Issued February 25, 1911.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE SOUTH DAKOTA AGRICULTURAL EXPERIMENT STATION, JAMES W. WILSON, DIRECTOR; CLIFFORD WILLIS, AGRONOMIST.

RECONNOISSANCE SOIL SURVEY OF WESTERN SOUTH DAKOTA.

BY

GEORGE N. COFFEY AND PARTY.

[Advance Sheets—Field Operations of the Bureau of Soils, 1909.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE
1911.

[PUBLIC RESOLUTION—NO. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Divisions of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., June 16, 1910.

SIR: During 1909 the reconnoissance survey of the Great Plains was continued by mapping the soils of that part of South Dakota west of the Missouri River, an extent of territory exceeding 40,000 square miles.

The accompanying map shows the soils by single types or groups of types, the unit of mapping being larger or smaller, according as the conditions of soil development were broad and simple or more complicated. In addition, it shows the character of the land within certain groups of soils wherever the surface features varied greatly and thus markedly influenced the agricultural value of the soil. The detail given is believed to be all that is warranted by the present status of settlement or by any development that can reasonably be expected for some years to come.

Mr. George N. Coffey, who had general supervision of the work in the field, was assisted by the following members of the Bureau's field force: Thomas D. Rice, A. E. Kocher, Rex E. Willard, William T. Carter, jr., L. C. Holmes, Allen L. Higgings, William T. Smith, Risden T. Allen, and J. V. Bopp, the last-named a member of the state experiment station staff, holding a temporary appointment in the Soil Survey.

I have the honor to transmit herewith the manuscript report and map covering this area, and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1909, as provided by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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RECONNOISSANCE SOIL SURVEY OF WESTERN SOUTH DAKOTA.

By GEORGE N. COFFEY and Party.

GENERAL DESCRIPTION OF THE AREA.

LOCATION AND EXTENT.

The area surveyed includes all of South Dakota west of the Missouri River. North Dakota forms the northern, the Missouri River the eastern, Nebraska the southern, and Wyoming and Montana the western boundaries. The northern, western, and southern boundaries are straight lines, but the eastern follows the meandering of the

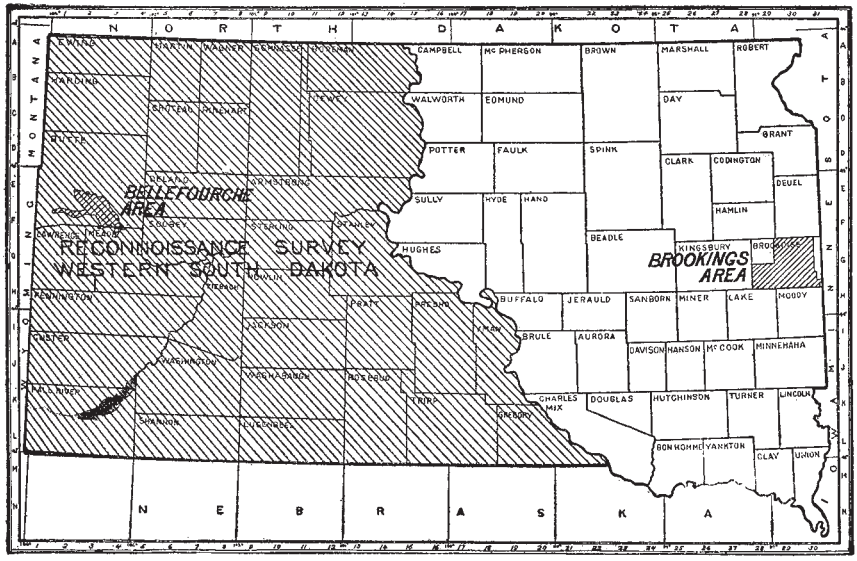


FIG. 1.—Sketch map showing area covered by the reconnoissance soil survey of western South Dakota.

Missouri River. From the North Dakota line to the mouth of the Cheyenne River the general direction of this stream is south, but here it turns to the southeast, causing the southern part of the area to extend about 100 miles farther east than the northern. The length of the area from east to west is about 280 miles at the southern boundary and 175 miles at the northern, while the width from north to south is 204 miles. This gives a total area of 42,219 square miles, or considerable more than one-half of the State.

The southeastern corner projects eastward slightly beyond longitude 98° 30′, while the western boundary extends about 2½ miles west of longitude 104° west from Greenwich. The southern boundary is practically 43° 30′ north latitude, while the northern falls only a few miles south of the parallel of 46°. The area is thus seen to extend through nearly 2½ degrees of latitude and 5½ of longitude.

This portion of South Dakota includes Gregory, Tripp, Lyman, Stanley, Fall River, Custer, Pennington, Lawrence, Meade, Perkins, Butte, and Harding counties, and the Pine Ridge, Rosebud, Lower Brule, Cheyenne, and a part of the Standing Rock Indian reservations. These reservations are divided into the unorganized counties of Todd, Mellette, Bennett, Washabaugh, Shannon, Washington, Armstrong, Schnasse, Dewey, and Carson. A large proportion of the Standing Rock and Cheyenne reservations was opened for settlement during the progress of the survey and many of these counties will doubtless soon be organized; in fact this has already been done in the case of Carson County.

GENERAL SURFACE FEATURES.

Western South Dakota lies in that part of the United States known as the Great Plains. In the extreme western part of the State occurs a small group of mountains called the Black Hills, and these really divide the area into two distinct physiographic provinces—the Black Hills and the Great Plains.

The Black Hills.

Rising as high as 4,000 feet above the surrounding plains and mantled with a dark forest covering of pine and spruce, the Black Hills form the most conspicuous feature of the landscape in the western part of South Dakota and eastern Wyoming, the higher peaks being visible from all the more elevated points of the plains for a distance of 50 to 100 miles. They consist of a great dome-shaped uplift which has been carved and deeply eroded, the character of the surface having been determined to a large extent by differences in the hardness or erosivity of the rocks, of which there are a great variety.

The outer portion of the hills consists of a hogback rim formed by the Dakota sandstone. This formation dips outward and downward and this gives a more or less steep slope toward the plains and nearly always a broken infacing escarpment toward the Red Valley, above which the ridge rises several hundred feet. Numerous streams, coming down from the higher hills, have cut through this rim, forming gateways to the Red Valley, lying just within.

This Red Valley, so called because of the red color of the soils, consists of an almost continuous depression encircling the hills, constituting a very prominent topographic feature. Its formation is due

to the exposure of soft, easily eroded rocks, and its width depends upon the steepness of the dip of the strata. Where this is greatest the valley is very narrow, but where the rocks are nearest horizontal it broadens out until it becomes 4 or 5 miles wide.

Going inward from this valley a rather steep rise takes place, sometimes being as much as 1,000 feet in less than 2 miles. This higher elevation consists of a limestone plateau with an infacing escarpment through which, especially on the eastern side, the streams have carved out deep, rocky canyons with almost precipitous walls. The plateau is broader and less broken in the western than in the eastern part of the Hills, but in general it consists of a rough, rocky country interspersed with "parks," abrupt hills, and precipitous canyons. This limestone plateau forms some of the highest portions of the Hills and in its western part constitutes the watershed from which the streams issue in every direction. Many of these streams have their head in shallow valleys, but as they extend outward the depth increases until the sides become perpendicular canyon walls sometimes a thousand feet high.

The central portion consists of an elevated, somewhat basinlike area, from which rise rocky ridges and mountainous peaks, the highest being the precipitous crags of Harney Peak, 7,240 feet above sea level—an elevation greater than is found anywhere in the eastern part of the United States. With the exception of a large part of the Red Valley and other numerous, narrow valleys along the streams, principally in their upper courses, the topography of the Black Hills is not favorable for agriculture, and this section is best suited to forestry. Nearly all is already included in the Black Hills National Forest.

The Plains.

By far the greater proportion of the survey consists of rolling eastward sloping plains, being a part of the physiographic province known as the Great Plains, which stretches from the Rio Grande northward far into Canada and from the foot of the Rocky Mountains eastward to the Mississippi Valley. These plains were originally almost level, except for a gentle slope toward the east, but erosion has considerably modified the surface configuration and the character of the uplands depends very largely upon the extent to which this has taken place.

Roughly speaking, the amount of erosion, and consequently the character of the surface, varies with the size of the streams. The larger ones have carved out valleys from 50 to 500 feet, or even more, below the general level of the uplands. In some cases the descent into the valleys is gradual and extends back for a number of miles, while in others it is very abrupt, being locally known as "breaks," and the country becomes practically impassable. Such

differences are largely due to variations in the hardness of the rock strata. Where a resistant layer occurs near the top of the slopes it tends to hold up the hills and the valleys really become canyons with almost precipitous walls.

The Missouri, Grand, Moreau or Owl, Cheyenne, Bad, White, and Little Missouri rivers are bordered by very broken, sometimes almost mountainous country, the larger areas being found along the Missouri and the lower portions of the other streams.

Nearly all of the streams are bordered by valleys varying from a few yards to 2 or 3 miles in width. The width, however, often has little relation to the size of the stream. The Missouri River has very little or no bottom lands along it, owing to the change in its course, which took place as a result of glaciation. The Little Missouri, however, has a bottom sometimes as much as 5 miles in width. In general the streams in the northwestern part of the State have much wider valleys in proportion to their size than in other sections. Many changes and adjustments in the drainage have evidently taken place here in comparatively recent geologic time.

Some of the streams, more especially the Cheyenne River, are bordered by level terraces which may be as much as 250 feet above the stream and extend back for as much as 8 or 10 miles.

Between the larger streams occur broad, rolling divides, more or less dissected by minor intermittent creeks and drains. Sometimes these divides have the nature of table-lands with quick descents to the streams, while in other sections they consist of ridges with long slopes.

Throughout a large proportion of the plains the most prominent feature of the landscape is the occurrence of isolated hills or buttes which rise from 50 to 500 feet above the surrounding country, forming conspicuous landmarks for miles around. These buttes represent the remnant of extensive formations which once covered the surface but have been removed by erosion. Their presence is due to the existence of a hard stratum which has prevented them from being worn away as rapidly as the surrounding formations. An exception to the general rule occurs in Bear Butte, which is composed of igneous rocks and represents an outlier of the Black Hills. Some of these buttes have flat tops, perhaps 3 or 4 miles in extent, while others are steep and broken.

The most interesting topographic feature in the entire survey is the "Bad Lands," which term is said to be a translation and contraction of the French for "bad lands to travel through." They represent an extreme case of erosion, and in many portions are so badly gullied that travel, even on foot, is practically impossible. The largest area, often spoken of as "the Big Bad Lands," is situated in the northern and northwestern part of the Pine Ridge Indian Res-

ervation, the extreme southwestern part of Stanley County, and the southeastern part of Pennington County. Other areas of less extent are found throughout the northwestern part of the State.

The general character of the topography in various parts of the area can be seen by reference to the map accompanying this report. Where the surface is level to rolling and permits of the use of farm machinery with little difficulty no hatching is used; where it becomes heavily rolling to hilly, making the use of machinery more or less difficult and in small areas impracticable, a parallel ruling is employed; and where it becomes so hilly and broken that farming is impracticable and the country adapted to grazing only cross-hatched lines are used. Of course this division on the map is more or less general and areas of one class had to be included in the other; but a very good idea of the relative surface features of the country can be given in this manner. Approximately 56 per cent of the area falls in the first class, 23 per cent in the second, and 21 in the third.

The general slope of the country is toward the east. The greater part of the Plains lies between the 2,000-foot and 3,000-foot contours.

The Missouri River at the Nebraska line is about 1,200 feet above sea level and at the North Dakota line about 1,700 feet. From the Missouri River there is a gentle rise toward the west until an elevation of slightly over 3,500 feet is reached in the northwestern part of the State and as much as 4,250 in the southwestern part, while the Black Hills, as already stated, rise to more than 7,000 feet.

REGIONAL DRAINAGE.

The drainage of the region is effected through the Missouri River and its tributaries. The extreme northwestern part of the State is drained by the Little Missouri, which flows northward along the western border of this part of the State into North Dakota. The streams running eastward have their headwaters very near this stream, and most of the water is carried off by them.

The Grand River rises near the northwestern corner of the State and flowing eastward enters the Missouri opposite Mobridge, draining the northern part of the State. Lying south of and paralleling the Grand through its entire course is the Moreau or Owl River, which drains a wide stretch of country in the north-central part of the area.

The Cheyenne River furnishes drainage to a larger area than any other tributary of the Missouri in this State. This stream rises in Wyoming and elbows its course around the southern end of the Black Hills, thence turns sharply northeastward and enters the Missouri just north of Fort Bennett. The Belle Fourche River has its beginning very near the Cheyenne, but runs to the north of the hills and joins the latter west of Pedro in eastern Meade County. Numerous smaller streams run down from the hills and enter the Cheyenne either

directly or indirectly through the Belle Fourche. The more important of these are Redwater, Spearfish, Whitewood, Box Elder, Rapid, Spring, Battle, French, and Lame Johnny creeks, and Fall River.

Eastern Pennington, southern Stanley, and northern Lyman counties are drained by the Bad River, which flows into the Missouri at Fort Pierre.

The White River enters the State from Nebraska in the southwestern corner of the Pine Ridge Indian Reservation and flows northeast to a point just south of Stamford, where it turns more nearly east and enters the Missouri south of Chamberlain. Many important tributaries, the largest being the Little White River, enter this stream from the south. Those on the north are very small and extend back only a short distance.

The drainage of the southeastern part of the Rosebud Indian Reservation and the southern part of Tripp County are effected through the Keyapaha River and of southern Gregory County through Ponca Creek.

Numerous small creeks and drainage channels are found throughout the area, which flow into the larger streams enumerated above. In the Plains only the larger streams are perennial, but in the Black Hills a very large percentage of even the smaller creeks carry water all the year round.

FORESTS.

The Plains consist of rolling treeless prairies, the only timber being found along the streams. All of the rivers and larger creeks were originally bordered by a fringe of trees, consisting principally of cottonwood, elm, ash, and box elder. Sometimes these belts are not more than 50 to 100 feet in width; sometimes they widen out to a mile or more; yet even in these narrow strips the moisture conditions are so very favorable that a large amount of small timber is crowded into them. The large demand for fuel, fence posts, and building material, caused by the recent advent of the homesteader, has led to the stripping of these streams of all trees in many sections, and unless more care is exercised a few years will see the entire disappearance of these bands of green threading their way through the Plains, offering protection from the sun in summer and shelter from storms in winter.

While these fringes of timber along the streams cover in the aggregate a considerable area, by far the most important forested area is found in the Black Hills. The larger rainfall and surface configurations here have been favorable to the growth of trees, and practically the entire area of the Hills is, or was originally, covered with a heavy timber growth, consisting principally of pine and spruce, with a smaller percentage of various other species. While wasteful methods of forestry, combined with destructive fires, have practically stripped the hills of trees in many sections, large tracts of valuable timber are still standing.

Realizing the importance of preserving these forests, national forests have been created by the Government, the largest of which includes nearly all of the Black Hills.

Aside from the large preserve in the Black Hills, five other smaller ones called the Sioux National Forest have been created in other sections. These include the Slim Buttes, Cave Hills, East and West Pine Hills, and Pine Ridge. Of these the Slim Buttes Reserve is the most extensive, comprising a strip from 3 to 6 miles east and west and 25 miles north and south. These areas are generally extremely rough and broken and consist either of buttes rising from 100 to 500 feet above the surrounding prairies or of deep erosions almost as much below. Occasionally a field can be found sufficiently level for cultivation, but these areas are so few and so inaccessible that the entire preserves may be classed as nonagricultural lands best suited from every standpoint to the growth of trees, and their continuance in forest can not but form a valuable asset to this section of the State.

POPULATION.

All of this section, in common with other parts of the country, was originally inhabited by Indians, the Sioux being the most important tribe represented, but unlike most other sections, there are still large areas which are inhabited exclusively by the red man.

The settlement of the country was stubbornly resisted and the fierce Sioux were not finally subdued and compelled to remain on the reservation until the battle of Wounded Knee was fought in 1889. Several large tracts of land are still held as reservations and the total Indian population in the area is about 17,000.

The following table shows the population by five-year periods, the even years being taken from the federal and the odd years from the state census:

Population of western South Dakota by five-year periods.

County.	1905.	1900.	1895.	1890.	1885.
Butte[a]	3,975	2,907	1,575	1,037	1,081
Custer	2,899	2,728	3,326	4,891	1,292
Fall River	4,222	3,541	4,168	4,478	472
Gregory	7,024	2,211	1,042	295	.....
Lawrence	21,060	17,897	14,345	11,673	10,326
Lyman	4,263	2,632	804	233	.....
Meade	5,405	4,907	3,553	4,640	.....
Pennington	6,078	5,610	5,163	6,340	3,224
Stanley	2,649	1,341	511	1,028	653
Indians	17,467	16,043	.....	.....	.....
Total	[b] 57,575	[b] 43,774	34,487	34,815	17,048

[a] Includes Harding and Perkins.

[b] Exclusive of Indians.

At the time of the last federal census (1900) the entire population of South Dakota west of the Missouri River, exclusive of Indians, was 43,774. According to the state census it had increased in 1905 to 57,575. The same authority estimates that 55,000 have been added in the last four years. A rapid movement of population is thus taking place. This is due in a large measure to the construction, within the last three years, of three important lines of railway, one from Chamberlain to Rapid City, another from Pierre to Rapid City, and a third from Mobridge westward near the northern boundary. In addition to and almost simultaneous with the building of these lines of railway there were opened for settlement large areas which had previously been held as Indian reservations, and this greatly stimulated the movement of population to this section.

The source of this immigration is varied, nearly all of the more Eastern States being represented. The greater number of settlers, however, have come from eastern South Dakota, Minnesota, Iowa, and eastern Nebraska. Many also of foreign parentage have settled in this section and filed claims to homesteads, the larger proportion of these being from Norway, Sweden, Germany, and various Russian provinces. The mining population of the Black Hills is very largely foreign.

Naturally the most rapid settlement has been along the railways and around the towns, but the movement has extended more or less over the entire area, outside of the Indian reservations, until a large proportion of the available agricultural lands has been filed upon. The ranchers and cowboys, who for many years were the only white inhabitants on the plains, are rapidly giving way to the homesteader.

As a whole the area is rather thinly settled, the number, using the estimated population for 1909, being about three persons per square mile. There are long stretches of country with only an occasional house to be seen. If the present rate of settlement continues, it will be only a few years before the country will be dotted with farmhouses.

The most important towns are situated in and around the Black Hills, the largest being Lead, with a population of about 8,000. Deadwood, only 5 miles distant, is almost as large. Both are dependent upon the mining interests. Rapid City, Bellefourche, Spearfish, Hot Springs, Custer, and Edgemont, with populations varying from 1,000 to 5,000, are very important centers. Lemmon is the largest town far away from the Hills and has, in two years' time, attained a population of nearly 1,500. A number of other towns, with population of 200 to 1,000 inhabitants, are located along the railways, most of them having been laid out within the last two or three years. Some small but locally important trading places are also found in various parts of the area away from the railroads.

TRANSPORTATION AND MARKETS.

The development of western South Dakota has been much retarded by the lack of adequate transportation facilities. The great Sioux Indian Reservation hindered the building of railroads across the Missouri River, and until 1907 practically the entire area outside the Black Hills was without transportation facilities.

Three large railroad systems now enter the area—the Chicago and Northwestern, the Chicago, Milwaukee and St. Paul, and the Chicago, Burlington and Quincy. The Northwestern has three important lines in this part of South Dakota. The oldest one, called the Fremont, Omaha and Missouri Valley, enters the southwestern part of the State from Nebraska, runs around the Hills, and, uniting at Rapid City with the Pierre, Rapid City and Western branch, extends on to Deadwood and Lead. From Buffalo Gap a branch extends to Hot Springs and another runs from Whitewood to Bellefourche. An extension northeastward from the latter point is now under construction. A third line enters the area in Gregory County and runs as far as Dallas.

One line of the Chicago, Milwaukee and St. Paul runs westward from Chamberlain to Rapid City, while the Pacific coast extension of this road crosses the northeastern part of the area, paralleling the North Dakota-South Dakota boundary about one-half of its distance west of the river. Two other branches of this road are being built westward from Mobridge along the Grand-Moreau and Moreau-Cheyenne divides.

The main line of the Chicago, Burlington and Quincy Railway to the northwest Pacific coast crosses the extreme southwestern part of the State. An arm reaches northward through the Hills to Lead and Deadwood, with branches to Spearfish and Hot Springs. A narrow-gauge line, used principally as a timber road, runs from Lead to Nemo.

An independent road called the Rapid City, Black Hills and Western connects Rapid City and Mystic. Another similar line runs from Bellefourche to Aladdin, Wyo.

The transportation facilities are not yet adequate, as there are some parts of the area as much as 70 miles from a railroad. New lines are under construction and other are being projected, and these when completed will do very much to improve the means of getting the products to market.

The above lines of railway give direct transportation to Minneapolis, St. Paul, Omaha, Kansas City, and Chicago, and these points form the principal markets of the area. Nearly all of the stock is shipped to one of these points. The mining and timber interests in the Black Hills create a considerable local demand for farm products and many farmers find ready sale for fruits and vegetables in Lead, Deadwood, and other towns of the Hills.

CLIMATE.

Climate and soil determine very largely the adaptability of a region for agricultural operations, and also the character of the agriculture that will prove possible and most profitable. A knowledge of both of these factors is of very great value to the agriculturist, especially in a new and rapidly developing section like western South Dakota.

The principal climatic factors to be considered are precipitation, temperature, and winds.

PRECIPITATION.

Moisture is absolutely essential to the growth of crops. The amount of precipitation in this section is so near the minimum for the successful conduct of agricultural operations that its importance as a climatic factor is relatively very great. More space is therefore devoted to the discussion of this factor and the data are given in more detail than would otherwise be justifiable.

The following table gives the annual records of precipitation at several important points in the area:

Annual precipitation for 1881 to 1908, inclusive.

	Ashcroft.	Oelrichs.	Rapid City.	Spearfish.	Fort Meade.	Pierre.[a]
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1881	.....	.....	.....	.....	15.06	14.85
1882	.....	.....	.....	.....	19.32	12.20
1883	.....	.....	.....	.....	27.05	19.91
1884	.....	.....	.....	.....	22.97	11.49
1885	.....	.....	.....	.....	13.25	20.82
1886	.....	.....	.....	.....	13.51	16.00
1887	.....	.....	.....	.....	18.93	14.26
1888	.....	.....	22.75	.....	20.00	14.77
1889	.....	.....	17.93	21.87	18.00	15.29
1890	.....	11.82	14.02	20.73	16.23	13.28
1891	.....	22.05	16.75	26.32	21.79	13.18
1892	.....	33.58	20.03	26.82	24.09	18.81
1893	13.64	16.82	9.61	22.85	19.12	14.56
1894	15.12	19.31	13.75	28.69	16.78	7.82
1895	13.17	18.92	15.48	.....	20.76	16.85
1896	19.46	17.57	13.68	.....	17.61	17.35
1897	10.50	16.85	12.32	18.92	16.62	18.84
1898	15.24	13.81	10.98	11.89	23.15	10.65
1899	14.41	20.65	16.71	17.54	20.37	20.00
1900	12.92	12.93	13.32	17.73	13.92	16.81
1901	11.39	24.34	23.25	19.14	23.28	17.14
1902	16.00	19.79	18.51	19.44	22.19	20.04
1903	13.21	18.57	21.28	29.41	23.89	19.53
1904	10.42	12.83	16.40	24.40	18.97	9.15
1905	13.77	21.73	27.06	27.85	30.37	20.46
1906	18.90	22.25	19.85	21.51	21.98	22.06
1907	15.45	17.20	18.40	25.64	29.20	14.02
1908	15.56	19.00	19.63	17.68	17.00	19.10
Mean	14.26	18.94	17.15	22.20	20.06	16.50

[a] The data for 1881 to 1891, inclusive, are for Fort Sully, some 20 miles northwest of Pierre, and are not included in the mean.

The following table gives the greatest, least, and average monthly precipitation at Pierre, Ashcroft, Rapid City, and Fort Meade:

Maximum, minimum, and average monthly precipitation.

	Pierre.			Fort Meade.			Ashcroft.			Rapid City.		
	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.
	Ins.	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*
January	1.66	0.01	0.46	2.90	0.10	0.76	0.93	0.07	0.57	0.63	0.06	0.34
February	1.15	.04	.44	2.30	.10	.68	.80	T.	.40	1.62	.02	.48
March	2.49	.10	1.33	5.53	.12	.82	2.78	.10	1.26	3.34	.14	1.17
April	3.86	.62	1.98	5.70	.25	2.33	1.90	.40	1.06	4.24	.41	1.93
May	4.65	.24	2.13	10.95	.35	4.10	4.21	.92	2.29	8.09	.53	3.49
June	6.09	.77	3.08	8.10	.48	3.65	5.82	1.05	2.94	7.53	.50	3.50
July	4.99	.90	2.35	10.33	.16	2.33	4.18	.32	1.76	9.66	.13	2.24
August	5.16	.21	2.01	5.55	.....	1.64	4.73	.42	1.36	5.67	.09	1.47
September	2.69	.20	1.11	2.90	.....	.81	2.49	.07	.94	2.67	.02	1.04
October	3.21	T.	.81	4.95	.....	1.02	2.24	T.	.52	2.29	.02	.77
November	1.92	T.	.55	2.36	.....	.59	1.90	.....	.49	1.16	.01	.37
December	2.21	T.	.50	1.70	T.	.58	1.10	.....	.40	.93	.01	.35

The greatest precipitation occurs in the Black Hills and in the southeastern part of the area and the least in the northwestern and along the lower Cheyenne River. There is apparently a slight decrease from south to north. Spearfish, which is situated in the edge of the Hills, shows an average annual precipitation of 22.20 inches. No complete records are available for a station near the center of the Hills, but a ten-year period from 1878 to 1887, at Deadwood, gave an average of 28.48 inches.

The annual precipitation in practically all sections is usually sufficient, if properly distributed, to insure the successful production of crops. A great deal, however, depends upon both the monthly and annual distribution. A study of the above tables will show that the amount of precipitation may vary decidedly from year to year and also for the same month in different years. Such variations, although they occur practically everywhere, are of more consequence in a section where the rainfall is near the minimum for successful farming. Years of insufficient rainfall and consequent low yields or failure of crops are to be expected and the provident farmer will prepare for them.

On the other hand, most of the precipitation occurs during the growing season. Using the average of the records at all stations the total amount from October to March, inclusive, is 4.22 inches or 0.70 inch per month, while in the six months from April to September it is 14.05 inches or 2.34 inches per month, more than three times as much. This distribution is very favorable to agriculture, as the rainfall comes during the season when most needed.

Another factor which should not be forgotten is that during the winter months most of the precipitation here is in the form of snow, much of which remains until spring, when it melts, and if the soil is in proper condition runs into the ground, thus practically increasing the amount of precipitation during the growing season.

There is a more or less general impression that the climate in this section is changing and that the plowing up of the country is causing a permanent increase in the rainfall. The records at Rapid City show that the rainfall for the last decade is considerably higher than for the preceding, and although the contrast is greater there than at any other point in the area, it is probably responsible, in some measure at least, for the idea that the rainfall is on the increase. Careful records here, as well as in other sections, extending over long periods, lead to the conclusion that no permanent change is taking place and that drier years may be expected in the future as in the past. A fuller appreciation of the necessity for conserving the moisture and a better understanding of the methods for accomplishing this, together with the selection of crops better suited to the soils and semiarid conditions, will doubtless do much to lessen the injury sustained in years of insufficient moisture.

Hailstorms which do much damage to crops sometimes occur, but are usually local in character.

The average depth of snow varies from 28.7 inches at Pierre and Rapid City to 64.4 and 53.2 inches at Spearfish and Oelrichs, respectively. March is the month of heaviest snowfall. Snowstorms, sometimes of sufficient intensity to justify the common term "blizzard," occur, although the latter are less frequent than is popularly supposed.

TEMPERATURE.

The average annual temperature is about 45° F., being a little lower in the northern and a little higher in the southern parts of the area. The southern portion, as well as the valleys in the Black Hills, are warmed in winter to some extent by the "chinook" winds, so common in Montana.

Like most of the Great Plains region, this section is characterized by decided monthly and annual ranges in temperature. The absolute annual range is about 150° F. Real winter does not usually set in until late in November. The winter temperature is low, but the dryness of the atmosphere makes the cold less severe than in more humid sections. Several days and even weeks may elapse without the thermometer rising above zero, while drops to −30° or even −40° may occur. In summer the days may be very warm, the thermometer sometimes registering above 100° F., but the nights are nearly always cool and pleasant. This is especially true in the Black Hills and, combined with the picturesque beauty of the scenery, is fast making this section a favorite summer resort.

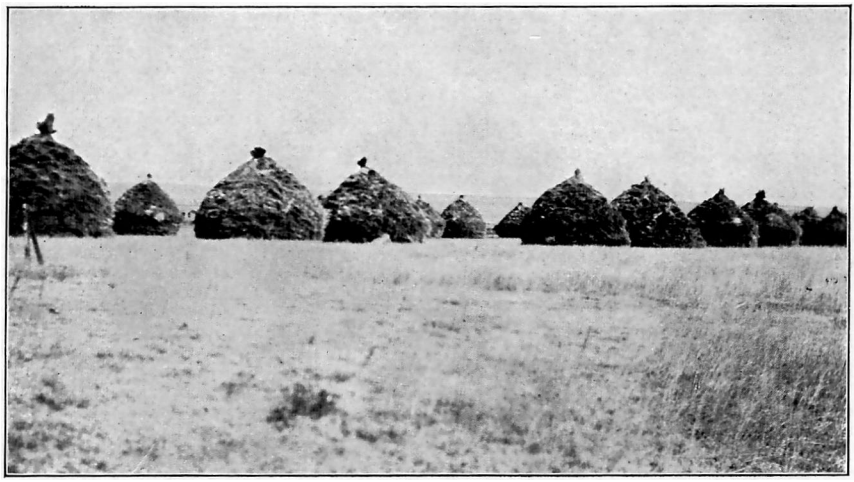


FIG. 1.—STACKS OF WHEAT GROWN UNDER "DRY FARMING" ON ROSEBUD SILTY CLAY LOAM.

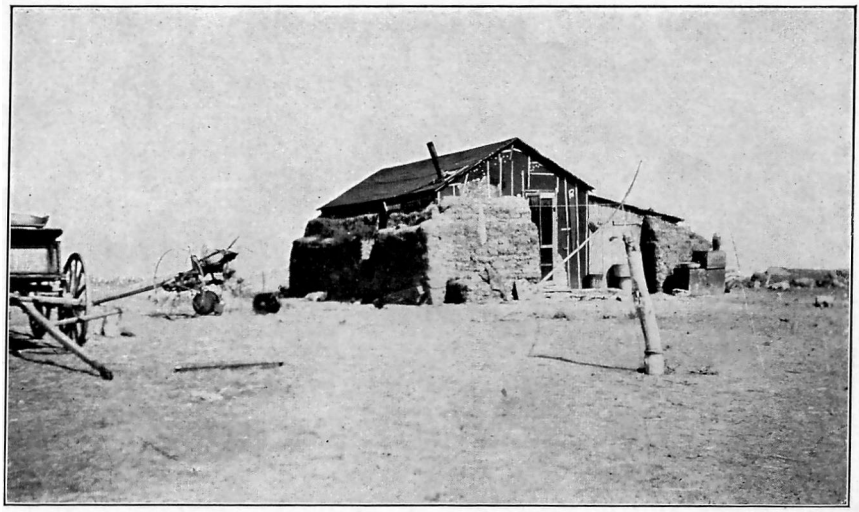


FIG. 2.—THE HOME OF THE HOMESTEADER.

[Sod is used to keep out the cold, and sometimes the entire house is constructed of this material.]

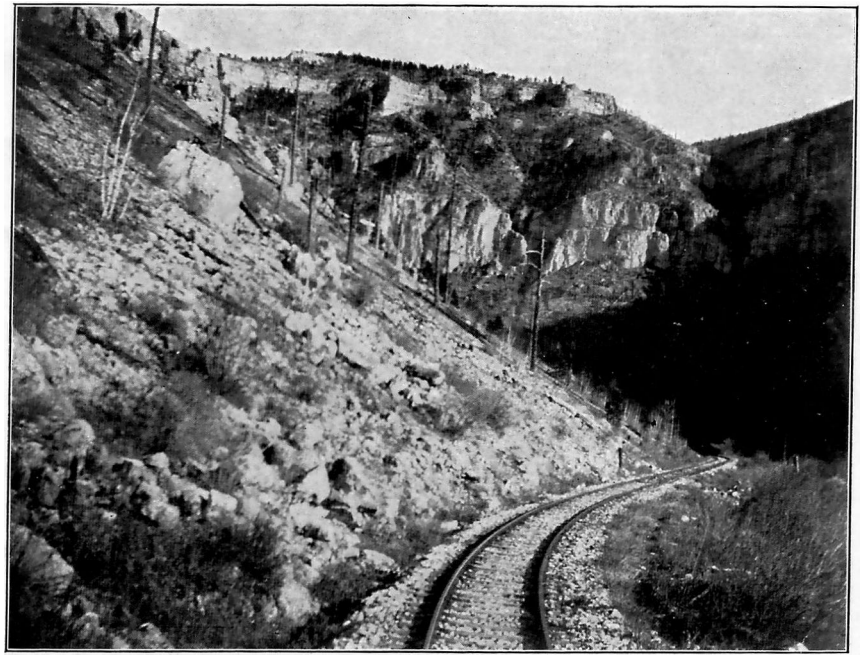


FIG. 1.—SPEARFISH CANYON, BLACK HILLS, SHOWING ROUGH, ROCKY CHARACTER OF COUNTRY.

[Trees find foothold in the almost perpendicular cliffs, which are of limestone and nearly 1,000 feet high.]

FIG. 2.—NONIRRIGATED OAT FIELD ON ALLUVIAL SOILS OF BELLE FOURCHE RIVER, EAST OF STURGIS.

The following table gives data relating to temperature, as compiled from the records of four principal Weather Bureau stations:

Highest, lowest, and mean monthly and annual temperature at four principal stations.

Month.	Pierre.			Ashcroft.			Spearfish.			Oelrichs.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Absolute maximum.	Absolute minimum.
	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
January	19	60	−30	19	63	−44	25	65	−30	23	63	−28
February	18	70	−39	18	67	−40	21	67	−30	20	67	−41
March	29	84	−15	27	82	−33	30	80	−20	31	83	−28
April	48	94	5	45	94	−12	46	88	1	46	102	7
May	60	98	30	56	98	16	55	93	−24	57	99	19
June	69	103	38	64	107	24	64	105	33	66	110	33
July	75	108	45	70	110	32	71	105	43	73	108	38
August	74	110	39	69	114	30	70	104	40	72	107	34
September	64	104	26	58	105	11	60	97	26	60	108	20
October	51	98	4	46	92	− 2	49	90	17	48	96	6
November	32	80	−16	30	80	−26	35	79	−11	33	87	−18
December	23	67	−19	24	69	−33	31	71	−17	26	64	−42
Annual	47	110	−39	45	114	−44	46	105	−30	46	110	−42

A killing frost may be expected in the northern part of the State about the 10th of September, and in the southern from one to two weeks later. Sometimes one may come as early as the last of August. The average date of the last killing frost in spring varies from about the first to the middle of May, although one may occur a month later.

In the following table the recorded dates of frost occurrence are given in detail for seven stations within the area surveyed:

Average date of the first killing frost in fall and the last in spring.

Stations.	Length of record, years.	Average date of—		Date of—	
		First killing frost in autumn.	Last killing frost in spring.	Earliest killing frost in autumn.	Latest killing frost in spring.
Ashcroft	16	Sept. 14	May 24	Sept. 4	June 20
Fort Meade	24	Sept. 23	May 7	Sept. 6	May 28
Oelrichs	18	Sept. 23	May 10	Sept. 2	May 30
Pierre	17	Sept. 30	Apr. 30	Sept. 12	May 19
Rapid City	21	Sept. 26	May 6	Sept. 13	May 21
Rosebud	14	Sept. 25	May 10	Sept. 10	May 30
Spearfish	18	Sept. 27	May 9	Sept. 11	June 21

WINDS.

In the Great Plains region the atmosphere is in almost constant motion. Winds often blow steadily for several days at a time, with only short periods of calm between. The average annual velocity at Pierre is 9.3 and at Rapid City 8.1 miles per hour. March, April, and May are the windiest months, the average velocity at Pierre during April being 12.1 and at Rapid City 9.3 miles per hour. Westerly and northwesterly winds prevail almost the entire year, except during the summer months in the eastern portion, when they are from the southeast.

SOILS.

The character of the soil in any region depends upon two great groups of factors; first, the character of the material from which it is derived; and, second, the processes by means of which this material has been converted into a medium capable of supporting plant growth. The first has to deal with soil-forming material; the second with soil-forming processes. The two sets of factors are intimately associated and a given soil condition is always the resultant of a definite combination of these soil-forming factors. Uniformity in the factors will give uniformity in soil, or a soil type, while any variation will as certainly result in a change in its character. A knowledge of these factors is therefore essential to a proper understanding of the soils of any region, and a brief discussion of the geological formations found in western South Dakota as well as the general processes which have been instrumental in producing soils from these formations will be given in this connection.

GEOLOGICAL FORMATIONS OR SOIL-FORMING MATERIAL.[a]

Western South Dakota presents a great variety of geological formations. Almost the entire geological column from the Archean to the latest Quaternary deposits is represented. This is due to the bringing to the surface of the older rocks in the great uplift which gave rise to the Black Hills. The Plains originally consisted of almost horizontal strata, which, in the Black Hills, were thrust upward, until in some places they are inclined at an angle of 45°, or even more. The rocks around the Hills therefore dip downward, a succession of younger and younger strata occurring outward from the center of the uplift. This can best be seen from the diagram (fig. 2).

[a] The discussion of the geology is based largely upon "The Geology and Underground Water Resources of the Central Great Plains," by N. H. Darton, and "Geology and Underground Waters of South Dakota," Water-Supply Paper 227, U. S. Geol. Survey, by the same author.

The oldest rocks in the area consist of the granites, gneisses, schists, and other igneous and metamorphic rocks, which constitute the center of the Hills. These give rise principally to stony soils or rough broken areas best suited to forestry. In some places small areas of cultivated land can be found, but these are too small to map in a reconnoissance survey. The soils from these crystalline rocks are very markedly different from those of the Plains, and are more like those of the eastern humid parts of the United States.

Above the crystalline rocks of pre-Cambrian age lies a great thickness of sedimentary rocks belonging to the Cambrian, Ordovician, and Carboniferous systems, which give rise to rough, broken, and stony country not suited to agriculture, and therefore no attempt was made to differentiate the soils. The rocks are limestone and sandstone, with some shale interbedded. The most conspicuous of these formations is the Pahasapa limestone, belonging to the Mississippian division of the Carboniferous system. This rock has very extensive outcrops in the Hills and constitutes much of the

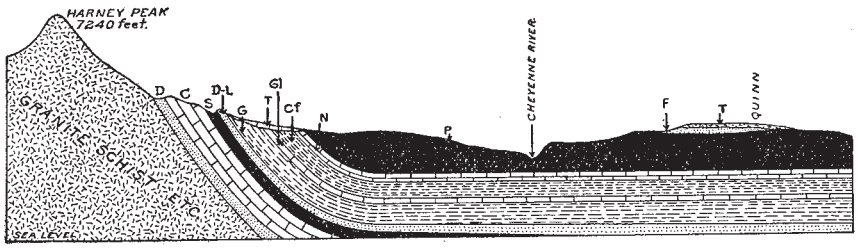


FIG. 2.—Cross section from Harney Peak through Quinn: *D*, Deadwood sandstone; *C*, Carboniferous limestones; *S*, Spearfish Red Beds; *D-L*, Dakota-Lakota sandstones; *G*, Graneros shale; *Gl*, Greenhorn limestone; *Cf*, Carlile formation; *N*, Niobrara formation; *P*, Pierre shale; *F*, Fox Hill or Laramie sandstones and shales; *T*, White River group.

plateau, which is especially well developed in the western portion. It is a hard limestone and usually gives a very stony country, although small areas of very fertile lands are found.

The oldest formation furnishing any considerable area of agricultural land is the Spearfish, probably of Triassic age. This formation consists of gypsiferous red beds which occur in the Red Valley and give rise to red soils, very distinct from anything else in the State, although very much like those derived from the Red Beds of Oklahoma and Texas.

Above the Spearfish formation occurs a succession of sandstones, shales, and limestones of Jurassic and Cretaceous age. These are capped by the Dakota sandstone, which, because of its hardness, has resisted erosion and formed the outer rim of the Hills. The country is generally too broken for agriculture, and consists largely of rough stony areas.

The Dakota sandstone is overlain by the Benton group of Cretaceous age. This group consists of shales separated by an impure slabby limestone, known as the Greenhorn limestone. The lower member or Graneros shale gives soils very much like the Pierre shale, although areas which are bare and worthless for agriculture are more numerous. The upper member or Carlile shale is more sandy and the soils usually more like those of the Laramie.

Just above the Benton group is 150 to 225 feet of chalk and calcareous shale, known as the Niobrara formation. In some places this gives a soil much like the Rosebud silt loam, while in others it is heavier. The outcrop is narrow and covers only a comparatively small area.

All of these sedimentary formations have been brought to the surface by the Black Hills uplift and occur as bands encircling the Hills. Only the Benton group and Niobrara formation occur in the Plains, and therefore the greater part of the agricultural section of western South Dakota is formed from strata of later age. These later shales, having been influenced very little by the uplift, are therefore almost horizontal, and consequently outcrop over large areas.

The oldest of these shales is the Pierre shale. This formation outcrops along the entire eastern border of the area, then narrowing, extends westward through the central portion and incloses the Black Hills as in the prongs of a great Y. It consists of dark to slate-colored clayey shales of rather uniform character which give rise to a distinct group of soils called the Pierre series. The heavier or clay member of this series predominates, causing the country where these shales outcrop to stand out in marked contrast to the sections occupied by the later and less clayey formations.

Nearly all of the northern third of the area consists of soft sandstones and sandy shales belonging to the Fort Union, Laramie, and Fox Hill formations of late Cretaceous time. These rocks give rise to another distinct group of soils which has been called the Morton series.

In the south-central portion of western South Dakota occur extensive Tertiary deposits, which consist here of two principal divisions—the White River group (Oligocene) at the bottom and the Arikaree formation (Miocene) above. With the exception of small detached areas around the Black Hills, these Tertiary formations are all characterized by a very light color, the bare erosions appearing almost as white as snow banks. The White River deposits consist principally of a pale flesh-colored to almost white silt loam, which often contains beds of fuller's earth. In its extension north of the White River it changes to silty clay or clay. These formations give rise to silt loam, silty clay loam, and silty clay soils, while the Arikaree formation, being more sandy, usually gives soils of lighter texture.

These soils have been grouped in the Rosebud series. A considerable part of the area covered by the White River group is very badly eroded, and is classed as "Bad Lands" or "Bad Land Basins."

On the divides near Hermosa the White River formation consists of sandstone and conglomerate of dark-brown color, which give a soil different from that in other sections and therefore called Hermosa loam.

The Pleistocene period is represented in western South Dakota by several divisions. Throughout a large proportion of the plains surrounding the Black Hills the surface is strewn with waterworn stones and gravel, probably of early Pleistocene age. In a few places these have been represented on the map by the gravel symbol (oo), but it was impossible to show all of these. This gravel is very noticeable on the divides near Rapid City. In most cases the gravel is simply scattered over the surface and does not influence very materially the character of the soil.

Along the Cheyenne River throughout almost its entire course there is found a series of gravel terraces situated from 100 to 500 feet above the present level of the stream. These terraces have characteristic soils which have been grouped in the Cheyenne series. It is probable that these terraces were formed at the time that all of the State east of the Missouri River was covered by a great sheet of ice. The present course of the Missouri was formed at that time and represents the southwestward extension of the ice.

A number of glacial bowlders are found west of the river, but these constitute about the only evidence of glacial action, and therefore no glacial soils occur in the area.

Deposits of wind-blown sand are found in the southwestern part of the State, principally in connection with the Arikaree formation, although of later age. Usually these eolian deposits are very sandy, but in some places contain enough fine material to give the texture of a sandy loam. These have given rise to Dunesand, Gannett fine sand, and Smithwick sandy loam.

The latest geological formation consists of the recent alluvial deposits, which are still being added to by every overflow of the streams. These deposits vary a great deal in character, especially in the vicinity of the Black Hills, and a diversity of soils has resulted.

SOIL-FORMING PROCESSES.

These different formations have furnished the material from which the soils of the area have been formed through the action of certain agencies or processes; and while changes in the character of the underlying material are largely responsible for the variations in the soils in one part of the area as compared with another, the processes by means of which this material has been converted into

actual soil have also had a marked influence in giving to the soils of this section some of their most distinctive characteristics.

The principal factors involved in these processes are included in or vary with the climate, so that soils formed under subhumid to semiarid conditions are always different from those occurring in regions of heavy precipitation. In the latter regions the more soluble constituents are leached out by carbonated waters, leaving the less soluble and usually more siliceous material behind. For this reason the soils in a region of lower rainfall always contain a larger percentage of soluble material than in more humid regions.

This is not only true of the soils, but also of the formations from which they have been derived. The material composing the sedimentary formations of this area has been brought from more arid sections to the west, where the breaking down of the rocks has been accompanied with very little leaching out of the more soluble minerals, and it therefore contains a much larger percentage of easily soluble matter than is found in the more humid eastern sections. In fact, the amount of soluble salts is so large in many of the rocks of this area, especially the shales, that excessive accumulations often occur, especially where moisture conditions favor their concentration.

The presence of considerable quantities of lime and other soluble material has a very important influence upon the amount and character of the organic portion of the soil. Under favorable moisture conditions their presence causes the organic matter to become humified and gives to the soil the dark color so pleasing to the farmer and so characteristic of prairie regions. While the moisture conditions here are less favorable for the accumulation of organic matter than farther east, so that the soils do not, in general, have as large a percentage of humus as in the more humid prairie regions, and, in fact, represent a transition from these to the lighter colored arid soils farther west, still they are in most cases fairly well supplied with this valuable constituent.

CLASSIFICATION.

Owing to the great variation in the character of the rocks, the agencies or processes of soil formation have given rise to a great variety of soils, differing in color and in mineralogical, chemical, and physical composition, as well as other properties. The types are related to each other in various ways and some means of classification must be adopted in order to bring out these relations.

According to differences in the underlying formations the soils may be divided into five groups: (1) Those formed from sandstones and shales, (2) those derived from unconsolidated or loosely consolidated light-colored calcareous deposits, (3) those of eolian origin, (4) those of the gravel terraces, and (5) those of alluvial origin. In addition

to these groups there are areas derived from crystalline rocks and others formed from limestones. Most of the region, however, underlain by these rocks is composed of rough land, and the small areas of cultivable soils could not be separated on the map.

Differences in the character of the material in these groups permits of further subdivisions. Where the soils are very similar in all their general characteristics except texture, the types have been placed in a series and given the same place name. A complete series would represent a gradation from a sand to a clay, but usually only a few members are present, and in some instances the conditions are so uniform that only one member of a series, or a miscellaneous type, is found. In other sections certain conditions, like Rough stony land and Bad Lands, rather than definite soil types, exist, and descriptive names are given to these.

In a general survey it is not practicable to make as fine separations as in one of more detail, and the material mapped as a type must necessarily often include wider variations in character, while sometimes two or more types have to be shown in one color on the map. Some types occur in large uniform areas and can easily be indicated, but where changes occur within short distances it is often impossible to separate out the individual types, and the map here is very general in its nature. In some cases the series only is shown, or the soils are classed as undifferentiated. The soils are especially complex around the Black Hills and along the line of contact between the Pierre and Morton series. In the Black Hills the proportion of farming land is so small, the character of the soils so varied, though usually stony, that no separation was attempted.

The following shows the classification of the soils made in this area:

Classification and area of soils.

Soil groups and types.	Proportion of type —			Total area of type.	Proportion of total area.
	Level to rolling.	Very rolling to very hilly.	Very hilly and broken.		
Soils from sandstones and shales:					
Morton series—	*Per cent.*	*Per cent.*	*Per cent.*	*Acres.*	*Per cent.*
Morton fine sandy loam	55	27	18	2,430,720	9.2
Morton loams	68	27	3	3,744,000	14.1
Morton clay	100	.....	.....	9,216	.1
Morton gumbo	92	7	1	396,288	1.5
Pierre series—					
Pierre loams and clay loams	86	13	1	2,421,504	9.1
Pierre clays	49	26	25	7,789,824	29.4
Miscellaneous—					
Spearfish loam	41	28	31	200,448	.8

Classification and area of soils—Continued.

Soil groups and types.	Proportion of type —			Total area of type.	Proportion of total area.
	Level to rolling.	Very rolling to very hilly.	Very hilly and broken.		
Soils from unconsolidated calcareous deposits:					
Rosebud series—	*Per cent.*	*Per cent.*	*Per cent.*	*Acres.*	*Per cent*
Rosebud fine sandy loam	62	22	16	599,040	2.2
Rosebud silt loam	64	30	6	2,626,560	9.9
Rosebud silty clay loam and clay	90	10	.....	205,056	.8
Miscellaneous—					
Hermosa loam	94	6	.....	119,808	.5
Bad Lands [a]	.....	.....	100	935,424	3.5
Bad Land Basins [b]	75	.....	25	292,608	1.1
Aeolian soils:					
Dunesand	46	54	.....	656,640	2.5
Gannett fine sand	100	.....	.....	57,600	.2
Smithwick sandy loam	33	67	.....	69,120	.3
Soils of the gravel terraces:					
Cheyenne series—					
Cheyenne loams	96	4	.....	311,040	1.2
Alluvial soils:					
Wade series—					
Wade fine sandy loam	100	.....	.....	223,488	.8
Wade loam	100	.....	.....	235,008	.9
Wade clay loam and clay	100	.....	.....	78,336	.3
Miscellaneous—					
Orman clay	100	.....	.....	327,168	1.2
Tripp silt loam	100	.....	.....	99,072	.4
Undifferentiated alluvial soils	100	.....	.....	663,552	2.5
Rough stony land and undifferentiated soils	.....	12	88	2,004,480	7.5
Total	56	23	21	26,496,000	.....

[a] Are derived in part from sandstones and shales.
[b] This is much dissected by deep, narrow erosions, although the general surface is nearly level.

The general characteristics of the different series, with a more detailed description of the individual soils, will now be given.

SOILS FROM SANDSTONES AND SHALES.

Morton Series.

The Morton series includes the light-brown to yellowish-brown soils overlying yellowish-brown to light-gray friable subsoils. The soils owe their origin to the weathering of sandstones and sandy shales principally of the Laramie formation. Some parts of the Carlile formation, as well the Fox Hill and Fort Union formations, give soils very similar to those of the Laramie, and these have been included in the same series.

Differences in the amount of sand, silt, and clay in the underlying rocks have given rise to differences in the texture of the resultant

soils, so that there may be found material varying in character from almost pure fine sand to that having a large percentage of clay. This difference has given rise to several members of the Morton series. A fine sand, fine sandy loam, loam, silt loam, clay loam, and clay can all be recognized. In a reconnoissance survey it was impracticable to separate all of these types and some combinations were necessary. The fine sand is of very limited occurrence and is included with the fine sandy loam; the loam and silt loam are grouped together and likewise the clay loam and clay.

In some sections it was impossible to differentiate these divisions on the map. For example, in the southeastern part of Perkins County and the northern part of Meade County occurs a large area on which the soils are about equally divided between the Morton silt loam, Morton fine sandy loam, and Morton gumbo. The soil around the heads of the streams is nearly always Morton gumbo, which extends for miles as shallow valleys from one-fourth to one-half mile in width, while the higher lands are either Morton silt loam or fine sandy loam. In such instances it has been necessary to map the country with the type which was predominant in that general section.

MORTON FINE SANDY LOAM.

Description.—The Morton fine sandy loam, to an average depth of about 10 inches, consists of a light-brown fine sandy loam. The texture, however, may vary from a light fine sandy loam to almost a loam. As a rule the crests of the ridges are covered by the lighter phase, while the sides of the hills are more likely to be heavier. Near the boundary of the silt loam the texture always becomes heavier. In some sections, notably to the west of High Bank Creek south of the Grand River, are a number of small areas that are much heavier in texture, although not separable from the fine sandy loam. The subsoil is usually a light-brown or gray fine sandy loam, usually heavier and lighter in color than the surface soil, a yellowish-brown silt loam being not uncommon at from 3 to 6 feet deep. Occasionally throughout the type are found spots where the sandy soil has been blown away, leaving small bodies of white silty clay a few rods across exposed at the surface. These are nearly always bare and are usually affected with alkali. Such bodies are found a little north of Ada post-office and also near the junction of Rabbit Creek with the Moreau River.

In the vicinity of Buffalo occur several small areas of sandy soil, really the Morton fine sand. Sometimes the surface has a small amount of organic matter which gives it much the same appearance as the fine sandy loam, but more frequently the material is so loose that once the sod is broken it is badly blown about by the wind.

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

Mechanical analyses of Morton 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.*
22394, 22396	Soil	0.0	0.6	5.6	50.0	18.9	9.3	9.9
22395, 22397	Subsoil	.1	.7	4.8	51.2	19.6	13.0	10.0

Origin.—The Morton fine sandy loam has been derived by weathering from the light-brown or gray Laramie sandstones. Because of the semiarid condition of the climate the weathering has proceeded rather slowly, and as the rolling topography has assisted the rains in removing the fine material it is not unusual on the slopes and crests of hills to find the hard, consolidated rock covered only by 1 or 2 feet of soil. The decay of organic matter has added a considerable amount of humus, which gives the darker color to the surface material and increases the power of the soil to retain moisture.

Topography.—The surface varies from practically level to rough and broken. A large part of the area south of the Moreau River is rough and unsuited to cultivation. Much of the area bordering the Grand River on the north is also rough, being cut by many streams which extend back into the uplands from the river.

Isolated buttes from 50 to 300 feet in height are found scattered over the area, being most numerous on the divides between the Grand and the Moreau River and the Moreau and the Cheyenne River. A range of buttes, locally known as Fox Ridge, is found on the latter divide, and constitutes one of the most prominent topographic features of the region. A number of buttes also occur in Twps. 16 and 17 N. and R. 23, 24, and 25 E. These vary from one-fourth mile to more than a mile apart and cover from one-eighth to one-half section each.

Location.—The Morton fine sandy loam is one of the most common soil types in northwestern South Dakota, but is not found in other parts of the State. An extensive and typically developed body occurs in the vicinity of Buffalo, in Harding County, and extends almost continuously in a southeastern direction to White Owl, in Meade County. Another equally extensive area is found along the Grand River, beginning south of Lemmon and extending eastward almost to the Missouri River. This area extends southward and covers a large proportion of the divide between the Grand and the Moreau River. Numerous smaller bodies occur as may be seen by reference to the map.

Native vegetation.—The vegetation on this soil is very markedly different from that on the silt loam and loam, and the areas can usually be recognized by the reddish color given by a coarse grass or broom sedge. One variety of grass is so common upon these sandy soils that it has been given the local name of "sand grass." All of the grasses are coarser and less nutritious than those upon the heavier soils.

Utilization.—Where the topographic features are favorable, the Morton fine sandy loam is a fair farming soil. Its loose, porous structure permits the rainfall to enter readily and makes cultivation easy. The sandy nature also causes it to warm up earlier in spring than the heavier soils. This makes it suited to crops which require early maturity, such as the various truck crops. Transportation facilities, however, practically prohibit the growing of these, except in very limited quantities. Potatoes do especially well, yielding from 100 to 150 bushels per acre in favorable seasons, the tubers being noted for their dry, mealy nature. Almost all kinds of root crops give good returns. During the wettest years this soil is well adapted to the growing of small grains, but in dry years these uncultivated crops are apt to suffer for lack of sufficient moisture. In the growing of corn and other cultivated crops, where the moisture may be conserved by tillage, the damage from this cause is not so great.

When well watered the Morton fine sandy loam is a very productive soil. Because of its open structure it dries out very rapidly in the spring and can be worked almost immediately after the frost has left the ground. This permits of early seeding and the saving of much valuable time. Because of its high position, crops are sometimes spared by frosts in fall while those on the lower types are injured. This has been known to give the type a growing period several days longer than that of the lower valley soils. For this reason, if sufficient moisture can be obtained, the Morton fine sandy loam is one of the best soils in the area upon which to produce the larger varieties of corn. In favorable years good yields of flax, barley, and wheat are produced. All of the type is adapted to grazing, and many of the rougher areas should undoubtedly be used solely for this purpose.

MORTON LOAMS.

Description.—Under this term are included the soils which would be mapped as Morton silt loam and Morton loam in a detailed survey These types are so closely related as regards structure, formation, and agricultural value, as well as occurrence—the bodies of loam at times being only strips between the silt loam and the fine sandy loam—that they appear in one color on the accompanying map.

The Morton loams include the soils which are intermediate in texture between the fine sandy loams on the one side and the clay loam and clay on the other. The texture therefore varies from a loam containing a considerable amount of fine sand to a heavy silt loam in which only a small percentage of sand is present. The greater part of the area, however, consists of a texture rather intermediate between these extremes, being either a silt loam or a loam in which the percentage of silt is very high. In the eastern extension of these soils the loam constitutes a large percentage of the whole, but going westward the silt loam becomes very largely predominant. One of the largest areas, a body about 150 square miles, having a rather sandy texture occurs in and around Twp. 12 N., R. 22 E., in the vicinity of Bear Creek. The loam is also of common occurrence throughout Harding County, the western part of Perkins County, and the northern part of Meade County, where it is most frequently found on ridges or where the silt loam approaches bodies of fine sandy loam.

The color of the Morton loams is usually a light brown, but may vary from almost black to a light yellowish gray, depending upon the amount of organic matter present. In general the eastern extension is darker than the western. Very little of the lighter color is found in eastern Perkins County and the Indian reservation, but farther west the lighter colored material occupies a much greater area than the darker. The two merge so gradually into each other that no dividing line can be drawn between them, but in general it may be said that the lighter begins in the vicinity of Bixby and increases westward toward the Montana line. The color is especially light in in the vicinity of Slim Buttes and east and west Short Pine Hills, a condition due to washings from the white limestone hills.

The soil extends to an average depth of 8 inches and is underlain by a yellowish or brownish silty clay loam subsoil. The texture of the subsoil varies with that of the surface soil, being more sandy where this is lightest and more clayey where this is heaviest. Along the lower courses of the Moreau and Grand rivers terraces from 1 to 3 miles in extent are not infrequent and these usually have a more sandy subsoil, with gravel and sand below 30 inches.

Near the border of the Pierre clay a mixed soil is found which partakes of the nature of the Morton loams and the Pierre clay. The soils in such sections are rather complicated, areas of several types being found within short distances. In the southeastern corner of Perkins County, in northern Meade County, and to a great or less extent elsewhere occur many small spots of Morton gumbo, which greatly reduces the value of the land.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Morton loams:

Mechanical analyses of Morton loams.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Loam:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
22398	Soil	0.2	0.1	1.1	16.0	20.7	39.1	22.4
22399	Subsoil	.0	.0	.8	12.2	19.7	34.9	31.6
Silt loam:								
22400	Soil	.3	.5	.9	4.6	16.6	57.1	20.0
22401	Subsoil	.2	.6	1.0	7.0	23.7	51.0	16.4

Origin.—Like other members of the Morton series, the loam and silt loam are derived from very fine-grained sandstones and sandy shales of the Laramie formation (with some areas from the Carlile) by the process of weathering and the addition of organic matter from the decay of vegetation. The amount of humus, and consequently the color, depends upon the moisture condition. On the level or lower lying areas, where the rainfall, as well as the soil water, has a tendency to gather, the organic matter has accumulated in larger amounts and to greater depths, so that the soil here is often almost black to a depth of 2 feet or more.

Topography.—The topography is chiefly level to rolling, only a comparatively small percentage being too rough for easy cultivation. Occasionally on the sides of ridges near the heads of streams washing and gullying have rendered it worthless for agricultural purposes, but the percentage of such land is very small, and where erosion has been extremely pronounced the areas have been mapped as Bad Lands. The surface is made up of broad undulating to rolling plains, often changing to broken and hilly along the streams. The most extensive areas of the latter occur along the upper part of the Grand River in northern Harding County.

Location.—The Morton loams are the most common soils in northwestern South Dakota. Southern Perkins County and northeastern Harding County are occupied almost entirely by these two soils. A large development is found around Lemmon and eastward along the North Dakota-South Dakota boundary. Much of the Fox Ridge country on the divide between the Moreau and Cheyenne rivers consists of these soils. A smaller area caps the divide north of Quinn in east Pennington and western Stanley counties. The Carlile formation in the vicinity of Bellefourche and also Edgemont gives rise to considerable areas of these soils.

The location of all the principal areas is shown in the map, but it should be understood that in many places the separation from other associated soils was impracticable.

Native vegetation.—The Morton loams support a good growth of native grasses, buffalo grass and grama grass both being very common.

Utilization.—These Morton loams are among the most productive soils in western South Dakota. Their ease of cultivation, retentiveness of moisture, and generally undulating surface makes them very desirable, and they have been much sought after by the homesteaders. The actual acreage under cultivation is as yet small, but is being rapidly extended each season, the breaking being confined largely to the vicinity of the towns. In the Indian reservation practically none of the type is under cultivation.

Oats, wheat, barley, and flax are well adapted to these soils, yielding in favorable seasons about 35, 20, 30, and 10 to 12 bushels per acre, respectively. Yields of 15 to 45 bushels of early maturing varieties of corn have been reported. Many kinds of vegetables for home use are grown, among which may be mentioned potatoes, beans, cabbage, peas, and turnips.

Most of the crops so far have been grown upon sod, and it is reasonable to suppose that as the soil is better prepared a more favorable showing will be made. Careful methods of conserving the moisture should be practiced, and if reasonable caution is taken farming on these loams should prove quite profitable.

MORTON CLAY.

Description.—The soil of the Morton clay consists of from 6 to 15 inches of brown silty clay. The subsoil is gray or drab clay, passing into drab or slate-colored shale at from 30 to 40 inches below the surface. Near the bases of buttes and where the weathering has not proceeded to a great extent the surface is frequently a dark slate color. When wet the surface is sticky and rather hard to cultivate, but is not so bad in this respect as the Pierre clay. After heavy rains the soil puddles and cracks in drying to a slight extent, making a suitable seed bed difficult to obtain. The soil is naturally impervious, and unless kept in a good state of cultivation is very apt to suffer from drought.

Origin.—The Morton clay is derived from the weathering of the beds of clayey shale which are occasionally found throughout the Laramie formation. As these shales nearly always contain a greater accumulation of salts than the surrounding sandstones, the resulting soils are nearly always affected more or less by injurious accumulations of alkali. Except at the immediate base of buttes, however, the type is well covered by a dense growth of nutritious grasses.

Topography.—With the exception of a few buttes north of Grand River, the type is comparatively level, being found chiefly at the bases of buttes. The surface drainage is good, but the impervious character of the subsoil is such that the downward passage of water is very slow.

Location.—Because of the small extent of the Morton clay the type is of little importance. The largest body, consisting of only a few square miles, is found north of the North Fork of the Grand River, in the vicinity of Grand River post-office. Another small body is found a few miles south of Camp Crook, on the east side of the Little Missouri River.

Utilization.—Very little of the Morton clay is under cultivation, though with proper preparation of the soil it is well adapted to the production of all the small grains commonly grown in the region. The type is also good for the production of tame grasses, and where too rough for cultivation it usually makes excellent grazing land.

MORTON GUMBO [a]

Description.—The Morton gumbo covers a soil condition rather than a distinct soil type. The texture varies, but the appearance and agricultural value are always about the same. The soil consists of from 1 to 3 or 4 inches of fine sandy loam, silt loam, or light clay loam, the varying texture being a notable characteristic. Very often along the Grand River there are considerable areas of fine sand several inches in depth, underlain by the compact clayey material. The lighter soil has quite frequently been blown or washed away, leaving the barren subsoil exposed. The subsoil varies from compact fine sandy loam to heavy sticky clay, which sometimes occurs in layers. The color of the soil varies from brown to white, the latter being due to white sand, white clay, or alkali. When due, to sand, the material is usually not more than a fraction of an inch in depth. The most characteristic feature of the Morton gumbo is the close physical structure which may obtain even when considerable quantities of fine sand are present. This condition is probably due to the puddling action of alkali.

A condition analogous to that of the Morton gumbo is sometimes seen in the Pierre clay. These areas are comparatively small in extent and are easily recognized by their scanty vegetation. The soil consists of very compact clay several feet in depth. Frequently in the Pierre clay are seen bare white spots strewn with a thin layer of reddish-brown shalelike fragments of gravel. In their present condition such areas have little agricultural value. Though there is a resemblance between this soil and the Morton gumbo, the two materials differ in that the former contains little sand and has its

[a] The term "gumbo" is used locally to designate material whose characteristics are markedly different in different parts of the country. Throughout the portion of this area occupied by the Morton soils it refers to a condition described in this report under the name "Morton gumbo." In the section where the Pierre soils occur the clays of this series, because of their heavy, sticky nature, are also termed "gumbo," as well as all other heavy soils. In fact, "clay" and "gumbo" are in this section used as synonymous terms.

derivation from the beds of Pierre shales, while the latter is formed from Laramie materials.

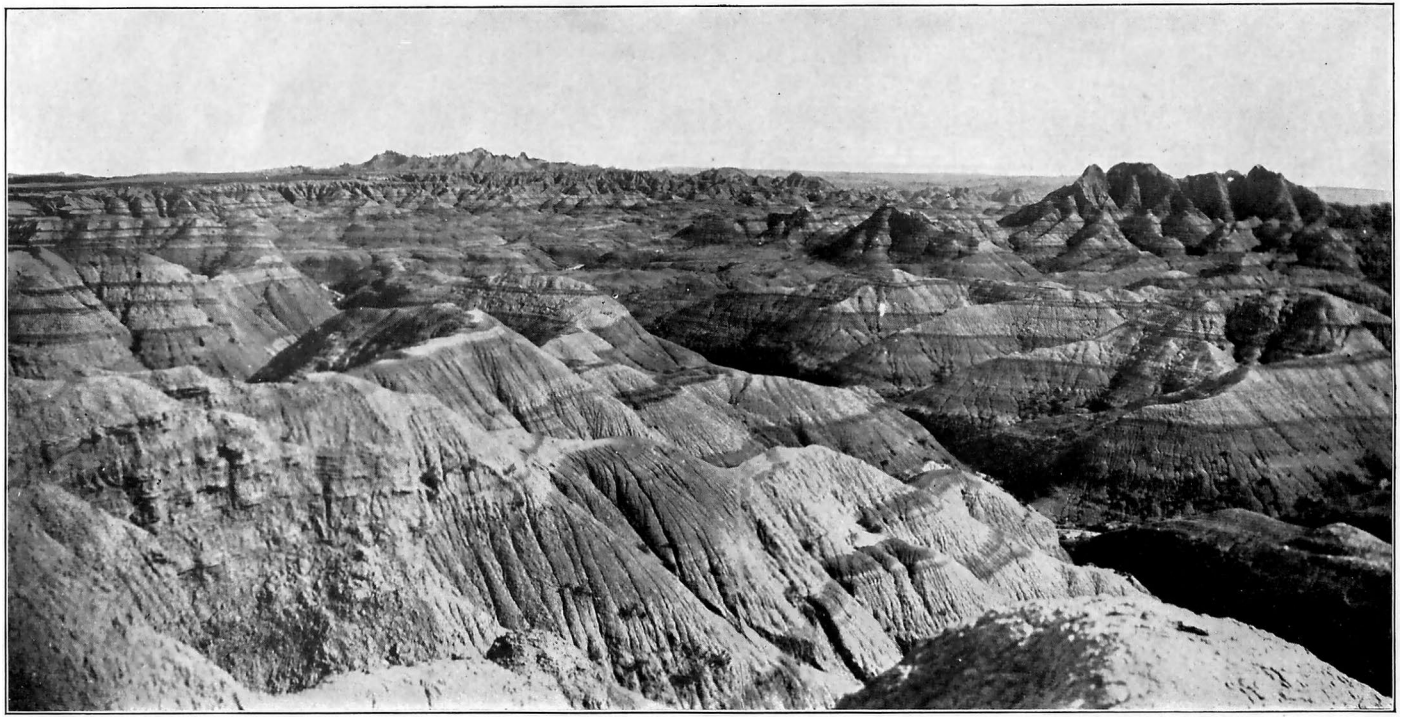
Origin.—The exact cause of the formation of the gumbo is not entirely clear. The most probable explanation is that it is due to the alkali which was either present in the rocks or has accumulated by means of seepage. Erosion has had an influence also, as many of these gumbo areas are situated at the foot of Bad Land walls.

Topography.—Practically all of the areas have a level topography. There are often small gullies running through these areas of gumbo, and in some cases, especially in the northeast section, the surface is broken. While it may occupy any topographic position, its most common occurrence is in lower lying areas near the heads of draws or in slight depressions in the uplands.

Location.—Although no large individual bodies are found, these conditions cover in the aggregate a considerable area. While small bodies are found in all parts of the survey occupied by the soils of the Morton series, the areas are most numerous in southwestern Perkins and northeastern Meade counties. In the latter, especially, nearly all of the streams give rise to a narrow strip of gumbo, and it is not uncommon to find not only here, but elsewhere, a strip from one-eighth to one-fourth mile in width, extending several miles. Only the larger areas could be shown on the map.

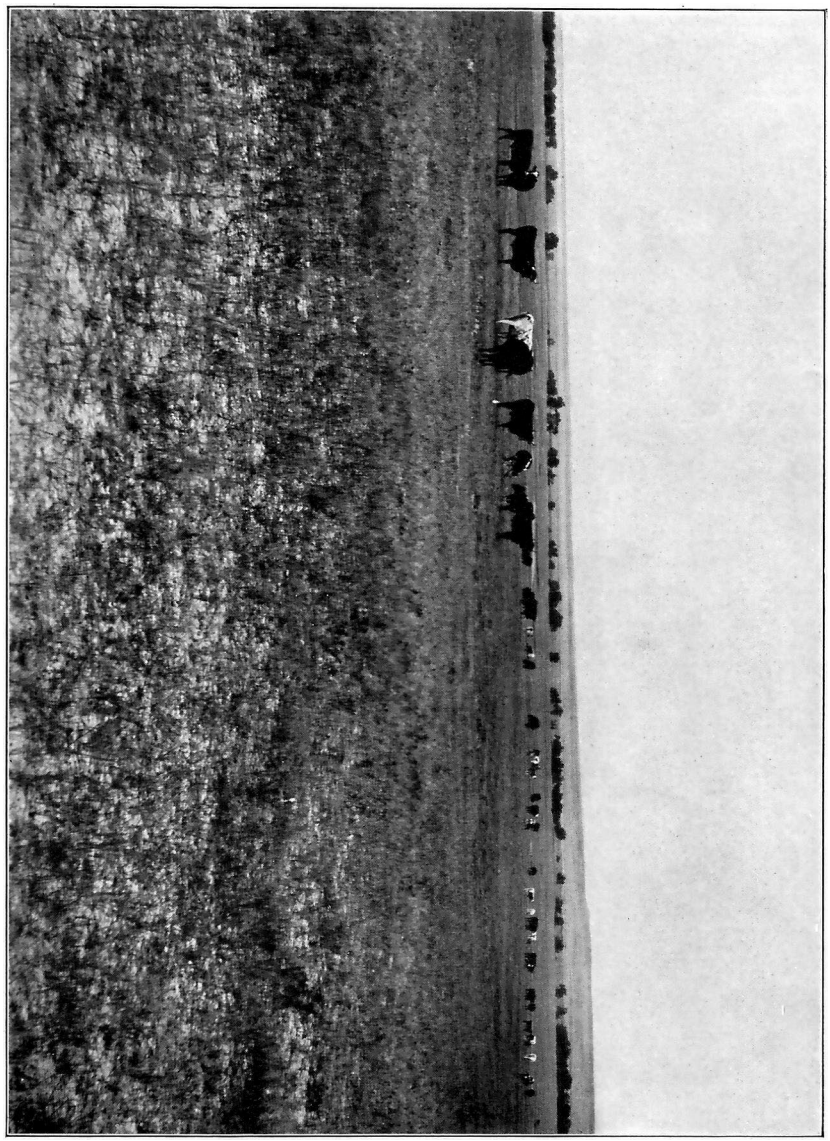
Native vegetation.—One of the most characteristic features of the Morton gumbo is the presence of numerous spots, from a few feet to several rods across, which are either entirely bare of vegetation or support only a scant growth of sagebrush and cactus. These bare spots are due to alkali and the puddled condition of the soil. Between these bare spots a fair growth of grass is usually found, the species being dependent upon the texture.

Utilization.—The Morton gumbo is an unsatisfactory soil in many ways, most of the bare spots during the first few years of cultivation being totally unproductive. In such places puddling begins with the first rain after cultivation ceases, the result being that the young seedlings reaching the crust are unable to force their way through and hence do not appear above the surface, or appearing, the pressure of the baking soil is too great for the young plant and as a result it dies. Or again, the alkali ascends to the surface with evaporation and kills the plants, unable to withstand such concentrations. With several years of cropping and the incidental mixing of the sands and clays a decided improvement is seen in the structure and crops become more promising. In connection with cultivation the application of barnyard manure has proved beneficial both in improving the structure and in reducing the harmful effects of the alkali. The Morton gumbo is of low agricultural value and its presence lowers the price of the farm upon which it may be found. The larger areas would best be left in pasture, as their cultivation would not prove profitable.



BAD LANDS.

[Much of the Bad Lands is absolutely barren, but small grassy areas occur and where they are numerous furnish excellent grazing.]



STRETCH OF IRRIGABLE LAND UNDER THE BELLE FOURCHE PROJECT.

Pierre Series.

Immediately south of the Morton soils occurs an extensive outcrop of gray to black heavy clayey shales, which have given rise to a group of soils included in the Pierre series. This series consists of dark-brown to yellow-brown surface soils underlain by heavy subsoils. The soils are derived from the Pierre and Graneros shales, principally the former, but some of those lighter in texture have probably been influenced by later deposits. The texture of this material varies from a loam through a silt loam and silty clay loam to a heavy clay. All of these classes could be recognized and separated in a detailed survey as well as some variation in the color, but in this survey only two divisions were made. The loam, silt loam, and lighter areas of the silty clay loam have been grouped together and will be called Pierre loams and clay loams, while the heavier portions of the silty clay loam, silty clay, and the clay will be called the Pierre clays. Of these the clay is the most extensively developed and this fact, coupled with the sticky or gumbo nature of the soil, causes the general area in which the Pierre series occurs to stand out in marked contrast to other sections occupied by lighter-textured soils.

Pierre loams and clay loams.

Description.—Under the term "Pierre loams and clay loams" are included soils differing considerably in both texture and color. The most usual texture is that of a loam, rather high in silt, or a heavy silt loam, although this varies from a loose friable loam through a silt loam to a silty clay loam, possessing some of the sticky nature of the Pierre clay or gumbo. A considerable amount of organic matter is usually present, giving to the soil a brown or grayish-brown color, not unlike that of the Morton loams.

At a depth ranging from 6 to 12 inches lighter colored, heavier, and much more compact material is encountered, which breaks up into cubes resembling in this respect the western adobes. This subsoil is a light grayish-brown, heavy silty clay loam to silty clay, which becomes lighter colored with depth and at 3 to 6 feet below the surface grades into gray or slate-colored shales.

While the general characteristics of these soils are as given above, there are variations which should be noted. In the area south and west of Bellefourche the surface soil is a brown loam, while the subsurface has a decided reddish tinge and the subsoil below 26 inches is friable and contains occasional streaks of reddish iron stains. Small mounds made up of silicious sandstone fragments and iron concretions are of frequent occurrence also. Along the southern border of this area the soil is very badly mixed, due to the upturning of the strata by the Black Hills uplift.

A large proportion of the area in Twp. 9 N., R. 17 E., is of the heavier phase and approaches very closely in character the Pierre clay and, in fact, many small areas of this type are present. The area north of Quinn, in what is known as the Peona basin, is also of this heavier phase. In this latter area bare spots much like the Morton gumbo are a constant feature along all the draws. In fact, this condition is very common wherever the Morton and Pierre soils adjoin, being especially noticeable on each side of Sulphur Creek, and a wide range in the agricultural value of the lands is the result.

Waterworn gravel and even small cobblestones are sometimes scattered over the surface, especially in the country surrounding the Black Hills, although some areas are found elsewhere. Along the Bad River, principally on the north side between Philip and Midland, this soil occurs as a high terrace and for several miles back from this stream and even on top of the divide between this stream and the White River, gravel is found. The soil here also has a considerable percentage of coarse sand, which is very noticeable in the roads because of its grinding under the wheels. In some small areas the subsoil here is underlain by gravel at a depth of 3 or 4 feet. Such can be seen just north of Midland and Philip.

The large area occurring south of the latter town is somewhat different from that in other sections. The surface soil is usually a distinct silt loam of a brown color, but on the slopes along the streams it becomes heavier and yellower and many outcrops of yellow clay were seen. This is especially prominent along White Willow Creek directly south of Philip, where many of the draws have white bare gumbo spots along them.

Around Oelrichs the soil is also silty and the subsoil is often lighter in color and more calcareous than in other areas. Much of this body resembles the Morton silt loam in general characteristics.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Pierre loams and clay loam:

Mechanical analyses of Pierre loams and clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Loam:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
22414	Soil	1.5	8.6	7.4	9.4	9.8	46.1	17.0
22415	Subsoil	1.9	12.3	8.7	11.1	11.9	28.3	25.1
Silt loam:								
22408	Soil	.0	.3	1.1	4.5	5.5	68.3	19.5
22409	Subsoil	.0	.1	.8	3.9	15.0	63.0	16.4
Clay loam:								
22412	Soil	.2	1.1	4.0	10.0	9.3	48.3	27.0
22413	Subsoil	.3	.9	3.7	11.2	12.7	47.5	23.8

Origin.—This type is derived principally from the lighter, more sandy shales of the Pierre and Graneros formations, chiefly the former. It has doubtless been influenced, in many places at least, by later deposits and it is very probable that the surface soil represents a remnant of Tertiary or Quaternary overwash. The presence of scattering waterworn gravel over the surface and the terracelike position of some areas furnish strong evidence of such action. The gravel on the higher divide is possibly of Tertiary age, representing the Chadron formation of the White River group. The terraces are probably Pleistocene and were formed during the damming of the eastern flowing stream by the ice. These terraces have not been formed by the deposition of material, but rather by simply smoothing off the shales, only a very small amount of material being left in the process.

Topography.—Gently rolling plains, table-lands, and terraces with low swells or ridges dividing the shallow, narrow valleys, are the most characteristic surface features. In only a few places were areas found where the topography is so rough as to preclude cultivation. The "breaks" along the streams are most often the Pierre clay. Limestone lentils have caused the formation of knobs, sometimes 50 feet high, while harder layers in the shale have resulted in a series of steps, as may be seen about 10 miles south of Philip.

Location.—These soils have quite an extensive development, especially near the central part of the area surveyed. In the section between Belvidere and Midland and westward to Philip and Cottonwood and thence northwestward for many miles beyond the Cheyenne River almost the entire country is covered by these soils. A strip about 6 miles wide begins south of Midland and extends eastward along the divide between the Bad and White rivers in northern Lyman County almost to the Missouri River. The country lying northeast of the Black Hills between Bellefourche and the Cheyenne River is occupied largely by these soils. Smaller areas occur around Oelrichs and west of Ardmore and in various other parts of the survey where the underlying rocks consist of the Pierre and Graneros shales.

Utilization.—In general these soils are very desirable for farming, being among the best in this part of South Dakota. Only a very small percentage of the land has been placed in cultivation. While the heavier areas are somewhat sticky and require careful handling to secure a good seed bed, the greater proportion can be cultivated without much difficulty. They are retentive of moisture, and if this is properly conserved good crops can be secured in any except the most unfavorable seasons. Wheat, oats, and corn are the principal crops, and give average yields of probably 12, 30, and 25 bushels, respectively. Twice or even thrice these yields have been reported where the best of cultivation has been given and the season very favorable.

The type supports a good growth of grass, much of which is cut for hay, while the rest is used as pasture. The yield of hay is considerably greater than on the Pierre clays, but hardly equal to the amount secured on the Morton loams.

PIERRE CLAYS.[a]

Description.—The most distinguishing characteristic of the Pierre clays is their heavy sticky nature, which has given to them the local name of "gumbo." The soil varies considerably in texture as well as in color, but this sticky nature is a constant feature. In texture the material ranges from a silty clay loam through a silty clay to a heavy clay.

The color is usually a yellowish brown to dark brown, but varies from a decided yellow on the one extreme to a black on the other, the difference being sufficient to justify a separation in a more detailed survey. Frequently a thin surface covering of ashy gray to white is found.

The subsoil, which is encountered at a depth of 6 to 10 inches, is a silty clay to heavy clay of a gray to yellowish-brown color. In some areas it is almost black. It is often mottled with white spots of lime, making these areas quite calcareous. Soft shale is usually encountered at 3 to 6 feet below the surface and on some of the badly eroded areas comes to the surface.

A very characteristic feature throughout the area of the Pierre clays is the cracking of the soil upon drying. In general, the heavier the texture the larger the cracks which will be formed. In some instances these extend to a depth of several feet. This tendency to crack or granulate causes the surface soil to become very loose and is a valuable property, as it enables the farmer to secure a proper seed bed much more readily than could be done otherwise. It also permits the rains to enter much more easily.

It was not possible to separate the different varieties of the Pierre clays which were found in this area, but some idea of the differences in character in various parts may be given. Limited areas of very black heavy clay occur in the vicinity of Bellefourche, around the head of the Moreau River, and to a less extent in other parts of the area. They are more common in the country around the Black Hills, where the gumbo is derived from the Graneros shale, or where the lowest portion of the Pierre shale outcrops. A small area was noted along Slim Butte Creek in the southeastern part of Fall River County. Small areas, where the surface material is composed largely of black shale chips, are not infrequent in connection with the black clay. Much of the soil in the Cheyenne Indian Reservation is very dark also, although hardly as black as that around Bellefourche.

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[a] See footnote on page 31.

A thin covering of light material is sometimes found over the clay in almost all sections of the area, but more especially in the southwestern. As this does not granulate itself and prevents the cracking of the underlying clay, the rainfall runs off instead of entering the soil, and cactus and other arid vegetation are common. This furnishes a striking illustration of the necessity for having the surface loose and open in order that the rainfall may enter. This crust is quite common where glacial bowlders and gravel are scattered over the surface, as is the case in the country west of the Cheyenne Indian Agency. In general, the soil in the southwestern part of the State is lower in organic matter and of a more decided yellow brown, or even a yellow color.

A large proportion of the extensive areas in Stanley and Lyman counties consist of the silty clay loam or silty clay, although large tracts of the heavy clay are found also. The areas around Quinn and Cottonwood have a somewhat lighter texture. Some "white gumbo" spots are found in this section, especially near the contact with the White River formation.

Where the topography is very broken erosion has been very active and the soil here is quite variable. Much of the surface soil has been removed and the subsoil or, where washing has been most pronounced, the soft shales exposed.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil of Pierre clays:

Mechanical analyses of Pierre clays.

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.*
22418, 22422, 22424.	Soil.....	0.1	0.8	3.0	8.9	6.4	44.8	35.8
22419, 22423, 22425.	Subsoil.....	.1	.9	3.3	8.6	7.7	42.6	36.7

Origin.—The Pierre clays are derived by weathering and the addition of organic matter from the Pierre and Graneros shales, principally the latter. Some small areas are derived from the heavier shales of the Carlile formation. To differences in the character of these shales are due the principal variations in the character of the soil.

Topography.—The surface of the Pierre clays is gently rolling to very hilly and broken, in some cases, as along the Missouri and lower Cheyenne rivers, even approaching the character of the Bad Lands. While there are large stretches of almost level land on the divides, especially in Butte, Stanley, and Lyman counties, the surface of the greater proportion is decidedly rolling. The drainage channels have usually cut out comparatively deep valleys with rounded ridges between.

The general character of the surface is indicated by cross-linings on the map, but rounded instead of sharp hills often make it very difficult to decide whether to cross-line or not. Such a condition exists in a very pronounced way in the southeastern part of Fall River County. Buttes of the peculiar shape known as "tepee buttes" are a characteristic feature of the topography in many sections.

Location.—The Pierre clays are the most extensively developed soils in western South Dakota. They occupy almost the entire east-central part of the survey, the country for many miles west of the Missouri River consisting almost entirely of the "gumbo" soils. Nearly all of Stanley and Lyman counties, northern Gregory and Tripp counties, and the southern and eastern parts of the Cheyenne Indian Reservation are occupied by these heavy types. Small, rather narrow strips occur along the Cheyenne and its larger tributaries in the central part of the survey, but the development here is limited. Northeast of Bellefourche a wide area extends northwest and southeast through Butte County, covering a very large percentage of the county. Another extensive development is found in Fall River County, in the southwestern part of the State. Many smaller tracts occur wherever the clayey Cretaceous shales form the surface.

Utilization.—At the present time nearly all of the Pierre clays are used for pasture or hay. The growth of grass is not generally as good as upon the loams, but varies in different sections both in quantity and in the species, depending very largely upon the texture of the soil. The predominating and characteristic grass upon the gumbo areas is the western wheat-grass (*Agropyron tenerum* Vasq.). Where the soil is very heavy and cracks very badly, or where erosion has been pronounced, as upon the steeper slopes, this grass is practically the only species present, and the growth there is nearly always very sparse and in some places bare spots are found. Where the soil becomes more silty in texture grama and buffalo grasses are mixed with the wheat-grass, the growth is dense and heavy, and the grass tall enough to cut for hay, yielding from one-fourth to one-half ton per acre.

The character of the grass furnishes a very safe index as to the relative value of the lands for agricultural purposes. Where this is very sparse the soil is usually so heavy and tenacious that it is almost impossible to get it in good physical condition. Where the growth of grass is heavy and a large proportion of grama and buffalo grass is present the soil is much more tractable and desirable for agriculture.

The Pierre clays are naturally strong soils, but their sticky nature makes them less desirable than those of lighter texture. If plowed when too wet, the soil bakes into hard clods, which are difficult to pulverize. If allowed to get dry, it becomes too hard to cultivate. The soil is, however, very retentive of moisture, and if a mulch is

provided after rains it can be conserved. Unless this is done the moisture is lost very rapidly and crops suffer during periods of insufficient rainfall. The silty clay loam is more easily pulverized than the heavier clay and the natural granulation aids greatly in securing a mulch.

The careful and observant farmer will plow and cultivate when the soil has dried out just enough not to adhere to the implements, for under this condition the soil breaks up into small granules, thus allowing the formation of a good mulch. When tilled properly the gumbo becomes surprisingly mellow, especially when a good supply of humus is present. A great deal of power is required for its cultivation. Only a small percentage of the areas occupied by these soils have been put under cultivation, and nearly all of this has been broken within the last two or three years. Definite statements as to yields were therefore difficult to secure, especially since these vary so much with the season. The crops that are being grown are wheat, oats, corn, flax, rye, barley, and emmer, or speltz. During good seasons wheat yields from 12 to 20 bushels, oats 35 to 50, corn 20 to 25, barley about the same, and speltz 30 to 40. Most of the farming so far has been upon sod and better and surer yields may be expected after the soil has been gotten into a good physical condition. The government experiment farm near Bellefourche is located upon the gumbo, and the results secured here indicate that dry farming can be made a success. Owing to its sticky nature, the cost of preparing and cultivating the land is considerably greater than on the lighter types of soil.

Miscellaneous.

Spearfish loam.

Description.—The red soil of the valley that encircles the Black Hills has been called Spearfish loam. On the deep tillable portion of the type the soil is a silty loam, with a good percentage of sand of the finer grades. It has in most places a dark-red color, but where the soil has not been removed by erosion, the accumulation of organic matter has imparted an almost black color to the topsoil. The subsoil is a red loam with much silt, and usually contains a slightly larger percentage of clay than the soil. Both soil and subsoil contain fragments of gypsum, and at depths of one to several feet beds of solid gypsum are found. It is the depth of the soil above the gypsum that determines the agricultural value of this type. Over a large part of the valleys mapped with this type, the depth of the soil is not sufficient to support crops. The portion that has been indicated as hilly on the map represents eroded slopes, where the soil is removed nearly as fast as it forms, and large outcrops of gypsum rock appear through the shallow soil.

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

Mechanical analyses of Spearfish 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.*
22428	Soil	0.2	0.2	0.4	6.0	37.0	43.2	13.0
22429	Subsoil	.0	.1	.7	2.9	29.0	49.4	18.1

Origin.—The Spearfish loam is formed by weathering from the gypsiferous Spearfish formation of the Triassic. The elevation of the Black Hills exposed the hitherto horizontal beds in the form of a ring. The easily decomposed gypsum was rapidly removed and a comparatively deep annular valley surrounds the main dome of the Black Hills, flanked on the other side by a rampart of hills having the steep slope facing inward. It is generally believed by geologists that the red color of the exposed materials is that of the unweathered material as it was laid down in some shallow sea under semiarid conditions, as deep borings show that the color persists throughout these beds.

Utilization.—The most extensively cultivated portions of the Spearfish loam may be seen in the Spearfish Valley, in Centennial Flat between Spearfish and Whitewood, and in Martin Valley northeast of Hot Springs. There are numerous small strips throughout the areas of the type that are farmed. Though the well-weathered soil has a good water-holding capacity, the deep underlying material is not so favorable for the retention of an underground supply, as the decomposition and removal of the gypsum makes the soil porous and destroys its water-holding capacity. In many places where the soil is deep enough to support crops they can not be depended upon in dry seasons. Much of this land, however, could be irrigated and made suitable for profitable vineyards, orchards, and truck gardens. The possibility of the utilization of these lands is limited, however, by the small quantity of water available and the difficulty of maintaining reservoirs in the porous gypsum soils.

The portions of the Red Valley which are indicated on the map as level or gently rolling represent the larger areas of tillable land. That shown as heavily rolling is not necessarily rough, but outcrops of gypsum and shallow soils make farming over a large part of it impossible without a better water supply. There are, however, small tracts of a few acres throughout this topography that are farmed. The country mapped as very rough and rolling consists of steeply eroded hillsides with massive outcrops of gypsum.

The portion of the Spearfish loam suited to farming is one of the most desirable soils of the State. Its texture and natural fertility adapt it to a wide range of crops. There is no doubt that the greater part of it will in time be devoted to fruits and truck crops, as these do exceptionally well. In the vicinity of Spearfish there are very profitable orchards that have been in bearing for several years. The soil is adapted to all crops of the region. Alfalfa does well under irrigation, and many good fields are growing under dry-farming methods. Alfalfa is cut two and often three times a year and the yield is about a ton to the cutting. Corn makes good yields. Wheat and oats are grown, the latter doing exceptionally well. Potatoes are grown for market on portions of this soil with much success.

SOILS FROM UNCONSOLIDATED CALCAREOUS DEPOSITS.

Rosebud Series.

In the southern part of the area the lighter-colored Tertiary deposits have given rise to another group of soils which have been included in the Rosebud series. This series has not been encountered in any of the previous surveys, and the name Rosebud was selected because of the extensive development of the series in the Indian reservation of this name.

One of the most characteristic features of this series is the white or pale flesh color of the deeper subsoil. The series consists of dark-gray or brown surface soils with light-colored, almost white, very calcareous subsoils. Because of the ease with which this material erodes the more hilly areas especially are dotted with bare white spots.

Differences in the texture of the material have given rise to a fine sandy loam, silt loam, and silty clay loam, with small areas of a loam and clay. The silt loam is by far the most important member of the series. The loam is of small extent and is included with the silt loam. The fine sandy loam covers considerable areas, especially where the Arikaree formation forms the surface. The silty clay loam and clay are almost entirely confined to the most northern extension of the White River formation. These two soils are so very closely associated that they could hardly be separated even in a detailed survey. The silty clay loam greatly predominates.

ROSEBUD FINE SANDY LOAM.

Description.—The Rosebud fine sandy loam to a depth of 12 to 18 inches, is a dark-gray or brown loamy fine sand to fine sandy loam, sometimes containing a large percentage of silt. The subsoil is usually lighter in color with an equal or greater amount of silt than the soil.

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

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.*
22390, 22438.....	Soil.....	0.0	0.8	7.1	54.2	22.4	8.4	7.1
22391, 22439.....	Subsoil.....	.0	2.1	9.4	48.3	23.1	7.7	9.0

Origin.—The soil is derived by weathering from sandy strata of the Arikaree formation, with probable accessions of wind-blown sand.

Location.—The type is found in areas of several square miles on the border between the Dunesand and the Rosebud silt loam, and it merges so gradually into these types that it is difficult to draw a sharp boundary. Considerable areas of the type are found in Tripp and Todd counties and in smaller patches in Gregory. In the Pine Ridge Reservation it occurs principally along Little White River north of Lacreek.

Topography.—The Rosebud fine sandy loam has a gently undulating to steeply-rolling topography in some places covering very broken and buttelike formations.

Native vegetation.—The native vegetation varies according to the amount of sand in the soil. In the more silty portions of the type the grasses are of the same varieties as those of the Rosebud silt loam, but on the more rolling sandy areas sand grass, needle grass, and blue-joint predominate with some yucca, though the latter is not so common as on the Dunesand.

Utilization.—This type has not been cultivated to any extent in the Indian reservations, but in the settled counties some of it is farmed. When first farmed, it produces good crops of corn and vegetables, and in favorable seasons the small grains do well. It is held by some that this soil will withstand drought better than the Pierre clays. After a number of years of steady cultivation the type will doubtless become less productive unless some effort is made by the farmer to maintain the supply of organic matter in the surface soil. Where it is not too sandy the soil is adapted to general farming, but corn, potatoes, and vegetables will be more successful than the small grains.

ROSEBUD SILT LOAM.

Description.—The soil of the Rosebud silt loam to an average depth of 10 inches is a very silty loam. The sand in the soil is composed of the very finest grades. In color it ranges in different localities from a light ashy gray to a dark brown, depending upon the quantity and character of the organic matter present. The sub-

soil, to a depth of 2 feet or more, is a light-gray or brown silty loam, containing in most localities more clay than the soil. Below this is a white, light-pink, or buff material that extends to a depth of several feet. The pink or flesh color is very noticeable on the west side of White River, in the southern part of the Pine Ridge Reservation. In all parts of the area covered by this type there are beds of white partly calcareous concretions at a depth of several feet below the surface, and often fragments of fossil bones are found embedded with the concretions.

The Rosebud silt loam is loose and friable and is easily brought into a good condition for tillage. The principal difficulty in handling this type is due to its tendency to wash. The silty material melts away rapidly under running water and on slopes and hillsides the erosion is excessive, so that eroded spots and incipient Bad Lands topography are a feature of the hilly areas. The areas of this type may be distinguished from a long distance by the white spots that fleck the hillsides. The Bad Lands, which have been mapped as a separate type, represent badly eroded country once covered by the Rosebud silt loam. On the broad level or gently rolling flats and valleys it will not be difficult with a little care to prevent gullying, but where there is any considerable slope washes must never be allowed to start.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil of the Rosebud silt loam:

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.*
22440, 22442.....	Soil.....	0.4	0.5	1.0	4.9	28.2	55.3	14.6
22441, 22443.....	Subsoil.....	.2	.5	1.0	1.6	16.5	62.8	17.4

Origin.—This type is the partly weathered product of the White River beds and some of the Arikaree formation. It is not easy to separate the soils derived from the White River group from those weathered from the more silty members of the Arikaree formation, and the agricultural values of the two are so similar as to make a separation of little importance. The changes which have taken place since the formations have been exposed to weathering have chiefly affected the lime content by the breaking down of the lime nodules and the removal of much of the calcareous matter.

Location.—The Rosebud silt loam is one of the most uniform and extensive soils of the State. It covers the greater part of the Pine Ridge Indian Reservation which lies east and south of White River. In this region it is broken only by the Bad Lands along White River

and the Dunesand and their associated types along the southern border. There are also considerable areas west of the White River along the western side of the reservation and some patches outside. In the Rosebud Reservation this soil is found in a number of large areas in the southern parts of Tripp and Todd counties and in the western part of Todd extending into the southern and southeastern part of Gregory County.

Topography.—The topography occupied by the Rosebud silt loam varies from the almost level plains north of Little White River to rough hills and broken country closely approaching the Bad Lands. East of Pine Ridge Agency the valley of the Little White River is a broad, level, very gently rolling plain capable of being made into a beautiful farming country. Several large flats also occur on the divide to the north. The slope toward White River is a plain broken by parallel northward-flowing streams several miles apart which have a rapid fall toward White River. The usual configuration between these streams is first a gentle slope from the streams having a width of one-fourth mile to 2 miles, all good farming land; then a more rolling topography with broken steplike patches where the hillside surface has given way; then an abrupt rise, sometimes as a cliff, to the highest altitude of the divides. Patches of Bad Lands traverse the country usually at a distance of several miles from the river where the streams are cutting most rapidly.

Native vegetation.—In the highest hill slopes and in the sheltered valleys of the hills there is usually a sparse growth of pine and cedar, the pine predominating on the hills. On some of the ranges the timber is commercially valuable and is being removed for public use. Except in the recently eroded spots, the entire surface of the uncultivated land has a thick covering of native grasses. Blue grama grass (*Bouteloua oligostachya*) usually predominates. This soil is not so well adapted to wheat grass (*Agropyron tenerum*) as the soils of the Pierre series, but it grows to some extent in all parts of the area and in many places it may be cut for hay.

Utilization.—A large area of this type is yet held by the Indians and utilized only for grazing and the cultivated portion has been farmed for so short a time that the value of the soil is not yet fully determined. Only a small area is cultivated in the reservation, but recently settled portions of Tripp County have been farmed with good results, and in Gregory nearly all of the type is under cultivation. The principal crops grown are wheat, oats, corn, and flax, with a little rye, barley, and emmer. Yields necessarily depend largely on the season and rainfall. In ordinary seasons wheat will average between 12 and 15 bushels to the acre, oats 30 to 40, and corn 20 to 30 bushels. In very dry seasons the best farmers can not secure these yields, while in the most favorable seasons good farmers may

get yields of 30 bushels of wheat or more to the acre. The new farming of this region has never stood the test of a very dry year, so that the average yield for good and bad years is yet to be ascertained. Apples, plums, grapes, and cherries grow well, but are often prevented from bearing by climatic conditions. Potatoes and other vegetables do well and are grown for home needs. This type should prove one of the best in the area for general farming.

ROSEBUD SILTY CLAY LOAM AND CLAY.

Description.—The Rosebud silty clay loam consists of 6 to 12 inches of brown or grayish-brown heavy silt loam to silty clay loam, underlain by a heavy silty clay loam to silty clay. The upper part of the subsoil is a drab or light grayish brown color, but this becomes lighter with depth and below 2 to 4 feet is almost white. Sometimes darker colored or red layers occur, but the white is the more usual.

In some places the heavy clayey strata come to the surface and give rise to the Rosebud clay, which is very sticky when wet and cracks open when dry, in these respects resembling the Pierre clays or gumbo, and the term "white gumbo" is sometimes used for this lighter colored material. These clay areas are quite frequent throughout the areas of the silty clay loam, although no very extensive tracts are found.

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

Mechanical analyses of Rosebud silty 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.*
22426	Soil	0.2	0.4	1.4	5.3	20.3	42.2	30.2
22427	Subsoil	.0	.2	.3	1.8	18.0	43.7	36.3

Origin.—These soils are derived from the heavier material of the White River group, the difference in texture being due to difference in the underlying formations.

Topography.—The greater proportion of these soils has a gently rolling surface, nearly all of them being suitable for cultivation. South of Wall the country is somewhat broken, although very little is too hilly for farming.

Location.—These soils are confined to the country from Wall south and east to Kadoka, the two main bodies being separated by a narrow strip of Bad Lands.

Utilization.—The silty clay loam supports a vigorous growth of grass which furnishes excellent pasture, as well as from one-fourth to one-half ton of hay per acre. The clay has a less dense growth and a larger percentage of wheat grass.

Only small tracts have been cultivated, but these have given good yields of wheat, oats, and corn. The silty clay loam should prove a good soil for the crops generally grown in this section. The clay is less desirable.

Miscellaneous.

BAD LANDS.

Description.—Throughout the Great Plains region there are areas having so distinct a topography that they are everywhere known as "Bad Lands." They have been produced by the rapid erosion of soft rocks and are more common in the Laramie formation in the northwestern part of South Dakota and in the White River group in the southwestern part. Along the slopes of swiftly flowing streams the silty soils and the underlying soft silty shales have melted away and great gullies and gorges with steep slopes have been cut. Over large areas these gullies run together so as to cover the entire surface, breaking up all the original plateau or leaving only small tables standing above the dissected waste. In large areas of the Bad Lands the topography may take various forms, depending upon the rapidity of erosion and the time which has elapsed, during which the sharp forms originally left could be smoothed by further weathering. There may be ranges of thin, jagged hills with sharp combs and ridges or large tracts cut down to the lower clays and covered by round bare hills. Pyramidlike buttes are a feature of the region and castellated forms and carvings of fantastic shapes all go to make up a scene of the utmost desolation. In nearly all the smaller tracts the bare and useless aspect of the Bad Lands is broken by filled-in valleys, slopes upon which vegetation maintains a precarious stand, and flat-topped grassy buttes, which have escaped in the down wearing of the country. Such small and irregular tracts, while not available for farming, constitute some of the best grazing land of the northwest. The grasses are of the best varieties for beef production, water is found at intervals, and the high bluffs shelter the cattle from the winter storms.

The soil in the Bad Lands, where any exists, varies with the character of the formations. In the Big Bad Lands it is largely the Rosebud silt loam. In the lower valleys and in the more northern extensions heavier, more clayey beds are exposed and the soil is the Rosebud silty clay loam or clay. In some places the Pierre shale has been exposed, giving rise to small areas of Pierre clays. Along the Little Missouri the Bad Lands are carved out of the Laramie formation and many small areas of Morton silt loam or fine sandy loam occur. A smaller percentage of the surface here is bare than where the Bad Lands are derived from the White River formation. A few small areas which consist of bare eroded areas of shale have been

mapped as Bad Lands. These are usually black and many iron concretions are present. These occur in areas of Pierre soils.

Origin.—As already brought out the Bad Lands are due to erosion. Certain conditions are, however, necessary for their formation. The material must be of such a character that it will erode easily but at the same time not crack, crumble, and fall down, else the almost perpendicular walls will not be formed. The amount of moisture must also be small or the freezing and thawing will cause the walls to crumble. Therefore Bad Lands are not found in humid regions. No typical Bad Lands occur in areas of Pierre shale, because when an erosion starts the sides of the gully fall, owing to the shrinking and swelling of the material, thus giving rise to rounded rather than sharp and serrated topographic features.

Location.—In the map accompanying this report the narrow strips of Bad Lands indicate the Bad Land walls, which mark the break between the high plains and the river slopes. They may run for miles as high cliffs, so steep as to be impassable except in a few places, and fringed at the foot by a belt of bare eroded buttes. In some places both walls and foothills occupy a width of only a few hundred yards, but more often they range from one-fourth to one-half mile in width. The most extensive area of the Bad Lands, and the most uniformly worthless from an agricultural standpoint, is what is known as the "Big Bad Lands," lying between the White and the Cheyenne River and Cedar and Cottonwood creeks. It covers several townships and is broken only by a few small Bad Land basins. Considerable areas occur at intervals along White River, usually at a distance of several miles from the stream. Nearly all the swiftly flowing creeks that flow north toward the Cheyenne or the White River have patches of Bad Lands at some point along their slopes.

Areas of smaller extent occur along the Little Missouri River and constitute a part of the extensive development farther north along this stream in North Dakota. The Slim Buttes, East and West Pine Hills, which consist of outlyers of the White River formation, are also composed very largely of Bad Lands.

Utilization.—The Bad Lands are adapted only to grazing and more or less to forestry. While much of the surface is entirely bare of vegetation, especially in the Big Bad Lands, the tops of the buttes, filled-in valleys, and arrested slopes are usually covered with buffalo, grama, and other grasses, furnishing good pasture. Sagebrush, weeds, and shrubs, found on the lower flats, keep the cattle alive when the short grass is covered by snow. In nearly every sheltered valley dense patches of cedar and on the buttes, like the East and West Pine Hills, pines are found, which on account of the demand for posts and poles, have now become of great value.

BAD LANDS BASINS.

Associated with the Bad Lands and the Rosebud soils and really representing in many respects an intermediate stage is a distinct topographic and soil condition, but not any definite soil type. There is rather a complex mixture of soil types with wash from the bare Bad Lands. It is not practicable therefore to give any type name to these areas, and the term "Bad Lands Basins," by which they are known locally, has been adopted.

The soil varies from a silt loam to a heavy clay, the larger proportion probably consisting of a yellow silty clay. Where the greater part of the wash is from the pale flesh-colored areas of the White River formation the silty soils of light color, sometimes much like the Rosebud silt loam, predominate. In the county southeast of Wall, principally along White Water Creek, the soil consists of a mingling of the Rosebud silty clay loam and of the Rosebud clay with areas of white silty or clayey wash from the Bad Land walls. Many bare spots of white clay are found. In some places practically all of the White River formation has been removed and the Pierre shale exposed, giving soils of heavy texture and darker color.

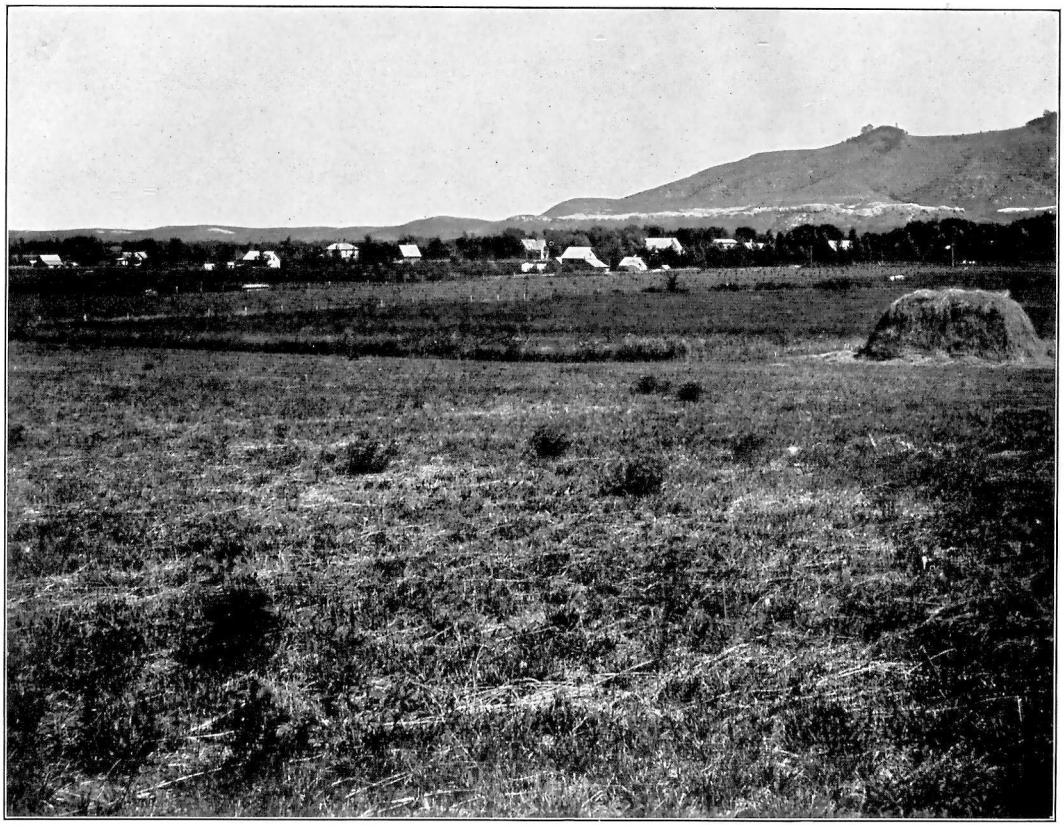
The Bad Land Basins represent areas where erosion has been checked either by wearing down to more resistant material or to practical base level. The material, which is being rapidly washed away from the Bad Lands, is arrested and spread out more or less over these basins.

The topography is rarely uniform over any considerable area. Patches of Bad Lands occur at intervals and individual buttes rise abruptly from the level floor. Where a change of base level has taken place, which is the case over a large number of these areas, the streams have begun to cut with great rapidity and the surface is dissected by deep, narrow gulches with perpendicular sides to such an extent that travel in any straight line is almost impossible.

The Bad Land Basins occur as narrow strips along nearly all valleys through the Bad Lands, as flat broad basins in the rougher country and at the foot of the Bad Land walls, facing the streams. The largest area stretches westward along the line of the Chicago, Milwaukee and St. Paul Railroad from near Kadoka almost to the Cheyenne River.

While the general character of these basins makes them better adapted to grazing than farming, a considerable proportion of the flats along the above railroad have been taken for homesteads and some farming has been carried on with success for two or three years. Wheat, oats, and corn have been the principal crops. The level areas that are not dissected by deep erosions usually have a good soil and where favorably located with respect to the railroad can be profitably used for farming. Where the basins are surrounded by the Bad

PLATE V.



Report of Bureau of Soils, U. S. Dept. of Agriculture, 1909.

SMALL TRACTS ARE VERY PROFITABLY FARMED IN THE SPEARFISH VALLEY. BLACK HILLS IN THE DISTANCE.

FIG. 1.—APPLE ORCHARD IN THE SPEARFISH VALLEY.

FIG. 2.—VIEW IN THE BELLE FOURCHE VALLEY, SHOWING IRRIGATED FARMS UNDER THE REDWATER CANAL.

Lands it is not likely that they will be utilized for farming, except in connection with stock raising. The lack of good water in many places is a serious hindrance to settlement and the difficulty of transportation through the Bad Lands makes general farming unprofitable.

HERMOSA LOAM.

Description.—The Hermosa loam varies widely in texture over different parts of its area, but in general the top soil may be described as a dark-brown heavy loam, having an average depth of 14 inches. As a characteristic feature of this type there is always present a small percentage of smooth gravel, usually quartz or limestone. The subsoil is a lighter-colored loam, with about the same texture and the same proportion of gravel as the top soil. At a depth of nearly 3 feet it loses its plasticity and becomes more friable.

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

Mechanical analyses of Hermosa 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.*
22381	Soil	2.1	4.4	3.4	9.0	17.7	32.4	30.7
22382	Subsoil	1.5	3.1	3.0	7.8	22.5	26.2	35.5

Origin.—This type is derived by weathering from several Tertiary rocks that outcrop in a broad band around the Black Hills. They consist of calcareous sandstones and conglomerates, materials originally derived from the wash from the Black Hills. In places the embedded pebbles are of limestone, but more often they are of quartz, surrounded by a calcareous matrix. All these materials weather to dark-brown calcareous soils, which may range in texture from somewhat sandy loams to very heavy loams, in some localities to clay loams, but the average and most common texture of the type is that first given.

Location and topography.—The Hermosa loam occurs in large irregular areas on plateaus between the creeks, over the region lying between Rapid Creek and Lame Johnny Creek and between the Black Hills and the Cheyenne River. The central part of those plateaus is fairly level or gently rolling, with steeper slopes and hilly land near the streams. In places the rock outcrops in such quantity as seriously to impair the agricultural value of the land, but the very stony areas have been mapped as Rough stony land. The elevation of the plateaus on which this soil occurs ranges from 3,000 to 3,500 feet above sea level. The most extensive and uniform area of the type

may be seen between Battle Creek and French Creek and east of the town of Hermosa. This ridge has nearly all been taken for homesteads, and farming has been carried on for several years on some parts of it.

Utilization.—The Hermosa loam is good farming land. It is fairly retentive of moisture and not so difficult to cultivate as the heavier gumbo soils. All the small grains do well. Corn has been grown to some extent and with success. Potatoes yield well and are a fairly certain crop, but they have been grown only for home use.

AEOLIAN SOILS.

While the wind has had some influence upon the formation of all soils in a semiarid region like western South Dakota, there are two soils in this area whose occurrence is due to the transportation of the soil material by this agency alone, while a third is largely formed by this action. These are the Dunesand, or Sandhill, the Smithwick sandy loam, and the Gannett fine sand. The first includes the very sandy material which is being shifted more or less by the wind, while the second represents areas where the amount of silt and clay present is considerably greater, owing in part to the larger amount present in the original material and in part to the breaking down of the sand grains through the agencies of weathering.

Throughout the sand hills occur valleys or flats in which the soil is largely formed from wind deposits, but has been modified to a greater or less extent by the washing of finer material from higher-lying areas. The soil is generally sandy and has been called the Gannett fine sand.

MISCELLANEOUS.

DUNESAND.

The Dunesand consists of 8 to 12 inches of fine sand having a dark-gray color due to organic matter. The subsoil is a fine sand of the same texture, but lighter in color to a depth of 30 inches. Below this depth it may pass in some places into a light-colored silty material, but more often the sand continues to a depth of many feet. The surface soil is loose and incoherent and liable to be drifted where it is exposed to full sweep of the winds and conditions are favorable. The sand grains consist largely of quartz, but a much larger proportion of other minerals is present than in the Dunesand in more humid regions.

According to topography, this type may be divided into two phases; the most extensive, comprising what is commonly known as the Sand Hills, extends for many miles over the southern part of South Dakota and covers a large area in Nebraska. There is also a large area of these hills in the northern part of the Pine Ridge

Reservation north of White River and southeast of Sheep Mountain. The Dunesand areas consist of steeply rolling hills and ridges which owe their origin to wind action. The material thus accumulated was probably derived by weathering from sandy beds of the Arikaree formation. In most places the sand is heaped up to a great height; in others a covering of sand has been distributed over more silty materials. A very small proportion of the surface sand is now drifting as vegetation soon obtains a foothold. The occasional drifting hills are small in extent and have a slow movement.

The native vegetation consists of a heavy growth of coarse grasses, of which the most common are "sand grass" (*Calamovilfa longifolia*) and blue joint (*Andropogon furcatus*). Weeds and wild roses are common and the yucca is characteristic of this type of soil. These grasses make good grazing and with the grasses of the plains give the variety which the stockman thinks beneficial to his cattle. It is probable that these grasses on more droughty land are more certain to be cured on the ground before frost than the grasses on the heavier soils. At present the sand hills in South Dakota are used only for grazing. Numerous valleys, described in this report as the Gannett fine sand, traverse the sand hills, furnishing hay and in many places grain to carry cattle through the winter. All water that falls on these hills sinks into the ground and issues as springs at the foot of the hills, furnishing an abundant supply of pure water.

The second phase of the Dunesand has a level or gently rolling topography. On the map with this report this type has been indicated without the cross lines that represent the more rolling character of the sand hill sections of the Dunesand. In texture the soil does not differ greatly from that of the sand hills, but the more level topography makes it more retentive of moisture and greatly enhances its agricultural value.

The native vegetation is more like that of the silty soils, with occasional patches of sand grass and some yucca. Very little of it is cultivated and farming will always be somewhat precarious on the loose sandy areas, though on the better areas corn, potatoes, and oats may be grown and good yields secured in seasons of adequate rainfall.

SMITHWICK SANDY LOAM.

Description.—The Smithwick sandy loam, to a depth of 8 to 12 inches, is a brown sandy loam underlain by a yellowish-brown sandy loam having a reddish tinge. Below 24 to 30 inches the subsoil is lighter in both color and texture, being a loamy sand. Enough silt and clay are present to give the soil a decidedly more loamy character and a greater water-holding capacity than the Dunesand. This fine material adheres to the coarser sand particles, causing them to stick together and stand up in banks like a much heavier soil. Consider-

able organic matter is also present, which increases the loaminess of the soil and helps prevent blowing. In some places the material is rather loose and sandy and drifts where exposed to the winds. In this way small tracts of typical Dunesand have been formed.

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

Mechanical analyses of Smithwick 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.*
22430	Soil	1.3	10.5	14.4	34.8	14.2	13.8	11.2
22431	Subsoil	.7	9.4	15.4	43.2	16.0	5.7	9.8

Origin.—The Smithwick sandy loam is undoubtedly derived from wind-blown material, but the great variation in the size of the sand grains, as well as the finer material adhering to them, indicates that this material has not been moved very far by this action. The latter would also tend to show that the sand had not been worked over very much by water before transportation to the uplands. The heavier texture of the surface material to a depth of about 2 feet is largely due to the weathering of the sand after its deposition in its present position, although some fine material may have been added as dust by the wind. The great variety of minerals present and the large number of sand grains composed of other minerals than quartz has been favorable to weathering.

Topography.—The surface is rolling to hilly, and in most cases it might be described as duny. Some of it is rather steep for cultivation, but the greater part can be farmed without much difficulty.

Location.—The largest development is in the section of country around and west of Smithwick, in Fall River County. It lies principally south of the Cheyenne River and west of the Chicago and Northwestern Railroad.

Utilization.—A large proportion of the type has been taken by homesteaders, who have farmed parts of it for some time with fair success. Corn, wheat, and oats are the general farm crops planted. The Smithwick sandy loam is probably the best truck and melon soil in the area. Tomatoes and watermelons have been grown with much success. Several fields of fine melons were seen. Potatoes also do well and are of excellent quality.

The soil is rather sandy to withstand severe droughts. Its porous nature, however, permits all the rain that falls to enter, and a mulch is easily maintained. This sandy material has in most places been blown over the Pierre shale, and as this is rather impervious the rain waters are stopped and caused to move horizontally, seeking to escape. This

causes a certain amount of subirrigation wherever these shales come near the surface, as they do around the border of the sandy areas. It is claimed that this increases the yield of crops in such areas very materially.

Most of the type is still used as pasture land, although the percentage in cultivation is increasing. Where the sod is broken care should be taken to prevent blowing, as this decreases the value of the land.

GANNETT FINE SAND.

Description.—The name Gannett fine sand has been applied to the soils of the obstructed valleys and flats among the sand hills. Being washed-in soil it has no uniform composition; but it may be described as a dark loamy sand, the sand being mainly of the finer grades. The loamy character of the soil is accentuated by the organic matter present.

Location.—The Gannett fine sand occurs where areas have been inclosed by the drifting sands or where level areas surrounded by the hills have been kept wet by the water oozing from the sand. In either case the soil is very sandy and is composed of the fine material washed from the Dunesand combined with the accumulated organic matter. The presence of the organic matter, the well-watered condition, and the different agricultural value have made it advisable to map this as a separate type.

Utilization.—The greater part of the Gannett fine sand has not yet been cultivated, and a large part of it can not be tilled until provision is made for better drainage. These areas are at present used as hay meadows, and they are so well adapted to this purpose that it is probably the best use to which they can be put. Combined with the nonagricultural sand hills, they are a valuable adjunct to a cattle ranch. Some of the well-drained portions have been cultivated with success. Corn has been the principal crop, and the yields have been good. Potatoes have also been grown for home use and for sale in the reservation. Oats do well on the better drained land.

SOILS OF THE GRAVEL TERRACES.

Cheyenne Series.

Numerous terraces occur at various elevations along the Cheyenne River and other streams. These terraces are built of deposits brought down from the Black Hills by streams, and being derived from various kinds of rocks and laid down at different stages of floods it is natural that the soils should vary widely and that their mapping and description should be a matter of some difficulty.

The soils of the terraces have been included in the Cheyenne series, which consists of types with brown surface soils and light-brown sub-

soils, underlain by beds of sand and gravel. The texture of the soil on these terraces exhibits a rather wide range, varying from gravelly and sandy loams to loam, and even clay loam. Several types of the series are therefore found, although it was not practicable to separate these on the map. The gravelly loam, sandy loam, and clay loam are of very limited occurrence, while the loam is very extensively developed. No detailed description of these unimportant members will be given, but they will be referred to incidentally under the description of the loams.

CHEYENNE LOAMS.

Description.—The Cheyenne loams consist of a brown loam to silty loam, 8 to 15 inches deep, underlain by a slightly heavier loam of a yellowish to grayish-yellow color. Some gravel and coarse sand are usually present, which makes the soil rather gritty, as is very evident in roads, where it grinds under the wheels. This material usually extends to a depth of several feet and is underlain by sand and gravel. The material is somewhat coarser nearer the Hills than farther out in the plains. The sand has a rather reddish tinge, and much fine material adheres to it. It is not very different from that which underlies the Smithwick sandy loam.

In some places the amount of gravel upon the surface is sufficient to constitute a gravelly loam. This represents areas where the gravel beds come near the surface, as along the border of the terraces, or where the currents were strong enough at the time of deposition to scatter the gravel over the surface. There are other places where the percentage of sand is large enough to constitute a sandy loam. The largest area of this character occurs upon the flats west of Cedar Creek, in the northwest part of the Pine Ridge Indian Reservation.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Cheyenne loams:

Mechanical analyses of Cheyenne loams.

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.*
22406	Soil	4.9	7.4	2.9	5.3	9.0	49.8	20.4
22407	Subsoil	1.0	1.8	1.0	1.7	25.5	58.2	10.9

Origin.—The terraces were formed during Pleistocene time, and while not of glacial origin were undoubtedly influenced, especially along the lower course of the Cheyenne River, by the damming up of the streams by the ice. It is difficult otherwise to account for their occurrence so far above the level of this stream. Weathering and the accumulation of organic matter have given rise to the Cheyenne loams from the material deposited in this manner.

Topography.—The Cheyenne loams occupy flat-topped terraces, usually elevated a hundred or more feet above the present stream valleys. The surface of these terraces is usually level to gently rolling, with very sharp breaks at the margins. Along the lower Cheyenne River there is a descent on all sides from the terraces to the heavier Pierre soils.

Location.—The largest development of the terrace soils occurs as a strip about 6 miles wide along the south bluff of the Cheyenne River in northern Stanley County. Smaller, less continuous areas are found along almost the entire length of this stream, as well as along Rapid Creek and other tributaries. Somewhat similar soils are seen in the Red Valley, especially around Spearfish, in connection with the Spearfish loam, from which they could not be differentiated on the map.

Utilization.—The Cheyenne loams, often spoken of as "tables," are highly valued for farming, and some of the most prosperous farming communities are located upon them. Wheat, corn, oats, and rye are grown and excellent yields are secured during favorable seasons. Potatoes also do well. The more sandy areas should produce good crops of truck and melons. A good growth of native grasses is found and the type furnishes excellent pasturage and hay. A supply of excellent drinking water is available at depths varying from 25 to 40 feet, and this is one of the factors which makes this soil so highly prized.

ALLUVIAL SOILS.

This term is used to include all soils formed by recent stream deposition; in popular parlance, the bottom lands. Owing to differences in the rocks from which the material has been washed, as well as to changes in the velocity of the current when the deposition was taking place, these soils show a great diversity, and a separation was in many cases impracticable. Where the wash is from the Morton soils of the uplands, the bottom soils have been grouped in the Wade series; where it is from the Pierre soils, the Orman[a] clay has resulted; and where from the Rosebud silt loam, the Tripp silt loam has been formed. Around the Black Hills and where the streams run across more than one of the above formations, so many kinds of materials have been mixed that only a detailed survey could show the individual types and the soils are shown upon the map and discussed in the report as "alluvial soils undifferentiated."

Wade Series.

All variations in texture from a sand to a clay can be found in the material washed from the Laramie formation, although it was not

[a] This type is more properly of lacustrine origin, as will be explained under the description.

practicable to separate all of the types, and the divisions made are entirely arbitrary. The separations, as shown on the map, simply represent the predominance of the texture given.

WADE FINE SANDY LOAM.

Description.—On account of the method of its formation, the Wade fine sandy loam is not uniform over any considerable area. In general it may be described as a fine sandy loam containing considerable organic matter which gives to it a brown to dark-brown color. There is no marked and consistent difference in soil and subsoil, although the latter is usually lower in humus and consequently of somewhat lighter color. The texture varies both vertically and horizontally as a result of variations in the velocity of the currents when the material was being laid down. The material is nearly always stratified, layers of fine sand, fine sandy loam, loam, and silt loam sometimes alternating within a 3-foot section. Gravel is not uncommon in the subsoil and may occasionally appear at the surface.

The Wade fine sandy loam embraces the most sandy soils found along the streams running through the areas occupied by the Laramie formation. The most sandy parts usually occur near the banks of the stream.

Origin.—The Wade fine sandy loam has been formed by the deposition by streams of the coarser material washed from the upland soils of the Morton series, principally the Morton fine sandy loam.

Topography.—The topography of this type is practically level. Slight undulations occur and the areas are cut by stream channels, sometimes abandoned long ago. The streams have usually cut down their present channels several feet below the surface of the bordering bottoms, and it is therefore only at times of high water that the bottoms are overflowed.

Location.—The Wade fine sandy loam is found chiefly along the Grand and Moreau rivers and their tributaries, especially where the Morton fine sandy loam constitutes the uplands. The principal areas are given on the map, but it is so closely associated with the loam that the separation of the two is very imperfectly made.

Utilization.—The type is now used almost exclusively for pasture. The principal grass is the sand grass. Where the areas are high and dry the growth is spare, but where water is nearer the surface it is more luxuriant and furnishes good pasture. It is a productive soil, easily cultivated, and well suited to agriculture. A few small areas are cultivated and give good yields of wheat, corn, and oats.

WADE LOAM.

Description.—While the Wade loam varies considerably in texture, it usually consists of a dark-brown to almost black loam to silt loam, which at a depth of 6 to 10 inches becomes slightly heavier in texture

and lighter in color. The amount of humus present is rather high, which causes the dark color. The subsoil color varies from brown to drab. At a depth usually greater than 3 feet sand and gravel are sometimes found, while not infrequently the subsoil has enough fine sand present to have a decidedly beneficial effect upon the underdrainage, particularly in level areas. This soil consists of material washed from the upland Morton soils, and the change from the latter group to the type under discussion is often gradual and the line of separation not very marked.

Along Valley Creek, in the vicinity of Harding, the soil is a deep, rich, black loam to silt loam overlying a subsoil of dark heavy silt loam or silty clay. Along the Little Missouri River it ranges from a heavy fine sandy loam to a light loam, with occasional spots of Morton gumbo; in fact along most of the streams the type is mixed with small bodies of fine sandy loam and gumbo.

Origin.—The Wade loam is alluvial in origin, having been washed down from the upland areas occupied by the Laramie shales and sandstones and deposited along the streams. Strictly speaking, the soil in some of the valleys, as at Harding, for example, is not altogether alluvial but in part colluvial, having been washed down from the hills rather than deposited by the streams.

Topography.—As this type occurs as bottom lands along the streams the surface is level to gently undulating. The slope is usually sufficient to give good drainage, but is in some areas so slight that water stands on the surface for several days after heavy rains.

Location.—The largest development occurs around Harding and along the Little Missouri River. Smaller areas are found along the streams throughout the section where the Morton loams form the uplands, although only the larger ones are shown upon the map.

Utilization.—Up to the present time (1909) probably not more than 1 per cent of the area is under cultivation, although most of it has been claimed by homestead entry. Where crops have been grown the reported yields have been good. At Harding it is said that 65 bushels of oats, 48 of barley, and 35 of wheat per acre have been produced. The average is not more than one-half of the above yields. Alfalfa has also been grown very successfully, as well as potatoes and various kinds of vegetables. Ease of cultivation, retentiveness of moisture, level topography, favorable situation for irrigation, and natural productiveness make the Wade loam one of the most valuable soils in western South Dakota for agricultural purposes.

WADE CLAY LOAM AND CLAY.

Description.—The Wade clay loam consists of 6 or 8 inches of dark grayish-brown heavy silt loam to clay loam, resting upon lighter colored and usually slightly lighter textured material of rather

friable structure. Not infrequently this soil contains a sufficient amount of sand to make it fairly easily tilled if plowed in the proper state of moisture.

Closely associated with the clay loam and occupying about an equal area is the Wade clay. This is a dark-gray to black silty clay, underlain at 6 to 10 inches by a stiff, tenacious clay of somewhat lighter color. Because of the heavy texture and close, compact structure the type is difficult to handle.

Owing to the small development and intimate association of these two soils it was not practicable to separate them on the map, so they are shown as one color. Numerous small areas of heavy gray "gumbo," covered only with a scattering growth of sage and cactus, also occur, especially in connection with the clay and, where such is the case, a good seed bed is almost impossible to secure.

Origin.—The types have been formed by the deposition of material brought down by the flood waters from the soils of the Laramie formation, the clay occurring in areas where the movement of water was least.

Topography.—The surface of these types is almost level and would require little work to fit them for irrigation. They occupy the lowest position along the stream and are subject to overflow during the early spring months and occasionally as late as May or June.

Location.—These soils are found only in comparatively narrow strips along the streams in the northwestern part of the State, the chief bodies being located on the wide flats along the Little Missouri River. Smaller areas occur along the North and South Forks of the Moreau River and their tributaries, as well as along Sulphur and Big Nasty creeks and other minor streams. Many of the smaller areas were not indicated upon the map.

Utilization.—These heavy soils are well adapted to the production of the various grasses and forage crops, but owing to the close structure, difficulty of cultivation—especially in case of the clay—their low position, endangering them to overflow, as well as to the occurrence of early frosts, it is not probable that they will be extensively used for the cultivated crops.

MISCELLANEOUS.

ORMAN CLAY.

Description.—The Orman clay consists of 6 to 10 inches of grayish-brown to dark-brown silty clay to clay, underlain by a grayish-brown to drab clay, which usually extends to a depth of several feet but may occasionally change into heavy sandy loam and gravel. The surface of the clay has a whitish appearance, owing to a thin surface crust of very light-colored material.

This soil is closely associated with the Pierre clay and possesses many of its characteristics. In part it represents a reworking of the same material. Like the Pierre clay it is sticky when wet and is often classed with this type as "gumbo." When dry the surface cracks; and if it has been stirred while wet, hard clods will be formed.

Origin.—The Orman clay represents Pierre shale or Pierre clay material which has been reworked and redeposited by water. In some cases the material has not been moved very far and occurs as colluvial wash from the adjacent hills; in others it has been carried farther and laid down as alluvium along the streams; in still others it has been washed into depressions or lakes and might here be considered as lacustrine. The essential characteristics are very much the same and no separation was considered necessary. In general, however, it may be said that the alluvial areas are lighter in texture and contain slightly more organic matter.

Topography.—Level flats or gently inclined foothill slopes are the characteristic topographic features. In the broad flats, like those along Indian and Owl creeks, the surface is so uniform and the fall so slight that water stands for several days after heavy rains. It is where such conditions exist that the white surface crust is found. Some small areas occur as depressions in the uplands and these also have very poor drainage. Where it is found as foothill slopes, surface drainage is sufficient and in some cases small gullies have been cut out by the water running across them from the hills.

Location.—The largest development is along Indian and Owl creeks near the Bellefourche reclamation project. It is also found along Middle and Crow creeks, as well as south of the Bellefourche River, in the vicinity of Snoma. Smaller areas are found along streams wherever the Pierre clay forms the soil of the uplands.

Utilization.—At the present time nearly all of this type is used for pasture. The grass is usually rather sparse and often cactus and sagebrush form the principal growth. The large tracts which are situated within the Bellefourche irrigation project are to be placed under irrigation. Around Snoma already a considerable area is irrigated from the Redwater canal and good crops of wheat, oats, and alfalfa are produced. This area is well drained and little trouble from alkali has so far been experienced.

In the detailed soil survey of the Belle Fourche area it was found that alkali is distributed generally thoughout this soïl and in such quantities that with irrigation there will be great danger of the larger proportion of the land being rendered worthless for agriculture. At present there is very little alkali in the first 18 inches of soil, but below that depth the percentage is high. The entire area of this soil in the western part of the irrigation project contained from 0.40 to 0.60 per cent of alkali to a depth of 6 feet.

Owing to the very level surface and the lack of adequate drainage, in order to prevent the accumulation of alkali more care will have to be taken in irrigating and cultivating this soil than with any other in the area. The alkali content of the subsoil is high, and under conditions which exist it is hard to see how damage is to be entirely prevented. By care in the use of water and by thorough cultivation a considerable time will elapse before any injurious effects will be noted. The early construction of drainage ditches would do much to aid in keeping down the alkali.

Because of the high salt content, inadequate surface drainage and difficulty in handling the heavy soil, very little of the Orman clay is under cultivation. Aside from the injurious effects of alkali the type is well adapted to grasses, forage corps, and small grains.

TRIPP SILT LOAM.

Description.—The Tripp silt loam consists of several feet of gray or whitish, very light-textured silt loam. The surface soil often contains a considerable amount of very fine sand.

There is often much other material mixed with this type in the river bottoms. Sandy spots are often found adjacent to the river bed, although of slight extent, while on the outer border of the bottom adjacent to the uplands and especially at the mouths of the larger creeks there is a long gentle slope of clay which may invade and take up a quarter mile strip on the outer border of the valley. This clay has probably been washed in here by the flowing surface waters, and its origin is doubtless largely colluvial.

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

Mechanical analyses of Tripp 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.*
22432	Soil	0.2	0.7	1.4	8.0	19.9	57.6	12.1
22433	Subsoil	.4	.1	.4	7.0	23.1	61.0	7.7

Origin.—The origin of the Tripp silt loam is alluvial, the soil having been formed by the deposition of the fine soil particles that have been carried by overflow waters from the Rosebud silt loam of the uplands.

Location.—This type occurs in the White River and little White River bottoms as a narrow strip from a few hundred feet to nearly a mile in width.

Topography.—The drainage of the type is good generally, although the topography is nearly level. The surface lies from 10 to 20 feet above the river bed.

Utilization.—The native growth of the Tripp silt loam is elm, ash, cottonwood, willow, etc., and some native grasses.

On the north side of the river some of the type is under cultivation. It produces good yields of crops in favorable seasons with sufficient rainfall. Corn in ordinary seasons yields from 20 to 30 bushels per acre; wheat from 15 to 20 bushels, and oats 40 to 60 bushels. It would be practicable to irrigate much of this type by damming the White or Little White River and running a system of sluices or canals along the edge of the bottom. The Little White River has a constant heavy flow of splendid water for irrigation purposes, and if this were utilized large quantities of all kinds of crops could be grown, even on the narrow bottoms. Potatoes, corn, and vegetables could be produced in great abundance with irrigation.

This land rarely ever overflows, although it has been known to do so. It is valued at from $20 to $25 an acre, depending on distance from railroads.

ALLUVIAL SOILS UNDIFFERENTIATED.

If a detailed study were made of the alluvial soils a number of additional types and series could be established. Where the Black Hills uplift has caused to be exposed at the surface a succession of markedly different geological formations, the alluvial soils are especially variable, the character of the alluvium varying with that of the rock from which it is derived.

Nearly all of the alluvial soils are characterized by a considerable proportion of organic matter and a dark-brown color. Where the material from the red Spearfish soils or the gypsiferous red beds constitutes a part of the alluvium a reddish color is imparted to the soils. This is especially pronounced along the Redwater River, as the name would suggest. These soils were grouped in the Vale series in the detailed survey of the Bellefourche area, and the following description of the Vale fine sandy loam and loam is taken from the report on that area.

The Vale fine sandy loam may consist of 6 feet of fine sandy loam, but is frequently underlain at 24 inches by a clay loam extending to a depth of 6 feet or more. The subsoil frequently contains thin layers of lighter material, usually a sandy loam. The texture of the surface soil varies considerably with the topography, some of the higher areas approaching a sand, owing to the removal of the finer material by surface washing, while lower lying areas approximate a heavy fine sandy loam or a silt loam. The clay loam subsoil is very compact, and below 6 feet it usually grades into a clay which extends to 12 or 16 feet, where it is underlain either by a heavy clay, locally known as "blue clay," or by a bed of waterworn gravel. The usual color of the soil is a reddish brown, which weathers to a light brown on the surface. The subsoil varies in color from a dark to a light reddish brown.

Dry farming and farming under irrigation are both practiced on the Vale fine sandy loam. In the dry-farming sections this soil produces good crops in years of average rainfall, alfalfa yielding on the average about 2 tons per acre, oats 25 bushels, and corn 15 bushels. In years of deficient rainfall dry-farm crops on this soil will hardly return

the seed planted in the spring. All of this type south of the Belle Fourche River and to a point about 2 miles east of Snoma is under irrigation, water being obtained from the Redwater Canal. Under irrigation this soil has proved well adapted to the crops grown in this section, alfalfa and oats giving heavy yields. Alfalfa produces from 5 to 7 tons per acre with three cuttings, oats 60 to 70 bushels, and wheat 25 to 35 bushels. Corn gives good returns, but in seasons of early frost it sometimes fails to mature. The soil is loose and easily handled, and with irrigation should prove adapted to a wider range of crops. A few small orchards are found upon this type, and the trees seem to be making a good growth. With proper protection from winds it is likely that apples, cherries, and a variety of small fruits would succeed.

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The Vale loam to a depth of from 12 to 30 inches, consists of a loam. This is underlain by a clay loam, rarely a clay, to a depth of 6 feet. In a few small areas the surface 2 inches is made up of fine sandy loam. Below 6 feet the soil is heavier, and at 12 to 16 feet it rests either on a heavy clay or on a bed of waterworn gravel. The soil contains varying quantities of gravel, particularly in the vicinity of old stream terraces. The color of the soil is brownish, with usually a reddish tinge, while the subsoil is darker and frequently contains yellowish-brown streaks.

Under irrigation alfalfa and small grains, principally oats and wheat, do well and the yields approximate those on the Vale fine sandy loam.

These descriptions give a very good idea of the alluvial soils along streams running through the red beds. In local areas the entire wash is from these beds and the soils are decidedly reddish, but where other material has been mixed with this the red in part or wholly disappears.

The greater part of these alluvial soils consists of loams and sandy loams, the heavier soils being almost entirely confined to streams running through the areas where the Pierre soils constitute the uplands.

Alkali, Boxelder, Rapid, Spring and some other creeks have rather heavy soils along them, especially in their lower courses where most of the material has come from the shales. The bottoms along these streams are generally very productive soils and when irrigated or in favorable seasons give excellent yields of the crops grown in this section.

Near the center of the Black Hills the small, often disconnected areas of alluvial soils consist principally of brown loam and fine sandy loam, usually containing quite a large percentage of mica, which has come from the degeneration of the micaceous granites, gneisses, and schists which constitute largely the core of the hills. The soils are very fertile and give excellent yields, oats potatoes, and hay being the most important crops.

As the Cheyenne River receives the drainage of almost the entire Black Hills as well as parts of the plains, a great variety of rock material has been mixed in the formation of the soils along it. Above Edgemont it is bordered by a considerable area of bottom land, which has been irrigated to some extent. Around the southern part of the Hills its bottoms are narrow, often furnishing little more than room

for the stream itself. Farther down the bottoms widen out, but seldom to more than a mile.

The upper portion of the White River runs through rather uniform silty material and the soil is therefore fairly uniform and has been classed as the Tripp silt loam, which has already been described. The lower half of its course is largely through the Pierre shale and the soils of the bottoms are mixed, consisting in some places of silt loam, brought down from the White River formation, and in others of rather heavy clay washed from the Pierre clay of the uplands. For this reason no attempt was made to separate the soils here.

In the southern part of Tripp and Gregory counties, principally along the Keyapaha River and Ponca Creek, the soils really belong to the Tripp series, but the texture varies so much that they could not be included with the Tripp silt loam and they have not been differentiated.

ROUGH STONY LAND AND UNDIFFERENTIATED SOILS.

Such a large proportion of the Black Hills section is entirely unfit for agriculture and the soils are so variant in character that no attempt was made, except in case of the Red Valley, to separate out the small areas of farming land or the different kinds of soil. Some of the larger areas of least broken topography, as around Custer, for example, have been indicated by cross lining. The greater proportion of the Black Hills can best be classed as Rough stony land, with many small areas where the bare rock forms the surface. The roughest and rockiest portion is found along the larger streams, which flow between canyon walls in places nearly a thousand feet high, giving very beautiful and picturesque scenery. Where the streams break through the plateau, capped by the Pahasapa limestone, the canyons are very deep and the country extremely broken.

While the greater part of the Black Hills consists of Rough stony land, numerous small areas of farming land, whose soils would be classified into different types in a more detailed survey, are interspersed through them. The character of the soil varies with that of the rock from which it is derived. Although a great many different kinds could doubtless be distinguished, they can be grouped into four divisions: (1) Those derived from the older crystalline rocks, like granites, gneisses, and schists; (2) those formed from limestone; (3) those derived from sandstone and shales; and (4) those deposited by streams.

The soils derived from the metamorphic and igneous rocks occur in the central part of the Hills, the largest cultivable area being found around Custer. The soil at this place consists of a brown to reddish-brown loam to silt loam, underlain by a reddish-brown to red subsoil. This soil resembles the Porters loam of the eastern United States.

This is a good soil, giving yields of hay, oats, potatoes, vegetables, and fruits above the average. In the country west of Nemo a different soil was observed. The rock here is a rather slaty schist which is very fissile and breaks down rather easily, so that rounded rather than sharp ridges are formed. The soil is a gray almost white very floury silt loam, underlain at 10 to 12 inches either by a hard, impervious silty clay or broken rock. The rock is usually only a few inches below the surface and seldom more than 3 feet. A few small patches are being cultivated, but most of this section is unsuited to farming.

The limestone soils are derived principally from the Pahasapa limestone, which forms a plateau around the older crystalline rocks of the center of the Hills. While most of the country where this rock outcrops is very rough and stony, there are some fairly level hilltops and depressions between the hills which can be farmed. The soil is a dark-brown loam to silt loam sometimes 3 or 4 feet deep, but usually underlain at 10 to 15 inches by a yellowish-brown subsoil of about the same texture. This is an excellent soil and grows fine crops of hay, oats, potatoes, wheat, and alfalfa. Several fields of the latter were seen which were apparently doing well.

The sandstone and shale soils are found principally around the outer part of the Black Hills. The sandstones give rise almost entirely to Rough stony land, although a few small areas of fine sandy loam of sufficient size to be cultivated were seen. The shales give rise to loam and silt loam areas of very limited extent.

Along many of the streams occur narrow valleys, seldom more than one-fourth mile in width, in which are found soils of alluvial origin. Most often the soil is a dark-brown loam, 3 feet or more deep, but areas of sandy, gravelly, and stony loams occur. Variation in the rocks from which the alluvial material has been derived is reflected in the character of the alluvium. Where the wash is from micaceous rocks, as, for example, around Custer, the valley soil contains a large quantity of mica. Where washed from the limestone it is rather darker and more calcareous. Spring-fed streams are found in all these valleys, and this, combined with the very productive nature of the soils, makes them very valuable agriculturally.

AGRICULTURE.

EARLY HISTORY AND PRESENT CONDITION.

The development of western South Dakota has been greatly retarded by the large proportion of the region held as reservations for the Indians. The great Sioux Reservation, which extended from the Missouri River westward almost to the Black Hills and from Nebraska northward into North Dakota, covering nearly one-half of the entire State west of the above stream, not only precluded any

FIG. 1.—FLOCK OF 2,500 SHEEP 9 MILES WEST OF OELRICHS.
[The advent of the homesteader has caused a decline in this industry.]

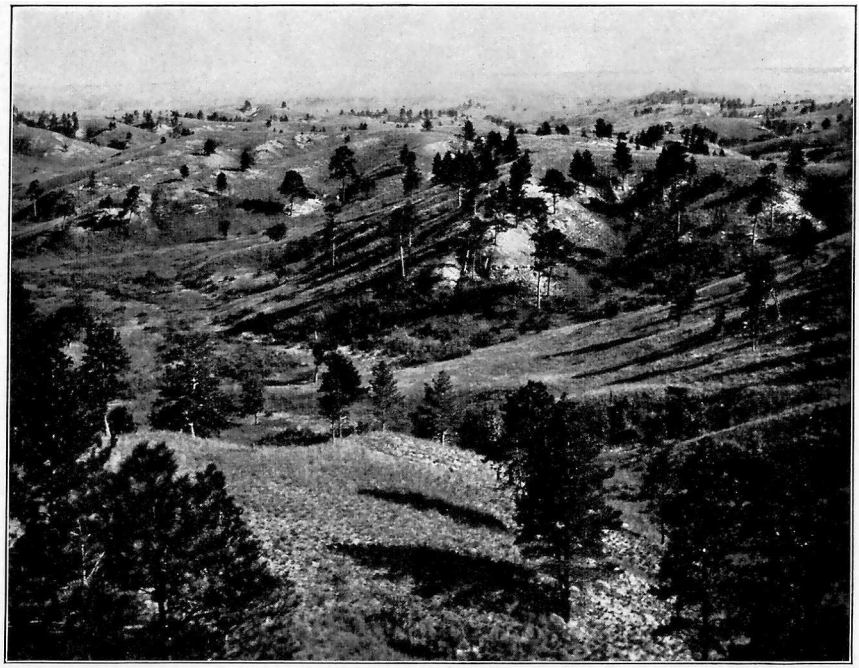

FIG. 2.—BROKEN COUNTRY ALONG PINE RIDGE ESCARPMENT WEST OF ROSEBUD, ADAPTED TO GRAZING AND FORESTRY.

settlement in the section actually included within its boundary, but also served as a barrier to the development of that part of the State lying west of it. About one-half of this reservation was opened to settlement in February, 1890, and a gateway for the advance of cultivation beyond the Missouri River provided. Other portions have been opened since, the latest addition being made during the progress of this survey.

The discovery of gold in the Black Hills in 1874 caused a rush of prospectors to this section. As many were rewarded by successful prospecting the development of the mineral wealth of the Hills went steadily onward, until to-day the largest gold mine in the world is being operated at Lead. At the time gold was discovered this territory was not open to exploration and settlement, and government troops were stationed here to prevent the ingress of population. The hopeful outlook intensified the interest of the prospector and homeseeker and they could not be kept out, so that soon the entire Hills region was overrun. This led to the opening up of western South Dakota to settlement.

About this time the cattlemen began to realize the wonderful palatability and high feeding value of the native grasses and the prairies were soon dotted here and there with herds of cattle. Excellent grazing opportunities gave an impetus to stock raising and for a number of years the cowboy lived in his element. Many fortunes were made at this time in the cattle industry, though, during a severe winter, some were brought to ruin.

Actual farming did not begin with the advent of the ranching industry, for no one thought of seeding many acres to grain. The settlers were few and widely scattered, often many miles apart. Ranchers living 10 to 20 miles from each other considered themselves as near neighbors. Most of the houses were built along streams, so that fuel and water were easily obtained. The grass was here more plentiful and the groves and bluffs afforded some winter protection.

Very little of the land was cultivated, not because the land was unproductive when tilled, but because most of the settlers thought that they could not afford to grow grain for market. The typical rancher had no gardens, for he felt it a waste of time to attempt to grow his own vegetables. He was sure that potatoes, beans, and other garden truck could be more cheaply bought. Very little hay was put up because of the scarcity of labor and the heavy expense. Sometimes a small supply of hay would have been a valuable asset to many cattlemen during an unusually hard winter, a late spring, or a blizzard. Frequently blizzards brought great hardship, much extra labor, and even ruin.

The building of the Fremont, Elkhorn and Missouri Valley Railway along the eastern foot of the Black Hills about 1887 greatly stimulated development in this section. Many settlers poor in purse and unskilled in farming came into this portion of the State and took up homesteads. Several successive years of insufficient rainfall during the late eighties and early nineties, combined with a lack of experience under new conditions, resulted in many disappointments and failures and caused the abandonment of most attempts at farming. A good number remained in the foothills, making a living by combined grain and stock farming.

As the lands open for homestead farther east were exhausted the price of land continued to rise, and the demand for free or cheaper land caused the settlers to push farther and farther west. Limited experiments indicated that many crops could be successfully grown by proper methods of moisture conservation in this section, though it had formerly been considered entirely unfit for farming. Then, in 1907, came the building of the Chicago and Northwestern and the Chicago, Milwaukee and St. Paul railroads from the Missouri River to Rapid City, as well as the Pacific coast extension of the latter through the northern part of the State. These opened up large stretches of country and gave a new impetus to settlement. Land along these lines was rapidly taken up and homeseekers pushed far away from them into the country. Houses sprang up over night and the development of western South Dakota took on a new meaning. The cattlemen were hemmed in on every side by homesteaders. Towns were laid out which soon grew to be prosperous villages, and to-day there are many settled communities where comfortable houses, commodious barns, and adequate farm equipment give the best evidence of a permanent population.

During the last few years the rainfall has been above the average, and less favorable ones must be expected. Those thinking of farming in this section should carefully consider the following statement taken from Farmers' Bulletin No. 226:

> Anyone who proposes to begin farming without irrigation in a region of light rainfall should be properly cautious. He should not be misled by glowing accounts of large crops; he should investigate carefully the possibilities of the particular region in which he expects to settle; he should have clearly in mind beforehand the kind of crop which he will produce, and he should not undertake dry farming if a failure of crops at the beginning will mean to him complete and permanent disaster. It should be clearly understood that farming in the semiarid regions without irrigation can not in the nature of things be as certain or as profitable as farming under favorable conditions in the humid regions.

STOCK RAISING.

For many years stock raising was practically the only industry throughout the Great Plains region, and while the coming of the homesteader has forced the breaking up of most of the larger ranches,

thousands of head of cattle, horses, and sheep may still be seen grazing upon the nutritious grasses which clothe the surface with green during the summer months and cure into excellent hay without cutting with the advent of fall, thus furnishing feed during the winter. Many of the ranchers formerly depended entirely upon the naturally cured hay for winter feed for their herds. This often resulted in much suffering and loss of stock during blizzards or when snow covered the surface and buried the grass for long periods, so that sufficient food could not be secured. Now the best ranchers always provide hay to guard against such losses.

According to the state census for 1905, there were at that time in western South Dakota, exclusive of Indian reservations, 191,411 cattle, 214,157 sheep, and 46,291 horses and mules. The same authority estimated in 1909 that these figures had been increased to 360,338 head of cattle, 102,877 horses, and 287,560 head of sheep. As much of the land in the Indian reservations has been leased to cattlemen, the total number for the entire area is doubtless considerably greater than the above figures.

While the system of large ranches must necessarily be abandoned, stock raising should and undoubtedly will continue as one of the most important industries. There are large areas of Bad Lands as well as "breaks" along the streams which are not suited to farming, although they afford excellent pasture for stock as well as protection during the storms of winter. Even in the sections best suited to cultivation every farmer should have some live stock in order that he may not be entirely dependent upon his crops when dry years come.

PRINCIPAL AGRICULTURAL PRODUCTS.

The principal agricultural products are wheat, corn, oats, barley, rye, emmer (or speltz), flax, hay, fruits, potatoes, melons, and other vegetables. These will be discussed under the headings General farm crops, Truck crops, and Fruits.

GENERAL FARM CROPS.

South Dakota belongs to that great northwest group of States which is known as a small-grain section. Her success in the production of wheat, oats, barley, and flax is not questioned, while the acreage in corn is being rapidly extended and large yields testify to her ability to grow this crop with great success also. In the past most of her products have been grown east of the Missouri River, but in due course of time and when properly farmed this section will furnish a much larger proportionate production along these lines.

The following table gives the total yield of the four most important of these crops:

Total yield of wheat, corn, oats, and barley in western South Dakota.[a]

Year.	Wheat.	Corn.	Oats.	Barley.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*
1904	274,034	584,443	766,810	77,577
1909	1,147,000	4,465,000	2,057,000	305,000

These figures indicate a very remarkable increase in the production of the cereal crops during the last five years. In case of the first three crops from one-fourth to one-half of the increase is referable to Gregory County alone, being the result of the very recent opening of this county to settlement. The principal increase in barley was in Butte County (including Harding and Perkins), almost one-half of the total crop produced being in this county.

Wheat.—The farmers are growing spring grains most extensively. Hard spring wheat does well in all the area. More care in preparation of the soil and the selection of seed will, however, materially increase the yields. Indifferent methods too often scarcely pay for the seed which is sown. Many fields are so badly infested with cockle, wild oats, or wild sunflowers as to make it hardly worth while to harvest the crop. These failures are unpardonable because they are entirely within the control of the farmer. The principal varieties of wheat are Fife, Blue Stem, and Velvet Chaff. These seem to have adapted themselves best to their environment, are hardy, give the best yields, and are not discriminated against by the miller. Occasionally some farmer has some other variety which does equally well. Durum (macaroni) wheat is being grown more widely year by year. It is better constituted to resist drought and gives fairly good yields even during exceptionally dry years. Much of it is grown to be used as feed, being readily eaten by stock. The Kubanka variety seems well suited to this section.

Within the last few years an attempt has been made to grow winter wheat. The Turkish Red varieties have been used, and if the past may be taken as a criterion a valuable crop has been added to the list. With even the indifferent soil preparation and seeding it has yielded well. In some instances where seed was simply disked in in the fall, a yield of over 30 bushels was obtained. Winter wheat should prove an advantage, because it gives opportunity to lessen spring labor, and this item is of considerable importance. Some

[a] The figures for 1904 are taken from the state census for the year 1905, which gives the yield of crops for the preceding year. Those for 1909 have been taken from the Ninth Annual Review of the Progress of South Dakota and represent the yield as estimated by the state census division of the department of history.

heads containing 62 grains were found this summer on a farm east of Boxelder.

Oats.—Oats do well and seem comparatively free from attacks of rust. Yields of from 40 to 60 bushels are not uncommon. The leading varieties are the larger white oats, belonging to the Seizure and Welcome groups. During the past year several farmers in widely different parts of the area have sown the Sixty Day oats, a small yellow variety, and are well pleased with the results. One expressed himself as being so well pleased that he wished he had seeded his entire farm to that variety. It is said that the oats produced in this section are very heavy, weighing 35 or even 40 pounds to the bushel.

Barley.—Barley has not been grown so extensively as oats or wheat, but wherever tried has invariably given good returns. Hanna has proved a good two-rowed variety. Near the Hills the hulless has produced grain of very good quality.[a]

Corn.—Practically all of the farms, even in the Hills, grow some corn. Even in seasons when it does not fully mature it furnishes a large quantity of forage. Corn should be a part of every farmer's rotation for several reasons. There is no better crop to grow in ridding the fields of weeds. It is a crop which requires no expensive machinery, is easily harvested, and brings a good price in the market. In the third place, it takes the place of summer fallow, and gives the best possible preparation for the growth of small grain the succeeding year. A variety should be selected which is not too large for the higher altitudes or northern latitude, one which will be sure to mature under average conditions. The Pride of the North is now being grown east of Whitewood at an altitude of about 3,000 feet and has yielded 27 bushels of shelled corn per acre. Many farmers cut it with a corn harvester and thrash it as they would grain. The stover is then used for roughage, while the corn is put into bags. Larger crops of wheat or oats can usually be obtained from land where a crop of corn has been produced the year before than where the crop follows small grain.

Hay.—Much of the hay at the present time is made from the native grasses of the prairies. There is no hay of better quality or any relished more by stock than western wheat grass. The native sod does not, however, yield heavily enough to make it the most profitable to grow. The native grass crop can be trebled by plowing the sod, growing a crop of corn, and then allowing it to revert to grass. Even after disking it comes up thicker and gives more hay. Along the old trails where the sod has been cut up more or less by wagons and the tramping of stock the western wheat grass is much

[a] For fuller information in regard to variety tests of small grains suited to the conditions found in western South Dakota see Circ. No. 59, Bureau of Plant Industry.

heavier, demonstrating that even a slight disturbance of the soil is beneficial.

If no great progress can be made along this line the native grass must be superseded by some cultivated forage plant. This will certainly prove to be alfalfa. This best of forage plants has now been grown in some localities for more than twenty-five years and fields of that age are yet giving profitable returns. Two crops can be harvested at all times and during some years three. It seems to flourish better on the medium heavy types of soil, seemingly preferring a heavy loam to a clay loam. Exceptionally fine crops are also obtained on the red soils of the Hills. On the above soils it produces fine seed, yielding as high as 8 to even 12 bushels per acre. Seed from this section of the country commands a good market price and there is always a demand which should make it a factor in determining the crops. It is a question whether clover will be able to endure the droughts, but in the Hills where irrigation can be used or where there is subirrigation it may do well. Timothy is grown quite extensively in the Hills and furnishes a good quality of hay.

TRUCK CROPS.

Although there are many soils in this section well adapted to trucking, the local demand for these crops has not been sufficient to encourage their production on a large scale, excepting a few crops like Irish potatoes, which are easily kept and will bear shipment for long distances. Besides potatoes, onions, tomatoes, and melons are produced in larger quantities than any other vegetables, although many other sorts are grown in greater or less quantities.

Potatoes are grown quite extensively, especially on the loam and sandy loam soils. The clay loams and clays are not so well suited to this crop, as the heavy texture causes the potatoes to be more watery and therefore of inferior quality. Potatoes constitute one of the most important crops in the narrow valleys throughout the Black Hills section and good yields of very fine quality are grown. The total yield for the entire area in 1904 was 232,613 bushels, of which a little over one-fourth were produced in Lawrence County. The average yield is about 100 bushels per acre. Under irrigation this is increased to 160 or 175 bushels, while yields of 300 bushels or even more have been secured. The average net profit under irrigation is estimated at $50 to $60 an acre. The Early Ohio and the Finch seem to be the favorite varieties.

The largest development in the trucking industry is in the Spearfish Valley, where probably something over 5,000 acres are under irrigation. A great many vegetables, including beans, peas, tomatoes, cucumbers, and onions, are grown here and sold largely in Lead and Deadwood. There is usually a good market, although an over-

production of some crop may occur. It is considered safest to plant a variety of crops, so that some very profitable one will be included.

Quite a little truck is also grown around Bellefourche. As a larger acreage is brought under irrigation the production will doubtless be much increased.

On the sandy soils, especially around Smithwick, watermelons and tomatoes are being raised in considerable quantities, without irrigation. Both of these crops do best on sandy soils. The quality of the melons is much superior to that of those produced on the heavier soils. In 1904 Lawrence County produced more than one-half of the melons grown west of the Missouri.

FRUITS.

The Black Hills and adjacent country is well adapted to fruit culture. The Red Valley seems especially well suited for this purpose, as exceptionally fine fruit is found here. The Spearfish Valley has the best developed and most extensive industry along this line. However, some fine fruit is now grown on Rapid Creek and Hot Springs and in other sections of the Hills. The fruits may be divided into two general classes, tree fruits and small fruits.

Tree fruits.—The principal tree fruits consist of apples, plums, and cherries. Of these, apples are by far the most important. In 1904 according to the state census there were in the area 28,804 apple trees, more than two-thirds of which were in Meade and Lawrence counties, and these yielded 28,048 bushels of apples. Many were young trees which had not begun to bear. The Yellow Transparent, Wealthy, and Duchess (of Oldenberg) are the most common varieties, although the Pewaukee, Longfield, McIntosh Red, Wolf River, and several others are grown. The trees here require about five years to begin to bear. Well-drained loams and sandy loams, especially those with a red color, are best suited to this crop.

Plums and cherries grow almost everywhere. Plums are sometimes injured by a freeze. The Cheney is regarded as probably the best native variety. An early variety is needed to insure ripening. Cherry trees were seen many miles east of the Hills. Some of these were brought from northern Illinois four years ago and appeared very strong, vigorous, and healthy, and have already borne fruit. A determined effort should be made by every farmer in the Plains to grow at least enough fruit for his own use.

Small fruits.—Small fruits do well, and the grower usually finds a ready market for his products. Strawberries grow wild upon the hillsides. Clyde, Bederwood, Warfield, Senator Dunlap, and Surprise are all good varieties for this section. One grower at Spearfish produced 37,500 quarts of good berries in one season. Raspberries are grown with success, the Loudon and Marlboro being considered among

the very best varieties. Currants are raised to a limited extent. Knights' Prolific and Pomona are thought to give the best results. One grower harvested 4,000 quarts from three rows 18 rods long. Among the varieties of gooseberries the Downing and Jostling are considered best.

ADAPTATION OF SOILS TO CROP.

As agriculture is in a formative stage in this section, very little attention has been given to the study of the kind or variety of crop best suited to the different soils. That variation in the soil is one of the determining factors in crop adaptation is clearly shown by the marked difference in native vegetation upon the various types. Every farmer therefore should study his own soils, and by selection and breeding develop varieties best adapted to the conditions on his own farm.

In general it may be stated that the sandy loams will be found better suited to the production of vegetables and melons than the heavier soils. The earliness of these types also makes them desirable for corn, as there will be less danger from frost. One of the most successful apple growers in the Hills recommends the planting of apples upon the red sandy loam and light loams, in many places quite stony, while the darker and heavier soils should be used for wheat, oats, and other general farm crops. Alfalfa does best on well-drained soils, free from alkali. The alluvial loams and clay loams are well suited to this crop. While many crops can be grown on almost any productive soil, the variety that will do best upon a sandy loam will usually prove less prolific and therefore less profitable upon a clay or "gumbo." In securing seed it is well to get it from a farm where the soil is as nearly similar as possible to the one upon which it is intended to plant it.

AGRICULTURAL METHODS.

The farmers have not yet given much thought to systemizing their farming operations. Some have come from cities; others from farms in the East, and have brought their methods with them; and still others have been in this section long enough to adopt the practices best suited to this semiarid region. Many have planted crops just to see whether they will grow. This fact having been demonstrated, it is now time to initiate a systematic method of farm management, in order that the greatest profit may be secured. While it is believed that farming can be made profitable here, and in fact this has already been done in many instances, the difficulties to be overcome are greater than in the more humid regions farther east. The present methods leave much to be desired, and every opportunity to improve them should be taken advantage of. The results secured by some

farmers who are using the most improved and approved methods show that good farming not only pays better in good seasons, but also that it will often assure fair yields when poor farming would result in total failure.

Dry farming.—There is no more important factor in determining the yield of crops than the moisture supply. In an area where the precipitation is often not large enough to supply a sufficient amount of moisture for the best development of crops and where it is irregular in distribution and frequently in the form of torrential downpours, the greatest care should be exercised to make the best possible use of all that falls. Methods of farming should therefore be such as will insure the entrance into the soil of as large a percentage as possible of the rainfall and then keep it there for the use of the crop. The methods employed by a majority of the farmers in this section fall far short of accomplishing these results, and for this reason the yields are not as large or as sure as they should be.

Sands and sandy loams are naturally more open and porous than soils of heavier texture; the rainfall can, therefore, enter these readily and very little runs off the surface. This is strikingly shown by the occurrence of perennial springs and streams around the border of the sand hills. The loams, silt loams, clay loams, and clays usually require loosening of the surface in order that the rainfall may penetrate with sufficient rapidity to prevent run-off, especially during very heavy showers. Farmers should, therefore, make it a practice to plow these soils deep and have them in good tilth.

Most of the good which should result from getting the rains to enter the soils will be lost unless the moisture is kept there until it can be used by the crops. The most practical and effective way of accomplishing this result is by means of a surface mulch. Cultivation should follow every rain so far as it is practicable in order to break up the crust which is formed and by the creation of a loose surface layer to prevent evaporation. Good cultivation of small grain as well as corn will help to save the much needed water. Harrowing of wheat and oats as late as possible, provided a crust has formed, will increase the yields, while the cultivation of corn should not cease until it has eared. Cultivation, however, should not be entirely confined to the time when crops are being grown, but should be begun as soon as possible after a crop has been removed, and continued whenever necessary and practicable until the next crop is sown and as long thereafter as the state of growth will permit.

On the sandy lands the methods must be such as to accomplish the above results and at the same time prevent blowing, which may cause much damage or even ruin, especially upon the looser sands. Leaving the surface rough and incorporating organic matter will tend to prevent blowing. The deeper sands had best be left in pasture as the

winds may cause much damage as soon as the vegetative covering is broken.

Organic matter greatly increases the water-holding capacity of the soil and a good supply should be maintained. However, if coarse or trashy material is turned under in a dry climate, some time will be necessary for its decomposition. It is best, therefore, to maintain humus by turning under green manures or by adding well-rotted stable manures.[a]

Under irrigation.—Under irrigation the methods are essentially different from those under dry farming. The farmer has to deal with the best means of getting the water over the land, so as to secure the maximum results and at the same time guard against a possible danger from alkali. The land must be gotten in condition so that the water can be readily applied and the method, time, and frequency of application must be considered. These will necessarily vary according to the character of the soil and the crop. In new irrigation districts there is nearly always a tendency to try to substitute irrigation for cultivation. Cultivation should usually follow irrigation as soon as practicable in order to conserve the moisture, thus not only decreasing the total quantity of water used, but also lessening the danger from accumulation of alkali.[b]

Rotation of crops.—As agriculture in this section is practically in its infancy, very little attention has been given to the subject of crop rotation. The best farmers, however, realize that the most profitable returns can not be maintained by the continuous growth of one crop. This fact has been proved so conclusively that every farmer should plan a system of rotation that will best answer his needs and conditions.

Corn and flax are used quite extensively as sod crops because of their adaptability to newly-turned land. Even with no cultivation these usually give fair returns. Corn should be followed by wheat or oats, as the ground is in excellent condition for these crops. It will be well to include some leguminous crop in the rotation in order to keep up the supply of nitrogen and humus in the soil.

The best rotation upon the various soils can be determined only after more experience and further experimentation. Every farmer should not only study his own conditions, but should keep in touch with the work done at the local experiment station.

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[a] For further discussion the reader is referred to Farmers' Bul. 266, "Management of Soils to Conserve Moisture," by George H. Failyer.

[b] For further discussion see Farmers' Buls. Nos. 158 and 263, which can be obtained free by application to the Secretary of Agriculture, Washington, D. C.

LABOR.

As in most farming sections in the West, farm labor is scarce and most of the work has to be done by the farmer and his family. The building of new lines of railway, the construction of the Bellefourche irrigation project, and the large mining and timber interests in the Black Hills absorb most of the available labor. When hands are employed by the year they receive from $25 to $30 a month. During the harvesting season twice the above amounts are often paid for transient labor.

TENURE, SIZE, AND VALUE OF FARMS.

The greater part of the land is worked by the owner, probably less than 20 per cent being cultivated otherwise. Some farms are run by a manager, and some rented, the number being nearly equally divided. Of the latter, something over one-half are rented on shares.

As a large part of the farm land has been recently homesteaded, the average size of farms is about 160 acres. Only a small percentage of this is actually under cultivation. In most cases only the area required for homesteading was broken and in many instances this has since been allowed to return to sod. The total area under cultivation is being rapidly increased.

In the parts of the area that are under irrigation the size of the farm is much smaller, 10 acres being considered a good-sized farm under intensive cultivation.

The price of land varies from a few dollars an acre to as much or more than $250. Rough land, which is suited to grazing only, sells at $2 to $10 an acre; that which is adapted to dry farming at $10 to $20 or sometimes $30 an acre; while some of the highly improved and irrigated farms have been sold for as much as $250 an acre. Unimproved land under the ditch has brought as much as $200. These higher prices are found principally in the Spearfish Valley. Under the Bellefourche project[a] some land is being offered for sale as low as $15 to $20 an acre.

While a large proportion of the best lands have been filed upon, especially near the railroads, there are still many tracts which are subject to homestead. These are being very rapidly taken up, and if the present rate continues most all of the public land suitable to farming will be appropriated within a very few years. There are, however, large areas like the Bad Lands and the "breaks" along the streams which are not adapted to farming, and some provision for leasing or disposing of them for grazing purposes ought to be made. The principal areas of such land are indicated upon the map by means of cross linings.

[a] Detailed information in regard to price and method of acquiring land under the Bellefourche project can be obtained by addressing the U. S. Reclamation Service, Bellefourche, S. Dak., or Washington, D. C.

IRRIGATION.

PRESENT AREAS UNDER IRRIGATION.

While it has been demonstrated that crops can be produced successfully in this section under dry farming in years of average rainfall, safer and larger yields can be secured by irrigation wherever this is practicable. The large number of perennial streams issuing from the Black Hills has led to the construction of several projects in the surrounding country, while smaller tracts are found in other sections.

The most extensive development along this line has taken place around Spearfish and Bellefourche. Probably something over 5,000 acres are under irrigation in the Spearfish Valley. The Red water Canal at Bellefourche has been in operation since 1878 and between 4,000 and 5,000 acres are being irrigated. A number of smaller projects are also in operation in this section.

The most important irrigation project in South Dakota is the Bellefourche project of the United States Reclamation Service. This tract includes an irrigable area of nearly 100,000 acres, of which 8,000 acres were served with water during the past season (1909). It is estimated that 42,000 acres can be supplied with water for 1910 crops.

Rapid and Battle creeks and Fall and Cheyenne rivers also have considerable areas along them which are under irrigation.

The following table, taken from Bulletin 210, Office of Experiment Stations, United States Department of Agriculture, entitled Irrigation in South Dakota, by Samuel H. Lea, state engineer, shows the areas under irrigation as well as those projected:

Areas under irrigation works and projects.

Project.	Areas to be under irrigation by January 1, 1909.	Additional area to be reclaimed under present projects.	Project.	Areas to be under irrigation by January 1, 1909.	Additional area to be reclaimed under present projects.
	Acres.	*Acres.*		*Acres.*	*Acres.*
Redwater Canal	5,000.00	.....	Grand River water district	.....	1,201.11
Spearfish Valley	5,335.00	.....	Moreau River water district	.....	434.88
Little Missouri water district	213.00	631.77	Bellefourche project	12,000.00	88,000.00
Bellefourche water district	3,242.13	1,872.21	Reservoir filings (estimated)	14,000.00	30,000.00
Elk Creek water district	75.00	727.20			
Rapid Creek water district	15,278.00	2,237.60			
Battle Creek water district	148.66	461.70			
Fall River water district	3,900.64	750.00	Total	61,901.03	129,956.47
South Cheyenne water district	2,708.60	3,640.00			

WATER SUPPLY.

The development of irrigation depends upon an adequate water supply. The possible sources may be grouped under three heads: First, perennial streams; second, flood and storm waters; and third, wells.

Nearly every stream issuing from the Black Hills carries water all the year round, although the amount may be very small in especially dry seasons. These will furnish water to increase the irrigated area very considerably, especially if storage reservoirs be constructed to hold the flood water. On the plains the Little Missouri, Grand, Moreau, Cheyenne, White, Little White, and the Missouri rivers are all perennial streams also, although the volume of the water is very variable in most of these and in some may cease to flow in very dry seasons. In addition to these there are numerous streams and drainage channels which carry large amounts of water after rains, along which storage reservoirs can be constructed and in this manner a total of several thousand acres irrigated.

A large proportion of the Plains is underlain by the Dakota sandstone, a water-bearing formation. Except near the Black Hills, it usually lies at such great depths that only a few wells have been sunk into it. Several small areas, especially around the Hills, are irrigated from these artesian wells.[a]

OPPORTUNITIES FOR EXTENSION.

The Missouri River and its larger tributaries have very narrow valleys, and although the water supply is sufficient to irrigate quite a large acreage there are very few tracts which are large enough to justify the installation of an expensive irrigation system. There are, however, some rather extensive areas which are well situated for irrigation. Most of these consist of alluvial soils, and their location is therefore indicated on the soil map.

One of these areas is found along the Grand River in the vicinity of Seim. This body, consisting of about 3,000 acres, is a high terrace and has an unusually level surface. Many others are found along the Grand and Moreau rivers and their tributaries.

One of the most important tracts in the State is situated along the Little Missouri. The irrigable lands begin to be most pronounced near the northern side of Twp. 20 N., R. 1 E., from where they extend southward up the river to beyond the boundary of the State. Near Ashcroft the valley widens out to 5 or more miles in width and continues so to beyond Camp Crook, about 8 miles south. Excellent

[a] For detailed data and discussion of the underground water supply see "Geology and Underground Waters of South Dakota," by N. H. Darton, Water-supply Paper, 227, U. S. Geol. Survey.

bodies of semialluvial land occur along the dry streams, which run back from the Little Missouri, especially in the township just referred to. The soil is a heavy, fine, sandy loam to light loam, most of which could be irrigated either by using the waters from the river or by constructing reservoirs in the hills to the west. In Twp. 19 N., R. 1 E., a small acreage is being irrigated with water caught in a reservoir in the foothills along the Montana state line, but the works are rather crude. Although the crop grown is native hay, the project is very profitable.

At Camp Crook a valley runs back from the river in a southeast direction for about 10 miles with an average width of about 1½ miles. At the above point the valley widens out to 6 or 8 miles and continues south to beyond Harding. This excellent valley, walled on either side by the Short Pine Hills, is one of the most valuable in the western part of the State. By constructing reservoirs at the base of the Hills much of the land could be irrigated, though it is doubtful if sufficient water could be obtained to irrigate the entire valley.

The full capacity of very few of the streams issuing from the Black Hills has yet been utilized, and there is an opportunity here for considerable extension of irrigated land.[a]

ALKALI.

In arid and semiarid regions, as already pointed out in this report, the soils almost always contain a comparatively large amount of soluble material, and there is always a possibility under irrigation of these salts becoming concentrated at the surface in sufficient quantity to injure or even to destroy crops unless proper precautions are taken to prevent it. When water is applied to these soils a portion of this soluble material goes into solution, and when the water is brought to the surface by capillarity and evaporated the salts are left behind. If this process is kept up for a sufficient length of time the percentage of salts in the surface soil becomes great enough to injure crops, and this condition is called "alkali." By reversing the process the salts may be washed out and the land reclaimed. It is much better, however, to adopt methods which will prevent such accumulation, as the cost of prevention is always much less than that of reclamation.

Only a very small percentage of the soils of this area are affected by alkali at the present time and it is probable that very little trouble will every be had from this cause under dry farming. The greatest danger comes with irrigation.

The presence of alkali may be due to its existence in the rocks from which the soils are derived, or to its accumulation as the results

[a] For further data and discussion of the various factors to be considered under irrigation, see Irrigation in South Dakota, by Samuel H. Lea, state engineer, Bull. 210, Office Experiment Stations, U. S. Department of Agriculture; also Soil Survey of Bellefourche Area, S. Dak., by A. T. Strahorn and C. W. Mann, of the Bureau of Soils.

or seepage or poor drainage. Examples of both origins are found in this area.

The Morton soils have very little alkali in them, except the Morton gumbo. The Rosebud and Cheyenne soils, Dunesand, Smithwick sandy loam, Pierre loam and clay loam, and Hermosa loam show very little evidence of its presence. In the Pierre clays almost every little draw contains salt grass and in many places white incrustations were noted upon the surface in the lower and poorer drained areas. As most of this type will be dry farmed no serious trouble is anticipated. Where irrigation is practiced care must be exercised else damage will result.

The soil type containing the largest amount of alkali is probably the Orman clay. In the survey of the Bellefourche area alkali was generally found distributed throughout the area of this type in sufficient quantity to cause much danger under irrigation. The entire area in the western part contains on an average from 0.40 to 0.60 per cent of alkali to a depth of 6 feet.

The lighter textured alluvial soils usually show little or no alkali but the heavier types, especially where the material has come from the Pierre shale, give evidence of its presence in considerable amounts.

The methods of handling the soil in order to lessen or prevent the damage from alkali are discussed by Strahorn and Mann as follows: [a]

> Certain methods of handling the soil will, however, tend to keep the alkali in the subsoil beyond the reach of most crops in all areas, except where the conditions of drainage are least favorable. The quantity of water applied should be no more than will furnish the crop with the necessary moisture, and a very thorough cultivation of the soil should be practiced at all times. Thus very little water will reach the subsoil, evaporation from the surface will be largely prevented and the moisture will be held for the use of the crop. In the case of alfalfa and small grains, frequent cultivation of the soil can not be had, but the thickness with which these crops cover the ground will largely prevent the evaporation of the water.
>
> On sloping lands the alkali is less likely to rise to the surface, since the water soaking into the lower soil will more likely come to the surface at lower levels. But for this reason care should be taken not to overirrigate the higher lands, otherwise the lower fields may have to be abandoned because of the increase of alkali.
>
> If the quantity of alkali shall increase to such an extent that the cultivation of the land is no longer profitable, the only satisfactory remedy will be thorough underdrainage in connection with copious flooding. Since the general texture of the soils is heavy, and there is no subsoil drainage, the use of any temporary methods, as flooding or scraping the surface, will only be an expense and waste of labor. The drainage of these heavy soils will be slow and costly, but it is the only means of permanent reclamation. It can not be too strongly impressed upon the farmers that the continued productivenesss of these soils can only be secured by the use of small quantities of water and a very thorough cultivation where the crop will permit, and it would be wise to underdrain the fields as soon as practicable as a preventive measure, whether the crops at the time are showing the effects of the alkali accumulations or not.

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[a] Soil Survey of Bellefourche area, South Dakota, by Strahorn and Mann. Bureau of Soils, U. S. Dept. Agr., 1907, p. 29.

SUMMARY.

The area surveyed includes all of South Dakota west of the Missouri River, a total of 42,219 square miles.

A large percentage consists of rolling plains with "breaks" along the streams and occasional "buttes" upon the uplands. The western part includes the Black Hills, of broken and more or less mountainous topography. The plains are treeless, except along the streams; the hills are largely timbered.

As a whole the area is comparatively thinly settled, but many settlers are moving in and most of the agricultural land has been homesteaded. Large areas are still held as Indian reservations.

Recent railroad construction has greatly improved transportation facilities, but further extension is needed and contemplated.

The climate is semiarid, but crops are successfully grown without irrigation, although years of insufficient rainfall occur. The average annual precipitation is about 18 inches. The winters are cold; the summer days warm, but nights cool.

The soils contain a relatively large amount of soluble material and are fairly well supplied with humus. Many varieties were found. The principal types are included in the Morton, Pierre, Rosebud, and Wade series, but some additional types occur. The soils vary from loose sands to heavy clays, giving opportunity for a wide range of crops. The Morton fine sandy loam, Rosebud fine sandy loam, and Smithwick sandy loam are fair farming soils and well suited to trucking. The Morton loams, Pierre loams and clay loams, Rosebud silt loam and silty clay loam, Spearfish loam, Hermosa loam, Cheyenne loams, and Wade loam are excellent soils for general farming. The Pierre clays, Wade clay, and Orman clay are productive soils, but are difficult to cultivate. Alluvial soils of marked productivity occur along the streams. The Bad Lands, Bad Lands Basins, Morton gumbo, Rough stony land, and Dunesand are best suited to grazing or forestry.

A transition from large ranches to a combination of general farming and stock raising is taking place.

The principal products are wheat, corn, oats, barley, rye, emmer, or speltz, flax, hay, potatoes, fruits, melons, and other vegetables. Fruits and truck are grown principally in and around the Black Hills.

Several areas are being irrigated, especially around Spearfish and Bellefourche, and there is opportunity for considerable extension.

The price of land varies from a few dollars per acre to as much as $250. Rough grazing land sells at $2 to $10; dry farming land, $10 to $20 and sometimes $30; improved irrigated farms as high as $250, but some irrigated land has sold as low as $15 to $20.

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