U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS.

IN COOPERATION WITH THE SOUTH DAKOTA AGRICULTURAL EXPERIMENT STATION.

SOIL SURVEY OF UNION COUNTY, SOUTH DAKOTA.

BY

J. A. KERR, IN CHARGE, AND W. I. WATKINS, OF THE U. S. DEPARTMENT OF AGRICULTURE, AND W. H. PIERRE AND J. A. MACHLIS, OF THE SOUTH DAKOTA AGRICULTURAL EXPERIMENT STATION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1921.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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[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 Division 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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SOIL SURVEY OF UNION COUNTY, SOUTH DAKOTA.

By J. A. KERR, in Charge, and W. I. WATKINS, of the U. S. Department of Agriculture, and W. H. PIERRE and J. A. MACHLIS, of the South Dakota Agricultural Experiment Station.

DESCRIPTION OF THE AREA.

Union County is the extreme southeastern county of South Dakota. It is situated in the fork of the Missouri and Big Sioux Rivers, which here form the State boundaries. The Missouri River, flowing southeast, separates the southern part of the county from Nebraska. The Big Sioux River, flowing south to the Missouri River along the eastern side of the county, separates it from Iowa. The county extends about 40 miles north and south. The northern part is about 14 miles wide; the southern part has an average width of about 8 miles. The total area of the county is 452 square miles, or 289,280 acres.

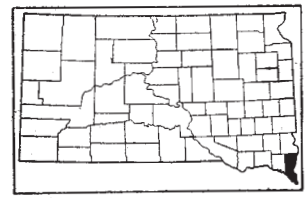

FIG. 19.—Sketch map showing location of the Union County area, South Dakota.

The central and northern parts of Union County, comprising about two-thirds of its area, are upland. The southern part lies in the wide bottoms of the Missouri River.

The upland lies in two main physiographic divisions. The eastern and larger division forms part of the loessial uplands widely developed in this and the adjoining States. The western upland is part of the wide morainal plain that occupies the valley of Vermilion River, which flows south to the Missouri River a few miles farther west.

The loessial uplands are high, rising rather abruptly from the bottoms of Big Sioux River and of lower Brule Creek, and reaching elevations of about 300 feet above these streams on the main ridges. For some distance back from these streams the country is quite hilly, with short valleys and hollows at frequent intervals leading directly to the streams. Farther within the hills the slopes are generally longer and more moderate, and there are belts of smooth or gently sloping land of considerable width on the crests of the ridges. The country gradually becomes more gently rolling toward the north, except for the narrow belt which drains directly to Big Sioux River. The wide drainage basin of upper Brule Creek has a very favorable topography, with long, gentle slopes to the streams and wide areas of undulating or gently rolling surfaces along the divides.

The morainal plain in the county lies in two distinct divisions. The northern part is high and broadly undulating. Though it marks the eastern limit of the glacial movement which produced it, it is not marked by any conspicuous elevations. A few small hills at its

southern end are capped with loess. In places the plain extends with gentle slopes down to the Brule bottoms, but for several miles it joins the loessial plain along a line connecting the heads of hollows leading to the creek. A few farms near Beresford are drained by well-established watercourses flowing west to Vermilion River, but the greater part of this plain drains to occasional shallow depressions without natural outlet for a shallow depth of water. A few of these, draining larger areas, form more or less permanent ponds. Some of them are in part marshy enough to support a growth of reeds. But generally the depth of water is too shallow to remain for any great length of time, either because the area drained is small or the excess water passes away through natural outlets or ditches.

The lower plain occupies a terracelike position with respect to the Missouri and Vermilion Rivers, and is locally called the "Bench." Its general elevation is around one hundred feet above the bottoms, but it slopes somewhat to the south toward the Missouri bottoms and to the east to Brule Creek and terminates with bluffs 20 to 60 feet high at the edge of the bottoms. The marginal part of the Bench is adequately drained by these slight slopes. Near the western border a small stream has formed a valley with gentle slopes for about 3 miles back and lies a little below the general level for 7 miles, but along its upper course it drains only a narrow strip of land. Several sections in the interior of the Bench are nearly flat and drain to numerous large and small shallow depressions. The topography is essentially that of a morainal plain.

Nearly the whole width of the Missouri River bottoms for a distance of 20 miles is included in the county, the river flowing in places along the foot of the hills on the southwest side. The bottoms are about 8 miles wide.

The main body of the bottom land between the Missouri and Big Sioux Rivers is built up to one general level, with only slight variations in relief and a slight general slope to the Big Sioux River. It is without natural drainage ways for long distances. The land has been built up mainly, apparently almost entirely, of deposits from the Missouri River, which is much the larger and muddier stream. The side next the Missouri consists mainly of higher sandy and silty deposits along successively abandoned loops, which show a gradual retreat of the river to the southwest side of the bottom. All but the most recent channels are filled in nearly to the general level. The north and east sides of the bottom are a wide unbroken expanse of deep clay deposits, established for a long time and unmarked by traces of river channels. Even where at Elk Point the sandy lands extend across to Big Sioux River, they are apparently only superficial. There is a slight but general fall toward the foot of the hills and Big Sioux River. The fall to Big Sioux River is continous, there being no higher light-textured deposits on its front, so that long drains are dug directly to the river.

The more recently abandoned channels occupied by O'Connor, Goodenough, Mud, and McCook Lakes, in the extreme southern part of the county, mark a former very tortuous stretch of river. The land lying within their loops is low, including a considerable proportion of land subject to annual or periodic overflow. Some of the sandy material here is incoherent and has been formed into dunes, standing above overflow.

The main body of bottom land stands fairly high above both streams, and, with little exception, is not subject to normal overflow. It is said that there has been no extensive overflow since 1880 and that the overflow of that year was due to an ice gorge. A lower flood plain immediately along the river lies about 20 feet below the main bottom and gives an avenue of escape for the flood waters where unimpeded.

The Big Sioux River also has developed a lower inner bottom, a few rods to a quarter mile in width. The wider stretches lie at fairly high levels and constitute good farm land, and only very narrow strips of land are nonagricultural. Apparently the height of the main bottom near Big Sioux River is somewhat uneven, and some stretches of it are subject to shallow overflow, or have so slight a fall that the surface water passes off very slowly. However, substantial houses are built here on the ordinary low foundations.

There is also a slightly depressed area of land near the foot of the hills and the Bench. The center of this area was naturally somewhat marshy. A drainage canal has been dug from it to Big Sioux River. So far as could be learned, no overflow from the Missouri River has passed into it for years. But it appears that at long intervals a part of it is overflowed to shallow depths.

The bottom lands of Big Sioux River above the Missouri bottoms have an average width of about 2 miles. They are quite evenly divided between this and the adjoining counties. For some 6 or 8 miles north from their juncture with the Missouri bottoms they are quite flat, with little development of lower levels next the stream. But the stream channel is rather deep, and levees of 3 to 6 feet in height give a measure of security against normal overflow. Above this stretch the bottoms are commonly benched, with developments of narrow, inner, low bottoms, high main levels, and considerable areas of terrace.

The creek bottoms in the loessial upland are rather wide, especially those along the upper course of Brule Creek. The creek bottoms as a rule are flat and poorly drained. The lower part of Brule Creek is more deeply intrenched, and the bottoms here are fairly well drained.

While the alluvial lands of the county are predominantly first bottoms, there are developments of terrace on the rivers and many of the local streams.

The extreme southeastern part of the Bench lies at a rather low level and has a cover of alluvial soil, apparently little deeper than the 3-foot section. From this terrace the land surface rises very gradually, and the transition from terrace soils to morainal soils is not clearly marked. But the soil nearly to the main level of the Bench has rather the appearance of terrace soil and was thus mapped. The slope of the surface is slight, but is adequate for drainage. There are also extensive areas of terrace in the county along the upper course of Brule Creek and of Big Sioux River. Those of Brule Creek are low, but well drained, mainly through good underdrainage. Those of Big Sioux River stand 5 to 20 feet above the first bottom and are also well drained. In addition to these typical terrace formations, representing old stream deposits left above overflow by subsequent lowering of a part of the bottom, there are also developments of colluvial and outwash plains along the bottoms in the loessial uplands. The

largest of these has been built up by Brule Creek where it enters the river bottom.

The river bottoms lie at elevations of a little more than 1,100 feet above sea level. The loessial uplands reach elevations of over 1,400 feet along the northern border, and the morainal plain rises to about 1,520 feet near Beresford.

The population of the county in 1920 was 11,099. Elk Point, the county seat, situated in the Missouri River bottoms, had a population of 1,470 in 1920; and Beresford, in the northwestern part, situated partly in Lincoln County, had 1,519 inhabitants in 1920. Alcester and Jefferson are smaller market towns.

The Sioux City and Dakota Division of the Chicago, Milwaukee & St. Paul Railway extends up the Missouri valley. The Sioux Falls and Eagan line of this railroad extends up the Big Sioux River valley, joining the other division at Elk Point. The Chicago & North Western Railway extends across the northern part of the county.

The county has a good public-road system, nearly all the section lines being open and well graded. Much of the Kiwanis Trail, which extends through the length of the county, has been surfaced with gravel from the deposits in the terraces of Brule Creek. The main earth roads are generally kept in excellent condition by methodical dragging through the spring and summer. They are frozen through the winter months.

Grain elevators have been built at all of the railroad towns of the county. The principal outside market is Sioux City, Iowa, situated on the east side of Big Sioux River near the southern end of the county. The city has large stockyards, packing plants, and grain elevators.

CLIMATE.

The records of the Weather Bureau station at Centerville, Turner County, show little variation from those of the station at Sioux City, Iowa, lying just southeast of the county, and indicate that the conditions apply with fair accuracy to the area surveyed.

The average period without killing frost is from May 10 to September 30, giving a growing season of ample length for the maturing of the standard varieties of dent corn. Corn planting is begun about May 1. Oats are sown about April 1. The latest killing frost on record in spring occurred on May 24, and the earliest in fall on September 15.

The summer temperatures are moderate, though occasional periods of hot south winds damage the crops in some seasons. The winters are long. They are dry, but the ground is frozen until late, giving a short season for spring plowing. There are light snowfalls through the winter, an average of 4 or 5 inches falling each month from November to March, affording protection to winter wheat for a considerable part of the winter. Cattle are commonly run in the cornstalk fields through the usual winter weather.

The mean annual precipitation at Centerville, Turner County, is 26.68 inches. Almost three-fourths of the precipitation falls during the spring and summer months. Altogether, the rainfall through

the growing season for corn is comparable to that of points farther within the Corn Belt,

The records of the station at Vermilion, situated in the Missouri bottoms in Clay County, indicate that the average temperature is about 2° higher, the average annual precipitation about 1½ inches greater, and the average frost-free season about two weeks longer in the bottoms of the Missouri River than at Centerville.

The following table, compiled from the records of the Weather Bureau station at Centerville, Turner County, gives the more important climatic data:

Normal monthly, seasonal, and annual temperature and precipitation at Centerville, Turner County.

(Elevation, 1,229 feet.)

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1904).	Total amount for the wettest year (1906).
	°F.	°F.	°F.	Inches.	Inches.	Inches.
December	22.6	60	−39	0.83	0.75	1.10
January	16.7	61	−44	.46	.44	.64
February	19.7	69	−33	.80	.32	.75
Winter	19.7	69	−44	2.09	1.51	2.49
March	31.3	79	−21	1.17	.61	1.94
April	47.1	99	14	2.02	2.88	1.16
May	57.3	96	19	4.04	1.06	3.16
Spring	45.2	99	−21	7.23	4.55	6.26
June	67.0	101	34	4.53	3.00	4.86
July	71.7	100	36	4.35	3.52	1.32
August	71.0	103	22	3.22	1.55	10.15
Summer	69.9	103	22	12.10	8.07	16.33
September	63.5	103	22	2.61	.61	6.00
October	50.2	90	4	1.92	4.02	3.87
November	35.9	77	−10	.73	.06	.37
Fall	49.9	103	−10	5.26	4.69	10.24
Year	46.2	103	−44	26.68	18.82	35.32

AGRICULTURE.

Although trading posts were established in this region by the early French fur companies, the Indians were hostile to settlers, and there was little agricultural development in the country west of Big Sioux River until about 1862, when treaties with Indians made this land available. The district had by that time been surveyed by the United States Land Office. The line of the Chicago, Milwaukee & St. Paul Railway was built about 1872, and by 1880 the lands of Union County had been generally homesteaded.

The agriculture of the county has consisted mainly in the production of the staple grain crops—corn, wheat, and oats. Large quantities of grain have been shipped, but stock raising has been an important industry.

The following tables compiled from the reports of the census indicate the trend and development of agriculture since 1880:

Population, improved land, number of farms, and proportion of farms operated by owners in 1880, 1890, 1900, 1910, and 1920.

Year.	Population.	Proportion of total area classed as improved land in farms.	Number of farms.	Proportion of farms operated by owners.
		Per cent.		*Per cent.*
1880	6,813	31	1,246	85
1890	9,130	64	1,373	75
1900	11,153	81	1,646	68.8
1910	10,676	84	1,488	58.4
1920	11,099	80	1,421	48.1

Acreage and production of the leading grain crops in 1879, 1889, 1899, 1909, and 1919.

Year.	Corn.		Wheat.		Oats.	
	Area.	Total production.	Area.	Total production.	Area.	Total production.
	Acres.	*Bushels.*	*Acres.*	*Bushels.*	*Acres.*	*Bushels.*
1879	18,739	305,189	5,026	13,023	2,624	30,672
1889	46,158	1,723,140	11,309	185,733	16,510	458,047
1899	73,121	2,773,740	22,570	251,950	18,456	574,330
1909	89,858	3,160,113	29,525	415,208	31,796	836,949
1919	90,585	3,794,645	38,554	324,108	32,208	978,035

Acreage in hay crops.

Year.	Hay.	hd hay.	Millet.	Timothy.	Timothy and clover.	Clover.	Alfalfa.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
1879[1]	23,039						
1889[1]	52,915						
1899		24,747	3,358			316	175
1909		19,780	455	2,063	8,671	145	902
1919		14,736		595	2,421	696	9,663

[1] Hay crop not reported in detail.

One of the significant features of this agricultural development is the gradual reduction of the acreage of prairie sod. Once land has been brought into cultivation, it has been used for the production of tilled crops almost continuously. Some fields have been cultivated continuously for 40 years or more, and half of the tilled land apparently for 30 years. Until about 1900 legumes or tame grasses were grown on a very small acreage. In 1920 the total acreage in corn, oats, and wheat was 70 per cent of the total improved acreage, while tame or cultivated grasses (hay other than wild or prairie hay) occupied only 6 per cent. That is, for every acre seeded down and cut for hay about 12 acres were in grain crops.

The decreased percentage of improved farm land in 1920 has little significance, although some land is being ruined by caving river banks. Excepting Riverwash and Dunesand, there is very little waste land in the county.

Average yields of the grain crops in general indicate the productiveness of the extensive soil types of the county. Under nearly continuous cultivation, the yields have been well maintained.

The production of tame hay crops in the rotation was at first unnecessary on account of the large acreage of unbroken prairie, from which wild hay could be obtained. Although this source of supply has been rapidly reduced, there is still, in nearly all parts of the upland, a large acreage of poorly drained bottom land producing good yields of a similar hay, so that the acreage of tame grasses is relatively small. Farmers on the upland without creek bottom often prefer to buy wild-hay land rather than to grow hay in the rotation. In earlier years the clover grown was mainly red clover. At present there is a large acreage in sweet clover; in 1921 it probably exceeded 1,000 acres. The tame grasses are now largely displaced by legumes; this selection is based primarily on the increased yields of the grain crops in succeeding years.

Corn is by far the most important crop of the county, occupying in 1920 nearly 40 per cent of the total improved acreage of the county. The standard varieties of dent corn mature well in this part of the State, and the production of seed corn is an important industry both in the bottoms and in the uplands. Reid Yellow Dent, Iowa Silvermine, and Wimple Yellow Dent are commonly grown. For June planting on low bottoms Pride of the North and Squaw corn are used in unfavorable years.

Corn is commonly grown in alternate years in rotation with wheat or oats, both on bottom and upland soils, but a considerable acreage is planted to corn two or more years in succession. Altogether the acreage in corn is about 30 per cent greater than the combined wheat and oats acreage. Following alfalfa or grass, or on manured land, yields may be maintained for several years in succession on all the principal bottom and upland soils. Very little corn is cut. But with the dry fall and winter weather stock may be run in the stalk fields for a long period.

Wheat is the principal small-grain crop in the river bottoms. Winter wheat is sometimes sown in standing corn, but generally the stalk land is disked in spring and spring wheat is sown. On some clay soils wheat may be grown for several years in succession, which gives time for the plowing of stubble and planting of winter wheat. Although winter wheat may winterkill, it outyields spring wheat on the average. Normal yields of spring wheat are about 8 to 20 bushels, and of winter wheat 10 to 25 bushels. Marquis and Velvet Chaff are popular varieties. Wheat is also grown to some extent in the uplands, but it does not yield as well as in the bottoms. It is grown quite extensively on recently broken land, even for years in succession.

At present oats are the common small-grain crop on the upland. Part of the crop is fed on the farm and part is marketed. Silver King is a popular variety. Oats are commonly sown with a wagon-box seeder and harrowed in. This method saves time and is said to prevent the growth of weeds, and is considered the most satisfactory method of seeding.

The small-grain crops are generally threshed from the shock. Formerly the straw was burned, but now most of it is used for forage and bedding.

Alfalfa was not commonly grown here until 1900, but in 1919 it occupied 9,663 acres, with a production of 24,636 tons of hay. It is by far the most extensively grown tame-hay crop in all parts of the county. Estimates of yields obtained in the field were generally put at 3 to 5 tons per acre. Alfalfa appears to be especially adapted to the climate and soils of this region. It thrives in the calcareous soils and produces hay of good color and quality. It is seeded in small grain, and little or no difficulty is encountered in obtaining a stand. A stand generally endures for five years or more, when the alfalfa is gradually displaced by bluegrass. Four or five cuttings are obtained, the first yielding about a ton, and the later cuttings up to about three-fourths ton per acre. The crop is used mainly for hay, but also forms good pasture, especially for hogs.

The yield of corn crops following five years of alfalfa is estimated to be increased on the average from 25 to 50 per cent for the first year or two, the yield then gradually returning to normal. It is said that after one year in alfalfa corn yields are increased somewhat for one to two years, and following five years in alfalfa appreciably increased yields are obtained for 10 years.

Timothy and clover mixed were grown in 1919 on 2,421 acres, with a production of 3,609 tons of hay. Although the crop is now largely displaced by alfalfa, it is valued in the uplands as giving a shorter rotation, and so is grown to some extent. It is generally harvested for two seasons and pastured one season. The timothy sod gives increased yields of corn, but the gain is not so large nor the effect so lasting as in the case of the legumes. It has been a rather common practice to apply manure on timothy sod before breaking. This practice gives heavy yields of corn for two or three years.

Wild grasses are one of the most important hay crops of the county. Wild and prairie grasses were cut in 1919 on 14,736 acres, yielding 20,318 tons of hay. Only a small part of the crop is upland or prairie hay. Most of it is a somewhat coarser hay from poorly drained bottom lands, principally the creek bottoms in the loessial upland. It is stated that this is relished by stock even more than upland hay. Generally only one cutting is made, either before or after the oats harvest; that is, in July or early August. Yields range from 1 to 2 tons per acre. The upland prairie hay is produced mainly on the flatter areas, which include more or less imperfectly drained land. Much of this hay is of bluestem. In places red clover and tame grasses appear in these meadows, but farmers prefer the unmixed prairie grasses.

Sweet clover has not been commonly grown for any great length of time, and the acreage grown in 1919 was not reported separately. Sweet clover was seen in many fields in all parts of the county in 1921, the total acreage probably exceeding 1,000 acres. It is apparently valued as much for soil improvement as for the hay or pasture obtained. It is seeded in small grains, and makes a rather heavy growth the first year, after the grain is harvested. It is pastured or harvested the second year, and the land returned to corn. Volunteer sweet clover is rather common on roadsides through the county, but does not spread in the fields. It is relished by stock and is not regarded as in any way harmful.

No statistics of the number of cattle and hogs raised in the county are available, nor of the numbers of cattle bought and fed for market. A few dairy or dual-purpose cattle are kept on most farms. The feeding of cattle bought in the country to the west, or at the Sioux City market, is, however, an important industry. The practice is apparently somewhat more common in the uplands than in the bottoms. Western sheep are also fed on some farms. The value of dairy products, exclusive of home use, in 1919, was $275,835; in 1909 it was $156,118. Cream is marketed at the railroad towns, or at the creamery at Nora. A number of hogs are kept on most farms, at least enough to use any soft corn. The total value of animals sold and slaughtered in 1909 was $1,050,562; this item is not returned by the 1920 census. Of course a considerable part of this sum would represent the value of feeders bought outside the county.

Poultry is kept on most farms. The value of poultry and eggs produced in 1919 was $284,843, a little more than the value of dairy products.

The climate is not especially favorable to fruit trees, but small orchards are grown on some farms both in the uplands and in the bottoms. In 1920 there were 8,286 apple trees, 1,955 plum trees, and 471 cherry trees of bearing age in the county. In 1910 the numbers were 17,799 apple trees, 11,428 plum trees, and 2,293 cherry trees. Fruit trees were generally injured in one unusually severe winter during the decade. The yields of fruit are not large or regular. The apples grown are mainly of the summer and fall varieties.

Throughout the county the farm buildings are substantial and well kept. The barns do not have large mows, but hay and straw keep well in the stack under the dry winter conditions. Most farms are equipped with large corncribs, and many farms have elevators and shellers operated by gas engines. Wheat is generally stored in the elevators at the local markets. The cultivated fields are rather commonly fenced with woven fencing.

Good water is obtainable, both in the bottoms and the uplands, from drilled wells. It is usually pumped by windmills.

The farm implements are generally large and are used with four-horse and six-horse teams. The most common plows are two-bottom 12-inch plows. The seed bed is generally prepared with disk harrows and wide, light smoothing harrows or drags. On a small part of the land corn is planted in checks. The drilled corn is worked with single-row cultivators, and the listed corn with two-row cultivators. Tractors are used to some extent, especially on the clayey "gumbo" river-bottom soils.

Nearly all the plowing is done in the fall. The stubble land is plowed as soon after threshing as possible. The soil is in good tilth at this time, and early plowing prevents the weeds from seeding. The land is frozen through the winter. Oats seeding begins about the 1st of April. It is seeded without plowing in disked stalk land. The fall-plowed land is then prepared for corn by disking and dragging. Most farmers leave some stubble or sod land to be manured through the winter, and this is plowed in April. Corn planting begins about the 1st of May and is finished as quickly as possible. Any stalk land not plowed at that time is double disked and listed. It is

estimated that over half the corn following corn is listed without plowing. Corn on plowed land will outyield that on disked land by 10 or 15 bushels, and it is very desirable to plow land at least every other year.

Labor was hired on 85 per cent of the farms of the county in 1919, the average outlay on these farms being $668.16.

There were 1,421 farms in the county at the last census, with an average size of 175.9 acres. Most of the land is farmed in quarter sections. There are no very large land holdings in the county. About 52 per cent of the farms were operated by tenants. Land is usually rented on shares; the rent is commonly one-half the crop. A large proportion of the grain produced on rented farms is marketed.

The average assessed value of farm lands in the county, as reported in the census, increased from $70.86 an acre in 1910 to $210.33 in 1920. Both upland and bottom farms at that time were selling at $200 to $300, in some cases as high as $500 an acre, and wild-grass meadowland sold at $150. Even the hilly pasture land along Big Sioux River sold for over $100. Land values have decreased since then, but with few sales it is difficult to estimate present values.

SOILS.

The soils of Union County owe their most striking and important characteristics to their geographic position. The decrease of rainfall westward in the United States and the corresponding diminished amount of moisture in the soil results in a less advanced degree of weathering and leaching of the soil material. Union County lies on the border between two great natural soil regions; that is, between the region in which the leaching of carbonates has extended to a depth of more than 3 feet and the region in which leaching is not now taking place to that depth and there is actually an accumulation of carbonates within the 3-foot section.

Climatic conditions, with their resulting soil differences, and to a less important degree the topographic features of the area, have combined to prevent the growth of trees and to favor a dense growth of short grasses. The soils of the county have therefore been developed under a grass vegetation and have those characteristics which are everywhere impressed upon true prairie soils. The most obvious characteristic of the surface soils, one that is common to prairie soils, which have developed under the influence of a moderate supply of moisture, is their dark color. This color is imparted by finely divided organic matter derived from the decay of grass roots and intimately mixed with the mineral constituents of the soil. All of the soils of the county, with the exception of small areas of recently deposited alluvium, Dunesand, and material recently exposed to weathering, have very dark surface soils, varying in color, according to locality, topography, and type, from a dark grayish brown to almost black.

The second common characteristic of the surface soils is the fine granular structure. In widely distributed silty and sandy types this structure, which may be described as a single-grained structure, gives the loose, mellow condition which characterizes these soils. The heavy types also break up under favorable moisture conditions into

a slightly coarser but still very fine granular structure. In the second horizon of the well-drained upland soils the material is heavier in texture and more coarsely granular, but in this area no type has any marked compaction in the subsoil. The color changes with depth from the surface to a brown, the transition zone usually having a thickness of 4 to 6 inches. This layer extends to depths of 18 to 24 inches below the surface. As a rule, neither this layer nor the surface soil contains sufficient carbonates to effervesce when treated with acid. The next lower layer is usually lighter in texture and looser than those above and approaches the parent material in color and structure. The color is light yellowish brown or light grayish brown; at less than 3 feet this material is streaked and splotched with gray or white, and in places the entire lower part of the 3-foot section is solid gray or white. This very light colored material is composed largely of carbonates, mainly lime carbonate. As this county is on the border of that region in which carbonates accumulate in the subsoil, it is in most places difficult to determine whether the carbonate present is carbonate of the parent material, which has not been removed by leaching, or carbonate which has been accumulated from above and possibly from below. This difficulty is greatest in the case of the soils of the Marshall series. The Barnes, Fargo, and Bearden soils are believed to have an actual accumulation of lime.

The profile described above may be taken as typical of the dark-colored well-drained soils that contain lime carbonate in the subsoil and is found in the soils of the Marshall, Barnes, and Bearden series. Variations from this profile are the basis for the differentiation of nearly all the series of dark-colored soils; more thorough leaching in certain soils may have removed the carbonate, or conditions of restricted drainage may have modified the character of the subsoil.

The Waukesha, O'Neill, and Judson series comprise the group of well-drained alluvial soils which have been largely leached of their lime to a depth of more than 3 feet. The Wabash series includes recent-alluvial soils which have been leached of their lime and have been developed under conditions of imperfect drainage and have gray or mottled subsoils.

The soils of the Fargo and Lamoure series form a group having dark-colored surface soils and heavy mottled subsoils in which there is sufficient lime to cause effervescence with acid. The Fargo series occurs in depressions in the upland, and the Lamoure series on the first bottoms subject to overflow by the streams.

The Cass and the Sarpy series include low alluvial soils which have sandy or gravelly subsoils and are usually calcareous. The principal difference between these two series is the color of the surface soils, the Cass being dark and the Sarpy light colored.

The Knox silt loam has a light-brown to yellowish-brown surface soil which grades into a yellowish-brown highly calcareous parent material. This soil owes its color to its immaturity. Rapid erosion has removed the dark-colored material from the surface as fast as it could be formed, and the partly weathered light-colored material has been left exposed.

The principal characteristics considered above are those imparted by the important soil-forming processes. It is believed that these forces have been predominant in fixing the most important charac-

teristics of the soil. In the classification of the soils into series, however, account has been taken of the composition, source, and the process of accumulation of the material from which the soils have developed. The soil series, therefore, consists of soil types that are similar in color, origin, and structural characteristics. The soil types of a series differ from each other mainly in the texture or relative coarseness and fineness of the surface soil. The soil type is the unit of soil mapping.

The upland of Union County is deeply covered with material transported and deposited by the ice sheets. The glacial drift includes material from many different rock formations, but has been transported for such long distances and so mixed in transportation and deposition that it is quite uniform over large areas. In Union County it is in a large measure derived from the beds of Cretaceous shale, sandstone, and limestone which underlie this general region and the country to the north. The drift is an unstratified mixture of coarse and fine textured soil, with gravel and bowlders. Clay and silt are apparently the predominant fine earth material of the drift, but below depths of 3 to 5 feet there is a considerable proportion of gravel and bowlders. The surface 3-foot section here contains few pebbles or bowlders. The materials were doubtless laid down under somewhat different conditions than usual, with more or less sorting by water from the melting ice. It has also probably been affected by some resorting and the addition of soil material by the winds.

The drift has been deeply covered by a later deposit of loess, the silty material which covers wide expanses of this region and which is generally regarded as an eolian deposit. The unweathered loess consists of light-brown or buff, uniformly fine-textured material; its texture is predominantly silty, with some clay and a small percentage of sand. It does not show stratification, but has a well-defined columnar structure and is sufficiently coherent to stand up in deep vertical cuts. But in the slower and more prolonged processes of erosion and valley formation it slumps and creeps down the hillsides, so that even in hilly country, such as much of the loessial upland of this county, it presents smooth and unbroken surfaces on all but the steepest slopes, where it shows small faults along its vertical planes, marking the surface like cow paths. The loess deposit in the county is of considerable depth. The present valleys had apparently been somewhat deeply formed at the time of its deposition, and it conforms to inequalities of the surface. The cores of the hills are quite generally of early drift, and in places on steep slopes the drift is near the surface. The loose covering is deepest on the ridges, but as a rule it extends well below the 3-foot depth, and in places it is said to have a depth of 50 feet or more.[1]

Deep deposits of glacial drift were brought into this county by two glacial movements from the north. The drift of the first glaciation was subsequently deeply covered with the loessial deposits which form the present surface of the eastern uplands. But later the loess covering in the western part of the county was carried away or covered with drift of a second glaciation, which flowed down the valley of the Vermilion, but not that of Big Sioux River. This later

[1] See Elk Point Folio, United States Geological Survey.

ice sheet deposited the drift of the present morainal plain. The surface of this plain has apparently received a shallow covering of loess. This is especially apparent at the boundary of the formations south of Beresford, where a considerable depth of loess covers the later till for some distance. Near the Missouri bottoms these later loessial deposits are several feet thick, and have in places developed the calcareous concretions characteristic of loess. However, this later deposit is so shallow over most of the till that the material of the 3-foot soil section is regarded as of glacial origin.

From these glacial drift and loess deposits all the upland soils of the area have been developed, and materials from these deposits reworked and deposited by the streams have given the alluvial soils of the local streams. Corresponding types of the Marshall, the Barnes, and the Bearden series may be similar in their profiles, and it is believed that under long exposure to the soil-forming processes they have reached a close similarity in composition, but they are placed in different series upon the basis of difference in manner of accumulation of the parent material. The Marshall soils have been developed upon loess, the Barnes soils upon glacial drift, and the Bearden upon alluvial deposits.

The alluvial soils of the county were also grasslands, except for some forested areas on the higher land adjoining the Missouri River. Alluvial soils which have been in place for a considerable length of time are greatly darkened by the content of organic matter from the decay of these grasses. The clay soils in the wide expanse of back land have been built up so slowly that the material has been darkened as it was deposited and the dark color extends to the depth of the soil section. The sandy soils on the Missouri River front have not been so greatly darkened, owing to several factors, including the more recent time of deposition, the development under a forest cover, and apparently also the drainage conditions. The sandy soils on Big Sioux River are dark. The soil materials deposited by Big Sioux River in the county are not highly calcareous. In the Missouri bottoms the sandy deposits are uniformly highly calcareous, and even the surface soil has generally not been leached. The clays are not so uniformly highly calcareous, and their surface soils are generally leached. The wash from the loessial hills consists mainly of the leached surface soil, but the poor drainage of the local creek bottoms has resulted in accumulation of lime. The better-drained creek-bottom soils are not highly calcareous.

In the slightly depressed areas of the morainal plain, which receive considerable run-off from the higher land and retain much of it until it evaporates, alkali salts have accumulated and reduce the crop yields in unfavorable seasons. The drainage waters from the Bench also have carried similar salts in solution to the river bottom, where they have been deposited in the depressed areas of back lands.

The terrace soils of the county are classified in four series. The Bearden soils are essentially the terrace equivalent of the Barnes soils of the upland. The Waukesha soils are developed from water-assorted glacial wash, laid down under first-bottom conditions. They have subsoils heavier than the surface soils and are not highly calcareous. The O'Neill soils are similar to the Waukesha, except that

they overlie open beds of sand and gravel and are somewhat droughty. The Judson soils consist principally of outwash from loessial soils, with only slight textural modification by weathering in place.

In the Missouri bottoms the soil material was quite thoroughly assorted and soil of one texture deposited without much interbedding with heavier or lighter soil to considerable depth. On the river front sandy material, with only thin interbedding of silt or clay, was deposited. These sandy soils were built up rapidly, in some cases a foot or more being deposited in one overflow. These soils, with relatively small accumulations of organic matter and a light-textured subsoil, were classified in the Sarpy series. The sandy soils of similar profile in the Big Sioux River bottom are dark and are classified in the Cass series.

First-bottom types that have dark-brown to black surface soils and a subsoil as heavy as or heavier than the surface soil and with a high content of carbonates are classed in the Lamoure series. Alluvial first-bottom types that are similar to the Lamoure soils in other respects, but are not highly calcareous, are classed in the Wabash series.

The soil types mapped in Union County are described in greater detail in subsequent pages of this report. Their distribution is shown on the accompanying soil map.

The following table shows the actual and relative extent of each soil type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marshall silt loam	101,312	35.0	Sarpy fine sand	3,968	1.4
Lamoure silt loam	29,056	11.5	Fargo silt loam	3,840	1.3
Light-colored phase	4,160		Cass silty clay loam	3,712	1.3
Barnes silt loam	15,936	10.6	Waukesha silt loam	3,328	1.2
Bench phase	14,592		Sarpy clay	3,200	1.1
Wabash clay	22,080	7.6	Cass silt loam	3,136	1.1
Lamoure clay	14,720	5.1	Knox silt loam	2,304	.8
Sarpy very fine sandy loam	10,176	3.5	Cass fine sandy loam	2,176	.8
Wabash silt loam	9,408	3.3	Sarpy silt loam	1,216	.4
Riverwash	8,192	2.8	Marshall sandy loam	1,024	.4
Cass clay	6,400	2.2	Dunesand	960	.3
Lamoure silty clay loam	6,208	2.1	Wabash fine sandy loam	640	.2
Lamoure very fine sandy loam, light-colored phase	5,888	2.0	O'Neill fine sandy loam	448	.2
Bearden silt loam	5,888	2.0	Total	289,280	.....
Judson silt loam	5,312	1.8			

MARSHALL SANDY LOAM.

The surface soil of the Marshall sandy loam typically is a dark-brown sandy loam 8 to 12 inches deep. The subsoil is a yellowish-brown to brownish-yellow sandy loam, which grades at about 18 to 24 inches into brownish-yellow loamy sand or sand.

The surface soil is variable in texture, for it has been more or less modified by a shallow covering or admixture of silty material. The texture ranges generally from sandy loam to loamy sand, but includes some loam, and at the other extreme some light-brown sand or coarse sand. The subsoil is quite uniform throughout the type. It is generally highly calcareous, though without concretions. Material of

this texture is of course not typical loess as it is usually defined; it is probably alluvial. Part of an area near Spink has an even surface and is quite distinctly an alluvial terrace.

The type is not extensive. It occurs in a narrow belt on the east side of the bottoms of Brule Creek and lies at elevations reaching a maximum of about 50 feet above the first bottom. The topography is generally sloping, the slope conforming to that of the adjoining loessial hills. It has good internal drainage, but is not considered especially droughty.

This type originally supported a good growth of prairie grasses. It is now generally in cultivation. Corn, oats, alfalfa, and clover are the principal crops. Under continued planting to grain crops the soil becomes loose and drifts. No part of the type has been modified very much by this drifting, for it has affected only the surface soil. After growing alfalfa or clover, the soil drifts very little, and good grain crops can be obtained for several years. The legumes produce well, alfalfa yielding about as well as on the heavier soils. Corn following these legumes may yield 50 bushels or more per acre.

MARSHALL SILT LOAM.

The surface soil of typical developments of the Marshall silt loam is a dark grayish brown or nearly black, mellow silt loam. This is underlain at about 8 to 12 inches by brownish-yellow silt loam, which in turn passes at about 18 to 24 inches into lighter brownish yellow or buff silt loam, with a small to large admixture of small lime concretions. The material of the lower subsoil is only slightly weathered and has practically the same appearance as the underlying loess. The lime carbonate has been largely leached from the surface soil and the upper part of the subsoil, including in places material in which lime concretions are embedded; but the lower subsoil is highly calcareous. The surface soil has a granular, mellow structure. Owing to its high content of organic matter, the cultivated soil remains spongy and yielding in cornfields through the fall, with very slight, weak crusting.

The texture of the soil is fairly uniform throughout the county, but the content of humus and of lime varies from place to place, mainly with differences in situation. On the upper slopes of the hillsides the removal of surface material by wash and creep has progressed nearly as fast as the leaching, so that the surface soil may be highly calcareous, and in places contains considerable quantities of lime concretions. Here the soil is not darkened so much nor to so great a depth as elsewhere, so that in some lights freshly cultivated land, seen at a distance, appears dark grayish or yellowish brown. On lower graded slopes the leached and darkened soil is in places accumulated to considerable depth. These variations occur not only in the hillier sections, but to some extent along gentle slopes. In places considerable quantities of calcareous soil and concretions have been brought to the surface by gophers.

There is also some variation in the texture of the material. Much of the loess in the southern part of the uplands has a relatively large content of very fine sand. The upper part of the deposit is silt, and the surface soil is apparently so largely derived from it that generally

it is distinctly silty. But on the shoulders and points of the hills where the soil is strictly residual, without admixture by creep and wash from above, the texture of the soil approaches a very fine sandy loam. The subsoil in the southern part of the loessial upland is generally as light as or lighter than the surface soil. In the undulating areas along divides in the northern part of the county the subsoil is somewhat heavier.

A flat variation of the Marshall silt loam occupies the outer part of the Bench along the Missouri bottoms. The soil of this is very dark, and is smooth and silty in texture. The loessial deposit from which it is derived is shallow, and near the upper edge of the Bench toward the north heavier material, consisting of or derived from till, may be encountered in the subsoil. Typical loessial concretions occur near the river bottoms, where the deposit is deepest, but farther north they have not been formed, and some chalky lime may be present in the lower subsoil. The topography is nearly level, but there is sufficient slope to give good drainage, and the soil is as productive as that derived from the deeper and earlier deposits.

The Marshall silt loam is the predominant loessial soil of the county. It occupies the undulating and gently rolling uplands of the northeastern part of the county, and is the principal soil in the hilly country nearer Big Sioux River and lower Brule Creek.

This is a productive soil. The very hilly land along the main streams is generally in permanent pasture of the native prairie grasses, but all the rest is good tillable farm land. There was practically no native tree growth on the type, but plantings of cottonwood, box elder, and some other trees make good growth.

Corn and oats are the principal crops, and all other crops are relatively unimportant. A small acreage of alfalfa is grown on most farms. Timothy and red clover are grown on some farms, and the use of sweet clover is becoming common. Bluegrass forms a large part of the growth of pasture land. A few farmers grow wheat on the fresher land, but oats is commonly regarded as more profitable. Corn normally yields about 35 to 50 bushels per acre, oats 30 to 40 bushels, spring wheat 8 to 12 bushels, and alfalfa yields about $2\frac{1}{2}$ to 5 tons per acre.

Corn and oats are generally grown in rotation. The value of growing legume crops in the rotation is generally appreciated. Alfalfa is commonly sown on the areas of shallow soil, where it yields as well as on the deeper soil, and where it is especially valuable in its effects upon the following grain crops. Much grain has been sold from these upland farms without greatly lessening their productiveness. The plowing under of stubble and cornstalks, with the large natural supply of organic matter has kept the soil in good physical condition. The soil has such absorptive capacity for water, especially under cultivation, that the run-off is not heavy. Even rather steep hillsides have not been gullied. However, the total removal of soil by long-continued washing has appreciably thinned the dark surface layer in places, and where fences cross the swales it can be seen that depressions in places have been filled in to a depth of 2 feet or more.

The hillier sections apparently produce about as well as the undulating areas. They were generally brought under cultivation later,

and in time will probably require the growing of legumes at shorter intervals to maintain crop yields and to reduce wash to a minimum.

The use of the grain crops produced depends largely on the distance from market, the quality of wild hay from the creek bottoms, the tenure of the land, and other factors. Oats are mainly a subsistence crop. Most farmers keep a few dairy cattle and raise enough hogs to use up any immature corn. A creamery is located at Nora, a village south of Alcester. On the larger farms, feeder cattle are fattened for market, or hogs are raised. However, large quantities of corn are still sold.

The price of this land varies according to topography and location. The highest prices are obtained for gently rolling land, and about half as much for rather hilly land at a distance from markets.

KNOX SILT LOAM.

The surface soil of the Knox silt loam is typically a grayish-brown or yellowish-brown friable silt loam. This is underlain at 6 to 10 inches by a lighter yellow friable silt loam, which grades rapidly into the slightly weathered loess. The surface soil is commonly somewhat leached of lime, but highly calcareous material is reached at depths of a few inches, and the subsoil also has a considerable content of small lime concretions.

The type is developed on eroded surfaces in the loessial hills, and the soil profile varies according to the rate of erosion. Where erosion is most rapid, as on the shoulders of the hills, the surface soil is light brownish yellow, very little darkened with organic matter, and highly calcareous, in places containing numerous lime concretions. On the smoother faces of steep slopes the surface soil is rather dark and not highly calcareous to a depth of 2 to 6 inches, where it passes abruptly into brownish-yellow calcareous soil.

The texture of the soil is somewhat variable. As a rule it is a smooth silt loam, with an appreciable content of very fine sand. But in places it approaches a very fine sandy loam. The larger content of a very fine sand is not noticeable in the surface soil where it contains considerable humus; and the subsoil has the same coherent structure as the silt loam, giving about the same moisture conditions.

The soil is not subject to rapid erosion while in grass, and where it occurs in small patches within areas of the Marshall silt loam and is cultivated it does not wash rapidly, apparently very little more than the Marshall. But accumulation of humus is a slow process; and as the growth of grasses on these spots of shallow soil has not been heavy, erosion has been more active than over Marshall areas, with the resulting lighter colored soil.

The type occurs in the hilly country in the southern part of the loessial uplands. It occupies fairly large areas on steep upper slopes and narrow ridges. On some very steep slopes facing the bottoms of Big Sioux River, gravelly drift may be encountered in the subsoil; in places it appears at the surface; and in a few places residual soil or rock is encountered in the 3-foot section. Except on these few slopes, the loess extends well below the 3-foot soil section. Farther back from the large streams the type occurs only as patches on the shoulders of the hills, with the Marshall silt loam occupying all except these patches. There is no sharp line of distinction between

the two soils. In mapping, the Knox silt loam was limited to distinctly light-colored soil or to dark soils so shallow that plowing would expose the light-colored material.

The larger areas of the type are in pasture of the native prairie grasses, which form a good sod and make good growth. Patches of this soil within the Marshall silt loam are farmed in connection with that type. When the available manure is applied to these spots they yield about as well as the Marshall soil. Many of the larger patches are used for alfalfa, which produces as well or nearly as well on the Knox as on the Marshall. Alfalfa increases the yields of the following corn crops for two or three years. Under more continuous cropping to corn, the Knox silt loam yields little more than half as much as the Marshall.

BARNES SILT LOAM.

The surface soil of the Barnes silt loam is a very dark grayish brown or almost black silt loam, 8 to 12 inches deep. The subsoil is a yellowish-brown silt loam, which passes at about 18 inches into yellow silty clay loam to silty clay. At a depth of about 3 feet the material grades into the unassorted glacial till, which contains gravel, but is so largely of silt and clay that the gravel is embedded and does not affect the passage of moisture. In general there is very little gravel in the soil section, but in places the surface soil has a small content of lime-incrusted gravel. The surface and subsurface soil layers ordinarily contain only moderate quantities of lime but at about 20 to 30 inches the subsoil becomes highly calcareous and carries in most areas considerable quantities of gray chalky material. The parent till also contains calcareous material, but there is apparently some concentration at the lower limit of leaching in the subsoil.

The most typical body of this soil is the large area in the northwestern part of the county. This is a high, undulating plain, overlooking the valley of Brule Creek on the east. The surface is smooth, but not flat, with long undulations a half mile or more from crest to crest. In places it slopes down to Brule Creek, but for several miles its general level is maintained up to the heads of hollows leading to Brule Creek, where the type gives way to loessial deposits. Parts of the plain are drained by well-defined waterways to Brule Creek or Vermilion River; but generally the run-off flows to shallow depressions without natural outlet. Some of the depressions are completely surrounded by considerably higher land; most of them, however, may be drained without deep ditching. The slope to these basins is sufficient to give adequate surface drainage.

The Barnes silt loam is productive and is nearly all under cultivation, except for occasional fields, including areas of poorly drained soil which are left in the native growth of prairie grasses. There is no native forest growth, but planted cottonwood and box elder make good growth.

The crops grown, the average yields, and farm practices in general are about the same as on the Marshall silt loam. The soils are essentially similar in agricultural value and are equally developed. Some farmers state that the Barnes silt loam, with its heavier subsoil, produces a little better in dry seasons than the Marshall silt loam. The

topography of the Barnes soil is slightly more favorable than that of the Marshall.

Strips of Barnes silt loam also occur on the hillsides along Big Sioux River and the steep slopes from the Bench to the river bottom. These areas are of loess over till at various depths, with rather shallow, in places gravelly, but fairly dark soil. They are used mainly for pasture.

The Barnes silt loam sells for about the same prices as the Marshall silt loam, but in a few cases it has brought even higher prices.

Barnes silt loam, bench phase.—The Barnes silt loam on the Bench, like that of the higher plain, has a surface deposit of loess, and the boundary between it and the Marshall silt loam on the south is arbitrarily drawn. Throughout the Bench the soil to a depth of nearly 3 feet is quite free of gravel, and altogether different from the unassorted, gravelly substratum. The principal difference between the soil on the Bench and that on the higher plain is largely a matter of topography. A marginal belt up to a mile in width is altogether of typical Barnes silt loam, but toward the interior, on flatter or perhaps slightly depressed places, there is some concentration of clay in the subsoil.

There are within this bench phase mapped areas of Fargo silt loam but there also occur numerous small areas and strips of Fargo soils and of soils intermediate between the Fargo and the Barnes series that could not be shown accurately on a map of the scale used in this survey. Several sections along the county line, besides containing a considerable proportion of Fargo silt loam, are generally somewhat inadequately drained, the water passing off slowly after heavy rains. Only a narrow strip of land drains naturally toward the lower lying areas of Fargo silt loam extending through these sections. In normal seasons, these flatter lands are planted in good season and yield as well as the more undulating areas. But in wet seasons planting is delayed, except where ditches have been dug. Ditches are not needed at close intervals, as they are only needed to drain away surface water. At present there is a larger area of land in bluegrass pasture or wild grasses in this section than in the northern plain. The pastures are principally on the Fargo silt loam, but the Barnes silt loam included may amount to 10 per cent of the total.

FARGO SILT LOAM.

The surface soil of the Fargo silt loam is a dark grayish brown to nearly black silt loam about 12 to 20 inches deep. The subsoil is a dark brownish drab silty clay loam to clay, somewhat mottled below with lighter gray and with brown iron stains. At least a part of the subsoil is of heavy clay, giving inadequate underdrainage. The surface soil does not carry large quantities of lime, but the lower subsoil is highly calcareous, with considerable quantities of gray chalky lime. In places there is more or less alkali present.

The type occupies shallow depressions in the morainal plain, and receives the run-off from the surrounding land. As a rule the areas are comparatively small and scattered. In some sections they make up a tenth or more of the land.

Some of the depressions are covered with water through the greater part of the year, but commonly there is an outlet for any great depth of water. These outlets are generally through narrow, faint depressions, unmarked by any channel and scarcely traceable. It appears that the water retained in most of these areas is naturally so shallow that it evaporates in a short time, and the depressions support a heavy growth of grasses. Lower depressions commonly occur in the center of large areas, with some growth of reeds. Some strips of this soil extend to established waterways, but they have no continuous channel and until ditched they drain very slowly. The larger areas of the type are generally very slightly depressed, and include strips and patches of higher land and of intermediate soils containing little clay.

Most of the areas are now drained of their surface water by ditches, and support a good growth of wild grasses, yielding 1 to 2 tons of hay per acre. The grasses are somewhat mixed now with red clover. When pastured, bluegrass displaces the native grasses.

Many of the smaller areas are farmed in connection with the surrounding Barnes silt loam, and where drained they yield as well as or better than the Barnes. In one case noted, alfalfa was seeded as the first crop and made heavy growth. Another area, after tiling, was said to outyield the Barnes considerably in the drier seasons.

The content of alkali is variable, but there are only a very few patches of unproductive land. The wild grasses and bluegrass thrive nearly everywhere. Under cultivation, the alkali is mostly concentrated in the subsoil, but in some seasons it rises to the surface soil and injures crops considerably. Applications of manure largely prevent injury from alkali.

JUDSON SILT LOAM.

The surface soil of the Judson silt loam is typically a dark grayish brown, almost black, mellow silt loam, about 10 to 15 inches deep. The subsoil is a lighter brown silt loam, which passes at a depth of about 20 inches into yellowish-brown to brownish-yellow silt loam. The soil is generally of uniform texture and friable structure throughout the 3-foot section. It has been developed from stream outwash and colluvial material rather than assorted sedimentary deposits.

The type occurs in numerous small areas on the terraces of Big Sioux River, and on colluvial slopes at the base of the hills. Within the hills it occurs in typical terrace situations, and also along the abandoned bottoms of diverted streams. The soil in these areas is similar to the Marshall silt loam, but has a somewhat greater depth of darkened soil than the adjoining rolling uplands. A large area of outwash material at the entrance of Brule Creek into the river bottom was mapped as of this type. This area lies on a terrace for some distance from the base of the hills, but it slopes gradually toward the river until much of it is very little higher than the general level of the river bottom. Brule Creek, however, is rather deeply intrenched, and the land has not been overflowed for a number of years.

The Judson silt loam has excellent moisture conditions and is very productive. It is nearly all under cultivation, corn, wheat, and oats being the principal crops. Corn yields normally about 35 to 50

bushels per acre, oats 30 to 40 bushels, spring wheat 8 to 20 bushels. Alfalfa produces well, yielding about 2½ to 5 tons per acre. Corn is by far the most important crop, being commonly grown in rotation with one of the small-grain crops.

WAUKESHA SILT LOAM.

The surface soil of the Waukesha silt loam is a dark grayish brown to nearly black silt loam about 10 to 14 inches deep. This is underlain by a brown or yellowish-brown silt loam to silty clay loam, passing at about 20 to 24 inches into yellow silty clay loam to silty clay. Highly calcareous soil is seldom found within the 3-foot soil section. The underlying material here is largely of gravelly and sandy wash, but it is well below the 3-foot depth nearly everywhere and does not make the soil droughty.

The type occupies terrace positions in the bottoms of Big Sioux River. These terraces generally stand some 10 to 15 feet above the first bottom, except that on the downstream side they may slope gradually to the first-bottom land. They are above overflow from the river, but occasionally receive deposits from small streams flowing out of the hills. The surface is smooth and slightly undulating.

The original growth was of prairie grasses, with little or no forest. Nearly all of the type has been brought under cultivation. Corn, oats, and wheat are the leading crops. Corn yields normally about 35 to 50 bushels per acre, spring wheat 8 to 20 bushels, oats 30 to 40 bushels.

O'NEILL FINE SANDY LOAM.

The surface soil of the O'Neill fine sandy loam is a dark-brown, fairly heavy fine sandy loam, about 8 to 12 inches deep. The subsoil is a yellowish-brown fine sandy clay to silty clay loam, underlain at depths of about 20 to 36 inches by loose stratified sand and gravel.

The type is inextensive in the county, occurring only in a few small areas on the terraces of Big Sioux River. It occupies some slightly mounded areas within areas of Waukesha silt loam and some narrow strips near the edge of the first bottom.

The O'Neill fine sandy loam is generally farmed with the associated Waukesha silt loam. The soil is somewhat subject to drought, but where legumes are grown in the rotation and manure is applied, the type yields well in normal years.

BEARDEN SILT LOAM.

The surface soil of the Bearden silt loam is typically a very dark grayish brown mellow silt loam, 10 to 14 inches in depth. The subsoil is a friable yellowish-brown to brownish-yellow silt loam or silty clay loam. The surface soil and upper subsoil are not strongly calcareous, but below the depth of leaching lime is generally accumulated in a layer of gray material.

The type occupies terrace positions along the bottoms of West Brule and Brule Creeks. The terraces along the lower course of the Brule Creek, where it flows along the Bench, are high and formed of shallow alluvial deposits over glacial till. The largest area of this soil, occupying the point of land at the entrance of the creek into the

river bottom, rises gradually from a low position at the point up to the general level of the Bench. The terraces about Spink are also nearly at the level of the Bench. The soil of these high terraces resembles that of the typical Barnes silt loam in color, drainage conditions, and productiveness. The surface is even, nearly level, and noticeably free of the shallow depressions common over most of the Bench.

The terraces on the upper 10 miles of the course of Brule Creek in the county are low, standing only 4 to 8 feet above the first bottom. The surface here is nearly level, and unmarked by drainage ways over considerable stretches. The material underlying these terraces is bedded sand and gravel, which in many places is reached at depths of 3 to 4 feet. At this depth the porous substratum does not cause droughtiness, but in such places the subsoil is not high in lime, consisting of material similar to that forming the subsoil of the Waukesha silt loam. The occurrence of lime in the subsoil is irregular. The type is similar to the Waukesha silt loam in productiveness.

CASS FINE SANDY LOAM.

The surface soil of the Cass fine sandy loam is a dark grayish brown, mellow fine sandy loam, 8 to 12 inches deep. This is underlain by lighter colored and lighter textured soil, generally ranging from fine sandy loam to fine sand, but with some interbedded layers of silt loam or loam.

The type is developed in the bottoms of Big Sioux River, near the stream, generally a little below the level of the main bottom. It is subject to overflow and at present is being built up in places, mainly with light grayish brown loamy fine sand or fine sand. These deposits are not general, but usually are made in narrow strips across loops of the river.

Overflows occur mainly in the spring months; normally the soil is well drained and is somewhat droughty. In places there is a tendency for cultivated land to wash out during overflows, and the greater part of the type has been left in the native grasses and is used for pasture or meadow. There is considerable bluegrass in pastures. A small part of the type is forested with cottonwood, box elder, ash, and other trees.

The higher and heavier textured variations of the type are cultivated. Corn is the principal grain crop. Fair to good yields are obtained on sod or manure land. Alfalfa thrives on these heavier areas, and a few good stands were observed. But the type as a whole is somewhat subject to drought and inherently less durable than the heavier soils, and adapted to use as pasture.

CASS SILT LOAM.

The surface soil of the Cass silt loam is a very dark grayish brown or black silt loam 12 to 20 inches in depth. This is underlain by lighter brown silt loam to silty clay loam. Within the 3-foot section this passes abruptly into lighter textured soil, usually a light-brown very fine sandy loam to loamy fine sand. The depth to this lighter material is somewhat variable, but it is commonly at least 2 feet. The surface soil does not have a high content of lime, but the sandy subsoil is strongly calcareous.

The type is not extensive in the county. It occurs mainly in the Missouri River bottom, generally adjoining areas of Sarpy very fine sandy loam. The surface is nearly flat, but drainage conditions are good. The soil has a crumbly structure and absorbs rainfall well, and the excess water drains to the sandy substratum.

The Cass silt loam is a productive soil and nearly all under cultivation. The silty layer is deep and retains a good supply of moisture, so that the type is for the most part well drained without undue droughtiness, and normal yields are obtained under a fairly wide range of moisture conditions. Corn yields 40 to 50 bushels per acre in good seasons; spring wheat 8 to 20 bushels; alfalfa is grown on a comparatively small acreage, yielding 2½ to 5 tons per acre.

CASS SILTY CLAY LOAM.

The surface soil of the Cass silty clay loam, which has an average depth of about 7 inches, varies in texture from a silty clay loam to a silty clay, and in color from a dark grayish brown to black. The upper subsoil, extending to depths of 20 to 24 inches below the surface, is a very dark grayish brown silty clay loam, differing little from the surface soil except in color, which is slightly lighter. The lower subsoil is a grayish-yellow or grayish-brown silty clay loam, which gradually passes at less than 3 feet into a silty loam or very fine sandy loam. This lighter material extends to a considerable depth and improves the drainage condition of the type, without being sufficiently porous near the surface to produce droughtiness.

The Cass silty clay loam occupies a total area of several square miles on the first bottoms of the Missouri River. The areas first appear about 2½ miles northwest of Elk Point and extend thence to the western boundary of the county. With the exception of two small areas, the type lies north of the Chicago, Milwaukee & St. Paul Railway.

The type has a smooth surface, and the greater part of it is under cultivation. The soil is ready for disking and planting in the spring before the heavier, deeper clay. The crop adaptations of the type are about the same as for the Wabash clay, but the yields average somewhat higher.

CASS CLAY.

The surface soil of the Cass clay is a dark-gray, dark grayish brown, or black silty clay or clay. This is underlain at about 8 to 12 inches by dark-brown to dark brownish drab silty clay to clay. Within the 3-foot section this passes abruptly into light-textured material, generally a light-brown very fine sandy loam to loamy fine sand, with interbedded layers of grayish-brown very fine sandy loam, the gray color being due to the presence of limy material. The depth to this lighter soil is variable, but usually is from 20 to 30 inches.

The Cass clay is not very extensive in the county. It occurs only in the higher "front" land of the Missouri River bottoms, occupying former river channels abandoned for a long time and filled in nearly to the level of the adjacent sandy soils. The largest areas are near Elk Point and Jefferson. Except in narrow strips along the contact of this type with higher lying sandy types, the drainage is good.

The Cass clay is productive, and about three-fourths of it is under cultivation. Corn and wheat are the principal crops. As compared to the deeper clays, the soil drains out somewhat better in wet seasons, and with good or heavy rainfall produces better crops, but in dry seasons it is affected earlier by drought. However, it appears that where the depth of clay is more than 2 feet, crops suffer little if any more than on the deeper clay soils.

The table below gives the results of mechanical analyses of samples of the soil, subsurface, and subsoil of the Cass clay:

Mechanical analyses of Cass clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
360611	Soil, 0 to 6 inches.....	0.0	0.4	1.3	9.5	16.8	47.7	24.2
360612	Subsurface, 6 to 24 inches..	.0	.1	.2	.4	1.6	29.1	69.0
360613	Subsoil, 24 to 36 inches.....	.0	.0	.0	.8	39.8	44.6	15.2

SARPY FINE SAND.

The surface soil of the Sarpy fine sand is a light yellowish brown to grayish-brown fine sand to loamy fine sand, about 6 to 8 inches in depth. The subsoil is a lighter yellowish brown or grayish-brown fine sand, with very little or no interbedding with heavier materials. Both soil and subsoil are highly calcareous.

The type is not extensive in Union County. It is developed mainly on the lower, comparatively recent deposits associated with the lakes in the extreme southern part of the county. A few areas occur on the main level of the bottom along the Missouri River above these lakes, and there are a few small areas in the bottoms of Big Sioux River.

The surface is somewhat uneven, with irregular hummocky patches in which the intervening depressions may be occupied by silty soil. Commonly these uneven areas are small, and after a period of cultivation the surface tends to become smooth. At intervals there are ridged hummocks 4 to 5 feet in height, but evidently not formed by the wind. In a few places, as in parts of the areas south of Mud Lake, the surface has somewhat the conformation of sand dunes.

A large part of the type is not under cultivation, but is in pasture of wild grasses and bluegrass or is forested with cottonwood, box elder, ash, and other trees. Corn and oats produce fair yields, except in dry seasons when yields are low. The soil is well suited to the production of watermelons and early vegetables. Alfalfa, sweet clover, and red clover grow well, but are more subject to winterkilling than on the heavier soil. Following these legumes, good crops of grain may be produced. Low yields are due to unfavorable moisture conditions and lack of organic matter, and not to deficiency of mineral plant food. The growing of legumes not only adds organic matter but increases the capacity of the soil for moisture and largely prevents drifting.

SARPY VERY FINE SANDY LOAM.

The surface soil of the Sarpy very fine sandy loam is a light-brown to yellowish-brown, fairly heavy, very fine sandy loam, 8 to 12 inches deep. This is underlain by material mainly of the same or nearly the same texture, including in most areas layers of very fine sandy loam or silt loam of a gray color caused by a high content of chalky lime. Both the soil and subsoil are highly calcareous.

The type occurs extensively in the Missouri River bottoms, in belts one-fourth to a half mile wide. These areas lie along former channels of the river, and only a little higher than the adjoining heavier textured soils, from which they rise slightly toward the river channel. The type generally forms the highest land in the main bottoms. The surface is smooth. There is little run-off, the soil absorbing most of the rainfall.

An inextensive variation of the type occupying lower areas than the typical soil has been developed more recently by the building up of fairly high bottoms of recent wash. This variation includes an area due south of Elk Point, occupying the western parts of sections 12, 13, and 24, T. 90 N., R. 50 W., and adjoining the higher typical soil along a line closely following the half lines of these sections. The variation also includes the land within the recently abandoned river channels occupied by the lakes in the extreme southern part of the county. Both surface soil and subsoil of this variation are lighter textured and lighter colored than the typical soil. This land is recognized as being droughty, giving large yields only in seasons of ample rainfall. Probably half of this land is in forest of cottonwood, box elder, ash, elm, and other trees.

Except for this lower variation, the type is highly productive and nearly all of it is under cultivation. Corn, wheat, and oats are the principal crops. Corn and one of the small grain crops are commonly grown in rotation. The average wheat yield is not as large as on the heavier soils. Corn yields as well as on the heavier soils, for the good underdrainage makes possible early planting and regular cultivation with little delay from wet weather. Even after heavy rains cultivation may be resumed the second day. The soil has not accumulated sufficient organic matter to give it a dark color, but it is essentially a very fertile soil. As generally cultivated, good moisture conditions are maintained, so that the intertilled crops withstand drought better than on the clay soils. Corn yields normally about 35 to 50 bushels per acre, spring wheat 8 to 16 bushels, oats 25 to 40 bushels. Alfalfa is grown on a small acreage. Apparently it yields as well on this as on the heavier types. It insures large increases in the yield of following grain crops. Sweet clover is coming into use and is adapted to a shorter rotation than alfalfa. This is a good soil for watermelons, potatoes, and garden vegetables.

Much of this land has been farmed to grain crops for years with infrequent seeding to clover and grasses and with small applications of manure. The plowing down of stubble and cornstalks has kept the soil in good tilth and prevented any noticeable drifting. Altogether yields have been well maintained, but the soil shows the effect

of heavy cropping sooner than the heavier soils. By growing legumes at intervals of several years the corn yields may be increased considerably. The yield of small grain can not be increased much, as heavier growth is likely to result in lodging.

SARPY SILT LOAM.

The surface soil of the Sarpy silt loam is a brown silt loam, 6 to 10 inches in depth. The subsoil is generally brown or brownish-drab silty clay loam or silt loam, which passes into light-textured material ranging from yellowish-brown very fine sandy loam to fine sand, with more or less interbedding of very fine sandy loam or silt loam, rather gray from a high content of chalklike lime. The depth of the silty upper subsoil usually ranges from 20 to 30 inches. The surface soil contains only moderate quantities of lime, but the sandy material of the subsoil is throughout highly calcareous.

The type is not extensive in the county. It occurs in the Missouri River bottoms, as a rule in strips adjoining the Sarpy very fine sandy loam. The underlying sand insures good underdrainage, and the subsoil is generally sufficiently fine textured to hold moisture well and prevent droughtiness.

Nearly all of the type is under cultivation. Corn and wheat are the principal crops. Oats are grown to supply feed for work stock. Alfalfa occupies a small acreage. Corn generally yields 35 to 50 bushels per acre, wheat 8 to 20 bushels, oats 25 to 50 bushels, alfalfa 2½ to 5 tons.

SARPY CLAY.

The Sarpy clay is a brown or grayish-brown silty clay to clay, slightly tinged and mottled with lighter shades of the same color. This is underlain at varying depths by light yellowish brown very fine sand or very fine sandy loam. The depth of the heavy soil varies greatly within short distances, but usually ranges from 12 to 24 inches. The surface soil is highly calcareous in places and in others contains little lime. The sandy subsoil is uniformly high in lime.

The type occurs in the Missouri River bottoms, occupying low areas subject to overflow, and receives fresh deposits at intervals. The surface soil has not accumulated much organic matter. The type is not extensive. It is developed mainly in the extreme southern part of the county. The soil is inherently fertile, and some higher areas are cultivated. The areas of shallower soil are droughty. The deeper more recently abandoned river channels are occupied by a marsh variation, subject to overflow for considerable periods, and supporting a heavy growth of reeds.

WABASH FINE SANDY LOAM.

The surface soil of the Wabash fine sandy loam is a very dark grayish brown moderately heavy fine sandy loam, extending without any marked lightening of color to depths of about 15 to 24 inches. It is underlain by somewhat lighter brown heavy fine sandy loam, loam, or silt loam, or interbedded layers of these textures. The texture of the surface soil varies within the range of sandy loam to loam. The material within the 3-foot profile contains only moderate quantities of lime.

The type is not extensive in the county, occurring only at intervals along the upper course of Big Sioux River. It occupies positions above ordinary overflow adjacent to the low inner bottom. It is almost level, being only slightly higher next the stream. It is well drained, has good absorptive capacity, and is a productive soil. Corn and oats are the principal crops. Corn yields normally about 35 to 50 bushels, oats 25 to 40 bushels, alfalfa 2½ to 5 tons per acre. Potatoes also do well, yielding 75 to 150 bushels per acre.

WABASH SILT LOAM.

The surface soil of the Wabash silt loam is a very dark grayish brown to black silt loam about 15 to 20 inches deep. The subsoil is a dark-brown silty clay loam to silty clay. The lower part of the 3-foot section becomes slightly lighter in color and in places is somewhat mottled with rusty brown. Neither the surface soil nor subsoil has a high content of lime.

This is the predominating soil in the Big Sioux River bottoms, generally occupying the main level of the bottom, with other soils on the lower levels along the stream. For some 6 or 8 miles above the entrance of the river into the Missouri bottoms, the main bottom is protected by levees, except where the front land forms natural levees. Along this part of the stream the bottoms have about the same general height above mean water level, without the depressed areas commonly present at the foot of the valley slopes. In places the land even rises somewhat toward the hills or benches on account of some filling in by streams from the upland. Farther north the bottoms are generally somewhat higher and not leveed. Considerable stretches have not been overflowed for years. The type grades into the terraces in places, but commonly, even when rather high above the river, it occupies first-bottom positions with reference to the local streams and consists in part of wash from them.

With the protection afforded by levees in places the type is generally safe from normal overflow, and the drainage conditions are good. The mellow soil absorbs most of the normal rainfall of the growing season. Though the lower subsoil is somewhat mottled in places, the underdrainage is evidently adequate. The conditions as regards moisture are dependent in part upon the substratum of sand and gravel, which apparently underlies the whole bottom at no great depth below the surface.

Along the local creeks this soil generally occupies a position next to channels that have been cut to considerable depth. Brule Creek has been fairly deeply entrenched for several miles back from its entrance to the Bench, and its bottoms here are above normal overflow. Good internal drainage has been developed here and the soil largely leached of lime, which appears in other soils in the bottoms of this creek.

The Wabash silt loam is a productive soil and is largely under cultivation. Occasional fields remain in the native grasses. Corn, wheat, and oats are the leading crops. Corn yields ordinarily 35 to 50 bushels, wheat 8 to 20 bushels, and oats 25 to 40 bushels per acre. Alfalfa thrives and is grown in small fields on many farms. The uplands adjoining these bottoms are rather hilly and are to a con-

siderable extent in pasture. Where they are farmed in connection with these bottoms cattle raising is commonly an important industry. On other farms some hogs and cattle are raised and considerable quantities of grain are marketed.

WABASH CLAY.

The surface soil of the Wabash clay is a dark grayish brown or dark brownish drab to almost black silty clay to clay, high in organic matter. There is very little variation in the soil texture to a depth of 3 feet. At about 8 to 16 inches the color becomes lighter, a drab or bluish gray faintly mottled with lighter shades of bluish gray. In places reddish-brown mottlings appear in the lower subsoil.

The material, to the depth of 3 feet, does not contain much lime, but in ditch banks a layer of calcareous soil containing small lime concretions appears in places a little below 3 feet. A few very small concretions appear locally in the soil or subsoil, but the soil in which they are embedded does not effervesce with acid. The surface soil is moderately plastic when wet, but on drying becomes crumbly, and under cultivation has a granular structure. Although it puddles if plowed when too wet, later drying and wetting restores its granular structure fairly well the same season.

This is the most extensive soil in the Missouri River bottoms of this county. It occupies the lower parts along the northeastern side, with only small developments of other soils near the Big Sioux River. The surface is flat, without natural watercourses or a perceptible change in elevation for miles. There is, however, a gradual slope toward Big Sioux River or toward the depressions next to the Bench, and the greater part of the type is naturally so well drained that it is suitable for farming without ditching under normal rainfall conditions. Most of it has not been overflowed for years, but occasionally some of the lowest parts of the type near Big Sioux River may be flooded for brief periods. Ditches have been dug to hasten the removel of excess water after heavy rains or overflows, and these ditches, which are shallow, have improved conditions, though they were not of a nature to prevent cultivation before. The low lime content in this soil in itself indicates that good drainage conditions have generally prevailed between overflows. In contrast is the very calcareous soil between the Wabash clay and the Bench, developed in areas of extremely poor drainage.

This is an important farming soil. About three-fourths of it is under cultivation; the rest is in native grasses, and there is practically no waste land. A larger proportion of land is left in grass on the farms in the lower situations, but a considerable part of the land in nearly all farms on the type is so occupied, not on account of inferior drainage, but because of its value as hay and pasture land. Corn and wheat are the principal grain crops. An acreage is reserved for oats grown for feed. Alfalfa is grown in small fields on many farms and sweet clover on a few. Corn normally yields about 35 to 50 bushels per acre, spring wheat 8 to 20 bushels, oats 25 to 40 bushels, alfalfa 2½ to 5 tons per acre. The native grasslands yield 1 to 2 tons of hay per acre. In pastures bluegrass, with some white clover, is gradually taking the place of the wild grasses. It is gen-

erally stated that this soil yields well in seasons of moderate rainfall. Wet weather reduces yields by delaying planting and cultivation, and dry weather is followed by low yields on poorly tilled land.

Corn is cultivated three to five times. Thorough cultivation is especially desirable on this land. The condition of the corn crop on different fields on this type is quite variable. The differences of growth in plowed and unplowed, well-cultivated and neglected, and early and late planted fields are very marked. Ordinary yields may range from 25 to 60 bushels. On many farms about as much corn is grown on this type as on the lighter soils.

The soil is not in condition for cultivation for three or four days after heavy rains, but on drying is not especially difficult to handle, and with favorable weather the crop can be kept fairly cultivated and yields well. A six-horse team is commonly used to pull a plow with two 12-inch bottoms. It is said that 3 or 4 acres of stubble land are generally plowed in a day—perhaps one-fourth or one-third less than on the silty soils.

In putting in the spring crops, the land is sometimes worked when wet. In many fields the space where the teams are turned is noticeably puddled, and the corn is inferior, but very few fields are in generally poor tilth. Even late in summer, after cultivation has been discontinued, the surface soil remains friable and only slightly crusted. Cracks an inch or more wide are generally formed down the middle of the corn rows during the dry weather of fall. This cracking is not so marked in grassland; but more or less of the surface soil falls or washes down these cracks in the cultivated fields.

The farmers on this type generally admit that a larger acreage of corn is planted than can be properly cared for in average seasons, especially where no part of the farm is of lighter soils. Some farmers plant 50 acres of corn per man. Although this is one of the strongest and most enduring soils of the county, corn yields are considerably increased following alfalfa or sweet clover or the use of manure. At present the bulk of the grain produced is marketed. Most farmers feed some hogs and keep a few dairy or dual-purpose cows. Many farmers are also prepared to feed cattle.

LAMOURE VERY FINE SANDY LOAM, LIGHT-COLORED PHASE.

The surface soil of the Lamoure very fine sandy loam, light-colored phase, is a brown to dark-brown very fine sandy loam, with a depth of about 8 to 12 inches. This is underlain by lighter brown very fine sandy loam with layers having such a large content of chalky calcareous material that they appear gray. At depths of about 18 to 30 inches this passes abruptly into dark-drab clay, somewhat mottled with brown.

Near the river front, about 6 miles southeast of Elk Point, an area has a lighter textured soil and is without conspicuous accumulations of lime in the subsurface. It was learned that this had been a clay area until 1889, when an exceptionally high flood left a deposit of sand, 12 to 18 inches deep, on the surface. It is probable that the larger area near Elk Point was formed under similar conditions.

The surface of the type is even, with very few hummocky places. Moisture conditions are good, the sandy soil absorbing the normal rainfall without becoming saturated. In crop adaptation and productiveness, little distinction can be made between this soil and the Sarpy very fine sandy loam, except that it is probably a somewhat more durable soil.

LAMOURE SILT LOAM.

The surface soil of the Lamoure silt loam is a very dark brown to black silt loam, with a high content of organic matter. This is underlain at about 8 to 16 inches by very dark drab silt loam to silty clay loam, somewhat mottled in the lower subsoil with lighter shades of drab. The surface soil is in places highly calcareous, and generally the soil contains much lime at depths of 8 to 20 inches, with the lower subsoil here and there showing considerable amounts of gray chalky material.

The type is extensive, occupying nearly the whole extent of creek bottoms throughout the loessial upland. The bottoms are broad and flat, and generally poorly drained. The stream channels are generally shallow and meandering, and in many places, even in valleys that drain considerable areas, there is no natural channel. Where channels are developed there is no perceptible rise to their banks and altogether the bottoms are of remarkably even height and flat surface.

Most of the streams opening out on the terraces of the Big Sioux River have no natural channel in the terrace, but the soil becomes better drained and leached near the creek mouths. On the large terrace at the northern boundary of the county the large area mapped as Lamoure silt loam is in position a terrace of Big Sioux River, lying at about the same level as the adjoining terrace soils. The Lamoure soil here is evidently outwash from the small creeks debouching from the upland, but is spread out so evenly and is so highly calcareous and poorly drained that it is essentially in the same condition as in the creek bottoms.

The creek bottoms are subject to overflow, and after floods or heavy rains the land remains saturated for a considerable time. The bottoms support a heavy growth of grasses, and the drainage conditions have favored the accumulation of large quantities of organic matter. This constituent modifies the soil structure, making it rather spongy, and in places it approaches the characteristics of muck. But the organic matter is not fibrous, the ground is firm underfoot even when saturated, and the grass is cut with horse-drawn mowers without difficulty. One cutting is made, yielding 1 to 2 tons per acre. Sometimes a light second cutting is obtained. Some better drained stretches, mostly along the smaller streams, are pastured. In such pastures bluegrass comes in and supplants the wild grasses.

In mapping these bottoms there were included with this type narrow bottoms toward the heads of small drainage ways, which typically consist of a narrow strip of poorly drained Lamoure silt loam with a narrow strip of slightly higher well-drained bottom and some higher partly colluvial soil. The stream channel is generally shallow, or it may be filled in for considerable distances, and the poorly drained

Lamoure soil covered with wash from the cultivated uplands of Marshall soil. Thus a loose, well-drained surface soil is formed, and many of these bottoms are cultivated. These soil conditions are complex and rather likely to be changed and probably extended farther downstream, so they were not separated in mapping. On the lower courses of some of these streams, and also on the lower course of the Big Sioux River, there are some well-drained areas of this soil. These do not contain, on the average, as much organic matter as the poorly drained soil, but are very dark in color. They are highly productive, being rather similar to the Wabash silt loam.

Lamoure silt loam, light-colored phase.—The Lamoure silt loam developed in the Missouri River bottoms is lighter in color than along the smaller streams of this region and is therefore mapped as a light-colored phase of the type. This soil occurs in association with the Sarpy very fine sandy loam, usually forming a well-defined intermediate soil between it and the very dark clayey soils still farther back from the channel. The surface soil is generally a moderately dark brown silt loam, about 8 to 12 inches deep. This is underlain by lighter brown material of similar or somewhat heavier texture. The subsoil is somewhat variable, with interbedded layers of various textures, but not including much sandy silt. Some layers of the subsoil contain much lime carbonate. The surface soil, although not highly calcareous, is mellow and has a crumbly structure.

The phase occupies some of the higher land of the main bottom and has not been overflowed in recent years. The surface is smooth and nearly level, but has a slight slope toward the clay lands farther away from the river. Moisture conditions are good, for the soil under cultivation ordinarily absorbs the rainfall of the growing season without becoming saturated.

The soil is productive and is nearly all under cultivation. Corn and wheat are the principal crops. Oats and alfalfa are grown on a small acreage. Corn normally yields about 30 to 50 bushels per acre, wheat 8 to 20 bushels, and alfalfa 2½ to 5 tons per acre. Some fields are in pasture, mainly of bluegrass.

The phase is plowed and cultivated more easily than the associated clay soils, and is in condition for cultivation sooner after rain. The cornfields can be kept in better tilth in wet seasons, and with fewer workings, so that generally this type outyields the clay in wet seasons, and also in very dry seasons. While the surface soil is not so dark as that of the typical Lamoure silt loam, it apparently has a sufficiently high content of organic matter for maximum production.

LAMOURE SILTY CLAY LOAM.

The surface soil of the Lamoure silty clay loam is a dark grayish brown to almost black silty clay loam, 6 to 8 inches in depth. This is underlain by very dark grayish brown silty clay loam to clay. The type as it occurs here quite commonly contains one or more thin layers of grayish-brown silty or very fine sandy material in the subsurface section, the gray color of which is due to chalky lime carbonate. The surface soil ordinarily contains little lime carbonate, and a large part of the subsoil gives no alkaline reaction.

This type generally occurs in a gradation zone between the calcareous silty soils of the front land and the leached Wabash clay back lands, and the separation of it from the Wabash clay is, of course, an approximation. At the line of separation the highly calcareous material, where present, is generally in the lower part of the subsoil. These strips of gradational soil occupy a considerable total area in the bottoms. The surface is flat, continuing the slight general slope of the Wabash clay toward the east.

The Lamoure silty clay loam has about the same agricultural value as the Wabash clay; a smaller part of it has been left in grasses.

LAMOURE CLAY.

The surface soil of the Lamoure clay is a dark-brown or dark brownish drab to black silty clay to clay. This grades at about 8 to 16 inches into dark-drab or slaty-gray clay mottled with lighter shades of the same color, and in places with some yellow and brown. The surface soil is usually leached of most of the lime carbonate, but at depths of 10 to 20 inches the subsoil in most areas is highly calcareous, with included layers of gray chalky material. The type is essentially similar to the Wabash clay, except for the lime in the subsoil.

The Lamoure clay is extensively developed in the Missouri River bottoms in the belt of irregular-shaped areas on the side of the bottoms next the Missouri, while the more thoroughly leached Wabash clay occupies the wide expanses of back land on the Big Sioux River side. The type occurs in large and small areas slightly below the level of the associated lighter textured soils. The surface is almost flat and unmarked by natural drainage ways for long distances. But the type was naturally sufficiently well drained by the slow movement of run-off to lower places, absorption, and evaporation to favor the growth of wild grasses. It is now ditched along roadsides and some interior land lines, which is apparently all that is necessary to fit the land for farming, so far as moisture conditions are concerned. The narrow crescentic areas of this soil mark former river channels. The surface slopes to the outside of the curves, where there may be a narrow strip of poorly drained land.

No distinction is made by farmers between the Lamoure clay and the Wabash clay. The higher content of lime in the former apparently does not influence crop production.

The rather extensive, somewhat depressed area adjacent to the Bench, near the western boundary of the county, is somewhat affected by alkali, which evidently has accumulated from drainage waters from the alkali soils of the Bench. Part of this area is shown on the map of the United States Geological Survey of 1908 as marsh. Since that date it has been drained by a canal dug through it leading to the Big Sioux River.

The soil here is very dark to a depth of 6 to 8 inches, where it grades into gray or dark-drab silty clay mottled with yellow and drab. Crystals of salts are abundant through the soil and subsoil. The land is nearly all in native grasses. It is said that before the drainage canal was dug the stand and growth of grasses on this soil, and apparently on some of the adjoining Wabash clay, was rather poor. The

present growth is similar to that on other soils, except that it is somewhat coarser. Bluegrass thrives and makes up a large part of the sod in pastures.

The recently deposited soil in the old channels and low places about the lakes in the extreme southern part of the county was included in this type. The deposits are predominantly of clay, for strong currents are prevented by the building up of natural dams at the ends of the old loops. The soil is being filled in, so that it is somewhat lighter in color than the typical soil. Not all of it is highly calcareous, but some layers of it are, and the surface soil shows a marked "buckshot" structure, slightly plastic when wet, but crumbling on drying. Cottonwood, willow, ash, and elm make a heavy growth. The higher situations are cleared and give good yields of corn, wheat, and alfalfa. Some fields are in pasture of native grasses, including a large proportion of bluegrass.

RIVERWASH.

The lower inner bottom through which the Missouri River meanders consists of unstable and nearly unproductive alluvium, classed as Riverwash. The material includes very fine sand, fine sand, loamy sand, and sandy loam, of grayish-brown to yellowish-brown color It contains some interbedded layers of clay, of no great thickness or extent, except possibly in the sloughs, and the material is altogether much lighter in texture and less coherent than that of the main bottom, not only at the surface, but to the depth of the channel.

Most of the Riverwash is built up to a fairly even height, a few feet above the normal stage of water, and extends back to the main bottom at about the same level, with narrow overflow channels at and near the outer margin. As overflows are confined to this comparatively narrow inner bottom, strong currents are developed during floods, deep deposits of sand are laid down, and from time to time the river is diverted to new channels, either by gradual shifting or by the enlarging of cut-offs. The material caves and washes readily.

Most of the Riverwash supports a dense growth of switch willow, with some cottonwood on higher places, and reeds and lilies in the sloughs. The cottonwood trees are seldom more than 8 inches in diameter.

The wash area is constantly being widened by caving, not only where the current of the river strikes, but even along cut-offs. By comparing this survey with that of the United States Geological Survey in 1908, it is seen that since then a maximum width of about a mile of high bottom has been caved away. A characteristic of these later deposits is that everywhere they are several feet lower than the main bottom. Only rather small areas of later deposits are sufficiently stable and productive to be classed as soils rather than wash. Some of this material was mapped as Dunesand. In general these recent soils, besides being low, are comparatively unstable and droughty.

There are also narrow strips of Riverwash along Big Sioux River. The material is commonly of grayish-yellow sand. It is not shifted about as much as the Missouri wash and has a heavier growth of forest. Along the upper course of the river in the county much of the soil thus mapped is heavy, and the land has some value for pasture.

DUNESAND.

The material mapped as Dunesand occurs in only a few areas in the Missouri River bottom. Apparently it is Riverwash, more or less ridged in deposition, blown and shaped by winds into typical dune topography. The largest area, in the center of the loop of Mud Lake, in the extreme southern part of the county, is evidently of comparatively recent formation. Most of it is high enough to be above overflow. It supports a fair growth of forest and is not blown by wind at present. The area within the loop of Lake Goodenough is ridged low Riverwash.

The area west of Elk Point is on the main level of the bottom and evidently an old formation. It consists in part of long, rather broad ridges, which might be alluvial deposits from swift currents, and in part of the high conical dunes which are common in drier regions, where they accumulate about clumps of more vigorous vegetation. The dunes are at least 20 feet high, and are undoubtedly wind blown, but they have been stable for a long time. The surface soil is loamy and coherent owing to the accumulation of organic matter from the growth of grasses. There is a scattering growth of trees and fair woodland bluegrass pasture.

SUMMARY.

Union County is situated in the extreme southeastern corner of South Dakota, in the fork of the Missouri and the Big Sioux Rivers. It comprises an area of 452 square miles, or 289,280 acres.

The uplands which occupy the central and northern parts of the county lie in two main divisions. The eastern and larger division is a high loessial plain, gently rolling in the northern and hilly in the southern and eastern parts. The western uplands are part of a wide morainal plain, in which drainage ways have not been generally established. The northern part of this plain is high and broadly undulating and is adequately drained to depressions or drainage ways. The southern part is lower and more nearly flat, with imperfect drainage in the interior.

The southern third of the county lies in the Missouri River bottoms. There are also comparatively wide bottoms on the Big Sioux River and the local streams. The bottoms of the rivers include, besides their main high bottoms, some areas of low Riverwash and also some development of terraces.

The population of the county is 11,099. The principal towns are Elk Point, the county seat, and Beresford. The county has good railroad facilities. Sioux City is the principal livestock market.

The mean annual rainfall is about 26.68 inches. Nearly three-fourths of the precipitation falls during the spring and summer months. The mean annual temperature is 46.2° F. The average period without killing frost is from May 10 to September 30.

The county has been settled largely since 1860. Grain production is the principal industry. Part of the grain is fed to livestock and part is marketed. Corn is by far the most important crop. Spring wheat is the principal small grain in the bottoms, and oats in the upland. Alfalfa is the principal tame-hay crop. There is a large acreage of native prairie and other grasses, which are a source of hay.

The livestock industries include hog and cattle raising, dairying on a small scale, and the fattening of feeder cattle. Corn and one of the small grains are commonly grown in rotation.

The upland soils of the county are developed upon transported material consisting of both glacial till and loess. Under prairie conditions, a large content of organic matter has been accumulated in the surface soil. The large lime content of the original material has been largely leached from the surface soils, and redeposited in the subsoil. But there has been little concentration of clay and no compaction of structure in the subsoil.

The normally developed loessial soil, occupying nearly all the loessial uplands of the county, is classified as the Marshall silt loam. It is a highly productive and durable soil. A lighter colored soil with a lower content of organic matter, developed on erosional surfaces in the loess, is classified as the Knox silt loam. It is not so productive and durable as the Marshall.

The soil normally developed on the morainal plain, except the occasional areas of depressional soil, is classified as the Barnes silt loam. It is very similar to the Marshall and is highly productive.

The Fargo silt loam occupies shallow depressions in the morainal plain. It supports a good growth of wild grasses, and when surface drainage is established is productive, except where alkali exists.

On the stream terraces the natural growth was also of prairie grasses, and soils that are similar to the upland soils have been developed. The Bearden silt loam is the terrace equivalent of the Barnes and Marshall silt loams. The Waukesha silt loam differs from the Bearden mainly in that the subsoil is not highly calcareous, either because of a low lime content in the alluvial material as deposited or as a result of leaching. The O'Neill fine sandy loam also is not highly calcareous; it is somewhat droughty on account of the light texture and open structure of the subsoil and substratum. The Judson silt loam consists of colluvial and outwash material from the loessial uplands.

The soils of the first bottoms are classified according to three primary factors—the accumulation of organic matter in the surface soil, the content of lime in the subsoil, and the texture of the subsoil as modifying drainage conditions.

The Cass soils are dark-brown, almost black soils, with light-textured subsoils. The Sarpy soils are brown soils with light-textured subsoils. Here they are highly calcareous. The Lamoure and the Wabash soils are dark-brown, almost black soils, underlain by dark-colored heavy subsoils. The Lamoure soils contain much lime; the Wabash soils little.

The Cass clay is developed inextensively in the Missouri River bottoms. Its subsoil is light textured, but the depth of heavy soil is generally sufficient to prevent any marked degree of droughtiness. The Cass silt loam is well drained, and produces well under the ordinary range of moisture conditions. The Cass fine sandy loam is rather droughty and is used mainly for pasture.

The Sarpy clay is developed mainly in rather low situations and is not cultivated. The Sarpy silt loam is similar to the Cass silt loam in agricultural value, although it has a lower content of organic matter. The Sarpy very fine sandy loam is extensively developed in the

Missouri River bottoms; it is well drained, easily tilled, and productive. The Sarpy fine sand is somewhat subject to drought, but in normal years is productive of corn, oats, and alfalfa.

The Wabash clay is the most extensive soil in the Missouri River bottoms. The soil, although heavy, has a crumb structure and is a strong, fertile soil. The Wabash silt loam is the most extensive soil in the Big Sioux River bottoms. It is well drained, mellow, and highly productive. The Wabash fine sandy loam associated with it is also a valuable farm soil. The Lamoure clay is extensively developed in the Missouri River bottoms. It is quite similar to the Wabash clay in appearance and general agricultural value. The Lamoure silty clay loam is somewhat easier to cultivate and is equally productive. The Lamoure silt loam is the predominating soil in the bottoms of the smaller streams. It is generally flat and poorly drained, but supports a heavy growth of native grasses. A light-colored phase of the Lamoure very fine sandy loam, occurring in the Missouri River bottoms, is a valuable farm soil.

Riverwash is unstable and unproductive land occurring quite extensively along the Missouri River. Dunesand consists of wind-blown sand, for the most part too unstable for cultivation and mainly in forest.

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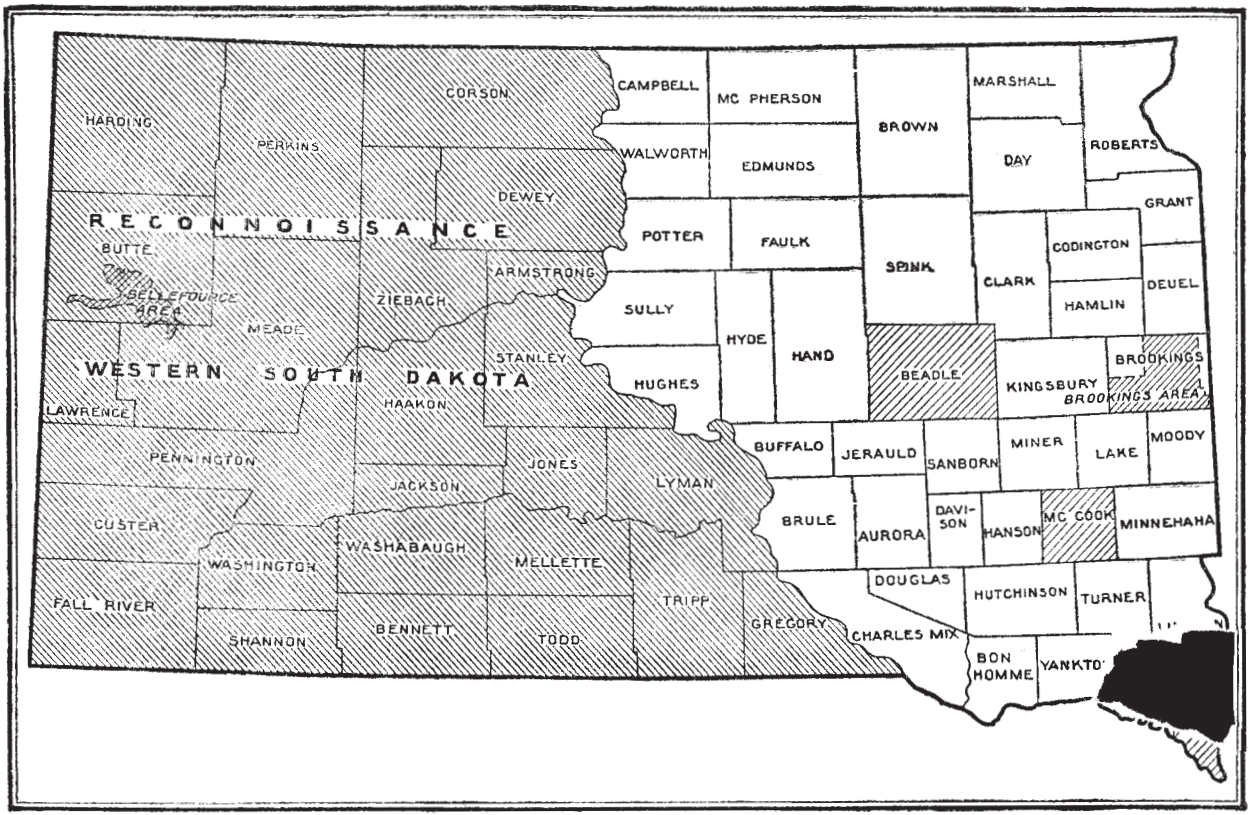

Areas surveyed in South Dakota, shown by shading.

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