a condition to give the best results is to supply the needed organic matter by growing legumes and plowing them under.

TRIPP SILT LOAM.

Description.—The Tripp silt loam typically consists of a rather smooth textured, light-gray fine sandy loam or silt loam. A rather friable structure characterizes the type as a whole, but limited areas are found where puddled and compacted conditions occur, owing to

a higher than normal content of silt and clay. The surface soil may extend quite uniformly to a depth of several feet or may be underlain at any depth below 5 inches by a slightly compact subsoil of similar materials, yet having a greater clay content. In exceptional cases the subsoil occurs as a clay loam or silty clay loam. The entire soil column is normally free from gravel or angular rock fragments and the permeable zone for plant roots is quite deep. The type is retentive of moisture and altogether would constitute one of the most valuable soils of its locality were it not for the excessive accumlations of alkali throughout its extent.

Location.—Only one body of the Tripp silt loam was encountered in this survey. It occurs near Alliance as an elongated valley plain varying in width from 1 to several miles. It borders Snake Creek and its tributaries from their sources to the point where the accumulated drainage finds an underground outlet through the Dunesand.

Topography.—This type has a level surface and is marked by no irregularities except the meandering, indistinct channel of Snake Creek. The outer borders of the plain are usually marked by a distinct bank or small bluff as the beginning of the higher-lying soils along the valley sides. Practically all the type is capable of tillage in so far as surface features are concerned.

Origin.—The Tripp silt loam is alluvial in origin, being the transported and reworked materials laid down by Snake Creek as an irregular, indistinct valley plain. Its formation has been slow, owing to the intermittent character of the parent stream, and has been accompanied by more or less thorough erosion of the original plain once occupied by the Rosebud silt loam. The type is formed of wash derived from the higher lying Rosebud silt loam and fine sandy loam. An accumulation of alkali has been brought about by unfavorable conditions of drainage. The run-off and subterranean drainage from a considerable section concentrates beneath this low-lying type and alkali is gradually deposited by a continuous evaporation from a relatively shallow water table.

Native vegetation.—The influence of alkali has prevented the growth of the native upland grasses so prevalent over the Rosebud soils. Salt grass is now the predominant species. Over restricted areas where the soil is comparatively free from alkali the native vegetation is not unlike that of the Rosebud series.

Utilization.—The Tripp silt loam is nearly all devoted to grazing. Some parts of it are used for the production of hay. Especially is this true of some of the narrower bodies in the upper valley, where very wet conditions prevail. An endeavor is being made to irrigate some areas of this soil by the storage of water, but any development along this line can not be extensive, because of a meager water supply and the presence of alkali. If plenty of water were available the re-

moval of alkali would be practicable, though the expense would probably not be justified. The present utilization will no doubt continue for some time.

SOILS FROM GLACIAL DEPOSITS.

O'Neill Series.

A relatively thin bed of gravelly glacial drift underlies the loess in the central and eastern parts of Nebraska. This coarse material is exposed along many of the small streams, but usually not in sufficient areas to affect any considerable extent of soil. In the extreme southeastern part of this area the drift is exposed extensively enough to form areas of gravelly soils, some of which are several miles in extent. In the northeastern part the erosion has uncovered the drift, and there are found very gravelly soils covered by a layer of loam of a thickness varying from 1 to 10 inches in different places.

Two types of soil have been derived wholly or in part from the drift. The O'Neill gravelly loam is found where the beds of gravel have very little, and in some places none, of the loam covering. This type is of very little agricultural value. The O'Neill loam usually has from 2 to 5 feet of loam, part of which is probably derived from wind-blown material from the loess areas. There has also been a weathering of the gravelly clay of the drift, producing a sticky gravelly clay subsoil.

O'NEILL LOAM.

Description.—The surface soil of the O'Neill loam is a dark-gray to brown loam, with an average depth of 10 inches. The sand content is of the finest grades, and there is always a varying percentage of silt, so that the texture ranges from a fine sandy loam to almost a silt loam. The dark color indicates the presence of finely divided organic matter, and it is more abundant in localities where vegetable remains could accumulate. The soil is underlain by two zones of material. The upper, which extends to a depth below the surface ranging from 20 to 30 inches, with an average of about 24 inches, is a light yellowish brown heavy loam to clay loam. There are usually scattering grains of coarse sand and fine gravel interspersed through the material. The clay is of a sticky character, giving this portion of the subsoil the nature of a sticky sandy loam or clay loam. It is usually compact and is somewhat impervious. Covered as it is with a loose loam, it forms a subsoil well adapted to retain moisture, and for this reason it is one of the most valuable farming soils in the northeastern part of this area. The second zone of this soil, which extends to a depth of many feet, is a mass of sand and gravel. Over much of the area the gravel is of small size, but there are occasional beds in which fragments one-half inch or more in diameter make up

the greater part of the mass. The gravel has the partly smoothed or subangular shape characteristic of glacial drift gravel, and is loose or only very slightly cemented, making an open, porous mass. In a few places the upper zone of this type is very thin, and the soil lies immediately over the gravel, which is slightly sticky in its upper portion. Such areas are of small extent. Another minor phase is found along the breaks of the streams north of O'Neill, particularly Eagle, Honey, and Camp Creeks, where the soil is a fine sandy loam, carrying a small quantity of fine gravel.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of this type:

Mechanical analyses of O'Neill loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370712	Soil	2.4	8.7	8.2	17.1	16.5	29.7	17.4
370713	Subsoil	1.9	6.8	8.7	16.7	7.2	32.5	25.9
370714	Lower subsoil.	9.7	18.2	16.7	37.5	6.1	4.8	6.5

Location.—The type is confined to Holt County, where the largest body occupies a large area in the shape of a right angle triangle lying in the north-central portion. The southern line of this triangle lies along Elkhorn River, with one angle two miles east of Stuart, the other a short distance east of O'Neill. It extends more than 18 miles north of O'Neill and has its apex near Turner. A smaller area of the type is found surrounding the town of Page and extending northeastward to the county line.

Topography.—Topographically the type occupies the broad undulating divide between the Niobrara and the Elkhorn Rivers and the broken slopes of several stream courses that traverse it. Only in small portions, however, is it so badly gullied as to be useless for agricultural purposes. The worst eroded tracts are found along the breaks of Eagle Creek north of O'Neill. In this locality the exposure of a large percentage of coarse sand and gravel has decreased the agricultural value of the land as much as its broken topography. Almost the entire drainage of the type is toward Niobrara River, although the area of the type extends almost to Elkhorn River.

Origin.—The O'Neill loam, while largely derived by weathering from glacial drift, has been modified by materials from other sources. The mass of gravel that composes the lower subsoil is clearly of glacial drift. Above this the sandy gravelly clay is probably the weathered product of a more clayey deposit of drift. The surface soil shows less evidence of purely glacial origin, but in many places

the drift has apparently entered into its composition. It is probable that the type as a whole represents a mass of glacial drift, partly weathered in its upper portion, over which materials of sandy and silty character have been deposited by wind and water. It is likely that loess once covered this region and that remnants of it have been incorporated into the surface soil.

Utilization.—The type, on account of its favorable topography and the loose condition of the surface soil, is easily tilled. The presence of the underlying sand assures adequate drainage. As a rule, the texture and arrangement of soil layers renders the type very retentive of moisture, but in a few localities where the surface layers are exceptionally shallow crops are liable to suffer in dry seasons. The soil is well adapted to the production of corn and small grains and potatoes. Corn, under favorable conditions of tilth and moisture, yields an average of 35 bushels to the acre. Where alfalfa has been tried yields have been fair, as the rainfall in this section of the State approaches the amount with which alfalfa can grow on the upland.

O'NEILL GRAVELLY LOAM.

Description.—The O'Neill gravelly loam is extensively distributed over the northeastern part of this area. It is for the most part a nonagricultural type, as the excessive drainage produced by the underlying mass of loose sand and gravel prevent profitable cultivation. In Keyapaha County, where the largest typical areas may be found, the shallow surface soil consists of a dark-gray or brown loam or sandy loam carrying a large percentage of medium and fine sand. The depth usually ranges from 3 to 5 inches on the more level portions, but on slopes the loam covering is very thin, and is frequently entirely absent, the gravel beds being exposed at the surface. The subsoil consists everywhere of a mass of coarse sand and gravel, with very little silt or clay. This material extends to a considerable depth in Keyapaha County, but thins out toward the west. By borings in Keyapaha County it was determined that the gravel stratum had an average thickness of 40 feet and rested upon a bed of clay or sandy clay. As revealed by these borings and by numerous exposures, the sand component of this mass ranges from medium to very coarse, and the grains are partially rounded or subangular. The gravel for the first few feet is usually fine to medium, but becomes coarser at a lower depth. In some places there are beds of coarser gravel which range from one-half to 1 inch in diameter. They invariably show the partially rounded or subangular shape characteristic of glacial gravel. The material is indiscriminately mixed and cross-bedded, without any regular assortment or stratification, showing its deposition as outwash from the front of a retreating glacier.

Location and topography.—The type occupies a number of irregularly shaped areas in Keyapaha County and smaller areas in Holt, Brown, and Rock Counties. In Keyapaha it covers the more level table-lands and the greater part has the loam covering. Where it has been subject to erosion, as is the case near the headwaters of small streams in Holt and Boyd Counties, the surface is badly dissected, and a considerable portion has the gravel exposed. In the southern part of the State it is confined to a few irregular areas occurring along the small tributaries of Republican River.

Origin.—The character of the material beneath the surface of this type, together with its cross-bedded arrangement, indicates its derivation from glacial material. As the ice sheet extended within a short distance to the east, it is entirely probable that this section was covered by drift materials borne by outwash from the glacier front. The composition of the loam covering of the gravel beds suggests that it, in part at least, is due to other agencies. It may be partly the weathered product of heavier glacial drift, but the character of the fine sand and silt and its dissimilarity to the underlying material would indicate that it was probably deposited over the surface by the wind. The extensive distribution of wind-blown material has influenced all soils in this region to a greater or less extent, and the proximity of drifting and easily moved sand hills to the west of this type and the vast loess deposits to the east are possible sources of the finer soil material.

Utilization.—The greater part of the O'Neill gravelly loam is used for pasture. It is well adapted to this purpose, as the short grasses, such as the grama and the buffalo, are mixed with the coarser grasses and weeds characteristic of the more sandy soils, affording the variety which the stockmen consider very desirable. The excessive drainage of the type makes it so droughty that cultivated crops are very uncertain, even in the humid regions. Here, where the normal rainfall is barely sufficient for the uses of the crop, the best soil conditions are necessary to conserve it, so that if the soil is not well adapted to retain moisture it is not advisable to undertake its cultivation. This applies particularly to the ordinary cultivated crops on the more gravelly portion of the type.

ALLUVIAL SOILS.

LINCOLN SERIES (TYPES UNDIFFERENTIATED).

Description.—The undifferentiated alluvial types of the recently formed flood plains that have been built up wholly or in part by sediments brought down from the loess-covered plains have been classed with the Lincoln series. The several soils of this group are so varied in texture and their areas are often so small in extent that

it has not seemed advisable in this survey to map them separately. Although in some sections of the State the total areas of these valley soils are comparatively unimportant, they are of great interest from an economic standpoint, since in the arid section of the State they give stability to the agriculture of the region by their high productiveness and their adaptability to crops, such as alfalfa, that are not suited to the upland. These soils range in texture from silty fine sandy loams to silty clay loams, but the prevailing type is a silt loam. A common characteristic of these soils, aside from their high silt content, is their dark color, by which they differ from the soils of the Platte series, and the absence of the beds of sand and gravel, by which they are distinguished from the soils of the Arkansas series.

Along the creeks on the north side of Platte River and along other streams in the southwestern portion of the Colby silt loam the bottom soils vary considerably in texture. Very few streams draw their sediments entirely from the loess region, and in this section they have their origin in the sand-hill region. In the upper portions of their course, where the two classes of sediments are intermingled, but farther down, there is to some extent a reassortment of the materials, so that there may be alternate or successive bands of some particular grade of sediment that may range from sand to clay. In some places a body of heavy soil may be found along one bend of the stream, while on the next bottom light-textured soils may predominate, depending upon the assorting power of the current at each place. Usually, however, some one grade of material will be prevalent along each stream, and below the sand-hill region a silty sandy loam is most common.

The silt loams and silty clay loams are more continuous along the streams in the southeastern part of the area, where the soil-forming sediments were derived almost entirely from the areas of silt loam. The smaller tributaries of Republican River are of this class. As a rule, the headwaters of the streams where they leave the upland have a silty alluvium composed simply of transported loess, but lower down a certain amount of assortment takes place, and we find bodies of either coarser or finer soils, but the silt loams and silty clay loams are predominant. On the slopes of the deeper stream courses shales, sandstones, and calcareous beds of various composition are exposed, and their weathered products have washed in and modified the silt soils. Usually they have the effect of modifying the soil by increasing the content of clay. On the other hand, toward the eastern part of the areas beds of sandy and gravelly drift exposed on the lower slopes below the loess add to the percentage of coarse material in the neighboring soils.

The average and most common soils of the valleys of the southeastern part of the area may be described as silty loams, with much fine sand, to an average depth of 15 inches, underlain by a heavier silty clay subsoil. The color is the characteristic dark gray to dark brown in the soil, becoming lighter in the subsoil. It is seldom that they present any difficulties of tillage, as they are friable and readily broken by the plow.

In the greater portion of Frontier, Hayes, and a few other counties the streams are influenced by the sandy soils to the northwest and fine sandy loams are more common. Along Republican River there has been more assorting of the soils and on the south side of the river in Dundy County there are extensive areas of sandy soils.

In the northern part of the loess-covered region, which lies southeast from and receives the drainage of the sand hills, the soils are largely sandy and contain a large percentage of organic matter by reason of their somewhat meadow-like condition.

A distinct phase of this soil occupies the outer edge of the flood plain of Platte River. This soil resembles the Colby silt loam so closely that in former detailed surveys made along the Platte it was mapped with that type. It covers a topographic position between the sandy and clay soils of the low flood plain and the sloping hillsides of the upland loess. Its lower area is almost level, but higher up it covers successively several terraces and the first gentle slopes at the foot of the loess hills, passing almost imperceptibly into the area of Colby silt loam. Its composition is so nearly that of the latter soil that it is impossible to determine their boundary, except by topography, and in many places the line shown between them has been arbitrary. The soil on these flats is a dark-brown heavy silt loam, 14 to 18 inches deep, underlain by a dark-brown silty clay loam.

In common with the soils of this series found in other States there is present throughout soil and subsoil a large percentage of soluble salts. On account of the good underdrainage afforded by the open, porous nature of the subsoil, there is little danger of excessive accumulation over any large area of the upper benches, but some of the undrained flats subject to seepage were always dangerously burdened with alkali. Under irrigation the danger is greatly increased on account of the tendency of the average farmer to use too much water on the land and to give too little attention to drainage. It is impossible in this report to describe all types of these soils, but some of the more important are given.

Laurel Series (Types Undifferentiated).

Description.—The Laurel soils are found along North Platte River from the point at which it crosses the Wyoming-Nebraska line to the southern boundary line of Dawson County. They form the surface

covering of the immediate valleys of the rivers mentioned and usually occupy the first and second terraces of the bottom. There is considerable variation in texture at different places, but the types have certain characteristics in common that influence their agricultural value. They range in color from a dark gray to a light brown, but light shades are prevalent and characteristic of these soils. In many places the pink and light buff colored silts washed in from the surrounding upland soils have imparted a lighter color to the valley soils. The surface soils are usually composed of finer materials, principally silts and fine sands, but they overlie beds of various grades of material deposited by the river at different stages of its history. Over the greater part of the valley beds of coarser sands and gravels are found at a depth of several feet, alternating with strata of silts and clays, representing the flood deposits of the stream during the shifting of its channel.

LAUREL SILT LOAM.[1]

Description.—The entire bottoms of the Platte and the North Platte Rivers where these soils occur are narrow, and so many soils occur in bands and small patches that a separation of all the types on a map of small scale was impossible. In the extreme western part of the area from Scottsbluff to the State line the prevailing type outside of the coarse material of the river bed is a silt loam, which, on a detailed survey, would have been mapped as the Platte silt loam. This soil is a light-brown silt loam containing a conspicuous amount of very fine sand. In low, wet localities the soil is of a darker color, due to the large amount of organic matter. The subsoil is more variable in texture, ranging from a loose, light-gray sand to a silt loam of the same color. As a rule the surface soil is mellow, friable, and easily tilled. On account of its heavy texture its usually damp condition and its low protected position it is not subject to removal by the wind, and water erosion does not take place except when incoming streams cut across the benches on which this soil is located.

This soil is found in the most arid portion of the State, and its constituent material has been derived from even more arid regions farther west, and, as is usually the case with soils formed under arid or partly arid conditions, it carries a large amount of soluble salts. The processes by which these salts are derived and concentrated in the soil are discussed elsewhere in this report. All soils washed into the lowlands of the Platte carry a large percentage of these salts, and the incoming waters from the higher lands bring these substances in solution.

On account of the position of this type and the porous nature of the subsoil, which permits good drainage, there is little danger of an

[1] This soil is not shown separately on the map.

excessive accumulation of alkali over any very large areas if proper methods of irrigation are used. Under the careless methods usually employed, especially in newly irrigated districts, a large portion of this type might be ruined in a short time. Too much care can not be taken by the individual farmers, and the people of the entire valley in the vicinity of Scotts Bluff should see that the best methods are used.

Location.—This type predominates over the entire valley of North Platte River west of Scotts Bluff, and there are extensive areas between Bridgeport and Minatare, with a typical body of this soil near Camp Clark. Areas of small extent are scattered along the North Platte and along the Platte as far as this series of soils extends. Numerous areas so small as to make it impracticable to separate them on a map of small scale also occur among the other types of this series.

Topography.—The topography is level, sloping in most cases slightly toward the river and to the southeast with a uniform grade of 7 feet to the mile. The type is seldom flooded, but is greatly in need of drainage. The careless use of irrigation water during the last 10 years is responsible for this condition. There has been a marked increase in waste land and swampy areas, many of which are now beginning to show alkali.

Origin.—The Laurel silt loam is an alluvial soil along the North Platte River, where the soil-forming materials have been derived from sediments of the arid regions and are now under semiarid conditions. For this reason the soil contains a large quantity of soluble salts (alkali) and are exceedingly rich in lime. In some places surface accumulations are already giving trouble.

The soil particles have been derived from the region to the west and comprise a rich assortment of rocks that contain feldspar and other minerals rich in the elements of fertility.

Native vegetation.—A sparse growth of cottonwood was originally the only tree growth, and this was restricted to the wetter locations. At present cottonwood, black locust, and willow grow well where the subsoil is kept moist by natural or artificial means. Cottonwood trees have attained a height of 40 feet or more and a diameter of 12 to 14 inches in 10 years under irrigation. At least three species of sedge and two of rushes grow in the wettest areas, while wild grasses furnish perennial pasture on the drained lands.

Utilization.—The Laurel silt loam has proved to be a valuable sugar-beet soil. From 5 to 20 tons per acre have been secured, the yield varying with the stand and seasonal conditions. The beets are sold by the ton, the price ranging from $4 to $4.25. With a sufficient rainfall irrigation is not necessary, manufacturers preferring a moderate yield of medium-sized beets, as under these conditions a higher percentage of sugar is obtained. The lower-lying lands produce good

yields of alfalfa without irrigation, though irrigation makes the crops more certain. From two to three cuttings are secured each season, aggregating 3 tons per acre. The wild grasses give from one-half to three-fourths tons of hay per acre.

The type sells when unimproved at $25 to $35 an acre, or $50 to $60 an acre when under cultivation.

LAUREL LOAMS.[1]

Description.—The Laurel loams include soils having a range from sandy loams to heavy silt loams. The predominant soil, however, is a loam to fine sandy loam. In either phase the sand content is usually of very fine grades, closely approaching silt. The most uniform property of these soils is the color, which is a light gray when they are thoroughly dry. When wet there is a remarkable change in their color, as they appear quite dark in the field. Where the land has been irrigated for some time and alfalfa has been grown, the soil is darker than elsewhere, owing to the accumulation of organic matter.

There is no uniformity in texture over any considerable area of these alluvial lands and the composition of the subsoil is even more variable than that of the soil. In some places the subsoil becomes lighter in texture with depth and may even pass into beds of sand and gravel, while in other places it becomes more compact and heavy. The alluvium of the Platte Valley is of great depth and it is probable that the larger part of it is underlain by a stratum of sand and gravel.

Location.—The loams of this type occur along the entire valley of the North Platte River and occupy the entire area of recent alluvium, except where the Laurel silt loam is developed. The area occurs in a strip of fairly uniform width, averaging about 3 miles. The sandier phases of the type are found both east and west of the town of Morrill, the area extending on the east as far as Mitchell.

Topography.—The Laurel loams occur on both the first and second terraces of the Platte River. The first terrace, or lower land, is subject to overflow when the river is high, but the greater part of the areas are at an elevation of 10 or 15 feet above the level of the stream and, as the river is at all points very wide, this slight elevation protects it from overflow. The surface is almost level, there being a very gentle slope toward the stream. Drainage is likely to be a serious problem, because of the low position of the type, which makes it a matter of some difficulty to get adequate slope. In late years the seepage from irrigated lands has been accumulating on the river bottoms and has made the problem of drainage more pressing. The seepage has already resulted in the formation of extensive marshy

[1] This soil is not shown separately on the map.

areas, which are rapidly increasing as the irrigation works are extended. In time the seepage waters will cause an accumulation of alkali over a considerable part of the bottom lands if means are not taken to prevent it.

Besides these principal soils found in the western part of the area, there are several other types of the same series of less extent. In the vicinity of North Platte a heavy loam type is found, which was described in the report of that area as follows:

The surface soil of the Laurel loam to a depth of about 12 inches consists of a brown to dark-brown silt loam which frequently contains large quantities of organic matter. The subsoil is a mealy, slate-colored to gray silt loam extending to a depth of at least 30 inches, below which it often becomes sandy, and frequently the underlying river gravels are encountered above 36 inches. Where the soil is very shallow sandy or gravelly material may be found at 20 to 24 inches. In some places muck is encountered at this same depth, and very often an inch or two of muck immediately overlies the gravel. Considerable mica is found throughout this soil. Along Whitehorse Creek the surface of the type is often slightly sandy, owing to the deposition of sand by the creek. This sandy material is never over 6 inches in thickness and has little influence on the agricultural value of the soil.

The Laurel loam occurs as an almost continuous strip along each side of the valley just below the soil washed down from the bluffs. In a few places it extends to the river, but it gives way more often to a gravelly loam or sandy loam soil.

Much of the Laurel loam is covered with water during the wet seasons and as a whole the soil is low, flat, and poorly drained. Only a few small areas were seen that were under cultivation. In general the practicability of drainage is very doubtful, as the fall in many cases is hardly sufficient to carry off the water.

Deposition of material is very slow; moving water is the process by which the Laurel loam has been formed. As the river retreated from the edges of the valley there was left an old channel on either side through which water flowed sluggishly when the river was high. This was probably in the nature of a swamp or marsh and gradually this silt deposit was made on top of the river gravels or muck. There is probably some alkali present in this type, but in no case has it accumulated in large enough quantities to injure the wild grasses which naturally cover this soil.

Practically none of the soil is farmed, its principal use being as meadow. The wild grasses yield about 1 ton of hay to the acre. This type is valued at $15 to $30 and rents for 50 cents to $1 an acre.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Laurel loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17777	Soil	0.2	3.0	2.6	14.9	14.8	50.3	13.3
17778	Subsoil	.1	1.3	1.7	12.2	16.7	44.9	22.6

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17777, 22.80 per cent; No. 17778, 38 per cent.

A gravelly loam type was found near North Platte and described in the report as follows:

The Laurel gravelly loam consists of a brown loam soil 12 to 20 inches deep underlain by river gravel or coarse sand. The average depth of the surface soil is about 18 inches. In the vicinity of the Laurel loam the surface is sometimes of a silty character, while on the better drained areas it frequently contains a large percentage of gravel. Near the rivers there occasionally occurs a phase of this type which has a loam to fine sandy loam surface about 8 inches deep. This is underlain by a rust-colored fine sand, which in turn is usually underlain by a coarse sand or gravel at 24 to 30 inches. This phase generally occurs north of the North Platte River, occupying only small adjacent areas.

This soil usually occurs in strips located in the central part of the valley and running parallel to the rivers. It has been formed by the deposition of a shallow layer of loamy material on the sands and gravels which at one time formed the river beds, and in a more rapidly moving current than that which deposited the silt composing the Laurel loam. Like the loam this soil is low lying and poorly drained. It also is more or less alkaline, but does not contain enough salt to injure the growth of the wild grasses.

The Laurel gravelly loam is seldom cultivated, and like the soil just described is utilized largely as meadow. The water table is in most cases at the surface of the gravelly subsoil, and consequently it will be difficult to drain this type thoroughly. There are a few areas that are high enough to be cultivated, but in such cases the surface is so gravelly that it does not return good yields. Some alfalfa is produced on these higher areas, but the yield is low and uncertain.

Land of this type of soil is valued at $15 to $25, and rents for 50 cents to $1 an acre. It is considered of about the same value as the poorly drained Laurel loam.

The following table gives the results of mechanical analyses of a fine-earth sample of the soil and subsoil of this type:

Mechanical analyses of Laurel gravelly loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17769	Soil	4.4	16.6	6.6	13.9	8.8	30.0	18.7
17770	Subsoil	8.2	29.9	13.9	27.3	8.9	5.4	6.4

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17769, 15.05 per cent; No. 17770, 1.32 per cent.

Both sandy and fine sandy loams are found in the Platte Valley which have the general characteristics of this type. The Laurel sandy loam is described in the North Platte report as follows:

The Laurel sandy loam to a depth of about 12 inches is a light-brown sandy loam or loamy sand, underlain by a yellowish, lighter sandy loam subsoil. The type is similar to the Gannett fine sand, though generally the sand is of coarser texture. Occasionally silt loam is encountered at 30 inches, while in some cases the subsoil contains a noticeable amount of clay at this same depth, especially where the type is associated with the North Platte loam.

The Laurel sandy loam occurs scattered through the valley, occupying higher areas than the surrounding types. Very often narrow strips of this sandy loam

are found along the banks of the rivers, in which case it has been formed by the sand blowing from the river beds in dry periods. Other areas occupy low ridges back from the rivers, and in such cases the soil seems to have been formed along old river channels, either having been built up by the water depositing the sand or by the wind blowing the sand from these old channels. The sandy loam of these ridges is of a coarser texture than that adjoining the rivers.

The soil is well drained and very often in cultivation. It dries out easily, and the crops suffer from lack of water in dry seasons unless irrigated. In a few cases alkali has accumulated in small quantities, but seldom is there enough to injure crops.

Alfalfa and sorghum are the principal crops grown on this soil. The greater part of it is still in pasture and meadow. It is valued at $20 to $30 an acre.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Laurel sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17761	Soil	0.5	9.1	11.9	34.7	23.1	14.8	6.7
17762	Subsoil	1.0	9.0	10.3	31.5	26.2	13.9	8.3

ARKANSAS SERIES (MAINLY SANDY TYPES).

Under the name Arkansas series have been classed the alluvial soils of the Platte Valley in the eastern part of the area, which have a position between the Riverwash of the stream channel and the soils of the Lincoln series on the outer edge of the valley. The soils are separated from those of the Laurel series by an arbitrary line drawn a few miles west of the town of Kearney.

The differentiation of the two series has been based upon variations in the properties of color and soluble salt content. They are similar in texture and origin and in possessing a substratum of sand and gravel at a depth of several feet. The gradual changes which take place as we follow these soils from west to east are those due to more thorough leaching and weathering under more humid conditions, which has resulted in a loss of soluble salts and in the accumulation of black organic matter.

The soils of the Arkansas series in this area comprise all gradations between coarse gravelly sands and sandy loams and fine sandy loams. The most common types are a fine sandy loam and a sandy loam, which in the detailed survey of the Grand Island area were incorrectly classed with the Sioux series.

The Sioux fine sandy loam was described as follows:

Description.—The soil of the Sioux fine sandy loam consists of a fine sandy loam of a dark-gray to blackish color, with a depth of from 10 to 15 inches. A few areas, especially along Wood River and the north channel of the Platte

River, are more nearly a fine loamy sand. In typical areas this soil contains large quantities of organic matter, which occasionally gives a silty feel to the soil.

The subsoil varies somewhat, but the largest and most typically developed areas are underlain to a depth of 36 inches by a fine to medium sandy loam of a light-brown color. In the lowland areas, near the streams, the subsoil is sometimes a loamy fine sand, while there are spots in the level upland areas where the subsoil is a medium sandy loam. The whole of this type is generally underlain by sand and gravel at a depth of from 3 to 8 feet.

Location.—This soil occurs in large areas along the channels of the Platte River, extending diagonally across the area from the southwest corner to the northeast side.

Topography.—The Sioux fine sandy loam has the most uniform surface features of any type found in the area. It occupies the broad, flat, level areas along the Platte River and the level areas found north of Grand Island. The country from Alda west to Shelton is nearly level, having a rise of only 6 feet to the mile. This area is called "second-bottom land" by the farmers, while the areas lying adjacent to the streams are known as "lowland," or "bottom land."

Drainage.—The soil has fairly good drainage in the upland or second-bottom areas, while the greater part of the entire area has an elevation of from 3 to 20 feet above the water level of the stream, which makes it possible successfully to use artificial drainage. Open ditches are seen throughout the type. These give good results and do not need to be placed very close together, as the subsoil is sufficiently sandy to allow the water readily to seep into the ditches. There are, however, some low areas of this soil near the streams which are poorly drained, and in wet seasons the crops on these places suffer from lack of proper cultivation. Only a small percentage of the Sioux fine sandy loam is subject to overflow.

Throughout this soil type occur small spots of alkali, due to imperfect drainage, but these are relatively unimportant and have not as yet given any trouble. They are usually very conspicuous, showing a white, barren surface, though in some instances they are covered with salt grass.

Origin.—This type of soil is of alluvial origin, being formed by the deposition and reworking of material by the Platte River and other streams in the area. The Platte River within the area, cutting its channel through the loess formation and running through a sand-hill region outside the area, carries large quantities of sand, fine sand, and silt, and it is through the deposition of this material that this soil has been formed. Since its deposition it has been flooded and reworked and constantly added to by fresh deposits. In some places a considerable amount of organic matter is found, even in the subsoil.

Utilization.—The Sioux fine sandy loam, in agricultural value, ranks second among the soils of this area. It produces good crops of corn, wheat, oats, alfalfa, sugar beets, barley, millet, potatoes, and sorghum. Corn yields from 25 to 50 bushels, wheat from 15 to 35 bushels, oats from 25 to 60 bushels, sugar beets from 8 to 18 tons, and alfalfa from 4 to 7 tons per acre. On the lowland areas a large quantity of wild grass is cut, which makes an excellent quality of hay.

The sandy loam member of this series is described under the name Sioux sandy loam in the report on the Grand Island area, as follows:

Description.—The surface soil of the Sioux fine sandy loam is a medium to coarse, gray to dark-gray sandy loam with a depth of from 8 to 12 inches. It usually has a small quantity of small rounded gravel scattered over the surface,

while in some places considerable organic matter gives it the feel of a loam with sharp sand particles scattered through it. In the areas of this soil type are found patches of sand, which occur as slight knolls. In these the soil is distinctly sandy, but their small extent does not permit their being shown on a map of the scale used. The subsoil is generally a light-colored, coarse, loamy sand to a depth of 36 inches, containing a high percentage of very coarse sand and small water-worn gravel. In a few places the subsoil of this type is a sandy loam very similar to the soil. At a depth of from 30 to 36 inches there is generally found a coarse sand mixed with large quantities of gravel.

Location.—The Sioux sandy loam occurs in large bodies in the vicinity of Grand Island, 3 miles south of that city on the Platte River, east of Alda along the Union Pacific Railroad, east of Shelton, and in many smaller areas scattered along the Platte River. It is found on the ridges or low bluffs along the north channel of the Platte River, where it rises some 3 to 10 feet above the bottom land, and in many places it forms the boundary between the meadow type and the Sioux fine sandy loam.

Drainage.—Considering its generally flat surface, the Sioux sandy loam has, for the most part, fairly good natural drainage, but some areas are so level that the rainfall can only be removed through seepage. The open and porous subsoil allows this to take place quickly and thoroughly. In years of scanty rainfall this soil dries out so readily that crops are considerably damaged, and it is only in favorable seasons that good crops are grown.

Origin.—The Sioux sandy loam is an alluvial soil, being formed by the deposition of material by the Platte River, and consists of sand, silt, and a small proportion of clay. The underlying coarse sand and water-worn gravel are very likely the old bed of the river.

Utilization.—The main crops grown upon this soil are corn, alfalfa, and oats, with some wheat and sugar beets. Corn does fairly well, producing from 15 to 40 bushels per acre in a favorable season. Wheat and oats give only moderate yields. Sugar beets are said to do well on this soil where the subsoil is more nearly a sandy loam. Alfalfa probably gives better returns than any other crop, but even with this crop the yield is light, being from 3 to 5 tons per acre. A considerable part of the Sioux sandy loam is devoted to pasture, especially on the large area near Grand Island.

Besides the types described above, the series is represented by sand and loamy sand members. The sand type has a soil consisting of 8 to 10 inches of medium to fine sand of dark-gray or brown color. The soil is often quite loamy on account of a small quantity of fine soil material and a large amount of organic matter. The subsoil is usually a medium to fine sand to a depth of 36 inches or more. It has a slightly lighter color than the soil. The texture is uniform over considerable areas, but in a few areas near the river water-worn gravel are found scattered through the subsoil below 2 feet, and there is nearly everywhere, as on the other Arkansas types, a bed of sand and gravel beginning at a depth of 3 to 10 feet.

The surface is usually slightly rolling, and the drainage is good, except in a few very low spots near the river, but these could be drained without great difficulty.

The soil is naturally adapted to the production of truck crops and is used to a small extent for this purpose. Alfalfa does better on this

type than any other in the area, the yields ranging from 3 to 5 tons. The more sandy and undrained areas are used only for hay meadows and pasture.

Miscellaneous Types.

Alluvial soils (types undifferentiated).

The alluvial soils of miscellaneous character of which the types were not separated include all soils of the minor streams which occur in a complex manner with an intermingling of small areas of various textures and frequent changes and insensible gradations from one texture to another, so that a separation in a survey of this kind was not practicable. The soils of the Platte River were not included in this group, nor were the soils of the Lincoln series, made up of reworked loess. As a rule, the sediments of the streams in the western part of the State have been brought down from regions covered by fine sandy and silty soils, and consisted of loams and silty loams, with occasional sandy areas.

The streams which flow out from the Sand Hills have built up valleys of very sandy soils. A few of the more prominent streams, with their characteristic soils, are given below.

Frenchman River alluvium.—This stream draws its sediments from various types of silty and sandy soils, and assortment has taken place until areas of various textures are found. The predominant types in Chase County are sandy loams, but lower down in its course the soils become heavier.

Lodgepole Creek alluvium.—The soils of this stream are composed principally of wash from silt loams, and the texture ranges from heavy sand loams to silt loams. These soils are not subject to overflow and make valuable farming land.

The undifferentiated alluvial soils along the minor stream courses in the northwestern part of the State are very limited in extent and comprised of a variety of types following the streams as very narrow fringes from one-fourth mile to about 4 miles in width. It is impossible to treat these soils as distinct types in this survey, because of the great amount of detail necessary and the small scale of the map. Such separations can only be properly made in detailed soil surveys.

White River alluvium.—Along the White River the soil varies from a loamy sand to a grayish silty clay loam. Where the river emerges from the outcropping areas of the sandy Arickaree formation, its alluvial deposits are fine sands and fine sandy loams, but farther down its course the deposits are naturally heavier. The area along this stream in Nebraska is very narrow, but some irrigation is practiced, and excellent crops of alfalfa, corn, potatoes, wild hay, wheat, and oats are produced. Dairying forms a leading industry of the prosperous farmers in this valley.

Niobrara alluvium.—The Niobrara River flows through the sandy soils of the Rosebud series in Sioux, Dawes, Boxbutte, and Sheridan Counties, and naturally most of the deposits along its course consist of loamy fine sands and fine sandy loams. There are, however, local areas of loam, clay loam, and silty clay loam. The alluvial belt is very narrow, varying from one-half to 2 miles. In a few places where irrigation is practiced good crops of alfalfa are grown. This is the only crop which receives irrigation. Good yields of corn and some wheat, oats, and potatoes are also produced. The crops along this stream, however, are not as good as those grown along the White River. In the moist places good yields of redtop, timothy, and wild meadow grasses are obtained. Some alkali is present in poorly drained, depressed areas along the stream, but not in sufficient quantities to affect agriculture.

Hat Creek alluvium.—The alluvial belt along Hat Creek, in Sioux County, is very small in extent. The upper part of this stream, like White River, is formed by a number of small creeks heading in the great escarpment along Pine Ridge, and therefore deposits of fine sand and silt occur along its upper course. Lower down, however, the stream passes through the Pierre formation, and its deposits in such places are mainly clay loams, silty clay loams, and clays. The lowlands along this stream are generally of little present value for farming lands, owing to the high content of alkali. Greasewood and salt grass are the characteristic vegetation. This belt of soil is a continuation of the Orman clay mapped along Hat Creek in South Dakota area. The soil is difficult to till because of its heavy texture.

Alluvium of Middle and South Loup Rivers.—These streams rise in the sand-hill region west and northwest of Custer County. The material along their courses, while passing through the dunes, is similar to that of the Dunesand, and since its deposit by the streams the wind has drifted it into small dunes. This sandy material follows the lowlands of Middle Loup after it enters the Colby silt loam in Custer County for 15 to 20 miles. Here, too, it has been blown into rounded hummocks, forming a mantle several feet deep over the Colby silt loam along the river valley. Beyond this the alluvium along Middle Loup River varies from a silt loam to a clay loam or silty clay loam. South Loup River enters the Colby silt loam in Logan County, and throughout its course in Custer County the material is similar to that along lower Middle Loup. A detailed soil survey would be able to separate a number of types along these two rivers and their small tributaries, though it could not be done in the present survey.

These alluvial deposits occupy nearly level, irregular-shaped belts, varying in width from 1 to 2 miles along South Loup to several miles

along Middle Loup River, with very narrow belts along minor streams. The native vegetation in these stream valleys consists of cottonwood, ash, elm, willow, cherry, wild plum, and a number of other shrubs. Several valuable species of grasses, including grama, are found in Custer County. In Custer County this alluvium forms excellent agricultural soils. Good yields of corn, grain, alfalfa, and wild hay are produced. The water table is nearer the surface, and crops suffer less for moisture than on the uplands. Some irrigation was formerly practiced along these stream valleys, but it has been discontinued owing to a succession of rainy years. Farmers located along these streams are generally prosperous, and the land sells for $25 to $75 an acre.

RIVERWASH.

The lowest member of the alluvial deposits along Platte River and its main branches is the bed of recent sediments over and through which the streams flow. It varies in width from one-half to more than a mile, and is continuous along the Platte and its main branches, North and South Platte, in their courses through the area. In the western part of the area this bed of recent alluvium coincides with the stream channel in times of high water, so that it is not indicated on the map outside of the stream, but farther east the river branches into many channels, and the intervening areas of Riverwash are shown. Coarse sands and gravel make up the greater part of this deposit, but beds and flats of silt and clay occur at intervals. The entire mass is porous, and in all parts of the area a portion of the stream water finds its way eastward below the surface, while in some parts of the area the entire normal flow of the stream is swallowed up, leaving the bed of the stream completely dry.

The beds of silt and clay become more frequent toward the eastern edge of the area, and much of the type might be regarded as Meadow. It has such a low position that it is subject to overflow, and hence has no value except as pasture.

BASSETT SILTY CLAY.

Description.—The Bassett silty clay consists of 6 to 12 inches of very dark gray to brown loam or sandy loam, overlying a subsoil of similar but more sticky and plastic material of a lighter color. This material in turn rests upon a dense silty clay, quite light in color, being in places almost white. The distance from the surface at which this material is found is usually 3 to 5 feet. The chief distinction between the intervening layer and the surface soil is the presence of a very large amount of organic matter in the surface layer, giving to it a darker color and a more loamy feel.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Bassett silty clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
370704	Soil	0.0	2.0	3.2	20.4	27.3	31.6	15.2
370705	Subsoil	.0	2.5	6.7	23.4	10.7	30.6	25.9

Location.—This type, though inextensive, is of considerable importance, as it produces excellent yields of native grass hay, the quality of which is not excelled by any produced in this section. It occupies the level and, in places, somewhat depressed areas in the vicinity of Bassett, Newport, and Stuart, and is one of the best types of the soils of the Elkhorn Valley.

Topography and drainage.—Owing to its level or even slightly depressed topography, the surface drainage is poor. The dense character of the subsoil renders the passage of water through it very slow, and it may justly be considered as a cold soil. In its present condition of development in seasons of average rainfall water stands on the surface of a large proportion of this soil type until quite late in the season, somewhat delaying the operations of haying. This delay is, however, compensated for by the yield and quality obtained. It is in seasons of extraordinary dryness or deficient rainfall that this soil type proves of the greatest value, when frequently the yield of hay is considerably in excess of that obtained on many other soil types in this section which are much more seriously affected by drought.

Origin.—The type is of alluvial origin and appears to have been the result of sedimentation at a time when the Elkhorn River was a much larger stream than at present; probably occupying the whole of a broad, shallow valley bordered by the higher areas of Dunesand, being in effect a shallow lake of comparatively quiet water. After the recession of the water into the present channel the surface layer of the newly deposited soil was probably somewhat modified by the blowing in of a small amount of the sandy material from the adjacent areas. This resulted in giving to the surface layer a more sandy texture than that of the deeper lying soil. The unevenness of the distribution of this material doubtless accounts for the variations that are observed in the surface soil of this type, which ranges from a loam to a sandy loam. In some places it is also found to be a fine sandy loam.

Utilization.—A prerequisite to the cultivation of this soil type is the adoption of some means to insure the adequate drainage of the areas occupied by it. This would probably be best accomplished by the introduction of systems of tiles so designed that the surplus water would be carried through them into open ditches of larger dimensions, such as already exist in the section occupied by this soil type, which have been constructed mainly for the benefit of the roads. Any measure of this kind, however, would entail considerable expense, and the lands so treated must be devoted to the intensive cultivation of some very remunerative crop in order to make the venture a paying one. The continuance of the use of this soil type for the production of hay, however, renders the use of such extensive measures unnecessary, an occasional open ditch being sufficient to remove the surplus water in practically every case.

SUMMARY.

The reconnoissance survey of western Nebraska covers the 51 counties that lie west of 98° 15′ west longitude, and comprises an area of 53,064 square miles, or 33,960,960 acres.

Physiographically the area is a part of the vast plateau known as the Great Plains, which slopes eastward from the Rocky Mountains. In this area it descends from an elevation of 5,300 feet to less than 1,700 feet above sea level. The topography varies from that of almost level plains to rugged, broken country, culminating in the western part in patches of true Bad Lands.

The climatic conditions in this region are those common to the Great Plains section. The temperature has a wide range between the hottest in summer and the coldest in winter, but the dryness of the atmosphere prevents either from being unbearable. The precipitation ranges from more than 26 inches in the eastern to less than 18 inches in the western part. While the entire area lies within the region of deficient rainfall, where occasional droughts must be expected, the eastern part has sufficient rainfall to make the average crop quite profitable. Toward the west the diminishing rainfall brings the average crop production nearly to the limit of profit. Strong winds and a dry atmosphere favor rapid evaporation and the best methods of cultivation are required to conserve moisture in the soil. In spite of these deficiencies dry farming is carried on with success in all parts of the area.

The area may be separated into three main physiographic divisions, the Loess Region, the Sand Hills, and the Plains.

The loess covers the southeastern part of the area. This silty material makes up entirely one type of soil, the Colby silt loam, and also enters into the composition of other sandy and alluvial soils.

The sand-hill region covers a great stretch of country in the north-central part of the area. The principal soil is the loose Dunesand, but on the borders and in basins in the hills there are found the loamy soils of the Valentine series.

In the northern part of the Plains region the Black Hills uplift has exposed a number of rock formations that have weathered into characteristic soils. The dark-colored Pierre shale has produced the brown, sticky clays of the Pierre series. The next higher formations, the Chadron and the Brule, give several fine sandy and silty types. On the High Plains proper there are exposed two extensive Tertiary formations; in the northern part the Arickaree, which weathers into the gray silty soils of the Rosebud series, and in the southern part the Ogallala, which gives the brown calcareous soils of the Sidney series.

There are extensive bodies of alluvial soil along Platte River and lesser strips along the smaller streams. The soils have a wide range of texture, but they are usually more productive than the surrounding upland soils, partly on account of subirrigation. There are several irrigation projects in successful operation in the western part of the State. On the upland soils a number of crops are grown—corn, wheat, oats, cane, hay, barley, and potatoes. In addition to these, the alluvial lands produce alfalfa and sugar beets.

There have been fluctuations in the agricultural population of the area, due to droughts, particularly in the western part, but at the present time the population is steadily increasing and the present prosperity of the region seems to be permanent.

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